DOE/EIS-0026-S-2

Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement

Summary

September 1997

Department of Energy
Carlsbad Area Office
Carlsbad, New Mexico

This Document Printed on Recycled Paper

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN, 37831; prices available from (423) 576-1301.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Copies of this document are available
(while supplies last) upon written request to:

U.S. Department of Energy
Carlsbad Area Office
P.O. Box 3090
Carlsbad, NM 88221

or by calling
1 (800) 336-9477

COVER SHEET

Lead Agency: U.S. Department of Energy

Title: Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement
Eddy County, near Carlsbad, New Mexico

Contact:

For further information about this Environmental Impact Statement, contact:

Harold Johnson, WIPP EIS
U.S. Department of Energy
101 W. Greene Street
Carlsbad, NM 88220
(505) 234-7349 phone
(505) 887-6970 fax

For general information on the Department of Energy's process for implementing the National Environmental Policy Act, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance
Office of the Assistant Secretary for Environment, Safety and Health
U.S. Department of Energy (EH-42)
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-4600 or leave a message at (800) 472-2756

Abstract:

The purpose of *the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II) is to provide information on environmental impacts regarding the Department of Energy's (DOE) proposed disposal operations at WIPP. To that end, SEIS-II has been prepared to assess the potential impacts of continuing the phased development of WIPP as a geologic repository for the safe disposal of transuranic (TRU) waste. SEIS-II evaluates a Proposed Action, three Action Alternatives based on the waste management options presented in the *Final Waste Management Programmatic Environmental Impact Statement*, and two No Action Alternatives. The Proposed Action describes the treatment and disposal of the Basic Inventory of TRU waste over a 35-year period. The Basic Inventory is that waste currently permitted in WIPP based on current laws and agreements. The Action Alternatives propose the treatment of the Basic Inventory and an Additional Inventory as well as the transportation of the treated waste to WIPP for disposal over a 150- to 190-year period. The three Action Alternatives include the treatment of TRU waste at consolidation sites to meet WIPP planning-basis Waste Acceptance Criteria, the thermal treatment of TRU waste to meet Land Disposal Restrictions, and the treatment of TRU waste by a shred and grout process. The No Action Alternatives propose the dismantling and closure of WIPP and storage of the waste. One No Action Alternative proposes treating the waste thermally before placing it in retrievable storage.

SEIS-II evaluates environmental impacts resulting from the various treatment options; the transportation of TRU waste to WIPP using truck, a combination of truck and regular rail service, and a combination of truck and dedicated rail service; and the disposal of this waste in the repository. Evaluated impacts include those to the general environment and to human health. Additional issues associated with the implementation of the alternatives are discussed to provide further understanding of the decisions to be reached and to provide the opportunity for public input on improving DOE's Environmental Management Program.

This page intentionally left blank.

SUMMARY

INTRODUCTION

The U.S. Department of Energy (hereafter the Department or DOE) needs to dispose of transuranic (TRU) waste generated by its past, present, and future activities in a manner that protects public health and the environment. In previous National Environmental Policy Act (NEPA) documents, the Department examined alternatives to repository disposal at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. In this document, the *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (SEIS-II), the Department assesses whether to dispose of TRU waste at WIPP. This document also assesses reasonable options for transportation and other activities associated with disposal, as well as reasonable alternatives concerning quantities, sources, and treatment of TRU waste before disposal.

TRU waste is contaminated with alpha-emitting radionuclides that are heavier than uranium (i.e., their atomic numbers are greater than that of uranium) and that have half-lives longer than 20 years at concentrations greater than 100 nanocuries per gram of waste. Key radionuclides found in TRU waste include americium-241 and several isotopes of plutonium (Pu-238, Pu-239, Pu-240, and Pu-241). Since 1970, DOE has segregated TRU waste from other radioactive waste and stored it in a manner that allows it to be retrieved. Several types of operations (current, past, or future) have generated or will generate TRU waste: (1) nuclear weapons development and manufacturing, (2) plutonium recovery, stabilization, and management, (3) research and development, (4) environmental restoration, and decontamination and decommissioning, (5) waste management, and (6) testing at facilities that are under DOE contract.

TRU waste exists in a variety of forms ranging from unprocessed laboratory trash, such as tools, glassware, and gloves, to solidified sludges from wastewater treatment. TRU waste is classified, for handling purposes, as contact-handled (CH) TRU waste or remote-handled (RH) TRU waste depending on the radiation dose rate at the surface of the waste container. In addition, about 60 percent of TRU waste is classified as TRU mixed waste because it also contains hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). A major component of TRU mixed waste is metallic lead, which is present primarily in the form of glovebox parts and lead-lined gloves or aprons. Some TRU mixed waste contains traces of organic solvents such as methylene chloride and carbon tetrachloride, both common cleaning agents. Some TRU mixed waste also is commingled with polychlorinated biphenyls (PCBs).

A 1981 Record of Decision (ROD), based on the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS), documented DOE's initial decision to proceed with the phased development of WIPP at a site near Carlsbad, New Mexico. In 1990, following construction of most of the WIPP facilities, the Department prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) to update the environmental record established in the FEIS. In the SEIS-I ROD, published in the Federal Register on June 22, 1990, DOE chose the Proposed Action alternative, which was to continue with a phased approach to WIPP by testing TRU waste underground at the facility. DOE subsequently decided to perform the tests in aboveground laboratories instead of at WIPP.

HIGHLIGHTS OF CHANGES SINCE PUBLICATION OF THE DRAFT SEIS-II

In response to stakeholder comments and requests and in an effort to ensure that SEIS-II incorporates the Department's latest planning efforts, changes have been made throughout SEIS-II since its publication in draft form in November 1996. Sidebars are used throughout the document to indicate where changes have been made. No sidebars, though, are used to indicate changes to text boxes, figures, or tables. Below is a list of some notable modifications:

- Two sites have been removed from the tables and the maps presented throughout the document. These two sites, the Pantex Site and Teledyne Brown Engineering, have moved the small amount (less than 1 cubic meter) of TRU waste reported in the Draft SEIS-II to Los Alamos National Laboratory and Rocky Flats Environmental Technology Site, respectively. Since they no longer have TRU waste, the impacts from the waste originating at these two sites are included in the impacts for Los Alamos National Laboratory and Rocky Flats Environmental Technology Site.

- Additional text boxes have been added to Chapter 3 and Chapter 5 that discuss the impacts of waste not disposed of in WIPP under the Proposed Action. Also, additional text has been added to Chapter 3 and Chapter 5 that discusses methods of reducing the period of disposal operations for each Action Alternative to 75 years or less and how impacts would change should DOE choose to use those methods.

- The Proposed Action has been identified as DOE's Preferred Alternative, although rail transportation would continue to be an option for future transportation of TRU waste.

- Additional discussions of current socioeconomic conditions and of WIPP site geology and hydrology have been added to Chapter 4.

- All references to planning documents and to related NEPA documents have been updated. New documents have been reviewed and changes to SEIS-II have been made as needed to ensure consistency with other planning efforts.

- A new appendix (Appendix J) has been added to discuss updated TRU waste inventory estimates and current TRU waste management initiatives.

- The analyses presented in Chapter 5 and in the appendices have been reviewed, redone as necessary, and their presentation revised, based on stakeholder comments on the draft. (See the summary of comments and changes in the Summary text box titled "Issued Raised During the SEIS-II Public Comment Period.")

- Performance assessment analyses have been redone based on stakeholder comments and requests. Two particular changes should be noted. First, new analyses indicate that in this document's most conservative scenarios, radionuclides and heavy metals would reach the Culebra Dolomite should a drilling intrusion occur. Second, the performance assessment results for No Action Alternative 2 have been reduced from 2,325 fatalities to 800 fatalities during 10,000 years. Neither number, though, takes into account potential deaths due to inadvertent intrusion. Chapter 5 now includes estimates of the impacts of intrusion.

- Volume III, the *Comment Response Document*, has been added to SEIS-II. Nearly 4,000 comments were received on the Draft SEIS-II. Those comments are summarized and responses to those comments are presented in the *Comment Response Document*.

The 1990 ROD committed the Department to prepare SEIS-II prior to a decision to dispose of waste at WIPP and determined that the scope of SEIS-II would include an analysis of the long-term performance of WIPP in light of new information obtained since 1990. It also stated that DOE would study the potential impacts to generator, storage, and treatment sites throughout the country of disposing of waste at WIPP.

Since SEIS-I and its ROD, several events have occurred that could affect the treatment and handling of TRU waste and a decision concerning its disposal at WIPP. In 1992, Congress passed the WIPP Land Withdrawal Act (LWA) (Public Law 102-579), which reserves the 16-section area surrounding the WIPP site for the construction, experimentation, operation, repair, maintenance, disposal, shutdown, monitoring, and decommissioning of WIPP. The LWA also limits the radiation permitted at WIPP and the total volume of TRU waste permitted to be disposed of. Also in 1992, Congress passed the Federal Facility Compliance Act (FFCAct), requiring DOE to prepare plans for developing treatment capacities and technologies for mixed waste, including TRU mixed waste. In 1996, Congress passed the National Defense Authorization Act for Fiscal Year 1997 (Public Law 104-201), which amended the LWA. Among other things, Public Law 104-201 provides that RCRA land disposal restrictions do not apply to waste disposed of at WIPP. Other changes since SEIS-I include regulatory and statutory changes, changes in the TRU waste inventory, and the development of new hydrologic and geologic information that may help DOE understand WIPP and its ability to isolate waste. SEIS-II takes into account all of the changed circumstances that might affect potential environmental impacts of TRU waste disposal at WIPP and closure of the WIPP facility once operations cease.

SEIS-II is an integrated part of DOE's overall decision regarding the disposal of TRU waste at WIPP. SEIS-II has been timed to take advantage of information presented in prior documents and to inform current and future planning efforts. The relationship between SEIS-II and major planning and compliance documents is as follows:

- Compliance *Certification Application:* This document, prepared in accordance with 40 CFR Part 194 and submitted to the U.S. Environmental Protection Agency (EPA) in October 1996 and accepted by the EPA in May 1997 is required by the LWA to demonstrate compliance with standards for disposal of TRU waste (40 CFR 191, Subparts B and C). Conceptual models and computer codes used for performance assessment calculations in the Compliance Certification Application (CCA) were used in SEIS-II to assess the long-term ability of WIPP to isolate radioactive waste from the accessible environment.

> ***LEGALLY BINDING ORDERS AND AGREEMENTS***
>
> DOE is subject to a number of legally binding agreements and orders concerning TRU waste. One example of such an order is the negotiated settlement agreement entered by the court in the case of *Public Service Co. v Batt*, Civil No. 91-0035-S-EJL (D. ID, October 17, 1995). DOE intends to keep its commitments pursuant to these binding agreements and orders.

- *Resource Conservation and Recovery Act Part B Permit Application:* This document, submitted April 1996, is the application to operate WIPP as a disposal facility, as defined

ISSUES RAISED DURING THE SEIS-II PUBLIC COMMENT PERIOD

During the public comment period that followed publication of the Draft SEIS-II in November 1996, stakeholders commented on a variety of issues, including the following:

- Several commenters expressed concern that the data, information, and computer codes used in SEIS-II are based on the Draft CCA and not the most current versions used in the CCA. The Draft SEIS-II used some near-final input from the CCA that underwent subsequent changes. The Final SEIS-II is consistent with the Final CCA.
- Several commenters questioned the validity of planning disposal operations for periods of time exceeding 100 years. In response, DOE has assessed the impacts of reducing the disposal periods.
- Some commenters said that SEIS-II documentation relied inappropriately on draft documents. (Many of these documents have since become final and are reflected in the Final SEIS-II.) The reliance on draft documents and the relationship between SEIS-II and other planning and compliance documents is discussed in Section 1.5 of SEIS-II and Chapter 11 of the SEIS-II *Comment Response Document*.
- Several commenters requested that the Additional Inventory (in the subsection titled "Inventories and Treatment" later in this Summary) be included in the Proposed Action. The Department has not made decisions regarding the excavation of much of this waste and would do so only following Comprehensive Environmental Response, Compensation and Liability Act or RCRA investigations and possibly following additional NEPA review. The Additional Inventory, therefore, is not part of the Proposed Action. Nevertheless, the impacts of disposition of the Additional Inventory are discussed under four scenarios.
- Numerous commenters were concerned with the level of emergency response training to communities along the WIPP transportation corridors and felt that training for first responders and medical providers must be completed before shipments begin. The Department addresses these concerns in Chapter 19 of the SEIS-II *Comment Response Document*.
- Several commenters expressed concern about the impacts of accidents and incident-free exposures if TRU waste shipments traveled through Santa Fe along St. Francis Drive or along the Pojoaque corridor. Some commenters stated that shipment of waste should be delayed until the Santa Fe bypass is complete. SEIS-II compares the impacts of shipping TRU waste down St. Francis Drive with those of shipping using the Santa Fe bypass in a text box in Section 5.1.
- Many commenters expressed concern over several issues regarding performance assessment and waste isolation, including the accuracy of predictions over 10,000 years, potential contamination of the environment over long periods of time, the use of appropriate computer codes, the use of engineered barriers, gas generation, human intrusion, and pressurized brine reservoirs. DOE has addressed these and other performance assessment issues in Appendices H and I of SEIS-II and in Chapter 13 of the SEIS-II *Comment Response Document*.
- Many commenters favored long-term monitored retrievable storage in newly designed aboveground structures at the generator sites, instead of disposal at WIPP. Some commenters favored development of transmutation technologies, treatment to reduce toxicity, and other geologic repository alternatives. DOE addresses these concerns in Chapter 3 of SEIS-II and in Chapter 1 of the SEIS-II *Comment Response Document*.
- Many commenters questioned the accuracy of knowledge of waste drum contents and the ability to characterize the waste. Concerns raised included lack of techniques to characterize waste drums, minimal sampling carried out, a lack of records, and inadequate quality assurance requirements. DOE discusses waste characterization in Appendix A of SEIS-II and in Chapter 2 of the SEIS-II *Comment Response Document*.
- Many commenters questioned the honesty, integrity, and conduct of DOE and the federal government with regard to WIPP. Examples of concerns raised included alleged lies and misinformation about the safety of WIPP and waste transportation; spending of funds to overcome opposition to WIPP; a DOE record of avoiding cleanups, contaminating land, and conducting radiation experiments on workers and the public; and seemingly schedule-driven actions of DOE and its neglect of needed site characterization work. DOE has responded to these comments in Chapter 3 of the SEIS-II *Comment Response Document*.
- Many commenters expressed concerns about the post-1970 TRU waste disposal mission of WIPP, including the possibility of expanding the mission to accommodate other types of nuclear waste or other types and amounts of TRU waste beyond current legal limits. WIPP's mission is discussed in Chapter 1 of SEIS-II and in Chapter 10 of the SEIS-II *Comment Response Document*.

under RCRA regulations (40 CFR Part 264). The application has been submitted to the New Mexico Environment Department, the state agency responsible for issuing the permit. (The New Mexico Hazardous Waste Act and its implementing regulations are the state analog to RCRA.) The application provides background information regarding the DOE proposals for operating WIPP and is, therefore, one of the foundations on which assumptions in SEIS-II concerning WIPP operations are based.

- *Final No-Migration Variance Petition:* This document, submitted to the EPA and published on June 14, 1996, is a petition to receive a variance from the RCRA Land Disposal Restrictions (LDRs) on the basis that the migration of hazardous constituents would not exceed health-based levels at the disposal unit boundary. However, such a variance is no longer required pursuant to the National Defense Authorization Act for Fiscal Year 1997, Public Law No. 104-201. The document also provides background information on the long-term ability of WIPP to isolate hazardous waste and has been summarized and incorporated by referenced throughout SEIS-II.

- *Waste Isolation Pilot Plant Safely Analysis Report (SAR), Revision 0:* The intent of this document, published in November 1995, is to examine the hazards associated with the disposal of CH-TRU and RH-TRU waste and to identify where mitigation is needed. The SAR provides accident analyses of CH-TRU and RH-TRU waste. These analyses have been incorporated into SEIS-II where appropriate.

- *Waste Isolation Pilot Plant Safety Analysis Report (SAR), Revision 1:* As with Revision 0, the intent of this document, published in March 1997, is to examine the hazards associated with the disposal of CH-TRU waste and to identify where mitigation is needed. The SAR provides accident analyses of CH-TRU waste (similar analyses for RH-TRU waste are not included). These analyses have been incorporated into SEIS-II, where appropriate.

- *Transuranic Waste Baseline Inventory Report, Revision 2 (BIR-2):* This report (as well as BIR-3, below), published in December 1995, provides the waste volumes, hazardous constituent inventories, and radionuclide data used by DOE in its regulatory compliance applications. BIR-2 (as well as BIR-3, below) is used as the basis for the SEIS-II waste volumes. SEIS-II supplements the radionuclide inventory with inventory data from the Integrated Data Base (IDB).

- *Transuranic Waste Baseline Inventory Report, Revision 3 (BIR-3):* This report, which DOE used for the WIPP CCA, includes information pertaining to waste that is currently eligible for disposal at WIPP under existing laws. BIR-3 waste volumes and hazardous constituent inventories are unchanged from BIR-2. The radionuclide inventories at some sites are changed. Also, information on complexing agents, nitrates, sulfates, phosphates, and cement was added because these components could potentially affect WIPP's ability to contain TRU waste. The information on complexing agents, nitrates, sulfates, phosphates, and cement was incorporated into the parameters used in the SEIS-II analysis of long-term performance. The adjusted volumes used for SEIS-II analyses are based upon BIR-3 inventories.

- *Remote-Handled Transuranic System Assessment:* This report, published in November 1995, discusses the disposal of DOE RH-TRU waste. The report discusses packaging RH-TRU waste at treatment sites in such a way that it could be handled as CH-TRU waste.

This would entail placing the RH-TRU waste in shielded payload containers to limit the radiation dose at the outer container surface to not more than 200 mrem/hr. This waste could then be handled and emplaced as CH-TRU waste. All other CH-TRU waste requirements would apply as well. This study also considered several options for RH-TRU waste emplacement, such as putting the waste in repository walls, in vertical boreholes in the floors of the repository, or in trenches mined in the repository floor. These considerations were used to determine the number of repository panels needed under the Proposed Action and the action alternatives in SEIS-II.

- *Remote-Handled Transuranic Waste Study:* This study was conducted, as required by the LWA, to evaluate the impacts of RH-TRU waste on the performance assessment of the repository and to determine the effects of RH-TRU waste as a part of the WIPP Total Inventory. Also, this study conducted a comparison of CH-TRU and RH-TRU waste to assess differences and similarities for gas generation, flammability and explosiveness, solubility, and brine and geotechnical interactions. The conclusions and findings of this study were considered when addressing TRU waste handling and performance assessment concerns in SEIS-II.

- *The National Transuranic Waste Management Plan:* This plan, published in September 1996, presents a TRU waste management system for the DOE Complex. The system maintains compliance with all binding consent orders, unilateral orders, and regulatory agreements concerning TRU waste and creates a management system that is consistent with the June 1997 Discussion Draft of the DOE Office of Environmental Management's *Accelerating Cleanup: Focus on 2006*. (New TRU waste volume estimates presented in the 2006 Plan Discussion Draft are discussed in Appendix J and Section 5.13.)

The Proposed Action, three action alternatives, two no action alternatives, and the subalternatives considered in SEIS-II comprise a wide range of options on which the Department can base the following decisions:

- Whether to open WIPP for disposal of TRU waste or continue to maintain the waste in storage. The two no action alternatives examine the impacts of not opening WIPP.

- Which types and quantities of TRU waste should be disposed of at WIPP or continued in storage. SEIS-II includes analyses of CH-TRU waste, RH-TRU waste, post-1970 defense TRU waste, nondefense TRU waste, commercial TRU waste, pre-1970 buried TRU waste, and PCB-commingled TRU waste. The alternatives differ in the waste types and quantities involved. For all alternatives, SEIS-II analyzes CH-TRU and RH-TRU waste, both separately and together.

- Which level of waste treatment should be required for disposal or storage. The three action alternatives differ in the treatment involved, as do the two no action alternatives.[1]

- Whether to transport TRU waste primarily by truck or by rail and truck (using rail as much as practical). Three transportation options (truck, commercial rail and truck, and dedicated

[1] DOE may decide, for site-specific reasons (e.g., volume reduction), to further treat TRU waste beyond the level required in the planning-basis WIPP Waste Acceptance Criteria (WAC), even under those alternatives that propose treatment to the WAC. For example, DOE may incinerate or thermally treat TRU waste at some sites, even though thermal treatment is not required by the current planning-basis WAC. Such decisions would be based on site-specific NEPA reviews.

rail and truck) are assessed for all alternatives except two: the Proposed Action, for which transportation by truck is proposed (although DOE's Preferred Alternative reserves the rail transportation option); and No Action Alternative 2, for which there would be no transportation. Decisions based on SEIS-II may combine the transportation options.

Portions of two or more of the alternatives analyzed in SEIS-II may be combined and used by the Department. For this reason, results in SEIS-II are presented separately for RH-TRU waste and CH-TRU waste, by each transportation option, and by inventory type. The impacts of numerous combinations of the options can be calculated by summing the impacts of the various analyses.

BACKGROUND

WIPP is located in Eddy County in southeastern New Mexico. It is about 50 kilometers (30 miles) east of Carlsbad, New Mexico, in an area known as Los Medaños ("the dunes"), a relatively flat, sparsely inhabited plateau with little surface water. The land is mainly used for grazing; other uses include potash mining and oil and gas exploration and development.

WIPP was authorized by Public Law 96-164 to provide a research and development facility for demonstrating the safe disposal of radioactive waste produced by national defense activities. DOE's decision to proceed with WIPP at the southeastern New Mexico site followed a thorough NEPA review and was announced in the 1981 ROD. The decision called for the phased development of WIPP for the disposal of TRU waste generated since 1970. The WIPP facility was originally designed to dispose of approximately 175,600 cubic meters (6.2 million cubic feet) of CH-TRU waste and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste in a 40-hectare (100-acre) excavated repository. Under the LWA, the total capacity has been reduced to 175,000 cubic meters (6.2 million cubic feet).

The major construction activities at WIPP have been completed. Surface facilities have been constructed, including the Waste Handling Building (WHB) where TRU waste would be received, inspected, and moved to the waste handling shaft for transfer underground. The constructed underground facilities include four shafts, the waste disposal area, an experimental area (now closed), an equipment and maintenance area, and connecting tunnels. These underground

LWA LIMITS

The LWA limits the amount and types of TRU waste that can be emplaced at WIPP. The limits include the following:

- WIPP capacity is limited to 175,600 cubic meters (6.2 million cubic feet) total TRU waste by volume.
- No more than 5 percent by volume of RH-TRU waste may have a surface dose rate in excess of 100 rem per hour.
- No RH-TRU waste may have a surface dose rate in excess of 1,000 rem per hour.
- RH-TRU waste containers shall not exceed 23 curies per liter maximum activity level averaged over the volume of the container.
- The total curies of RH-TRU waste shall not exceed 5,100,000 curies.

In addition, the Consultation and Cooperation Agreement (C&C Agreement) with the State of New Mexico limits the volume of RH-TRU waste to 7,080 cubic meters (250,000 cubic feet).

facilities were excavated in the Salado Formation, 655 meters (2,150 feet) beneath the land surface. DOE also has excavated the first panel, which consists of seven disposal rooms. This panel is currently ready to receive waste.

STAKEHOLDER OUTREACH AND INVOLVEMENT ACTIVITIES

DOE conducted several activities prior to the SEIS-II public scoping period to inform the public of the Department's intent to prepare SEIS-II. Letters were sent to SEIS-II stakeholders, including private citizens, elected officials, tribal leaders, and public affairs officers, announcing the Department's plan to prepare SEIS-II. A Fact Sheet and the DOE Carlsbad Area Office Monthly Stakeholder Calendar for August 1995 were also distributed to stakeholders to notify the public of the upcoming SEIS-II scoping activities. In addition, an informal telephone survey was conducted to gather stakeholder suggestions about the structure of the SEIS-II scoping meetings.

SEIS-II public scoping activities included the following:

- A Notice of Intent (NOI) published in the Federal Register on August 23, 1995 (60 FR 43779), and a notice reopening the comment period published in the Federal Register on October 13, 1995

- A public comment period from August 23, 1995, to October 16, 1995

- Public scoping meetings held in Carlsbad, New Mexico, on September 7, 1995; Albuquerque, New Mexico, on September 12, 1995; Santa Fe, New Mexico, on September 14, 1995; Denver, Colorado, on September 19, 1995; Boise, Idaho, on September 20, 1995; and a second meeting in Denver, Colorado, on October 11, 1995

The NOI listed the times and locations of the public scoping meetings and the length of the public scoping period.

The Department issued the Implementation Plan for SEIS-II in May 1996. The Implementation Plan provides background information on WIPP, describes the Department's purpose and need for the WIPP project, and describes the SEIS-II work plan. It also describes the scoping process, major issues identified during the scoping process, and contains a brief discussion of how major scoping issues will be addressed in SEIS-II. Copies of the Implementation Plan were distributed to state, tribal and local governments, U.S. Congressional delegates from states with an interest in the WIPP project, all parties who provided scoping comments, and other interested parties.

Fact Sheets were prepared by the Department to provide stakeholders with additional information on topics related to SEIS-II. Two Fact Sheets, one on prescoping activities and the other on postscoping activities, have been distributed to parties on the SEIS-II mailing list. Fact Sheets were also distributed at the public scoping meetings. These sheets provided information on the NEPA process, the WIPP project, the DOE reading rooms, the role of public participation in the decision process, and other topics relevant to SEIS-II. The Department also will distribute Fact Sheets upon completion of the Final SEIS-II and publication of the ROD to all parties on the SEIS-II mailing list.

DOE published the Draft SEIS-II Notice of Availability (NOA) in the FR on November 29, 1996 (61 FR 60690). The NOA provided information on how the public could obtain copies and provide comments on the Draft SEIS-II, and the locations, dates, and times of the Draft SEIS-II hearings.

More than 900 copies of the Draft SEIS-II and 1,200 copies of the Draft SEIS-II Summary were distributed to federal, state, local, Tribal officials, and the general public. Three fact sheets were distributed along with the Draft SEIS-II and the Summary: an overview of how the public could provide comments on the Draft SEIS-II and the public hearing schedule; a list of the SEIS-II reading rooms and a list of the alternatives analyzed in the Draft SEIS-II.

DOE had initially established a 60-day public comment period that included the public hearing process. In response to public requests for more time to study the Draft SEIS-II, DOE subsequently extended the public comment period to 90 days (62 FR 4989). The public was also provided the opportunity to comment at a series of public hearings held in the following locations: Albuquerque, New Mexico on January 6 and 7, 1997; Santa Fe, New Mexico on January 8, 9, 10, 1997; Carlsbad, New Mexico and Denver, Colorado on January 13, 1997; Richland, Washington and Boise, Idaho on January 15, 1997; Oak Ridge, Tennessee on January 21, 1997; and North Augusta, South Carolina on January 23, 1997.

More than 700 individuals attended the hearings and more than 300 individuals provided oral testimony. The SEIS-II public hearings were scheduled after the holiday season to afford more people the opportunity to attend them. In addition, DOE staff attended meetings in New Mexico, Oregon, and Idaho to give presentations on SEIS-II. Recognizing that not every individual, organization, or agency could or would attend a public hearing, DOE invited comments on the Draft SEIS-II by mail, facsimile, and the Internet and received more than 150 letters.

DESCRIPTION OF THE ALTERNATIVES

SEIS-II analyzes six alternatives: the Proposed Action; Action Alternatives 1, 2, and 3; and No Action Alternatives 1 and 2. Action Alternatives 1, 2, and 3, and No Action Alternative 1 have one or more subalternatives and transportation options. These alternatives, subalternatives, and options vary in the waste inventory considered, the type of treatment, and the type of transportation.

Inventories and Treatment

For SEIS-II, the Basic Inventory includes the defense TRU waste that has been placed in retrievable storage since 1970 and the defense TRU waste that would continue to be generated through 2033 from plutonium stabilization and management activities, environmental restoration, decontamination and decommissioning, waste management, and defense testing and research. Table S-1 shows the TRU waste that comprises this inventory and its location. Such defense TRU waste can be disposed of at WIPP under the LWA, up to the capacity limits in the LWA and the Consultation and Cooperation Agreement with New Mexico (C&C Agreement). (A discussion of updated volumes and TRU waste locations from the 1997 *National Transuranic Waste Management Plan* is presented later in this Summary, throughout SEIS-II, and in Appendix J.)

DOE also owns or controls other TRU waste including nondefense, commercial, and previously disposed of waste. The previously disposed of waste includes waste buried prior to the 1970 decision to keep TRU waste in a retrievable manner. In SEIS-II, this waste is referred to as the

Additional Inventory. The Additional Inventory also includes all nondefense or commercial waste that DOE believes will be generated through 2033. Currently, the commercial and nondefense waste is not permitted at WIPP under the terms of the LWA. Table S-2 presents the volumes and locations of this waste. Included in the Additional Inventory is a small amount of waste (720 cubic meters or 25,430 cubic feet) that has been commingled with PCBs. The impacts of disposing of this small amount of waste are estimated in SEIS-II for alternatives that include thermal treatment of waste.

Table S-1
Basic Inventory TRU Waste Volumes [a]

	Stored (1995) (cubic meters)		Estimated Total through 2022 [b] (cubic meters)		Projected Total through 2033 [c] (cubic meters)	
Site [d]	**CH-TRU**	**RH-TRU**	**CH-TRU**	**RH-TRU**	**CH-TRU**	**RH-TRU**
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering and Environmental Laboratory (INEEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	--- [e]	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. TRU waste containing more than 50 parts per million of PCBs cannot be disposed of at WIPP without applicable permits. The Basic Inventory is waste that resulted from defense activities and that was placed in retrievable storage pursuant to the Atomic Energy Commission policy of 1970 and TRU waste reasonably expected to be generated by these ongoing activities. Volumes have been rounded. Actual totals may differ due to rounding. Projected totals have not been adjusted in anticipation of disposal. A discussion of updated volumes and TRU waste locations presented in the *National Transuranic Waste Management Plan* is presented in Appendix J, throughout SEIS-II, where appropriate, and later in this Summary.

[b] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2.

[c] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033. Total includes TRU waste to be generated for 35 years.

[d] Sites in boldface were included in SEIS-I. INEEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.

[e] Dashes indicate no TRU waste.

Table S-2
Additional Inventory TRU Waste Volumes [a, b, c]

Site [d]	PCB-Commingled (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	--- [e]	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering and Environmental Laboratory (INEEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Additional Inventory includes PCB-commingled TRU waste, commercial TRU waste, nondefense TRU waste, and TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. A discussion of updated volumes and TRU waste locations presented in the *National Transuranic Waste Management Plan* is presented in Appendix J, throughout SEIS-II, where appropriate, and later in this Summary.

[b] The volume of TRU waste includes the 1995 existing and projected waste through 2033.

[c] Actual totals may differ due to rounding.

[d] Sites in boldface also store post-1970 defense TRU waste, see Table S-1. The remaining four sites currently have no post-1970 defense TRU waste.

[e] Dashes indicate no TRU waste.

CONSERVATISM OF TRU WASTE VOLUME ESTIMATES

TRU waste inventory estimates, as used throughout SEIS-II, embody many conservative assumptions to ensure bounding analyses of maximum, reasonably foreseeable impacts. The following reflect some of the conservative assumptions.

- The BIR-3 estimates of TRU waste volumes include projections that may overestimate TRU waste volumes. For instance, in both the Basic Inventory and the Additional Inventory, volume estimates include projections of waste yet to be generated. Though the Department's TRU waste generation due to defense activities has decreased because of a change in the nation's nuclear weapons needs, the projections of future waste also include waste anticipated by activities such as decontamination and decommissioning. These activities, which would include cleaning and disassembling facilities, can generate a great deal of TRU waste, but whether that waste will actually be generated and whether it will be CH-TRU or RH-TRU waste is uncertain. For the purposes of analyses, SEIS-II has used the estimates included in BIR-3, even though the volume of such future-generated waste may be lower.

- The Additional Inventory includes estimates of TRU waste produced prior to 1970 and believed to have been disposed of in trenches at some of the sites. Since DOE's definition of TRU waste has changed and some of the buried waste would probably be classified as low-level waste under current definitions, the amount that is actually TRU waste is unknown. For the purposes of analyses, all of this waste, as estimated in BIR-3, is considered part of the Additional Inventory and the effects of its disposal at WIPP are assessed in the SEIS-II action alternatives. SEIS-II analyzes 141,000 cubic meters (5 million cubic feet) of TRU waste that has been previously disposed of. Currently, though, DOE estimates that only 80,000 cubic meters (2.8 million cubic feet) of this waste would be excavated.

- The C&C Agreement between the State of New Mexico and DOE limits the amount of RH-TRU waste allowable at WIPP to 7,080 cubic meters (250,000 cubic feet). The Department's Proposed Action proposes disposing of this amount of RH-TRU waste, although the actual amount may be as low as 4,300 cubic meters (150,000 cubic feet). The lower figure reflects the current plans for disposing of this waste in the walls of WIPP panel rooms before emplacement of CH-TRU waste in the rooms. At startup, delays in preparing the RH-TRU waste for shipment are anticipated, which would result in the emplacement of some CH-TRU waste before RH-TRU waste is ready for WIPP. To ensure that SEIS-II disposal analyses are conservative, the analyses for the Proposed Action were conducted as if the full 7,080 cubic meters of RH-TRU waste would be emplaced.

- Application of the LWA and the C&C Agreement would limit the amount of CH-TRU waste allowable under the Proposed Action to 168,500 cubic meters (5,950,000 cubic feet), but only 143,000 cubic meters (5,050,000 cubic feet) is estimated to be in the Basic Inventory. Still, because of the potential for excavation of previously disposed of waste (which would then be classified as newly generated) and the potential for treatment of alpha-emitting, low-level waste that could convert currently non-TRU waste forms into TRU waste by concentrating transuranic radionuclides (as discussed in the cumulative impacts analysis), and repackaging of RH-TRU waste to meet the criteria of CH-TRU waste, SEIS-II analyses consider the effects of filling WIPP to its allowable capacity.

- While the LWA and C&C Agreement include limits on the volume of TRU waste that can be emplaced, there is considerable uncertainty concerning how much of a container's volume is made up of TRU waste and how much is void space. Many of the containers would include a great deal of void space, particularly for RH-TRU waste; the actual volume of waste in a drum or cask, therefore, may be much less than the volume of the drum or cask. For the purposes of analyses in SEIS-II, the volume of the drum or cask is used, as if the drum or cask were full without void space.

While volume changes to the TRU waste inventory could reduce or increase the effects calculated in SEIS-II, the best estimates available have been used and conservative assumptions have been incorporated to ensure that the results would actually be less than those presented. A text box entitled "Factors to Consider in Combining Alternatives" (presented in Chapter 5) explains in more detail how the results would change as inventory volumes change.

When both the Basic Inventory and Additional Inventory are considered together, the combined volume is called the Total Inventory in SEIS-II. The Total Inventory, therefore, includes all of the TRU waste that DOE is currently responsible for and all DOE TRU waste anticipated through 2033. The waste in the Total Inventory is stored or would be generated at the 22 sites shown on Figure S-1. (Certain alternatives involve the Total Inventory excluding TRU waste commingled with PCBs.)

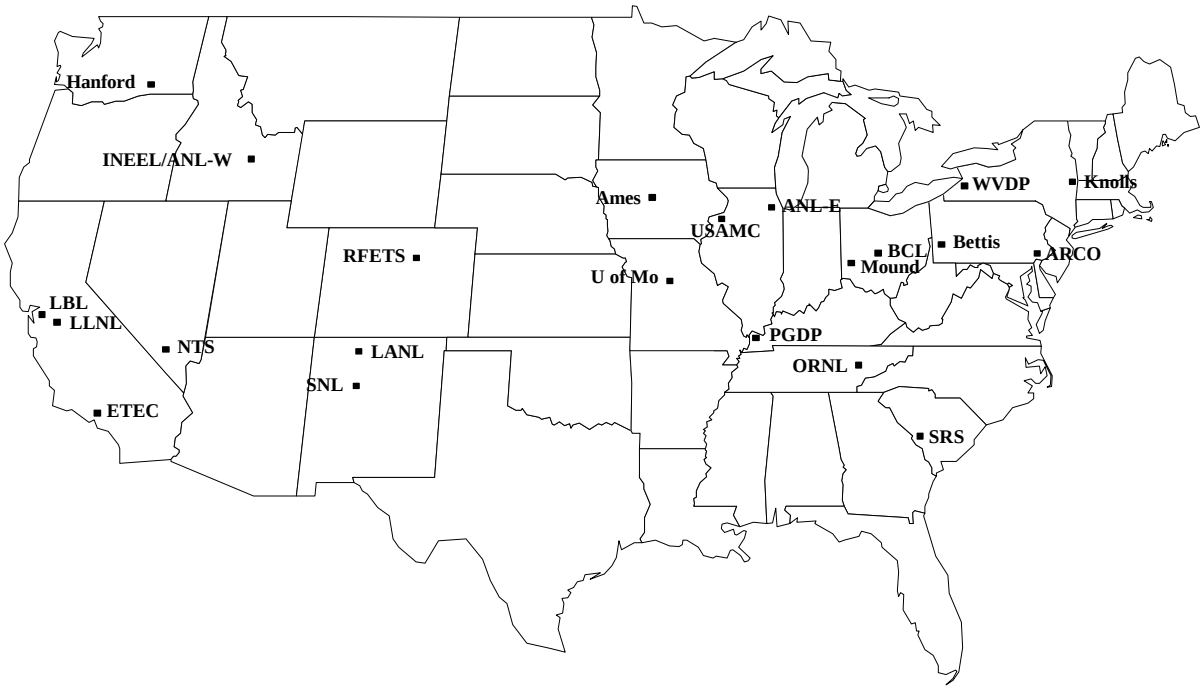
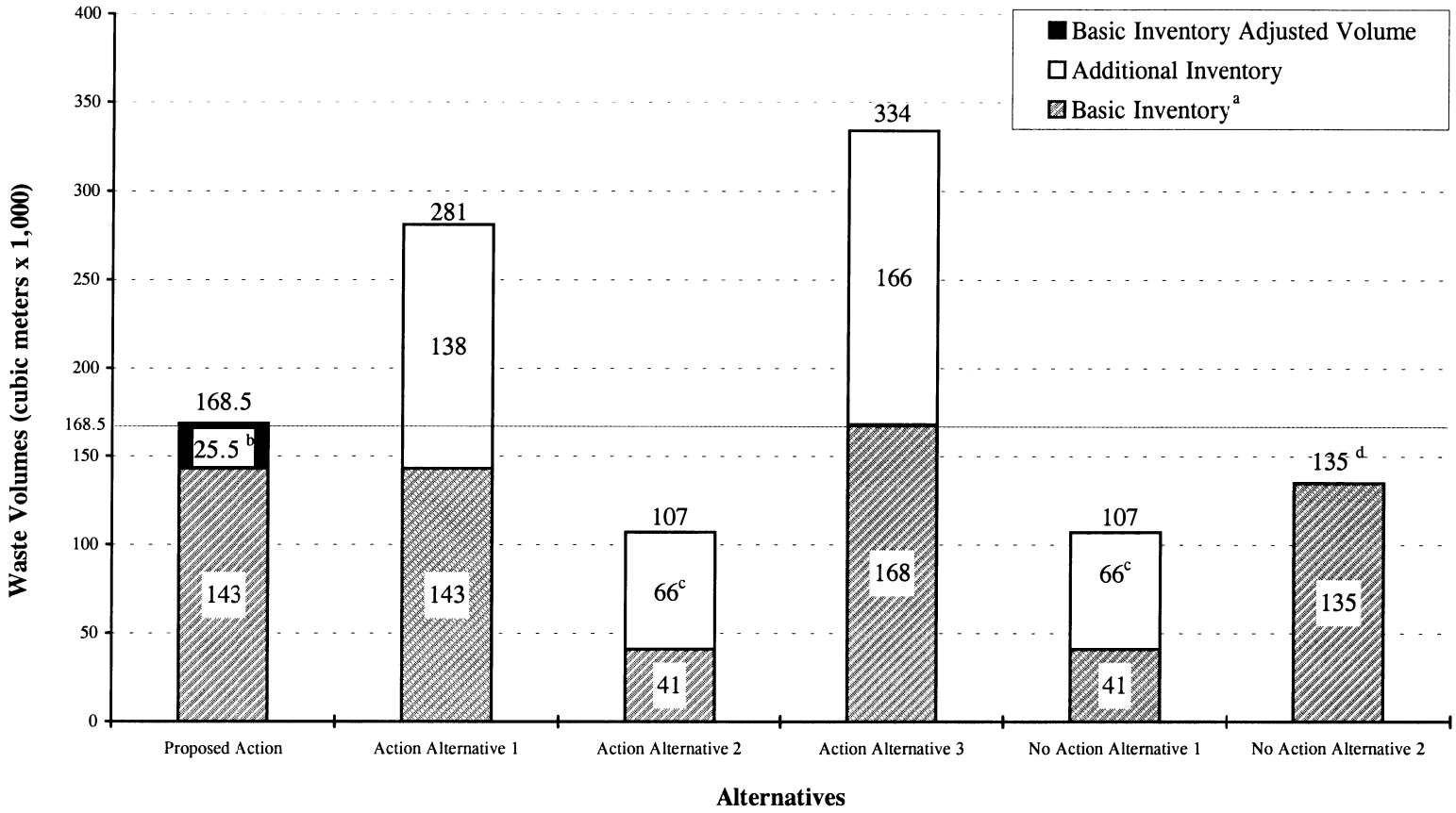


Figure S-1
Approximate Location of the SEIS-II TRU Waste Sites [a]

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

The waste volumes presented in Tables S-1 and S-2 are not the volumes that would be emplaced at WIPP under the Proposed Action or the action alternatives. The emplaced volumes would be different due to three factors. First, the LWA and agreements with the State of New Mexico limit the volumes of CH-TRU and RH-TRU defense waste permitted at WIPP. These limits establish the maximum volume of defense TRU waste that would be disposed of at WIPP under the Proposed Action.

The action alternatives consider larger volumes and additional types of waste and may require amendment of the LWA and/or the C&C Agreement to be fully implemented. Second, packaging waste for emplacement changes its volume; in particular, the volume of RH-TRU waste increases by 43 percent once the volume of its containers is considered. Finally, three different methods of treating the waste are considered in SEIS-II alternatives; two of these treatment methods (thermal treatment and shred and grout treatment) substantially change the volume of waste. The volumes of TRU waste that would be emplaced under each SEIS-II action alternative, after adjustment for the three factors described above, are presented in Figures S-2 and S-3 and in Table S-3.



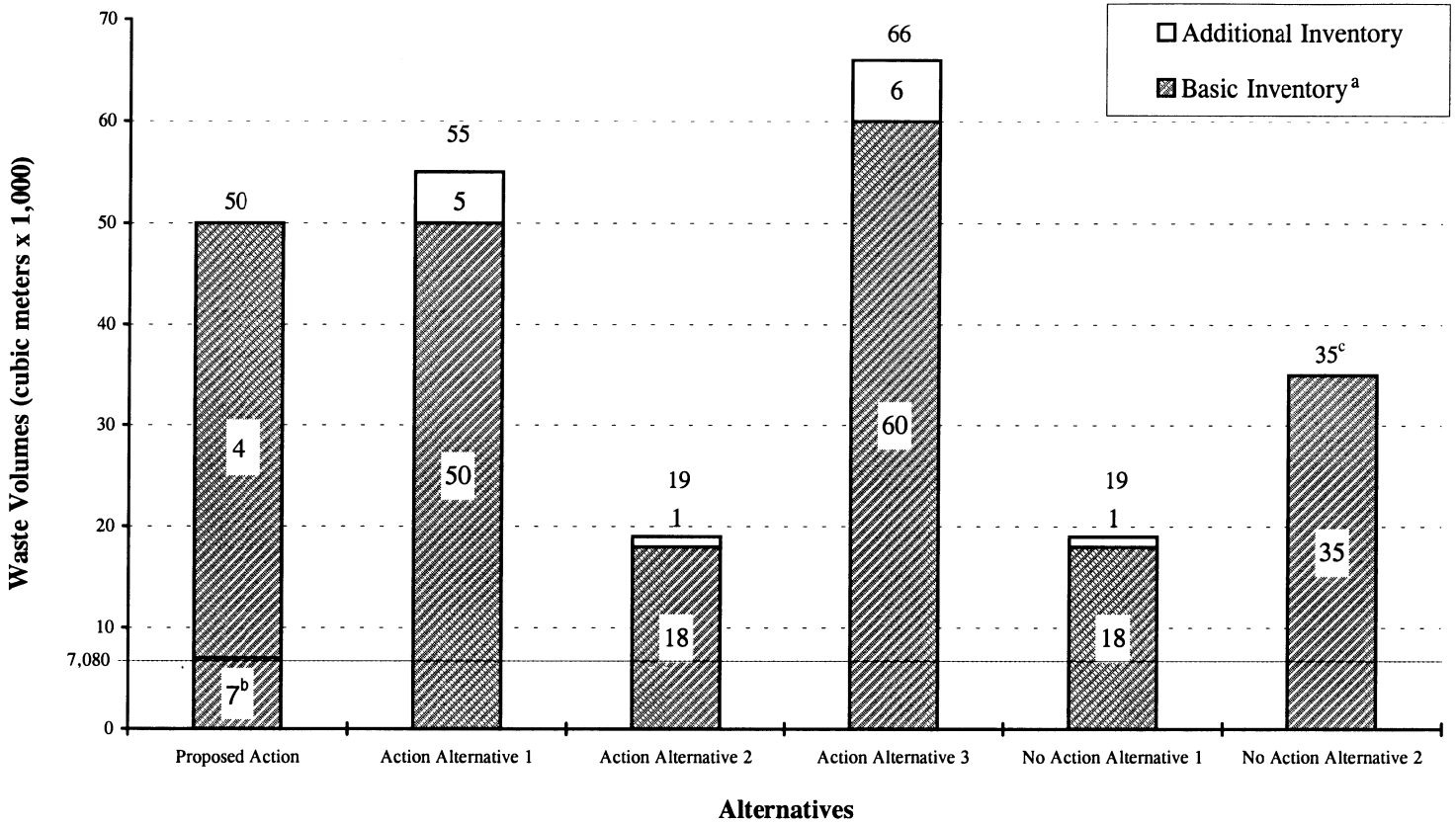
[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] The CH-TRU waste Basic Inventory is adjusted from approximately 143,000 cubic meters to 168,500 cubic meters in order to evaluate the total volume of CH-TRU waste allowable at WIPP under current laws and agreements.

[c] Includes TRU waste commingled with PCBs.

[d] Only 73,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated. Therefore, the post-treatment waste volume of the Basic Inventory is not the same as for the Proposed Action and Action Alternative 1.

Figure S-2
CH-TRU Post-Treatment Waste Volumes by Alternative



[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] Only 7,080 cubic meters of the Basic Inventory (14 percent of the Basic RH-TRU inventory) was evaluated for WIPP disposal under the Proposed Action because of the WIPP disposal limit established under the C&C Agreement with the State of New Mexico. The excess RH-TRU waste would be treated to WAC and stored at non-WIPP treatment sites.

[c] Only 32,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated. Therefore, the post-treatment waste volume of the Basic Inventory is not the same as for the Proposed Action and Action Alternative 1.

Figure S-3
RH-TRU Post-Treatment Waste Volumes by Alternative

Table S-3
TRU Waste Post-Treatment Volumes (in cubic meters) [a]

Proposed Action		Action Alternative 1		Action Alternative 2 (All Subalternatives)	
CH-TRU Waste	**RH-TRU Waste**	**CH-TRU Waste**	**RH-TRU Waste**	**CH-TRU Waste**	**RH-TRU Waste**
168,500	7,080	281,000	55,000	107,000	19,000
Action Alternative 3		**No Action Alternative 1 (Both Subalternatives)**		**No Action Alternative 2 [b]**	
CH-TRU Waste	**RH-TRU Waste**	**CH-TRU Waste**	**RH-TRU Waste**	**CH-TRU Waste**	**RH-TRU Waste**
334,000	66,000	107,000	19,000	135,000	35,000

[a] SEIS-II is based on BIR-3, which incorporates the volumes in BIR-2. These estimates have been adjusted to emplacement volumes, though no waste would be emplaced under the no action alternatives. For most recent waste volume projections, see Appendix J.
[b] Only 73,000 cubic meters of CH-TRU waste and 32,000 cubic meters of RH-TRU waste would be treated.

The three treatment methods considered in SEIS-II are treatment to meet the current planning-basis WIPP Waste Acceptance Criteria (WAC), treatment by a shred and grout process, and treatment by a thermal process to meet the RCRA LDRs. Each is discussed below:

- The treatment method that changes the waste volume the least is treatment to meet the planning-basis WAC. The WAC are based on the level of treatment that is currently required by applicable regulations (such as U.S. Department of Transportation regulations) or current DOE policies. The current planning-basis WAC, the fifth revision of the WAC, was the basis for SEIS-II analyses. The WAC may be revised again in the future. In particular, if DOE decides to treat the waste using a shred and grout or thermal process, using that process would become part of the WAC.

- One SEIS-II action alternative (Action Alternative 3) considers treatment of the waste by shredding it and sealing it in grout. This method of treatment reduces the gas generation potential of the waste; however, it also substantially increases the volume of waste.

- Another method of treating waste uses a thermal process that would substantially condense the waste and remove many of the hazardous constituents of the TRU mixed waste. Waste commingled with PCBs could be treated using a thermal process and then disposed of at WIPP. Action Alternatives 2A, 2B, and 2C and No Action Alternatives 1A and 1B consider treatment using a thermal process.

Where appropriate, SEIS-II incorporates and expands upon the analyses in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS), published in May 1997, which analyzed the impacts of centralizing, regionalizing, and decentralizing treatment of TRU waste at various sites throughout the nation and used the three treatment methods being considered in SEIS-II. For the WM PEIS alternatives, three basic consolidation options were considered. For its Decentralized Alternative, the WM PEIS estimated impacts of treating TRU waste primarily where it is currently stored or where it would be generated. For its Regionalized Alternatives, the

WM PEIS analyzed the impacts of transporting waste to regional sites and treating it there. For its Centralized Alternative, the WM PEIS considered shipping the CH-TRU waste to WIPP and treating it at a new treatment facility that would be built there and shipping the RH-TRU waste to two centralized RH-TRU waste treatment facilities.

The WM PEIS preferred alternative would treat TRU waste at the facilities where that waste currently is stored or would be generated except that waste at Pantex and Sandia National Laboratories (SNL) would be shipped to Los Alamos National Laboratory (LANL) for treatment, a portion of the TRU waste at the Rocky Flats Environmental Technology Site (RFETS) would be sent to Idaho National Engineering and Environmental Laboratory (INEEL) for treatment, Savannah River Site (SRS) may send its RH-TRU waste to Oak Ridge National Laboratory (ORNL) for treatment, and the ORNL may send its CH-TRU waste to SRS for treatment.

SEIS-II uses and builds upon the WM PEIS analyses of potential waste treatment locations under these consolidation schemes. Each SEIS-II alternative is based on a similar alternative presented in the WM PEIS. (See Appendix B for details on each WM PEIS alternative; see the text box later in this summary for details on which SEIS-II alternative matches which WM PEIS alternative; see the text box later in this summary on the impacts of the WM PEIS preferred alternative.)

Although SEIS-II incorporates by reference, and where appropriate, updates and adjusts information from the WM PEIS, the potential actions analyzed in SEIS-II are not connected to the potential actions analyzed in the WM PEIS. To further explain, the WM PEIS evaluates alternative configurations for managing five types of waste, including TRU waste, that are at DOE sites or are otherwise under DOE's control or responsibility. The alternative configurations range from managing the wastes where they are presently located to transporting them to one centralized site for management. The WM PEIS evaluates trends in various impacts as alternative configurations become more or less centralized. The WM PEIS postulates three generic types of treatment for TRU waste, in order to analyze the impacts of treating and storing TRU waste under the various alternative configurations. These generic treatments allow DOE, in the WM PEIS, to compare the relative impacts of centralized, regionalized, and decentralized treatment and storage. To reduce the potential impacts of storing untreated wastes, DOE must decide, pursuant to the WM PEIS, the most cost-effective and environmentally preferable configuration to treat and store TRU waste, regardless of whether the Department decides to dispose of this waste at WIPP.

In addition to TRU waste, the WM PEIS analyzes four other types of waste: high-level waste, low-level waste, low-level mixed waste, and hazardous waste. These wastes would not be disposed of at WIPP, and management of these wastes is unrelated to, and outside the scope and purpose of, SEIS-II.

SEIS-II, in contrast, is the third in a series of staged NEPA reviews of the WIPP proposal and focuses on WIPP disposal of TRU waste. SEIS-II analyzes impacts and alternatives for disposal at WIPP, transportation to WIPP, and associated activities not addressed in, and not within the scope of, the WM PEIS. SEIS-II involves additional and different workers, time frames, transportation modes, alternatives, and affected environments. SEIS-II inventories include TRU waste buried prior to 1970 and projections of TRU waste that may be generated during the next 35 years.

Decisions associated with whether to dispose of TRU waste at WIPP can and should be made regardless of any decisions made pursuant to the WM PEIS. Furthermore, decisions for TRU waste disposal are far removed from decisions on management of the other types of waste analyzed in the WM PEIS. Decisions concerning WIPP pursuant to SEIS-II will not automatically trigger or prejudice decisions for high-level waste, low-level waste, hazardous waste, and low-level mixed waste that may be made pursuant to the WM PEIS. As such, SEIS-II and the WM PEIS have different purposes, meet different needs, and are independently justified.[1]

Proposed Action: Basic Inventory, Treat to WAC, Dispose of at WIPP (Preferred Alternative, Reserving Rail Transportation for Future Consideration)

Under the Proposed Action, DOE would continue with the phased development of WIPP by disposing of post-1970 defense TRU waste in the WIPP repository. This action would dispose of 175,600 cubic meters (6.2 million cubic feet) of the Basic Inventory. Because only 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste can be disposed of at WIPP (under current laws and agreements), additional RH-TRU waste in this inventory (43,000 cubic meters [1.5 million cubic feet]) would be treated to the planning-basis WAC and kept in storage until another disposal solution is found. (Under the revised estimates in the *National Transuranic Waste Management Plan*, there would not be such "excess" RH-TRU waste. See Appendix J.) For the purposes of analysis in SEIS-II, disposal is assumed to begin by 1998.

Current data and projections indicate that 18 sites would generate Basic Inventory waste or currently have it in storage. TRU waste would first be treated at the 18 sites as necessary to meet planning-basis WAC. Any consolidation would occur in the manner described in the ROD to be issued for the WM PEIS. Such consolidation could be at the 10 largest generator-storage sites (as in the WM PEIS Decentralized Alternative) or at fewer sites (as in the WM PEIS preferred alternative). For purposes of analysis, SEIS-II assumed consolidation at the 10 largest generator-storage sites; not consolidating the waste, and consolidating it in a manner similar to the WM PEIS preferred alternative, are also discussed in SEIS-II.[2]

Under the Proposed Action, only trucks would transport the TRU waste. CH-TRU waste would be transported in TRUPACT-II containers, which have been certified by the U.S. Nuclear Regulatory Commission (NRC). RH-TRU waste would be transported in RH-72B casks, which are currently awaiting NRC certification. Potentially, some CH-TRU waste may be transported in HALFPACKs, which are smaller TRUPACT-IIs that are being designed by DOE and have yet to be certified by NRC. The currently designated truck routes are somewhat different from those presented in SEIS-I, in part because states have modified the state-designated routes; however, the routes comply with U.S. Department of Transportation requirements and use the Interstate Highway System or state-designated alternate routes. Transportation could include shipments between the generator-storage sites and would involve shipments from generator-storage sites (potentially the 10 largest) to WIPP. Rail transportation is analyzed as part of the action alternatives and is reserved for further consideration under the Preferred Alternative.

[1] The analyses presented in the WM PEIS and SEIS-II are more understandable and useful for decision making and for informing the public than they would be if combined in a single, less focused document.

[2] The consolidation scheme presented in SEIS-II is intended for the purpose of analyzing the impacts and may not reflect the actual movement of waste that will occur.

Each truck transporting CH-TRU waste would carry as many as three TRUPACT-IIs, containing a total load of up to forty-two 55-gallon drums or six standard waste boxes. At WIPP, the waste packages would be removed from the transport pallets and stacked three high in the disposal panels. Each disposal panel would accommodate approximately 81,000 55-gallon drum equivalents (both drums and waste boxes would be used for disposal) approximately equal to 16,700 cubic meters (590,000 cubic feet) of CH-TRU waste. Each truck transporting RH-TRU waste would carry one RH-72B cask within which would be a single canister containing up to three 55-gallon drums of RH-TRU waste. The process of filling the disposal rooms with RH-TRU waste would be coordinated between the generator-storage sites and WIPP, because the RH-TRU waste would be placed in the walls of the panel rooms and in the walls of the access tunnels before they were filled with CH-TRU waste. Sacks of magnesium oxide backfill would be placed around the emplaced CH-TRU waste as an engineered barrier to provide chemical control over the solubility of actinides in the post-closure repository environment. Each disposal panel would accommodate 730 canisters, equivalent to 650 cubic meters (22,950 cubic feet) of RH-TRU waste. On average, personnel at WIPP could unload and dispose of the waste in about 50 TRUPACT-IIs and about eight RH-72B casks per week.

Under the Proposed Action, WIPP would receive and dispose of the Basic Inventory for 35 years. DOE would close the repository when all waste disposal areas were filled or when WIPP would achieve a capacity of 175,600 cubic meters (6.2 million cubic feet) of TRU waste. Final facility closure would include the placement of a repository sealing system. As explained in more detail in the RCRA Part B Permit Application, the planned repository sealing system would consist of natural and engineered barriers within the WIPP repository that would prevent water from entering it and impede the gases or brines from migrating out. The seal design for the repository shafts would use materials that may include highly compacted crushed salt, clay, concrete, and asphalt. The salt, when consolidated over time, would preclude the downward flow of groundwater into the repository and the upward movement of brine or gas that may be contaminated. The Department would decommission the WIPP site in a manner that would allow for safe, permanent disposition of surface and underground facilities and that would be consistent with then-applicable regulations. Little or no contamination of facilities would be expected. Usable equipment would be removed and surface facilities would be dismantled. A berm would be constructed around the perimeter of the waste panel footprint. DOE would restore the areas occupied by the salt pile (generated during excavation of the repository) and surface facilities, and, if necessary, any of the area overlying the repository, although surface disturbance of this area would be minimal. This decommissioning period is anticipated to take up to 10 years. There are no changes since SEIS-I to the proposed long-term controls for WIPP, which would include active controls, monitoring, and permanent markers or signs and other passive controls.

The Department's Preferred Alternative is to proceed with WIPP disposal of defense TRU waste treated to planning-basis WAC under the Proposed Action. Under the Preferred Alternative, the Department would initially transport waste by truck and would continue to explore the availability of safe and cost-effective commercial rail transportation.

The Department has identified the Proposed Action (reserving the option of future rail transportation) as its Preferred Alternative for a number of reasons, including the following: the Proposed Action would provide long-term isolation of TRU waste from the accessible environment, and the Proposed Action is consistent with DOE's obligations under agreements and court orders and with the LWA.

THE PROPOSED ACTION AND THE ADDITIONAL INVENTORY

During the public comment period that followed publication of the Draft SEIS-II in November 1996, stakeholders requested that the Department discuss, as part of the Proposed Action, the impacts of leaving in place or treating and storing the Additional Inventory. The Additional Inventory, as shown in Table 2-3, largely comprises TRU waste disposed of prior to 1970 by burying the waste near the surface. The Department currently has no plans to excavate, treat, and store all of this waste. Such a decision would be made on a site-by-site basis, following RCRA and Comprehensive Environmental Response, Compensation and Liability Act investigations, and probably following additional NEPA review. The Additional Inventory, therefore, is not a part of the Proposed Action. Nevertheless, in response to stakeholders' requests, Chapter 5 now includes text boxes like this one that present an assessment of human health impacts based on analyses done for the action alternatives and no action alternatives described in Chapter 3 of SEIS-II. The scenarios on which these impacts are based include the following:

- All Additional Inventory would be left as currently stored or buried. The impacts for this scenario would be similar to the Additional Inventory impacts of No Action Alternative 2.
- All Additional Inventory would be excavated, treated to planning-basis WAC, and stored at current locations for approximately 70 years. During the 70 years, the Department would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 1.
- All Additional Inventory would be excavated, shipped to six thermal treatment facilities, treated, and then stored for approximately 70 years. During the 70 years, the Department would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 2A.
- All Additional Inventory would be excavated, shipped to four thermal treatment facilities, treated, and then stored for 70 years. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 2B.

In contrast, the action alternatives would require amendments to the LWA and/or the C&C Agreement with New Mexico. The no action alternatives would not meet the Department's purpose and need for action, would not meet court orders and treatment plans, and would result in long-term impacts that would be avoided under the Proposed Action.

Action Alternative 1: Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP

Under Action Alternative 1, DOE would dispose of nearly all TRU waste at WIPP. The Total Inventory would include both the Basic Inventory and the Additional Inventory, but it would not include TRU waste commingled with PCBs. This alternative would dispose of 336,000 cubic meters (11.9 million cubic feet) of treated TRU waste, nearly twice the volume of the Proposed Action. All 22 sites shown on Figure S-1 currently store or would generate this waste over a 35-year period. The waste would be treated to planning-basis WAC at the sites where it is located

SEIS-II AND THE WM PEIS ALTERNATIVES

Each SEIS-II alternative reflects an alternative in the WM PEIS in the way consolidation of waste is assumed.

The SEIS-II Proposed Action assumes, for the purposes of analyses, consolidation similar to the WM PEIS Decentralized Alternative, which was the basis for the WM PEIS preferred alternative. As in the WM PEIS Decentralized Alternative, the Proposed Action assumes that TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the 10 facilities with the largest volume of waste to await disposal at WIPP. Those 10 sites are Hanford, LANL, INEEL, Argonne National Laboratory – East (ANL-E), SRS, RFETS, ORNL, Lawrence Livermore National Laboratory (LLNL), Nevada Test Site (NTS), and the Mound Plant (Mound). The SEIS-II inventory includes small quantities of TRU waste from several sites that were not considered for the WM PEIS. Waste from these sites would be consolidated at the closest site with larger volumes, if necessary.

The SEIS-II Action Alternative 1 also assumes, for analysis purposes, consolidation similar to the WM PEIS Decentralized Alternative. TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the same 10 facilities as assumed for the Proposed Action. (The major difference between the SEIS-II Proposed Action and the SEIS-II Action Alternative 1 is the amount of waste to be disposed of.)

The three SEIS-II Action Alternative 2 subalternatives assume, for analysis purposes, consolidation similar to the WM PEIS Regionalized 2, Regionalized 3, and Centralized Alternatives. In each, the TRU waste would be consolidated at treatment sites where it would be treated by a thermal process to meet the RCRA LDRs. The three different consolidation options considered under Action Alternative 2 are:

- **Action Alternative 2A:** Assumes for analysis that CH-TRU waste would be treated at Hanford, SRS, RFETS, LANL, and INEEL/Argonne National Laboratory – West (ANL-W). Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Regionalized 2 Alternative.

- **Action Alternative 2B:** Assumes for analysis that CH-TRU waste would be treated at Hanford, SRS, and INEEL/ANL-W. Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Regionalized 3 Alternative.

- **Action Alternative 2C:** Assumes for analysis that CH-TRU waste would be treated at WIPP. Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Centralized Alternative.

The SEIS-II Action Alternative 3 is similar to the WM PEIS Regionalized 1 Alternative. For both alternatives, TRU waste would be consolidated at regional sites throughout the country and treated by a shred and grout process before shipping the TRU waste to WIPP. CH-TRU waste would be treated at Hanford, LANL, RFETS, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

The two SEIS-II No Action Alternative 1 subalternatives are similar to the WM PEIS Regionalized 2 and Regionalized 3 Alternatives. The waste would be treated at the same sites described above for the SEIS-II Action Alternatives 2A, 2B, and 2C. SEIS-II No Action Alternative 1A is similar to the WM PEIS Regionalized 2 Alternative; SEIS-II No Action Alternative 1B is similar to the WM PEIS Regionalized 3 Alternative.

The SEIS-II No Action Alternative 2 is similar to both the WM PEIS Decentralized and No Action Alternatives. The currently stored waste would be left untreated. Newly generated waste would be treated to WAC. All waste would be stored at the sites where it is currently stored or would be generated.

or would be generated. It is assumed that the waste would then be consolidated at the 10 sites with the largest volumes until its disposal. This storage is referred to as lag storage throughout SEIS-II.

For the purposes of analysis, waste disposal at WIPP is assumed to begin in 1998; disposal would extend over a 160-year period, until 2158. The 160-year period is anticipated due to the greater volume of waste, the expected throughput rate anticipated at WIPP, and the time needed to excavate additional waste panels. Shipment of waste to WIPP would have three options: by truck only, by regular rail and truck (from those sites that do not have rail access), or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

Commenters requested that DOE include information in the Final SEIS-II on how operation periods under the action alternatives could be reduced and how such reduced operation periods would change the impacts presented in Chapter 5. To reduce the operation time under Action Alternative 1 to 60 years from 160 years, DOE would construct an additional RH-TRU WHB and four new shafts. Additional employees would be hired to operate the new building; additional excavation and emplacement crews also would be employed. The excavation rate for new panels would increase, although the number of panels would remain the same as for the 160-year period discussed above. Capital costs and annual operating costs would increase. All transportation to WIPP would occur during 53 years of operation. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.

Action Alternative 2: Total Inventory (Including PCB-Commingled Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP

Under Action Alternative 2, DOE would dispose of TRU waste at WIPP after thermally treating it to meet the LDRs. This alternative would dispose of 126,000 cubic meters (4.5 million cubic feet) of TRU waste and would include both the Basic Inventory and the Additional Inventory. TRU waste containing PCB-commingled material is included in the inventory for this alternative. All 22 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage.

For Action Alternative 2, three different consolidation and treatment subalternatives are considered[1]:

- Action Alternative 2A. DOE would treat CH-TRU waste at the Hanford Site (Hanford), SRS, RFETS, LANL, and INEEL/Argonne National Laboratory – West (ANL-W). RH-TRU waste would be treated at Hanford and ORNL.

- Action Alternative 2B. DOE would treat CH-TRU waste at Hanford, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

- Action Alternative 2C. DOE would treat CH-TRU waste at WIPP. RH-TRU waste would be treated at Hanford and ORNL.

[1] Decisions on whether and how waste would be consolidated and, if so, the treatment locations would be made in the TRU waste ROD for the WM PEIS.

Waste treatment would begin in 2010, after the treatment facilities had been constructed, and would continue for 35 years. Waste disposal also would begin in 2010 and would continue over a 150-year period, until 2160. Thermal treatment concentrates the waste, which is itself a long-term source of energy produced by radioactive decay. In order to satisfy thermal loading requirements that are part of WIPP's basic design criteria, thermally treated waste would require approximately the same number of panels (i.e., approximately 75) as other methods of treating the same quantities of waste. The 150-year period would be necessary because of the time needed to excavate the required waste panels. Between treatment and disposal of the waste, lag storage would be conducted at the treatment sites. Shipment of waste to WIPP would be by truck only, by regular rail and truck, or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

To reduce the operation period under Action Alternative 2 to 70 years from 150 years, DOE would construct three additional shafts early in the operation period to enable faster excavation and emplacement. This would result in higher capital costs, although annual operating costs would remain essentially the same. Additional excavation crews would be hired. The excavation rate for new panels and the emplacement rate of waste canisters would increase. All transportation of waste to WIPP would occur during 58 years of operation. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.

Action Alternative 3: Total Inventory (Except PCB-Commingled Waste), Treat by Shred and Grout, Dispose of at WIPP

Under Action Alternative 3, DOE would dispose of TRU waste at WIPP after treating it by a shred and grout process. This alternative would dispose of 400,000 cubic meters (14.1 million cubic feet) of TRU waste and would include both the Basic Inventory and most of the Additional Inventory. TRU waste containing PCB-commingled material is excluded from this alternative. All 22 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage. The CH-TRU waste would be treated at Hanford, LANL, RFETS, SRS, and INEEL/ANL-W. The RH-TRU waste would be treated at Hanford and ORNL.

Waste treatment would begin in 2010, after the treatment facilities had been constructed, and would continue for 35 years. Following treatment, lag storage would be conducted at the treatment sites. Waste disposal would begin in 2010 and would continue until 2200. The 190-year period is anticipated due to the greater volume of waste, the expected throughput rate at WIPP, and the time needed to excavate additional waste panels. Shipment of waste to WIPP would be by truck only, by regular rail and truck, or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

To reduce the operation time under Action Alternative 3 to 75 years from 190 years, DOE could construct a new RH-TRU Waste Handling Building and four new shafts. Two additional excavation crews would be hired, increasing the excavation rate for panels. Capital costs and annual operating costs would increase. All transportation of waste to WIPP would occur during the final 63 years of the reduced operation period because 12 years would still be needed to design and construct treatment facilities. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.

No Action Alternative 1: Total Inventory (Including PCB-Commingled Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP

Under No Action Alternative 1, DOE would dismantle and close WIPP beginning in 1998. Closure of the facility would take 10 years. Under this alternative, DOE also would treat all DOE TRU waste by a thermal process to meet the LDRs and store it for an indefinite period at the treatment sites. About 126,000 cubic meters (4.5 million cubic feet) of TRU waste would be treated and stored; this includes both the Basic Inventory and the Additional Inventory and includes TRU waste commingled with PCBs. All 22 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage. Waste treatment would begin in 2010 after treatment facilities and newly engineered storage facilities had been constructed at the treatment sites. Two consolidation and treatment subalternatives are considered for No Action Alternative 1:

- No Action Alternative 1A. DOE would treat CH-TRU waste at Hanford, LANL, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. These sites would then store the waste indefinitely.

- No Action Alternative 1B. DOE would treat CH-TRU waste at Hanford, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. These sites would then store the waste indefinitely.

Shipment of waste to the treatment sites would be by truck only, by regular rail and truck, or by dedicated rail and truck. For the purpose of analyses, it was assumed that CH-TRU waste packaging (standard 55-gallon drums) would last 20 years; therefore, the waste would be overpacked at 20-year intervals. RH-TRU waste would not be repackaged because its specially designed containers would last much longer than 20 years.

No Action Alternative 2: Basic Inventory, Treat Newly Generated Waste to WAC, Store at Generator Sites, Dismantle WIPP

Under No Action Alternative 2, DOE would dismantle and close WIPP, leave existing TRU waste as it is, treat newly generated waste to meet WAC, and store all waste. This alternative would store 105,000 cubic meters (3.7 million cubic feet) of TRU waste. Twenty-two sites would either generate this waste over a 35-year period or currently have it in storage. Each site would be responsible for storage of its current and newly generated TRU waste. New facilities may be constructed if necessary, pursuant to future NEPA reviews, but the analyses consider storage only in existing facilities. There would be no planned shipment of waste to consolidation sites unless it was deemed necessary in the future to ensure the safe storage of TRU waste.

Table S-4 gives a tabular comparison of the major features of the Proposed Action and the alternatives.

Alternatives Considered But Not Analyzed

SEIS-II does not include detailed analyses of several alternatives discussed during the public scoping process and the comment period for the Draft SEIS-II. These alternatives were not analyzed in detail because — depending on the alternative and as discussed in Chapter 3 — they are

Table S-4
Summary of WIPP SEIS-II Alternatives

Comparison Parameters	*Proposed Action (Preferred Alternative):* **Basic Inventory, Treat to WAC, Dispose of at WIPP**	*Action Alternative 1:* **Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP**	*Action Alternative 2:* **Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP**	*Action Alternative 3:* **Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP**	*No Action Alternative 1:* **Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP**	*No Action Alternative 2:* **Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]**
Waste Type	Defense-related, post-1970 TRU waste in retrievable storage and newly generated through the year 2033 (Basic Inventory).	Basic Inventory plus other DOE-owned or controlled waste including non-defense, commercial, previously disposed of waste, and excluding PCB-commingled waste (Additional Inventory).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Basic Inventory plus Additional Inventory (excluding PCB-commingled waste).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Same as Proposed Action.
Post-Treatment Volume[b] to be Disposed of at WIPP, or Stored	CH-TRU: 168,500 m^3 (5,950,000 ft^3) RH-TRU: 7,080 m^3 (250,000 ft^3) Excess Waste[c] RH-TRU 43,000 m^3 (1,500,000 ft^3)	CH-TRU: 281,000 m^3 (9,900,000 ft^3) RH-TRU: 55,000 m^3 (2,000,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 334,000 m^3 (11,800,000 ft^3) RH-TRU: 66,000 m^3 (2,300,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 135,000 m^3 (4,800,000 ft^3) RH-TRU: 35,000 m^3 (1,200,000 ft^3)
Waste Consolidation Locations (assumed for purposes of analyses; actual consolidation would be in accordance with the ROD for the WM PEIS)	18 sites total - WAC treatment of CH-TRU at the largest sites and store at 10 largest sites[d]. Ship to WIPP. - WAC treatment of RH-TRU at Hanford, INEEL/ANL-W, ORNL, and LANL. Ship to WIPP.	22 sites total - Same as Proposed Action except two other sites (LBL, WVDP) consolidate and treat CH-TRU at Mound and Hanford.	22 sites total Action Alternative 2A - LDR treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2B - LDR treatment of CH-TRU at Hanford, INEEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2C - LDR treatment of CH-TRU at WIPP. - LDR treatment of RH-TRU at Hanford and ORNL.	22 sites total - Shred and grout treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - Shred and grout RH-TRU at Hanford and ORNL.	22 sites total No Action Alternative 1A - LDR treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. No Action Alternative 1B - LDR treatment of CH-TRU at Hanford, INEEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL.	Minimal consolidation to ensure safe storage; however, no sites would ship to WIPP.
Waste Treatment	Treat to meet WAC.	Treat to meet WAC.	Thermal treatment to meet the LDRs (including PCB-commingled waste).	Treatment by shred and grout.	Thermal treatment to meet the LDRs (including PCB-commingled waste). Package every 20 years indefinitely.	Newly generated waste treated to WAC.

Table S-4
Summary of WIPP SEIS-II Alternatives — Continued

Comparison Parameters	*Proposed Action (Preferred Alternative):* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Transportation Mode	Truck. The Preferred Alternative reserves the option of rail transportation.	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Truck only.
Disposal Operations	CH-TRU stacked in disposal rooms. RH-TRU placed in horizontal boreholes. RH-TRU disposal would start 6 years after CH-TRU and 7,080 m^3 (250,000 ft^3) of RH-TRU can be disposed of. 10 panel equivalents required at WIPP.[f]	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 68 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 75 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 71 panel equivalents required at WIPP.	No disposal. CH-TRU and RH-TRU would be in newly engineered, monitored storage at treatment sites.	No disposal. CH-TRU and RH-TRU continue to use existing storage.
WIPP Operations Time Frame [g]	Receive and emplace waste beginning 1998 for 35 years. Decommissioning for 10 years and active institutional control for 100 years, ending in 2143.	Same as Proposed Action, lag storage for 125 years and disposal would be for 160 years, until 2158; active institutional control ending in 2268.	Waste disposal and thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Lag storage for 115 years. Disposal would be for 150 years, until 2160. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2270.	Waste disposal and shred and grout treatment would begin in 2010 after treatment facility construction Lag storage for 155 years. Disposal would be for 190 years, until 2200. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2310.	Dismantle and close WIPP in 10 years. Thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Package and manage indefinitely at treatment sites.	Dismantle and close WIPP. Sites generate waste for 35 years beginning in 1998. Storage at the generator-storage sites evaluated for 35 years, ending in 2033. Active institutional control at generator-storage sites until 2133.
WIPP Institutional Control Site Area	70 hectares (175 acres)	360 hectares (890 acres)	395 hectares (976 acres)	375 hectares (927 acres)	20 hectares (50 acres) (Only for 10 years during decommissioning)	20 hectares (50 acres) (Only for 10 years during decommissioning)

[a] New facilities may be constructed in the future pursuant to future NEPA review.

[b] These values correspond to the Post-Treatment Consolidated Volume and Post-Treatment Disposal Volume data in Tables 3-1 through 3-16; differences in the numbers are due to rounding. The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites.

[c] Recent estimates in the *National Transuranic Waste Management Plan* indicate there would be no excess RH-TRU waste; see Appendix J and information later in this summary.

[d] The 10 largest generator-storage sites are ANL-E, Hanford, INEEL/ANL-W, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS.

[e] Maximum rail is used to denote that 18 of the 22 sites have rail facilities nearby; the remaining sites would ship by truck. Areas and volumes have been rounded.

[f] Under the Proposed Action, the consequence analysis for RH-TRU waste is based on 7,080 cubic meters (250,000 cubic feet), the maximum disposal volume of RH-TRU waste that is allowable at WIPP under the Consultation and Cooperation Agreement. The disposal strategy is to emplace RH-TRU waste canisters in the panel room walls prior to stacking CH-TRU waste in the rooms. At startup, however, a lag in RH-TRU waste availability is anticipated that would result in only CH-TRU waste initially being disposed of. The actual amount of RH-TRU waste disposed of, therefore, may be as low as 4,300 cubic meters.

[g] These time frames are those presented in the Draft SEIS-II. For reduced time frames, see Sections 3.2.2.4, 3.2.3.4, and 3.2.4.4.

not technically viable, would not adequately or economically meet DOE's need to safely dispose of TRU waste in a timely manner, involve additional environmental and policy concerns that would need to be accommodated, or are otherwise unreasonable in the present context. The following alternatives were not analyzed in detail: transmutation, co-processing TRU waste with high-level waste and vitrifying it, disposal in space, underground detonation, subseabed disposal, deep borehole disposal, greater confinement (shallow borehole disposal), geologic repositories at sites other than WIPP, the use of developing technologies to neutralize or change the natural rate of radioactive decay, and alternative engineered barriers (in lieu of magnesium oxide backfill).

AFFECTED ENVIRONMENT AT WIPP

The environment that would be affected by activities described in SEIS-II is essentially the same as that presented in the FEIS in 1980 and SEIS-I in 1990. A few changes have occurred, though, and some new information is now available. The following sections discuss the more notable of these changes and the sources of some of the new information.

Land Use

Since SEIS-I, a multi-year research effort has been initiated to document the population and ecology of several species. Additional seeding of reclamation sites has been undertaken. A comprehensive WIPP archeological database has been created. Vegetation is now monitored for evidence of stress induced by climate and salt tailings. In 1994, DOE requested and was granted permission by the U.S. Bureau of Land Management to construct a short access road. Three plans have been published on emergency and facility security. Seven new wells have been installed to monitor water quality.

Air Quality

Since publication of SEIS-I, activities conducted at the WIPP site have had little effect on the air quality at the site. Two changes have occurred to air monitoring programs. In 1991, a volatile organic compound (VOC) monitoring program was established at WIPP after the EPA determined that migration of VOCs might be a concern in conjunction with the then-planned test phase at WIPP. On October 30, 1994, after DOE decided not to conduct underground experiments at WIPP and after DOE notified the EPA, monitoring of pollutant gases at the WIPP Ambient Air Monitoring Station was discontinued.

Geology and Hydrology

Additional studies and analyses have provided new information regarding geology and hydrology since publication of SEIS-I. Several examples are listed below:

- Extensive testing of the Salado Formation's salt beds and interbeds has resulted in confirmation of the Salado's extremely low permeability.
- Recent test data have enabled improved predictions of pressures at which Salado interbeds will likely fracture and relieve elevated gas pressures within the repository.
- Refined modeling of gas generation suggests that elevated gas pressure may slow down or stop brine inflow, thereby slowing gas-generation processes.

- Three-dimensional modeling of groundwater flow in the Rustler Formation suggests a very small amount of vertical flow and a preponderance of horizontal flow within the Culebra Dolomite.

- Recent tests on the Culebra Dolomite have provided new data on contaminant transport in the Culebra and on the Culebra's potential to retard radionuclides. Geophysical surveys have indicated that pressurized brine occurs in three or four discrete areas of the Castile Formation, which is located below the Salado.

Rare, Threatened, and Endangered Species

The threatened, endangered, candidate, and proposed species present in Eddy County, New Mexico, have changed since SEIS-I. In 1995, DOE obtained new lists from the U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and the New Mexico Energy, Minerals, and Natural Resources Department regarding the presence of federally threatened, endangered, and candidate species, state-listed rare and endangered animals, and state-listed rare and endangered plant species in Eddy County, New Mexico. Since SEIS-I, more than 60 new species have been added to these lists, none of which have been found within the WIPP Land Withdrawal Area during preparation of DOE's biennial surveys. No threatened and endangered species and no critical habitat for these species were found in a 1996 survey of the WIPP Land Withdrawal Area.

Cultural Resources Management

In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources at WIPP to DOE. Also, since publication of SEIS-I in 1990, additional cultural resource surveys have been conducted at WIPP. Based on inventory data and assuming environmental homogeneity and a fairly even distribution of archaeological sites, DOE estimates that the WIPP site may contain about 99 archaeological sites and 153 locations where isolated artifacts may be found. There are no known Native American sacred sites or burials in the Land Withdrawal Area. DOE and the State of New Mexico have signed a Joint Powers Agreement that includes provisions specifying how DOE will satisfy its obligations regarding cultural resources under Sections 106 and 110 of the National Historic Preservation Act.

Socioeconomics

Since publication in 1990 of SEIS-I, the following changes have occurred:

- Census information from the 1990 census has become available. Demographic characteristics in SEIS-II are based on 1990 U.S. Bureau of the Census information as well as more recent data.

- Recent employment and wage information has become available. SEIS-II uses 1994 information provided by the New Mexico Department of Labor and the University of New Mexico Bureau of Business and Economic Research, as well as more recent data.

Transportation

Some transportation routes have been modified since SEIS-I. The current primary truck transportation routes are indicated in Figure S-4.

AFFECTED ENVIRONMENTS AT THE TEN MAJOR GENERATOR-STORAGE SITES

The following sections briefly summarize the affected environments at the 10 major generator-storage sites. These 10 sites account for more than 99 percent of the Total Inventory.

Argonne National Laboratory-East (ANL-E)

ANL-E occupies 690 hectares (1,700 acres) in northeast Illinois, approximately 35 kilometers (22 miles) southwest of downtown Chicago, Illinois. Only 80 hectares (200 acres) of the site are used for DOE activities; the rest is devoted to forest and landscape areas.

ANL-E is located in a Class II Prevention of Significant Deterioration (PSD) air quality area. The site and the surrounding counties are classified by the EPA as severe nonattainment areas for the criteria pollutant ozone. ANL-E uses two principal aquifers for its water supply. The upper aquifer is about 60 meters (200 feet) thick and supplies potable water. The other aquifer is below the first, lying between 150 and 460 meters (500 and 1,500 feet) beneath the surface.

Species listed by the federal government as threatened or endangered are not known to reside on the ANL-E site. The site is frequented by one bird species listed as endangered by the state. As of 1994, with ANL-E completely surveyed, 43 prehistoric and six historic archeological properties had been discovered and recorded, and no sites had been listed with the National Register of Historic Places (NRHP) or designated as National Historic Landmarks. Three sites were potentially eligible for the NRHP.

The region of influence (ROI) accounts for 95.4 percent of the site's employee residential distribution. The ROI total population in 1992 was 6,568,800. Within the ROI, Whites comprise approximately 68.5 percent of the population, Blacks comprise 21.2 percent, and Hispanics comprise 12.1 percent. In 1989, about 9 percent of all families were below the poverty level. About 4,500 persons were employed at ANL-E.

The radiation dose from normal accident-free operations in 1994 would result in 3×10^{-3} latent cancer fatalities (LCF) to the population that resided within 80 kilometers (50 miles) of the site. The population within this area was 7,900,000. The annual dose from airborne radionuclides to the maximally exposed individual (MEI) during 1994 would result in an 8×10^{-9} probability of an LCF. The corresponding dose is far below the National Emission Standard for Hazardous Air Pollutants (NESHAP) limit.

Hanford Site (Hanford)

Hanford covers about 1,450 square kilometers (560 square miles) of the southeastern part of the State of Washington. The nearest city, Richland, Washington, borders the site on its southeast corner.

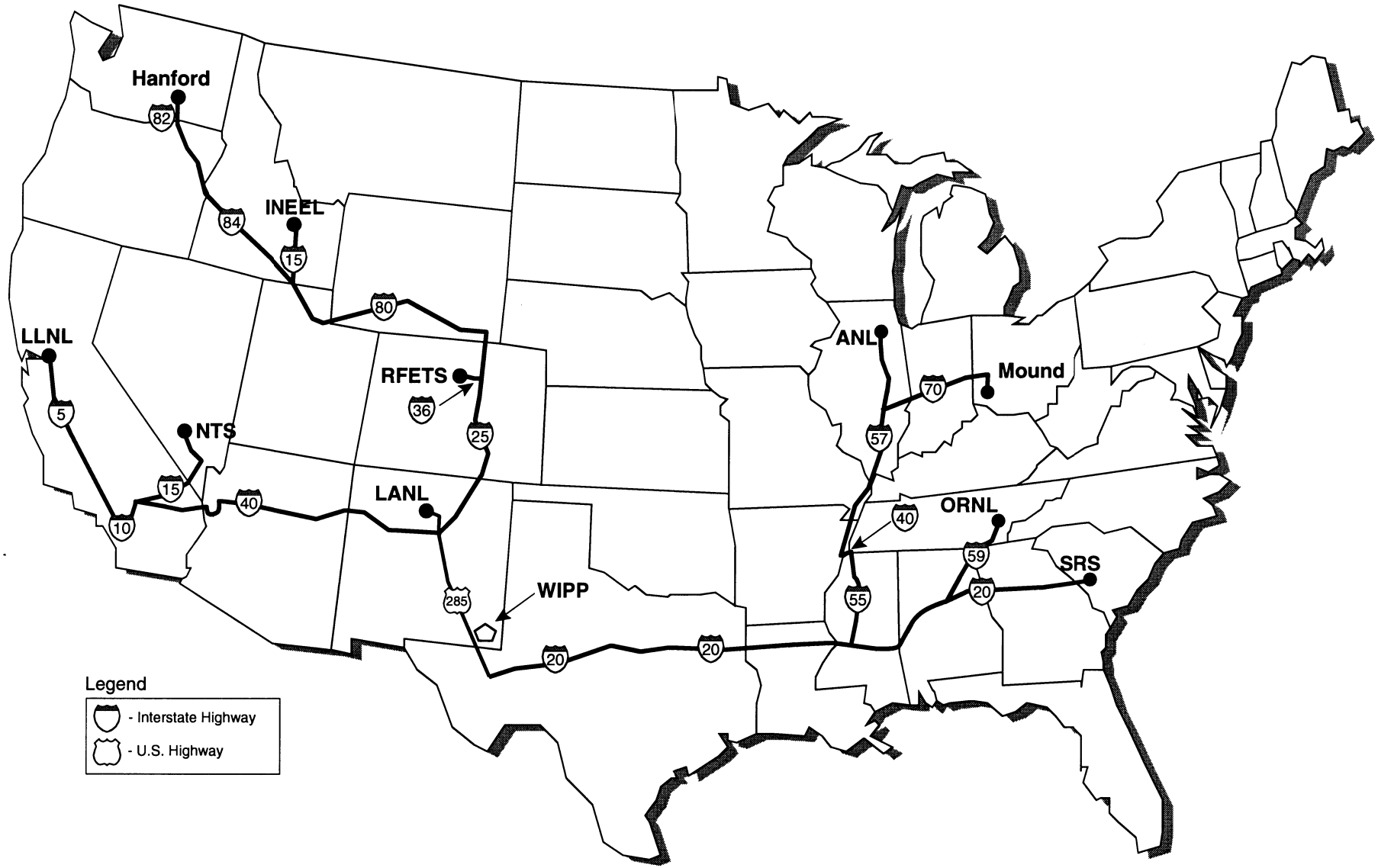


Figure S-4
Proposed TRU Waste Truck Transportation Routes from the 10 Major Generator-Storage Sites

Air quality in the Hanford region is well within state and EPA standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the "particulate matter less than or equal to 10 micrometers in diameter" (PM_{10}) standard. The Columbia River passes through the northern part of Hanford and forms part of the eastern boundary. The water quality of the Columbia River is high, and the river contributes part of the water supply for the site and for nearby cities. Radiological monitoring shows low levels of radionuclides in the river, well below concentration guidelines established by EPA drinking water standards. Groundwater beneath the site is not used for human consumption or food production, except for one well used for drinking water. Levels of radionuclides have been detected in this well; however, the levels are well below EPA drinking water standards. Hanford is included on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List.

Six species of birds that have been listed as endangered or threatened by the state or federal government frequent the Hanford site. One mammal species found there is considered endangered by the state and four plant species are considered threatened or endangered. In addition, there are 12 other species of animals classified as species of concern by the state or federal government. As of 1992, 248 prehistoric archeological sites had been discovered and recorded, 48 of which are on the NRHP. In addition, 11 historic archeological sites and 11 other properties are also listed on the NRHP.

The primary socioeconomic impact area is the tri-cities (Richland, Kennewick, and Pasco) and the counties of Franklin and Benton, in Washington State. The environmental justice ROI, which is the area within an 80-kilometer (50-mile) radius from the site, contains about 380,000 people.

This ROI includes a 20 percent minority, 18 percent low-income, and 19 percent Hispanic population. The site employs about 14,200 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties.

DOE has entered into agreements with the tribal governments representing the Yakama Indian Nation, Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. These agreements pertain to the core environmental programs and the emergency preparedness and response program.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-4} LCF. The population within this area was 380,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-9} probability of an LCF. The corresponding dose is far below the NESHAP limit.

Idaho National Engineering and Environmental Laboratory (INEEL)

INEEL encompasses 230,000 hectares (568,000 acres) within five counties in southeastern Idaho. The site is about 44 kilometers (27 miles) west of Idaho Falls, Idaho. About 2 percent of the total INEEL site area (4,600 hectares [11,400 acres]) is used for facilities and operations.

Concentrations of criteria pollutants at the site are below the National Ambient Air Quality Standards (NAAQS) and below state standards and PSD limits. INEEL overlies the Snake River Plain Aquifer, a sole-source aquifer and the largest aquifer in Idaho. This aquifer is also the source of all water used at INEEL. Inside the site boundary, several radionuclide concentrations

have exceeded the EPA maximum contaminant limits for drinking water. Outside the site boundary, all contaminant levels measured have been below the EPA limits. INEEL is included on the CERCLA National Priorities List.

Two species considered endangered by the federal government and nine species considered species of concern potentially frequent the site.

The socioeconomic ROI is the seven-county area where more than 95 percent of INEEL's approximately 6,400 employees reside. About 2.5 percent of the ROI population (104,654 in 1991) was Native American and 5.5 percent was Hispanic. Approximately 14 percent of this population was low-income.

DOE has entered into an agreement with the tribal governments representing the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation. This agreement is designed to enhance Tribal technical and scientific capability in the areas of environmental restoration, emergency preparedness and response, and management of cultural resources.

The annual radiation dose from normal operation of the site would have resulted in 2×10^{-4} LCF to the population within 80 kilometers (50 miles) of the site in 1994. The population within this area was 120,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-9} probability of an LCF. The corresponding dose is below the NESHAP limit.

Lawrence Livermore National Laboratory (LLNL)

LLNL includes the Livermore site, the adjoining Sandia National Laboratories, California (SNL-CA) site and the LLNL experimental test site (Site 300). The Livermore site is approximately 64 kilometers (40 miles) east of San Francisco, California, and about 5 kilometers (3 miles) east of Livermore, California.

The Livermore site is in the San Francisco Bay Area Interstate Air Quality Control Region. This region has been classified as a nonattainment area for two criteria pollutants: carbon monoxide (CO) and ozone (O_3). Site 300 is located within the San Joaquin Valley Unified Air Pollution Control District. This area is classified as a nonattainment area for O_3 and PM_{10}.

The San Andreas fault system, the Sur-Nacimiento fault system, and the Coast Range thrust fault system are the major fault systems in the area. These major regional faults along with local faults are potential sources of ground motion at LLNL. In January 1980, an earthquake sequence on a local fault produced two earthquakes of magnitudes 5.5 and 5.6. These earthquakes caused structural damage at the Livermore and SNL-CA sites. Larger earthquakes on more distant faults, such as the San Andreas, do not substantially affect the hazard estimation for LLNL.

LLNL is investigating and identifying characteristics of groundwater contamination at Site 300. Several plumes of VOCs and tritium have been identified in shallow and deeper bedrock aquifers in this area and several adjacent off-site areas. LLNL is working with the EPA and the State of California to remediate these plumes. LLNL is included on the CERCLA National Priorities List.

Fifty-nine species considered by the federal or state government to be threatened or endangered or that have other special status are found on and in the vicinity of the Livermore site. Ten of these species have been observed on the site, including the bald eagle. Since 1974, several

archaeological investigations have taken place at the Livermore site and Site 300. No prehistoric sites have ever been located at the Livermore site. Cultural resource investigations at Site 300 have resulted in the discovery of seven prehistoric sites, 21 historic sites, and one site with elements of each.

Four counties comprise the socioeconomic ROI in which 97.2 percent of the approximately 7,850 Livermore site and Site 300 employees reside. In 1990, the population in the ROI was 2,952,000. This population was predominantly White (69 percent). Approximately 8.4 percent of the families were living below the poverty level in 1989.

The annual radiation dose during normal operations in 1994 would have resulted in 4×10^{-4} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 6,300,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-8} probability of an LCF. The corresponding dose is far below the NESHAP limit.

Los Alamos National Laboratory (LANL)

LANL is located in north-central New Mexico, 97 kilometers (60 miles) north-northeast of Albuquerque, New Mexico, and 40 kilometers (25 miles) northwest of Santa Fe, New Mexico. The 11,300-hectare (28,000-acre) LANL site and adjacent communities are situated on the Pajarito Plateau.

LANL and its surrounding counties are considered attainment areas with respect to applicable NAAQS. All surface water drainages and groundwater from the Pajarito Plateau flow toward the Rio Grande. Groundwater in the LANL area occurs in four modes: shallow alluvium in canyons, perched water, the unsaturated zone between the surface and the main aquifer, and the main aquifer. LANL and the nearby communities are entirely dependent on groundwater for their water supply. The primary, secondary, and radiochemical groundwater quality, as measured from wells and springs in the main aquifer, are below DOE-derived concentration guides and the New Mexico standards applicable to a DOE drinking water system.

LANL is located on the Pajarito Plateau, which lies between the Jemez Mountains on the west and the Rio Grande on the east. Deep southeast-trending canyons, separated by long, narrow mesas, dissect the surface of the plateau. Studies have determined the area has three active faults. The strongest earthquake in the past 100 years within a 80-kilometer (50-mile) radius had an estimated magnitude of 5.5 to 6 measured on the Richter scale and a Modified Mercalli Intensity of VII.

Thirty-four federal- or state-listed threatened, endangered, or other special status species may be found in the vicinity of LANL. Five of these species have been observed at LANL. Approximately 75 percent of LANL has been inventoried for cultural resources. More than 1,000 prehistoric sites have been recorded, and approximately 95 percent of these sites are considered eligible or potentially eligible for inclusion on the NRHP. More than 40 historic resources have been recorded at LANL, and about 90 percent of the resources are considered eligible or potentially eligible for the NRHP, based on their association with the broad historic theme of the Manhattan Project and initial nuclear production.

Three counties comprise the socioeconomic ROI in which 94.7 percent of LANL's 9,700 employees reside. In 1990, the ROI population was 152,300. The population in the ROI is predominantly White (79.8 percent) and 12.1 percent of the families are below the poverty level.

DOE has entered into an agreement with Tribal governments representing the Pueblos of Santa Clara, Cochiti, Jemez, and San Ildefonso. This agreement is designed to build Tribal technical and scientific capability in environmental restoration and waste management and to assist the Tribes in participating in DOE decision making.

The radiation dose from normal operations in 1994 would result 2×10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 220,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 4×10^{-6} probability of an LCF. The corresponding dose is below the NESHAP limit.

Mound Plant (Mound)

Mound is located in west-central Ohio within the city limits of Miamisburg, Ohio, about 16 kilometers (10 miles) south-southwest of Dayton, Ohio. Mound occupies about 124 hectares (306 acres) and is situated on the highlands overlooking the Great Miami River.

The Air Quality Control Region comprising the facility has been classified as attainment of the NAAQS for nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead. However, Montgomery County has been classified as nonattainment for O_3 and total suspended particulates. The major aquifer in the area, the Buried Valley Aquifer (also called the Great Miami Aquifer), is the major source of the area's potable water. Typically, groundwater occurs 6 to 8 meters (20 to 25 feet) below ground surface in the valley. There has been minor contamination of the groundwater by Mound activities. Tritium and plutonium have been detected in the Miamisburg water supply at levels far below regulatory limits. Some VOCs in on-site groundwater exceed EPA levels; however, off-site concentrations are far lower and none exceed EPA levels.

The site lies within the range of one federally-listed bat species and contains a single individual of a state-listed endangered plant species. The only historic landmark in the vicinity of the site is the Miamisburg Mound, an ancient mound located 120 meters (390 feet) east-southeast of the site. It is believed to be a burial place of a member of the Adena culture of Mound Builders which inhabited the Ohio region in prehistoric times. The site itself does not contain any properties listed or eligible for the NRHP.

Miamisburg is largely residential, with limited regular rail and industrial development. The 1990 population of the city was 17,770. The facility employs about 1,200 people, the majority of whom live either in Miamisburg or in immediately adjacent areas.

The radiation dose from normal operations in 1994 would have resulted in 1×10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 3 million. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-8} probability of an LCF. The corresponding dose is far below the NESHAP limit.

Nevada Test Site (NTS)

NTS occupies 3,500 square kilometers (1,350 square miles) of desert valley and Great Basin mountain terrain in southern Nevada, 105 kilometers (65 miles) northwest of Las Vegas, Nevada. NTS is designated as an attainment or unclassified area with respect to all applicable NAAQS. Since promulgation of regulations, no PSD permits have been required for any emissions source at NTS. There are no continuously flowing streams at NTS, but there are permanent on-site water

bodies, including natural springs and water-well overflow ponds, that are not associated with wastewater disposal. Groundwater is the only source of drinking water in the NTS area. Only three locations evidenced detectable tritium levels on a consistent basis. In all three cases, the tritium activity has been less than 2 percent of the primary maximum contaminant limit for tritium (20,000 picocuries per liter).

Thirteen federal- and state-listed threatened, endangered, and other special status species are present in the vicinity of NTS. The peregrine falcon is the only known species at NTS that is on the federal endangered species list. Approximately 6 percent of NTS has been inventoried for cultural resources, and more than 1,200 prehistoric sites have been found and recorded. Many of these sites may be eligible for listing on the NRHP.

Two counties comprise the economic ROI; 97 percent of the 1,600 NTS employees live within these two counties. The ROI population totaled 865,144 in 1992. The population in the ROI is predominantly White (81.5 percent), and in 1989, 7.5 percent of the population was below the poverty level.

DOE has entered into two separate agreements with the Consolidated Group of Tribes and Organizations, which is composed of 17 tribes representing three ethnic groups (Western Shoshone, Owens Valley Paiute, and Southern Paiute) with cultural or historic ties to NTS. These agreements were intended to foster a government-to-government relationship and to encourage involvement in programs associated with NTS operations.

The radiation dose from normal operations in 1994 would result in 0.3 LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 33,000 that year. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit.

Oak Ridge National Laboratory (ORNL)

ORNL is part of the Oak Ridge Reservation (ORR), which is located about 32 kilometers (20 miles) west of Knoxville, Tennessee, in the rolling terrain between the Cumberland Mountains and Great Smoky Mountains.

As of 1991, the area within the Air Quality Control Region was designated as an attainment area with respect to all NAAQS for criteria pollutants.

Substantial cleanup activities are required both on-site and off-site. Background groundwater quality is generally good in the near surface aquifer zones and poor in the bedrock aquifer below 305 meters (1,000 feet) due to high total dissolved solids. The contaminated sites include past waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities. ORR is included on the CERCLA National Priorities List.

There are 88 federal- and state-listed threatened, endangered, and other special status species that have been identified on or in the vicinity of ORR. More than 20 cultural resource surveys have been conducted on ORR. Over 45 prehistoric sites have been identified and recorded. One site has been included in the NRHP, and several more are considered potentially eligible. More than 240 historic resources have been identified and recorded, and 50 of those sites may be eligible for the NRHP. The Graphite Reactor, located on the site, is a National Historic Landmark.

Four counties comprise the economic ROI; about 92 percent of ORR employees live in these four counties. The 1990 population of this ROI was about 489,000. Minorities comprised 8.4 percent of this population, and 10.6 percent of this population was below the poverty level.

The radiation dose from normal operations in 1994 would result in 2×10^{-2} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 940,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 9×10^{-7} probability of an LCF. The corresponding dose is below the NESHAP limit.

Rocky Flats Environmental Technology Site (RFETS)

RFETS covers almost 17 square kilometers (7 square miles) in northern Jefferson County, Colorado. The site is located east of the foothills of the Rocky Mountains, approximately 25 kilometers (16 miles) northwest of Denver, Colorado.

RFETS is located in an Air Quality Control Region that is a nonattainment area for the NAAQS criteria pollutants CO, O_3, and PM_{10}.

There are five ephemeral streams at RFETS that form a west-to-east surface drainage pattern. The primary source of flood potential is from flash flooding in these streams; however, most facilities are located outside the 500-year flood plain. No aquifers in the area are sole source aquifers under the Safe Drinking Water Act regulations. The results of 1992 groundwater quality monitoring indicate that the groundwater in the area contains elevated levels of several VOCs, several radionuclides, and other contaminants.

There are 40 federal- and state-listed threatened, endangered, candidate, and other special status species that are known to occur or may occur at RFETS. In addition, the Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*) was recently proposed for federal listing. RFETS has no properties designated as National Historic Landmarks or listed on the NRHP. According to the Colorado Historic Society, portions of the site have been the subject of at least three cultural resource investigations. The historic cultural resources in the area are archaeological sites or standing structures associated with homesteads and ranching.

Five counties comprise the economic ROI; 92.5 percent of the site's 3,500 employees reside in these five counties. In 1990, the ROI population was 1,790,600. The population was predominantly White (86.2 percent) with 7.2 percent of the total population living below the poverty level.

The radiation dose from normal operations in 1994 would have resulted in 1×10^{-4} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 2,100,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 1×10^{-9} probability of an LCF. The corresponding dose is far below the NESHAP limit.

Savannah River Site (SRS)

SRS is located approximately 20 kilometers (12 miles) south of Aiken, South Carolina, bordering the State of Georgia at the Savannah River. Land use at SRS, which comprises 80,200 hectares (198,000 acres), is generally categorized as forest, water, or developed facility locations. A total 77,400 hectares (191,000 acres) of SRS are undeveloped, of which 72 percent are forested.

SRS is located near the center of the Augusta-Aiken Interstate Air Quality Control Region. The areas within SRS and its surrounding counties are classified by the EPA as attainment areas with respect to the NAAQS for criteria pollutants.

The site lies within an area where earthquakes capable of producing structural damage are not likely to occur. Probabilistic seismic hazard curves were developed for all DOE sites in the 1980s, and the results for SRS indicated that a peak acceleration of 0.19 gravity was associated with a probability of 2×10^{-4} per year (5,000-year return period). Since 1985, three earthquakes, all of Richter magnitude 3.0 or less, have occurred in the immediate area of SRS.

The primary surface water feature is the Savannah River, which borders the site for approximately 32 kilometers (20 miles) to the southwest. There are six major streams that flow through SRS into the Savannah River. There are approximately 190 Carolina bays scattered throughout the site. Carolina bays are naturally occurring land depressions that can hold water. The Savannah River and on-site streams are classified as fresh water suitable for primary and secondary contact recreation, as a source for drinking water supply following conventional treatment, fishing, and industrial and agricultural uses. Groundwater quality ranges from excellent (soft and slightly acidic) to poor (exceeding EPA drinking water standards for several constituents) in the vicinity of some waste sites. SRS is included on the CERCLA National Priorities List.

Sixty-one species have been identified at SRS that are listed as threatened, endangered, or having other special status by the state and federal government. There is potential habitat in some areas for the Red Cockaded Woodpecker. More than 800 prehistoric sites have been identified, although fewer than 8 percent have been evaluated for eligibility to the NRHP. Approximately 400 historic sites have been identified within SRS. Ten of these sites are eligible for the NRHP.

The SRS economic ROI is composed of four counties in which 87 percent of all SRS employees reside. SRS employees in those counties comprise 4.6 percent of the total employment in the regional economic area. The total population in the ROI in 1990 was 460,028. Approximately 37 percent were minorities; 14 percent were below the poverty level.

The radiation dose from normal operations in 1994 would result in 8×10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 620,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit.

ENVIRONMENTAL CONSEQUENCES

The potential environmental consequences of the Proposed Action, three action alternatives, and two no action alternatives are described below. They also are presented in a table at the end of this Summary.

Land Use and Management

Under the Proposed Action, DOE would occupy the land at WIPP transferred to it by the LWA. The Department also would lease selected land outside the WIPP withdrawal area for such uses as groundwater surveillance pads, signs, and transportation and utility corridors. No substantial impacts would occur to established local land use patterns under the Proposed Action. However, the WIPP site would continue to limit drilling and mining activities, and grazing and public access

to the site would be controlled. Pursuant to Public Law 104-201, DOE may acquire two oil and gas leases. As part of the decommissioning of the facility, an earthen berm would be constructed above the repository to delimit the 70-hectare (173-acre) disposal area. There would be no impacts to established local land use patterns beyond the site from decommissioning.

For the action alternatives, the area within the earthen berm would be larger and vary from 360 to 395 hectares (890 to 976 acres); otherwise, land use impacts would be similar to the Proposed Action. For the no action alternatives, impacts on the WIPP site would be minimal because there would be no disposal of waste; thus, decommissioning would be limited to the removal of buildings and the sealing of shafts. The disturbed area would not exceed 20 hectares (50 acres).

Construction and operation of TRU waste treatment and storage facilities are expected to have negligible impacts on land uses at DOE treatment and storage sites and are not expected to conflict with site development plans for the following reasons: land requirements for these facilities would be relatively low (less than 11 hectares); the facilities would be located in developed areas or areas appropriate for development; and the facilities would not be located in sensitive areas (such as known cultural resource areas, sensitive habitats, wetlands, and flood plains). The analysis shows that the TRU waste facilities would require less than 1 percent of the land available for waste operations at any DOE site proposed. This would give DOE considerable flexibility in locating the treatment facilities.

Air Quality

Under the Proposed Action and the action alternatives, WIPP disposal operations would result in small increases in the annual average concentrations of PM_{10}, NO_2, and SO_2. In each case, the increase would be less than 2 percent of the respective annual regulatory limit. Releases of the criteria pollutants O_3 and lead from the operation of WIPP would be negligible. Ten years of decommissioning would result in some small increases in annual concentrations of some pollutants but would result in no long-term impacts.

Emissions from WIPP disposal operations could reach higher percentages of the short-term (24-hour) emission limits. These higher percentages, though, were based on conservative modeling assumptions. Emissions of NO_2 for the Proposed Action and for each of the action alternatives could be as high as 65 percent of the 24-hour limit if underground and surface diesel equipment and both backup diesel generators were operating concurrently. The PM_{10} emissions could be as high as 57 percent of the 24-hour limit, due mainly to very conservative assumptions of salt pile fugitive dust emissions.

Except at RFETS, LLNL, and ANL-E, which are in nonattainment areas for some pollutants, most levels of criteria pollutants would be less than 10 percent of applicable regulatory criteria pollutant standards under each alternative. However, during treatment under Action Alternative 2A, radionuclide releases could potentially reach 134 percent of the regulatory standards at RFETS, and under Action Alternative 2B, treatment-related releases could reach 10 percent of the standard at INEEL. Under Action Alternative 2C, treatment-related releases could reach 137 percent of the regulatory standards at WIPP.

Releases above the regulatory standard would require mitigation measures, such as additional HEPA (High Efficiency Particulate Air) filtration, to ensure releases remained below the allowable limit. Treatment under the other action alternatives or the Proposed Action would not result in

releases of radionuclides or other hazardous or toxic air pollutants in excess of regulatory standards.

Biological Resources

DOE recently conducted surveys at the WIPP site for federally or state-listed threatened or endangered species and habitats. No such species were identified. Therefore, disposal operations at WIPP under the Proposed Action are not expected to impact endangered, threatened, proposed, or candidate plant and animal species listed by the federal government or endangered, threatened, or rare and sensitive species listed by New Mexico. No critical habitat for endangered or threatened species is known to occur on the WIPP site. WIPP site activities are not expected to affect long-term ecosystem balance or biodiversity, although negligible impacts to the overall plant and animal communities near the WIPP site would occur from WIPP operations. Decommissioning and closure of the WIPP site, which would include reclamation of the salt pile area, would affect a total of 70 hectares (173 acres). These activities would result in the short-term loss of much of the plant community and avian and small mammal habitat within and near the area. DOE would return decommissioned WIPP land to a stable ecological condition and maintain or enhance the condition of wildlife habitat within the WIPP Land Withdrawal Area.

Biological resource impacts for the action alternatives would be similar to those for the Proposed Action, except for an increase in the land that would be disturbed by construction of a berm around the perimeter of, and permanent markers over, the disposal area. The area disturbed by decommissioning under the action alternatives would range from 360 to 395 hectares (890 to 976 acres). Under the no action alternatives, the impacts would be less than those under the Proposed Action because the area disturbed at WIPP would be limited to 20 hectares (50 acres).

Construction and operation of treatment facilities for TRU waste should not affect regional populations of nonsensitive plant and animal species because no more than 11 hectares (28 acres) would be disturbed at any site and because the habitats for these species are well established regionally near the proposed treatment sites. Threatened and endangered species appear at most of the DOE sites considered for waste management and treatment facilities. Such species, therefore, could potentially be impacted. Because relatively little land would be required for the waste management and treatment facilities, DOE should be able to locate the new facilities to avoid impacts to such species and sensitive habitat areas. When specific facility locations are proposed, DOE will contact the U.S. Fish and Wildlife Service and state agencies and enter into formal consultation under the Endangered Species Act, where required.

Cultural Resources

Under the Proposed Action, no impacts to cultural resources would occur as part of the WIPP waste handling or emplacement operations. However, those activities that disturb the land in conjunction with closure and decommissioning may have potentially adverse impacts on two archaeological sites that are located within the surface closure area. Both of these sites are eligible for inclusion on the NRHP. One of these sites may require further testing, avoidance, and mitigation, in accordance with the Joint Powers Agreement between DOE and the State of New Mexico under the National Historic Preservation Act and other statutes.

Under the action alternatives, shipping and disposal operations at WIPP would not impact the cultural resources of the area. However, decommissioning activities could disturb 11 prehistoric

archaeological sites that are potentially eligible for inclusion in the NRHP. These prehistoric archaeological sites are located in a 10-square-kilometer (4-square-mile) area that is centrally located within the WIPP site. Under the no action alternatives, no impacts to known cultural resource properties at WIPP would occur.

Construction and operation of TRU waste management and treatment facilities could adversely affect cultural resources, but because the acreage requirements of these facilities remain relatively low at any one site, the adverse affects can probably be avoided for all alternatives. Site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed.

Noise

Truck transport of waste through Carlsbad under the Proposed Action would result in a negligible increase in background noise levels from normal automobile and truck traffic. Transportation noise impacts were based on a maximum of eight trucks per day, which would correspond to the WIPP throughput rate of 50 TRUPACT-IIs and eight RH-72B casks per week. Most of the waste would enter Carlsbad from the north on Highway 285. Trucks would travel through Carlsbad at random times throughout the day.

Under the action alternatives, noise impacts from trucks would be similar to those of the Proposed Action. If the waste were transported by rail and truck (with rail service used as much as is practical), railroad noise impacts in Carlsbad would increase slightly. The impacts would correspond to the time needed for an additional 13 to 16 fully loaded railroad cars per week to pass through the area. All waste destined for WIPP would travel through Carlsbad to Loving where it would be diverted to WIPP via a dedicated rail spur. For No Action Alternatives 1A and 1B, noise impacts would be negligible from truck or rail transportation during transportation to treatment facilities. For No Action Alternative 2, there would be no transportation and thus no impacts.

Because treatment facilities would probably be placed at industrial-type sites along high traffic volume corridors, construction and operation of those facilities should not substantially increase ambient noise levels. There is a potential for sensitive receptors to be impacted. Impacts to sensitive species or habitats would be mitigated when planning the treatment facilities.

Water Resources and Infrastructure

Annual incremental increases in water, wastewater, or power usage would be negligible and within existing capacity under the Proposed Action and all action alternatives. The WIPP facility has been designed to handle emplacement of the waste volumes proposed and its current or planned infrastructure capacity would not be exceeded. Current roadways and planned traffic volumes due to disposal operations also would be compatible. Under the no action alternatives, use of infrastructure resources would gradually decrease until WIPP were closed. No resources would be used following closure.

Impacts from treatment of the waste were assessed for water, power, wastewater, and on-site transportation needs. Treatment operations under the Proposed Action and Action Alternative 1 would result in a 5.9 percent increase in wastewater at Hanford and minor on-site transportation impacts at Hanford, INEEL, and LANL. Action Alternative 2A would result in a 6.6 percent increase in power usage at INEEL, a 7.8 percent increase in wastewater usage at Hanford, and

minor on-site transportation impacts at Hanford, INEEL, and LANL. Action Alternative 2B would result in a 6.6 percent increase in power usage at INEEL, a 7.8 percent increase in wastewater at Hanford and minor on-site transportation impacts at Hanford and INEEL. Action Alternative 2C would result in a 6.6 percent increase in power usage at INEEL and a 50 percent increase in power usage at WIPP. It also would result in 80 percent more wastewater at WIPP. Under Action Alternative 2C, a 162 percent increase in employment would result in minor impacts to on-site transportation resources at WIPP, and minor on-site transportation impacts at Hanford would result from a 6 percent increase in employment. At WIPP under Action Alternative 2C, increases in the volume of wastewater and road usage would be expected to require new or modified facilities. Action Alternative 3 would result in a 6.4 percent increase in power usage at INEEL, a 7 percent increase in wastewater at Hanford, and minor on-site transportation impacts at Hanford, INEEL, and LANL. No Action Alternative 1A would result in a 6.6 percent increase in power usage at INEEL, a 7.8 percent increase in wastewater at Hanford, and minor on-site transportation impacts at Hanford, INEEL, and LANL. No Action Alternative 1B would result in a 6.6 percent increase in power usage at INEEL, a 7.8 percent increase in wastewater at Hanford, and minor on-site transportation impacts to Hanford and INEEL. There would be only minor infrastructure treatment impacts from No Action Alternative 2 because only newly generated waste would be treated.

Socioeconomics

Financial figures used throughout SEIS-II in describing life-cycle costs are presented in terms of 1994 dollars and discounted costs; economic impacts are presented in terms of 1994 dollars. Life-cycle costs for the Proposed Action and the alternatives are presented in Table S-5. The total life-cycle cost (in 1994 dollars) of the Proposed Action would be $19.03 billion, which includes costs for waste management facilities at 10 assumed treatment sites, waste transport, and WIPP operations. It also includes the storage costs for RH-TRU waste in the Basic Inventory that is in excess of the 7,080 cubic meter (250,000 cubic feet) limit. (Updated volume estimates, under which there would not be such excess RH-TRU waste, and the impacts on cost, transportation, and other impacts are discussed later in this Summary and in Appendix J.)

For the Proposed Action, the total life-cycle waste treatment would include construction, operation and maintenance, and decontamination and decommissioning at the assumed treatment sites. The waste management facilities would process, treat, and package waste inventories to meet WAC treatment standards over 35 years. All costs presented below are in 1994 dollars; discounted costs are presented in Table S-5.

The cost of storing the excess RH-TRU waste in the Basic Inventory would be $310 million. Overall, waste treatment and storage costs would be $12.14 billion ($11.80 billion waste treatment plus $310 million excess RH-TRU waste storage). The total cost of waste transportation ($1.59 billion) would include consolidation of the waste volumes at the 10 treatment sites and shipment of the treated waste to WIPP over a 35-year period for emplacement. The total budget at WIPP over the life of the project would be $5.3 billion. Life-cycle costs for the action alternatives are based on longer operation times, as outlined in Table S-4. When truck transportation is proposed, total life-cycle costs would range from $30.28 billion for No Action Alternative 1A to $59.67 billion for Action Alternative 3. Of the three transportation modes, regular rail was found to be the least costly and dedicated rail the most costly.

Table S-5
Life-Cycle Costs (in billions of 1994 dollars with discounted dollars in parentheses)

Life-Cycle Cost Information	Proposed Action (Preferred Alternative)	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Total Waste Treatment and Storage Facility Cost	12.14 (6.56)	21.39 (11.86)	27.69 (15.36)	30.55 (16.94)	28.70 (15.92)	24.34 (13.50)	29.36 (16.28)	31.76 (17.61)	1.64 (0.91)
Total Waste Transportation Cost by Truck	1.59 (0.88)	4.91 (0.78)	2.99 (0.51)	3.30 (0.56)	2.91 (0.49)	6.84 (0.91)	0.07 (0.04)	0.24 (0.13)	---
Total Waste Transportation Cost by Regular Rail	---[a]	1.64 (0.26)	1.01 (0.17)	1.14 (0.19)	0.91 (0.15)	2.34 (0.31)	0.03 (0.02)	0.16 (0.89)	---
Total Waste Transportation Cost by Dedicated Rail	---	11.32 (1.79)	6.86 (1.16)	7.48 (1.26)	6.54 (1.10)	15.69 (2.10)	0.25 (0.14)	1.18 (0.65)	---
Total WIPP Budget	5.30 (2.52)	24.65 (3.68)	23.33 (3.70)	23.33 (3.70)	23.33 (3.70)	28.49 (3.61)	0.85 (0.77)	0.85 (0.77)	0.85 (0.77)
Total Life-Cycle Cost (Truck Transportation)	19.03 (10.13)	50.95 (16.32)	54.01 (19.56)	57.18 (21.19)	54.94 (20.10)	59.67 (18.03)	30.28 (17.09)	32.85 (18.52)	2.49 (1.68) [b]
Total Life-Cycle Cost (Regular Train)	---[a]	47.68 (15.80)	52.03 (19.22)	55.02 (20.83)	52.94 (19.76)	55.17 (17.42)	30.24 (17.07)	32.77 (18.47)	---
Total Life-Cycle Cost (Dedicated Train)	---	57.36 (17.33)	57.88 (20.21)	61.36 (21.90)	58.57 (20.72)	68.52 (19.21)	30.46 (17.19)	33.79 (19.04)	---

[a] Under the SEIS-II Preferred Alternative, regular rail transportation is reserved as a future possibility. Such rail transportation would be less costly than truck transportation.
[b] Life-cycle cost does not include transportation.

Note: The methods and assumptions used to estimate the various life-cycle cost components are described in Appendix D. Actual totals may differ due to rounding and to miscellaneous costs, such as facility decontamination and decommissioning. Discounted costs are presented in parentheses.

Economic impacts in the WIPP region (region of influence, or ROI) under the Proposed Action and action alternatives are presented in Table S-6. Overall, the Proposed Action would have a stabilizing influence on the regional economy near WIPP. Similarly, WIPP would remain a stable federal employer under the other action alternatives, providing direct employment for 1,095 project personnel. The continued operation of WIPP would provide annual direct and indirect production of $317 million of goods and services, provide $126 million of annual labor income, and support 3,538 jobs (including the 1,095 project personnel) in the ROI. These economic impacts are based on an assumed average annual project budget of $180 million per year over a 35-year waste emplacement period extending from 1998 through 2033.

The Carlsbad area would receive approximately 85 percent of the ROI economic impacts associated with WIPP.

TRU waste treatment and associated waste management activities would support direct, indirect, and induced jobs. The Proposed Action would support about 11,900 jobs in the ROIs of the 10 potential treatment sites (ANL-E, Hanford, INEEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, SRS). Action Alternative 1 would support about 22,500 jobs in the ROIs; Action Alternative 2 would support approximately 28,000, 28,500, and 7,200 jobs for subalternatives 2A, 2B, and 2C, respectively; and Action Alternative 3 would support about 24,900 jobs. No Action Alternative 1 would support about 29,300 and 29,800 jobs for subalternatives 2A and 2B, respectively; No Action Alternative 2 would support about 2,300 jobs.

Table S-6
Economic Impacts in the WIPP ROI [a]

SEIS-II Alternative	Duration of WIPP Operations	Average Annual Output of Goods and Services ($Millions, 1994)	Average Annual Total Employment	Average Annual Labor Income ($Millions, 1994)
Proposed Action (Preferred Alternative)	35 years	317	3,538	126
Action Alternative 1	160 years	317	3,538	126
Action Alternatives 2A and 2B	150 years	317	3,538	126
Action Alternative 2C	150 years	616	6,876	245
Action Alternative 3	190 years	317	3,538	126
No Action Alternative 1 [a]	10 years	143	1,592	57
No Action Alternative 2 [a]	10 years	143	1,592	57

[a] Annual impacts under the no action alternatives would occur throughout the decommissioning period. Decommissioning would occur over a 10-year period.

Transportation

The following are among the analyses conducted to estimate impacts from transporting TRU waste.

- The overall number of traffic accidents and the number of resulting fatalities and injuries were estimated. These impacts are dependent upon the number of additional trucks that transportation of TRU waste would place on the nation's highways and not on the

radioactive or hazardous materials being transported. These impacts, therefore, are "nonradiological impacts."

- Accident-free radiological impacts were estimated. These impacts are associated with the external radiation present around a TRUPACT-II or RH-72B as it is being shipped. The general public and transportation workers would be exposed to very low levels of radiation both during transportation and while a shipment is stopped. These impacts are "accident-free radiological impacts."

- The impacts from specific accident scenarios in which a TRU waste package is breached and releases radioactive or hazardous materials were estimated. These impacts are "radiological impacts from transportation accidents."

The following subsections discuss the results of these analyses.

Nonradiological Impacts

Under the Proposed Action, during the 35 years of transportation, 56 accidents, 39 injuries, and five fatalities were estimated for transportation of TRU waste by truck. (Though rail transportation was not analyzed under the Proposed Action, use of rail transportation is reserved for future consideration under the Preferred Alternative; if rail transportation were used, impacts are expected to be lower.) The greatest potential impacts would occur under Action Alternative 3, with 239 accidents, 165 injuries, and 22 fatalities during 190 years of transportation by truck. The impacts from truck transportation of TRU waste under Action Alternative 1 would be 171 accidents, 119 injuries, and 16 fatalities during the 160 years of transportation. The impacts for the three subalternatives of Action Alternative 2 indicate that the number of accidents during the 150 years of transportation would range from 105 to 123, the number of injuries would range from 74 to 86, and the number of fatalities would range from 10 to 11. Under No Action Alternative 1A, the impacts from truck transportation would be five accidents, four injuries, and no fatalities during the 35 years of transportation. The impacts from truck transportation of TRU waste under No Action Alternative 1B would be 13 accidents, 12 injuries, and 1 fatality during 35 years of transportation. There would be no transportation proposed under No Action Alternative 2.

If regular rail service were used as much as practical, with trucks transporting the remainder of the waste for the action alternatives or No Action Alternative 1, the number of fatalities overall would be approximately half those estimated for truck transportation alone. This is because the number of fatalities per rail-car mile and per truck are about the same and because twice as many TRUPACT-IIs or RH-72B casks can be shipped on each rail car; the number of shipments (and fatalities), therefore, is reduced by half.

If dedicated rail service were used for the action alternatives or No Action Alternative 1 with rail cars shipping TRU waste exclusively, approximately 14 times the number of fatalities from regular rail service for each alternative would be expected as a result. This is largely from the increase in the number of trains when dedicated rail service is used.

Accident-Free Radiological Impacts

Two types of accident-free radiological impacts were independently estimated. The first type was the nonoccupational impact: the impact to the general public living along the highways or traveling on the highways at the same time as the TRU waste shipments. The conservative nature (i.e., tendency to overestimate impacts) of the assessment methods for accident-free transportation impacts is discussed in Section 5.1.8.3 and Appendix E. Actual impacts are likely to be smaller than estimated. The second type of accident-free radiological impact was the occupational impact: the impact to inspectors and others whose jobs would expose them to the radiation from TRUPACT-IIs and RH-72B casks.

ESTIMATING RADIOLOGICAL IMPACTS

Estimation of potential human health impacts involves a series of calculations that indicate the potential health consequence of a particular action or accident, and the probability that the action or accident would occur. Impacts can be calculated both for individuals and for a population. The probability of occurrence for routine actions is 1.0, meaning the action (e.g., chronic release from a permitted exhaust point) will occur at regular intervals, typically daily, over a year of operations. The probability of occurrence for accidents, therefore, is between zero and 1.0, indicating the chance that the nonroutine event might occur sometime during the entire operations period.

The health effect of concern from low levels of radiation exposure is a radiation-induced cancer fatality. To quantify the radiological impact, the radiation dose must be calculated. The dose is a function of the exposure pathway (external, inhalation, or ingestion) and the type and quantity of radionuclides involved. After the dose is estimated, the health impact is calculated from current internationally recognized risk factors. For this document, potential radiological impacts are based on a scenario that includes prudently conservative release, exposure, and risk factor estimates. Because of the use of conservative assumptions, the impact estimates bound any that would be expected.

The unit of radiation dose for an individual is the rem. A millirem (mrem) is 1/1,000 of a rem. The unit of dose for a population is person-rem and is determined by summing the individual doses of an exposed population. Dividing the person-rem estimate by the number of people in the population would indicate the average dose to a single individual. The impacts from a small dose to a large number of people can be estimated from population (i.e., collective) dose estimates.

To estimate the human health impact from radiation dose, a dose-to-risk factor that indicates the potential for a latent cancer fatality, or LCF, is used. An LCF is a fatality resulting from a cancer that was originally induced by radiation, but which may occur years after the exposure. The dose-to-risk factor for low (less than 20 rem) annual doses is 0.0005 LCF per person-rem for the general public, which includes the very young and the very old, and 0.0004 for the worker population. For example, a population dose of 2,000 person-rem is estimated to result in one additional cancer fatality (0.0005 x 2,000 = 1) in the general public. The dose-to-risk factor for an individual is doubled if the individual dose rate is greater than 20 rem/year (20,000 mrem per year).

The average individual in the United States receives a dose of 0.3 rem (300 mrem) each year from background radiation. Background radiation sources include radon that has concentrated in homes from foundation soil sources, uranium found in rocks used as building materials, and cosmic radiation from the earth's atmosphere. The average lifetime chance or probability of cancer to a member of the public from a 70-year exposure due to background radiation is about 0.01 (i.e., 70 x 0.3 x 0.0005). That is, the best current radiation risk estimates are that one in 100 people will die from cancer due to background radiation.

During the 35 years of transportation under the Proposed Action, nonoccupational impacts could result in 3 LCFs. (Though rail transportation was not analyzed under the Proposed Action, use of rail transportation is reserved for future consideration under the Preferred Alternative; if rail transportation were used, impacts are expected to be lower.) Among the alternatives, Action Alternative 3 would have the greatest nonoccupational, accident-free radiological impact from 190 years of truck transportation (15 latent cancer fatalities or LCFs). No Action Alternative 1A would have the least nonoccupational radiological impact (less than 1 LCF). (No transportation is proposed for No Action Alternative 2.) Action Alternatives 2A and 2B would have nonoccupational impacts estimated at 6 and 7 LCFs respectively during 150 years of transportation, Action Alternative 2C would have 6 LCFs during 150 years of transportation, and Action Alternative 1 would have 11 LCFs during 160 years of transportation.

Nonoccupational, accident-free exposure impacts from rail transportation are generally ten times lower than those impacts from truck transportation, due to additional shielding during stops. Action Alternative 3 would have the maximum potential impact for accident-free rail transportation (2.0 LCFs).

Under the Proposed Action, accident-free occupational impacts from truck transportation would result in 0.3 LCF. (Though rail transportation was not analyzed under the Proposed Action, use of rail transportation is reserved for future consideration under the Preferred Alternative; if rail transportation were used, impacts are expected to be lower.) Action Alternative 3 would have the greatest occupational impacts, resulting in 1 LCF from accident-free transportation. Accident-free transportation under Action Alternatives 2A and 2B would result in 0.5 and 0.7 LCF each, and 0.5 LCF would result from Action Alternative 2C. Under Action Alternative 1 and No Action Alternatives 1A and 1B, the occupational impacts would result in 0.7, 0.02, and 0.07 LCF, respectively.

Occupational accident-free doses from rail transportation could be up to 100 times lower than from truck transportation, due to the lower number of shipments (half as many) and the increased distance between the shipping containers or casks and the crews. Also, no impacts would be expected from the release of hazardous chemicals in TRU mixed waste during accident-free transportation, because the containers used to transport the waste are not vented and, therefore, no releases would occur.

Radiological Impacts From Transportation Accidents

Two types of analyses were conducted to determine the radiological impacts associated with transportation accidents. The first estimated the aggregate radiological impacts during transportation from each of the 10 major potential treatment sites to WIPP. For this analysis, a conservative radionuclide inventory was used that assumed every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowed by the planning-basis WAC. The probabilities of occurrence for each of eight severity categories, the distance from each site, and the number of shipments were considered for this first analysis. The total accident impact from each of the 10 potential sites was obtained by summing the impacts calculated for each severity category.

For each alternative except Action Alternative 3, the total LCFs were estimated to be less than 1. For Action Alternative 3, the estimate was 1.2 LCFs.

The second type of analysis assessed bounding accident scenarios. Two scenarios involved the breach of a TRUPACT-II and two involved the breach of an RH-72B. The accidents were assumed to occur under conditions that would maximize, within reasonable bounds, the impacts to exposed population groups. Results for this second analysis are summarized below:

- *Breach of a TRUPACT-II with a maximum radionuclide inventory*: The inventory considered for this analysis was a shipment of three TRUPACT-IIs, each with the maximum number of drums, and each drum containing the maximum level of radionuclides permitted under the planning-basis WAC. The accident scenario considered the breach of one of the three TRUPACT-IIs in an urban area under weather conditions that would maximize the radiation dose to the population. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action Alternative 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 16 LCFs, and the dose to a hypothetical MEI would result in a 0.06 probability of an LCF. For Action Alternatives 2A and 2B, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 3×10^{-4} probability of an LCF. The reduced impacts are due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

- *Breach of an RH-72B with a maximum radionuclide inventory*: The inventory considered for this analysis was a shipment of one RH-72B cask containing the maximum level of radionuclides permitted under the planning-basis WAC. The accident scenario considered the breach of the RH-72B cask in an urban area under weather conditions that would maximize the radiation dose to the population. The analyses indicated that for the Proposed Action, Action Alternatives 1 and 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 16 LCFs, and the dose to the MEI would result in a 0.06 probability of an LCF. For Action Alternatives 2A, 2B, and 2C, the dose would result in less than 1 LCF and that to the MEI would result in a 3×10^{-4} probability of an LCF. The reduced impacts are due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed the MEI.

- *Breach of a TRUPACT-II with average concentrations of radionuclides*: The inventory considered for this analysis was a shipment of three TRUPACT-IIs containing the average concentration of radionuclides found at SRS, which had the highest average concentration. The accident scenario was otherwise identical to that above. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action Alternative 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 3 LCFs, and the dose to the MEI would result in a 0.04 probability of an LCF. For Action Alternatives 2A and 2B, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 2×10^{-4} probability of an LCF. The reduced impacts are again due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

- *Breach of an RH-72B with average concentrations of radionuclides*: The inventory considered for this analysis was a shipment of an RH-72B cask containing the average concentration of radionuclides found at Hanford, which had the highest average concentration. The accident was otherwise identical to that above. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action

UNDERSTANDING SCIENTIFIC AND EXPONENTIAL NOTATION

Scientific notation is used in this document to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10	**Negative Powers of 10**
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
$10^6 = 1{,}000{,}000$ (or 1 million)	$10^{-6} = 0.000001$ (or 1 in 1 million)

A power of 10 is also commonly expressed as "E", where "E" means "x 10". For example, 3×10^5 can also be written as 3E+5, and 3×10^{-5} is equivalent to 3E-5. Therefore, 3E+5=300,000 and 3E-5 = 0.00003. This is called exponential notation.

The data tables in this section use exponential notation for numbers that are either very large or very small. The text uses scientific notation to convey these numbers.

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3E-6 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

Alternative 3, and No Action Alternatives 1A and 1B, the dose to the population would result in 0.04 LCF, and the dose to the MEI would result in a 7×10^{-4} probability of an LCF. For Action Alternatives 2A, 2B and 2C, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 4×10^{-6} probability of a LCF. The reduced impacts are again due to thermal treatment of the waste before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

The severe rail transportation accident analyses assumed the breach of two RH-72B casks or two TRUPACT-IIs; thus, the impacts for a rail accident would double those calculated for a truck accident.

In an effort to reduce the impacts estimated in the transportation analysis, the carrier selected by DOE would provide tractors and drivers who would not work on other contracts. The drivers would be technically qualified and experienced and would be required to complete training in 28 categories, including hazardous and radioactive material transportation. Drivers would carry instructions regarding protocol in the event of an accident and would be trained in package recovery operations. The DOE Carlsbad Area Office has completed and made available an emergency-response plan involving TRU material transport.

Human Health (During Accident-Free Operations)

Potential human health impacts estimated in SEIS-II analyses include the impacts from waste treatment (for all alternatives), waste storage (for all alternatives), and waste disposal at WIPP (for the Proposed Action and the action alternatives). The impacts presented include exposure to

radiation and hazardous chemicals for members of the public, workers not directly involved in handling containers of TRU waste (called noninvolved workers), and workers who would directly handle containers of TRU waste (called involved workers). The findings included the following:

- No incidence of cancer or noncarcinogenic health effects from exposure to the hazardous chemicals in TRU mixed waste would be anticipated to the public or workers under any alternative.

- Thermal treatment of waste under Action Alternatives 2A, 2B, and 2C, and under No Action Alternatives 1A and 1B could result in 1 to 2 radiation-related LCFs, depending on the alternative and the treatment site, to members of the public at the treatment sites due to the thermal treatment. No LCFs from treatment for members of the public would occur under any other alternative, including the Proposed Action. Waste treatment could result in 1 to 2 LCFs in involved worker populations under Action Alternatives 1, 2A, 2B, 2C, 3 and No Action Alternatives 1A and 1B. Waste treatment (to meet planning-basis WAC) could result in 1 LCF to involved worker populations under the Proposed Action. Under Action Alternatives 1 and 3, 1.5 LCFs could result for involved worker populations.

- Waste storage operations could result in 1 LCF to involved worker populations under No Action Alternative 1 and 3 LCFs under No Action Alternative 2. The other alternatives would have no LCFs for involved workers at lag storage or long-term storage sites.

- Waste disposal operations at WIPP could result in 1 LCF to involved worker populations under the Proposed Action and Action Alternative 1. The other action alternatives would have no LCFs for the involved workers.

- No radiation-related LCFs would be anticipated among the noninvolved worker population under any alternative.

The impacts of each alternative are summarized below. The quantitative impacts refer to those impacts resulting from the treatment of the maximum inventory potentially included under each alternative.

Proposed Action

For members of the public, treatment of CH-TRU and RH-TRU waste to meet the planning-basis WAC would result in radiological impacts of 2×10^{-4} LCFs for the total population within 80 kilometers (50 miles) of all treatment facilities. For the MEI, the radiological impacts would be a 2×10^{-9} probability of an LCF. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities. The impact to the MEI would be a 2×10^{-11} probability of cancer.

Storage of the excess RH-TRU waste inventory at Hanford and ORNL, should it be necessary, would result in radiological impacts to the public of 2×10^{-5} LCF in the population and a

THE WM PEIS PREFERRED ALTERNATIVE

For the purposes of analysis in the Draft SEIS-II Proposed Action, the Department assumed that TRU waste treatment would be partially consolidated in accordance with the Decentralized Alternative of the WM PEIS. Since publication of the Draft SEIS-II, the Final WM PEIS identified a preferred alternative which was a combination of the WM PEIS Alternatives. If TRU waste were treated at the locations identified in the WM PEIS preferred alternative, there would be a slight impact on the analysis set forth in SEIS-II, although there would be no changes in health and other impacts. The modifications to impacts, should the Department select the WM PEIS preferred alternative, are shown below.

RH-TRU waste from SRS would be consolidated at ORNL before disposal at WIPP.

For purposes of analysis of this potential consolidation, the waste volumes used for the WM PEIS have been used. The inventory used for other SEIS-II analyses shows no RH-TRU waste at SRS. The WM PEIS inventory includes up to 21 cubic meters [700 cubic feet] of RH-TRU waste, nearly all of it to be generated during the next 20 years. The number of shipments of RH-TRU waste involved would be approximately 23. The additional miles would also be small because SRS is east of ORNL (the waste would travel west, then south to WIPP). The overall additional impacts (when added to the impacts of the 7,957 shipments in the Basic Inventory) would be small (0.03 additional accidents, 0.03 additional injuries, and 0.004 additional fatalities). Radiological impacts to the occupational population would be 1×10^{-4} LCFs and for nonoccupational populations would be 3×10^{-3} LCFs. (If this waste went directly to WIPP, the impacts would be the same as those presented for the Proposed Action.)

The CH-TRU waste at ORNL would be consolidated at SRS before disposal at WIPP.

A total of 1,700 cubic meters (60,000 cubic feet) or 251 shipments of waste would be transported. The additional transportation would result in 0.1 additional accidents, 0.1 additional injuries, and no additional fatalities. Additional radiological impacts to the occupational population would be 4×10^{-4} LCFs. The radiological impacts to the public would decrease slightly (by 5×10^{-5} LCFs) because of a difference in accident rates along the roadways. The number of shipments would be spread over 35 years, averaging less than 10 shipments per year. Because CH-TRU waste at SRS would be transported to WIPP during the same 35-year period, only small additional impacts to the cost and risk from storage would occur.

Some RFETS CH-TRU waste would be shipped to INEEL for treatment before shipment to WIPP.

Recent estimates are that about 1,000 cubic meters (35,000 cubic feet) of RH-TRU waste would be shipped to INEEL for treatment before shipment to WIPP. For purposes of analysis, the number of shipments was conservatively estimated at 250, though would probably be lower. Additional impacts from this transportation would be 0.25 additional accidents, 0.06 additional injuries, and 0.1 additional fatalities.

Waste from small generator sites (with the exception of SNL) would be shipped directly to WIPP instead of being consolidated before shipment to WIPP. Waste from SNL would be consolidated at LANL.

Approximately 25 shipments of CH-TRU waste at the small generator sites would be directly shipped to WIPP under either the WM PEIS preferred alternative or scenarios where there is no consolidation, and the number of shipments from the potential consolidation sites would probably be reduced. Although routes from the small generator sites have not been proposed, impacts from the additional miles, if any, to be traveled by so few shipments (when compared to the 29,766 shipments for the total campaign) would be so small that the results from the total shipping campaign would not change. For RH-TRU waste, 958 shipments (931 of them from Battelle Columbus Laboratory) would transport waste directly to WIPP, and there would be a one for one reduction in the number of RH-TRU waste shipments from the consolidation sites (because RH-TRU waste would not be repackaged at the potential consolidation sites). The mileage when shipping directly to WIPP would be nearly the same as when first consolidating that waste. Therefore, it is unlikely that there would be additional impacts during the shipping campaign.

1×10^{-9} probability of an LCF for the MEI (at ORNL only). (Updated estimates indicate there would be no excess RH-TRU waste; see Appendix J.) Hazardous chemical impacts include a cancer incidence of 3×10^{-4} in the total population and a 4×10^{-8} probability of an LCF for the MEI (at ORNL)[1].

Disposal operations at WIPP would result in the radiological impacts to the public of 3×10^{-4} LCF in the population and a 3×10^{-7} probability of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-5} in the population and a 3×10^{-8} probability of cancer for the MEI.

For noninvolved workers (those who would not directly handle TRU waste), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 7×10^{-6} LCF to the total noninvolved worker population of all treatment facilities. The impacts to the maximally exposed noninvolved worker would be a 3×10^{-9} probability of an LCF. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 1×10^{-10} probability of cancer for the maximally exposed noninvolved worker.

Should it be necessary, storage of the excess RH-TRU inventory at Hanford and ORNL would result in radiological impacts to the noninvolved worker populations of 4×10^{-5} LCF and a 1×10^{-8} probability of an LCF for the MEI (at ORNL). Hazardous chemical impacts would include a cancer incidence of 6×10^{-4} in the total noninvolved worker population and a 4×10^{-8} probability of cancer incidence for the maximally exposed noninvolved worker (at Hanford).

Radiological impacts to the noninvolved worker from disposal operations at WIPP could result in 4×10^{-4} LCF in the noninvolved worker population and a 4×10^{-7} probability of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-4} in the noninvolved population and a 1×10^{-7} probability of cancer for the maximally exposed noninvolved worker.

For involved workers (those who would handle TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste could be 1 LCF to the total involved worker population of all treatment facilities. Hazardous chemical impacts would include a cancer incidence of 2×10^{-5} in the total involved worker population of all the treatment facilities.

From disposal operations at WIPP, radiological impacts would result in 1.0 LCF or less in the involved worker population. Hazardous chemical impacts would result in a cancer incidence of 0.01 in the involved worker population.

Action Alternative 1

For members of the public, treatment to planning-basis WAC of CH-TRU and RH-TRU waste would result in radiological impacts of 2×10^{-4} LCF for the total population within 80 kilometers (50 miles) of all treatment facilities. For the MEI, the radiological impacts would be a 1×10^{-9} probability of an LCF. Hazardous chemical impacts would include a cancer incidence of 6×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and a

[1] Hazardous chemical impacts are relatively high compared to radiological impacts because TRU waste containers are vented through carbon filters which filter out radioactive particulates. The gases that vent through the filters are relatively high in hazardous constituents while few gaseous radionuclides are emitted.

3×10^{-11} probability of cancer to the MEI. Lag storage at treatment sites would result in radiological impacts to the public of 1×10^{-2} LCF in the population and a 2×10^{-6} probability of an LCF for the MEI (ORNL). Hazardous chemical impacts would include a cancer incidence of 3×10^{-3} in the population and a 1×10^{-7} probability of an LCF for the MEI (LANL).

Disposal operations at WIPP would result in radiological impacts to the public of 3×10^{-4} LCF in the population and a 5×10^{-7} probability of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-5} in the population and a 2×10^{-8} probability of cancer for the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of CH-TRU and RH-TRU waste would be 8×10^{-6} LCF in the total noninvolved worker population of all treatment facilities and an 8×10^{-9} probability of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 2×10^{-7} in the total noninvolved worker population of all treatment facilities and a 2×10^{-10} probability of cancer for the maximally exposed noninvolved worker. Lag storage at the treatment sites would result in radiological impacts at 4×10^{-2} LCF in the population and an 8×10^{-6} probability of an LCF for the maximally exposed noninvolved worker (ORNL). Hazardous chemical impacts would include cancer incidence of 5×10^{-3} in the population and a 5×10^{-7} probability of an LCF for the maximally exposed noninvolved worker (INEEL).

Disposal operations at WIPP would result in radiological impacts at 4×10^{-4} LCF in the noninvolved worker population and a 4×10^{-7} probability of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-4} in the noninvolved population and a 9×10^{-8} probability of cancer for the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 2 LCFs in the total involved worker population of all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 3×10^{-5} in the total involved worker population of all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts of 1 LCF or less in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.04 or less in the involved worker population.

Disposal operations at WIPP would result in radiological impacts of 1 LCF or less in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.03 or less in the involved worker population.

The entire disposal operations period under Action Alternative 1 is estimated to be 42 years for CH-TRU waste and 160 years for RH-TRU waste. The aggregate impacts to the public over the 160 years within 80 kilometers (50 miles) of WIPP and lag storage sites are estimated to be 0.01 LCF from radiation exposure and a cancer incidence of 5×10^{-3} from hazardous chemical exposure. The aggregate impacts over the 160 years to the noninvolved worker populations at WIPP and lag storage sites are estimated to be 0.05 LCF from radiation exposure and a cancer incidence of 0.01 from hazardous chemical exposure. The aggregate impacts to the involved worker populations at WIPP and lag storage sites are estimated to be 2 LCFs or less from radiation exposure and a cancer incidence of 0.1 or less from hazardous chemical exposure.

Action Alternative 2

For members of the public, treatment of CH-TRU and RH-TRU waste under Action Alternatives 2A, 2B, and 2C would result in radiological impacts of 2, 2, and 1 LCFs, respectively, in the total population within 80 kilometers (50 miles) of all treatment facilities and a 3×10^{-5}, 5×10^{-5}, and 2×10^{-4} probability of an LCF, respectively, to the MEI. Hazardous chemical impacts would include a probability of cancer incidence of 3×10^{-7} under each option in the population within 80 kilometers (50 miles) of the treatment facilities and a 2×10^{-11} probability of cancer to the MEI.

Lag storage at treatment sites under Action Alternatives 2A, 2B, and 2C would result in radiological impacts to the public of 1×10^{-3}, 6×10^{-4}, and 1×10^{-4} LCF, respectively, in the population, and 2×10^{-7} (at LANL), 1×10^{-8} (at SRS), and 1×10^{-7} (at WIPP) probability of an LCF, respectively, for the MEI. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

Disposal operations at WIPP under each Alternative 2 subalternative would result in radiological impacts to the public of 5×10^{-5} LCF in the population and a 1×10^{-7} probability of an LCF for the MEI. For each subalternative, there would be no hazardous chemical impacts.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from treatment of TRU waste under Action Alternatives 2A, 2B, and 2C would be 0.1, 0.1, and 0.06 LCF, respectively, in the total noninvolved worker population of all the treatment facilities and a 5×10^{-5} (at RFETS), 2×10^{-4} (at Hanford), and 2×10^{-4} (at WIPP) probability of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 1×10^{-10} probability of cancer for the maximally exposed noninvolved worker.

Lag storage at the treatment sites would result in radiological impacts of 2×10^{-2} , 2×10^{-2}, and 4×10^{-4} LCF in the noninvolved worker population and a 1×10^{-6} (SRS), 1×10^{-6} (SRS), and 1×10^{-7} (WIPP) probability of an LCF for the maximally exposed noninvolved worker. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

Disposal operations at WIPP would result in radiological impacts of 2×10^{-4} LCF in the noninvolved worker population and a 2×10^{-7} probability of an LCF for the maximally exposed noninvolved worker for all subalternatives. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 2, 1, and 1 LCFs in the total involved worker population at all the treatment facilities. Hazardous chemical impacts would include a probability of cancer incidence of 6×10^{-5}, 9×10^{-5}, 8×10^{-5} in the total involved worker population of all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts of 0.4 LCF or less in the involved worker population. There would be no hazardous chemical impacts.

Disposal operations at WIPP would result in radiological impacts of 0.4 LCF or less in the involved worker population. There would be no hazardous chemical impacts.

The entire disposal operations period under Action Alternative 2 is estimated to be 22 years for CH-TRU waste and 150 years for RH-TRU waste. The aggregate impacts during the 150 years to the public within 80 kilometers (50 miles) of WIPP and lag storage sites expected are estimated to be a maximum of 1×10^{-3} LCFs from radiation exposure. The aggregate impacts during that period to the noninvolved worker populations at WIPP and lag storage sites are estimated to be a maximum of 0.02 LCFs from radiation exposure. The aggregate impacts during the 150 years to the involved worker populations at WIPP and lag storage sites are estimated to be no more than 0.4 LCF from radiation exposure.

Action Alternative 3

For members of the public, treatment of CH-TRU and RH-TRU waste would result in radiological impacts of 4×10^{-3} LCF in the total population within 80 kilometers (50 miles) of all the treatment facilities and a 4×10^{-7} probability of an LCF to the MEI. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and a 2×10^{-11} probability of cancer to the MEI.

Lag storage at treatment sites would result in radiological impacts of 2×10^{-3} LCF in the population and a 3×10^{-7} probability of an LCF for the MEI (at LANL). Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} in the population and a 3×10^{-7} probability of an LCF for the MEI (at Hanford).

Disposal operations at WIPP would result in radiological impacts of 2×10^{-4} LCF in the population and a 3×10^{-7} probability of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 1×10^{-5} in the population and a 1×10^{-8} probability of cancer for the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 7×10^{-4} LCF in the total noninvolved worker population of all treatment facilities and a 2×10^{-7} (LANL) probability of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 2×10^{-7} in the total noninvolved worker population at all the treatment facilities and a 1×10^{-10} (ORNL) probability of cancer for the maximally exposed noninvolved worker.

Lag storage at treatment sites would result in radiological impacts of 4×10^{-2} LCF in the population and a 2×10^{-6} probability of an LCF for the maximally exposed noninvolved worker (SRS). Hazardous chemical impacts would include a cancer incidence of 9×10^{-3} in the population and a 4×10^{-7} probability of an LCF for the maximally exposed noninvolved worker (Hanford).

Disposal operations at WIPP would result in radiological impacts of 3×10^{-4} LCF in the noninvolved worker population and a 3×10^{-7} probability of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 5×10^{-5} in the noninvolved worker population and a 5×10^{-8} probability of cancer for the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 2 LCFs in the total involved worker population at all the

treatment facilities. Hazardous chemical impacts would include a cancer incidence of 4×10^{-5} in the total involved worker population at all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts of 0.6 LCF or less in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.1 or less in the involved worker population.

Disposal operations at WIPP would result in radiological impacts of 0.2 LCF or less in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 7×10^{-3} or less in the involved worker population.

The entire disposal operations period under Action Alternative 3 is estimated to be 57 years for CH-TRU waste and 190 years for RH-TRU waste. The aggregate impacts to the public within 80 kilometers (50 miles) of WIPP and lag storage sites expected over the entire disposal operations period are estimated to be 3×10^{-3} LCFs from radiation exposure and a cancer incidence of 4×10^{-3} from hazardous chemical exposure. The aggregate impacts to the noninvolved worker populations at WIPP and lag storage sites are estimated to be 0.07 LCF from radiation exposure and a cancer incidence of 0.02 from hazardous chemical exposure. The aggregate impacts to the involved worker populations at WIPP and lag storage sites are estimated to be 0.6 and 0.3 LCF, respectively, from radiation exposure and a cancer incidence of 0.4 from hazardous chemical exposure.

No Action Alternative 1

For members of the public, treatment of TRU waste under No Action Alternatives 1A and 1B would result in radiological impacts of 2 LCFs under each alternative in the total population within 80 kilometers (50 miles) of all treatment facilities and a 3×10^{-5} (RFETS) and 5×10^{-5} (Hanford) probability of an LCF, respectively, to the MEI. Hazardous chemical impacts would include a cancer incidence of 3×10^{-7} for both subalternatives in the population within 80 kilometers (50 miles) of the treatment facilities and a 2×10^{-11} (ORNL) probability of cancer to the MEI under both subalternatives.

Storage operations at the treatment sites would result in radiological impacts of 1×10^{-3} and 7×10^{-4} in the population and a 2×10^{-7} (LANL) and 2×10^{-9} (ORNL) probability of an LCF for the MEI. There would be no hazardous chemical impacts.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from treatment of TRU waste under No Action Alternatives 1A and 1B would be 0.1 LCF in the total noninvolved worker population of all the treatment facilities and a 5×10^{-5} (RFETS) and 2×10^{-4} (Hanford) probability of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 1×10^{-10} probability of cancer for the maximally exposed noninvolved worker under both subalternatives.

Storage operations at treatment sites would result in radiological impacts of 0.02 LCF in the population and a 1×10^{-6} (SRS) probability of an LCF for the maximally exposed noninvolved worker. There would be no hazardous chemical impacts.

For involved workers (those handling TRU waste directly), treatment of CH-TRU and RH-TRU waste would result in radiological impacts of 2 and 1 LCFs, respectively, for each subalternative in the total involved worker population of all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 6×10^{-5} and 9×10^{-5} in the total involved worker population of all the treatment facilities.

Storage operations at consolidation sites would result in radiological impacts of 0.4 LCF in the involved worker population.

During the initial 100-year operations period under No Action Alternative 1, the aggregate impacts to the public within 80 kilometers (50 miles) of the storage sites are estimated to be a maximum of 3×10^{-3} LCF from radiation exposure. The aggregate impacts to the noninvolved worker populations at the storage sites are estimated to be a maximum of 0.06 LCF from radiation exposure. The aggregate impacts to the involved worker populations at the storage sites are estimated to be 1 LCF from radiation exposure.

No Action Alternative 2

For members of the public, treatment of TRU waste under No Action Alternative 2 would result in radiological impacts of 1×10^{-3} LCF in the total population within 80 kilometers (50 miles) of all treatment facilities and an 8×10^{-8} probability of an LCF (at LANL) to the MEI. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and 2×10^{-11} probability of cancer (at ORNL) to the MEI.

Storage operations at generator sites would result in radiological impacts of 0.01 LCF in the population and 2×10^{-6} (ORNL) probability of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} in the population and 4×10^{-8} (LANL) probability of cancer to the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 8×10^{-5} LCF in the total noninvolved worker population of all the treatment facilities and a 4×10^{-8} probability of an LCF (at LANL) to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 1×10^{-10} probability of cancer (ORNL) for the maximally exposed noninvolved worker.

Storage operations at generator sites would result in radiological impacts of 0.04 LCF in the population and a 4×10^{-5} (ORNL) probability of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} LCF in the population and 2×10^{-7} (INEEL) probability of cancer to the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 0.4 LCF in the total involved worker population at all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 8×10^{-6} in the total involved worker population at all the treatment facilities.

Storage operations at generator sites would result in radiological impacts of 1 LCF or less in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.04 or less in the involved worker population.

During a 35-year period (operations and institutional control) under No Action Alternative 2, the aggregate impacts to the public within 80 kilometers (50 miles) of the storage sites are estimated to be 0.03 LCF from radiation exposure and a cancer incidence of 6×10^{-3} from hazardous chemical exposure. The aggregate impacts to the noninvolved worker populations at the storage sites are estimated to be 0.1 LCF from radiation exposure and a cancer incidence of 6×10^{-3} from hazardous chemical exposure. The aggregate impacts to the involved worker populations at the storage sites are estimated to be 3 LCFs or less from radiation exposure and a cancer incidence of 0.1 or less from hazardous chemical exposure.

Facility Accidents

Potential radiological impacts from treatment, storage, and disposal facility accidents were analyzed and are presented in this discussion. Although the initiating events of the accidents vary for the three stages (treatment, storage, and disposal), the general approach was to evaluate: (1) a high-frequency/low-consequence accident for each of the three stages; (2) a low-frequency/ high-consequence operational accident for each of the three stages; and (3) an accident that would be beyond-design-basis of and involve the collapse of the applicable treatment or storage facility. However, a broader suite of accidents was evaluated for the WIPP facility. A potential beyond-design-basis accident could be triggered by a number of initiating events, such as an earthquake, tornado, or plane crash, depending on the site. For the purposes of analysis in SEIS-II, an earthquake is assumed to initiate the beyond-design-basis accident for treatment and storage facilities. While the annual frequency of a design-basis earthquake varies for DOE sites across the country (1×10^{-3} or less), the frequency of a beyond-design-basis earthquake that would result in a loss of confinement and a collapse of the building has been estimated at 1×10^{-5} for purposes of these analyses. The analyses were conducted to estimate the difference in impacts among the types of waste treatment and not to make a decisions regarding specific treatment sites.

The results presented below are those for the high-frequency/low-consequence accident (with estimated annual occurrence frequencies of 0.1 to 0.01), the beyond-design-basis earthquake accident and the hoist failure accident, which provide the range of consequences for the accidents evaluated.

The analyses were conducted in such a manner as to indicate the differences between the types of waste treatment and not to make a decision regarding specific treatment sites. The impacts were calculated for specific sites based on TRU waste inventory, population, and types of treatment. Only Action Alternative 2 and No Action Alternative 1 would destroy the PCBs in the TRU waste commingled with PCBs.

Treatment Facility Accidents

<u>High-Frequency/Low-Consequence Accident (Waste Spill/Waste Drum Failure)</u>

The maximum radiological impact to the public from a high-frequency/low-consequence accident during the treatment of CH-TRU waste to meet the planning-basis WAC would be at RFETS where

3×10^{-4} LCFs were estimated. The highest thermal treatment impact would be at RFETS where 1×10^{-3} LCFs were estimated. Treatment by shred and grout would have a maximum impact of 1×10^{-4} LCFs at RFETS.

Maximum radiological impacts to the MEI would range from a 1×10^{-7} probability of an LCF at LANL for the treatment of TRU waste to the planning-basis WAC, to a 5×10^{-7} probability of an LCF at LANL for thermally treated waste. The maximum radiological impact to the MEI for shred and grout treatment was estimated to be a 6×10^{-8} probability of an LCF at LANL.

For the alternatives that consider treatment of CH-TRU waste to the planning-basis WAC, the maximum radiological impacts to the maximally exposed noninvolved worker was estimated to be a 4×10^{-7} probability of an LCF at Hanford. For alternatives that include thermally treating waste, the maximum impact to the maximally exposed noninvolved worker would be at Hanford for which a 1×10^{-6} probability of an LCF was estimated. For the alternative that considers treating TRU waste using a shred and grout process, the maximum impact to the maximally exposed noninvolved worker was estimated to be a 2×10^{-7} probability of an LCF at Hanford.

The potential radiological impacts from RH-TRU waste treatment accidents are greatest at the ORNL site for all accident scenarios and receptors; however, they are four to five orders of magnitude less than the impacts from CH-TRU waste treatment accidents.

Beyond-Design-Basis Accident (Collapse of Building Due to Earthquake)

The population impact from a beyond-design-basis accident during the treatment of CH-TRU waste to meet planning-basis WAC would be 3 LCFs at RFETS and Hanford (Proposed Action, Action Alternative 1, and No Action Alternative 2). Treatment by shred and grout (Action Alternative 3) would have a maximum impact of 6 LCFs at Hanford and RFETS. Thermal treatment (Action Alternatives 2A and 2B and No Action Alternative 1) would have an impact of 480 LCFs at RFETS, 440 LCFs at Hanford, 180 LCFs at LANL, and 28 LCFs at WIPP under Action Alternative 2C.

Maximum impacts to the MEI would result in a 0.6 probability of an LCF at LANL for the thermal treatment of TRU waste (Action Alternatives 2A and 2B and No Action Alternative 1) and a 2×10^{-3} probability of an LCF at LANL (Proposed Action, Action Alternative 1, No Action Alternative 2). Under Action Alternative 3, the maximum radiological impact to the MEI would be a 5×10^{-3} probability of an LCF at LANL. Maximum radiological impacts to the MEI for Action Alternative 2C would be a 1.0 probability of an LCF at WIPP.

Impacts to the maximally exposed noninvolved worker would range from a 0.01 probability of an LCF at INEEL for treatment to meet planning-basis WAC (Proposed Action, Action Alternative 1, and No Action Alternative 2) to a 1.0 probability of an LCF at all sites for thermal treatment (Action Alternatives 2A and 2B and No Action Alternative 1). Thermal treatment at WIPP under Action Alternative 2C would have an impact of a 1.0 probability of an LCF to the maximally exposed noninvolved worker. Treatment by shred and grout (Action Alternative 3) would have a 0.02 probability of an LCF at Hanford, INEEL, and LANL.

The potential radiological impacts from RH-TRU waste treatment accidents are greatest at the ORNL site for all accident scenarios and receptors; however, they are four to five orders of magnitude less than the impacts from CH-TRU waste treatment accidents.

Waste Storage Accidents

High-Frequency/Low-Consequence Accident (Container Drop, Puncture, and Lid Failure)

Maximum radiological impacts to the population from a high-frequency/low-consequence accident (a drum spill) for TRU waste treated to planning-basis WAC would be 5×10^{-4} LCFs at RFETS. (The annual frequency of occurrence of this accident would be 1×10^{-2}.) Maximum impacts due to thermally treated TRU waste and TRU waste treated by shred and grout are estimated to be 3×10^{-5} LCFs at RFETS.

Maximum radiological impacts to the MEI would be highest when storing TRU waste treated to the planning-basis WAC, with a 3×10^{-7} probability of an LCF at ORNL. Maximum impacts to the MEI under shred and grout treatment would be at LANL where an 8×10^{-9} probability of an LCF was estimated. Under thermal treatment, impacts to the MEI at WIPP under Action Alternative 2C are estimated to be a 1×10^{-8} probability of an LCF.

Maximum radiological impacts to a maximally exposed noninvolved worker are estimated to be a 4×10^{-7} probability of an LCF at Hanford when storing TRU waste treated to the planning-basis WAC. Maximum impacts to the maximally exposed noninvolved worker would be the same for waste treated thermally or by a shred and grout process with a 2×10^{-8} probability of an LCF at Hanford and LANL.

Beyond-Design-Basis Accident (Collapse of Building Due to Earthquake)

Maximum population impacts from a beyond-design-basis accident for storage of waste treated to the planning-basis WAC would range from 300 LCFs at RFETS (Action Alternative 1 and No Action Alternative 2) to 6 LCFs at INEEL and ORNL. Maximum impacts to the public under both thermal and shred and grout treatment (Action Alternatives 2A, 2B, and 2C, Action Alternative 3, and No Action Alternative 1) would range from 10 LCFs at RFETS to less than 1 LCF at INEEL.

Maximum impacts to the MEI would range from a 5×10^{-4} probability of an LCF at Hanford and LANL (Action Alternative 1) to a 6×10^{-3} probability of an LCF at WIPP. Maximum impacts to the MEI for Action Alternatives 2A, 2B, and 2C and No Action Alternative 1 are estimated to be a 0.08 probability of an LCF at WIPP. Under Action Alternative 3, the maximum impacts to the MEI are estimated to be a 5×10^{-3} probability of an LCF at Hanford. The impacts to the MEI under the Proposed Action were calculated to be a 0.1 probability of an LCF (Hanford).

Maximum impacts for the maximally exposed noninvolved worker would be the greatest under Action Alternative 1, with one LCF expected at Hanford and SRS. There would be a maximum 0.05 probability of an LCF at INEEL for thermal treatment (Action Alternative 2 and No Action Alternative 1) and a 0.04 probability of an LCF at SRS under shred and grout treatment (Action Alternative 3).

WIPP Disposal Accidents

High-Frequency/Low-Consequence Accident (Container Drop, Puncture, and Lid Failure)

The maximum radiological impact to the population from a high-frequency/low-consequence accident (drum puncture and spill), having an annual occurrence frequency of 0.01, would be

greatest for TRU waste treated to the planning-basis WAC; the impact was estimated as 0.02 LCFs. Should the TRU waste be treated thermally or by a shred and grout process, the impact from this accident was estimated to be 9×10^{-4} LCFs to the population. The radiological impacts to the MEI would be highest when disposing of TRU waste treated to the planning-basis WAC; an impact of 2×10^{-4} probability of an LCF was estimated. Should the waste be treated thermally or by a shred and grout process, the impact is estimated to be a 1×10^{-5} probability of an LCF. The maximally exposed noninvolved worker would have a 2×10^{-4} probability of an LCF and the maximally exposed involved worker would have a 0.06 probability of an LCF for such an accident involving TRU waste treated to the planning-basis WAC. For waste treated by a thermal or shred and grout process, the estimated impact to the maximally exposed worker would be a 1×10^{-5} probability of an LCF from the container-drop accident.

Low-Frequency/High-Consequence Accident (Failure of the Waste Shaft Hoist)

The impacts to the population from a hoist failure while fully loaded with CH-TRU waste (maximum consequence accident), having an annual occurrence frequency of $< 1 \times 10^{-6}$, would be greatest under Action Alternatives 2A, 2B, and 2C and Action Alternative 3, with 29 LCFs. The Proposed Action and Action Alternative 1 would have an impact of 5 LCFs. The radiological impacts to the MEI are estimated to be a 0.6 probability of an LCF under Action Alternative 2 and Action Alternative 3, and a 0.08 probability of an LCF under the Proposed Action and Action Alternative 1. The maximally exposed noninvolved worker would have a 0.5 probability of an LCF under Action Alternative 2 and Action Alternative 3, and a 0.06 probability of an LCF under the Proposed Action and Action Alternative 1. Because the no action alternatives do not propose disposal activities, there would be no risk to the public, MEI, or noninvolved worker for these accidents. For involved workers, the impacts could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris).

Industrial Safety

The accident rate at DOE facilities is less than half the national average for industry, which means that DOE and its contractors experience considerably fewer injuries, illnesses, and fatalities than occur in private industry for similar work. For estimating WIPP impacts from operation and decommissioning, salt excavation activities were considered to be equivalent to construction activities which have a higher injury and illness rate than all other labor categories combined. SEIS-II analyses, therefore, are conservative.

During the 45 years of operation and decommissioning at WIPP under the Proposed Action, two fatalities are projected to occur. The largest number of industrial safety fatalities would occur under Action Alternative 3, which would continue for 200 years (190 years for disposal and 10 years for decommissioning) and dispose of a greater amount of waste; it would result in seven fatalities.

Industrial safety fatalities from treatment under the Proposed Action would be four. The largest number of industrial safety fatalities due to treatment would be nine under Action Alternative 2A.

Long-Term Post-Closure Performance

The performance of the WIPP repository was evaluated for the first 10,000 years following the decommissioning of the WIPP site. The performance assessment for WIPP evaluated the potential release of radioactive substances and the probability that such substances would cause LCFs. The assessment also evaluated the probability of excess cancer incidence from releases of hazardous constituents, expressed as a hazard index. The analyses were conducted using median and 75th percentile parameter values selected from statistical distribution of modeling parameters for both undisturbed and disturbed conditions.

The analyses of undisturbed WIPP repository conditions for a period of 10,000 years following decommissioning indicate similar impacts under the Proposed Action and all of the action alternatives. No movement of brine- or gas-phase TRU waste beyond the 5-kilometers (3.1-mile) subsurface lateral boundary was predicted nor would there be any release to the Culebra Dolomite of the Rustler Formation, the principal water-bearing unit overlying WIPP (Figures S-5, S-6, S-7, and S-8). Thus, long-term undisturbed disposal of TRU waste at WIPP is not expected to contribute any impact to human health as long as the repository is not disturbed after decommissioning.

SEIS-II analyses also considered the impacts should a drilling crew drill into the repository. Impacts to a maximally exposed member of the drilling crew and a well geologist who participate in drilling the exploratory borehole were assessed. The maximum numbers of LCFs resulting from acute exposures of an MEI drilling crew member to CH-TRU and RH-TRU waste in drill cuttings were 4×10^{-4} for the Proposed Action; 4×10^{-4} for Action Alternative 1; 1×10^{-4} for Action Alternative 2; and 3×10^{-4} for Action Alternative 3. LCFs resulting from acute exposure of a well site geologist to CH-TRU and RH-TRU wastes in drilling cuttings were 3×10^{-9} for the Proposed Action; 5×10^{-9} for Action Alternative 1; 1×10^{-8} for Action Alternative 2; and 4×10^{-9} for Action Alternative 3.

The impact of an exploratory borehole that penetrates the WIPP repository and a hypothetical pressurized brine reservoir also was evaluated. Analyses evaluated the potential for pressurized brine to enter the repository and move upward to overlying water-bearing units such as the Culebra Dolomite. Under the most conservative SEIS-II scenarios, the brine pressure would be sufficient to transport waste to the overlying water-bearing units (see Figure S-9). Analysis of impacts of such a release, though, found the impacts to be virtually zero (4×10^{-41} LCF).

At the storage sites under No Action Alternative 1, radionuclides and hazardous metals would be incorporated into a more dense and durable waste form that would limit the release of wastes into the accessible environment. VOCs would be removed in the treatment process and would not be present in emplaced waste. Once waste containers degrade, direct release from a thermally-treated waste form (e.g., metal slag or glass) would be controlled by corrosion and dissolution of metal or glass and natural forces responsible for erosion rather than the leaching process that controls radionuclide and metal contaminant releases from less competent waste forms. The number of aggregate LCFs for all sites over 10,000 years was estimated to be less than 8×10^{-4} LCFs for No Action Alternative 1A and 3×10^{-4} LCFs for No Action Alternative 1B for the Total Inventory. Nevertheless, people who might intrude upon the stored waste could receive radiation doses that would greatly exceed current regulatory limits.

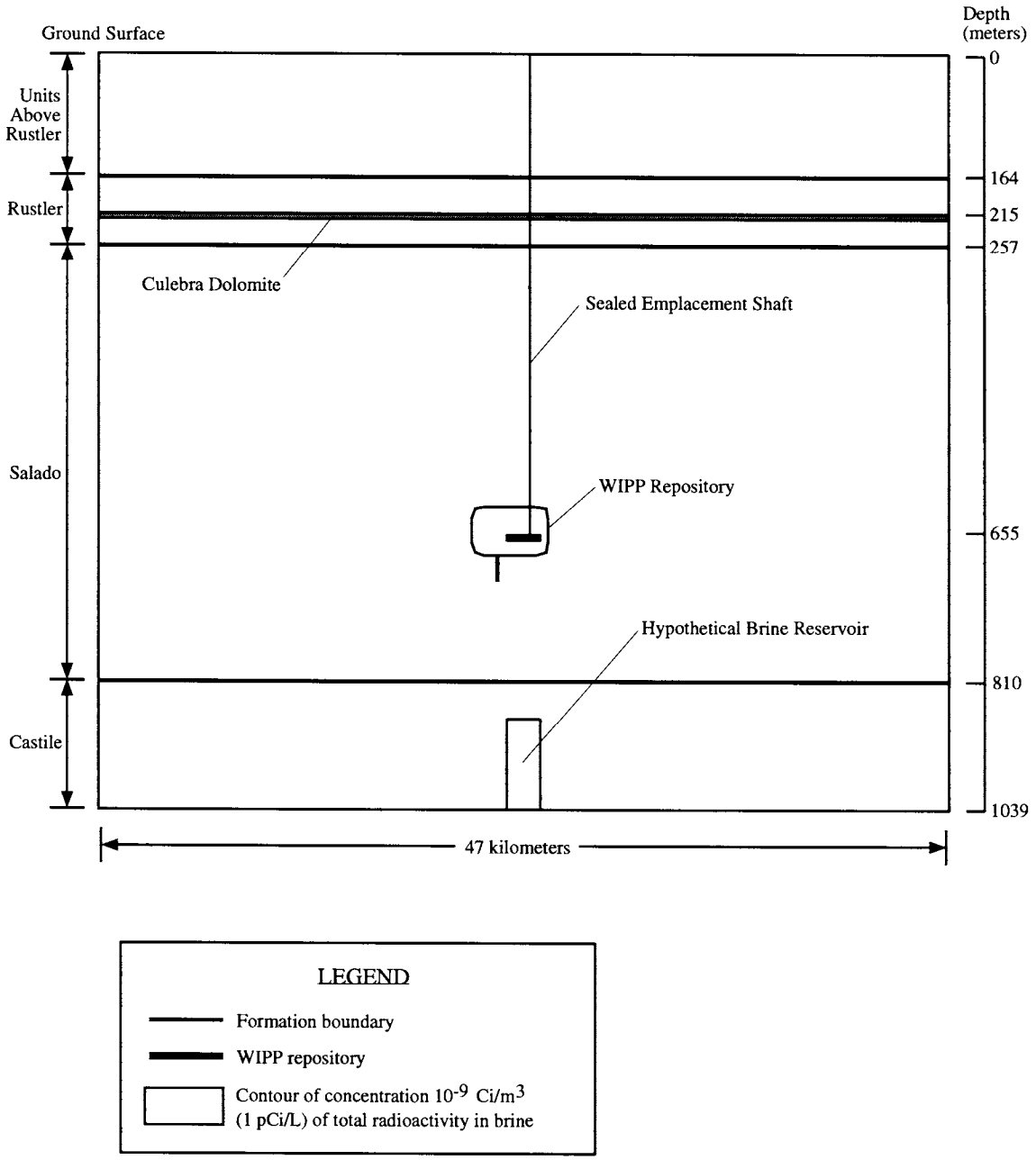


Figure S-5
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) for the Proposed Action

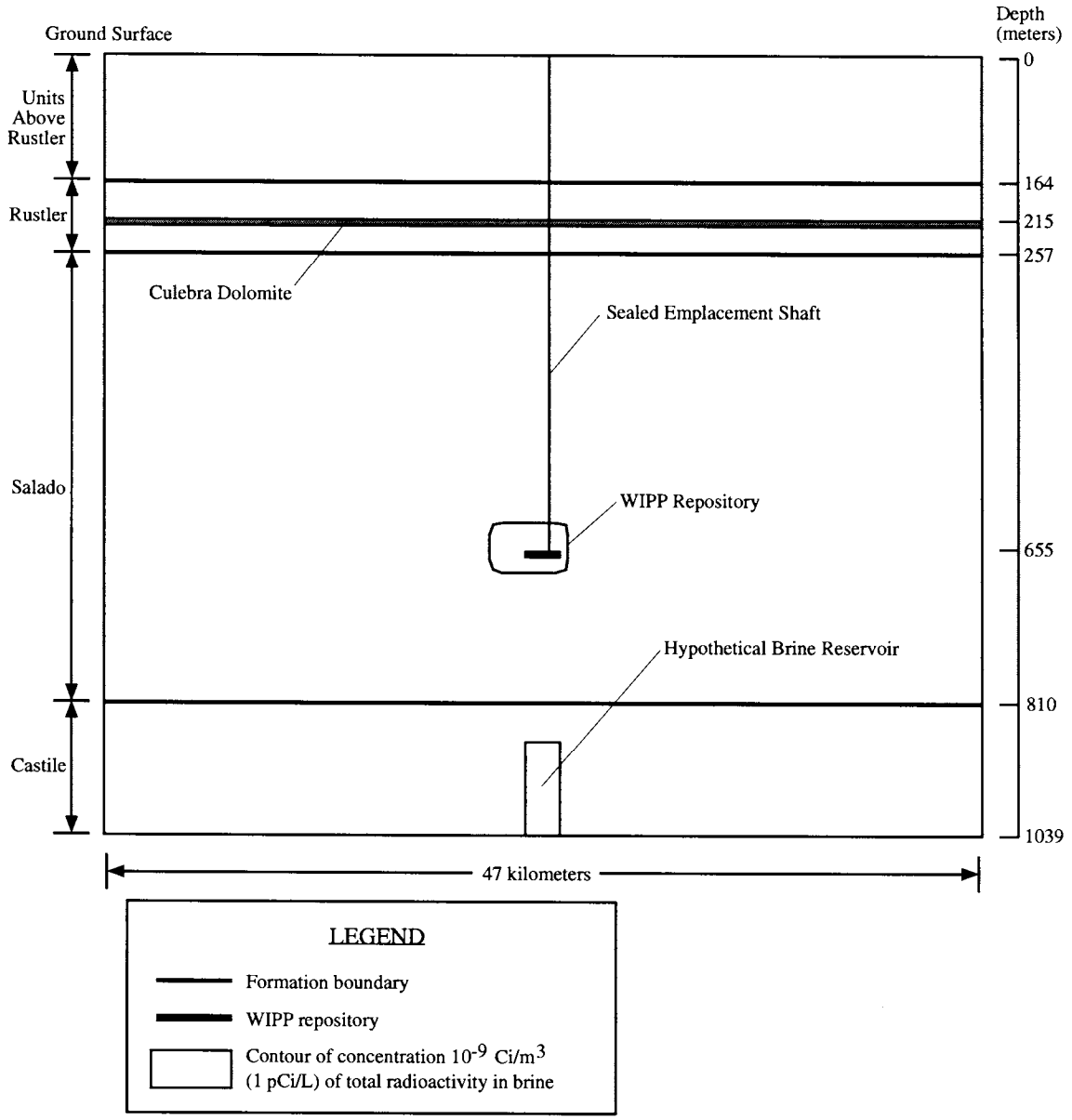


Figure S-6
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) for Action Alternative 1

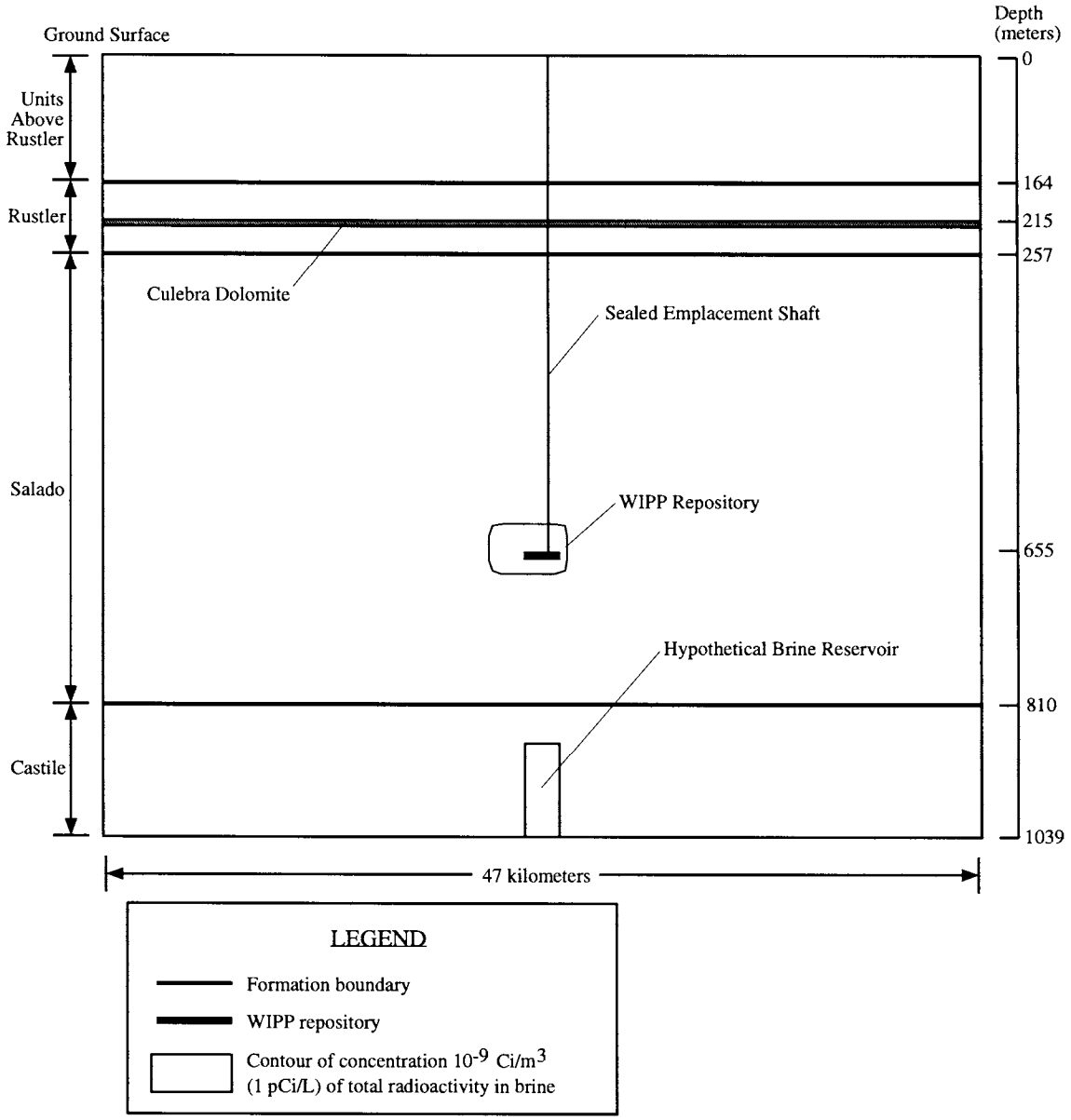


Figure S-7
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) for Action Alternative 2

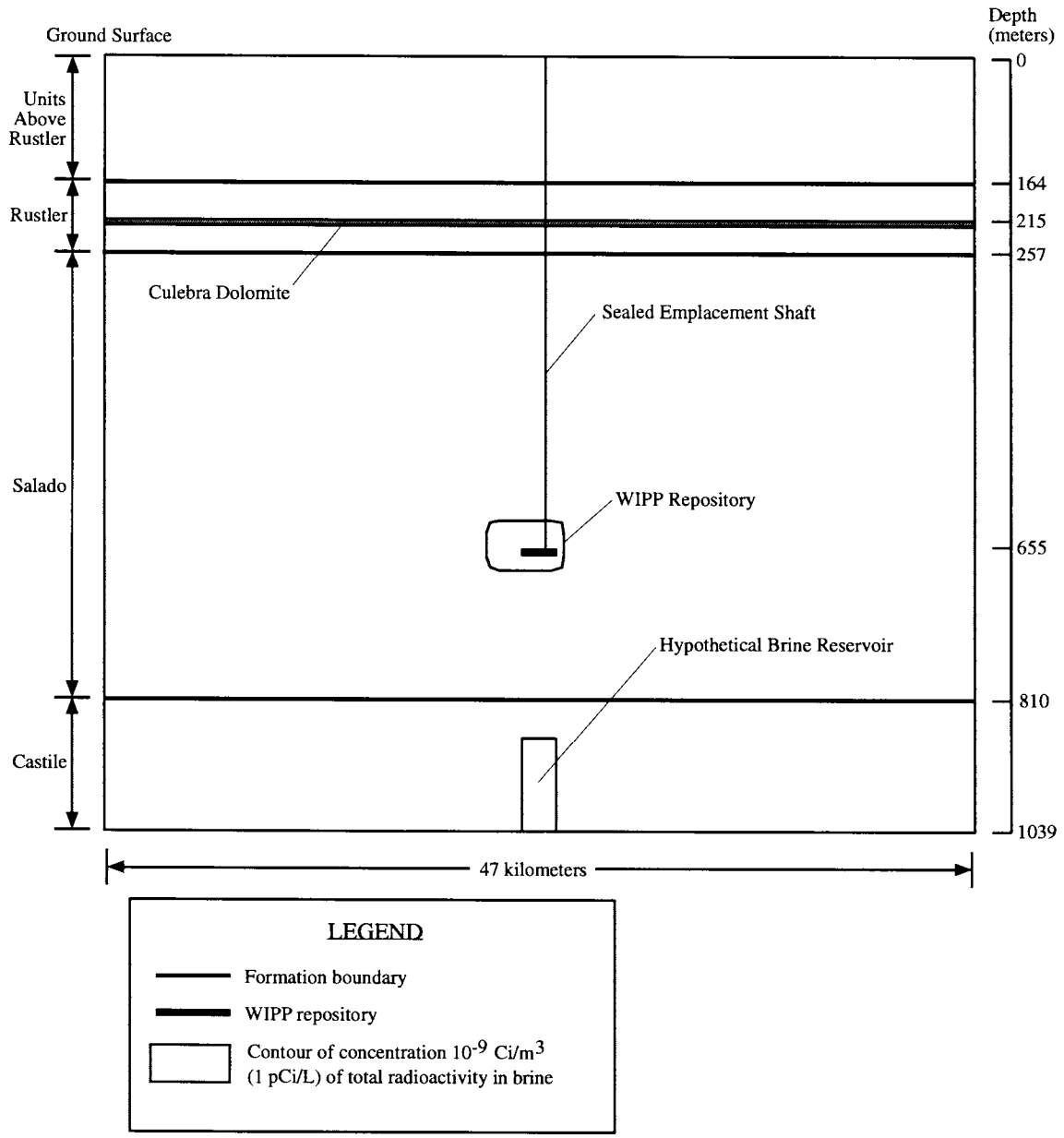


Figure S-8
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 19) for Action Alternative 3

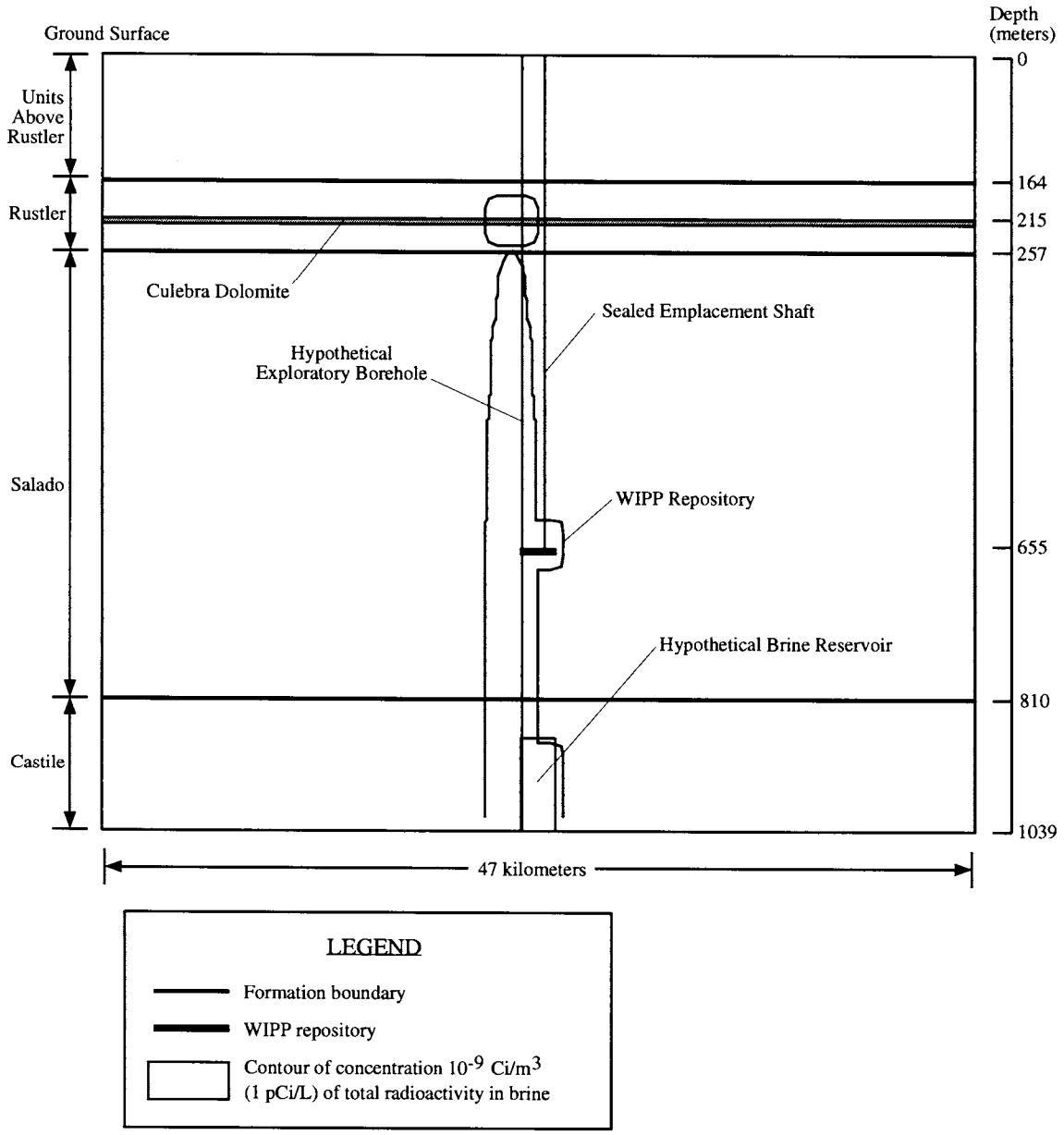


Figure S-9
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) for the Proposed Action

Under No Action Alternative 2, the environmental and human health impacts were estimated at seven of the 10 major generator and storage sites. These sites include Hanford, INEEL, LLNL, LANL, ORNL, RFETS, and SRS. The analysis focused on these seven major sites because 99 percent of the estimated waste volume and inventory will be generated and stored at these sites. Other sites considered but not examined in this analysis included ANL-E, Mound, and NTS.

The human health impacts of TRU waste were estimated for two types of exposures: (1) exposure from inadvertent human intrusion into areas of TRU waste storage and previously buried TRU waste, and (2) exposure from long-term source-term releases to surface and subsurface environmental exposure points. Analysis of intrusion for waste stored under the ground surface considered impacts of directly drilling into the wastes and gardening over the exhumed waste cuttings. Analysis of intrusion for waste stored aboveground considered impacts of an individual scavenging into the wastes and a farm family living over the wastes.

LCFs resulting from acute exposures to CH-TRU and RH-TRU wastes in drill cuttings ranged from 7×10^{-6} to 4×10^{-4} for a hypothetical drilling crew member and 2×10^{-4} to 4×10^{-3} for a hypothetical gardener over the seven sites analyzed. LCFs resulting from acute exposures to CH-TRU and RH-TRU wastes also ranged from 6×10^{-4} to 0.02 for a hypothetical scavenger and 0.2 to 1 for a hypothetical family farmer over the seven sites analyzed.

During any period of the 10,000 years, the estimated lifetime probability of an LCF to an MEI from environmental release of contaminants originating from buried and surface-stored wastes at the seven generator-storage sites ranged from 3×10^{-6} to 4×10^{-3}. The highest LCF was estimated for INEEL.

The estimated lifetime population LCFs from exposure to contaminated air or surface water at each site would range from 4×10^{-5} to 7. The highest impact (at the RFETS) was calculated as nearly 100 times higher than any other site. If waste were released from either loss of institutional control or natural disaster, the aggregate impacts from the seven sites over 10,000 years for release of the combined Basic and Additional Inventories would result in about 800 LCFs.

The maximum lifetime cancer incidence for exposed populations from hazardous chemicals was estimated to be less than 1×10^{-3} over the seven sites. The aggregate lifetime cancer incidence from the seven sites over 10,000 years was estimated at 0.002.

Retrieval and Recovery

For the purposes of SEIS-II, retrieval was defined as removing intact TRU waste containers before closure of WIPP. The calculations were based on retrieval of the waste from one full panel. For SEIS-II, recovery was defined as removal of all of the waste from the repository after closure and after the salt would have reconsolidated, breaching the TRU waste containers.

For the analysis of retrieval impacts, it was assumed that 17,560 cubic meters (620,000 cubic feet) of waste would be removed and transported back to its treatment site. The maximum aggregate LCF in the involved worker population was estimated as 0.03. No noncarcinogenic effects would be expected, and impacts to the public and noninvolved workers would be smaller by at least an order of magnitude. Transportation impacts for returning the waste would be the same as for transporting it to WIPP. The total impacts would be about one-tenth the impacts of the Proposed Action.

For the analysis of recovery impacts, it was estimated that 3,370,000 cubic meters (119 million cubic feet) of waste and contaminated material would have to be removed, packaged, and shipped. Involved workers were assumed to be administratively limited to 1 rem per year. Based on 100 workers and a 35-year work period per worker, the total worker-population dose would be 20,000 person-rem over the entire 200-year recovery period. The total LCFs in the involved worker population would be about 8. The total expectation of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 1×10^{-3}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected. Health impacts to the public and to noninvolved workers would be expected to be three orders of magnitude (1,000 times) larger than the values presented for Alternative 3. For transportation impacts, the maximum radiological impacts have been calculated to occur from nonoccupational exposures resulting in an estimated 15 LCFs. Vehicle-related traffic fatalities have been calculated to increase to 185 due to a proportional increase in waste and transportation miles.

Environmental Justice

DOE is in the process of developing environmental justice guidance, pursuant to Executive Order 12898. This guidance will be finalized after stakeholder comments, concerns, and opinions are received, reviewed, and incorporated, as appropriate.[1] The approach taken in this SEIS-II analysis may depart somewhat from the guidance that is eventually issued or from the approach taken in other documents. Information concerning minority populations for New Mexico as a whole is included in this section in response to public comments.

For purposes of this analysis, a high and adverse human health or environmental impact is a significant deleterious human health or environmental impact. A disproportionate impact to a minority or low-income population is one that substantially exceeds, or is likely to exceed, the same type of impact in the larger community. A disproportionately high and adverse human health or environmental impact would occur when the adverse human health or environmental effects are significant, and the risk or rate to a minority or low-income population from exposure (or multiple exposures) to the environmental or health hazard(s) substantially exceeds, or is likely to exceed, the risk or rate to the general population.

The SEIS-II environmental justice analysis for the vicinity of WIPP addresses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations within an 80-kilometer (50-mile) area of the WIPP site. The shaded areas in Figures 4-11 and 4-12 show the percentage of minority populations and low-income populations, respectively, in census blocks around the WIPP site. Minorities comprise about 36.8 percent of the population in the 80-kilometer (50-mile) area around WIPP, and low-income individuals about 21.5 percent of this population.

Approximately 38 percent of New Mexico's population is Hispanic. Approximately 9 percent of New Mexico's population is Native American.

The populations within an 80-kilometer (50-mile) area of the non-WIPP treatment sites are described in Chapter 4 of SEIS-II. SEIS-II also incorporates by reference the maps of the census tracts containing greater than 50 percent minority and low-income populations within the

[1] The Council on Environmental Quality has also developed draft "Guidance for Addressing Environmental Justice Under the National Environmental Policy Act."

80-kilometer (50-mile) area of treatment sites that are included in Appendix C of the WM PEIS. Of note for environmental justice assessments are LANL and SRS, where minorities constitute greater than 55 percent and 35 percent, respectively, of the total populations within the 80-kilometer (50-mile) area.

For treatment, potentially high and adverse human health effects could occur during normal, accident-free treatment operations at some treatment sites as a result of TRU waste management activities under the three Action Alternative 2 subalternatives. Several areas in the vicinity of WIPP contain a greater percentage of minorities than some other areas within the 80-kilometer (50-mile) area of WIPP and the population of the United States as a whole. It is possible, therefore, that adverse health impacts (estimate of 1 fatality) from routine or accident-free thermal treatment of waste at WIPP under Action Alternative 2C would disproportionately affect the minority populations in the vicinity of WIPP. The prevailing winds at both SRS and LANL would direct treatment releases away from the concentrations of minority and low-income populations that exist around those sites.

At all treatment sites, treatment accidents would be unlikely so that accidents would not be expected to impact off-site populations; also, the impacts from treatment accidents would depend on meteorological conditions at the time of the accident. For these reasons, it is not likely that adverse environmental or human health impacts would disproportionately affect the minority or low-income populations at any of the treatment sites.

Potentially high and adverse impacts as defined above may occur as a result of waste transportation activities. Because all TRU waste would travel through New Mexico, residents of the State could be affected by transportation activities, although impacts would be spread throughout the transportation corridors. Routine truck transportation could cause between 3 (under the Proposed Action) and 15 (under Action Alternative 3) public fatalities over the life of the project from radiation exposure. These impacts are likely to be much lower because of conservative assumptions used in the analysis (e.g., assuming more stops than would actually occur). For the Proposed Action, less than 5 percent of the radiological impacts would be to those living along the highways. The ethnic and income distribution of travelers and workers at rest stops, where the impacts would primarily occur, would vary over time and by location. Thus, potential high and adverse impacts from routine transportation would not be likely to disproportionately affect minority or low-income populations.

Under the action alternatives, there could be from 5 (using truck transportation under the Proposed Action) to 264 fatalities (using dedicated rail under Action Alternative 3) from traumatic injuries sustained in accidents involving transportation vehicles. For truck transportation, accidents not involving a release of radioactivity are most likely to affect those traveling along the same route; for rail transportation, such accidents are most likely to affect those traveling near railroad crossings. Accidents would be random events that could occur on any segment of the transportation routes. Whether such travelers are minority or low-income individuals cannot be predicted. Therefore, any high and adverse impacts from transportation accidents are not likely to disproportionately affect minority or low-income populations.

Severe transportation accidents that breach the transport package could result in up to 16 LCFs (from release of radioactive material) under any of the action alternatives. Accidents involving a release of radioactive material are most likely to affect residents and travelers along the transportation corridors, although the probability that an accident would involve a release of

radioactive material is low (1.5×10^{-5} per accident). As noted above, accidents would be random events that could occur on any segment of the transportation routes. Whether the affected people would be minorities or low-income individuals cannot be predicted. Therefore, any high and adverse impacts from transportation accidents are not likely to disproportionately affect minority or low-income populations.

REDUCING OPERATIONS PERIODS

Stakeholders requested a detailed discussion of the changes in impacts should the Department reduce the operations period for WIPP under Action Alternatives 1, 2, and 3 from 160, 150, and 190 years to 60, 70, and 75 years, respectively. Under Action Alternatives 1 and 3, the operations period could be reduced by constructing an additional WHB for RH-TRU waste, constructing four new shafts, and tripling the number of excavation and emplacement crews; additional costs would total $80 million in capital costs and $165 million in annual operating costs (in 1994 dollars). Under Action Alternative 2, the operational period could be reduced by constructing three new shafts and tripling the number of excavation and emplacement crews; additional costs would total $80 million in capital costs and $165 million in annual operating costs (in 1994 dollars).

No additional economic impacts would be expected at the treatment facilities because the facilities and their periods of operation would be identical to those discussed in SEIS-II for the 160-, 150-, and 190-year scenarios presented in SEIS-II.

The number of years required to ship waste from the treatment facilities to WIPP would also be reduced as the result of the shorter operations period: from 160 to 53 years under Action Alternative 1, from 150 to 58 years under Action Alternative 2, and from 190 to 63 years under Action Alternative 3. The aggregate nonradiological impacts would remain the same, except that they would occur within the shorter time period. The accident-free radiological impacts to occupational and nonoccupational populations were reported as cumulative impacts over the entire shipping campaign; therefore, no increase in impacts would be noted. However, because the MEIs would be exposed to more shipments, the estimated exposure to MEIs would triple. All accident impacts would be identical to those described earlier.

The size of the WIPP underground facility would remain the same; therefore, the land use, biological resource, and cultural resource impacts would be similar to those cited in SEIS-II. Construction of the new building under Action Alternatives 1 and 3 would increase the air quality impacts slightly for the period of construction; however, other air quality impacts would be negligible. Noise impacts would triple as a result of the increased rate of shipments through Carlsbad. Water quality and infrastructure impacts may occur as a result of the new facilities and additional work crews.

Human health impacts associated with lag storage would decrease. The impacts to the public, noninvolved workers, and involved workers at WIPP over the entire operations period would remain the same but would be compressed into one-third of the time. Impacts to the MEI at WIPP would triple because the waste that would be emplaced during a lifetime would triple. Industrial safety impacts would increase by 10 percent because of the increase in the number of workers. There would be no change in long-term performance assessment results.

The greatest change under Action Alternatives 1, 2, and 3 would be in life-cycle costs. Overall, life-cycle costs would decrease by approximately $12 billion to $15 billion in 1994 dollars as a result of reduced operations periods for these alternatives.

For disposal at WIPP, normal accident-free operations would not cause significant adverse human health or environmental impacts, and thus there would be no such impacts that could disproportionately affect minority or low-income populations. For disposal accidents, the most severe accident (the waste hoist failure) could cause up to 4 public fatalities for the Proposed Action and up to 24 fatalities for Action Alternative 3. However, the annual probability of this accident is 4.5×10^{-7}. Therefore, although possible, disproportionately high and adverse effects on minority or low-income populations would not be expected.

SUMMARY OF IMPACTS

Over the life of the campaign, routine operations under the Proposed Action could result in five estimated worker fatalities at waste treatment sites and three worker fatalities at WIPP. Truck transportation under the Proposed Action could result in an estimated additional eight deaths among members of the public and crew. Although highly unlikely, the most severe accident, a severe truck accident with a maximum radionuclide inventory having a frequency of less than 7.5×10^{-7} per accident, could result in an additional 16 deaths. The waste disposed of at WIPP under the Proposed Action would be isolated from the environment for more than 10,000 years unless an intrusion by drilling occurred. If an intrusion occurred, radionuclides could reach the Culebra Dolomite, but impacts would be negligible (4×10^{-41} LCFs) because physical properties of the Culebra Dolomite restrict movement of contamination toward a receptor during 10,000 years. Health impacts due to any released waste at the storage sites could vary depending on the population density in the vicinity at the time the waste was released. The Proposed Action would be the least expensive of the action alternatives ($19.03 billion in 1994 dollars, $10.13 billion when the costs are discounted).

Action Alternative 1 could result in an estimated six worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 1 could result in an estimated additional 29 deaths (28 among members of the public). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. The waste disposed of at WIPP under Action Alternative 1 would be isolated from the environment for more than 10,000 years, and Action Alternative 1 would effectively isolate all DOE TRU waste generated and expected to be generated over 35 years (except for a small quantity of PCB-commingled waste) unless an intrusion by drilling occurred. If an intrusion occurred, radionuclides could reach the Culebra Dolomite, but impacts would be negligible (2×10^{-27} LCFs). Action Alternative 1 costs would be $50.95 billion in 1994 dollars ($16.32 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 2 could result in an estimated seven to twelve worker fatalities at the waste treatment sites and one to two fatalities to the populations in the vicinity of the treatment sites (with subalternatives 2A and 2B having higher impacts than subalternative 2C). An estimated six worker fatalities would result from disposal operations at WIPP under all subalternatives. Truck transportation under Action Alternative 2 could result in an estimated additional 17 to 20 deaths (16 to 19 among members of the public). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 480 deaths. The waste disposed of at WIPP under Action Alternative 2 would be isolated from the environment for more than 10,000 years, and Action Alternative 2 would effectively isolate all DOE TRU waste generated and

expected to be generated over 35 years unless an intrusion by drilling occurred. If an intrusion occurred, radionuclides could reach the Culebra Dolomite, but impacts would be negligible (7×10^{-28} LCFs). Action Alternative 2 costs would range from $54.01 billion to $57.18 billion ($19.56 billion to $21.19 billion when discounted), depending on the subalternative and assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 3 could result in an estimated seven worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 3 could result in an estimated additional 39 deaths (38 among members of the public). The most severe accident under this alternative would be the failure of the WIPP waste hoist (with an annual frequency of 4.5×10^{-7} or less) and could result in an additional 29 deaths. The waste disposed of at WIPP under Action Alternative 3 would be isolated from the environment for more than 10,000 years, and Action Alternative 3 would effectively isolate all DOE TRU waste generated and expected to be generated over 35 years (except for a small quantity of PCB-commingled waste) unless an intrusion by drilling occurred. If an intrusion occurred, radionuclides could reach the Culebra Dolomite, but impacts would be negligible (2×10^{-27} LCFs). Action Alternative 3 costs would be $59.67 billion ($18.03 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 1 could result in an estimated 10 to 11 worker fatalities at the waste treatment sites and 2 fatalities to the populations in the vicinity of the treatment sites (depending on the subalternative). No worker deaths would be estimated to result from closure activities at WIPP. Truck transportation under No Action Alternative 1 could result in an estimated zero deaths to workers and one death to members of the public. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 480 deaths. No Action Alternative 1 would restrict access for 100 years to all DOE TRU waste generated and expected to be generated over 35 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, the thermally treated waste form would restrict migration of the waste initially, but the waste would eventually become more mobile as the vitrified waste form eroded. If the waste were released, deaths to the public over 10,000 years would depend in part on population densities and distributions, but no deaths would be expected based on current densities and distributions under No Action Alternative 1. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 1 costs would range from $30.28 to $32.85 billion ($17.09 to $18.52 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 2 could result in an estimated two worker fatalities at the waste storage sites and no worker deaths from closure activities at the WIPP site. No transportation is assumed under No Action Alternative 2, and no deaths would result. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. No Action Alternative 2 would restrict access to the currently stored and newly generated portion of DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, estimated deaths would total

800 for the Total Inventory over 10,000 years given current population densities and distributions. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 2 costs would be $2.49 billion ($1.68 billion when discounted).

Table S-7 summarizes the results of SEIS-II analyses.

CHANGES DUE TO OTHER TRU WASTE VOLUME ESTIMATES

Since the completion of the analyses in the Draft SEIS-II, DOE has continued to update the estimates of stored and to-be-generated TRU waste volumes at the various generator sites. In particular, T*he National Transuranic Waste Management Plan* includes updated estimates of the stored and projected volumes of TRU waste at the generator sites. SEIS-II analyses are based on the TRU waste volumes published in BIR-3, although the updated *National Transuranic Waste Management Plan* estimates and associated impacts are also presented in SEIS-II (see Apendix J).

Overall, *The National Transuranic Waste Management Plan* has 5,662 cubic meters (199,951 cubic feet) more CH-TRU waste than the SEIS-II Basic Inventory (before adjustment to the 168,500 cubic meters [5,950,000 cubic feet] allowed by the LWA). This is an increase of 4 percent. *The National Transuranic Waste Management Plan* reports more than 30,000 cubic meters (1,059,000 cubic feet) less of RH-TRU waste than the SEIS-II Basic Inventory. This is a decrease of 86 percent.

The SEIS-II Proposed Action (the Preferred Alternative) presents impacts adjusted to the treatment and disposal of 168,500 cubic meters (5,950,000 cubic feet) of CH-TRU waste (the maximum allowed under the Land Withdrawal Act) and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste (the maximum allowed under the C & C Agreement with the State of New Mexico). Using T*he National Transuranic Waste Management Plan* in the same manner, no change would occur in the impacts for the Proposed Action except for the elimination of impacts related to storage of excess RH-TRU waste. (No excess RH-TRU waste would be left at ORNL and Hanford.)

For the generator-storage sites with significant changes in waste volumes, individual site impacts could vary to a greater extent than indicated by the differences in the total volumes noted above. Under Action Alternatives 1, 2, and 3 and for the individual sites, the following changes would be expected:

- Negligible changes to the impacts would be anticipated in areas of land use and management, biological resources, cultural resources, noise, water resources and infrastructure, long-term performance, or consequences of lag storage accidents. No change would be expected in consequences from treatment accidents or WIPP disposal accidents.

- Changes in the estimated impacts for human health, life-cycle costs (except transportation costs), air quality, industrial safety, and economics would be directly related to changes in CH-TRU and RH-TRU waste volumes. Site impacts would change, as presented in the "percent difference" columns of Table J-1 for CH-TRU waste and Table J-2 for RH-TRU waste. Unlike most other impact areas, CH-TRU waste is a much higher contributor to impacts for involved workers than is RH-TRU waste; therefore, large decreases in RH-TRU waste volumes would have little impact for involved workers. However, at

Table S-7
Summary of SEIS-II Environmental Impacts

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Land Use and Management									
Treatment Facility Sites	No substantial impacts identified beyond the treatment facilities. Treatment facilities would require no more than 11 hectares, less than 1% of land available at each site for each alternative. Treatment facilities, therefore, could be located in developed areas or areas appropriate for development. Sensitive areas, including wetlands, flood plains, sensitive habitats, and cultural resource areas would be avoided.								No substantial impacts. Only newly generated waste would be treated.
WIPP (during operations)	DOE would occupy the land transferred by the LWA and lease some other land. WIPP would continue to limit drilling and mining activities, and grazing and public access to the site and may acquire oil and gas leases. No other impacts would occur to local land use beyond the site.						Impacts would be minimal because no waste would be emplaced.		
WIPP (area impacted by closure)	70 hectares	360 hectares	395 hectares	395 hectares	395 hectares	375 hectares	20 hectares	20 hectares	20 hectares
Air Quality									
Treatment Facility Sites (As a percentage of the most stringent applicable regulatory standard. Emissions for sites and pollutants not specifically noted would be less than 10% of the most stringent applicable regulatory standard).	RFETS, CO, 17%.		LANL, radionuclides, 134%. RFETS, CO, 24%. INEEL, PM_{10} 10%.	INEEL, radionuclides, 10%. INEEL, PM_{10}, 10%.	WIPP, radionuclides, 137%. WIPP, SO_2, 12%. WIPP, PM_{10}, 25%.	RFETS, CO, 20%.	LANL, radionuclides, 134%. RFETS, CO, 24%, INEEL, PM_{10}, 10%.	INEEL, radionuclides, 10%. SRS, radionuclides, 48%. INEEL, PM_{10}, 10%.	RFETS, CO, 17%.
WIPP Operations (percent of applicable EPA or state standard)	Annual average: negligible increases of O_3 and lead; less than 2% increases in PM_{10}, NO_2, and SO_2. Short-term (24-hour) emission limits: PM_{10} - 57%, NO_2 - 65%, SO_2 - 7%, CO - 3% of standards, releases of lead and ozone would be minimal.						WIPP would not be operated. WIPP would be dismantled.		
Biological Resources									
Treatment Facility Sites	Threatened and endangered species appear at many of the proposed treatment sites and could potentially be impacted. Such species and their critical habitats would be avoided through appropriate consultation, site selection, monitoring, and mitigation measures. Because the treatment sites would require less than 1% of the land available at any site, critical habitats could be avoided at most sites.								No impacts because only minimal treatment would occur.
WIPP (disturbed land area)	Federally- or state-listed or protected, threatened, endangered, and proposed species occur in Eddy County and potentially at the WIPP site, although there have been no threatened, endangered, or proposed species or critical habitats recently observed at the WIPP site by DOE during completion of its recent biennial environmental compliance reports. DOE recently conducted biological surveys at the WIPP site and identified no endangered or threatened species. No impacts to biodiversity or ecosystem balance would be expected. Impacts to other plant and animal species may occur during closure and construction of a berm around the WIPP site. The affected area would differ based on the areas listed above under land use.						Minimal impacts during closure of current facility.		

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Cultural Resources									
Treatment Facility Sites	Although cultural resources are present at many sites, specific treatment facility locations are unknown. Acreage need at any one site is 11 hectares or less. Potential impacts will be avoided or mitigated based on site-specific cultural resource surveys.								No impacts. Treatment would be minimal.
WIPP Resource Sites Potentially Impacted (during operations)	None.						No impacts. WIPP would not be operated.		
WIPP Resource Sites Potentially Impacted (during closure)	Two. Potential impacts would be avoided or mitigated in accordance with the Joint Powers Agreement.	Eleven due to larger surface closure area. Potential impacts would be avoided or mitigated in accordance with the Joint Powers Agreement.					No impacts for the no action alternatives. Closure would only involve the 20 acres on which current facilities have been built.		
Noise									
Treatment Sites	Negligible increase in noise due to waste transportation or treatment facility operation because treatment facilities would probably be placed at industrial-type sites along high-traffic volume corridors. Project-specific impacts to sensitive receptors could occur. Assessment of potential impacts would be conducted in site-wide or project-specific NEPA documentation.								No impacts because transportation would not occur and treatment would be minimal.
WIPP	Negligible increase in noise due to additional daily truck or train traffic. Only 8 trucks per day would travel to WIPP if trucks are used; only 13 to 16 rail cars per week if trains are used.						Not applicable to the no action alternatives. No transportation to WIPP would occur and WIPP would not be operated.		
Water Resources and Infrastructure									
Treatment Sites 1. Water 2. Power 3. Wastewater 4. On-site Transportation	3. Hanford - 5.9% 4. Hanford, INEEL, and LANL - minor impacts	2. INEEL - 6.6% 3. Hanford - 7.8% 4. Hanford, INEEL, and LANL – minor impacts	2. INEEL – 6.6% 3. Hanford - 7.8% 4. Hanford, and INEEL - minor impacts	2. INEEL – 6.6%; WIPP - 50% 3. WIPP - 80% 4. WIPP - 162%; Hanford - minor impacts	2. INEEL - 6.4% 3. Hanford - 7% 4. Hanford, INEEL, and LANL - minor impacts		2. INEEL – 6.6% 3. Hanford - 7.8% 4. Hanford, INEEL, and LANL - minor impacts	2. INEEL – 6.6% 3. Hanford - 7.8% 4. Hanford, and INEEL – minor impacts	No impacts.
Disposal Operations at WIPP	Annual incremental infrastructure impacts at WIPP would be negligible and within capacity for disposal operations.						Decreasing use of resources, none after decommissioning of WIPP.		

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Socioeconomics									
Treatment/Storage Sites									
Life-Cycle Costs (millions of 1994 dollars)	12,140	21,390	27,690	30,550	28,700	24,340	29,360	31,760	1,640
Annual Employment (supported jobs)	11,900	22,500	28,000	28,500	7,200	24,900	29,300	29,800	2,300
Disposal Operations at WIPP									
Life-Cycle Costs (millions of 1994 dollars)	5,300	24,650	23,330	23,330	23,330	28,490	850	850	850
Annual Goods & Services (millions of 1994 dollars)	317	317	317	317	616	317	-317	-317	-317
Annual Employment (supported jobs)	3,538	3,538	3,538	3,538	6,876	3,538	-3,538	-3,538	-3,538
Annual Labor Income (millions of 1994 dollars)	126	126	126	126	245	126	-126	-126	-126
Total Life-Cycle Cost by Mode of Transportation (millions of 1994 dollars); discounted totals using a 4.1 percent annual inflation rate are presented in parentheses									
Total Life-Cycle Costs--Truck	19,030 (10,130)	50,950 (16,320)	54,010 (19,560)	57,180 (21,190)	54,940 (20,100)	59,670 (18,030)	30,280 (17,090)	32,850 (18,520)	No shipments of TRU waste would occur under this alternative. Total life-cycle cost without transportation is 2,490 (1,680).
Total Life-Cycle Costs--Regular Rail	No rail transportation analyzed under Propsed Action; rail transportation reserved under Preferred Alternative.	47,680 (15,800)	52,030 (19,220)	55,020 (20,830)	52,940 (19,760)	55,170 (17,420)	30,240 (17,070)	32,770 (18,470)	
Total Life-Cycle Costs--Dedicated Rail		57,360 (17,330)	57,880 (20,210)	61,360 (21,900)	58,570 (20,720)	68,520 (19,210)	30,460 (17,190)	33,790 (19,040)	
Transportation									
Truck									
Number of Truck Shipments to Consolidation Sites and WIPP	CH - 29,793 RH - 8,915	CH - 41,056 RH - 66,012	CH - 43,313 RH - 30,149	CH - 51,240 RH - 30,149	CH - 41,151 RH - 30,149	CH - 67,844 RH - 82,860	CH - 538 RH - 8,254	CH - 8,466 RH - 8,254	No shipments of TRU waste would occur under this alternative.
Nonradiological Truck Impacts									
Truck Accidents	56	171	109	123	105	239	5	13	
Truck Injuries	39	119	76	86	74	165	4	12	
Truck Fatalities	5	16	10	11	11	22	0.3	1	
Truck Pollution Fatalities	0.1	0.5	0.4	0.5	0.4	0.7	0.03	0.07	

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Radiological Truck Impacts									No shipments of TRU waste would occur under this alternative.
Accident-Free Population Impacts to Crews (LCFs)	0.3	0.7	0.5	0.7	0.5	1.0	0.02	0.07	
Accident-Free Population Impacts to the Public (LCFs)	3.0	11	6	7	6	15	0.4	0.9	
Highest Lifetime Accident-Free Impact to MEIs (probability of an LCF)	8.5E-3	8.6E-3	4.6E-3	4.9E-3	4.5E-3	9.9E-3	Not Analyzed.	Not Analyzed.	
Rail									
Nonradiological Rail Impacts	Transportation by rail not anaylzed under the Proposed Action; rail transportation is reserved under the Preferred Alternative.								
Fatalities Using Regular Rail Service		8	5	6	6	11	0.2	0.5	
Fatalities Using Dedicated Rail Service		112	70	84	84	154	2.8	7	
Radiological Rail Impacts									
Accident-Free Population Impacts to Crews (Regular and Dedicated) (LCFs)		0.03	0.03	0.03	0.03	0.05	8.6E-4	3.7E-3	
Accident-Free Population Impacts to the Public (Regular and Dedicated) (LCFs)		1.5	0.9	1	0.9	2.0	0.07	0.1	
Accidents									
Transportation Accidents (Truck)									
Population Impacts with Conservative Inventory (LCFs)	CH - 16 RH - 16	CH - 16 RH - 16	CH - <1 RH - <1	CH - <1 RH - <1	CH - 16 RH - <1	CH - 16 RH - 16	CH - 16 RH - 16	CH - 16 RH - 16	
Population Impacts with Average Inventory (LCFs)	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - <1 RH - <1	CH - <1 RH - <1	CH - 3 RH - <1	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - 3 RH - 0.04	
MEI Impact with Conservative Inventory (probability of an LCF)	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH – 3E-4 RH - 3E-4	CH – 3E-4 RH – 3E-4	CH – 0.06 RH – 3E-4	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	
MEI Impact with Average Inventory (probability of an LCF)	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 2E-4 RH - 4E-6	CH - 2E-4 RH - 4E-6	CH – 0.04 RH – 4E-6	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	
Aggregate Potential Truck Accident Impacts to Populations Along All Transportation Routes (LCFs)	0.4	0.8	0.7	0.7	0.7	1.2	6.8E-3	0.02	

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Transportation Accidents (Rail)									No shipments of TRU waste would occur under this alternative.
Population Impacts with Conservative Inventory (LCFs)	No rail transportation is proposed under the Proposed Action; rail transportation is reserved under the Preferred Alternative.	CH - 32 RH - 32	CH - <1 RH - <1	CH - <1 RH - <1	CH - 32 RH - <1	CH - 32 RH - 32	CH - 32 RH - 32	CH - 32 RH - 32	
Population Impacts with Average Inventory (LCFs)		CH - 6 RH - 0.08	CH - <1 RH - <1	CH - <1 RH - <1	CH - 6 RH - <1	CH - 6 RH - 0.08	CH - 6 RH - 0.08	CH - 6 RH - 0.08	
MEI Impact with Conservative Inventory (probability of an LCF)		CH - 0.12 RH - 0.12	CH - 3E-4 RH - 3E-4	CH - 3E-4 RH - 3E-4	CH - 0.12 RH - 3E-4	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	
MEI Impact with Average Inventory (probability of an LCF)		CH - 0.08 RH - 1E-4	CH - 2E-4 RH - 4E-6	CH - 2E-4 RH - 4E-6	CH - 0.08 RH - 4E-6	CH - 0.08 RH - 1E-4	CH - 0.08 RH - 1E-4	CH - 0.08 RH - 1E-4	
Aggregate Potential Rail Accident Impacts (LCFs) to Populations Along All Rail Routes		0.8	0.7	0.7	0.7	1.2	6.8E-3	0.02	
Human Health									
Routine Radiological Impacts (LCFs) [a]									
Treatment									
Involved Worker Population	0.8	1.5	1.7	1.3	0.6	1.5	1.7	1.3	0.4
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	7E-6 3E-9	8E-6 8E-9	0.1 5E-5	0.1 2E-4	0.06 2E-4	7E-4 2E-7	0.1 5E-5	0.1 2E-4	8E-5 4E-8
Public Population MEI	2E-4 9E-9	2E-4 1E-9	2.4 3E-5	2.3 5E-5	0.9 2E-4	4E-3 4E-7	2.4 3E-5	2.3 5E-5	1E-3 8E-8
***WIPP Operations* [b] (LCFs) [a]**							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	≤1	≤1	<0.4	<0.4	<0.4	0.3	≤1.1	≤1.1	≤3
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	4E-4 4E-7	5E-4 4E-7	2E-4 2E-7	2E-4 2E-7	2E-4 2E-7	5E-4 3E-7	0.06 1E-6	0.06 1E-6	0.1 4E-5
Public Population MEI	3E-4 3E-7	4E-4 5E-7	5E-5 1E-7	5E-5 1E-7	5E-5 1E-7	3E-4 3E-7	3E-3 2E-7	2E-3 2E-9	0.03 2E-6
Lag Storage[c] Public Population Impacts Lag Storage Noninvolved Worker Population	No lag storage for the Proposed Action.	1E-2 0.05	1E-3 2E-2	8E-4 2E-2	3E-4 1E-3	3E-3 0.07	No lag storage for the no action alternatives.		
Excess RH-TRU Waste Storage Public Population Impacts[d] Excess RH-TRU Waste Storage Noninvolved Worker Population[d]	2E-5 4E-5	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Routine Hazardous Chemical Impacts (Cancer Incidence)									
Treatment at Treatment Sites									
Involved Worker Population	2E-5	3E-5	6E-5	9E-5	8E-5	4E-5	6E-5	9E-5	8E-6
Noninvolved Worker Population	1E-7	2E-7	1E-7	1E-7	1E-7	2E-7	1E-7	1E-7	1E-7
Maximum Exposed Noninvolved Worker	1E-10	2E-10	1E-10	1E-10	1E-10	1E-10	1E-10	1E-10	1E-10
Public Population	4E-7	6E-7	3E-7	3E-7	3E-7	4E-7	3E-7	3E-7	4E-7
Maximum Exposed Individual	2E-11	3E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11
WIPP Operations [a]							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	0.01	0.04	No impacts because the TRU waste would be thermally treated.			≤0.01	None because TRU waste would be thermally treated.		≤0.1
Noninvolved Worker Population	1E-4	1E-4				9E-5			6E-3
Maximum Exposed Noninvolved Worker	1E-7	9E-8				5E-8			2E-7
Public Population	2E-5	3E-5				2E-5			6E-3
Maximum Exposed Individual	3E-8	2E-8				1E-8			4E-8
Lag Storage[c] Public Population	No lag storage for the Proposed Action.	5E-3				4E-3	None because there is no lag storage for the no action alternatives.		
Lag Storage Noninvolved Worker Population		0.01				0.02			
Excess RH-TRU Waste Storage Public Population Impacts[d]	3E-4	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							
Excess RH-TRU Waste Storage Noninvolved Worker Population[d]	6E-4								
Selected Facility Accidents [a]									
Treatment Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	0.01	0.01	1	1	1	0.02	1	1	0.01
Maximally Exposed Individual	2E-3	2E-3	1	1	1	5E-3	1	1	2E-3
Public Population	3	3	480	480	28	6	480	480	3
Storage Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	3E-3	1.0	0.05	0.05	0.1	0.04	0.02	0.02	0.7
Maximally Exposed Individual	5E-4	0.1	5E-3	5E-3	0.08	5E-3	0.08	0.08	0.1
Public Population	0.9	300	10	9	2	10	10	10	300
WIPP Disposal (Hoist Failure, frequency of 4.5E-7) LCFs									
Maximally Exposed Noninvolved Worker	0.06	0.06	0.5	0.5	0.5	0.5	No impacts because disposal does not occur under the no action alternatives.		
Maximally Exposed Individual	0.08	0.08	0.6	0.6	0.6	0.6			
Public Population	5	5	29	29	29	29			

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Industrial Safety									
Waste Treatment (fatalities)	4	4	9	7	6	5	9	7	0.7
Construction and Operations (fatalities)	2	6	6	6	6	7	0.8	0.8	0.6
Performance Assessment of Treatment Sites and WIPP									
Treatment Sites - Human Intrusion [e]									
Radiological Impacts (probability of an LCF)									
Driller	4E-4 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the action alternatives, and TRU waste is managed indefinitely under No Action Alternatives 1A and 1B.							1E-6 to 3E-5
Gardener	3E-3 [f]								4E-3 to 0.06
Scavenger	0.01 [f]								6E-4 to 0.02
Family Farm	1 [f]								0.2 to 1
Treatment Sites - Environmental Release									
Radiological Impacts (probability of an LCF)									
MEI (probability of an LCF)	5E-5 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives. For No Action Alternatives 1A and 1B, it was assumed the waste would be managed indefinitely.							3E-6 to 4E-3
Population (LCFs)	3E-4 [f]								4E-5 to 7
Aggregate Population Impacts over 10,000 years	4E-3 [f]	Does not apply to these alternatives because there is no waste at the treatment sites.					8E-4	3E-4	807
Hazardous Chemical Impacts (Cancer Incidence)									
MEI	9E-7 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the action alternatives, and TRU waste is managed indefinitely under No Action Alternative 1.							1E-7 to 5E-3
Population	5E-6 [f]								5E-7 to 3E-4
WIPP - Human Intrusion (based on the intrusion in the repository scenario)									
Maximum Radiological Impacts Drilling Crew Member (probability of an LCF; dashes indicate no analyses were performed because scenarios are inapplicable)									
CH-TRU Waste Panel	---	4E-4	1E-4	1E-4	1E-4	3E-4	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	---	1E-5	2E-6	2E-6	2E-6	1E-5			
Mixed CH-TRU and RH-TRU Panel	4E-4	4E-4	---	---	---	3E-4			
Maximum Radiological Impacts Site Geologist (probability of an LCF)									
CH-TRU Waste Panel	3E-9	3E-9	7E-9	7E-9	7E-9	2E-9	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	3E-9	5E-9	1E-8	1E-8	1E-8	4E-9			
Environmental Justice									
Treatment sites and WIPP	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.				Impacts are possible at WIPP during treatment.	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.			

Table S-7
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
TRU Waste Retrieval (of one panel of waste before repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	4E-5	4E-5	4E-5	4E-5	4E-5	4E-5			
Public Population	3E-5	3E-5	3E-5	3E-5	3E-5	3E-5			
Transportation									
Accident-Free Population Impacts to Crews (LCFs)	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Accident-Free Population Impacts to the Public (LCFs)	0.3	0.3	0.3	0.3	0.3	0.3			
Traffic-Related Fatalities	0.5	0.5	0.5	0.5	0.5	0.5			
TRU Waste Recovery (of all waste after repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	8	8	8	8	8	8	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	0.3	0.3	0.3	0.3	0.3	0.3			
Public Population	0.2	0.2	0.2	0.2	0.2	0.2			
Transportation									
Accident-Free Population Impacts to Crews (LCFs)	1	1	1	1	1	1	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Accident-Free Population Impacts to the Public (LCFs)	15	15	15	15	15	15			
Vehicle Emission Effects Fatalities	7	7	7	7	7	7			
Traffic-Related Fatalities	185	185	185	185	185	185			

[a] The probability of an LCF occurring to the MEI or maximum exposed noninvolved worker, and the number of LCFs to the populations.
[b] Under the no action alternatives, this category represents impacts from storage.
[c] Lag storage is storage pending shipment to WIPP. Lag storage does not include long-term storage of waste (such as any excess RH-TRU waste under the Proposed Action) that will not be shipped to WIPP.
[d] Recent estimates in the *National Transuranic Waste Management Plan* indicate there would be no excess RH TRU waste; see Appendix J and information later in this summary.
[e] People who might intrude upon the stored waste could receive radiation doses that would greatly exceed current regulatory limits.
[f] Impacts from any excess RH-TRU waste. Scaled from No Action Alternative 2.

Note: For details on impacts due to the Additional Inventory (for the Proposed Action) see the text box "The Additional Inventory and the Proposed Action" in this summary. For information on how impacts would change should WIPP's operations period be reduced to 175 years or less, see the text box "Reducing Operations Periods" in this summary.

WIPP, large decreases in the amount of RH-TRU waste volumes would reduce the operations time needed for excavation and emplacement, reducing industrial safety and economics impacts.

- Changes in transportation impacts, including costs, are directly related to the number of shipments, which is dependent upon the type of waste treatment. Tables J-4 and J-5 present detailed CH-TRU and RH-TRU waste shipment information for all sites under all alternatives using *The National Transuranic Waste Management Plan* volumes. Table J-6 (and Table S-8 presented here) summarize the differences in shipments and the percentages of the total inventories between *The National Transuranic Waste Management Plan* and the Basic Inventory.

Overall, impacts would be slightly lower using data from *The National Transuranic Waste Management Plan* because, although CH-TRU waste volumes are slightly higher, the RH-TRU waste volumes are markedly lower (except for the impacts to the involved workers, as noted above). The difference is quite marked for transportation impacts because of the reduction of nearly 61,000 shipments of RH-TRU waste under Action Alternative 3 (see Table S-8).

Table S-8
Comparison of Shipments Between Alternatives Using
***The National Transuranic Waste Management Plan* and Basic Inventory**

Alternatives	Number of Shipments to WIPP for the Total Inventory			
	NTRUWM Plan	BIR-3	Difference	Percentage of BIR-3 Shipments (NTRUWM/BIR-3)
Proposed Action				
CH-TRU Waste	27,988	29,766 [a]	-1,778	94%
RH-TRU Waste	7,626	7,957	-331	96%
Action Alternative 1				
CH-TRU Waste	41,027	41,003	24	100%
RH-TRU Waste	11,509	62,162	-50,653	19%
Action Alternative 2A				
CH-TRU Waste	43,749	42,775	974	102%
RH-TRU Waste	4,028	21,895	-17,867	18%
Action Alternative 2B				
CH-TRU Waste	43,750	42,774	976	102%
RH-TRU Waste	4,028	21,895	-17,867	18%
Action Alternative 2C				
CH-TRU Waste	43,431	41,206	2,225	105%
RH-TRU Waste	11,507	62,160	-50,653	19%
Action Alternative 3				
CH-TRU Waste	65,922	67,309	-1,387	98%
RH-TRU Waste	13,808	74,606	-60,798	19%

[a] RH-TRU waste volumes are adjusted to the limits of the C&C Agreement. CH-TRU waste volumes are adjusted to reflect the capacity allowed under the LWA taking into account the RH-TRU waste limits of the C&C Agreement.

Changes in volume-dependent impacts (for example, human health impacts) would be expected at some sites. The changes in impacts would be greatest at INEEL, a major generator, treatment, and potential consolidation site under all alternatives, where volume-dependent impacts could increase by about 124 percent. Impacts at RFETS would increase by about 50 percent and at SRS by less than 10 percent. Impacts at Hanford would decrease dramatically: approximately 50 percent from

CH-TRU waste and 90 percent from RH-TRU waste. ORNL impacts, mainly from RH-TRU waste, would be about 60 percent lower. Impacts at LANL, the other key generator site, would also decrease by about 15 to 20 percent.

Additional information on how these impacts would change, as well as information on other waste volumes, is presented in Appendix J.

This page intentionally left blank.

DOE/EIS-0026-S-2

Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement

Volume I
Chapters 1-6

September 1997

Department of Energy
Carlsbad Area Office
Carlsbad, New Mexico

This Document Printed on Recycled Paper

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN, 37831; prices available from (423) 576-1301.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Copies of this document are available
(while supplies last) upon written request to:

U.S. Department of Energy
Carlsbad Area Office
P.O. Box 3090
Carlsbad, NM 88221

or by calling
1 (800) 336-9477

COVER SHEET

Lead Agency: U.S. Department of Energy

Title: Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement
Eddy County, near Carlsbad, New Mexico

Contact:

For further information about this Environmental Impact Statement, contact:

Harold Johnson, WIPP EIS
U.S. Department of Energy
101 W. Greene Street
Carlsbad, NM 88220
(505) 234-7349 phone
(505) 887-6970 fax

For general information on the Department of Energy's process for implementing the National Environmental Policy Act, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance
Office of the Assistant Secretary for Environment, Safety and Health
U.S. Department of Energy (EH-42)
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-4600 or leave a message at (800) 472-2756

Abstract:

The purpose of *the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II) is to provide information on environmental impacts regarding the Department of Energy's (DOE) proposed disposal operations at WIPP. To that end, SEIS-II has been prepared to assess the potential impacts of continuing the phased development of WIPP as a geologic repository for the safe disposal of transuranic (TRU) waste. SEIS-II evaluates a Proposed Action, three Action Alternatives based on the waste management options presented in the *Final Waste Management Programmatic Environmental Impact Statement*, and two No Action Alternatives. The Proposed Action describes the treatment and disposal of the Basic Inventory of TRU waste over a 35-year period. The Basic Inventory is that waste currently permitted in WIPP based on current laws and agreements. The Action Alternatives propose the treatment of the Basic Inventory and an Additional Inventory as well as the transportation of the treated waste to WIPP for disposal over a 150- to 190-year period. The three Action Alternatives include the treatment of TRU waste at consolidation sites to meet WIPP planning-basis Waste Acceptance Criteria, the thermal treatment of TRU waste to meet Land Disposal Restrictions, and the treatment of TRU waste by a shred and grout process. The No Action Alternatives propose the dismantling and closure of WIPP and storage of the waste. One No Action Alternative proposes treating the waste thermally before placing it in retrievable storage.

SEIS-II evaluates environmental impacts resulting from the various treatment options; the transportation of TRU waste to WIPP using truck, a combination of truck and regular rail service, and a combination of truck and dedicated rail service; and the disposal of this waste in the repository. Evaluated impacts include those to the general environment and to human health. Additional issues associated with the implementation of the alternatives are discussed to provide further understanding of the decisions to be reached and to provide the opportunity for public input on improving DOE's Environmental Management Program.

This page intentionally left blank.

TABLE OF CONTENTS — VOLUME I

GLOSSARY GL-1

ACRONYMS AND ABBREVIATIONS AC-1

MEASUREMENTS AND CONVERSIONS MC-1

HALF-LIVES OF SELECT RADIONUCLIDES R-1

CHAPTER 1: INTRODUCTION 1-1

1.1 PURPOSE AND NEED FOR ACTION 1-1
1.2 OVERVIEW 1-1
1.3 WIPP NEPA COMPLIANCE HISTORY 1-4
1.4 NEED FOR A SECOND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT 1-7
1.5 THE RELATIONSHIP OF SEIS-II TO OTHER DOE PLANNING DOCUMENTS 1-9
1.6 CONTENT OF SEIS-II 1-15
1.7 REFERENCES CITED IN CHAPTER 1 1-17

CHAPTER 2: BACKGROUND INFORMATION 2-1

2.1 OVERVIEW OF TRU WASTE IN THE DOE COMPLEX 2-1
2.1.1 Introduction 2-2
2.1.2 TRU Waste 2-3
2.1.3 Waste Management at the Generator-Storage Sites 2-6
2.1.4 Waste Isolation Pilot Plant 2-10
2.2 TRU WASTE TREATMENT 2-15
2.2.1 Treatment to Meet Planning-Basis WAC 2-16
2.2.2 Shred and Grout Treatment 2-17
2.2.3 Thermal Treatment 2-18
2.3 STAKEHOLDER OUTREACH AND INVOLVEMENT ACTIVITIES 2-20
2.4 REFERENCES CITED IN CHAPTER 2 2-24

CHAPTER 3: DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES 3-1

3.1 PROPOSED ACTION: BASIC INVENTORY, TREAT TO WAC, DISPOSE OF AT WIPP (PREFERRED ALTERNATIVE RESERVING RAIL TRANSPORTATION FOR FUTURE CONSIDERATION) 3-2
3.1.1 Activities at the Generator-Storage Sites 3-4
3.1.2 Transportation Activities 3-6
3.1.2.1 Shipping Procedures 3-7
3.1.2.2 Shipping Routes 3-9

3.1.3 Activities at WIPP 3-10
3.1.3.1 Excavation Operations 3-10
3.1.3.2 TRU Waste Handling Operations at the Surface 3-10
3.1.3.3 Emplacement Operations for CH-TRU Waste 3-12
3.1.3.4 Emplacement Operations for RH-TRU Waste 3-12
3.1.3.5 Closure and Decommissioning 3-13
3.2 ALTERNATIVES 3-16
3.2.1 Action and No Action Alternatives 3-16
3.2.2 Action Alternative 1: Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP 3-16
3.2.2.1 Activities at the Generator-Storage Sites 3-17
3.2.2.2 Transportation Activities 3-19
3.2.2.3 Activities at WIPP 3-21
3.2.2.4 Reducing Operation Time 3-21
3.2.3 Action Alternative 2: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP 3-22
3.2.3.1 Activities at the Generator-Storage Sites 3-23
3.2.3.2 Transportation Activities 3-25
3.2.3.3 Activities at WIPP 3-28
3.2.3.4 Reducing Operation Time 3-33
3.2.4 Action Alternative 3: Total Inventory (Except PCB-Commingled Waste), Treat by Shred and Grout, Dispose of at WIPP 3-33
3.2.4.1 Activities at the Generator-Storage Sites 3-37
3.2.4.2 Transportation Activities 3-37
3.2.4.3 Activities at WIPP 3-38
3.2.4.4 Reducing Operation Time 3-38
3.2.5 No Action Alternative 1: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP 3-39
3.2.5.1 Activities at the Generator-Storage Sites 3-44
3.2.5.2 Transportation Activities 3-46
3.2.5.3 Activities at WIPP 3-46
3.2.6 No Action Alternative 2: Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP 3-46
3.2.6.1 Activities at the Generator-Storage Sites 3-46
3.2.6.2 Transportation Activities 3-48
3.2.6.3 Activities at WIPP 3-48
3.3 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL 3-48
3.4 COMPARISON OF THE PROPOSED ACTION AND ALTERNATIVES 3-51
3.5 PREFERRED ALTERNATIVE 3-57
3.6 REFERENCES CITED IN CHAPTER 3 3-66

CHAPTER 4: DESCRIPTION OF THE AFFECTED ENVIRONMENTS 4-1

4.1 EXISTING ENVIRONMENT AT THE WIPP 4-1
4.1.1 Land Use and Management 4-1
4.1.2 Air Quality, Climate, and Noise 4-6
4.1.3 Geology and Hydrology 4-9
4.1.3.1 Geology 4-10
4.1.3.2 Hydrology 4-19
4.1.4 Biological Resources 4-34
4.1.5 Cultural Resources 4-35
4.1.6 Socioeconomic Environment 4-38
4.1.6.1 Background Characteristics 4-39
4.1.6.2 Role of WIPP in the Economic Base 4-39
4.1.6.3 Environmental Justice 4-42
4.1.7 Transportation 4-45
4.1.8 Background Radiation 4-45
4.2 EXISTING ENVIRONMENT AT THE TEN MAJOR GENERATOR-STORAGE SITES 4-46
4.2.1 Argonne National Laboratory-East (ANL-E) 4-46
4.2.2 Hanford Site (Hanford) 4-48
4.2.3 Idaho National Engineering and Environmental Laboratory (INEEL) 4-51
4.2.4 Lawrence Livermore National Laboratory (LLNL) 4-54
4.2.5 Los Alamos National Laboratory (LANL) 4-56
4.2.6 Mound Plant (Mound) 4-58
4.2.7 Nevada Test Site (NTS) 4-60
4.2.8 Oak Ridge National Laboratory (ORNL) 4-62
4.2.9 Rocky Flats Environmental Technology Site (RFETS) 4-63
4.2.10 Savannah River Site (SRS) 4-65
4.3 REFERENCES CITED IN CHAPTER 4 4-67

CHAPTER 5: ENVIRONMENTAL IMPACTS 5-1

5.1 IMPACTS OF THE PROPOSED ACTION (PREFERRED ALTERNATIVE, RESERVING RAIL TRANSPORTATION FOR FUTURE CONSIDERATION) 5-3
5.1.1 Land Use and Management 5-4
5.1.2 Air Quality 5-4
5.1.3 Biological Resources 5-6
5.1.4 Cultural Resources 5-7
5.1.5 Noise 5-8
5.1.6 Water Resources and Infrastructure 5-9
5.1.7 Socioeconomics 5-9
5.1.7.1 Life-Cycle Costs 5-10
5.1.7.2 Economic Impacts 5-11
5.1.8 Transportation 5-12
5.1.8.1 Route Characteristics and Shipment Projections 5-13

5.1.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation 5-14
5.1.8.3 Accident-Free Radiological Impacts from Truck Transportation 5-16
5.1.8.4 Radiological Impacts from Truck Transportation Accidents 5-20
5.1.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents 5-23
5.1.9 Human Health Impacts from Waste Treatment and Disposal Operations 5-26
5.1.9.1 Public 5-28
5.1.9.2 Noninvolved Workers 5-29
5.1.9.3 Involved Workers 5-30
5.1.9.4 Storage of Excess RH-TRU Waste 5-32
5.1.10 Facility Accidents 5-34
5.1.10.1 Waste Treatment Accidents 5-34
5.1.10.2 Excess RH-TRU Waste Storage Accident 5-38
5.1.10.3 WIPP Disposal Accidents 5-39
5.1.11 Industrial Safety 5-42
5.1.12 Long-Term Performance 5-43
5.1.12.1 Impacts of Undisturbed Conditions 5-45
5.1.12.2 Impacts of Disturbed Conditions 5-47
5.1.12.3 Long-Term Storage of Excess RH-TRU Waste..... 5-53
5.2 IMPACTS OF ACTION ALTERNATIVE 1 5-53
5.2.1 Land Use and Management 5-55
5.2.2 Air Quality 5-55
5.2.3 Biological Resources 5-56
5.2.4 Cultural Resources 5-56
5.2.5 Noise 5-57
5.2.6 Water Resources and Infrastructure 5-57
5.2.7 Socioeconomics 5-58
5.2.7.1 Life-Cycle Costs 5-58
5.2.7.2 Economic Impacts 5-59
5.2.8 Transportation 5-60
5.2.8.1 Route Characteristics and Shipment Projections 5-60
5.2.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation 5-60
5.2.8.3 Accident-Free Radiological Impacts from Truck Transportation 5-61
5.2.8.4 Radiological Impacts from Truck Transportation Accidents 5-62
5.2.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents 5-63
5.2.8.6 Impacts from Rail Transportation 5-63

5.2.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations 5-66
5.2.9.1 Public 5-66
5.2.9.2 Noninvolved Workers 5-68
5.2.9.3 Involved Workers 5-70
5.2.10 Facility Accidents 5-72
5.2.10.1 Waste Treatment Accidents 5-72
5.2.10.2 Waste Storage Accidents 5-72
5.2.10.3 WIPP Disposal Accidents 5-75
5.2.11 Industrial Safety 5-76
5.2.12 Long-Term Performance 5-76
5.2.12.1 Impacts of Undisturbed Conditions 5-77
5.2.12.2 Impacts of Disturbed Conditions 5-77
5.2.13 Reducing WIPP Operations for Action Alternative 1 5-81
5.3 IMPACTS OF ACTION ALTERNATIVE 2 5-82
5.3.1 Land Use Management 5-82
5.3.2 Air Quality 5-83
5.3.3 Biological Resources 5-83
5.3.4 Cultural Resources 5-84
5.3.5 Noise 5-85
5.3.6 Water Resources and Infrastructure 5-85
5.3.7 Socioeconomics 5-86
5.3.7.1 Life-Cycle Costs 5-86
5.3.7.2 Economic Impacts 5-89
5.3.8 Transportation 5-90
5.3.8.1 Route Characteristics and Shipment Projections 5-91
5.3.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation 5-92
5.3.8.3 Accident-Free Radiological Impacts from Truck Transportation 5-92
5.3.8.4 Radiological Impacts from Truck Transportation Accidents 5-94
5.3.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents to WIPP 5-96
5.3.8.6 Impacts from Rail Transportation 5-96
5.3.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations 5-97
5.3.9.1 Public 5-98
5.3.9.2 Noninvolved Workers 5-100
5.3.9.3 Involved Workers 5-102
5.3.10 Facility Accidents 5-104
5.3.10.1 Waste Treatment Accidents 5-104
5.3.10.2 Waste Storage Accidents 5-108
5.3.10.3 WIPP Disposal Accidents 5-111
5.3.11 Industrial Safety 5-113
5.3.12 Long-Term Performance 5-114
5.3.12.1 Impacts of Undisturbed Conditions 5-115

5.3.12.2 Impacts of Disturbed Conditions 5-115
5.3.13 Reducing WIPP Operations for Action Alternative 2 5-119
5.4 IMPACTS OF ACTION ALTERNATIVE 3 5-120
5.4.1 Land Use and Management 5-120
5.4.2 Air Quality 5-120
5.4.3 Biological Resources 5-121
5.4.4 Cultural Resources 5-121
5.4.5 Noise 5-122
5.4.6 Water Resources and Infrastructure 5-122
5.4.7 Socioeconomics 5-122
5.4.7.1 Life-Cycle Costs 5-122
5.4.7.2 Economic Impacts 5-123
5.4.8 Transportation 5-124
5.4.8.1 Route Characteristics and Shipment Projections 5-124
5.4.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation 5-125
5.4.8.3 Accident-Free Radiological Impacts from Truck Transportation 5-125
5.4.8.4 Radiological Impacts from Truck Transportation Accidents 5-126
5.4.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents 5-127
5.4.8.6 Impacts from Rail Transportation 5-127
5.4.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations 5-128
5.4.9.1 Public 5-129
5.4.9.2 Noninvolved Workers 5-130
5.4.9.3 Involved Workers 5-132
5.4.10 Facility Accidents 5-135
5.4.10.1 Waste Treatment Accidents 5-135
5.4.10.2 Waste Storage Accidents 5-137
5.4.10.3 WIPP Disposal Accidents 5-140
5.4.11 Industrial Safety 5-143
5.4.12 Long-Term Performance 5-143
5.4.12.1 Impacts of Undisturbed Conditions 5-144
5.4.12.2 Impacts of Disturbed Conditions 5-144
5.4.13 Reducing WIPP Operations for Action Alternative 3 5-146
5.5 IMPACTS OF NO ACTION ALTERNATIVE 1 5-147
5.5.1 Land Use and Management 5-147
5.5.2 Air Quality 5-148
5.5.3 Biological Resources 5-148
5.5.4 Cultural Resources 5-149
5.5.5 Noise 5-149
5.5.6 Water Resources and Infrastructure 5-149
5.5.7 Socioeconomics 5-150
5.5.7.1 Life-Cycle Costs 5-150
5.5.7.2 Economic Impacts 5-151

5.5.8 Transportation 5-152
5.5.8.1 Route Characteristics and Shipment Projections 5-152
5.5.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects..... 5-152
5.5.8.3 Accident-Free Radiological Impacts from Truck Transportation 5-153
5.5.8.4 Radiological Impacts from Truck Transportation Accidents..... 5-153
5.5.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents..... 5-153
5.5.8.6 Impacts from Rail Transportation 5-154
5.5.9 Human Health Impacts from Waste Treatment and Storage Operations 5-154
5.5.9.1 Public 5-155
5.5.9.2 Noninvolved Workers 5-156
5.5.9.3 Involved Workers 5-158
5.5.10 Facility Accidents 5-160
5.5.10.1 Waste Treatment Accidents..... 5-160
5.5.10.2 Waste Storage Accidents 5-160
5.5.11 Industrial Safety 5-160
5.5.12 Long-Term Performance 5-161
5.6 IMPACTS OF NO ACTION ALTERNATIVE 2 5-162
5.6.1 Land Use and Management 5-162
5.6.2 Air Quality 5-162
5.6.3 Biological Resources 5-162
5.6.4 Cultural Resources..... 5-163
5.6.5 Noise 5-163
5.6.6 Water Resources and Infrastructure 5-163
5.6.7 Socioeconomics..... 5-163
5.6.7.1 Life-Cycle Costs 5-163
5.6.7.2 Economic Impacts 5-163
5.6.8 Transportation 5-164
5.6.9 Human Health Impacts from Waste Treatment and Management Operations..... 5-164
5.6.9.1 Public 5-164
5.6.9.2 Noninvolved Workers 5-165
5.6.9.3 Involved Workers 5-166
5.6.10 Facility Accidents 5-167
5.6.10.1 Waste Treatment Accidents..... 5-168
5.6.10.2 Waste Storage Accidents 5-168
5.6.11 Industrial Safety 5-168
5.6.12 Long-Term Performance 5-168
5.7 RETRIEVAL AND RECOVERY 5-175
5.7.1 Waste Retrieval..... 5-175
5.7.1.1 Operational Impacts of Waste Retrieval..... 5-175
5.7.1.2 Transportation Impacts of Waste Retrieval..... 5-176
5.7.2 Waste Recovery 5-176
5.7.2.1 Operational Impacts of Waste Recovery 5-177

5.7.2.2 Transportation Impacts of Waste Recovery 5-178
5.8 ENVIRONMENTAL JUSTICE..... 5-179
5.9 CUMULATIVE IMPACTS..... 5-181
5.9.1 Cumulative Impacts in the Vicinity of WIPP..... 5-181
5.9.2 Cumulative Transportation Impacts 5-183
5.9.3 Cumulative Impacts at Treatment Sites..... 5-184
5.10 MITIGATION MEASURES..... 5-185
5.11 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY .. 5-187
5.12 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES..... 5-187
5.13 CHANGES DUE TO OTHER TRU WASTE VOLUME ESTIMATES 5-187
5.14 REFERENCES CITED IN CHAPTER 5..... 5-189

CHAPTER 6: CONSULTATIONS AND PERMITS 6-1

LIST OF TABLES — VOLUME I

Table 1-1 Current and Anticipated DOE TRU Waste (in cubic meters) 1-4

Table 1-2 WIPP NEPA Documents Since SEIS-I 1-7

Table 2-1 Final TRU Waste Form Code Groups and Definitions 2-4

Table 2-2 Basic Inventory TRU Waste Volumes 2-6

Table 2-3 Additional Inventory TRU Waste Volumes 2-7

Table 2-4 List of WIPP Reading Rooms 2-22

Table 3-1 TRU Waste Volumes (Basic Inventory) for the Proposed Action 3-3

Table 3-2 CH-TRU Waste Volumes for Action Alternative 1 3-18

Table 3-3 RH-TRU Waste Volumes for Action Alternative 1 3-19

Table 3-4 CH-TRU Waste Volumes for Action Alternative 2A 3-24

Table 3-5 RH-TRU Waste Volumes for Action Alternative 2A 3-25

Table 3-6 CH-TRU Waste Volumes for Action Alternative 2B 3-27

Table 3-7 RH-TRU Waste Volumes for Action Alternative 2B 3-28

Table 3-8 CH-TRU Waste Volumes for Action Alternative 2C 3-30

Table 3-9 RH-TRU Waste Volumes for Action Alternative 2C 3-31

Table 3-10 CH-TRU Waste Volumes for Action Alternative 3 3-34

Table 3-11 RH-TRU Waste Volumes for Action Alternative 3 3-35

Table 3-12 CH-TRU Waste Volumes for No Action Alternative 1A 3-40

Table 3-13 RH-TRU Waste Volumes for No Action Alternative 1A 3-41

Table 3-14 CH-TRU Waste Volumes for No Action Alternative 1B 3-43

Table 3-15 RH-TRU Waste Volumes for No Action Alternative 1B 3-44

Table 3-16 TRU Waste Volumes for No Action Alternative 2 3-47

Table 3-17 Summary of WIPP SEIS-II Alternatives 3-52

Table 3-18 Summary of SEIS-II Environmental Impacts 3-58

Table 4-1 Species of Special Concern in Eddy and Lea Counties, New Mexico 4-36

Table 4-2 1990 Population and Community Characteristics by County in ROI 4-40

Table 4-3 Income, Poverty, and Housing Characteristics (1989-1992) by County in ROI 4-40

Table 4-4 1994 ROI County Employment and Covered Wages (in millions of 1994 dollars) .. 4-41

Table 4-5 Radionuclides Sampled in the Vicinity of WIPP 4-46

Table 5-1 Impacts on Air Quality at WIPP for the Proposed Action 5-6

Table 5-2 Life-Cycle Costs for the Proposed Action (in millions of 1994 dollars) 5-10

Table 5-3 Economic Impacts Within the WIPP ROI for the Proposed Action 5-12

Table 5-4 Number of Truck Shipments to WIPP for the Proposed Action 5-13

Table 5-5 Mileage for Shipping TRU Waste by Truck to WIPP for the Proposed Action 5-14

Table 5-6 Nonradiological Impacts of Transporting TRU Waste by Truck for the Proposed Action 5-15

Table 5-7 Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for the Proposed Action (LCFs) 5-18

Table 5-8 Lifetime Accident-Free Radiological Impacts to MEIs from Truck Transportation for the Proposed Action (Probability of an LCF) 5-19

Table 5-9 Aggregate Radiological Impacts from Potential Truck Transportation Accidents for the Proposed Action (LCFs) 5-21

Table 5-10 Hazardous Chemical Impacts for a Severe Truck Transportation Accident for the Proposed Action 5-25

Table 5-11 Lifetime Human Health Impacts to the Public from Waste Treatment and WIPP Disposal Operations for the Proposed Action 5-28

Table 5-12 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and WIPP Disposal Operations for the Proposed Action 5-30

Table 5-13 Lifetime Human Health Impacts to Involved Workers from Waste Treatment and WIPP Disposal Operations for the Proposed Action 5-31

Table 5-14 Impacts from Storage of Excess RH-TRU Waste for the Proposed Action 5-34

Table 5-15 Treatment Accident Scenarios for the Proposed Action 5-35

Table 5-16 Radiological Consequences of Treatment Accidents for the Proposed Action 5-36

Table 5-17 Radiological Consequences of an Excess RH-TRU Waste Storage Accident for the Proposed Action 5-39

Table 5-18 WIPP Disposal Accident Scenarios for the Proposed Action 5-40

Table 5-19 Radiological Consequences of WIPP Disposal Accident Scenarios for the Proposed Action 5-40

Table 5-20 Average Occupational Injury/Illness and Fatality Rates (per worker-year) 5-42

Table 5-21 Industrial Safety Impacts from Operations and Decommissioning of WIPP for the Proposed Action 5-43

Table 5-22 Life-Cycle Costs for Action Alternative 1 (in millions of 1994 dollars) 5-58

Table 5-23 Economic Impacts within the ROI for Action Alternative 1 5-59

Table 5-24 Number of Truck Shipments to WIPP for Action Alternative 1 5-60

Table 5-25 Nonradiological Impacts of Transporting TRU Waste by Truck for Action Alternative 1 5-61

Table 5-26 Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for Action Alternative 1 (LCFs) 5-61

Table 5-27 Radiological Impacts to MEIs from Truck Transportation for Action Alternative 1 (Probability of an LCF) 5-62

Table 5-28 Aggregate Radiological Population Impacts from Truck Transportation Accidents for Action Alternative 1 (LCFs) 5-62

Table 5-29 Impacts From Rail Transportation for Action Alternative 1 5-65

Table 5-30 Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1 5-67

Table 5-31 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1 5-69

Table 5-32 Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1 5-71

Table 5-33 Storage Accident Scenarios Evaluated for Action Alternative 1 5-73

Table 5-34 Radiological Consequences from Storage Accidents for Action Alternative 1 5-74

Table 5-35 Industrial Safety Impacts from WIPP Operations and Decommissioning for Action Alternative 1 5-76

Table 5-36 Life-Cycle Costs for Action Alternative 2A (in millions of 1994 dollars) 5-87

Table 5-37 Life-Cycle Costs for Action Alternative 2B (in millions of 1994 dollars) 5-88

Table 5-38 Life-Cycle Costs for Action Alternative 2C (in millions of 1994 dollars) 5-89

Table 5-39 Economic Impacts within the WIPP ROI for Action Alternatives 2A, 2B, and 2C..... 5-90

Table 5-40 Number of Truck Shipments to WIPP for Action Alternatives 2A, 2B, and 2C..... 5-91

Table 5-41 Nonradiological Impacts of Transporting TRU Waste by Truck for Action Alternatives 2A, 2B, and 2C 5-92

Table 5-42 Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for Action Alternatives 2A, 2B, and 2C (LCFs) 5-93

Table 5-43 Radiological Impacts to MEIs from Truck Transportation for Action Alternatives 2A, 2B, and 2C (Probability of an LCF)..... 5-94

Table 5-44 Aggregate Radiological Population Impacts by Truck Accidents for Action Alternatives 2A, 2B, and 2C (LCFs)..... 5-95

Table 5-45 Impacts From Rail Transportation for Action Alternatives 2A, 2B, and 2C 5-96

Table 5-46 Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternatives 2A, 2B, and 2C..... 5-98

Table 5-47 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternatives 2A, 2B, and 2C..... 5-101

Table 5-48 Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for the Action Alternative 2 Subalternatives 5-103

Table 5-49 Treatment Accident Scenarios Evaluated for the Action Alternatives 2 Subalternatives 5-105

Table 5-50 Radiological Consequences of Treatment Accidents for the Action Alternative 2 Subalternatives 5-106

Table 5-51 Storage Accident Scenarios Evaluated for the Action Alternative 2 Subalternatives 5-108

Table 5-52 Radiological Consequences of Storage Accidents for the Action Alternative 2 Subalternatives 5-109

Table 5-53 WIPP Disposal Accident Scenarios for the Action Alternative 2 Subalternatives 5-111

Table 5-54 Radiological Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives 5-112

Table 5-55 Industrial Safety Impacts from WIPP Operations and Decommissioning for the Action Alternative 2 Subalternatives 5-114

Table 5-56 Life-Cycle Costs for Action Alternative 3 (in millions of 1994 dollars) 5-123

Table 5-57 Economic Impacts within the WIPP ROI for Action Alternative 3 5-124

Table 5-58 Number of Truck Shipments to WIPP for Action Alternative 3 5-124

Table 5-59 Nonradiological Impacts of Transporting TRU Waste by Truck for Action Alternative 3 5-125

Table 5-60 Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for Action Alternative 3 (LCFs) 5-126

Table 5-61 Radiological Impacts to MEIs from Truck Transportation for Action Alternative 3 (Probability of an LCF) 5-126

Table 5-62 Aggregate Radiological Population Impacts for Truck Transportation Accidents for Action Alternative 3 (LCFs) 5-127

Table 5-63 Impacts From Rail Transportation for Action Alternative 3 5-128

Table 5-64 Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3 5-129

Table 5-65 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3 5-131

Table 5-66 Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3 5-133

Table 5-67 Treatment Accident Scenarios Evaluated for Action Alternative 3 5-135

Table 5-68 Radiological Consequences of Treatment Accidents for Action Alternative 3 5-136

Table 5-69 Storage Accident Scenarios Evaluated for Action Alternative 3 5-137

Table 5-70 Radiological Consequences of Storage Accidents for Action Alternative 3 5-138

Table 5-71 WIPP Disposal Accident Scenarios for Action Alternative 3..... 5-140

Table 5-72 Radiological Consequences of WIPP Disposal Accidents for Action Alternative 3 5-141

Table 5-73 Industrial Safety Impacts from WIPP Operations and Decommissioning for Action Alternative 3 5-143

Table 5-74 Life-Cycle Costs for No Action Alternative 1A (in millions of 1994 dollars) 5-150

Table 5-75 Life-Cycle Costs for No Action Alternative 1B (in millions of 1994 dollars) 5-151

Table 5-76 Economic Impacts Within The WIPP ROI for No Action Alternative 1 5-152

Table 5-77 One-Way Waste Transportation Miles for No Action Alternative 1 5-152

Table 5-78 Population Impacts from Truck Transportation for No Action Alternative 1 5-153

Table 5-79 Impacts of Rail Transportation for No Action Alternative 1 5-154

Table 5-80 Lifetime Human Health Impacts to the Public from Waste Treatment and Storage Operations for No Action Alternatives 1A and 1B 5-156

Table 5-81 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations for No Action Alternative 1..... 5-157

Table 5-82 Lifetime Human Health Impacts to Involved Workers from Waste Treatment and Storage Operations for No Action Alternative 1..... 5-158

Table 5-83 Annual Involved Worker Population Impacts from CH-TRU Waste Overpacking Operations for No Action Alternatives 1A and 1B (LCFs) 5-159

Table 5-84 Industrial Safety Impacts from WIPP Decommissioning and Site Storage for No Action Alternative 1..... 5-161

Table 5-85 Life-Cycle Costs for No Action Alternative 2 (in millions of 1994 dollars) 5-164

Table 5-86 Lifetime Human Health Impacts to the Public from Waste Treatment and Storage Operations Under No Action Alternative 2 5-165

Table 5-87 Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations Under No Action Alternative 2 5-166

Table 5-88 Lifetime Human Health Impacts to Involved Workers from Waste Treatment and Storage Under No Action Alternative 2 5-167

Table 5-89 Industrial Safety Impacts from WIPP Decommissioning and Site Waste Management Under No Action Alternative 2 5-168

Table 5-90 Radiological Impacts to Inadvertent Intruders Following Loss of Institutional Control for Seven Major Generator-Storage Sites (probability of an LCF) 5-171

Table 5-91 Maximum Lifetime MEI and Population Impacts for Seven Major Generator-Storage Sites Under No Action Alternative 2 5-173

Table 5-92 Noncarcinogenic Hazardous Chemical Impacts to MEIs at Seven Major Generator-Storage Sites for No Action Alternative 2 5-174

Table 5-93 Aggregate LCFs Over 10,000 Years for Seven Major Generator-Storage Sites After Loss of Institutional Control for No Action Alternative 2..... 5-174

Table 5-94 Source Documents Describing Other Activities Included in the Cumulative Impact Analysis 5-182

Table 5-95 Comparison of Shipments Between Alternatives Using *The National Transuranic Waste Management Plan* and Basic Inventory..... 5-189

Table 6-1 Active, Pending, and Potentially Required Permits for the Waste Isolation Pilot Plant Disposal Operations 6-2

Table 6-2 Laws and Regulations Relevant to the WIPP Disposal Phase 6-3

This page intentionally left blank.

LIST OF FIGURES — VOLUME I

Figure 1-1 Approximate Location of SEIS-II TRU Waste 1-6

Figure 2-1 Approximate Location of SEIS-II TRU Waste 2-8

Figure 2-2 The Location of WIPP 2-12

Figure 2-3 WIPP Surface Structures 2-13

Figure 2-4 Plan View of WIPP Underground Facility 2-14

Figure 3-1 Movement of Waste for the Proposed Action 3-5

Figure 3-2 Movement of Waste for Action Alternative 1 3-20

Figure 3-3 Movement of Waste for Action Alternative 2A 3-26

Figure 3-4 Movement of Waste for Action Alternative 2B 3-29

Figure 3-5 Movement of Waste for Action Alternative 2C 3-32

Figure 3-6 Movement of Waste for Action Alternative 3 3-36

Figure 3-7 Movement of Waste for No Action Alternative 1A 3-42

Figure 3-8 Movement of Waste for No Action Alternative 1B 3-45

Figure 3-9 CH-TRU Post-Treatment Waste Volumes by Alternative 3-54

Figure 3-10 RH-TRU Post-Treatment Waste Volumes by Alternative 3-55

Figure 4-1 Land Use Within 80 Kilometers (50 Miles) of WIPP 4-3

Figure 4-2 WIPP Areas 4-4

Figure 4-3 Windroses for 1991-1994 4-8

Figure 4-4 WIPP Site Location in Southeastern New Mexico 4-11

Figure 4-5 Regional Geologic Column 4-12

Figure 4-6 Regional Earthquake Epicenters Occurring after 1962 4-15

Figure 4-7 Oil, Gas, and Injection Wells in the Nine-Township Area Centered on the WIPP Site 4-18

Figure 4-8 Annual Number of Oil and Gas Wells Completed in the Nine-Township Area Centered on the WIPP Site 4-19

Figure 4-9 Active, Inactive, and Abandoned Potash Facilities in Eddy and Lea Counties, Southeastern New Mexico, Within the Carlsbad Potash District 4-20

Figure 4-10 Locations of Wells Completed in the Culebra Dolomite in the Vicinity of the WIPP Site and Water-Level Changes in Observation Well H-9b Between 1988 and 1996 4-32

Figure 4-11 Minority Population 4-43

Figure 4-12 Low-Income Population 4-44

Figure 5-1 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) for the Proposed Action 5-46

Figure 5-2 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) for the Proposed Action 5-50

Figure 5-3 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) for Action Alternative 1 5-78

Figure 5-4 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 9) for Action Alternative 1 5-80

Figure 5-5 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) for Action Alternative 2 5-116

Figure 5-6 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 14) for Action Alternative 2 5-118

LIST OF TEXT BOXES — VOLUME I

Chapter 1 Transuranic Waste 1-1

Highlights of Changes Since Publication of the Draft SEIS-II 1-2

LWA Limits 1-3

Chapter 2 Key Definitions 2-1

Waste Acceptance Criteria (WAC) 2-2

TRU Waste Transportation Packaging 2-3

Legally Binding Orders and Agreements 2-9

Objectives of TRU Waste Treatment 2-15

Chapter 3 Further NEPA Analysis 3-1

TRANSCOM System 3-7

Conservatism of TRU Waste Volume Estimates 3-8

The Proposed Action and the Additional Inventory 3-13

SEIS-II and the WM PEIS Alternatives 3-49

Chapter 4 Changes in Site Land Use and Management 4-1

Changes in Air Quality Monitoring 4-6

Key Elements Concerning Geology and Hydrology 4-9

Changes in Rare, Threatened, and Endangered Species 4-34

Changes in Cultural Resources Management 4-35

Changes in Socioeconomics 4-38

Radiological Environment 4-45

Chapter 5 Environmental Analyses 5-2

Comparing Alternatives 5-3

Life-Cycle Costs and Discounting 5-11

Estimating Radiological Impacts 5-17

Understanding Scientific and Exponential Notation 5-19

Fractional LCFs 5-20

Estimating Accident Risk 5-21

Transportation Impacts of the Santa Fe Bypass 5-23

Estimating Hazardous Chemical Impacts 5-24

Uncertainties in Transportation Impact Analyses 5-26

Radiological Impacts Other than LCFs 5-27

Overview of Uncertainties in Human Health Impact Estimates 5-33

Criticality 5-37

The Proposed Action and the Additional Inventory 5-51

The WM PEIS Preferred Alternative 5-52

Factors to Consider in Combining Alternatives 5-54

Intrusion at WIPP at Generator-Storage Sites 5-169

GLOSSARY

actinide	An element in the series beginning with element 89 (actinium) and continuing through element 103 (lawrencium). All the transuranic nuclides considered in this document are actinides.
activity	A measure of the rate at which a material emits nuclear radiation, usually given in terms of the number of nuclear disintegrations occurring in a given length of time. The common unit of activity is the curie, which amounts to 37 billion disintegrations per second. The International Standard unit of activity is the becquerel and is equal to one disintegration per second.
aerosolize	The process of converting a solid or a liquid into an airborne suspension of fine particles (an aerosol).
aggregate	The sum total; for purposes of SEIS-II, the accumulated effect or quantity by successive additions, often over time.
air quality	A measure of the quantity of pollutants in the air.
alluvium	Clay, silt, sand, and/or gravel deposits found in a stream channel or in low parts of a stream valley that is subject to flooding. Ancient alluvium deposits frequently occur above the elevation of present-day streams.
alpha particle	A positively charged particle emitted in the radioactive decay of certain nuclides. Made up of two protons and two neutrons bound together, it is identical to the nucleus of a helium atom.
ambient air	The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.
anhydrite	A mineral consisting of anhydrous calcium sulfate: $CaSO_4$.
aqueous	Related to water.
aquifer	Geologic unit sufficiently permeable to conduct groundwater.
argillaceous rocks	Rocks containing appreciable amounts of clay.
atmosphere	The layer of air surrounding the earth.
atmospheric dispersion	Movement of a contaminant as a result of the cumulative effect of the random motions of the air. Equivalent to eddy diffusion.
atom	Smallest unit of an element that is capable of entering into a chemical reaction and displays the other properties of the element.

backfill	Materials, such as salt or a mixture of salt and other materials, used to reduce void volumes in storage panels or drifts.
background radiation	Radiation from: (1) naturally occurring radioactive materials, as they exist in nature prior to removal, transport, or enhancement or processing by man; (2) cosmic and natural terrestrial radiation; (3) global fallout as it exists in the environment; (4) consumer products containing nominal amounts of radioactive material or emitting nominal levels of radiation; and (5) radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or past human activities.
basin	A topographic or structurally low area compared to the immediately adjacent areas.
bedded	Arranged in layers or beds. Usually, but not exclusively, applied to sedimentary deposits.
Bell Canyon Formation	A sequence of rock strata that forms the topmost unit of the Delaware Mountain Group.
berm	An earthen enbankment; a long artificial mound of stone or earth similar to a dike or levee.
bound	To estimate or describe an upper limit on a potential environmental consequence when uncertainty exists.
bounding	That which represents the maximum reasonably foreseeable event or impact. All other reasonably foreseeable events or impacts would have fewer and/or less severe environmental consequences.
°C	Degree Celsius. °C = 5/9 x (°F - 32).
caliche	Calcium carbonate ($CaCO_3$) deposited in the soils of arid or semiarid regions.
cancer	Any malignant new growth of abnormal cells or tissue.
canister	In this document, a container, usually cylindrical, for remotely handled transuranic waste. The waste will remain in this canister during and after emplacement at Waste Isolation Pilot Plant. A canister affords physical containment but not shielding; shielding is provided during shipment by a cask.
carcinogen	An agent capable of producing or inducing cancer.
carcinogenic	Capable of producing or inducing cancer.

cask	A massive shipping container providing shielding for highly radioactive materials and holding one canister.
Castile Formation	A Permian age rock unit of evaporites (interbedded halite and anhydrite) that immediately underlies the Salado Formation, the rock unit in which disposal rooms are excavated.
cloudshine	The pathway of direct external dose from the passing cloud of dispersed radioactive material.
commercial waste	Nuclear waste deriving from commercial sources. These are principally power reactors, but also include research laboratories and medical facilities.
committed dose equivalent	The predicted dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. It does not include dose contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert). (1 rem = 0.01 sievert).
committed effective dose equivalent	The sum of the committed dose equivalents to various organs or tissues in the body from radioactive material taken into the body, each multiplied by the tissue-specific weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
community	A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land values, or exposed to industry that stimulates unwanted noise, odors, industrial traffic, particulate matter, or other nonaesthetic impacts.
concentration	The amount of a substance contained in a unit quantity (mass or volume) of a sample.
conservative	When used with predictions or estimates, leaning on the side of pessimism. A conservative estimate is one in which the uncertain inputs are used in the way that provides a reasonable upper limit of the estimate of an impact.
contact-handled transuranic waste	TRU waste that does not require shielding other than that provided by its container to protect those handling it from radiation exposure. The radiation level at the outer surface of the container is specified as no more than 200 millirem per hour.
containment	Retention of a material or substance within prescribed boundaries.
contamination	The presence of excess radioactive material from a U.S. Department of Energy activity in or on a material or property.

creep	The continuous, usually slow deformation of solid rock resulting from constant strain acting over a long period of time. Salt will creep much faster than limestone, in a manner similar to ice in a glacier.
creep closure	Closure of underground openings, especially openings in salt, by creep flow of the surrounding rock under lithostatic pressure.
criteria pollutants	Six pollutants (ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide) known to be hazardous to human health and for which the U.S. Environmental Protection Agency sets National Ambient Air Quality Standards under the Clean Air Act.
critical habitat	The specific areas within the geographical area occupied by a species at the time it is listed as threatened or endangered on which are found those physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection. It also includes specific areas outside the geographical area occupied by the species at the time it is listed if these areas are determined to be essential for the conservation of the species.
criticality	A state in which a self-sustaining nuclear chain reaction is achieved.
Culebra Dolomite	The lower of two geologic units of water-bearing dolomite within the Rustler Formation.
cumulative impacts	Cumulative impacts are those impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.
curie	A unit of radioactivity equal to 37 billion (3.7×10^{10}) disintegrations per second.
Darcy's law	A mathematical relationship that describes the flow through porous media.
decommissioning	The removal from active service of a facility.
decontamination	The removal of unwanted material (especially radioactive material) from the surface or from within another material.
defense waste	Nuclear waste deriving from the manufacture of nuclear weapons and the operation of naval reactors. Associated activities, such as the research carried on in the weapons laboratories, also produce defense waste.
degradation	A process of transition. To decompose (a compound) by stages.

Delaware Basin	An area in southeastern New Mexico and the adjacent parts of Texas where the Permian sea deposited a large thickness of evaporites some 220 to 280 million years ago. It is partially surrounded by the Capitan Reef.
design life	The design life of components or systems generally refers to the estimated minimum period of time that the component or system is expected to perform within specifications before the effects of aging result in performance deterioration or a requirement to replace the component or system.
diffusion	Movement of atoms, ions, or molecules of one substance into or through another as a result of thermal or concentration gradients.
diffusion, molecular	Movement of a contaminant as the result of the cumulative effect of the random motions of molecules along a concentration or thermal gradient.
disposal	In this document, permanent disposition of waste in a repository. Use of the word disposal" implies that no need for later retrieval is expected. It also implies a minimal need for surveillance.
Disposal Phase	The period in which the U.S. Department of Energy proposes to permanently emplace transuranic wastes in the Waste Isolation Pilot Plant.
dissolution	The process whereby a material is taken into solution. Selective dissolution of minerals may produce cavities and caves, or enlarged fractures in a rock formation.
dissolution front	The boundary of a geologic region within which rock is dissolving. In this document, the term particularly refers to the wedge-like leading edge of salt dissolution at the interface between the Rustler and Salado Formation.
distribution coefficient	In an aquifer, the ratio of the concentration of a substance absorbed by the rock to the concentration of the substance remaining in solution. A large distribution coefficient implies that the substance moves much more slowly than the groundwater. It is measured in units of cubic centimeters per gram or equivalent.
disturbed rock zone	The disturbed rock zone is a volume of rock adjacent to an underground excavation in which mechanical properties (e.g., elastic modulus) and hydraulic properties (e.g., permeability and degree of saturation) have been changed because of the excavation.
dolomite	A sedimentary rock consisting primarily of the mineral dolomite: $CaMg(CO_3)_2$.
dose (absorbed dose)	The energy imparted to matter per unit mass by ionizing radiation. The unit of absorbed dose is the rad (or gray [Gy]). In SEIS-II, it is used as a general term for dose equivalent, total effective dose equivalent, and committed dose equivalent.

dose conversion factor	A numerical factor used in converting radionuclide intake (curies) in the body to the resultant dose equivalence (rem or person-rem).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert).
dose rate	The radiation dose delivered per unit time (e.g., rem per hour).
dual porosity	Having fracture porosity as well as interconnected pores (matrix porosity).
ecology	The science dealing with the relationship of all living things with each other and with the environment.
economic sector	A distinctive part of the economy of a geographic region defined by a standard industrial classification scheme. One such scheme defines "major" sectors and divides them into subsectors; for example, the major sector "trade" contains the subsectors "wholesale trade" and "retail trade." Another classification scheme specifies "primary" and "secondary" sectors; the criterion for including a sector in the primary classification is that its level of activity is generally not controlled by the level of economic activity in the region; a primary industry, in other words, produces goods and services for export from the region.
effective dose equivalent	The sum of the products of the dose equivalent received by specified organs or tissues of the body and a tissue-specific weighting factor. The effective dose equivalent is expressed in units of rem (or sievert).
effluent	Liquid or airborne material released to the environment. In common usage, however, the term "effluent" implies liquid release.
EIS	Environmental impact statement; a document required by the National Environmental Policy Act for proposed major Federal actions involving potentially significant environmental impacts.
E/Q (E over Q)	A measure of atmospheric dispersion for short-term (acute) atmospheric releases using gaussian dispersion plume modeling, with units of s/m^3. For a given point or location at some distance from the source, it represents the time-integrated air concentration ($Ci \bullet s/m^3$) divided by the total release from the source (Ci). Integrated air concentrations used are usually plume centerline values. E/Qs are typically used for releases lasting no longer than 8 to 24 hours.
element	One of the known chemical substances that cannot be divided into simpler substances by chemical means.
endangered species	Plants and animals that are threatened with extinction, serious depletion, or destruction of critical habitat. Requirements for declaring a species endangered are contained in the Endangered Species Act.

energy	The capacity for doing work.
environment	The sum of all external conditions and influences affecting the life development and, ultimately, the survival of an organism.
environmental monitoring	The act of measuring, either continuously or periodically, some quantity of interest, such as radioactive material in the air.
ephemeral stream	A stream channel that carries water only during part of the year, immediately after periods of rainfall or snowmelt.
equilibrium	A state of rest in a chemical or mechanical system. Chemical: The state of a reaction in which its forward and reverse reactions occur at equal rates so that the concentrations of the reactants do not change with time. Mechanical: Forces in one direction are equal and opposite to those in the opposing direction. Flow of salt to fill the excavated cavity is an attempt by the salt to reattain a state of mechanical equilibrium.
erosion	Removal and transport of materials by wind, ice, or water on the earth's surface.
evaporite	A sedimentary rock composed primarily of minerals produced by partial or total evaporation of sea water.
evapotranspiration	Loss of water from the earth's surface to the atmosphere by a combination of evaporation from the soil, lakes, streams, and transpiration from plants.
exposure	A measure of the ionization produced in air by X or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element.
°F	Degree Fahrenheit. $°F = (°C \times 9)/5 + 32$.
fault	A fracture or a zone of fractures along which there has been displacement parallel to the fracture.
fissile	Describes a nuclide that undergoes fission upon absorption of neutrons of any energy.
fission (nuclear)	The splitting of a heavy nucleus typically into two approximately equal parts (infrequently three parts), which are nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or can be induced by nuclear bombardment.
fission product	An element or compound resulting from fission.

formation	A mappable geologic body of rock identified by lithic characteristics and stratigraphic position. Formations may be combined into groups or subdivided into members.
40 CFR Part 191	The U.S. Environmental Protection Agency standard for managing and disposing of spent nuclear fuel and high-level and transuranic wastes. Subpart A deals with managing and storage of wastes, while Subpart B covers long-term isolation and disposal.
fraction	A small part of the total. The particulate fraction is that part of the waste in a particulate form.
gamma	Short-wavelength electromagnetic radiation (high-energy photons) emitted in the radioactive decay of certain nuclides. Gammas are the same as gamma rays or gamma waves.
geology	The science that deals with the earth; the materials, processes, environments, and history of the planet, especially the lithosphere, including the rocks, their formation, and structure.
gross alpha	The total rate of alpha particle emission from a sample, without regard to energy distribution or source nuclides.
gross beta	The total rate of emission of beta particles from a sample, without regard to energy distributions or source nuclides.
groundshine	The pathway of direct external dose from radioactive material that has deposited on the ground after being dispersed from the accident site.
groundwater	All subsurface water, especially that contained in the saturated zone below the water table.
gypsum	A soft mineral consisting of hydrous calcium sulfate: $CaSO_4$**A**$2H_20$.
habitat	The part of the physical environment in which a plant or animal lives.
half-life	Time required for a radionuclide to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life; that is, half of a particular radionuclide will decay in a specified amount of time; then half of the remaining portion will decay in the same amount of time, and so on. Half-life can also refer to the length of time that a chemical/radionuclide/ biological agent remains in the body. Each material has biologically unique half-lives, depending on the substance, the organ of concern, and its route of elimination.
halite	A mineral composed of sodium chloride, NaCl.

hazard index	An indicator of the potential toxicological hazard from exposure to a particular substance. The hazard index is equal to an individual's estimated exposure divided by the U.S. Environmental Protection Agency's substance-specific reference dose.
hazardous waste	Hazardous constituents regulated by the Resource Conservation and Recovery Act and defined in 40 CFR 261 Subparts C and D.
head	When used in a hydraulic sense, it is understood to mean static head. The static head is the height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.
headspace	The space between the container lid and the waste inside the container.
high efficiency particulate air filter	This filter is designed to remove 99.9 percent of particles as small as 0.3 micrometer in diameter from a flowing air stream.
high-level waste	The highly radioactive waste material that results from the reprocessing of spent nuclear fuel. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.
historic resources	The sites, districts, structures, and objects associated with historic events, persons, or social or historic movements.
horizon	A particular layer in a sequence of rock units. The waste-emplacement horizon in the Waste Isolation Pilot Plant is a specific level about 655 meters (2,150 feet) below the surface in the Salado Formation at which openings are being excavated for waste disposal.
hot cell	A heavily shielded enclosure for handling and processing (by remote means or automatically) or storing highly radioactive materials.
hydraulic conductivity	A quantity that describes the rate at which water flows through an aquifer. It has units of length/time and is equal to the hydraulic transmissivity divided by the thickness of the aquifer.
hydraulic gradient	A quantity that describes the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.
igneous	A rock or mineral that crystallizes from magma, molten rock.
immediately dangerous to life and health	A term that represents a maximum airborne concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

in situ	In the natural or original position; i.e., in place.
intensity (earthquake)	A measure of the effects of an earthquake on humans and structures at a particular place. It is measured in numerical units on the modified Mercalli scale.
interbed	A bed of one kind of rock occurring between or alternating with beds of another rock type.
ionization	The process that creates ions. Nuclear radiation, X-rays, high temperatures, and electric discharges can cause ionization.
ionizing radiation	Radiation capable of displacing electrons from atoms or molecules to produce ions.
isotope	An atom of a chemical element with a specific atomic number and atomic weight. Isotopes of the same element have the same number of protons but different numbers of neutrons. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus. For example, uranium-235 is an isotope of uranium with 92 protons and 143 neutrons and uranium-238 is an isotope of uranium with 92 protons and 146 neutrons.
karst	A topography characterized by sinkholes, caves, and disappearing streams formed by dissolution in limestone, dolomite, and evaporite bedrock.
kelvin	A unit of temperature, abbreviated K, equal to the degree Celsius expressed as: $°K = °C + 273$.
lag storage	The storage of TRU waste that has been certified to the WAC and is awaiting shipment to the WIPP facility for disposal.
latent cancer fatalities	Deaths resulting from cancer that has become active after a latent period following radiation exposure. Latent cancer fatalities can be calculated for the public by using the risk conversion factor of $5x10^{-4}$ deaths per person-rem and for the worker by using the risk conversion factor of $4x10^{-4}$ deaths per person-rem.
leaching	The process of extracting a soluble component from a solid by the percolation of a solvent, such as water, through the solid.
lineament	A geologic term for straight or gently curved, linear topographic features.
lithostatic pressure	The vertical pressure at a point in the earth's crust equal to the weight of the overlying column of rock.
Los Medaños	The area in southeastern New Mexico surrounding the Waste Isolation Pilot Plant site. In English, it means "dune country."

low-income population	A population where 25 percent or more of the population is identified as living in poverty.
low-level waste	Radioactive waste not classified as high-level waste, transuranic waste, or uranium or thorium mill tailings.
Magenta Dolomite	The upper of the two dolomite layers within the Rustler Formation that are locally water-bearing.
magnitude (earthquake)	A measure of the total energy released by an earthquake. It is commonly measured in numerical units on the Richter scale. Each unit, e.g. 7, is different from an adjacent unit by a factor of 30.
maximally exposed individual (MEI)	A hypothetical member of the public who is exposed to a release of radioactive or chemically hazardous material in such a way (by combination of location, dietary habits, etc.) that the individual will likely receive the maximum dose from such release.
member	A division of a formation differentiated by separate or distinct lithology or complex of lithologies.
migration	The natural travel of a material through the air, soil, or groundwater.
mitigate	To take practicable means to avoid or minimize environmental harm from a selected alternative.
molecular weight	The weight of a molecule of a chemical expressed in atomic mass units.
Nash Draw	A shallow 8-kilometer- (5-mile-) wide valley open to the southwest located to the west of the Waste Isolation Pilot Plant site.
National Environmental Policy Act	This Act was designed to promote inclusion of environmental concerns in Federal decision-making.
National Register of Historic Places	A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state, or national importance.
noninvolved worker	For this document, a worker who is not involved in the operation of a facility when a radioactive release occurs.
NO_x	Oxides of nitrogen, primarily nitrogen oxide and nitrogen dioxide. These are produced primarily by combustion of fossil fuels, and can constitute an air pollution problem.

nuclide	A species of atom, characterized by its number of protons, number of neutrons, and energy state.
order of magnitude	A multiple of ten. When a measurement is made with a result such as 3×10^7, the exponent of 10 (here 7) is the order of magnitude of that measurement. To say that this result is known to within an order of magnitude is to say that the true value lies between (in this example) 3×10^6 and 3×10^8.
organic compounds	Of or designating carbon compounds. (Some simple compounds of carbon, such as carbon dioxide, are frequently classified as inorganic compounds.)
overpack	A container put around another container. In the Waste Isolation Pilot Plant, overpacks would be used on damaged or otherwise contaminated drums, boxes, and canisters that would not be practical to decontaminate.
oxide	A compound consisting of an element combined with oxygen.
ozone	A molecule of oxygen in which three oxygen atoms are chemically attached to each other.
package	In the regulations governing the transportation of radioactive materials, the packaging together with its radioactive contents as presented for transport.
packaging	A shipping container without its contents.
particulates	Solid particles and liquid droplets small enough to become airborne.
PE-Ci	Plutonium-239 equivalent curies are used as a radioactive hazard index factor that relates the radiotoxicity of transuranic radionuclides to that of plutonium-239.
permeability	The capability of a soil or rock to transmit a fluid.
person-rem	A measure of the radiation dose to a given population; the sum of the individual radiation doses received by that population.
pH	A measure of the hydrogen ion concentration in aqueous solution. Pure water has a pH of 7, acidic solutions have a pH less than 7, and alkaline solutions have a pH greater than 7.
physiographic	Geographic regions based on geologic setting.

planning-basis Waste Acceptance Criteria	The U.S. Department of Energy document, currently in revision number 5, that describes the criteria by which unclassified transuranic waste will be accepted for emplacement at the Waste Isolation Pilot Plant and the basis on which these criteria were established. The current planning-basis for waste acceptance criteria is a compendium of the minimal requirements established by law, regulation, and U.S. Department of Energy orders that transuranic waste must meet to be transported to and disposed of at the Waste Isolation Pilot Plant. The treatment selected pursuant to the Supplemental Environmental Impact Statement-II analyses could result in modifications to the waste acceptance criteria.
PM_{10}	Particulate matter with a 10-micron or less aerodynamic diameter.
point source	A source of effluents that is small enough in dimensions that it can be treated as if it were a point. The converse is a diffuse source. A point source can be either a continuous source or a source that emits effluents only in puffs or for a short time.
pollution	The addition of an undesirable agent to the environment in excess of the rate at which natural processes can degrade, assimilate, or disperse it.
polyhalite	A relatively hard and brittle evaporite mineral: $K_2MgCa_2(SO_4)_4\mathbf{A}\cdot 2H_2O$. In the Delaware Basin, it is often associated with anhydride.
population dose	The sum of the radiation doses received by the individual members of a population.
population-weighted E/Q	A measure of the atmospheric dispersion across an entire populated sector following an acute release. For a given 22.5° compass sector, it is the sum of the product of the E/Q and the population for each of the ten segments comprising the sector, with units of person•s/m^3. (See also E/Q [E over Q].)
porosity	Percentage of void space in a material.
potash	Potash is the common industrial term for potassium in various chemical combinations with sodium, magnesium, chlorine, and sulfate.
potentiometric surface	Surface to which water in an aquifer would rise by hydrostatic pressure. It is usually represented in figures as a contour map, in which each point indicates how high the water would rise in a well tapping that aquifer at that point.
progeny	Stable or radioactive elements formed by the radioactive decay of another nuclide, which is the “parent.”
pyrophoric	Spontaneously igniting in air; producing sparks by friction.

Quality Factor	A modifying factor used to calculate the dose equivalent from absorbed dose. The quality factor can vary by type and energy of the ionizing radiation.
radiation	Ionizing radiation; e.g., alpha particles, beta particles, gamma rays, X-rays, neutrons, protons, and other particles capable of producing ion pairs in matter. As used in this document, radiation does not include nonionizing radiation.
radioactive decay	The spontaneous transformation of one nuclide into a different nuclide or into a different state of the same nuclide. The process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).
radioactive waste	Materials from nuclear operations that are radioactive or are contaminated with radioactive materials and for which there is no practical use or for which recovery is impractical.
radioactivity	The property or characteristic of radioactive material to undergo spontaneous transformations (“disintegrations” or “decay”) with the emission of energy in the form of radiation. It means the rate of spontaneous transformations of a radionuclide. The unit of radioactivity is the curie (or becquerel). (1 curie = 3.7×10^{10} becquerel).
radionuclide	A nuclide that emits radiation by spontaneous transformation.
radionuclide inventory	A list of the kinds and amounts of radionuclides in a container or a source. Amounts are usually expressed in activity units: curies or curies per unit volume.
recharge	In groundwater hydraulics, the addition of water to the zone of saturation; also, the amount of water added.
Record of Decision	The document, publicly available, by which a Federal department or agency decides on an alternative presented and evaluated through the environmental impact statement process.
reference dose	The reference dose is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime (subchronic reference dose), or during a lifetime (chronic reference dose).
rem	A common (or special) unit of dose equivalent, effective dose equivalent, or committed dose equivalent.
remote-handled transuranic waste	TRU waste that requires shielding in addition to that provided by the container to protect people nearby from radiation exposure. By definition, the radiation level at the outer surface of the container is greater than 200 millirem per hour and less than 1,000 rem per hour.

repository	A facility for disposal of radioactive waste.
reserves	Mineral resources that can be extracted profitably by existing techniques and under present economic conditions.
Resource Conservation and Recovery Act	This Act was designed to provide “cradle to grave” control of hazardous chemical wastes.
resources	Mineralization that is concentrated enough, in large enough quantity, and in a physical and chemical form such that its extraction may be possible in the future.
retrievable storage	Storage of radioactive waste in a manner designed for recovery without loss of control or release of radioactivity.
RH-72B	A packaging designed to transport remote-handled transuranic waste. The cask is a circular cylinder providing shielding from the radioactive contents. The cask is designed to provide double containment of a vented canister that is 3 meters (10 feet) long by 0.67 meter (2.2 feet) in diameter. The vented canister weighs 1,000 kilograms (2,200 pounds) and has a payload of approximately 2,631 kilograms (5,800 pounds), which is approximately 0.89 cubic meters (31 cubic feet) of waste.
risk	The likelihood of suffering a detrimental effect as a result of exposure to a hazard. In accident analysis, the probability weighted consequence of an accident, defined as the accident frequency per year multiplied by the consequence.
runoff	The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and either infiltrates or eventually returns to streams.
Rustler Formation	The evaporite beds, including mudstones, of Permian age that immediately overlie the Salado Formation in which the Waste Isolation Pilot Plant disposal levels are built.
Salado Formation	The Permian Age evaporite unit within which wastes would be disposed of in the Waste Isolation Pilot Plant repository.
San Simon Swale	A broad depression about 24 kilometers (15 miles) east of the Los Medaños site, open to the southeast.
scenario	A set of conditions presumed for the purpose of estimating doses by analysis.
seismicity	All of the earthquakes that may occur in a region, regardless of magnitude.
shaft	A man-made hole, either vertical or steeply inclined, that connects the surface with an underground excavation.

shield	Material used to reduce the intensity of radiation that would irradiate personnel or equipment.
slurry	A suspension of fine particles in a liquid, in which the solid constituents are easily carried along by the liquid.
solubility	The degree to which a compound in its pure state will dissolve; water is the solvent used for determining aqueous solubility of a compound.
sorption	The binding on a microscopic scale of one substance to another, such as by adsorption or ion exchange.
source term	The kinds and amounts of radionuclides that may lead to an assumed release of radioactive material.
spent fuel or spent nuclear fuel	Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.
storage	Temporary placement of waste in a facility. Storage usually implies the need for continued surveillance.
strata	Layers of rock.
stratigraphy	The study of layered sequences of rocks.
surface water	A creek, stream, river, pond, lake, bay, sea, or other waterway that is directly exposed to the atmosphere.
tectonic activity	Movement of the earth's crust, produced by internal forces, such as uplift, subsidence, folding, faulting, and seismic activity.
Ten Drum Overpacks	A metal container (73 inches high and 72 inches in outside diameter) similar to the standard waste box, designed to efficiently use the inner containment vessel of the TRUPACT-II. Authorized packaging configurations are as follows: ten 55-gallon drums, one standard waste box, or four 55-gallon drums within a standard waste box.
threatened species	Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Requirements for declaring a species threatened are contained in the Endangered Species Act.
throughput	The number of TRUPACT-IIs and RH-72Bs capable of being processed at the WIPP Waste Handling Building in a given time period (i.e., 50 TRUPACT-IIs and 8 RH-72Bs per week).
total effective dose equivalent	The sum of the effective dose equivalent from radiation sources external to the body during the year plus the committed effective dose equivalent from

radionuclides taken into the body. A 50-year time interval is assumed for determining committed dose.

TRANSCOM — A satellite-based tracking and communication system established by the U.S. Department of Energy.

transmissivity — A quantity defined in the study of groundwater hydraulics that describes the rate at which water may be transmitted through an aquifer. It has units of length^2/time.

transmutation — Any process in which a nuclide is transformed into a different nuclide, or more specifically, when transformed into a different element by a nuclear reaction.

transuranic mixed waste — Transuranic waste that is commingled with Resource Conservation Recovery Act-regulated hazardous wastes as defined in 40 CFR Part 261, Subparts C and D.

transuranic radionuclide — A nuclide with an atomic number (number of protons) greater than that of uranium (92). All transuranic radionuclides are radioactive.

transuranic waste — Waste materials (excluding high-level waste and certain other waste types) contaminated with alpha-emitting radionuclides that are heavier than uranium with half-lives greater than 20 years and occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from plutonium reprocessing and fabrication as well as research activities at U.S. Department of Energy defense installations.

TRUPACT — Transuranic Package Transporter.

TRUPACT-II — TRUPACT-II is the package designed to transport contact-handled transuranic waste to the Waste Isolation Pilot Plant site. It is a cylinder with a flat bottom and a domed top that is transported in the upright position. The major components of the TRUPACT-II are an inner, sealed, stainless steel containment vessel within an outer, sealed, stainless steel containment vessel. Each containment vessel is nonvented and capable of withstanding 345 kilopascals (50 pounds per square inch) of pressure. The inner containment vessel cavity is 1.8 meters (6 feet) in diameter and 2 meters (6.75 feet) tall, with a capability of transporting fourteen 0.21-cubic-meter (55-gallon) drums, two standard waste boxes, or one 10-drum overpack.

tuff — Volcanic rock formed of welded or compacted volcanic ash.

void volume — That part of the total volume not occupied by the solid volume. The void volume may contain either liquid or gas.

volatile organic compound — Any compound containing carbon and hydrogen in combination with any other element that has a vapor pressure of 77.6 millimeters of mercury (1.5 pounds per square inch) absolute or greater under actual storage conditions.

volatilization — To evaporate at normal temperatures and pressures.

vug — A cavity, often with a mineral coating of different composition than the surrounding rock.

Waste Acceptance Criteria (WAC) — A set of minimum waste characteristics criteria that the U.S. Department of Energy has established as a planning basis for waste that would be emplaced at the Waste Isolation Pilot Plant. Should disposal operations at the Waste Isolation Pilot Plant be approved, these planning-basis criteria (or some modification of them) would become the WAC. The WAC may change based on decisions in the Record of Decision for SEIS-II that change these minimum requirements.

waste form — The condition of the waste. This phrase is used to emphasize the physical and chemical properties of the waste.

Waste Isolation Pilot Plant — The facility near Carlsbad, New Mexico, that has been designated to be an operational site for evaluating disposal capabilities of bedded salt for U.S. Department of Energy-generated transuranic waste.

waste matrix — The material that surrounds and contains the waste and, to some extent, protects it from being released into the surrounding rock and groundwater. Only material within the canister (or drum or box) that contains the waste is considered part of the waste matrix.

$\overline{X}/Q'$ (chi-bar over Q prime) — A measure of the average atmospheric dispersion for long-term (chronic) atmospheric releases using a gaussian dispersion plume modeling, with units of s/m^3. For a given point or location at some distance from the source, it represents the average air concentration in Ci/m^3 divided by the release rate (Ci/s). Typically, the concentration used is the average centerline value for individuals and is averaged over a specific sector of a polar grid surrounding the release point for populations. $\overline{X}/Q'$s are used for long-term (chronic) releases, often on the order of months or years.

ACRONYMS AND ABBREVIATIONS

3D	three dimensional
µR/hr	microroentgen per hour
ACGIH	American Conference of Governmental Industrial Hygienists
AEC	U.S. Atomic Energy Commission
AIHA	American Industrial Hygiene Association
AIS	Air Intake Shaft
ALARA	as low as reasonably achievable
Ames	Ames Laboratory-Iowa State University
ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
AQCR	Air Quality Control Regulations
ARCO	ARCO Medical Products Company
ATSF	Atchison, Topeka, and Santa Fe Railroad
BBER	Bureau of Business and Economic Research of the University of New Mexico
BCL	Battelle Columbus Laboratories
BEIR-III	1980 report of the Committee on Biological Effects of Ionizing Radiation of the National Academy of Sciences/National Research Council.
BEMR	Baseline Environmental Management Report
Bettis	Bettis Atomic Power Laboratory
BIR-2	Baseline Inventory Report, Revision 2
BIR-3	Baseline Inventory Report, Revision 3
BLM	U.S. Bureau of Land Management
BNL	Brookhaven National Laboratory
Bq	becquerel
BSEP	Brine Sampling and Evaluation Program
°C	degree Celsius
C&C	Agreement for Consultation and Cooperation
CAO	Carlsbad Area Office
CAST	Colorado Allstate Trucking
CCA	Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant
CCDF	Complementary Cumulative Distribution Function
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CH_4	methane
CH-TRU	contact-handled transuranic
Ci	curie
cm^2	square centimeters
CMR	Central Monitoring Room
CO	carbon monoxide
CO_2	carbon dioxide
CoC	contaminant of concern

CR	concentration ratio
CSR	Compliance Status Report
D&D	decontamination and decommissioning
DBE	design-basis earthquake
DCF	dose conversion factor
Department	U.S. Department of Energy
DDREF	Dose and Dose Rate Effectiveness Factor
DF	dose factor
DLR	Dewey Lake Redbeds
DOE	U. S. Department of Energy
DOT	U.S. Department of Transportation
DRZ	disturbed rock zone
EA	Environmental Assessment
EEG	Environmental Evaluation Group
EIS	Environmental Impact Statement
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
E/Q	atmospheric dispersion factor for short-term releases
ER	environmental restoration
ERPG	Emergency Response Planning Guideline
ETEC	Energy Technology Engineering Center
°F	degree Fahrenheit
FEIS	Final Environmental Impact Statement for the Waste Isolation Pilot Plant
FEPs	features, events, and processes
FFCAct	Federal Facility Compliance Act
FGE	fissile-gram equivalent
F.I.R.E.	Fire, Insurance and Real Estate
FONSI	finding of no significant impact
FR	Federal Register
FRA	Federal Railroad Administration
ft^3	cubic feet
FY	fiscal year
GENII	Generation II Code Package
H_2S	hydrogen sulfide
Hanford	Hanford Site
HEPA	high-efficiency particulate air
HI	hazard index
hour/km	hours per kilometer
HQ	DOE Headquarters
HRCQ	highway route-controlled quantities
ICC	Interstate Commerce Commission
ICRP	International Commission on Radiological Protection
IDB	Integrated Data Base
IDLH	immediately dangerous to life or health
IMPLAN	IMpact analysis for PLANing
INEEL	Idaho National Engineering and Environmental Laboratory
IRIS	Integrated Risk Information System
ISC3	Industrial Source Complex computer code
ISCLT3	Industrial Source Complex long-term model

ISCST3	Industrial Source Complex short-term model
kg	kilogram
kg/m^3	kilograms per cubic meter
Knolls	Knolls Atomic Power Laboratory
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LCF	latent cancer fatality
LDR	Land Disposal Restrictions
LET	linear energy transfer
LLNL	Lawrence Livermore National Laboratory
LWA	Waste Isolation Pilot Plant Land Withdrawal Act
m^3	cubic meters
MAP	Mitigation Action Plan
MB	marker bed
MEI	maximally exposed individual
mg	milligram
mg/m^3	milligrams per cubic meter
MgO	magnesium oxide
mg/s	milligrams per second
mi	mile
ml	milliliter
Mound	Mound Plant
MOU	Memorandum of Understanding
mph	miles per hour
MRA	modular risk analysis
mrem	millirem
mrem/hr	millirem per hour
MSHA	Mining Safety and Health Administration
m/s	meters per second
MWIR95	Mixed Waste Inventory Summary Report 1995
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEFTRAN	Network Flow and Transport
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIOSH	National Institute of Occupational Safety and Health
NM	New Mexico
NMDG&F	New Mexico Department of Game and Fish
NMDOL	New Mexico Department of Labor
NMED	New Mexico Environment Department
NMEMNR	New Mexico Energy, Minerals, and Natural Resources Department
NO_2	nitrogen dioxide
NOA	Notice of Availability
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission

NRHP	National Register of Historic Places
NSC	National Safety Council
NTS	Nevada Test Site
NUTS	Nuclide Transport System
O_3	ozone
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
Pa	Pascal
Pantex	Pantex Plant
Pb	lead
PCB	polychlorinated biphenyl
pCi	picocurie
PE-Ci	plutonium-239 equivalent curies
PEIS	Programmatic Environmental Impact Statement
PEL	permissible exposure limit
PGDP	Paducah Gaseous Diffusion Plant
PIC	Passive Institutional Controls
PM_{10}	particulate matter less than or equal to 10 micrometers in diameter
PNNL	Pacific Northwest National Laboratory
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million volume
PSD	prevention of significant deterioration
RBP	Radiological Baseline Program
RC	retrieval and characterization
RCRA	Resource Conservation and Recovery Act
RfD	reference dose levels
RFETS	Rocky Flats Environmental Technology Site
RH-72B	remote-handled transuranic waste shipping container (proposed)
RH-TRU	remote-handled transuranic
ROD	Record of Decision
ROI	region of influence
RSPA	Research and Special Programs Administration
SAR	Safety Analysis Report
SEIS-I	Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant
SEIS-II	Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement
s/m^3	seconds per cubic meter
s/mg	seconds per milligram
SIC	Standard Industrial Classification
SMC	Salado Mass Concrete
SNL	Sandia National Laboratories
SNL-CA	Sandia National Laboratories, California
SNM	special nuclear material
SO_2	sulfur dioxide

SO_x	oxides of sulfur
SPM	Systems Prioritization Methodology
SRS	Savannah River Site
STEL	short-term exposure limit
SVOC	semivolatile organic compound
SWB	standard waste box
SWIFT II	Sandia Waste Isolation Flow and Transport (computer software)
TBE	Teledyne Brown Engineering
TCC	TRANSCOM Control Center
TCLP	Toxicity Characteristic Leaching Procedure
TDEM	time-domain electromagnetic
TDOP	Ten Drum Overpack
TDS	total dissolved solids
TEDE	total effective dose equivalent
TI	transportation index
TRANSCOM	Transportation Tracking and Communications System
TRC	total recordable case
TRU	transuranic
TRUCON	TRUPACT Content Codes
TRUPACT-II	Transuranic package transporter - II
TSCA	Toxic Substance Control Act
TSP	total suspended particulates
TWA	time-weighted average
UDF	unit dose factor
UEF	unit exposure factor
UIF	unit impact factor
U of Mo	University of Missouri
USAMC	U.S. Army Materiel Command
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
VR	volume ratio
W	watts
WAC	planning-basis Waste Acceptance Criteria
WAC-4	Waste Acceptance Criteria, revision 4
WAC-5	Waste Acceptance Criteria, revision 5
WGA	Western Governors Association
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WM PEIS	Final Waste Management Programmatic Environmental Impact Statement
WVDP	West Valley Demonstration Project
$\overline{X}/Q'$	atmospheric dispersion factor for chronic releases

This page intentionally left blank.

MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this supplemental environmental impact statement (SEIS-II). Definitions of technical terms can be found in the Glossary.

EXPONENTIAL NOTATION

Exponential notation is used in SEIS-II to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using exponential notation, as 1E+9. Translating from exponential notation to a more traditional number requires moving the decimal point either right (for a positive number after the E) or left (for a negative number after the E). If the value given is 5.0E+2, move the decimal point two places (insert zeros if no numbers are given) to the right of its present location. The result would be 500. If the value given is 5.0E-4, move the decimal point four places to the left of its present location. The result would be .0005.

ROUNDING

Some numbers in SEIS-II have been rounded, therefore sums and products throughout the document may not be consistent. A number was rounded only after all calculations using that number had been made. Numbers that are actual measurements were not rounded.

The waste volumes were rounded in the following manner:

124,756.2	rounded to	125,000
61,423.7	rounded to	61,000
1,476.4	rounded to	1,500
242.4	rounded to	240
16.7	rounded to	17
8.5	rounded to	9
0.3	rounded to	1

The total waste volumes for the proposed action were not rounded because these volumes were established by the Waste Isolation Pilot Plant Land Withdrawal Act.

UNITS OF MEASURMENT

The primary units of measurement used in this report are metric units with English equivalents enclosed in parentheses. DOE Order 5900.2A, " Use of the Metric System of Measurement," prescribes the use of this system in DOE documents. Table MC-1 lists the mathematical values or formulas needed for conversion between metric and English units. Table MC-2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

Table MC-1
Metric Conversion Chart

To Convert to Metric			To Convert out of Metric		
If You Know	**Multiply By**	**To Get**	**If You Know**	**Multiply By**	**To Get**
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
gallons	0.00378	cubic meters	cubic meters	264.55	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.038	cubic yards
Weight					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.45360	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths then add 32	Fahrenheit
Force					
pounds per square inch	6,895	pascals	pascals	0.000145	pounds per square inch

Table MC-2
Names and Symbols for Units of Measure

Length

Symbol	Name
cm	centimeter
ft	foot
in	inch
km	kilometer
m	meter
mi	mile
mm	millimeter
µm	micrometer

Numerical Relationships

Symbol	Meaning
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
2σ	two standard deviations

Volumes and Concentrations

Symbol	Name
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
in^3	cubic inches
L	liter
m^3	cubic meter
mL	milliliter
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard

Rate

Symbol	Name
m^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
km/h	kilometers per hour
mi/h	miles per hour

Sound

Symbol	Name
dB	decibel
dBA	A-weighted decibel

Area

Symbol	Name
ac	acre
cm^2	square centimeter
ft^2	square foot
ha	hectare
in^2	square inch
km^2	square kilometer
mi^2	square mile

Mass

Symbol	Name
g	gram
kg	kilogram
mg	milligram
µg	microgram
ng	nanogram
lb	pound
ton	metric ton (1E + 6 g)

Temperature

Symbol	Name
°C	degrees Centigrade
°F	degrees Fahrenheit
°K	degrees Kelvin

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). Table MC-3 presents these metric prefixes.

Table MC-3
Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa	E	1 000 000 000 000 000 000 = 10^{18}
peta	P	1 000 000 000 000 000 = 10^{15}
tera	T	1 000 000 000 000 = 10^{12}
giga	G	1 000 000 000 = 10^{9}
mega	M	1 000 000 = 10^{6}
kilo	k	1 000 = 10^{3}
hecto	h	100 = 10^{2}
deka	da	10 = 10^{1}
deci	d	0.1 = 10^{-1}
centi	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro	µ	0.000 001 = 10^{-6}
nano	n	0.000 000 001 = 10^{-9}
pico	p	0.000 000 000 001 = 10^{-12}
femto	f	0.000 000 000 000 001 = 10^{-15}
atto	a	0.000 000 000 000 000 001 = 10^{-18}

RADIOACTIVITY UNITS

Sections of SEIS-II deal with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC-4). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of both.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of rem (Table MC-5). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in the section entitled Select Radionuclides.

CHEMICAL ELEMENTS

A list of chemical elements, chemical constituents, and their nomenclature is presented in Table MC-6.

Table MC-4
Names and Symbols for Units of Radioactivity

Radioactivity	
Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1E-3 Ci)
µCi	microcurie (1E-6 Ci)
nCi	nanocurie (1E-9 Ci)
pCi	picocurie (1E-12 Ci)

Table MC-5
Names and Symbols for Units of Radiation Dose

Radiation Dose	
Symbol	Name
mrad	millirad (1E-3 rad)
mrem	millirem (1E-3 rem)

Table MC-6
Elemental and Chemical Constituent Nomenclature

Symbol	Constituents	Symbol	Constituents
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
B	boron	Pu	plutonium
Be	beryllium	SF_6	sulfur hexafluoride
CO	carbon monoxide	Si	silicon
CO_2	carbon dioxide	SO_2	sulfur dioxide
Cu	copper	Ta	tantalum
F^-	fluoride	Th	thorium
Fe	iron	Ti	titanium
MgO	magnesium oxide	U	uranium
N	nitrogen	UO_2	uranium oxide
Ni	nickel	V	vanadium
NO_2-	nitrite	W	tungsten
NO_3-	nitrate	Zn	zinc

This page intentionally left blank.

HALF-LIVES OF SELECT RADIONUCLIDES

Symbol	Radionuclide	Half-Life
Ac-225	Actinium-225	10.0 days
Ac-227	Actinium-227	21.8 years
Ac-228	Actinium-228	6.13 hours
Ag-109m	Silver-109m	39.8 seconds
Am-241	Americium-241	432 years
Am-243	Americium-243	7,380 years
At-217	Astatine-217	32 milliseconds
Ba-137m	Barium-137m	2.55 minutes
B-7	Boron-7	53.4 days
Bi-210	Bismuth-210	5.01 days
Bi-212	Bismuth-212	60.6 minutes
Bi-213	Bismuth-213	46 minutes
Bi-214	Bismuth-214	19.8 minutes
Bk-249	Berkelium-249	311 days
C-14	Carbon-14	5,730 years
Cd-109	Cadmium-109	453 days
Ce-144	Cerium-144	284 days
Cf-249	Californium-249	352 years
Cf-252	Californium-252	2.64 years
Cm-242	Curium-242	163 days
Cm-243	Curium-243	28.5 years
Cm-244	Curium-244	18.1 years
Cm-245	Curium-245	8,500 years
Cm-246	Curium-246	4,730 years
Cm-247	Curium-247	1.56E + 7 years
Cm-248	Curium-248	3.39 E + 5 years
Co-60	Cobalt-60	5.27 years
Cs-134	Cesium-134	2.06 years
Cs-137	Cesium-137	30.0 years
Eu-152	Europium-152	13.33 years
Eu-154	Europium-154	8.8 years
Eu-155	Europium-155	4.96 years
Fr-221	Francium-221	4.8 minutes
H-3	Hydrogen-3	12.4 years
I-129	Iodine-129	1.57E + 7 years
Kr-85	Krypton-85	10.7 years
Ni-63	Nickel-63	96 years
Np-237	Neptunium-237	2.14E + 6 years
Np-239	Neptunium-239	2.35 days
Pa-231	Protactinium-231	3.28E + 4 years
Pa-233	Protactinium-233	27.0 days

Symbol	Radionuclide	Half-Life
Pa-234m	Protactinium-234m	1.17 minutes
Pb-209	Lead-209	3.25 hours
Pb-210	Lead-210	22.3 years
Pb-212	Lead-212	10.6 hours
Pb-214	Lead-214	26.8 minutes
Pm-147	Promethium-147	2.62 years
Po-210	Polonium-210	138 days
Po-212	Polonium-212	0.305 microseconds
Po-213	Polonium-213	4.2 microseconds
Po-214	Polonium-214	164 microseconds
Po-216	Polonium-216	0.15 microseconds
Po-218	Polonium-218	3.05 minutes
Pr-144	Praseodymium-144	17.3 minutes
Pu-236	Plutonium-236	2.85 years
Pu-238	Plutonium-238	87.7 years
Pu-239	Plutonium-239	24,065 years
Pu-240	Plutonium-240	6,537 years
Pu-241	Plutonium-241	14.4 years
Pu-242	Plutonium-242	3.76E + 5 years
Pu-244	Plutonium-244	8.26E + 7 years
Ra-223	Radium-223	11.4 days
Ra-226	Radium-226	1,600 years
Ra-228	Radium-228	5.75 years
Rn-220	Radon-220	55.6 seconds
Rn-222	Radon-222	3.82 days
Ru-106	Ruthenium-106	368 days
Sb-125	Antimony-125	2.77 years
Sm-151	Samarium-151	90 years
Sr-90	Strontium-90	29.1years
Tc-99	Technetium-99	2.13E + 5 years
Th-228	Thorium-228	1.91 years
Th-230	Thorium-230	7.7E + 4 years
Th-232	Thorium-232	1.41E + 10 years
U-232	Uranium-232	72 years
U-233	Uranium-233	1.59E + 5 years
U-234	Uranium-234	2.45E + 5 years
U-235	Uranium-235	7.04E + 8 years
U-236	Uranium-236	2.34E + 7 years
U-238	Uranium-238	4.47E + 9 years
Y-90	Yttrium-90	64.0 hours
Zr-95	Zirconium-95	64.0 days

This page intentionally left blank.

CHAPTER 1
INTRODUCTION

This chapter presents the underlying purpose and need for action, the National Environmental Policy Act (NEPA) compliance history for the Waste Isolation Pilot Plant (WIPP), the need for the second supplemental environmental impact statement (SEIS-II), the relationship of SEIS-II to other planning documents, and a description of the contents of this document.

1.1 PURPOSE AND NEED FOR ACTION

The U.S. Department of Energy (DOE or the Department) needs to dispose of transuranic (TRU) waste generated by past, present, and future activities in a manner that protects public health and the environment. In previous NEPA documents, the Department examined alternatives to repository disposal at WIPP. In this document, the Department assesses whether and, if so, how to dispose of TRU waste at WIPP.

1.2 OVERVIEW

TRU waste has been generated since the 1940s as part of the nuclear defense research and production activities of the federal government. Several types of operations (current, past, or future) have generated or will generate TRU waste: (1) nuclear weapons development and manufacturing, (2) plutonium recovery, stabilization, and management, (3) research and development, (4) environmental restoration, and decontamination and decommissioning, (5) waste management, and (6) testing at private institutions and universities under DOE contract.

Until about 1970, TRU waste, then classified as low-level waste, was disposed of in shallow trenches without an intent to retrieve it. In 1970, it was determined that TRU waste should be isolated and disposed of in a different manner than low-level waste. Thus, the Atomic Energy Commission, a DOE predecessor agency, adopted a policy

TRANSURANIC WASTE

TRU waste is defined as "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste, (B) waste that the Secretary has determined, with concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; or (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations" (WIPP Land Withdrawal Act, Public Law 102-579).

TRU elements, each having several isotopes, are radioactive and typically man-made. The half-lives of many are considerably longer than 20 years. For instance, the half-life of one isotope of plutonium is 24,000 years.

TRU waste is further classified as contact-handled (CH) TRU waste or remote-handled (RH) TRU waste. CH-TRU waste has radioactivity levels that are low enough to permit workers to directly handle the containers in which the waste is kept. This level of radioactivity is specified as a dose rate of no more than 200 millirems per hour (mrem/hr) at the outside surface of the container. RH-TRU waste has a surface dose rate greater than 200 mrem/hr, so workers use remote manipulators to handle containers of RH-TRU waste. TRU mixed waste is CH-TRU or RH-TRU waste that also contains hazardous materials, such as lead or organic solvents regulated by the Resource Conservation and Recovery Act (RCRA).

HIGHLIGHTS OF CHANGES SINCE PUBLICATION OF THE DRAFT SEIS-II

In response to stakeholder comments and requests and in an effort to ensure that SEIS-II incorporates the Department's latest planning efforts, changes have been made throughout SEIS-II since its publication in draft form in November 1996. Sidebars are used throughout the document to indicate where changes have been made. No sidebars, though, are used to indicate changes to text boxes, figures, or tables. Below is a list of some notable modifications:

- Two sites have been removed from the tables and the maps presented throughout the document. These two sites, the Pantex Site and Teledyne Brown Engineering, have moved the small amount (less than 1 cubic meter) of TRU waste reported in the Draft SEIS-II to Los Alamos National Laboratory and Rocky Flats Environmental Technology Site, respectively. Since they no longer have TRU waste, the impacts from the waste originating at these two sites are included in the impacts for Los Alamos National Laboratory and Rocky Flats Environmental Technology Site.

- Additional text boxes have been added to Chapter 3 and Chapter 5 that discuss the impacts of waste not disposed of in WIPP under the Proposed Action. Also, additional text has been added to Chapter 3 and Chapter 5 that discusses methods of reducing the period of disposal operations for each Action Alternative to 75 years or less and how impacts would change should DOE choose to use those methods.

- The Proposed Action has been identified as DOE's Preferred Alternative, although rail transportation would continue to be an option for future transportation of TRU waste.

- Additional discussions of current socioeconomic conditions and of WIPP site geology and hydrology have been added to Chapter 4.

- All references to planning documents and to related NEPA documents have been updated. New documents have been reviewed and changes to SEIS-II have been made as needed to ensure consistency with other planning efforts.

- A new appendix (Appendix J) has been added to discuss updated TRU waste inventory estimates and current TRU waste management initiatives.

- The analyses presented in Chapter 5 and in the appendices have been reviewed, redone as necessary, and their presentation revised, based on stakeholder comments on the draft. (See the summary of comments and changes in the Summary text box titled "Issued Raised During the SEIS-II Public Comment Period.")

- Performance assessment analyses have been redone based on stakeholder comments and requests. Two particular changes should be noted. First, new analyses indicate that in this document's most conservative scenarios, radionuclides and heavy metals would reach the Culebra Dolomite should a drilling intrusion occur. Second, the performance assessment results for No Action Alternative 2 have been reduced from 2,325 fatalities to 800 fatalities during 10,000 years. Neither number, though, takes into account potential deaths due to inadvertent intrusion. Chapter 5 now includes estimates of the impacts of intrusion.

- Volume III, the *Comment Response Document*, has been added to SEIS-II. Nearly 4,000 comments were received on the Draft SEIS-II. Those comments are summarized and responses to those comments are presented in the *Comment Response Document*.

requiring that TRU waste be placed in containers and stored in a manner so as to be retrievable from storage within 20 years. The most recent estimates of TRU waste are presented in *The National Transuranic Waste Management Plan* (DOE 1996h). According to *The National Transuranic Waste Management Plan*, approximately 102,025 cubic meters (3.6 million cubic feet) of defense CH-TRU waste and 1,941 cubic meters (69,000 cubic feet) of defense RH-TRU waste are in retrievable storage at waste sites around the country. Defense TRU waste is TRU waste that has been generated due to defense activities.

In addition to the currently stored TRU waste, defense CH-TRU and RH-TRU waste would continue to be generated through the year 2033 from continuing site activities, waste management activities, and decontamination and decommissioning of DOE facilities. The most current estimate for newly generated CH-TRU waste is 38,437 cubic meters (1.4 million cubic feet) and for newly generated RH-TRU waste is 2,816 cubic meters (100,000 cubic feet). These estimates are less than previous estimates, mainly due to changes when decommissioning and decontamination activities may occur. (See Appendix J for additional discussion of *The National Transuranic Waste Management Plan* volumes.)

LAND WITHDRAWAL ACT (LWA) LIMITS

The LWA limits the amount and types of TRU waste that can be emplaced at WIPP. The limits include the following:

- WIPP capacity is limited to 175,600 cubic meters (6.2 million cubic feet) total TRU waste by volume.
- No more than 5 percent by volume of RH-TRU waste may have a surface dose rate in excess of 100 rem per hour.
- No RH-TRU waste may have a surface dose rate in excess of 1,000 rem per hour.
- RH-TRU waste containers shall not exceed 23 curies per liter maximum activity level averaged over the volume of the container.
- The total curies of RH-TRU waste shall not exceed 5,100,000 curies.

In addition the Consultation and Cooperation Agreement (C&C Agreement) with the State of New Mexico limits the volume of RH-TRU waste to 7,080 cubic meters (250,000 cubic feet).

To conservatively estimate potential impacts, analyses in SEIS-II are based on the larger total volumes in the earlier *Transuranic Waste Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996e), which incorporates the waste volumes of its second revision (BIR-2) (DOE 1995j), although analyses based on *The National Transuranic Waste Management Plan* are also included (see Appendix J and Section 5.13). The SEIS-II estimates, based on BIR-3, include 62,000 cubic meters (2.2 million cubic feet) of stored defense CH-TRU waste and 3,600 cubic meters (127,000 cubic feet) of stored defense RH-TRU waste. SEIS-II estimates also include 73,000 cubic meters (2.6 million cubic feet) of newly generated defense CH-TRU waste and 32,000 cubic meters (1.1 million cubic feet) of newly generated defense RH-TRU waste that will be generated through 2033.

DOE estimates that approximately 138,000 cubic meters (4.9 million cubic feet) of CH-TRU waste and 3,100 cubic meters (108,000 cubic feet) of RH-TRU waste was previously disposed of by near surface burial. Disposal of this buried waste at WIPP (if excavated) is also considered under SEIS-II action alternatives. Table 1-1 shows the TRU waste inventory.

Table 1-1
Current and Anticipated DOE TRU Waste (in cubic meters) [a]

Type	CH-TRU Waste	RH-TRU Waste
Stored Through 1995	62,000	3,600
Newly Generated Through 2033 [b]	73,000	32,000
PCB-Commingled	720	0
Commercial/Nondefense	200	450
Previously Disposed of Nondefense	138,000	3,100

[a] The inventory for SEIS-II is based on BIR-3 (DOE 1996e). More recent volumes are presented in Appendix J.
[b] Defense TRU waste.

Continued storage of TRU waste at the generator-storage sites poses potential problems. For example, some of the metal drums used to store TRU waste are showing signs of corrosion, and the contents of these drums eventually will have to be repackaged. Additional storage facilities would be needed at the generator-storage sites. Additional worker exposures to penetrating radiation would occur due to repackaging and inspection of waste containers. New treatment capacity would also be needed because much of the TRU mixed waste (which is about 60 percent of the waste volume discussed above) is subject to Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR) and cannot be placed in or on the land unless it is treated to satisfy those restrictions. However, recent amendments to the Land Withdrawal Act (LWA) allow WIPP to accept RCRA waste without meeting the restrictions. Also, continued storage at certain sites may require modification of legally binding agreements between DOE, the U.S. Environmental Protection Agency (EPA), and/or the states where the waste is located.

In recognition of the potential problems posed by continued storage of TRU waste, the Congress passed The National Security and Military Applications of Nuclear Energy Act of 1980 (Public Law 96-164) authorizing DOE to develop a research and development facility to demonstrate the safe disposal of radioactive waste that has resulted or will result from defense activities and that is exempted from regulation by the U.S. Nuclear Regulatory Commission (NRC) (i.e., defense TRU waste).

This legislation resulted in the design of a centralized repository for the disposal of TRU waste (after appropriate NEPA review—see below) known as WIPP. The site selected for the repository is located approximately 50 kilometers (30 miles) east of Carlsbad, New Mexico. In 1992, Congress confirmed the need for the disposal of TRU waste by passage of the WIPP Land Withdrawal Act (Public Law 102-579). The LWA reserved the area surrounding the WIPP site for construction, experimentation, operation, repair and maintenance, disposal, shutdown, monitoring, decommissioning, and other activities associated with WIPP. DOE is now proposing to continue the phased development of WIPP by disposing of TRU waste resulting from defense activities and programs.

1.3 WIPP NEPA COMPLIANCE HISTORY

In 1980, DOE prepared the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) to assess the potential environmental impacts of developing WIPP and of alternatives

for disposing of or managing defense TRU waste. The FEIS proposed a two-phased approach to the development of WIPP: (1) a site and preliminary design validation program and (2) full construction (DOE 1980).

The alternatives analyzed in the FEIS included the following:

- *Alternative 1: The No Action Alternative*. A research and development facility to demonstrate the safe disposal of TRU waste would not be developed, and post-1970 TRU waste would continue to be retrievably stored.

- *Alternative 2:* The two-phased approach to developing WIPP at its proposed site in southeastern New Mexico would be implemented.

- *Alternative 3*: TRU waste stored at Idaho National Engineering and Environmental Laboratory (INEEL) would be disposed of in the first available repository for high-level radioactive waste.

- *Alternative 4*: A decision on the site for WIPP would be delayed until at least 1984 to allow for the investigation of alternative sites.

In a Record of Decision (ROD) published by DOE on January 28, 1981 (46 Federal Register [FR] 9162), the Department selected Alternative 2, to proceed with the phased development of WIPP at the site in southeastern New Mexico. DOE designed the facility to accommodate 175,600 cubic meters (6.2 million cubic feet) of CH-TRU waste and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste. The Department concluded in the ROD that the adverse environmental impacts of the phased development of WIPP would be minor and that there would be minimal risk of any release of radioactivity to the environment.

After construction of most of the WIPP facilities, the Department prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) to update the environmental record established in the FEIS.

SEIS-I evaluated the impacts of the following three alternatives:

- *Proposed Action Alternative:* A phased approach to develop WIPP would continue, as authorized by Public Law 96-164 and as modified by changes proposed in SEIS-I, by beginning an underground WIPP Test Phase.

- *No Action Alternative:* No waste would be emplaced at WIPP. Storage of TRU waste would continue at the generator-storage sites, and new storage facilities would be built.

- *Alternative Action:* Only those tests that could be performed without emplacing waste underground would be conducted until it was determined that WIPP complies with EPA standards and other regulatory requirements for the long-term protection of the environment from the disposal of TRU waste.

The SEIS-I ROD, published by DOE on June 22, 1990 (55 FR 25689), chose the Proposed Action Alternative. The 1990 ROD also committed the Department to prepare SEIS-II before the disposal phase and to provide an analysis of the long-term performance of WIPP in light of new information

obtained since 1990. The WIPP Test Phase was to have involved the testing of TRU waste underground at WIPP. In October 1993, DOE decided not to conduct the Test Phase. DOE decided that the experiments could be adequately performed at a lower cost in aboveground laboratories as part of the ongoing experimental program.

The 1990 ROD also stated that a more detailed analysis of the impacts of processing and handling TRU waste at the generator-storage facilities would be conducted. The Department has analyzed TRU waste management activities in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997b). The WM PEIS analyzes environmental impacts at the potential locations of treatment and storage sites for TRU waste; SEIS-II addresses impacts associated with alternative treatment methods, the disposal of TRU waste at WIPP and alternatives to that disposal, and the transportation to WIPP. (SEIS-II also includes potential transportation between generator sites.) Figure 1-1 shows the locations of facilities that currently store or will generate TRU waste during the 35-year period analyzed in SEIS-II.

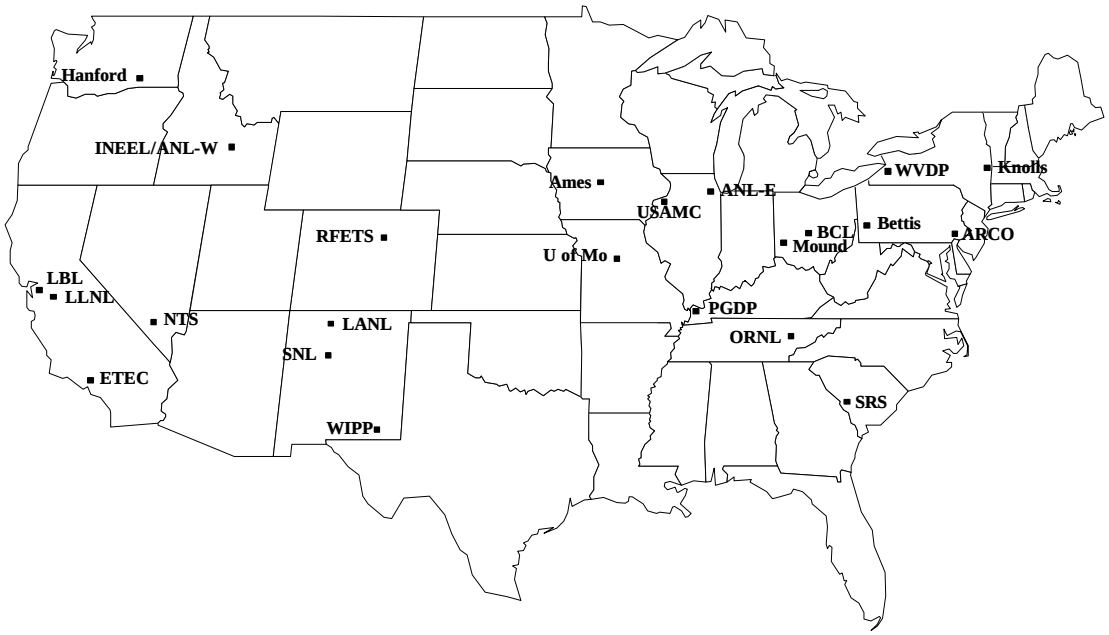


Figure 1-1
Approximate Location of SEIS-II TRU Waste [a]

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

Since SEIS-I, DOE has published three environmental assessments (EA) and two supplement analyses related to WIPP. These documents are summarized in Table 1-2. The Department also published a mitigation action plan (MAP) on July 10, 1991 (DOE 1991) for actions to prevent or reduce the environmental impacts associated with DOE's selected alternative. DOE issues an annual report on the progress made in implementing the MAP and the effectiveness of any mitigation and will continue to do so until the mitigation activity is complete. The report is issued annually on the anniversary date of the MAP. DOE has issued the WIPP Annual Mitigation Reports each year since the MAP was published (DOE 1992, 1993, 1994, 1995c, 1996f, and 1997d).

Table 1-2
WIPP NEPA Documents Since SEIS-I

Document Title	Document Description
Environmental Assessment for the Proposed Actinide Source-Term Test Program at Los Alamos National Laboratory (1995) (DOE/EA-0977)	This EA examined the site-specific environmental impacts of conducting tests at Los Alamos National Laboratory as part of the WIPP experimental program. A finding of no significant impact (FONSI) was issued on January 23, 1995.
Environmental Assessment for the Construction and Operation of the Carlsbad Environmental Monitoring and Research Center (1995) (DOE/EA-1801)	This EA examined the impacts of construction by New Mexico State University and continued Department funding of the operations of the Carlsbad Environmental Monitoring and Research Center. The center independently monitors environmental impacts for ongoing and future WIPP operations as part of its aim to improve environmental monitoring techniques. A FONSI was issued on October 10, 1995.
Environmental Assessment for the Construction and Operation of the Sand Dunes to Ochoa Powerline Project (1995) (DOE/EA-1109)	This EA examined the impacts of constructing a second powerline to supply electricity to WIPP. The Department adopted the Bureau of Land Management's EA and FONSI on May 19, 1995.
Supplement Analysis of Proposed Waste Characterization and Packaging Activities at the Idaho National Engineering Laboratory for the WIPP Test Program (1991) (DOE/EIS-0026-FS/SA1)	This supplement analysis described the environmental impacts of conducting some of the WIPP waste characterization activities at two locations at Idaho National Engineering and Environmental Laboratory, rather than at one location as described in SEIS-I. The activities analyzed included (1) certification and storage of CH-TRU waste at the existing Radioactive Waste Management Complex, (2) characterization and repackaging of these wastes into bins or 55-gallon drums at the existing Hot Fuel Examination Facility, and (3) transportation of wastes along the 26-mile route between the two facilities. The Department determined that these activities did not involve any substantial changes to the SEIS-I Proposed Action or notable new circumstances or information bearing on the environmental impacts, and no further NEPA documentation was required.
Supplement Analysis of Proposed Transportation Routes to the Waste Isolation Pilot Plant and Discovery of Deviated Gas Well at WIPP (1991) (DOE/EIS-0026-FS/SA2)	This supplement analysis described the selection of some TRU waste transportation routes and the discovery of a deviated gas well at WIPP. The analysis also described a directionally drilled or deviated gas well on Section 31 that was drilled in 1982. The Department determined that these activities did not involve substantial changes to the SEIS-I Proposed Action or notable new circumstances or information bearing on the environmental impacts. Therefore, DOE decided that no additional NEPA documentation was required.

1.4 NEED FOR A SECOND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

In addition to the Department's 1990 ROD commitment to prepare SEIS-II, regulatory and statutory changes and changes in the TRU waste inventory and waste acceptance criteria have occurred since the SEIS-I was issued. Also, new hydrologic and geologic information is available that may affect the performance assessment of WIPP and its ability to isolate waste. SEIS-II, therefore, takes into account all of the changed circumstances since 1990 that might affect the potential environmental impacts from the WIPP disposal and closure phases. Some of these changes are presented below.

- *Identification of Additional TRU Waste Generator Sites*. SEIS-I identified 10 principal generator-storage sites which have over 99 percent of the TRU waste volume that would be sent to WIPP. In the WM PEIS, the Department identified 10 additional sites that generate and store small amounts of TRU waste that may be disposed of at WIPP. Recent waste volume surveys have identified two other sites that store small quantities of TRU waste that were not identified in the WM PEIS.

- *Changes in TRU Waste Volumes and Waste Forms*. Estimates of the volumes of TRU waste and the final waste forms have changed since 1990. The volume changes are due to the reduction of activities associated with the production of nuclear weapons in the United States and better estimates of waste volumes obtained from the generator-storage sites. The changes in expected final waste forms reflect plans of certain generator-storage sites to treat their TRU waste in a manner that would alter its current form.

- *Changes in Compliance Status of Previously Disposed of TRU Waste*. Until about 1970, DOE disposed of TRU waste in shallow trenches. SEIS-I did not consider this waste in its analyses. Since SEIS-I, it has become evident that compliance with RCRA or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) may require excavation of a portion of this previously disposed of TRU waste. If excavated, this waste would be considered newly generated. In SEIS-II, an estimate of the previously disposed of inventory is included and analyzed as part of the action alternatives.

- *Passage of the LWA*. The LWA, which transferred the WIPP site from the U.S. Department of the Interior to DOE, included provisions that might affect the environmental impacts of some WIPP disposal alternatives. As an example, one section of the Act allows no more than 175,600 cubic meters (6.2 million cubic feet) of total TRU waste volume and 5.1 million curies of RH-TRU waste to be disposed of at WIPP. Other parts of the Act require studies of rail and truck transportation, RH-TRU waste, and waste processing and volume reduction technologies. In 1996, Congress passed the National Defense Authorization Act for Fiscal Year 1997 (Public Law 104-201), which amended the LWA. Among other things, Public Law 104-201 provides the RCRA land disposal restrictions do not apply to WIPP.

- *Acquisition of New Data from the Experimental Program*. Since 1990, the Department has continued the experimental program and has acquired additional information about the WIPP site, TRU waste, and the potential interactions that may occur between the two. The results of this continuing program include new data that may more clearly define environmental impacts from WIPP. For example, there are reduced uncertainties about the rate and magnitude of gas generation from TRU waste, which bears on the long-term ability of the repository to isolate waste from the environment.

- *Carlsbad Area Office/Waste Isolation Pilot Plant Waste Minimization and Pollution Prevention Awareness Program Plan* (DOE 1995b). In 1995, DOE published this plan, which calls for a 10 percent reduction in the amount of sanitary waste generated by using source reduction techniques and a further 15 percent reduction by implementing improved recycling activities, a 30 percent reduction in the amount of RCRA-regulated waste, and the conduct of pollution prevention assessments to identify opportunities for further improvements.

- *Publication of the WM PEIS (May 1997)*. The Department has prepared a nationwide study examining the environmental impacts of managing five types of DOE radioactive and hazardous waste, including TRU waste. This study provides information on the potential impacts of various siting alternatives, which DOE will use in deciding where to locate treatment, storage, and/or, depending on the type of waste, disposal facilities. For TRU waste, the Department would identify DOE sites for treatment and storage facilities but not the type of treatment to be performed. The WM PEIS presents new information on TRU waste management. There are some differences in the waste inventories and generator-storage sites discussed in the WM PEIS and in SEIS-II. The differences are due in part to the different time periods analyzed in the WM PEIS and SEIS-II. The differences, and the reasons for them, are explained in Appendix B.

- *Changes to the Planning-Basis Waste Acceptance Criteria (WAC)*. The Department has revised the allowable activity for CH-TRU waste that could be placed in WIPP. The maximum plutonium-239 equivalent activity (PE-Ci) for untreated CH-TRU waste is 80 PE-Ci for a drum and 130 PE-Ci for a standard waste box. If overpacked in standard waste boxes or ten-drum overpacks, untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity. Drums containing solidified or vitrified CH-TRU waste, though, may contain up to 1,800 PE-Ci of activity per drum without overpacking (DOE 1996c).

- *Changes to the Transportation Routes*. Changes have been made to the planned transportation routes presented in SEIS-I.

- *Changes to the TRUPACT-II Certificate of Compliance (NRC 1989)*. NRC has modified the Certificate of Compliance (No. 9218, Revision No. 6). These changes included the addition of tritium-contaminated waste as authorized contents and the revision of generic quality assurance activities. These changes do not affect the ability of the package to meet the requirements of Title 10, Code of Federal Regulations (CFR), Part 71.

- *Changes in the Status of Relevant Regulations*. In 1993, EPA issued the Environmental Standards for Management and Disposal of TRU Waste codified in 40 CFR Part 191 and in 1996 issued criteria to certify and determine WIPP's compliance with these standards to be codified in 40 CFR Part 194 (61 FR 5224, February 9, 1996).

1.5 THE RELATIONSHIP OF SEIS-II TO OTHER DOE PLANNING DOCUMENTS

The NEPA process is a part of DOE's planning process. Council on Environmental Quality (CEQ) regulations encourage integrating environmental impact statements (EIS) "with other planning at the earliest possible time to insure that planning and decisions reflect environmental values" (40 CFR Part 1501.2). SEIS-II has been timed to take advantage of information presented in prior documents and to inform current and future planning efforts. The relationship among major planning and compliance documents and SEIS-II is as follows:

- *Compliance Certification Application (DOE 1996i):* This document, prepared in accordance with 40 CFR Part 194 and submitted to the EPA in October 1996 and accepted by the EPA in May 1997, is required by the LWA to demonstrate compliance with standards for disposal of TRU waste (40 CFR 191, Subparts B and C). Conceptual models and computer codes used for performance assessment calculations in the Compliance

Certification Application (CCA) were used in SEIS-II to assess the long-term ability of WIPP to isolate radioactive waste from the accessible environment.

- *Resource Conservation and Recovery Act Part B Permit Application (DOE 1996a):* This document, submitted April 1996, is the application to operate WIPP as a disposal facility, as defined under RCRA regulations (40 CFR Part 264). The application has been submitted to the New Mexico Environment Department, the state agency responsible for issuing the permit. (The New Mexico Hazardous Waste Act and its implementing regulations are the state analog to RCRA.). The application provides background information regarding the DOE proposals for operating WIPP and is, therefore, one of the foundations on which assumptions in SEIS-II concerning WIPP operations are based.

- *Final No-Migration Variance Petition (DOE 1996d):* This document, submitted to the EPA and published on June 14, 1996, is a petition to receive a variance from the RCRA LDRs on the basis that the migration of hazardous constituents would not exceed health-based levels at the disposal unit boundary. However, such a variance is no longer required pursuant to the National Defense Authorization Act for Fiscal Year 1997, Public Law No. 104-201. The document also provides background information on the long-term ability of WIPP to isolate hazardous waste and has been summarized and incorporated by referenced throughout SEIS-II.

- *Waste Isolation Pilot Plant Safely Analysis Report (SAR), Revision 0 (DOE 1995i):* The intent of this document, published in November 1995, is to examine the hazards associated with the disposal of CH-TRU and RH-TRU waste and to identify where mitigation is needed. The SAR provides accident analyses of CH-TRU and RH-TRU waste. These analyses have been incorporated into SEIS-II where appropriate.

- *Waste Isolation Pilot Plant Safety Analysis Report (SAR), Revision 1, (DOE 1997a):* As with Revision 0, the intent of this document, published in March 1997, is to examine the hazards associated with the disposal of CH-TRU waste and to identify where mitigation is needed. The SAR provides accident analyses of CH-TRU waste (similar analyses for RH-TRU waste are not included). These analyses have been incorporated into SEIS-II, where appropriate.

- *Transuranic Waste Baseline Inventory Report, Revision 2 (BIR-2) (DOE 1995j):* This report, published in December 1995, provides the waste volumes, hazardous constituent inventories, and most of the radionuclide data used by DOE in its regulatory compliance applications. BIR-2 (as well as BIR-3, below) is used as the basis for the SEIS-II waste volumes. SEIS-II supplements the radionuclide inventory with inventory data from the Integrated Data Base (IDB) (DOE 1995e).

- *Transuranic Waste Baseline Inventory Report, Revision 3 (BIR-3) (DOE 1996e):* This report, which DOE used for the WIPP CCA, includes information pertaining to waste that is currently eligible for disposal at WIPP under existing laws. BIR-3 waste volumes and hazardous constituent inventories are unchanged from BIR-2. The radionuclide inventories at some sites are changed. Also, information on complexing agents, nitrates, sulfates, phosphates, and cement was added because these components could potentially affect WIPP's ability to contain TRU waste. The information on complexing agents, nitrates, sulfates, phosphates, and cement was incorporated into the parameters used in the SEIS-II

analysis of long-term performance. The adjusted volumes used for SEIS-II analyses are based upon BIR-3 inventories.

- *Remote-Handled Transuranic System Assessment (DOE 1995h):* This report, published in November 1995, discusses the disposal of DOE RH-TRU waste. The report discusses packaging RH-TRU waste at treatment sites in such a way that it could be handled as CH-TRU waste. This would entail placing the RH-TRU waste in shielded payload containers to limit the radiation dose at the outer container surface to not more than 200 mrem/hr. This waste could then be handled and emplaced as CH-TRU waste. All other CH-TRU waste requirements would apply as well. This study also considered several options for RH-TRU waste emplacement, such as putting the waste in repository walls, in vertical boreholes in the floors of the repository, or in trenches mined in the repository floor. These considerations were used to determine the number of repository panels needed under the Proposed Action and the action alternatives in SEIS-II.

- *Remote-Handled Transuranic Waste Study (DOE 1995f):* This study was conducted, as required by the LWA, to evaluate the impacts of RH-TRU waste on the performance assessment of the repository and to determine the effects of RH-TRU waste as a part of the WIPP Total Inventory. Also, this study conducted a comparison of CH-TRU and RH-TRU waste to assess differences and similarities for gas generation, flammability and explosiveness, solubility, and brine and geotechnical interactions. The conclusions and findings of this study were considered when addressing TRU waste handling and performance assessment concerns in SEIS-II.

- *The National Transuranic Waste Management Plan (DOE 1996h):* This plan, published in September 1996, presents a TRU waste management system for the DOE Complex. The system maintains compliance with all binding consent orders, unilateral orders, and regulatory agreements concerning TRU waste and creates a management system in support of the DOE Office of Environmental Management's *Accelerating Cleanup: Focus on 2006* (DOE 1997c). (New TRU waste volume estimates presented in this plan are discussed in Appendix J and Section 5.13.)

Based on these documents, DOE believes it has sufficient information to meaningfully evaluate the environmental impacts of the proposal to dispose of TRU waste at WIPP and of the alternatives to that proposal.

In addition, several DOE NEPA documents that are related to SEIS-II either have been completed since SEIS-I, are being prepared, or have been proposed. As discussed below, DOE is preparing project-level, site-wide, and programmatic NEPA documents that address TRU waste management facilities or potential TRU waste generating activities throughout the DOE complex. These parallel efforts are being undertaken to expedite compliance with site-specific consent orders and settlements and to meet DOE's responsibilities under NEPA. The decisions that may result from these NEPA reviews may change the amount of TRU waste at DOE facilities. The amount of waste used for SEIS-II quantitative analyses does not reflect these possible decisions. The potential volume changes, though, are expected to be small relative to the total amount of waste considered for the SEIS-II calculations.

Final Waste Management Programmatic Environmental Impact Statement (Published in 1997, [DOE 1997b])

The relationship between SEIS-II and the WM PEIS (DOE 1997b) is set forth in Appendix B of this document. SEIS-II uses the WM PEIS to support its analyses in two principal ways. First, it uses the WM PEIS results as a baseline, updates that information, and adjusts the impacts according to differences in the concentration of radionuclides and differences in waste volume from the addition of buried waste. Second, SEIS-II alternatives use the locations of proposed treatment facilities presented in the WM PEIS (DOE 1997b).

The WM PEIS preferred alternative assumes that TRU waste would be treated to planning-basis WAC at the facilities where it is currently stored or would be generated, except that waste at the Pantex Plant and Sandia National Laboratories (SNL) would be shipped to Los Alamos National Laboratory (LANL) for treatment, Rocky Flats Environmental Technology Site (RFETS) would send a portion of its TRU waste to INEEL for treatment, Savannah River Site (SRS) would send its RH-TRU waste to Oak Ridge Reservation for treatment, and the Oak Ridge Reservation would send its CH-TRU waste to SRS for treatment.

Although SEIS-II incorporates by reference and, where appropriate, updates and adjusts information from the WM PEIS, the potential actions analyzed in SEIS-II are not connected to the potential actions analyzed in the WM PEIS. To further explain, the WM PEIS evaluates alternative configurations for managing (treating, storing, or disposing of) five types of waste, including TRU waste, that are at DOE sites or are otherwise under DOE's control or responsibility. The alternative configurations range from managing the wastes where they are currently located to transporting them to one centralized site for management. The WM PEIS evaluates trends in various impacts as alternative configurations become more or less centralized. The WM PEIS postulates three generic types of treatment for TRU waste, in order to analyze the impacts of treating and storing TRU waste under the various alternative configurations (although the WM PEIS does not address TRU waste disposal, recognizing that a disposal decision would be made on the basis of the WIPP SEIS-II). These generic treatments allow DOE, in the WM PEIS, to compare the relative impacts of centralized, regionalized, and decentralized treatment and storage. To reduce the potential impacts of storing untreated wastes, DOE must decide, pursuant to the WM PEIS, the most cost-effective and environmentally preferable configuration to treat and store TRU waste, regardless of whether the Department decides to dispose of this waste at WIPP.

In addition to TRU waste, the WM PEIS analyzes four other types of waste: high-level waste, low-level waste, low-level mixed waste, and hazardous waste. These wastes would not be disposed of at WIPP, and management of these wastes is unrelated to, and outside the scope and purpose of, SEIS-II.

SEIS-II, in contrast, is the third in a series of staged NEPA reviews that focuses on WIPP disposal of TRU waste. SEIS-II analyzes impacts and alternatives for disposal at WIPP, transportation to WIPP, and associated activities not addressed in, and not within the scope of, the WM PEIS. SEIS-II involves additional and different workers, time frames, transportation modes, alternatives, and affected environments. Decisions associated with whether to dispose of TRU waste at WIPP can and should be made regardless of any decisions made pursuant to the WM PEIS. Furthermore, decisions for TRU waste disposal are far removed from decisions on management of the other types of waste analyzed in the WM PEIS. Decisions concerning WIPP pursuant to SEIS-II will not automatically trigger or prejudice decisions for high-level waste, low-level waste,

hazardous waste, and low-level mixed waste that may be made pursuant to the WM PEIS. As such, SEIS-II and the WM PEIS have different purposes, meet different needs, and are independently justified.[1]

Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement (Published in 1996, DOE/EIS-0229)

This programmatic environmental impact statement (PEIS) (DOE 1996j) analyzes alternatives for the storage and disposition of weapons-usable fissile materials that originate in the United States. Weapons-usable fissile materials are those that could be used to make nuclear weapons and include various isotopes of plutonium (except plutonium-238, which is used as an energy source for space missions) and uranium highly enriched in uranium-235. Specifically, this PEIS analyzes alternatives for the storage of surplus weapons-usable plutonium and highly enriched uranium until any disposition, the storage of nonsurplus weapons-usable plutonium and highly enriched uranium, and the disposition of surplus plutonium. Storage alternatives for plutonium and uranium include using current storage facilities (no action alternative), upgrading current facilities, consolidating plutonium storage at a new facility, and co-locating plutonium and highly enriched uranium storage at a new facility. Disposition alternatives for plutonium include several alternatives in the following categories: emplacement in a deep borehole; immobilization in glass, ceramic, or metal; and fabrication into mixed oxide fuel with subsequent burning in nuclear reactors. The Department issued its ROD on this PEIS on January 21, 1997. The Department decided to pursue a dual strategy for disposing of excess plutonium that would immobilize some (and potentially all) of the inventory in a glass or ceramic material, and allows the burning of some of the surplus plutonium as mixed oxide fuel in existing reactors, depending upon subsequent decisions. The Department is preparing a *Surplus Plutonium Disposition Environmental Impact Statement* (Notice of Intent, May 22, 1997, 62 FR 28009**)**. The disposition of surplus weapons-usable plutonium (a fissile material) could produce approximately 4,500 cubic meters (158,000 cubic feet) to 7,000 cubic meters (245,000 cubic feet) of TRU waste for disposal at WIPP. (The additional TRU waste is discussed in the Cumulative Impacts section of Chapter 5.)

Los Alamos National Laboratory Site-Wide Environmental Impact Statement (Draft in Preparation)

DOE is preparing a site-wide EIS for LANL that will include an analysis of existing and planned waste management activities, including those for TRU waste, for the next 5 to 10 years (DOE 1995g). The potential environmental consequences that would result from the implementation of existing and anticipated activities, possible mitigation measures, site-specific strategies for TRU waste management, and projects reasonably expected during this period will be addressed.

Final Environmental Impact Statement for the Nevada Test Site and Off-site Locations in the State of Nevada (Published in 1996, DOE/EIS-0243-F)

A site-wide EIS was prepared to help define the future mission of the Nevada Test Site (DOE 1996g). This site-wide EIS evaluated resource management alternatives that would support current and future defense related missions, research and development, waste management,

[1] DOE believes that the analyses presented in the WM PEIS and SEIS-II are more understandable and useful for decision making and for informing the public than they would be if combined in a single, less focused document.

environmental restoration, infrastructure maintenance, and facility upgrades and alternative uses over the next 5 to 10 years. The Department issued its ROD on this PEIS on December 13, 1996.

With respect to TRU and TRU mixed waste, the Department decided to continue onsite storage pending the development of DOE disposal decisions. The Department also decided to construct a facility for characterizing and certifying TRU waste for offsite disposal.

Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site Environmental Impact Statement (Draft in Preparation)

DOE is preparing an EIS (Notice of Intent, 61 FR 58866, November 19, 1996) to decide how and where certain non-weapons-usable plutonium residues and scrub alloy, currently located at the RFETS, would be managed. DOE previously analyzed the stabilization of the approximately 106,000 kilograms (233,690 pounds) of plutonium residues at the RFETS for safe interim storage in the *Solid Residue Treatment, Repackaging, and Storage Environmental Assessment* (DOE 1996b). This EIS will analyze treatment alternatives for approximately 42,000 kilograms (92,594 pounds) of the plutonium residues and all of the scrub alloy in storage at the RFETS.

Site-Wide Environmental Impact Statement for the Rocky Flats Environmental Technology Site (Preparation Suspended)

DOE has issued a Notice of Intent (59 FR 4001, August 5, 1994) to prepare a site-wide EIS for the RFETS. The Notice described the intended scope of the site-wide EIS as providing a basis for selection of a site-wide strategic approach for nuclear materials storage, waste management, cleanup, and economic conversion, as well as project-level decisions for land use, management of nuclear materials, deactivation of RFETS facilities, decontamination and decommissioning of existing facilities, and possible on-site and off-site transportation of radioactive, hazardous, and mixed waste. The scope of the site-wide EIS has been modified so that issues associated with the safe interim storage of plutonium at RFETS will be analyzed in the Plutonium Interim Storage EIS (Notice of Intent, 61 FR 37247, July 17, 1996), and completion of the site-wide EIS has been suspended.

Savannah River Site Waste Management Final Environmental Impact Statement (Published in 1995, DOE/EIS-0217)

DOE issued the *Savannah River Site Waste Management Final Environmental Impact Statement* (DOE 1995d) that evaluates the construction and operation of low-level mixed waste and TRU mixed waste facilities identified in the *Savannah River Site Treatment Plan* developed under the Federal Facility Compliance Act (FFCAct) and the effects of minimizing, treating, storing, and disposing of liquid high-level radioactive, low-level radioactive, hazardous, mixed (radioactive and hazardous), and TRU waste. The EIS is intended to support decisions on the operation of specific treatment, storage, and disposal facilities over the next 10 years and to provide a baseline for analyses of future waste management activities. A ROD (60 FR 55249 [1995]) was issued October 30, 1995, announcing DOE's intention to implement the moderate treatment configuration alternative for storing, and treating transuranic waste, among others. The ROD also indicated that DOE will issue additional RODs pertaining to the treatment of mixed low-level radioactive and TRU mixed waste following negotiations with the State of South Carolina under the Federal Facility Compliance Act.

Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (Published in 1995, DOE/EIS-0203-F)

Based upon this programmatic and site-wide EIS (DOE 1995a), DOE issued an ROD on June 1, 1995 (60 FR 28680), which when implemented might result in the acceptance of off-site TRU waste from other DOE sites for treatment (pending negotiations under the FFCAct and decisions to be made based on the WM PEIS). DOE issued an amendment to the ROD on March 8, 1996 (61 FR 9441) incorporating the terms of the settlement agreement and court order in *Public Service Co. v. Batt*. The settlement agreement/court order requires shipment of INEEL TRU waste to WIPP or other such facility by a target date of December 31, 2018.

1.6 CONTENT OF SEIS-II

This SEIS-II is composed of six chapters and twelve appendices, as follows:

- *Chapter 1, Introduction:* This chapter defines the purpose and need for agency action. It also presents an overview of the WIPP project, a summary of its NEPA compliance history, and discussions of other DOE NEPA efforts and planning documents.

- *Chapter 2, Background Information:* This chapter provides an overview of DOE's TRU waste management throughout its facilities, includes details on the WIPP project and facility, presents a discussion of the TRU waste inventories, and summarizes relevant stakeholder outreach and involvement activities.

- *Chapter 3, Description of the Proposed Action and Alternatives:* This chapter is a description of the Proposed Action (Preferred Alternative) and each of the alternatives. The Proposed Action is to proceed with the phased development of WIPP by disposing of retrievably stored and future-generated defense TRU waste after treatment to the planning-basis WAC, up to the limits of the LWA and the DOE—New Mexico Agreement for Consultation and Cooperation. There are three alternatives to the Proposed Action, each involving different TRU waste treatment options and different waste volumes. There are two no action alternatives, one in which TRU waste would remain at various DOE sites in compliance with applicable regulations and another in which TRU waste would be stored at consolidation sites. WIPP would not open if either no action alternative is selected.

- *Chapter 4, Description of the Affected Environments:* This chapter summarizes and updates the description of the affected environment contained in the FEIS and SEIS-I and discusses new information regarding the hydrogeology at the WIPP site. It also summarizes the affected environment at the 10 major generator-storage sites.

- *Chapter 5, Environmental Impacts:* This chapter presents analyses of postulated radionuclide and hazardous chemical releases and exposures for the Proposed Action and action alternatives, the impacts that would result both from routine transportation and operations and from transportation and operational accidents, and the potential impacts of closing WIPP under the no action alternatives and from long-term repository performance after closure under the Proposed Action and the action alternatives. This chapter also includes discussions of environmental justice, the potential impacts of waste retrieval and recovery, cumulative impacts, and mitigation measures. Additional discussions include

unavoidable adverse impacts, i.e., those that may remain following mitigation; short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and irreversible or irretrievable commitment of resources that would result from implementation of the Proposed Action.

- *Chapter 6, Consultations and Permits:* This chapter discusses the agencies and persons consulted and provides the status of compliance with key regulatory requirements.

- *Appendix A, Waste Inventory:* This appendix provides information on the characteristics and quantities of DOE TRU waste.

- *Appendix B, Summary of the Waste Management Programmatic Environmental Impact Statement and Its Use in Determining Human Health Impacts:* This appendix provides an overview of that information in the WM PEIS that is relevant to SEIS-II.

- *Appendix C, Air Quality:* This appendix describes the methods used for analyzing potential impacts to air quality at WIPP for routine emissions of nonradiological air pollutants during normal operations.

- *Appendix D, Life-Cycle Costs and Economic Impacts:* This appendix discusses the technical approach and sources of information used to estimate the life-cycle costs and economic impacts of the SEIS-II alternatives.

- *Appendix E, Transportation:* This appendix forms the basis for transportation impact analysis results and discusses plans for transporting TRU waste.

- *Appendix F, Human Health:* This appendix describes the methods used to estimate human health impacts that result from radioactive material and hazardous chemical exposures and intakes.

- *Appendix G, Facility Accidents:* This appendix describes the methods used to estimate the impacts of facility accidents, both at WIPP and at treatment, consolidation, and storage facilities.

- *Appendix H, Long-Term Consequence Analysis for Proposed Action and Action Alternatives:* This appendix describes the analytical methods, codes, and exposure calculations used to determine the impacts from postulated long-term release scenarios.

- *Appendix I, Long-Term Consequence Analysis for No Action Alternative 2:* This appendix describes the analytical methods, codes, and exposure calculations used to determine the impacts from postulated long-term release scenarios.

- *Appendix J, Changes in the Department of Energy's Transuranic Waste Management Program*: This appendix describes other DOE TRU waste inventories and waste management practices.

- *Appendix K, List of Preparers and Contributors:* This appendix provides the names and credentials of those persons involved in the preparation of SEIS-II.

- *Appendix L, Distribution List:* This appendix contains a list of the individuals that received a copy of either the full Draft SEIS-II document and/or the Summary.

1.7 REFERENCES CITED IN CHAPTER 1

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1991, *Mitigation Action Plan for the Records of Decision for the Waste Isolation Pilot Plant Final and Supplement Environmental Impact Statements*, DOE/WIPP 91-030, July, Washington, D.C.

DOE (U.S. Department of Energy), 1992, *1992 Annual Mitigation Report for the Waste Isolation Pilot Plant*, DOE/WIPP 92-043, July, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1993, *1993 Annual Mitigation Report of the Waste Isolation Pilot Plant*, WIP:93:0007, July, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994, *1994 Annual Mitigation Report of the Waste Isolation Pilot Plant*, WIP:94:0001, July, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement*, DOE/EIS-0203-F, April, Washington, D.C.

DOE (U.S. Department of Energy), 1995b, *Carlsbad Area Office/Waste Isolation Pilot Plant Waste Minimization and Pollution Prevention Awareness Program Plan*, WIPP/CAO-95-2105, May, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995c, *1995 Annual Mitigation Report of the Waste Isolation Pilot Plant*, WIP:95:0002, July, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995d, *Savannah River Site Waste Management Final Environmental Impact Statement*, DOE/EIS-0217, July, Washington, D.C.

DOE (U.S. Department of Energy), 1995e, *Integrated Data Base Report-1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Revision 11, September, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DOE (U.S. Department of Energy), 1995f, *Remote-Handled Transuranic Waste Study*, DOE/CAO 95-1095, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995g, *Implementation Plan for Los Alamos National Laboratory Site-Wide Environmental Impact Statement*, DOE/EIS-0238, November, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1995h, *Remote-Handled Transuranic System Assessment*, DOE/CAO-95-1143, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995i, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 0, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995j, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 2, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP-91-005, Revision 6.0, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Solid Residue Treatment, Repackaging, and Storage Environmental Assessment*, DOE/EA-1120, April, Golden, Colorado.

DOE (U.S. Department of Energy), 1996c, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, WIPP-DOE-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Final No-Migration Variance Petition*, DOE/CAO-95-2043, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996e, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996f, *1996 Annual Mitigation Report of the Waste Isolation Pilot Plant*, WIP:96:0001, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996g, *Final Environmental Impact Statement for the Nevada Test Site and Off-site Locations in the State of Nevada*, DOE/EIS-0243-F, August, Las Vegas, Nevada.

DOE (U.S. Department of Energy), 1996h, *The National Transuranic Waste Management Plan*, DOE/NTP-96-1204, Revision 0, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996i, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996j, *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*, DOE/EIS-0229-F, December, Washington, D.C.

DOE (U.S. Department of Energy), 1997a, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997b, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200, May, Washington, D.C.

DOE (U.S. Department of Energy), 1997c, *Accelerating Cleanup: Focus on 2006*, DOE/EM-0327, June, Washington, D.C.

DOE (U.S. Department of Energy), 1997d, *1997 Annual Mitigation Report for the Waste Isolation Pilot Plant*, WIP:97:0001, June, Carlsbad, New Mexico.

NRC (U.S. Nuclear Regulatory Commission), 1989, *Safety Evaluation Report, TRUPACT-II Shipping Container, Certificate of Compliance No. 9218*, Revision 0, Washington, D.C.

This page intentionally left blank.

CHAPTER 2
BACKGROUND INFORMATION

This chapter provides an overview of the management of transuranic (TRU) waste throughout U.S. Department of Energy (DOE or the Department) facilities, presents details on the Waste Isolation Pilot Plant (WIPP) and its history, and concludes with a summary of stakeholder outreach and involvement activities relevant to the preparation of this second supplemental environmental impact statement (SEIS-II).

2.1 OVERVIEW OF TRU WASTE IN THE DOE COMPLEX

During the past 50 years, DOE and its predecessor agencies have been responsible for atomic energy and nuclear weapons research and production. The nuclear weapons complex has consisted of major facilities, including those at large reservations in the states of Nevada, Idaho, Washington, and South Carolina. In New Mexico and California, national laboratories have designed weapons, most of which were assembled in Texas, from components fabricated in Colorado, Florida, Missouri, Ohio, Tennessee, and Washington (DOE 1997).

TRU waste results from defense activities and programs of the U.S. government. Several types of operations (current, past, or future) have generated or will generate TRU waste: (1) nuclear weapons development and manufacturing; (2) plutonium recovery, stabilization, and management; (3) research and development; (4) environmental restoration, and decontamination and decommissioning; (5) waste management at various DOE and other government facilities and laboratories; and (6) testing at private institutions and universities under contract to DOE. TRU waste also results from commercial activities subject to regulation by the U.S. Nuclear Regulatory Commission (NRC) and from DOE-sponsored activities that are not considered to be defense activities or programs.

KEY DEFINITIONS

Defense TRU Waste: TRU waste that results from defense activities. Since 1970, this waste has been placed in retrievable storage. It continues to be generated from environmental restoration, decontamination and decommissioning activities, waste management programs, and testing and research.

Nondefense TRU Waste: TRU waste that currently is restricted from disposal in WIPP by the WIPP Land Withdrawal Act (LWA) because it does not result from defense activities.

Commercial TRU Waste: TRU waste produced by commercial facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) and restricted from disposal in WIPP because it does not result from defense activities. DOE is managing some of this waste at the direction of Congress.

Polychlorinated Biphenyl (PCB)-Commingled TRU Waste: TRU waste that contains 50 parts per million or greater of PCBs and is subject to regulation under the Toxic Substances Control Act (TSCA). This waste is currently restricted from disposal in WIPP unless treated in compliance with the TSCA or unless WIPP receives a permit to dispose of TRU waste under the TSCA.

Previously Disposed of Waste: TRU waste that, prior to 1970, was disposed of in shallow burial pits, and that, if excavated, would be considered newly generated waste, potentially eligible for disposal in WIPP.

WASTE ACCEPTANCE CRITERIA (WAC)

The WAC was first developed in 1989 and revised several times, most recently in 1996. These criteria govern the form, packaging, and transport of TRU waste to be disposed of at WIPP, should WIPP disposal be approved. These criteria also address WIPP operations and safety requirements, transportation requirements, waste package requirements, Resource Conservation and Recovery Act (RCRA) requirements, and performance assessment requirements. Overall, they consolidate the minimum requirements of all laws, regulations, and DOE internal requirements that apply to TRU waste transportation and disposal and establish specific minimum waste characteristics which TRU waste must meet before it can be accepted and emplaced at WIPP.

The WAC establish the conditions that govern the physical, radiological, and chemical composition for TRU waste, setting weight, thermal, and radiological limits. Weight limits are established for TRUPACT-II containers, contact-handled (CH) TRU waste drums, and shipments so that shipments will not exceed highway weight limits. Thermal power limits, which define the amount of heat that may be produced by radioactive decay, are established for waste containers to limit the concentration of flammable gas which may be generated within the container. Radiological criteria include the maximum plutonium-239 equivalent activity (PE-Ci) for containers and for stored TRU waste to avoid the potential for nuclear criticality.

For the purposes of SEIS-II analyses, all waste would be packaged at a minimum to the current planning-basis WAC. In addition, the alternatives examine more extensive treatment by a shred and grout or thermal process. Even if treated by a shred and grout or thermal process, though, all waste must necessarily also meet the minimum criteria embodied in the WAC to be disposed of at WIPP. Also, to be transported for consolidation or treatment, TRU waste must meet minimum WAC requirements, which include transportation requirements.

The version of the WAC used for the SEIS-II analyses was Revision 5 (DOE 1996b), the most current planning-basis WAC. As laws and regulation change, and should new waste criteria be developed as a result of SEIS-II, the WAC will be revised to reflect the new requirements.

2.1.1 Introduction

For the purposes of SEIS-II, TRU waste is broadly categorized to include (1) defense waste of the type that was subject to previous WIPP-related National Environmental Policy Act (NEPA) reviews and (2) other defense and nondefense waste for which DOE retains management responsibility. The *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) examined the impacts of transporting and disposing of waste that resulted from defense activities and that was placed in retrievable storage pursuant to a 1970 Atomic Energy Commission policy (see Section 1.2) and TRU waste that was reasonably expected to be generated by these ongoing activities and programs. For the purposes of SEIS-II, this defense TRU waste inventory is hereafter referred to as the “Basic Inventory.”

Other defense and nondefense TRU waste not previously included in the waste inventory by the FEIS or SEIS-I include (1) nondefense and commercial TRU waste (comprising 0.2 percent of the total TRU waste volume), (2) defense TRU waste commingled with PCBs, (3) and defense (and perhaps some nondefense) TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. This TRU waste inventory is hereafter referred to as the “Additional Inventory.”

In addition, SEIS-II refers to the "Total Inventory," which is the sum of the Basic and Additional Inventories.

Previously disposed of TRU waste excavated in compliance with RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act, or as a result of DOE's own cleanup initiatives would be considered newly generated waste and as such could become potentially eligible for WIPP disposal.

2.1.2 TRU Waste

TRU waste contains transuranic radionuclides and may also contain other radionuclides. Most TRU radionuclides decay through the emission of alpha radiation. However, transuranic and other radionuclides present in the waste may emit beta, gamma, X-ray, and neutron radiation as well. Alpha (helium nuclei) and beta (electron) radiation are particulate emissions that cannot penetrate the walls of TRU waste containers and present a health hazard only if the particles are inhaled or ingested. Gamma (photon), X-ray (electromagnetic), and neutron (uncharged particle) radiation can penetrate the walls of waste containers and may present an external dose hazard to individuals near the containers. Gamma and X-ray radiation can be shielded to reduce the radiation dose to workers using high density materials such as lead or steel; neutrons must be shielded using materials with high hydrogen content such as water, plastic, or paraffin. Radionuclides americium-241, an X-ray emitter, barium-137m, a gamma-emitter that is a decay product of cesium-137, and cobalt-60, another gamma-emitter, are the main contributors to external dose from TRU waste that would be disposed of at WIPP under the Proposed Action and the action alternatives.

TRU waste is categorized as either CH-TRU or remote-handled (RH) TRU based on the external dose rates at the surface of the waste container. TRU waste is considered CH-TRU waste if the external dose rate at the outer surface of the waste container is 200 millirem per hour or less. TRU

TRU WASTE TRANSPORTATION PACKAGING

The Department plans to use two packagings to transport TRU waste; a third is under consideration.

***TRUPACT-II*:** The TRUPACT-II would be used to transport CH-TRU waste. The NRC has certified these containers. To achieve NRC approval, these containers must endure fire, water immersion, and free drops without leakage. Each container has the capacity to hold fourteen 55-gallon drums, two standard (0.9-meter x 1.4-meter x 1.8-meter [3.1-foot x 4.5-foot x 5.9-foot]) waste boxes, or a 10-drum overpack which fits one standard waste box or ten 55-gallon drums. Each TRUPACT-II has an allowable capacity of 2,835 kilograms (6,250 pounds). Up to three TRUPACT-IIs can be transported on a specially designed trailer, and up to six containers can be carried on a specially adapted rail car.

RH-72B: The RH-72B cask would be used to transport RH-TRU waste. The Department is currently awaiting NRC certification of the RH-72B cask. This package is designed to shield personnel and the environment from penetrating radiation that is produced by RH-TRU waste. The canister within each cask can hold up to 3,630 kilograms (8,000 pounds). One RH-72B cask can be carried on a specially designed trailer, and up to three casks can be carried on a specially adapted rail car.

HALFPACK: The HALFPACK is being developed by the Department and is a shorter, lighter version of the TRUPACT-II. It would allow the shipment of waste containers too heavy to be shipped efficiently in a TRUPACT-II because of U.S. Department of Transportation weight limitation requirements. The HALFPACK would hold half the volume of waste as the TRUPACT-II.

waste with an external dose rate greater than 200 millirem per hour is considered RH-TRU waste; however, RH-TRU waste with an external dose rate greater than 1,000 rem per hour (1,000,000 millirem per hour) at the outer surface of the container cannot be disposed of at WIPP because it is prohibited by the LWA.

DOE has developed a coding system, comprised of waste matrix code groups, to organize waste streams by their physical and chemical properties. Eleven waste matrix code groups for waste having similar physical and chemical properties have been used to categorize CH-TRU waste and RH-TRU waste (DOE 1996c). These code groups are listed in Table 2-1.

TRU mixed waste is defined as any TRU waste that is commingled with a hazardous waste regulated by RCRA, as defined in Title 40, Code of Federal Regulations (CFR) 261, Subparts C and D. TRU waste containing hazardous chemical constituents has physical and radiological characteristics similar to TRU waste that does not contain these constituents. The majority of TRU mixed waste contains relatively small quantities of spent halogenated solvents, which were used in

Table 2-1
Final TRU Waste Form Code Groups and Definitions

Final TRU Waste Form Code Group	Definition
Combustible	Debris that is approximately 95 percent or more, by volume, combustible materials. Examples of combustible debris are materials constructed of plastic, rubber, wood, paper, and cloth.
Filter	Debris that is approximately 50 percent or more, by volume, High Efficiency Particulate Air (HEPA) filters or additional filters constructed of more than one material type (e.g., metal, inorganic nonmetal, and combustibles).
Graphite	Debris that is approximately 95 percent or more, by volume, graphite-based solid materials. Graphite debris includes crucibles, graphite components, and pure graphite.
Heterogeneous	Debris that is at least 50 percent by volume materials that do not meet criteria for assignment into other categories. For example, waste that is a mixture of metal and combustible debris, neither of which comprises 95 percent or more of the waste by volume.
Inorganic nonmetal	Debris that is approximately 95 percent or more, by volume, inorganic nonmetal material. Examples of waste in this group include glass and ceramics.
Lead/cadmium metal	Debris that is approximately 95 percent or more, by volume, metal that contains bulk lead or cadmium as part of the matrix. Examples of this waste include glovebox parts with lead clad in stainless-steel or cadmium sheets.
Uncategorized metal	Debris that is approximately 95 percent or more, by volume, metal but either lacks sufficient information to enable characterization into one of the other categories or contains both lead and cadmium as part of the bulk matrix.
Salt	Debris that is at least 50 percent by volume salts. Stable pyrochemical salt is an example of this group.
Soil	Debris that is approximately 95 percent or more, by volume, soil. This includes sand, silt, and rock/gravel where rock/gravel volumes total less than 50 percent of the matrix.
Solidified inorganic	Debris that is at least 50 percent by volume inorganic process residues. This group includes solidified sludges and small particles.
Solidified organic	Debris that is at least 50 percent by volume organic process residues. These are defined as process residues with a base structure that is primarily organic. The matrix may contain some inorganic solids content such that approximately 20 percent by weight of the waste would remain as residue ash/solids following incineration. Examples include organic resins, organic sludges and solidified organic liquids.

cleaning and degreasing of equipment, glassware, and components. Based on sampling of gases within TRU waste drums, the most common volatile organic hazardous constituents are methylene chloride, carbon tetrachloride, and 1,1,1-trichloroethane (DOE 1996c). TRU mixed waste also contains various RCRA-regulated metals. These metals are usually associated with solid materials, such as lead shielding and chromium-based stainless steel. Lead, chromium, and cadmium are the most prevalent heavy metals in TRU mixed waste. TRU mixed waste is approximately 60 percent of the Department's TRU waste.

For the TRU waste that would be disposed of at WIPP, DOE has created the planning-basis WAC (DOE 1996b). These criteria specify all of the requirements that must be met by each waste generator-storage site before its TRU waste is shipped to WIPP and disposed of and govern the physical, radiological, and chemical composition of the waste, as well as requirements for waste packaging. Criteria have been developed for shipping, packaging, waste form, waste package, data package, and other miscellaneous criterion categories. These criteria address WIPP operations and safety, transportation, waste package requirements, RCRA requirements, and WIPP performance assessment requirements.

For example, some of the criteria under the waste package requirements include the following:

- The maximum gross weight of the TRUPACT-II with payload is 8,730 kilograms (19,250 pounds) and the maximum gross weight of the canister of the RH-72B cask is 3,630 kilograms (8,000 pounds).

- Total gross weight of a transporter including payload is 36,300 kilograms (80,000 pounds).

- The maximum plutonium-239 equivalent activity (expressed as PE-Ci) for untreated TRU waste is 80 PE-Ci for a drum or 130 PE-Ci for a standard waste box. If overpacked in standard waste boxes or 10-drum overpacks, untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity. Drums containing solidified or vitrified CH-TRU waste may contain up to 1,800 PE-Ci of activity per drum. RH-TRU waste canisters may not exceed 1,000 PE-Ci (DOE 1996b).

- Liquid waste cannot exceed 2 liters (0.5 gallons) in a CH-TRU waste drum, 8 liters (2 gallons) in a standard waste box, or 6 liters (1.5 gallons) in a RH-TRU waste canister.

- The maximum removable surface contamination on drums is 50 picocuries (pCi) per 100 square centimeters (16 square inches) for alpha-emitting radionuclides and 450 pCi per 100 square centimeters (16 square inches) for beta and gamma-emitting radionuclides.

- The maximum thermal power must be less than 40 watts for a TRUPACT-II and be less than 300 watts for a RH-TRU waste canister.

Future additions or revisions to the planning-basis WAC may be necessary; for example, additional RCRA requirements may be issued or results of the WIPP performance assessment studies may require changes. Any changes to the planning-basis WAC based on SEIS-II analyses will be identified in the Record of Decision (ROD). Section 2.2.1 and Appendix A discuss planning-basis WAC further.

2.1.3 Waste Management at the Generator-Storage Sites

The locations and volumes of the TRU waste inventory are given in Table 2-2 (for the Basic Inventory) and Table 2-3 (for the Additional Inventory).

The 1990 SEIS-I (DOE 1990) stated that WIPP may eventually dispose of post-1970 defense TRU waste from 10 sites. These sites are identified in Table 2-2. Since 1990, DOE has identified 12 additional sites that either store or are anticipated to generate TRU waste. Eight of these sites store or generate TRU waste considered to be part of the Basic Inventory (Table 2-2). TRU waste

Table 2-2
Basic Inventory TRU Waste Volumes [a, b]

	Stored (1995) (cubic meters)		Estimated Total through 2022 [c] (cubic meters)		Projected Total through 2033 [d] (cubic meters)	
Site [e]	**CH-TRU**	**RH-TRU**	**CH-TRU**	**RH-TRU**	**CH-TRU**	**RH-TRU**
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering and Environmental Laboratory (INEEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	---	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. TRU waste containing more than 50 parts per million of PCBs cannot be disposed of at WIPP without applicable permits. The Basic Inventory is waste that resulted from defense activities and that was placed in retrievable storage pursuant to the Atomic Energy Commission policy of 1970 and TRU waste reasonably expected to be generated by these ongoing activities. Volumes have been rounded. Actual totals may differ due to rounding. Projected totals have not been adjusted in anticipation of disposal. A discussion of updated volumes and TRU waste locations presented in the *National Transuranic Waste Management Plan* is presented in Appendix J, throughout SEIS-II, where appropriate, and in the Summary.

[b] Dashes indicate no waste.

[c] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2.

[d] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033. Total includes TRU waste to be generated for 35 years.

[e] Sites in boldface were included in SEIS-I. INEEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.

Table 2-3
Additional Inventory TRU Waste Volumes [a, b, c]

Site [d]	PCB-Commingled (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	--- [e]	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering and Environmental Laboratory (INEEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Additional Inventory includes PCB-commingled TRU waste, commercial TRU waste, nondefense TRU waste, and TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. A discussion of updated volumes and TRU waste locations presented in the *National Transuranic Waste Management Plan* is presented in Appendix J, throughout SEIS-II, where appropriate, and in the Summary.

[b] The volume of TRU waste includes the 1995 existing and projected waste through 2033.

[c] Actual totals may differ due to rounding.

[d] Sites in boldface also store post-1970 defense TRU waste, see Table 2-2. The remaining four sites currently have no post-1970 defense TRU waste.

[e] Dashes indicate no waste.

stored at the remaining four sites (ARCO, Knolls, LBL, and WVDP) is part of the Additional Inventory (Table 2-3). Together, TRU waste at these 22 sites account for all waste analyzed as part of SEIS-II (see Figure 2-1).

Additional information about the TRU waste inventory can be found in Appendix A. The waste volumes shown in Tables 2-2 and 2-3 are based on 35 years of future projected generation beginning in 1998, plus the TRU waste in retrievable storage (see Appendix J for updated inventory information). Projections between 1995 and 1998 are included. DOE recognizes that TRU waste may continue to be generated after 2033 but believes that volume projections beyond 2033 are too speculative to be useful for the analyses at this time; however, DOE may include projections beyond 2033 in any future NEPA analyses.[1]

There is uncertainty in the total waste volume figures presented in Tables 2-2 and 2-3. The projections beyond 2022 are extrapolations based on the projected waste generation rates between 1995 and 2022 and provide bounding estimates for use in the analyses. The amount of previously disposed of TRU waste that could be retrieved for eventual storage or disposal is highly uncertain. Decisions on disposition of waste and contaminated media from environmental restoration activities are made on a cleanup-by-cleanup basis, and such decisions have not been made for many of the Department's environmental restoration activities. Also, the Department is in the process of characterizing and developing cleanup strategies for many contaminated sites and, therefore, cannot precisely determine what type or volume of waste might result from cleanup of those sites.

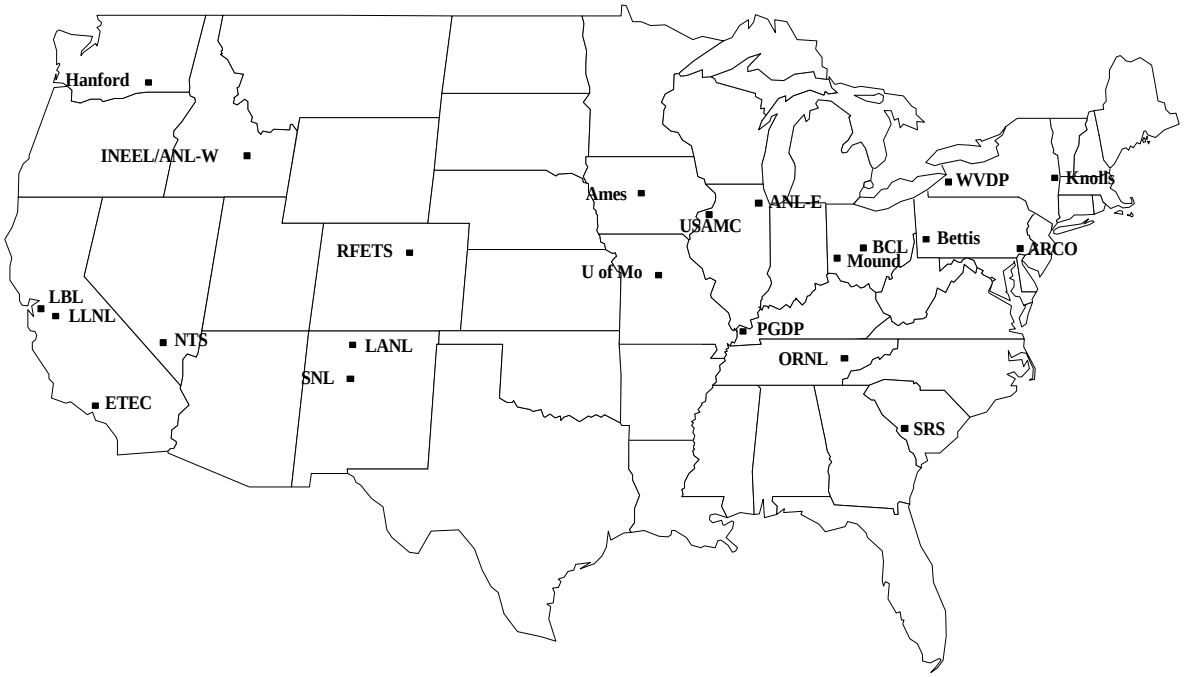


Figure 2-1
Approximate Location of SEIS-II TRU Waste [a]

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

[1] While SEIS-II provides an analysis of impacts based on 35 years of waste generation, the Department's current RCRA Part B Permit Application (DOE 1996a) is based on 25 years and will be renewed every 5 years.

In addition, the waste volumes used for SEIS-II analyses are estimates of "emplaced waste volumes" (the volumes of the containers that TRU wastes would be emplaced in), not actual waste volumes inside the containers, except as noted. DOE recognizes that virtually all containers would contain some void space and that some containers may be only partially filled (for instance, to meet limits on weight or thermal power for transportation).

The ROD (55 Federal Register [FR] 25689) based on SEIS-I (DOE 1990) stated that SEIS-II would examine in greater detail waste management at the generator-storage sites. Later in 1990, DOE announced its intent to prepare a programmatic environmental impact statement for managing the treatment, storage, and disposal of radioactive and hazardous waste in the DOE Complex, including the treatment and storage of TRU waste (55 FR 42633). Also, in 1992, the U.S. Congress passed the Federal Facility Compliance Act (FFCAct) requiring DOE to prepare plans for developing treatment capacities and technologies for mixed waste. The FFCAct requires the site treatment plans to be submitted to the states or the U.S. Environmental Protection Agency (EPA) for review, and authorizes the states or EPA to issue orders requiring compliance with the plans. The *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997), published in June 1997, was developed in parallel with the FFCAct site treatment plans.

To date, DOE has submitted FFCAct site treatment plans for a majority of its sites, and in most cases orders or settlements have been reached with the states and EPA. Certain orders and settlements also include schedules for transporting treated TRU waste to WIPP. DOE has reached a negotiated settlement with the State of Idaho concerning TRU waste that was entered by the court in the case of *Public Service Co. v Batt*, Civil NO 91-0035-S-EJL (D. ID, October 17, 1995). DOE intends to keep its commitments pursuant to these binding agreements and orders. The Order issued to LANL requires DOE to complete treatment of TRU mixed waste to applicable regulatory standards by December 31, 2010. By September 30, 2023, Oak Ridge National Laboratory (ORNL) must complete shipment of stabilized RH-TRU waste sludges and CH- and RH-TRU solids to WIPP. And at RFETS, newly generated TRU mixed waste cannot be stored for longer than two years once WIPP begins accepting mixed TRU waste from RFETS.

The site treatment plans reflect DOE's strategy for the management of TRU mixed waste. Most of the FFCAct agreements allow the Department to continue to store TRU mixed waste without treating it to meet the RCRA Land Disposal Restrictions (LDR), recognizing that DOE has plans to decide whether to dispose of this waste at WIPP. (Such TRU mixed waste could be disposed of at WIPP without treatment to meet the RCRA LDRs under the recent amendments to the LWA in Public Law 104-201.) The LANL FFCAct agreement is an exception to this general rule, requiring DOE to begin planning for the LDR treatment of LANL TRU mixed waste but allowing renegotiation should WIPP open. Treatment of all the TRU waste to meet the LDRs is still a reasonable alternative and is analyzed in SEIS-II.

Under any of the alternatives assessed in SEIS-II, the generator-storage sites would maintain the capability to manage TRU waste generated in the future. In general,

LEGALLY BINDING ORDERS AND AGREEMENTS

DOE is subject to a number of legally binding agreements and orders concerning TRU waste. One example of such an order is the negotiated settlement agreement entered by the court in the case of *Public Service Co. v Batt*, Civil No. 91-0035-S-EJL (D. ID, October 17, 1995). DOE intends to keep its commitments pursuant to these binding agreements and orders.

the facilities would vary by site depending on the waste streams and volumes generated and could have the capability to do the following:

- Safely store TRU waste generated from the various waste streams
- Characterize TRU waste which could involve radioassay and nondestructive testing, headspace sampling, inner-bag gas sampling, drum venting, solids sampling, real-time radiography, and visual sampling
- Treat TRU waste through size reduction, vitrification, or thermal treatment
- Certify TRU waste to meet planning-basis WAC requirements
- Package TRU waste
- Load TRU waste containers

These facilities would provide the generator-storage sites with the capability to prepare TRU waste for shipment to the major treatment sites. Treatment sites would have capabilities similar to those listed above for the generator-storage sites but would generally be sized to handle a greater volume of TRU waste.

Additional information regarding alternatives for the management of TRU waste, as studied in the WM PEIS, may be found in Appendix B.

2.1.4 Waste Isolation Pilot Plant

In 1957, the National Academy of Sciences concluded that the most promising method of disposal of high-level waste seemed to be in bedded salt deposits. Some of the most favorable characteristics of bedded salts included (1) that they were generally found in geologically stable regions that were capable of waste isolation for hundreds of millions of years, (2) that salt beds were essentially dry, with no intergranular liquids, and (3) that salt would creep and encapsulate wastes for long periods of time following disposal.

Following a study of salt beds throughout the Permian Basin, which includes the Delaware Basin in Eastern New Mexico and large areas of Kansas, West Texas, and Oklahoma, the WIPP site was selected during the early 1970s as a research and development facility to demonstrate the safe disposal of radioactive waste resulting from defense-related activities. Eastern New Mexico was specifically selected as the area for the WIPP site in early studies by ORNL (Appendix MASS, CCA [Doe 1996e]) because it best met the following criteria:

Characteristics	Requirement
Depth of Salt	1000 to 2500 feet
Thickness of Salt	at least 200 feet
Lateral Extent of Salt	Sufficient to protect against dissolution
Tectonics	Low historical seismicity, no salt-flow structures nearby

Characteristics (cont'd)	Requirement (cont'd)
Hydrology	Minimal groundwater
Mineral potential	Minimal
Existing Boreholes	Minimal number (No Deep Boreholes within two miles of the site)
Population Density	Low
Land Availability	Federal Land Preferred (Three square miles and a two-mile-wide buffer zone)

DOE's predecessor agency selected a candidate site in bedded salt beds contained within the Salado Formation northeast of the present WIPP site in 1974. However, field investigations conducted to confirm existing site information found unexpected geologic structures such as steeply dipping beds, missing units, and brine containing hydrogen sulfide near the deeper planned repository depths. This early site was deemed unacceptable and a search for a new site was initiated in late 1975 which identified the present site.

The WIPP site is located in southeastern New Mexico (Figure 2-2). The site is approximately 50 kilometers (30 miles) east of Carlsbad, New Mexico, in an area known as Los Medaños, a relatively flat, sparsely inhabited plateau with little surface water (DOE 1990). WIPP consists of the 41-square-kilometer (16-square-mile) area under the jurisdiction of DOE pursuant to LWA. The WIPP site boundary was established to ensure that at least 1.6 kilometers (1 mile) of intact salt exists laterally between the waste disposal area and the accessible environment and to ensure that no permanent residences will be established in close proximity to the facility.

WIPP includes surface and underground facilities that would support waste handling and emplacement. These facilities were discussed in Section 2.2 of SEIS-I (DOE 1990). The principal surface structure at WIPP is the Waste Handling Building (WHB) (Figure 2-3). The primary function of the WHB and its associated systems is to unload TRU waste (from the TRUPACT-II for CH-TRU waste and from the RH-72B cask, if it is NRC certified for RH-TRU waste) and to transfer the containers of TRU waste to the underground disposal area through a waste shaft. The WHB contains four functional areas: the CH-TRU waste handling area, the RH-TRU waste handling area, the WHB support area, and the waste shaft (DOE 1996c). Other surface facilities include the hoist houses, support building, guard and security building, water pump house, TRUPACT-II maintenance building, training building, office trailers, exhaust filter building, warehouse and shops, engineering building, drill core storage building, and the safety and emergency services building.

The WIPP underground facilities are located at the repository horizon 655 meters (2,150 feet) beneath the surface (Figure 2-4). These facilities include the waste disposal area, an experimental region (deactivated in 1995 and 1996), access tunnels, and associated support facilities (DOE 1996c). The underground support facilities include those needed to service and maintain equipment for excavation and disposal operations, monitor for contamination, and allow limited decontamination of personnel and equipment, if necessary. All WIPP facilities currently have protection for potential fire, tornado, lightning, high wind, and other types of natural disasters. All underground facilities also are inspected by both the Occupational Safety and Health Administration and the Mine Safety and Health Administration.

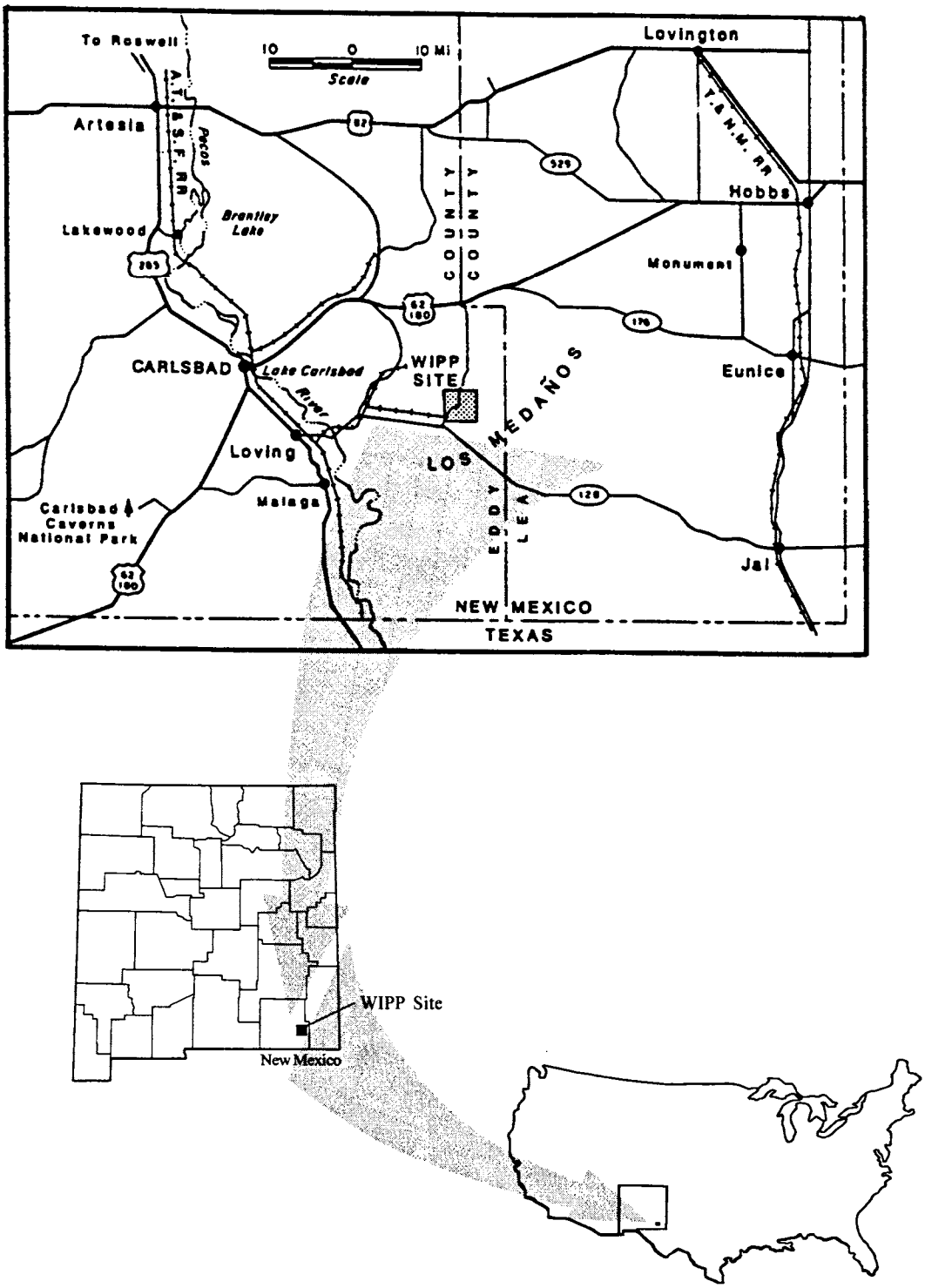
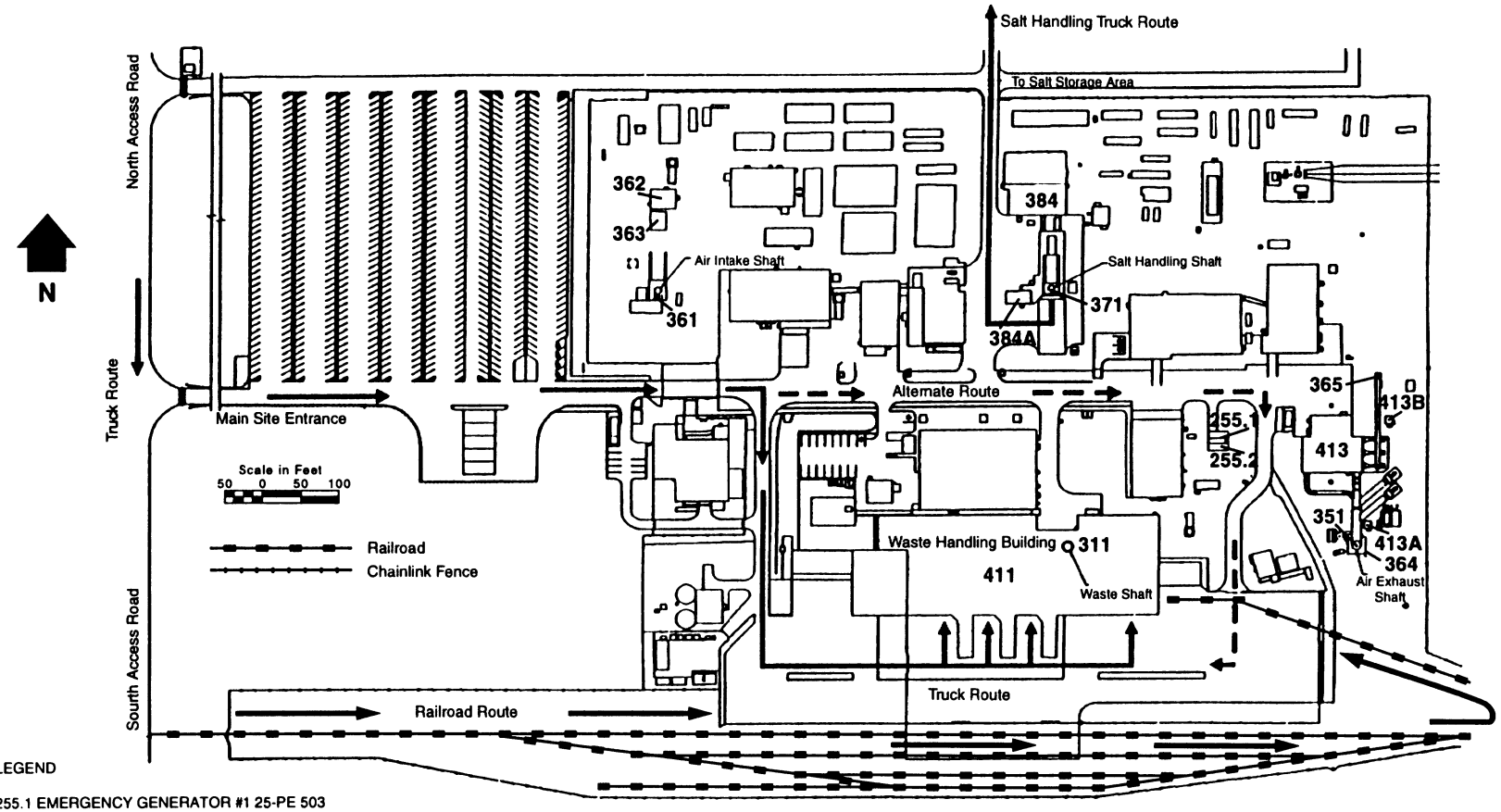


Figure 2-2
The Location of WIPP



LEGEND

255.1 EMERGENCY GENERATOR #1 25-PE 503
255.2 EMERGENCY GENERATOR #2 25-PE 504
311 WASTE SHAFT
351 EXHAUST SHAFT
361 AIR INTAKE SHAFT
362 AIR INTAKE SHAFT/HOIST HOUSE
363 AIR INTAKE SHAFT/WINCH HOUSE
364 EFFLUENT MONITORING INSTRUMENT SHED A
365 EFFLUENT MONITORING INSTRUMENT SHED B
371 SALT HANDLING SHAFT
384 SALT HANDLING SHAFT HOISTHOUSE
384A SALT HOIST OPERATIONS
411 WASTE HANDLING BUILDING
413 EXHAUST-SHAFT FILTER BUILDING
413A MONITORING STATION A
413B MONITORING STATION B

Figure 2-3
WIPP Surface Structures

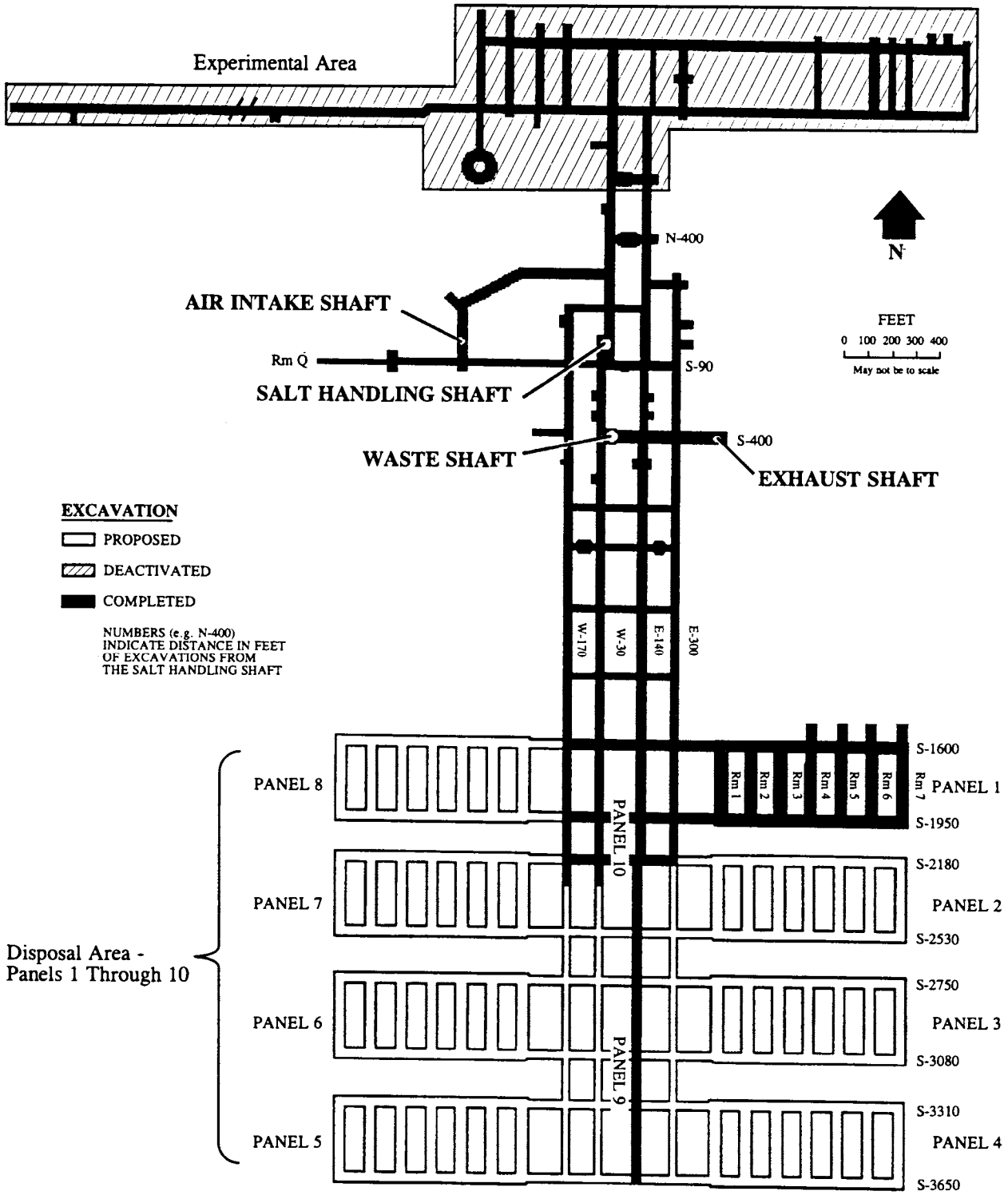


Figure 2-4
Plan View of WIPP Underground Facility
(655 meters [2,150 feet] below ground level)

One underground panel (panel 1) has been excavated. Seven additional panels and the north-south accessways (i.e., panel-equivalents 9 and 10) would be necessary to accommodate the 175,600 cubic meters (6.2 million cubic feet) of TRU waste permissible under LWA. Each panel would consist of seven waste disposal rooms, each about 91 meters (300 feet) long, 10 meters (33 feet) wide, and 4 meters (13 feet) high. Pillars between rooms would be 30 meters (100 feet) wide. Rockbolts or other types of ground control techniques would be used, as necessary, to ensure safe conditions during waste emplacement activities (DOE 1996c).

2.2 TRU WASTE TREATMENT

Although there are many different physical, chemical, and thermal treatment methods that have been previously tested or are in development for TRU waste treatment (DOE 1995c), the three types of treatment in SEIS-II are the same as those considered in the WM PEIS (DOE 1997). To ensure that the full range of potential impacts were considered, SEIS-II examined three types of treatment based on increasing levels of complexity: a minimal level of treatment needed to meet planning-basis WAC, an intermediate level of treatment using a shred and grout process, and a more complex level of thermal treatment sufficient to comply with the RCRA LDRs. DOE maintains that the impacts from these three levels of treatment represent a full range of impacts for available treatment methods.

The Proposed Action and one alternative would treat and package TRU waste only as needed to meet planning-basis WAC. A second alternative would use a shred and grout process, increasing the volume of the TRU waste by encapsulating it in cement. One alternative and one no action alternative would use a thermal treatment process to destroy organic components of the TRU waste and fuse the remainder into a glass or ceramic product, or possibly, into a metal ingot. Both CH-TRU and RH-TRU waste would be treated by the same processes; only the handling of the TRU waste would vary.

These three levels reasonably bound the potential environmental impacts for other types of treatment that might be developed for future TRU waste application. DOE will select the type of treatment necessary to satisfy disposal and storage criteria. The decisions that DOE makes on the basis of SEIS-II may be a combination of the treatment methods analyzed. This means that two or more of the treatment options may be selected for different portions of the waste.

OBJECTIVES OF TRU WASTE TREATMENT

TRU waste needs to be treated in order to put it in a form that would allow it to be safely handled, transported, and disposed of.

Treatment requirements are established to ensure compliance with requirements established by law, regulations, and DOE internal orders that are designed to protect the safety and health of workers. For example, planning-basis WAC prohibit waste containing over 50 parts per million of PCBs because land disposal of that waste would require a permit under TSCA. Other planning-basis WAC limitations, such as limitations on free liquids, are imposed because of the potential impacts of certain waste forms on the ability of WIPP to isolate the radioactive portion of the waste as required by EPA regulations (40 CFR Part 191).

Several RCRA requirements, including the prohibitions on explosives, compressed gases, and corrosive materials, are incorporated into the planning-basis WAC.

2.2.1 Treatment to Meet Planning-Basis WAC

Planning-basis WAC (DOE 1996b) defines the physical, quality assurance, handling, and documentation requirements that must be met for a container of TRU waste to be accepted at WIPP for disposal. The requirements specify TRU waste characteristics and limits and include radionuclide content, activity levels, and permissible shipping container weight. Explosives, compressed gases, and corrosive materials are prohibited by planning-basis WAC. Restrictions are set on amounts of residual liquids, thermal power, and pyrophoric materials. Planning-basis WAC includes WIPP-specific requirements as well as requirements set by various regulatory agencies, including the NRC, EPA, and U.S. Department of Transportation. Stored TRU waste may be WAC-certified or may need treatment to meet planning-basis WAC certification requirements.

Chapter 5 of this document explains how impacts would differ among alternatives if portions of the total waste volume analyzed were treated under each treatment option should the Department decide to combine two or more treatment options.

The baseline process used by treatment sites to ensure that TRU waste meets planning-basis WAC includes:

- TRU waste retrieval from storage
- TRU waste characterization in accordance with the *Transuranic Waste Characterization Quality Assurance Program Plan* (DOE 1995e)
- TRU waste treatment and packaging as needed to allow shipment in the TRUPACT-II or RH-72B packaging. Waste treatment might involve removing or solidifying residual liquids, neutralizing corrosive and deactivating reactive wastes, removing and puncturing compressed gas containers, solidifying particulates, and recementing stored TRU waste sludges. Waste treatment also may require the repackaging of existing TRU waste to fit into the appropriate shipping containers and the removal of items that do not conform with the WAC.
- TRU waste certification to planning-basis WAC

TRU waste characterization is an important step in determining whether the final TRU waste form meets planning-basis WAC. Depending on the TRU waste matrix code groups, characterization would include some or all of the following:

- Nondestructive, nonintrusive assay to identify and quantify the radionuclides in the TRU waste
- Radiographic analyses to determine the physical form of TRU waste in closed containers
- Container headspace gas analysis to detect the presence of hydrogen, methane, or EPA-listed volatile organic compounds
- Solids analyses for the presence of heavy metals such as lead, cadmium, or beryllium
- Visual inspection of an appropriate number of containers to verify quality control

Treatment sites would properly treat TRU waste identified as nonconforming during characterization. Treatment facilities would be designed to protect workers, the public, and the environment from exposure to radioactive and hazardous materials.

Planning-basis WAC uses thermal power limits as a surrogate for the gas generation potential of TRU waste. When TRU waste is in close proximity to organic materials, hydrogen gas can be produced, and hydrogen gas can be an explosion hazard. Thermal power limits vary according to the radiation and the packaging of the TRU waste within a container. For example, the hydrogen concentration for waste transported in a TRUPACT-II is limited to no greater than 5 percent (within the innermost layer of packaging) over a 60-day period. Because packaging CH-TRU waste in plastic bags inhibits the dispersal of the generated gas, the rate of gas dispersion decreases with increasing bag layers. Therefore, the more bag layers present in CH-TRU waste packaging, the greater the amount of gas present, the lower the allowed thermal power (DOE 1994) and thus, a smaller volume of CH-TRU waste would be allowed per waste container to limit gas generation. For the purposes of analyses in SEIS-II, it was assumed that no bags were used (bagless posting), thereby maximizing the volume of waste in a container and the concentration of waste that would be emplaced at WIPP. This assumption also would reduce the number of waste shipments.

2.2.2 Shred and Grout Treatment

In a shred and grout treatment process, TRU waste would be shredded to achieve a relatively uniform size and then mixed with grout. Small particles and free liquids would be immobilized with this process and any pyrophoric or corrosive characteristics of the TRU waste would be eliminated. Shred and grout treatment may also reduce the gas generation potential of TRU waste forms that already meet WAC. The gas generation potential in this case refers to the production of methane and other gases by rusting metals and decomposing materials.

An optimum shred and grout process for TRU waste treatment has not yet been selected by DOE. Site-specific NEPA review would be prepared by the Department if this type of treatment were selected for use at the treatment sites. The process selected may be modeled after commercially available technology.

Shredding TRU waste would be accomplished through a mechanical device that cuts, tears, or breaks the TRU waste into small uniform pieces. Most commercially available shredders feed the material between counter-rotating drums with intermeshing knives or teeth. For example, RFETS purchased a shredder that is designed to reduce graphite molds, HEPA filters, and process filters to pieces no larger than 2.5 x 5 x 5 centimeters (1 x 2 x 2 inches). The WIPP *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995b) describes a shredding process that would result in pieces with a maximum dimension of 10 centimeters (4 inches).

Both organic and inorganic solid TRU waste would be suitable for treatment by shred and grout. Shredding generally reduces the TRU waste volume by allowing more efficient packing of smaller pieces; however, adding grout tends to increase the overall volume by about 20 percent.

Portland cement, sand, and fresh water are typically used to make grout. An alternate formulation has a cement base, salt for aggregate rather than sand, and simulated WIPP brine in place of fresh water. Additives would be used to control the long-term behavior of the grout. In addition, the formulation and application of the grout could be optimized for various TRU waste streams. For example, one process would combine the TRU waste and the grout before placing the mix in

drums; another would add TRU waste and grout in alternating layers and then vibrate the drums; a third process would add grout to drums filled with TRU waste and then vibrate the drums.

TRU waste treatment facilities would check waste drums for radioactive contamination, decontaminate as necessary, then weigh, label, and temporarily seal the drums. After letting the grout mixture cure for several days, waste drums would undergo an inspection, and permanent lids would be installed. Finally, waste drums would undergo inspection to certify that they meet planning-basis WAC.

Much of the shred and grout treatment would be conducted using remote handling techniques, even for CH-TRU waste, because of the potential for airborne contaminant release during the shredding process. Facilities and processes would be designed to protect workers, the public, and the environment from exposure to radioactive and hazardous materials.

2.2.3 Thermal Treatment

Thermal treatment of TRU mixed waste would be designed to meet the LDRs as well as similar requirements of the TSCA. Such treatment would destroy or immobilize the hazardous substances that RCRA and TSCA regulate. (Although thermal treatment to meet RCRA LDRs would otherwise be necessary for about 60 percent of the TRU waste that DOE owns or is responsible for, the recent amendments to the LWA in Public Law 104-201 exempts WIPP disposal from such RCRA requirements.) DOE is currently pursuing plans to use a thermal treatment process at Idaho National Engineering and Environmental Laboratory to treat both TRU mixed waste and TRU waste commingled with PCBs. Existing or future NEPA documentation has or would be prepared by the Department for these treatment facilities.

Thermal treatment involves exposing TRU waste to temperatures in excess of 3,000 degrees Celsius (°C) (5,400 degrees Fahrenheit [°F]). Nearly all TRU mixed waste streams in the DOE complex could be treated thermally, including solid combustibles and heterogeneous debris. The high temperatures would destroy organic materials and convert inorganic components to either a glassy slag, a metal phase, or a consolidated waste form. These phases could be separated out and offer the potential for recycling. Such high temperature treatment processes might also include a secondary, fuel-fired combustion chamber for treating off-gases to ensure a high efficiency in destroying all organic materials, regardless of the initial properties of the TRU waste.

Most of the alpha-emitting radionuclides and heavy metals would be bound as oxides in the slag, which would be expected to pass the EPA toxicity characteristics leach procedure. Thermal treatment may offer improved waste isolation because radionuclides and heavy metals in the slag would be less soluble in the brine and, in the event of human intrusion by drilling, less waste would be drawn to the surface in the drilling muds. The gas generation potential of thermally treated waste would also be less than that of untreated TRU waste.

The thermal process would produce aqueous liquids that would need to be neutralized and wet solids, debris, and residues that would need to be disposed of as low-level waste (DOE 1997). DOE would consider the impacts of these waste streams in future NEPA studies when selecting a specific thermal treatment process (i.e., vitrification, plasma hearth, etc.) and a specific site for a treatment facility.

Potential thermal treatment processes are discussed in a 1995 DOE publication entitled *Alternatives to Incineration Technical Area Status Report* (DOE 1995a). Summaries of three of these processes follow:

Plasma Torch and Electric Arc Technologies

Both the plasma torch and electric arc technologies involve a high-voltage discharge in a gas to form a plasma. They differ in that the plasma torch process involves plasma discharge in a flowing gas that stabilizes the arc and provides the thermal source. In contrast, the electric arc process involves plasma discharge in a nonflowing gas medium that provides the primary energy for heating and melting the TRU waste. The two plasma technologies can accept a variety of TRU wastes and TRU waste matrices. Depending on the system design, TRU waste liquids, soils and sludges, and even entire containers may be melted to form a molten slag.

A reducing environment is typically used to thermally treat volatile organic constituents. Process byproducts are synthetic off-gases and organics, which are combusted in an afterburner. Because very small gas volumes are used in these systems, only small volumes of off-gas are produced. Molten solid material can be continuously removed by overflow or poured by batch to form a leach-resistant, vitrified (glassy) TRU waste form.

Vitrification

Vitrification is the process of converting materials into a glass or glass-like substance. Temperatures used in this process are typically between 1,000°C to 1,600°C (1,800°F to 2,900°F). Thermal vitrification processes destroy organic constituents by pyrolysis or combustion. These processes also immobilize inorganics by incorporating them in the glass product. Various types of electric melters could be used to vitrify TRU waste, including vertical and horizontal joule, induction, microwave, and plasma and electric arc melters.

In the joule, induction, and microwave melters, molten glass is heated internally to form a pool of molten glass in a refractory lined or “cold wall” steel vessel. In many of these melters, a cold cap, or crust, is formed on the top of the melt from the feed as it is introduced to the top of the melter. This cap would act as the interface between incoming TRU waste and the molten glass. The bottom of the cap forms an interface where the feed material melts as it enters the glass matrix. The cold cap also serves to filter particulates and to condense and retain volatilized radionuclides and heavy metals for possible reincorporation into the melt. Water and organics volatilize from the cap and enter the plenum, a pressurized enclosure where the organics may be oxidized or reformed with the steam. Organic destruction may also occur through pyrolysis in the melt or in a secondary combustion chamber.

Molten Salt

The molten salt oxidation process consists of a bath of molten salts maintained at 700°C to 950°C (1,300°F to 1,700°F) to oxidize organic components of TRU mixed waste and to retain radionuclides, metals, and acid gases in a salt residue. During operation, a mixture of liquid or solid particulate TRU waste and air is injected into the bottom of the melt which is contained in a ceramic-lined vessel. The high temperature and intimate contact with the molten salt causes the rapid reaction of the organic material with the oxygen in the air to produce conventional combustion products.

The final products of this process would be a glass or ceramic slag, a metal ingot (depending on the original TRU waste form), and treated off-gas. This treatment process would reduce the original TRU waste volume by about 35 percent or less. The glass or ceramic slag product would contain all or most of the TRU waste. The metal ingot product could be sufficiently free of radionuclides that it would be suitable for disposal as low-level waste or recycled material. In either case, the slag and potentially the metal ingot would be characterized for certification to meet the planning-basis WAC. Most materials recovered from the off-gases would be cycled to ensure their incorporation into the slag. The treated off-gas would meet facility-specific release limits, as dictated by facility permits.

2.3 STAKEHOLDER OUTREACH AND INVOLVEMENT ACTIVITIES

DOE conducted several activities prior to the SEIS-II public scoping period to inform the public of the Department's intent to prepare SEIS-II. Letters were sent to SEIS-II stakeholders, including private citizens, elected officials, tribal leaders, and public affairs officers, announcing the Department's plan to prepare SEIS-II. A Fact Sheet and the DOE Carlsbad Area Office Monthly Stakeholder Calendar for August 1995 were also distributed to stakeholders to notify the public of the upcoming SEIS-II scoping activities. In addition, an informal telephone survey was conducted to gather stakeholder suggestions about the structure of the SEIS-II scoping meetings.

SEIS-II public scoping activities included the following:

- A Notice of Intent (NOI) published in the Federal Register on August 23, 1995 (60 FR 43779), and a notice reopening the comment period published in the Federal Register on October 13, 1995

- A public comment period from August 23, 1995, to October 16, 1995

- Public scoping meetings held in Carlsbad, New Mexico, on September 7, 1995; Albuquerque, New Mexico, on September 12, 1995; Santa Fe, New Mexico, on September 14, 1995; Denver, Colorado, on September 19, 1995; Boise, Idaho, on September 20, 1995; and a second meeting in Denver, Colorado, on October 11, 1995

The NOI listed the times and locations of the public scoping meetings and the length of the public scoping period.

The Department issued the Implementation Plan for SEIS-II in May 1996. The Implementation Plan provides background information on WIPP, describes the Department's purpose and need for the WIPP project, and describes the SEIS-II work plan. It also describes the scoping process, major issues identified during the scoping process, and contains a brief discussion of how major scoping issues will be addressed in SEIS-II. Copies of the Implementation Plan were distributed to state, tribal and local governments, U.S. Congressional delegates from states with an interest in the WIPP project, all parties who provided scoping comments, and other interested parties.

Fact Sheets were prepared by the Department to provide stakeholders with additional information on topics related to SEIS-II. Two Fact Sheets, one on prescoping activities and the other on postscoping activities, have been distributed to parties on the SEIS-II mailing list. Fact Sheets were also distributed at the public scoping meetings. These sheets provided information on the NEPA process, the WIPP project, the DOE reading rooms, the role of public participation in the

decision process, and other topics relevant to SEIS-II. The Department also will distribute Fact Sheets upon completion of the Final SEIS-II and publication of the ROD to all parties on the SEIS-II mailing list.

DOE published the Draft SEIS-II Notice of Availability (NOA) in the FR on November 29, 1996 (61 FR 60690). The NOA provided information on how the public could obtain copies and provide comments on the Draft SEIS-II, and the locations, dates, and times of the Draft SEIS-II hearings.

More than 900 copies of the Draft SEIS-II and 1,200 copies of the Draft SEIS-II Summary were distributed to federal, state, local, Tribal officials, and the general public. Three fact sheets were distributed along with the Draft SEIS-II and the Summary: an overview of how the public could provide comments on the Draft SEIS-II and the public hearing schedule; a list of the SEIS-II reading rooms (which has been reprinted as Table 2-4); and a list of the alternatives analyzed in the Draft SEIS-II.

DOE had initially established a 60-day public comment period that included the public hearing process. In response to public requests for more time to study the Draft SEIS-II, DOE subsequently extended the public comment period to 90 days (62 FR 4989). The public was also provided the opportunity to comment at a series of public hearings held in the following locations: Albuquerque, New Mexico on January 6 and 7, 1997; Santa Fe, New Mexico on January 8, 9, 10, 1997; Carlsbad, New Mexico and Denver, Colorado on January 13, 1997; Richland, Washington and Boise, Idaho on January 15, 1997; Oak Ridge, Tennessee on January 21, 1997; and North Augusta, South Carolina on January 23, 1997.

More than 700 individuals attended the hearings and more than 300 individuals provided oral testimony. The SEIS-II public hearings were scheduled after the holiday season to afford more people the opportunity to attend them. In addition, DOE staff attended meetings in New Mexico, Oregon, and Idaho to give presentations on SEIS-II. Recognizing that not every individual, organization, or agency could or would attend a public hearing, DOE invited comments on the Draft SEIS-II by mail, facsimile, and the Internet and received more than 150 letters.

Table 2-4
List of WIPP Reading Rooms

NAME	ADDRESS
U.S. Department of Energy Headquarters [a] Public Reading Room	Room 1E-190/Forrestal Building Freedom of Information Reading Room 1000 Independence Ave. S.W. Washington, DC 20585
Defense Nuclear Facilities Safety Board [a]	625 Indiana Ave. N.W., Suite 700 Washington, DC 20004
Scientific and Technical Information Center U.S. Department of Energy Reading Room [a]	P.O. Box 62 Oak Ridge, TN 37831
Thomas Branigan Memorial Library	200 East Picacho Las Cruces, NM 88001
New Mexico State Library [a]	325 Don Gaspar Santa Fe, NM 87503
Pannell Library New Mexico Junior College	5317 Lovington Highway Hobbs, NM 88240
Carlsbad Public Library [a] Public Document Room	101 South Halagueno Carlsbad, NM 88220
Zimmerman Library University of New Mexico [a] Government Publications	Roma Ave. and Yale Blvd. Albuquerque, NM 87131-1466
Martin Speare Memorial Library	New Mexico Institute of Mining and Technology Leroy and Bullock Campus Station Socorro, NM 87801
U.S. Department of Energy FOIA Public Reading Room	Technical-Vocational Institute Montoya Campus Library 4700 Morris NE Albuquerque, NM 87111
Raton Public Library	244 Cook Ave. Raton, NM 87740
New Mexico State University Library	P.O. Box 30001 Las Cruces, NM 88003
U.S. Department of Energy Public Reading Room [a]	1776 Science Center Dr. Idaho Falls, ID 83702
INEEL Boise Office	816 West Bannock Suite 306 Boise, ID 83702
Shoshone-Bannock Library HRDC Building	Bannock and Pima Fort Hall, ID 83203
University of Idaho Library University of Idaho	Rayburn St. Moscow, ID 83202
Moscow Environmental Restoration Information Office	530 South Ashbury Suite 2 Moscow, ID 83842
Pocatello Public Library	113 South Garfield Pocatello, ID 83201
Idaho State University Library	741 South 7th Ave., Box 8089 Pocatello, ID 83209
Twin Falls Public Library	434 2nd St. East Twin Falls, ID 83301
Standley Lake Library	8485 Kipling St. Arvada, CO 80005
Superfund Records Center U.S. Environmental Protection Agency	999 18th St. 5th Floor Denver, CO 80202
U.S. Department of Energy Public Reading Room Rocky Flats Operations [a]	Front Range Community College Library 3645 West 112th Ave. Level B, Center of the Building Westminster, CO 80030
Citizens Advisory Board	9035 N. Wadsworth Pkwy Suite 2250 Westminster, CO 80021

[a] Reference documents are available at these locations

Table 2-4
List of WIPP Reading Rooms — Continued

NAME	ADDRESS
U.S. Department of Energy Public Reading Room Richland Operations Office	Washington State University Tri-Cities 100 Sprout Rd. Room 130 West Richland, WA 99352
U.S. Department of Energy Public Reading Room	9800 South Cass Ave. Building 201 Argonne, IL 60439
U.S. Department of Energy Public Reading Room Nevada Operations Office	2621 Losee Rd. North Las Vegas, NV 89030-4129
U.S. Department of Energy Public Reading Room Oakland Operations Office	1301 Clay St. Room 700 N Oakland, CA 94612
U.S. Department of Energy Public Reading Room	Miamisburg Senior Adult Center 305 Central Ave. Miamisburg, OH 45342
Texas State Library Information Services Division	1201 Brazos St. Austin, TX 78701
Wyoming State Library Government Documents	Supreme Court Building 2301 Capitol Ave. Cheyenne, WY 82002
Idaho National Engineering and Environmental Laboratory Pocatello Office	1651 AT Ricken Dr. Pocatello, ID 83201
Idaho National Engineering and Environmental Laboratory Twin Falls Office	233 2nd St. North Suite B Twin Falls, ID 83301
Information Center Colorado Department of Public Health and Environment	4300 Cherry Creek Dr. South Building A Denver, CO 80222-1530
U.S. Department of Energy Public Reading Room	55 Jefferson Cir. Oak Ridge, TN 37830
Community Reading Room	Los Alamos National Laboratory P.O. Box 1663, MS A-117 Los Alamos, NM 87545
Mobile Public Library Federal Document Collection	701 Government St. Mobile, AL 36602-1499
Arkansas State Library Federal Document Collection	One Capitol Mall Little Rock, AR 72201
Flagstaff City-Coconino County Public Library	300 West Aspen Flagstaff, AZ 86001
Atlanta-Fulton Public Library Federal Document Collection	One Margaret Mitchell Square, N.W. Atlanta, GA 30303-1089
Indiana State Library Federal Document Collection	140 North Senate Ave. Indianapolis, IN 46204-2296
Kansas State Library Federal Document Collection	State Capitol Building Topeka, KS 66612
Mississippi State Law Library Federal Document Collection	450 High St. Jackson, MS 39215-1040
Missouri State Library Federal Document Collection	600 West Main Jefferson City, MO 65102
Oregon State Library Federal Document Collection	State Library Building 250 Winter Street, N.E. Salem, OR 97310-0640
The Navajo Nation U.S. Environmental Protection Agency	c/o Levon Benally, Jr. P.O. Box 339 Window Rock, AZ 86515
State Library Louisiana	760 North Third St. Baton Rouge, LA 70802
The Oklahoma Department of Libraries	200 N.E. 18th St. Oklahoma City, OK 73105

[a] Reference documents are available at these locations

2.4 REFERENCES CITED IN CHAPTER 2

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1994, *TRUPACT-II Content Codes (TRUCON)*, DOE/WIPP 89-004, Revision 8, WIPP Project Office, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *Alternatives to Incineration Technical Area Status Report*, DOE/MWIP-26, April, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995c, *Radioactive Waste Processing and Volume Reduction Technology Study*, DOE/CAO-95-3102, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995d, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 2, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995e, *Transuranic Waste Characterization Quality Assurance Program Plan*, DOE/CAO-94-1010, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP 91-005, Revision 5.2, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996c, *Final No-Migration Variance Petition*, DOE/CAO-96-2160, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996e, *Title 40 CFR 191 Combliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

CHAPTER 3
DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

The following sections provide descriptions of the Proposed Action, three action alternatives, and two no action alternatives. Section 3.4 presents a summary table of the Proposed Action and alternatives. The chapter closes with a discussion of the alternatives that are not analyzed in detail in this second supplemental environmental impact statement (SEIS-II), a summary of impacts, and a detailed discussion of the preferred alternative.

In the Notice of Intent that initiated the public scoping process for SEIS-II, the Department of Energy (DOE or the Department) preliminarily identified a Proposed Action, two action alternatives, and a no action alternative. Comments received during the scoping process identified the need for an additional action alternative and another no action alternative.

The Proposed Action, three action alternatives, and two no action alternatives presented in this chapter, therefore, comprise a wide range of options from which the Department can make decisions. Among the decisions that can be supported by these options are the following:

- Whether to open the Waste Isolation Pilot Plant (WIPP) for disposal of transuranic (TRU) waste or continue to maintain the waste in storage. The two no action alternatives examine the impacts of not opening WIPP.

- Which portions of contact-handled (CH) TRU and remote-handled (RH) TRU waste inventory (identified in Chapter 2 as the Total Inventory consisting of the Basic Inventory and Additional Inventory) should be disposed of at WIPP or continued in storage. Analyses of the alternatives include the impacts of both inventories.

- Which minimal level of waste treatment should be required in the Waste Acceptance Criteria (WAC) to meet disposal performance standards or storage requirements prior to the disposal of or storage of waste.[1] The three action alternatives differ in the treatment proposed, as do the two no action alternatives.

FURTHER NEPA ANALYSIS

The Department would conduct site-specific National Environmental Policy Act (NEPA) analyses to assess the impacts of siting and operating individual waste treatment facilities before making final decisions concerning whether to construct and operate those facilities.

- Whether to transport TRU waste primarily by truck or by rail. Three transportation options (truck, commercial rail, and dedicated rail) are assessed for all alternatives except the Proposed Action, where transportation by truck is the only option considered, and No Action Alternative 2, where there is no transportation.

[1] DOE may decide, for site-specific reasons, to treat TRU waste to levels beyond the minimal level ultimately required in the WAC. Such a decision would be based on further site-specific NEPA review.

Decisions based on SEIS-II may be a combination of the options presented within the alternatives analyzed. This means that portions of two or more of the alternatives analyzed in SEIS-II may be combined and used by the Department for the management or disposal of TRU waste.

The Preferred Alternative is the Proposed Action, reserving the possibility of using rail transportation in the future following appropriate NEPA review. Additional detail on the Preferred Alternative is presented at the end of this chapter.

The following sections describe the Proposed Action; Action Alternatives 1, 2, and 3; and No Action Alternatives 1 and 2.

3.1 PROPOSED ACTION: BASIC INVENTORY, TREAT TO WAC, DISPOSE OF AT WIPP (PREFERRED ALTERNATIVE RESERVING RAIL TRANSPORTATION FOR FUTURE CONSIDERATION)

The Department's Proposed Action is to continue with the phased development of WIPP by disposing of TRU waste at the facility, as authorized by Public Laws 96-164, 102-579, and 104-201. For the purposes of analyses in this document, WIPP disposal is assumed to begin in 1998. Under the Proposed Action, DOE would dispose of defense TRU waste that has been placed in retrievable storage and that would continue to be generated from plutonium stabilization and management, environmental restoration, decommissioning activities, waste management programs, and testing and research during the 35-year period from 1998 to 2033 (i.e, waste included in the Basic Inventory). Table 3-1 presents the volume of TRU waste included in this Basic Inventory.

However, SEIS-II analyses assumed disposal of 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste, much less than the RH-TRU waste Basic Inventory. This volume was analyzed because it is the volume allowed by the Consultation and Cooperation (C&C) Agreement with the State of New Mexico. For CH-TRU waste, SEIS-II analyses were performed using a disposal volume of 168,500 cubic meters (5,950,000 cubic feet), which is greater than the CH-TRU waste Basic Inventory. This volume was analyzed because when added to the RH-TRU waste volume above, the total disposal volume was that allowable under the Land Withdrawal Act (LWA).

(More recent waste volume estimates presented in Appendix J show a decrease in the volume of RH-TRU waste, to a volume that could be completely disposed of at WIPP. As explained in Chapter 2, the SEIS-II analyses are based on a more conservative inventory.)

Management at WIPP of the Additional Inventory described in Chapter 2 is not analyzed as part of the Proposed Action. Alternatives for management of the Additional Inventory are presented in Action Alternatives 1, 2, 3, and No Action Alternative 1, discussed later in this chapter. Existing RH-TRU waste in the Basic Inventory that exceeds the amount allowable by current laws and agreements is identified as "excess waste." It was assumed, for the purposes of analyses, that the excess RH-TRU waste, which amounts to approximately 43,000 cubic meters (1,500,000 cubic feet), would be located at the Hanford Site (Hanford) and Oak Ridge National Laboratory (ORNL) and would remain in storage at these sites for an indefinite number of years following treatment.[1]

[1] For the purposes of analyses in SEIS-II, it was assumed that waste would be shipped from all four RH-TRU waste consolidation sites at similar rates so that the entire projected INEEL and LANL RH-TRU waste volumes would be accepted, and the remaining capacity for RH-TRU waste disposal would be filled proportionally with waste from ORNL and Hanford. New waste estimates presented in Appendix J indicate that all waste may be disposed of.

Table 3-1
TRU Waste Volumes (Basic Inventory) for the Proposed Action [a]

Site [c]	Site Volume Through 2033 (cubic meters)		Pretreatment Consolidated Volume [b] (cubic meters)		Post-Treatment Disposal Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU [d]	RH-TRU [e]
Hanford Site (Hanford)	57,000	29,000	57,000	29,000	57,000	42,000
Los Alamos National Laboratory (LANL)	21,000	230	21,000	230	21,000	330
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	220	29,000	2,000	30,000	2,800
Argonne National Laboratory - West (ANL-W)	1,000	1,700	--- [g]	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	200	---
Savannah River Site (SRS)	12,000	---	12,000	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	17,000	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,800	3,700	1,900	5,300
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	1,200	---
Nevada Test Site (NTS)	630	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	340	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	---	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	---	---	---	---
Ames Laboratory – Iowa State University (Ames)	1	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	---	---	---
Total	**135,000**	**35,000**	**135,000**	**35,000**	**143,000** [h]	**50,000** [i]
Disposal Volume Allowed by LWA and the C&C Agreement	**---**	**---**	**---**	**---**	**168,500** [h]	**7,080** [i, j]

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 parts per million (ppm) of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Volumes have been rounded. Actual totals may differ due to rounding. The site volumes through 2033 match the final columns on Table 2-2.

[b] Volumes include consolidation of waste as indicated on Figure 3-1.

[c] Sites in boldface were included in SEIS-I.

[d] Post-treatment volumes have been adjusted to meet packaging and transportation requirements to meet planning-basis WAC.

[e] Values represent WIPP emplacement volumes, except for Hanford and ORNL which may not be able to emplace all of their RH-TRU waste at WIPP. (New volume estimates, as presented in Appendix J, indicate all waste could be emplaced.)

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, are counted as one site in SEIS-II.

[g] Dashes indicate no waste.

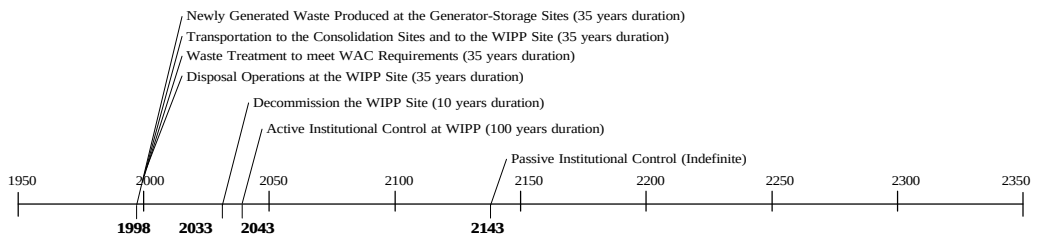
[h] Though 143,000 cubic meters of CH-TRU waste are part of the Basic Inventory, additional CH-TRU waste may become a part of that inventory should RCRA or CERCLA action lead to retrieval of previously disposed of waste. Therefore, SEIS-II assesses the impact of the entire disposal volume allowed, 168,500 cubic meters.

[i] All LANL and INEEL RH-TRU waste is assumed to be disposed of; RH-TRU waste disposed of for Hanford would be approximately 2,800 cubic meters; that for ORNL would be 1,100 cubic meters (after consolidation).

[j] The LWA limits the total RH-TRU waste curie content of WIPP to 5.1 million. Under the Proposed Action, the total curie content associated with the 7,080 cubic meters would be less than 1 million curies.

Current data and projections indicate that 18 sites would generate Basic Inventory waste or currently have it in storage. TRU waste would first be treated at the 18 sites as necessary to meet planning-basis WAC. Consolidation under the Proposed Action would occur in the manner described in the ROD to be issued for the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997). Such consolidation could be at the 10 largest generator-storage sites (see Figure 3-1) as in the WM PEIS Decentralized Alternative or at fewer sites as in the WM PEIS (DOE 1997) preferred alternative. For purposes of analysis, SEIS-II assumed consolidation at the 10 largest generator-storage sites; not consolidating the waste and consolidating it in a manner similar to the WM PEIS preferred alternative are also discussed in the text.[1]

The timeline below presents the approximate schedule for waste disposal activities under the Proposed Action. The disposal of TRU waste at WIPP would begin in 1998 and continue for 35 years, through the year 2033, at which time the facility would be closed. Decommissioning activities of WIPP would take up to 10 years (2043) and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2143.



Timeline for the Implementation of the Proposed Action

3.1.1 Activities at the Generator-Storage Sites

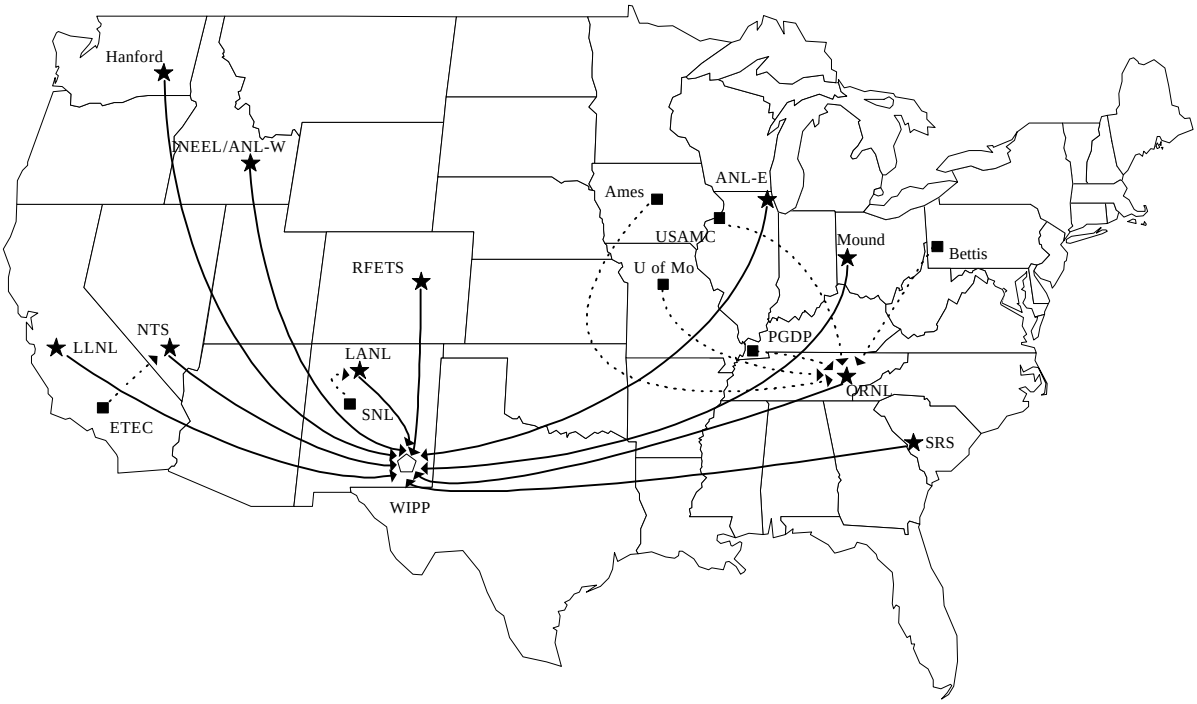
This section describes WIPP-related activities that would occur under the Proposed Action at various generator-storage sites throughout the DOE complex. The WM PEIS and Chapter 4 of SEIS-II contain information on the sites themselves.

The 18 generator-storage sites would consolidate CH-TRU waste at 10 consolidation sites for subsequent shipment to WIPP. Of the seven RH-TRU waste sites, three sites would ship their RH-TRU waste for consolidation prior to shipment to WIPP. The flow of waste described here is assumed for analysis of potential environmental impacts, but the Department may adjust the configuration later in the WM PEIS Record of Decision.

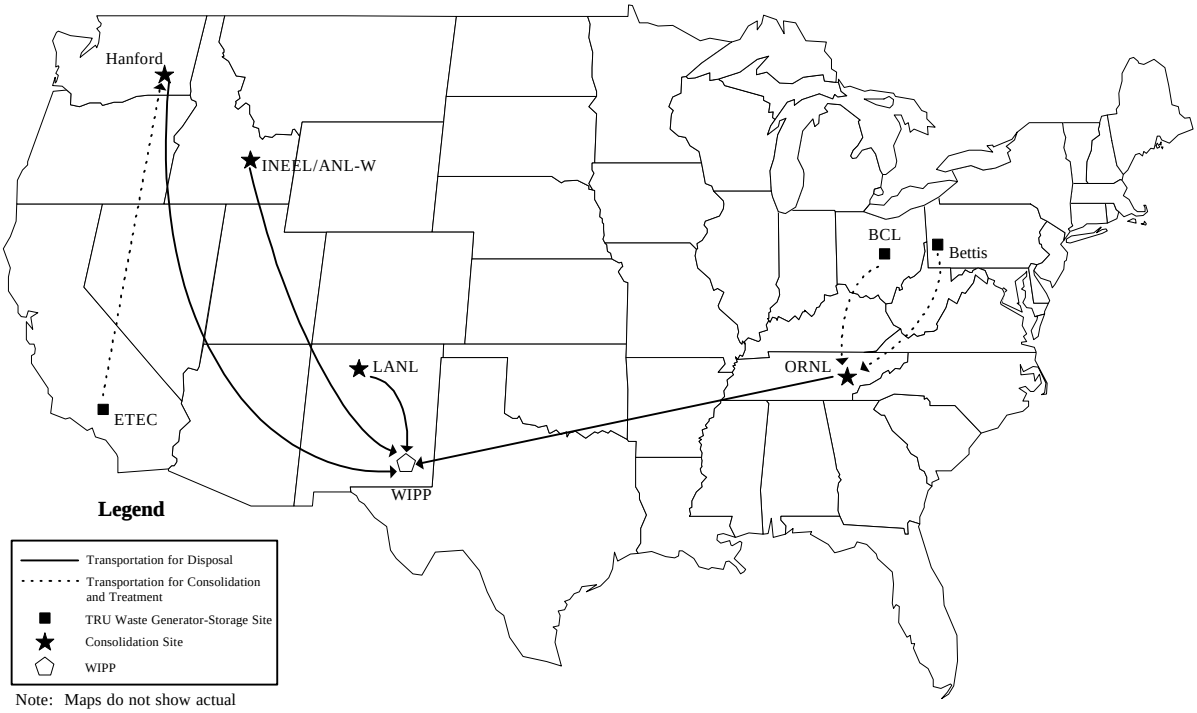
The type of treatment performed would depend on whether the waste is already certified as meeting WAC. Some waste may require treatment and packaging to meet WAC. For purposes of analysis, all waste has been assumed to be treated and packaged to

[1] The consolidation scheme presented in SEIS-II is intended for the purpose of analyzing the impacts and may not reflect the actual movement of waste that will occur.

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-1
Movement of Waste for the Proposed Action [a]
(For complete names of facilities and waste volumes, see Table 3-1)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

planning-basis WAC (using mobile treatment units where appropriate).[1] This could include, for example, reducing size and packaging, adding absorbents to eliminate free liquids, packaging, and assaying and sampling to ensure that packaging and transportation certification criteria have been met.

One aspect of the WAC addresses the generation of hydrogen gas in the TRUPACT-II during shipment. The assumption has been made that all CH-TRU waste will be packaged using bagless posting (i.e., no plastic bag liners will be used in waste containers). Bagless posting offers a lower gas generation rate than using one or more layers of plastic bagging materials and therefore results in fewer shipments (see Appendix A).

Each site preparing to ship TRU waste to WIPP would coordinate with WIPP personnel for scheduling purposes. Together, site and WIPP personnel would arrange for shipment from the site to WIPP using either the TRUPACT-II or the RH-72B cask.

3.1.2 Transportation Activities

Under the Proposed Action, trucks transporting TRU waste in U.S. Nuclear Regulatory Commission (NRC)-certified transportation containers (certified under 10 CFR Part 71) and traveling over U.S. Department of Transportation (DOT) and state-designated routes would transport the TRU waste between the generator-storage sites and from the consolidation sites to WIPP. Trucks would transport CH-TRU waste in TRUPACT-IIs and RH-TRU waste in RH-72B casks. The rate at which both CH-TRU waste and RH-TRU waste would arrive at WIPP for disposal would be based on the WIPP waste handling throughput rate and the storage area. On average, WIPP facilities would handle about 50 TRUPACT-IIs of CH-TRU waste and about eight RH-72B casks of RH-TRU waste per week. WIPP currently has no permits to store backlogged shipments, although it may obtain a permit to store small amounts of waste in its Waste Handling Building. DOE proposes to obtain the Resource Conservation and Recovery Act (RCRA) permits for limited nonroutine storage capacity in the Waste Handling Building (see Figure 2-3), but the time that incoming waste can spend in the staging area is limited. The Safety Analysis Report for Packaging attached to Certificate of Compliance No. 9218 (NRC 1997) limits the time a TRUPACT-II can remain sealed (with waste inside) to a maximum of 60 days, due to the potential for hydrogen gas accumulation within the TRUPACT-II. WIPP operations managers would meet these requirements through continuous coordination with the treatment sites to control the time and rate at which CH-TRU and RH-TRU waste arrives at WIPP for disposal.

Currently, the Department is proposing the use of trucks to transport waste. The Department has investigated and continues to investigate the possibility of using rail transportation but considers it less reasonable at this time. The primary factors that make rail carriage less reasonable are the following: (1) limited interest of the rail carriers in handling the shipments, (2) higher cost of dedicated rail transportation as compared to truck transportation, (3) the initial cost of acquiring additional TRUPACT-IIs needed for rail transportation (because three times as many TRUPACT-IIs would be needed for each shipment) and of acquiring or modifying rail cars for transport, and (4) DOE's inability to obtain rail carrier assurance that TRUPACT-II transit will

[1] At the smaller sites, use of mobile characterization and/or treatment units was assumed. Any emissions from these mobile units would be HEPA (High Efficiency Particulate Air) filtered. The characterization, packaging, and treatment performed by the mobile units would be on such a small volume of waste that there would be virtually no additional waste, and virtually no radiological or hazardous chemical impacts to workers or the public would be expected.

TRANSCOM SYSTEM

DOE has developed a transportation tracking and communications system that is used to track truck and rail shipments. This satellite-based system, the Transportation Tracking and Communications (TRANSCOM) system, has been in operation since 1989. Since its inception, the TRANSCOM System has tracked over 500 shipments for DOE. The use of TRANSCOM is mandated by DOE Order 460.2, *Departmental Materials Transportation and Packaging Management*.

The mission of the TRANSCOM system is to provide tracking and communications for shipments of radioactive materials, hazardous materials, and other high-visibility shipping campaigns, as specified by DOE. The TRANSCOM system is managed and operated at the TRANSCOM Control Center (TCC) in Oak Ridge, Tennessee, for DOE.

The TRANSCOM system provides the TCC staff, shippers, carriers, receivers, and state, Tribal, and federal users with the ability to view information about shipments and communicate with each other during shipment tracking. Information about shipment contents, points of contact, routes, status, locations, and emergency response information is available to local emergency response teams and each user. The information is displayed in tabular and graphical form using a series of national, state, and county maps. The vehicle location can be determined to within a few meters, with position updates as frequently as every 60 seconds. Drivers are alerted to adverse weather or road conditions.

enable DOE to unseal the TRUPACT-II within 60 days, as required by NRC. Regular rail transportation, because of its lower cost and accident risk, is still considered a desirable option for some waste transportation in the future, provided the factors that make it currently less reasonable can be mitigated. Though rail transportation was not analyzed under the Proposed Action, use of rail transportation is reserved for future consideration under the Preferred Alternative; if rail transportation were used, impacts are expected to be lower than impacts from truck transportation.

3.1.2.1 Shipping Procedures

The DOE *Transuranic Materials Transportation Guide* (DOE 1996b) establishes the procedures to be followed for shipping TRU waste; essentially, these are the same procedures planned earlier and reported in the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). DOE personnel, the generator-storage sites, and the carriers would comply with all applicable rules, regulations, and orders pertaining to the packaging, marking, labeling, inspection, and transportation of TRU waste as issued by the DOT, DOE, the U.S. Environmental Protection Agency (EPA), and NRC.

Each generator-storage site would ensure that the TRU waste to be shipped meets WAC, that the waste is properly loaded into the TRUPACT-II or RH-72B cask, that all DOE procedures have been followed, that labels and placards are in compliance with DOT regulations, and that bills of lading are entered correctly into the TRANSCOM system. The generator-storage sites will follow the requirements for Type A packages described in Title 49, CFR Part 173. The Department would be prepared to provide emergency response support in the event of an accident.

A contract carrier would provide dedicated drivers and tractor-trailer trucks to transport TRU waste to WIPP. The trailers and packagings are owned by DOE. Specific responsibilities of the carrier would include providing drivers who are qualified according to DOT requirements (49 CFR Part 391) and ensuring that vehicles are operated in a safe manner. The carrier would ensure that both the tractor and the trailer are in operating condition prior to leaving the shipper's premises and

CONSERVATISM OF TRU WASTE VOLUME ESTIMATES

TRU waste inventory estimates, as used throughout SEIS-II, embody many conservative assumptions to ensure bounding analyses of maximum, reasonably foreseeable impacts. The following reflect some of the conservative assumptions.

- The BIR-3 estimates of TRU waste volumes include projections that may overestimate TRU waste volumes. For instance, in both the Basic Inventory and the Additional Inventory, volume estimates include projections of waste yet to be generated. Though the Department's TRU waste generation due to defense activities has decreased because of a change in the nation's nuclear weapons needs, the projections of future waste also include waste anticipated by activities such as decontamination and decommissioning. These activities, which would include cleaning and disassembling facilities, can generate a great deal of TRU waste, but whether that waste will actually be generated and whether it will be CH-TRU or RH-TRU waste is uncertain. For the purposes of analyses, SEIS-II has used the estimates included in BIR-3.

- The Additional Inventory includes estimates of TRU waste produced prior to 1970 and believed to have been disposed of in trenches at some of the sites. Since DOE's definition of TRU waste has changed and some of the buried waste would probably be classified as low-level waste under current definitions, the amount that is actually TRU waste is unknown. For the purposes of analyses, all of this waste, as estimated in BIR-3, is considered part of the Additional Inventory and the effects of its disposal at WIPP are assessed in the SEIS-II action alternatives. SEIS-II analyzes 141,000 cubic meters (5 million cubic feet) of TRU waste that has been previously disposed of. Currently, though, DOE estimates that only 80,000 cubic meters (2.8 million cubic feet) of this waste would be excavated.

- The C&C Agreement between the State of New Mexico and DOE limits the amount of RH-TRU waste allowable at WIPP to 7,080 cubic meters (250,000 cubic feet). The Department's Proposed Action proposes disposing of this amount of RH-TRU waste, although the actual amount may be as low as 4,300 cubic meters (150,000 cubic feet). The lower figure reflects the current plans for disposing of this waste in the walls of WIPP panel rooms before emplacement of CH-TRU waste in the rooms. At startup, delays in preparing the RH-TRU waste for shipment are anticipated, which would result in the emplacement of some CH-TRU waste before RH-TRU waste is ready for WIPP. To ensure that SEIS-II disposal analyses are conservative, the analyses for the Proposed Action were conducted as if the full 7,080 cubic meters of RH-TRU waste would be emplaced.

- Application of the LWA and the C&C Agreement would limit the amount of CH-TRU waste allowable under the Proposed Action to 168,500 cubic meters (5,950,000 cubic feet), but only 143,000 cubic meters (5,050,000 cubic feet) is estimated to be in the Basic Inventory. Still, because of the potential for excavation of previously disposed of waste (which would then be classified as newly generated) and the potential for treatment of alpha-emitting, low-level waste that could convert currently non-TRU waste forms into TRU waste by concentrating transuranic radionuclides (as discussed in the cumulative impacts analysis), and repackaging of RH-TRU waste to meet the criteria of CH-TRU waste, SEIS-II analyses consider the effects of filling WIPP to its allowable capacity.

- While the LWA and C&C Agreement include limits on the volume of TRU waste that can be emplaced, there is considerable uncertainty concerning how much of a container's volume is made up of TRU waste and how much is void space. Many of the containers would include a great deal of void space, particularly for RH-TRU waste; the actual volume of waste in a drum or cask, therefore, may be much less than the volume of the drum or cask. For the purposes of analyses in SEIS-II, the volume of the drum or cask is used, as if the drum or cask were full without void space.

While volume changes to the TRU waste inventory could reduce or increase the effects calculated in SEIS-II, the best estimates available have been used and conservative assumptions have been incorporated to ensure that the results would actually be less than those presented. A text box entitled "Factors to Consider in Combining Alternatives" (presented in Chapter 5) explains in more detail how the results would change as inventory volumes change.

during the trip. Drivers would be required to make routine visual safety inspections of the tractor, trailer, and containers either every 160 kilometers (100 miles) or every two hours, in addition to routine inspections required by DOE, DOT, and affected states. The carrier or any other person operating a motor vehicle that contains a Class 7 (radioactive) material for which placarding is required must comply with routing and training requirements in 49 CFR Part 397, Subpart D. Carriers would keep current copies of their maintenance certificates in their vehicles at all times.

In the event of an accident, the carrier driver would notify emergency first-responders via cellular phone and would notify the Central Monitoring Room (CMR) at WIPP via TRANSCOM. A senior DOE official or the DOE Carlsbad Area Office (CAO) Incident/Accident Team Leader would assist those in charge at the accident. DOE resources would be made available to local authorities, as appropriate, to support the mitigation of the accident, including, but not limited to, package recovery and site cleanup. In the event of an accident involving a fire, breach, release, or suspected radioactive contamination, the carrier would follow established procedures to obtain any needed federal, state, or local assistance or technical advice. Drivers would carry instructions for actions to be taken in the event of an accident and would be trained in package recovery procedures (see Appendix E). Any carrier accident, no matter how minor, would be reported to the CAO Transportation Manager, the WIPP Traffic Manager, the CMR operator, and DOE Headquarters Emergency Operations Center via the DOE Albuquerque Operations Office. If not already notified by the carrier, the shipper would be notified by the CMR operator.

Delays in scheduled arrival may occur from time to time due to weather conditions, maintenance checks, and other factors at the treatment sites. All schedule delays of two or more hours from the shipping, receiving, or transit time would be reported immediately to the CMR, which would notify the shipper or receiver, as appropriate. If a shipment were delayed, a new scheduled time of arrival would be arranged. There would be no “deadlines” for a shipment to be received at WIPP.

The carrier’s management plan provides guidance from the Western Governors Association and DOE on the selection of suitable safe parking areas. As instructed, carriers would use designated DOE or Department of Defense sites, or an area designated by the affected state as a safe parking area, in the event of a shipping layover. If no DOE, Department of Defense, or state-designated site were available, the driver would select a site based on criteria related to the nearby population size, proximity, and security and would notify the nearest state police district office.

3.1.2.2 Shipping Routes

Under the Proposed Action, transportation could include shipments between the generator-storage sites and from the 10 largest generator-storage sites to WIPP. The states through which the trucks would pass would designate shipment routes in consultation with DOE. Figures in Appendix E show the currently designated routes. These routes, as well as any chosen in the future, would comply with DOT requirements, use the Interstate Highway System or other state-designated roads, and use the shortest routes to access the interstate highways. The routes also would bypass urban areas if this could be done safely and efficiently. The requirements for state-routing designation are provided in 49 CFR Part 397, Subpart 103, and the procedures by which highway routing can be preempted are prescribed in 49 CFR Part 397, Subpart E.

3.1.3 Activities at WIPP

At the time of SEIS-I (DOE 1990), all surface facilities, shafts, and hoist facilities had been constructed. Underground, an initial waste disposal panel (Panel 1) had been excavated and was ready to accommodate the Test Phase activities (see Section 2.1.4). These physical facilities, which are described in SEIS-I, are essentially unchanged.

3.1.3.1 Excavation Operations

Under the Proposed Action, a total of ten panel-equivalents (in the panels and access tunnels) would be needed to dispose of the waste. DOE has excavated the first panel, which consists of seven disposal rooms and, from an engineering viewpoint, could receive waste now. The Department would excavate the additional disposal panels as needed. The Department estimates that it would require up to three years to excavate a panel.

The massive salt beds at a depth of 655 meters (2,150 feet) creep slowly in response to pressure from the overlying rock and would eventually cause the excavated openings within the salt beds to close. This is the reason why "just-in-time excavation" would be used. Just-in-time excavation is based on the concept that when additional room is needed for waste disposal, a new panel would be excavated and ready for use "just in time." This means that each panel would be excavated, filled, and closed in a time frame that would minimize the potential for hazardous conditions such as roof falls.

The Department would maintain each excavation (e.g., panel room) until it is filled. Personnel working underground would conduct a monitoring and excavation maintenance program in compliance with a long-term ground control plan (WID 1995). In addition to regular visual inspections, geotechnical instrumentation would provide continuous information about rock mass movement and deformation. Every underground worker would have the responsibility and authority to close a suspect area to entry until it has been inspected by excavation safety personnel. Unsafe or potentially unsafe areas would be remediated by bringing down loose rock or installing control measures such as wire mesh and roof bolts. The facilities would be inspected a minimum of four times a year by the Mine Safety and Health Administration, as required by Section 11 of the Land Withdrawal Act.

Salt that results from the excavation of the panels would be stored aboveground in the existing salt pile, which would be 12 hectares (30 acres) in size. Management of the salt pile may include selling or disposing of unneeded salt under the Materials Act of 1947. The salt pile would stabilize naturally, and a drainage pond would contain runoff. Salt would be retained at the site for potential use in permanent shaft seals and markers upon closure of WIPP.

3.1.3.2 TRU Waste Handling Operations at the Surface

CH-TRU waste would arrive at WIPP on tractor-trailer trucks, each of which can carry up to three TRUPACT-IIs. Thus, each truck shipment could deliver up to forty-two 55-gallon drums, six standard waste boxes of CH-TRU waste, or three Ten Drum Overpacks. RH-TRU waste would also arrive by truck. Each truck could carry one RH-72B cask. Each cask contains a canister holding up to three 55-gallon drums of RH-TRU waste or up to 0.89 cubic meters (31 cubic feet) if drums are not used inside the canister.

For CH-TRU waste, the Department has developed detailed procedures for unloading the trucks, opening the TRUPACT-IIs, inspecting the packages, preparing packages to be moved underground, and then moving them to the underground. Conceptually, the process is as follows: When a truck arrives at the Waste Handling Building, it would be inspected for load integrity and the presence of radioactive contamination. The truck would be unloaded, and the TRUPACT-IIs moved to a specially designed platform with equipment and testing facilities. Each time another barrier surface of the container assembly was uncovered, the waste packages would be checked for surface radiation levels and contamination. The packages then would be placed on pallets for transport to underground emplacement.

CH-TRU waste shipping packages or waste containers with surface contamination less than or equal to 20 disintegrations per minute alpha or 200 disintegration per minute beta/gamma would not need to be decontaminated prior to handling. If surface contamination on the exterior of the shipping package or waste container is detected in amounts less than 2,000 disintegrations per minute alpha or 20,000 disintegrations per minute beta/gamma over an area less than or equal to 0.56 square meters (6 square feet), the shipping package or waste container would be decontaminated prior to any further steps in the waste handling process (DOE 1996a). If surface contamination in excess of these levels was detected, the canister or drums would be put into an outer sleeve and a lid would be welded on using remote handling equipment. The shipping package or waste container would either be returned to the treatment site, shipped to a different DOE site if the original shipper does not have suitable facilities, or shipped to a non-DOE site for decontamination. In all cases, the waste would be packaged and certified prior to return shipment to WIPP. In the unlikely event that the external surface contamination is too great to allow safe return and transportation to a shipping site, DOE would take necessary isolation, safety, and decontamination measures. DOE could potentially dispose of any such packages or containers in WIPP, upon appropriate RCRA Part B Permit modification.

The Department proposes to use backfill material, with components added that would minimize the mobility of radionuclides during the repository's post-closure phase, to aid in complying with the requirements of 40 CFR Part 191.13. The mobility of radionuclides, which is determined in part by their solubility in brine, is dependent on the physical and chemical conditions present in the repository, particularly those anticipated as a result of gas generation from the degradation of waste. The purpose of the added component (magnesium oxide) is to react with the brine in such a way that radionuclide solubility and, therefore, the mobility are lowered. Details on the theory behind the current plans for this backfill are described in Appendix D22 of the WIPP RCRA Part B Permit Application (DOE 1996a).

The backfill, in mini sacks of polyethylene or other suitable material, would be manually emplaced in the external voids of each seven-pack unit (a collection of seven drums) just before the seven-pack is positioned on the waste stack. A similar process would be used for standard waste boxes, except that the mini sacks would be hung from the lift clips on the boxes.

For RH-TRU waste to be shipped in the RH-72B cask, the Department would not finalize the waste handling operations procedures until the NRC certifies the RH-72B transportation cask. In general, the procedures would be similar to the sequence described for the CH-TRU waste and the TRUPACT-II. One difference would be that RH-TRU waste would be handled in canisters made of quarter-inch steel with welded lids. Using remote manipulators, the RH-TRU waste canisters

would be removed from the RH-72B casks and placed in a room specially designed for shielding radiation. Subsequent testing operations would be conducted in this room until the canisters would be sent down the waste handling shaft.

3.1.3.3 Emplacement Operations for CH-TRU Waste

At the repository horizon station of the waste handling shaft, specially designed transporters would take the CH-TRU waste pallets from the shaft to the disposal room. Forklifts with a specially designed handling mechanism would then remove the waste from the transport pallets and stack the waste packages three high, leaving up to 1.2 meters (4 feet) of room for ceiling clearance. Each disposal panel would accommodate approximately 81,000 55-gallon drum equivalents (both drums and waste boxes will be used for disposal) equivalent to 16,700 cubic meters (590,000 cubic feet) of CH-TRU waste. DOE would coordinate filling the disposal rooms with RH-TRU waste because the RH-TRU waste would be placed in the walls before filling each room with CH-TRU waste.

In addition, supersacks containing magnesium oxide backfill would be handled and placed with the same technique as used for normal waste handling operations. Once each row of waste units is in place, a layer of six supersacks would be placed on top of them. Finally, magnesium oxide minisacks would be manually stacked on the floor in the space between the waste stack and the panel wall and placed horizontally or vertically. Backfill placed in this manner would remain protected until exposed when sacks are broken during creep closure of the room and compaction of the backfill and waste.

After each panel has been filled, it would be closed using the panel closure system. For the purposes of analyses, the system would be considered passive and consist of either a standard rectangular concrete barrier or an enlarged, tapered concrete barrier. The barrier would be emplaced in both the panel air-intake and air-exhaust tunnels and contact-grouted at the interface between the barrier and the tunnel walls. Contact-grouting involves filling the void spaces. The panel closure system has been designed to add a margin of assurance to limit the migration of hazardous constituents during the 35-year operational and facility closure period and to withstand a potential methane explosion from the accumulation of gas in the panel (see Appendix I of the RCRA Part B Permit Application).

3.1.3.4 Emplacement Operations for RH-TRU Waste

For shielding purposes, the RH-TRU waste canisters would be placed into horizontal boreholes in the walls of the disposal rooms and access tunnels. The horizontal emplacement holes, about 0.9 meters (3 feet) in diameter, would be drilled on 2.4-meter (8-foot) centers to a depth of 4.9 meters (16 feet). Additional holes would be placed in the access tunnels at each end of the disposal rooms. Specially designed insertion equipment would be used to place the RH-TRU waste canisters at the back of the horizontal drill holes and then plug the holes with a massive carbon-steel plug. Once the RH-TRU waste emplacement holes in a disposal room were all used and closed, emplacement of CH-TRU waste would begin (DOE 1995a).

For purposes of analysis, it has been assumed that each RH-TRU waste canister contains three 55-gallon drums containing a total of 0.624 cubic meters (22 cubic feet) of waste. The emplacement volume - which includes the drums of waste, spacers between the drums, and the canister itself - would occupy 0.89 cubic meters (31 cubic feet).

Each disposal panel would accommodate about 730 canisters, equivalent to an emplacement volume of 650 cubic meters (22,950 cubic feet). The SEIS-II analyses are based on the assumption that 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste would be disposed of. The greater volume of RH-TRU waste in SEIS-II than that used for the RCRA Part B Permit Application (DOE 1996a) would be disposed of in the access tunnels, Panels 9 and 10. To account for this difference, these tunnels would each need to be modified to accommodate 1,060 canisters, equivalent to 944 cubic meters (33,000 cubic feet) of waste.

3.1.3.5 Closure and Decommissioning

Under the Proposed Action, WIPP would receive and dispose of TRU waste for 35 years through the year 2033. This is 10 years longer than anticipated in SEIS-I because the Department now has more complete information on the TRU waste inventory and revised estimates of the time needed to treat the waste to meet planning-basis WAC.

DOE would close the repository when WIPP achieves a capacity of 175,600 cubic meters (6.2 million cubic feet) of TRU waste. Final facility closure would include the placement of a

THE PROPOSED ACTION AND THE ADDITIONAL INVENTORY

During the public comment period that followed publication of the Draft SEIS-II in November 1996, stakeholders requested that the Department discuss, as part of the Proposed Action, the impacts of leaving in place or treating and storing the Additional Inventory. The Additional Inventory, as shown in Table 2-3, largely comprises TRU waste disposed of prior to 1970 by burying the waste near the surface. The Department currently has no plans to excavate, treat, and store all of this waste. Such a decision would be made on a site-by-site basis, following RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) investigations, and probably following additional NEPA review. The Additional Inventory, therefore, is not a part of the Proposed Action. Nevertheless, in response to stakeholders' requests, Chapter 5 now includes text boxes like this one that present an assessment of human health impacts based on analyses done for the action alternatives and no action alternatives described in Chapter 3 of SEIS-II. The scenarios on which these impacts are based include the following:

- All Additional Inventory would be left as currently stored or buried. The impacts for this scenario would be similar to the Additional Inventory impacts of No Action Alternative 2.
- All Additional Inventory would be excavated, treated to planning-basis WAC, and stored at current locations for approximately 70 years. During the 70 years, the Department would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 1.
- All Additional Inventory would be excavated, shipped to six thermal treatment facilities, treated, and then stored for approximately 70 years. During the 70 years, the Department would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 2A.
- All Additional Inventory would be excavated, shipped to four thermal treatment facilities, treated, and then stored for 70 years. The impacts for this scenario would be very similar to the Additional Inventory treatment and storage impacts presented for Action Alternative 2B.

repository sealing system. As explained in more detail in the RCRA Part B Permit Application (DOE 1996a), the planned repository sealing system would consist of natural and engineered barriers within the WIPP repository that would prevent water from entering it and impede gases or brines from migrating out.

Current plans for the shaft sealing system propose completely filling the shaft with engineered materials possessing high density and low permeability. Shaft seal components for that portion of the shaft that is within the Salado Formation would provide the primary barrier by limiting fluid transport along the shaft during and beyond the 10,000-year period. Shaft seal components within the Rustler Formation would limit commingling between brine-bearing members, as required by state regulations. Shaft seal components from the Rustler to the surface would fill the shaft with common materials of high density, consistent with good engineering practice. A synopsis of each component is given below:

- Shaft Station Monolith. At the bottom of each shaft, a salt-saturated concrete monolith would support the local roof. A salt-saturated concrete, called Salado Mass Concrete (SMC), is currently specified and would be placed using a conventional slickline construction procedure where the concrete would be batched at the surface. SMC has been tailored to match site conditions.

- Clay Columns. A sodium bentonite would be used for three compacted clay components in the Salado and Rustler Formations. Although alternative construction specifications are viable, labor-intensive placement of compressed blocks is currently planned because of proven performance. Clay columns would effectively limit brine movement from the time they are placed to beyond the 10,000 year regulatory period.

- Concrete-Asphalt Waterstop Components. Concrete-asphalt waterstop components would be comprised of three elements: an upper concrete plug, a central asphalt waterstop, and a lower concrete plug. Three such components are located within the Salado Formation. These concrete-asphalt waterstop components would provide independent shaft cross-section and disturbed rock zone (DRZ) seals that limit fluid transport, either downward or upward.

- Compacted Salt Column. Each shaft seal would include a column of compacted WIPP salt with 1.5 percent weight water added to the natural material. Construction demonstrations have shown that mine-run WIPP salt could be dynamically compacted to a density equivalent to approximately 90 percent of the average density of intact Salado salt. The remaining void space would be removed through consolidation caused by creep closure.

- Asphalt Column: An asphalt-aggregate mixture currently is specified for the asphalt column, which would bridge the Rustler/Salado contact.

- Concrete Plugs. A concrete plug would be located just above the asphalt column and would be keyed into the surrounding rock.

- Earthen Fill. The upper shaft would be filled with locally available earthen fill. Most of the fill would be dynamically compacted (the same method used to construct the salt column) to a density approximating the surrounding lithologies.

The Department would decommission the site in a manner that would allow for safe, permanent disposition of surface and underground facilities, which would be consistent with the then-applicable regulations. Little or no contamination of facilities would be expected. Equipment and facilities would be decontaminated as necessary. Useable equipment would be removed and surface facilities dismantled. A berm would be constructed around the perimeter of the closure area, which would include 70 hectares (175 acres). The area above the 10 panel equivalents would be 50 hectares (125 acres), the area of the salt pile would be 12 hectares (30 acres), and the area of the surface facilities would be 8 hectares (20 acres). The height of the berm would be sufficient to identify the closure area and impede access. DOE would restore the areas occupied by the salt pile and surface facilities and, if necessary, any of the area overlying the disposal panel area, although surface disturbance of this area would be minimal. This decommissioning period is anticipated to take up to 10 years. Any salt remaining after WIPP closure and construction of the berm would be sold or disposed of in accordance with the Materials Act of 1947.

There are no changes since SEIS-I to the anticipated long-term controls for the WIPP site after the Department closes it, which would include active controls, monitoring, and passive controls. The 100-year active institutional control period would extend through the year 2143, during which the Department would use a fence and an unpaved roadway along the perimeter of the repository surface footprint area (the waste disposal area projected to the surface) to control access. The fence line would be posted with signs that warn of the danger and that state that access by unauthorized persons is prohibited. Routine, periodic patrols and surveillances of the protected area would be conducted as well as periodic inspection and necessary corrective maintenance of the fence, signs, and roadway. In addition, the Department would prohibit drilling within the LWA to preclude inadvertent intrusion into the repository.

The Department would place a number of permanent markers to inform and warn subsequent generations that radioactive waste is buried there. This permanent marker system would be designed to minimize the likelihood of human intrusion. Current plans include markers that would do the following:

- Identify the site
- Relay warning messages
- Use multiple methods for marking the site
- Use multiple means of communications (e.g., language, pictographs, scientific diagrams)
- Use multiple levels of complexity within individual messages on individual marker system elements
- Be constructed of materials with little intrinsic value

Other actions under consideration by DOE are the following:

- Construction of an “information center,” located in the middle of the area, with more information on the type of waste disposed of at WIPP, why the waste is dangerous, and why TRU waste should not be disturbed
- Placement of additional warning messages approximately 6 meters (20 feet) beneath the surface, within the perimeter

- Placement of large permanent magnetic materials and radar reflectors within the berm so that the site could be remotely detected
- Creation of off-site archival records at several local, state, and federal organizations

3.2 ALTERNATIVES

SEIS-II analyzes a total of five alternatives to the Proposed Action, including two no action alternatives. The following sections describe these alternatives. A summary table is presented at the end of this section.

3.2.1 Action and No Action Alternatives

DOE identified the alternatives to the Proposed Action for analyses according to CEQ guidance (46 Federal Register 18026), which indicates that an agency should consider alternatives that are practical or feasible from the technical and economic standpoint and using common sense. Using this guidance and considering the prior LWA requirement that the Department make recommendations for the disposal of all DOE-owned or controlled TRU waste, it is reasonable to examine alternatives that include disposing of all DOE-owned or controlled TRU waste at WIPP. In addition, the CEQ regulations implementing NEPA require a No Action Alternative (40 CFR Part 1502.14 (d)). DOE recognizes that these alternatives may, at least in part, require amendment of existing laws or agreements negotiated with EPA and/or involved states. Nevertheless, under NEPA, DOE is required to consider reasonable alternatives even if they are in conflict with existing law. The fact that DOE is considering these alternatives for the NEPA process should not be construed as meaning that the Department intends to implement any action that would violate the law or violate legally binding agreements negotiated pursuant to law.

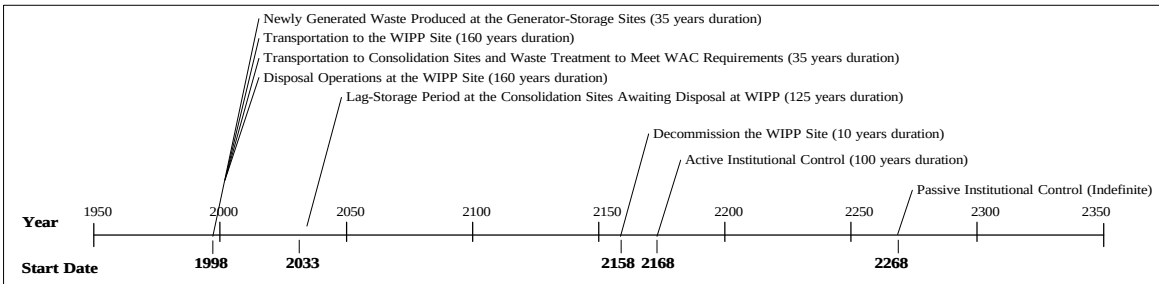
The number of disposal panels required for each alternative is influenced by the 10,000-watt-per-surface-acre design limit on heat load for waste disposed of at WIPP. Consistent with the RCRA Part B Permit Application, an average heat load of 60 watts per RH-TRU waste canister is assumed for the Proposed Action and the alternatives (the actual heat load has been calculated at about 1 watt per canister). Additional mining would be necessary under the action alternatives to distribute the RH-TRU waste as required by the surface acre thermal power limitations. The operational time periods for the action alternatives are driven by current maximum RH-TRU waste emplacement and/or mining rates, which are used only to make the alternatives easily comparable to each other and the Proposed Action. If any of the action alternatives were chosen, waste handling and mining operations could be modified to allow shorter operational time periods, and actual RH-TRU waste heat loads would probably require less mining than that assumed for the alternatives.

3.2.2 Action Alternative 1: Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP

For this alternative, WIPP would accept nearly all TRU waste for disposal. The waste would include the Basic Inventory (with the potential excess RH-TRU waste) plus the Additional Inventory. Only TRU waste commingled with polychlorinated biphenyls (PCB) would not be disposed of at WIPP. The waste would be treated to planning-basis WAC and then shipped to the 10 sites with the largest volumes of waste for consolidation. PCB-commingled waste would

continue to be managed at the generator sites. Table 3-2 presents the CH-TRU waste volumes, and Table 3-3 presents the RH-TRU waste volumes for Action Alternative 1. These tables list the site volume, pretreatment consolidated volume, and post-treatment volume for the Basic Inventory, Additional Inventory, and the combined total (Total Inventory) for each treatment site. DOE could not dispose of some of these additional waste types at WIPP under the current laws and agreements that regulate WIPP. Figure 3-2 shows the flow of TRU waste between sites and shipment to WIPP for Action Alternative 1.

The timeline below presents the approximate schedule for waste disposal activities under Action Alternative 1. Sites would generate waste for 35 years, beginning in 1998. The disposal of TRU waste at WIPP would begin in 1998 and continue for approximately 160 years, ending in 2158. The duration of disposal operations for Action Alternative 1 is based on the time needed to emplace the total volume of RH-TRU waste, assuming a maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996b), and an operating time of 50 weeks per year. (Section 3.2.2.4 discusses how operations times could be reduced for this alternative.) Decommissioning activities would last for up to 10 years and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2268.



Timeline for the Implementation of Action Alternative 1

3.2.2.1 Activities at the Generator-Storage Sites

The activities at the generator-storage sites would be the same as those described for the Proposed Action, except that they would involve approximately twice as much waste based on BIR-3 estimates. The volumes shown in Tables 3-2 and 3-3 reflect the currently stored and projected volumes and the volumes after any packaging and treatment necessary to meet planning-basis WAC. The generator-storage sites would consolidate all CH-TRU waste at 10 treatment sites after treating the waste to meet WAC for subsequent shipment to WIPP. The generator-storage sites would ship RH-TRU waste to four treatment sites for subsequent shipment to WIPP. Waste treatment would occur over 35 years, through the year 2033.

Although all of the TRU waste could be treated and packaged by 2033, much of the waste would be placed in lag storage at the treatment sites awaiting shipment to WIPP. The lag storage would continue for some waste for 125 years. During that period, storage facilities would be constructed and replaced every 50 years. CH-TRU waste awaiting transportation to WIPP would be packaged every 20 years. RH-TRU waste would be stored in canisters made of quarter-inch steel.

Table 3-2
CH-TRU Waste Volumes for Action Alternative 1 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	57,000	63,000	120,000	57,000	63,000	120,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	21,000	14,000	35,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	86,000	30,000	57,000	87,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	200	---	200	200	---	200
Savannah River Site (SRS)	12,000	4,900	17,000	12,000	4,900	17,000	12,000	4,900	17,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	17,000	---	17,000
Oak Ridge National Laboratory (ORNL)	1,700	56	1,700	1,800	260	2,100	1,800	260	2,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	1,200	---	1,200	1,200	---	1,200
Nevada Test Site (NTS)	630	---	630	630	---	630	630	---	630
Mound Plant (Mound)	300	---	300	300	---	300	340	---	340
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**273,000**	**135,000**	**138,000**	**273,000**	**143,000**	**138,000**	**281,000**

[a] The inventory for SEIS-II is based on BIR-3,which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-2.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is not included.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

Table 3-3
RH-TRU Waste Volumes for Action Alternative 1 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	29,000	1,000	30,000	42,000	1,500	43,000
Los Alamos National Laboratory (LANL)	230	120	350	230	120	350	330	170	490
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	220	440	660	2,000	440	2,400	2,800	630	3,400
Argonne National Laboratory - West (ANL-W)	1,700	--- [g]	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	2,000	5,600	5,200	2,700	8,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	80	80	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**50,000**	**5,000**	**55,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-2.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included.
[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

3.2.2.2 Transportation Activities

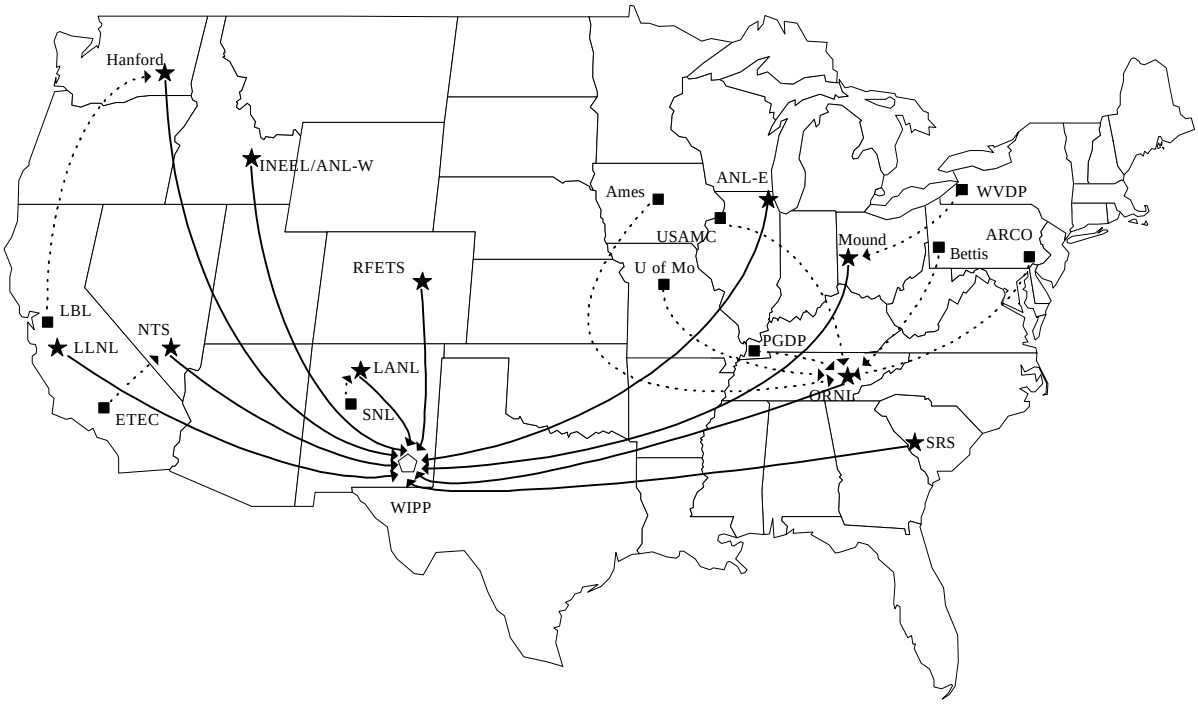
Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- Almost three times as many shipments would be required to ship the CH-TRU and RH-TRU waste to WIPP, due mainly to the additional RH-TRU waste to be shipped to WIPP under Action Alternative 1 (almost eight times more).

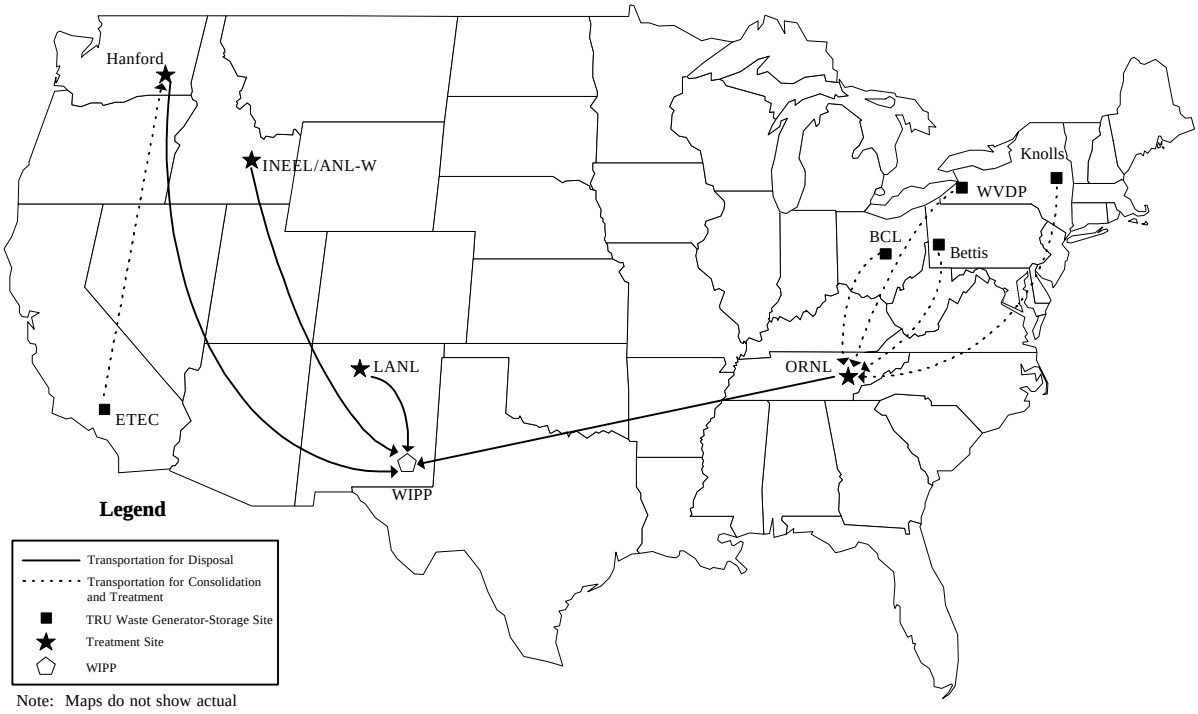
- The period of shipping to WIPP would extend for 160 years, through the year 2158.

- TRU waste may be shipped by truck and by commercial and dedicated rail from the 10 major treatment sites to WIPP. SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses trucks only, as described under the Proposed Action. The other two scenarios use a mix of commercial rail and truck transportation or dedicated rail and truck transportation. Rail transportation would be used to the maximum extent practicable, and thus the term “maximum rail” is used to indicate

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-2
Movement of Waste for Action Alternative 1 [a]
(For complete names of facilities and waste volumes, see Tables 3-2 and 3-3)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

the emphasis on rail use. Trucks would be used instead of rail from Los Alamos National Laboratory (LANL) and the Nevada Test Site (NTS) because railroads do not currently exist from those sites. DOE would not build new rail lines. WIPP already has a rail spur leading to the facility.

3.2.2.3 Activities at WIPP

Under Action Alternative 1, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be the same as those for the Proposed Action. This alternative would extend the operations time frame to as late as the year 2158, and WIPP would accept a larger total volume of TRU waste. A total of 68 panels would be excavated to accommodate the additional waste, with 17 panels to accommodate CH-TRU and RH-TRU waste and 51 panels for RH-TRU waste only (due to a 10,000 watt-per-acre limit). Any expansion of WIPP capacity beyond current limits would require changes to the LWA and the C&C Agreement, as well as permits to operate WIPP.

As with the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in panel walls. Other RH-TRU waste disposal options may be considered, including vertical boreholes or trenches in the floors of disposal rooms. In addition, waste currently considered to be RH-TRU waste at the generator-storage sites may be packaged there to meet CH-TRU waste requirements, not exceeding a dose rate of 200 millirem per hour at the container surface. This waste would then be emplaced as CH-TRU waste at WIPP.

Closure and institutional controls would be the same as those for the Proposed Action, except that due to the additional years of operation, decommissioning and the active institutional control period would extend through the year 2268. A berm would be constructed around the perimeter of the site that is 360 hectares (890 acres), 340 hectares (840 acres) of which lies above the 68 panel-equivalents, 12 hectares (30 acres) of which would be for the salt pile, 8 hectares (20 acres) of which would be for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities and, if necessary, any of the area overlying the disposal panel equivalents, although surface disturbance of this area would be minimal.

3.2.2.4 Reducing Operation Time

During the public comment period following publication of the Draft SEIS-II, stakeholders stated that the 160-year operations period for Action Alternative 1 was too long and requested that the Department reduce the operations period in some manner. Several commenters requested that the Final SEIS-II include greater detail on how reducing the operation's period would change the impacts presented in Chapter 5 of this document.

DOE has included in Chapter 5 of this document an assessment of impacts should the operation's period be reduced from 160 years to 60 years by constructing additional facilities at the WIPP site and by employing additional excavation and emplacement crews. The assumptions and description of operations presented above would apply, except for the following modifications:

- During the first seven years of the 60-year period, waste would be emplaced in WIPP as described above. In addition, during those seven years, planning and construction of an additional RH-TRU waste handling building would be completed. This new building

would include two RH-TRU waste handling areas. In addition, four new shafts would be constructed, including one waste handling shaft, one salt handling shaft, an air intake shaft, and exhaust shaft. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.

- For the final 53 years, all current facilities plus the new facility would be in operation. Two additional excavation crews would be employed, enabling the reduction in operations time from 160 to 60 years. During these 53 years, the emplacement rate would increase from 8 canisters a week to 24 a week. Excavation of new panels would increase from one every two years to three every two years. The same number of panels would be needed.

- In all, an additional 90 people would be employed to operate the new building, its RH-TRU waste operations, and additional excavation and emplacement crews.

- New capital costs would be about $80 million; operating costs would increase by 10 percent.

- All transportation to WIPP would occur over a 60-year period.

3.2.3 Action Alternative 2: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP

For Action Alternative 2, DOE would treat waste with a thermal process designed to meet the Land Disposal Restrictions (LDR) for TRU mixed waste. The analysis performed for this alternative assumes a 65 percent reduction in the volume of waste due to thermal treatment. WIPP would accept all TRU waste for disposal, which would include the Basic Inventory (including the excess RH-TRU waste) plus the Additional Inventory. For this alternative, the Additional Inventory also includes TRU waste commingled with PCBs. DOE could not dispose of some of the waste types included in the Additional Inventory at WIPP under the current laws and agreements that regulate WIPP.

Three different consolidation and treatment subalternatives are considered under Action Alternative 2. These subalternatives are referred to as Action Alternative 2A, 2B, or 2C and vary only in the location of the treatment sites.

- Under Action Alternative 2A, CH-TRU waste would be treated at Hanford, Savannah River Site (SRS), Rocky Flats Environmental Technology Site (RFETS), LANL, and Idaho National Engineering and Environmental Laboratory (INEEL)/Argonne National Laboratory-West (ANL-W). RH-TRU waste would be treated at Hanford and ORNL.

- Under Action Alternative 2B, CH-TRU waste would be treated at Hanford, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

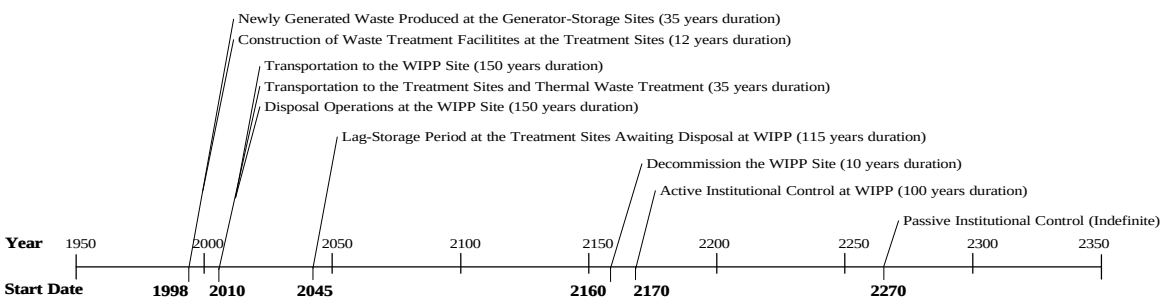
- Under Action Alternative 2C, CH-TRU waste would be treated at WIPP. RH-TRU waste would be treated at Hanford and ORNL.

Table 3-4 presents the CH-TRU waste volumes and Table 3-5 presents the RH-TRU waste volumes for Action Alternative 2A. These tables list the volume by site, pretreatment consolidated volume, and post-treatment volume for the Basic Inventory, Additional Inventory, and Total Inventory. Figure 3-3 shows the flow of TRU waste between sites and shipment to WIPP.

Table 3-6 presents the CH-TRU waste volumes and Table 3-7 presents the RH-TRU waste volumes for Action Alternative 2B. Figure 3-4 shows the flow of TRU waste between sites and shipment to WIPP.

Table 3-8 presents the CH-TRU waste volumes and Table 3-9 presents the RH-TRU waste volumes for Action Alternative 2C. Figure 3-5 shows consolidation of TRU waste and shipment to WIPP. DOE would consolidate and treat CH-TRU waste at WIPP and RH-TRU waste at Hanford and ORNL.

A timeline below presents the approximate schedule for disposal activities under the Action Alternative 2 subalternatives. Sites would generate waste for 35 years, beginning in 1998. It would take 12 years to design and construct the treatment facilities for Action Alternatives 2A, 2B, and 2C. The disposal of TRU waste would begin in 2010 and continue for 150 years, ending in 2160. The disposal operations duration is based on the time needed to excavate the panels and emplace the total volume of RH-TRU waste, assuming a maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996b), and an operating time of 50 weeks per year. Decommissioning activities would last for up to 10 years and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2270. (See Section 3.2.3.4 for discussion of how time periods could be reduced for this alternative.)



Timeline for the Implementation of Action Alternative 2

3.2.3.1 Activities at the Generator-Storage Sites

Under this alternative, the generator-storage sites would prepare twice as much waste as under the Proposed Action, and the waste would be treated by a thermal process to meet the RCRA LDRs. Thermal treatment may involve a vitrification process. The process would vaporize organic matter, thereby reducing the total volume of waste. A vitrification process would add silicon-based materials that would result in a glass-like product. The volumes shown in Tables 3-4 through 3-9 reflect the currently stored or projected volumes and the treatment method. To be conservative, it has been assumed that all waste treatment facilities would be designed and constructed over a period of 12 years and would be ready for operation in the year 2010. (Some sites may be able to

Table 3-4
CH-TRU Waste Volumes for Action Alternative 2A [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	20	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-3.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

Table 3-5
RH-TRU Waste Volumes for Action Alternative 2A [a]

	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
Site [d]	**Basic Inventory**	**Additional Inventory [e]**	**Total Inventory**	**Basic Inventory**	**Additional Inventory [e]**	**Total Inventory**	**Basic Inventory**	**Additional Inventory [e]**	**Total Inventory**
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-3.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

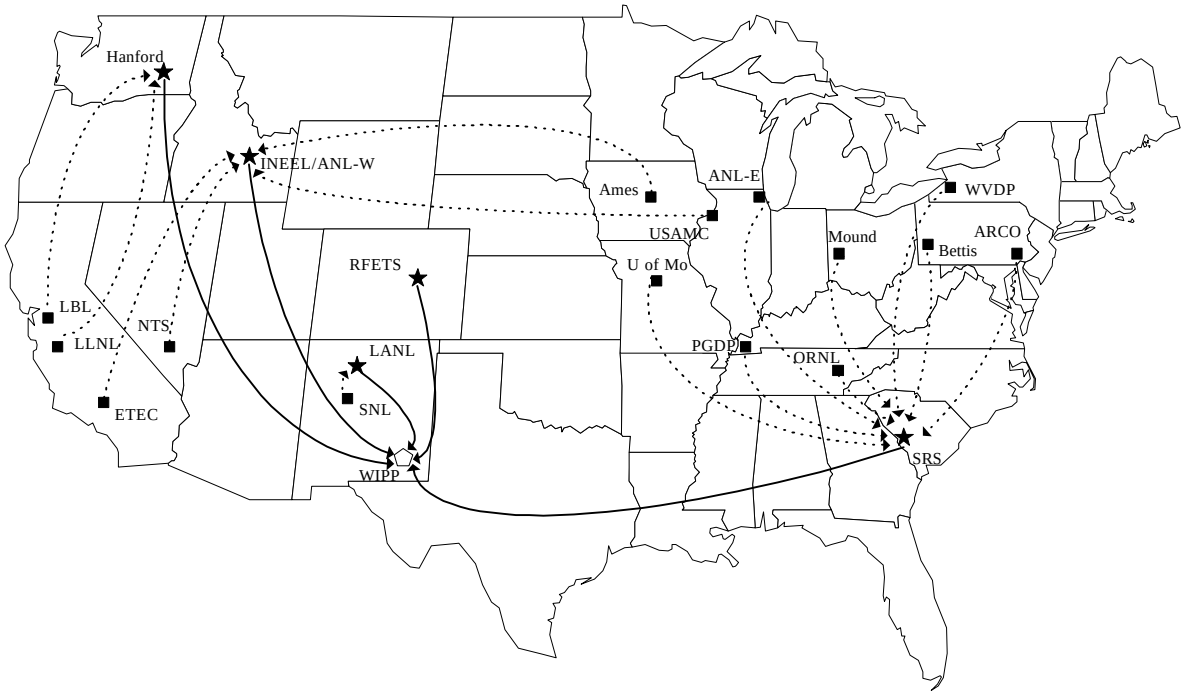
procure such services earlier.) Waste treatment would occur over 35 years, through the year 2045, and lag storage of the TRU waste awaiting shipment (under Action Alternatives 2A and 2B) would occur for 115 years, also through the year 2160. Under these alternatives, lag storage would be required due to the rate at which the panels could be excavated. The lag storage would be similar to that described in Section 3.2.2.1.

3.2.3.2 Transportation Activities

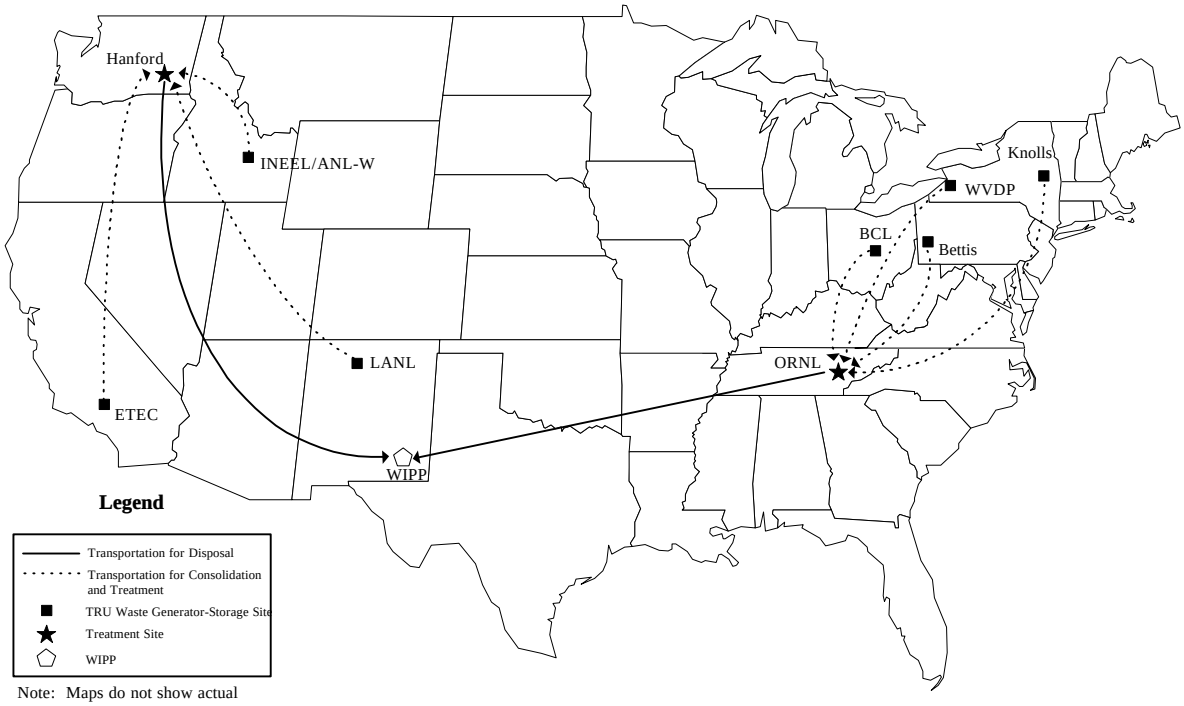
Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- The period of shipping to WIPP would continue for 150 years, through the year 2160 (compared to 35 years under the Proposed Action).
- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses only trucks, as described under the Proposed Action. The other two use a

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-3
Movement of Waste for Action Alternative 2A [a]
(For complete names of facilities and waste volumes, see Tables 3-4 and 3-5)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

Table 3-6
CH-TRU Waste Volumes for Action Alternative 2B [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-4.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste.

[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

Table 3-7
RH-TRU Waste Volumes for Action Alternative 2B [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-4.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste.

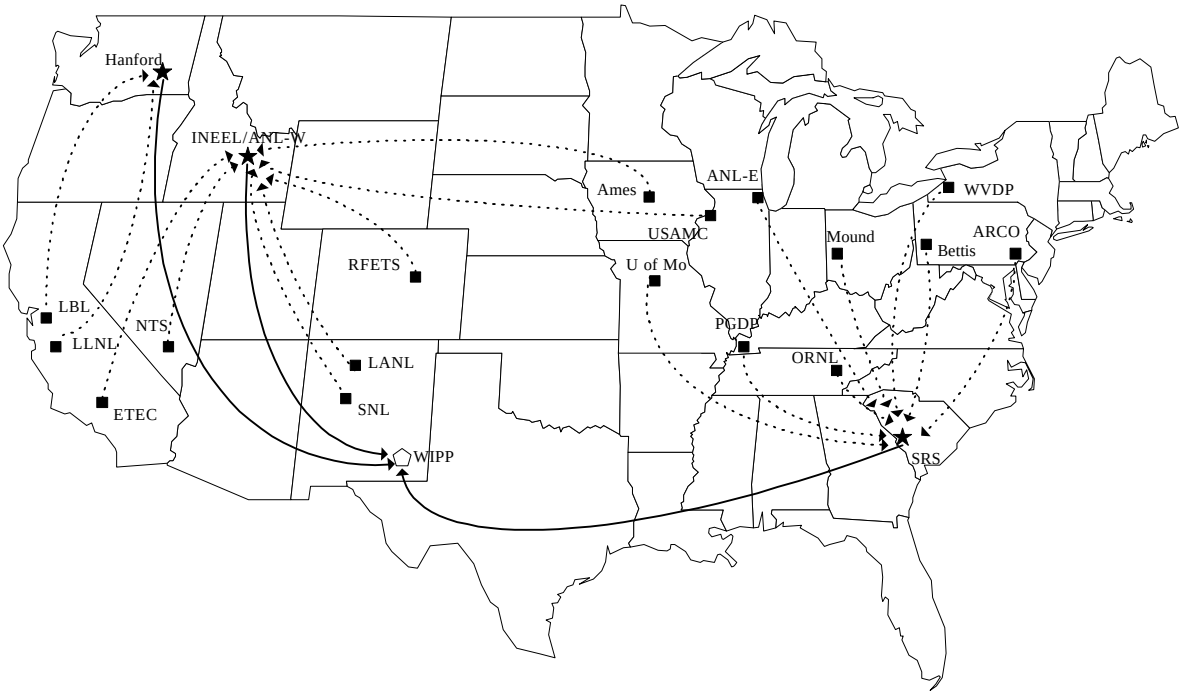
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

mix of maximum commercial rail and truck transportation or maximum dedicated rail and truck transportation, as described in Section 3.2.2.2. WIPP already has a rail spur leading to the facility. Because little storage is permitted at WIPP, all of the transportation scenarios would be spread over the 150-year shipping period.

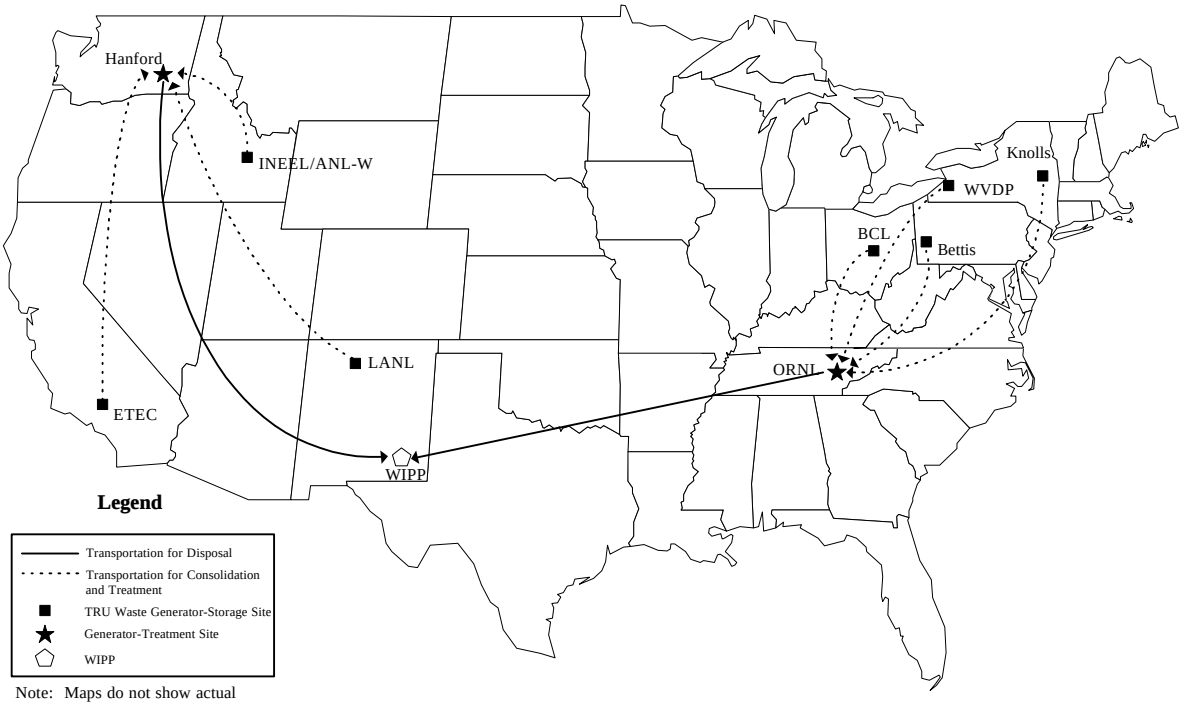
3.2.3.3 Activities at WIPP

Under Action Alternative 2, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be similar to the Proposed Action. However, this alternative would extend the operations time frame to as late as the year 2160 even though the overall emplaced waste volume would be smaller than that under all of the other alternatives. As noted above, thermal treatment results in an overall volume reduction of 65 percent. The same quantity of radionuclides would now be present in 35 percent of the original volume; therefore, radionuclide concentration and thermal power generation would increase by a factor of approximately three. Because of the increased thermal power output, CH-TRU waste and RH-TRU waste would be placed in separate panels to meet the WIPP design specifications for thermal power. About 12 panels would be required for CH-TRU waste disposal

CH-TRU Waste



RH-TRU Waste



Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Generator-Treatment Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-4
Movement of Waste for Action Alternative 2B [a]
(For complete names of facilities and waste volumes, see Tables 3-6 and 3-7)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

Table 3-8
CH-TRU Waste Volumes for Action Alternative 2C [a]

Site [b]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume (cubic meters)			Post-Treatment Disposal Volume (cubic meters)		
	Basic Inventory	Additional Inventory [c]	Total Inventory	Basic Inventory	Additional Inventory [c]	Total Inventory	Basic Inventory	Additional Inventory [c]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	--- [d]	---	---	---	---	---
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [e]	28,000	57,000	85,000	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	---	---	---	---	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory(ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
WIPP [f]	---	---	---	135,000	139,000	274,000	47,000	60,000	107,000
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Sites in boldface were included in SEIS-I.

[c] TRU waste commingled with PCBs is included.

[d] Dashes indicate no waste.

[e] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[f] TRU waste is consolidated and treated at WIPP.

Table 3-9
RH-TRU Waste Volumes for Action Alternative 2C [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

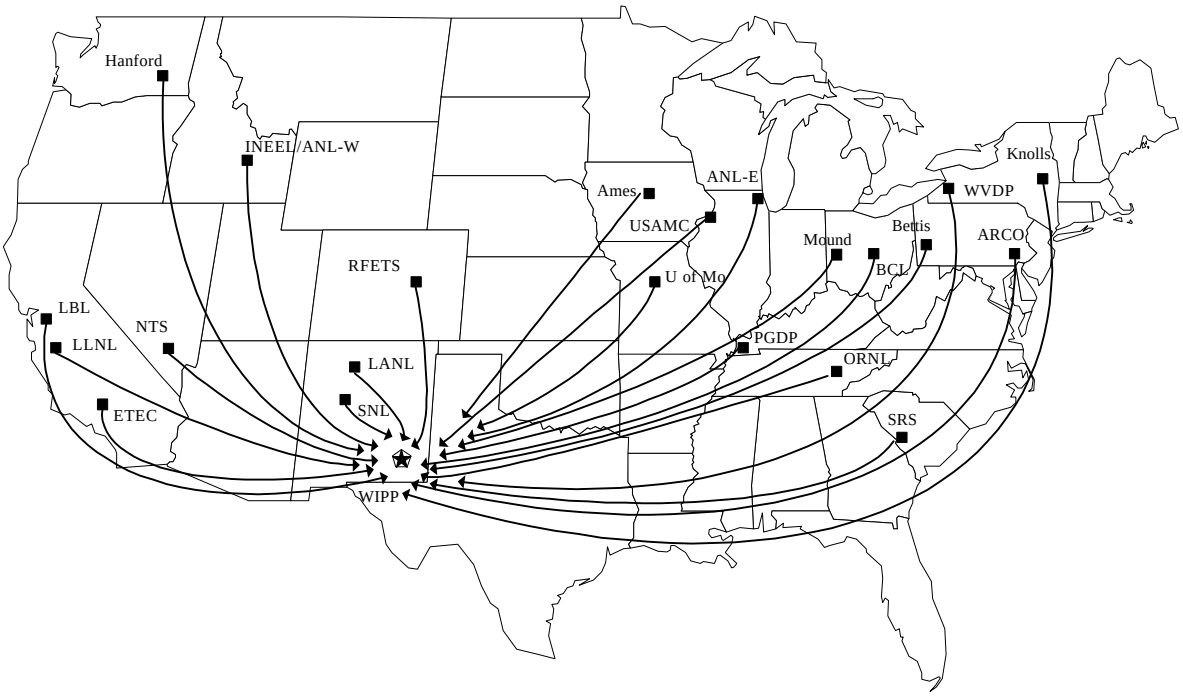
[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-5.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-II.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

and about 63 panels would be required for RH-TRU waste disposal, 75 panels total. The time required for excavation of 75 panels, at a rate of two years per panel, is the basis for the 150-year operation period. Any expansion of WIPP capacity would require changes to the LWA and the C&C Agreement.

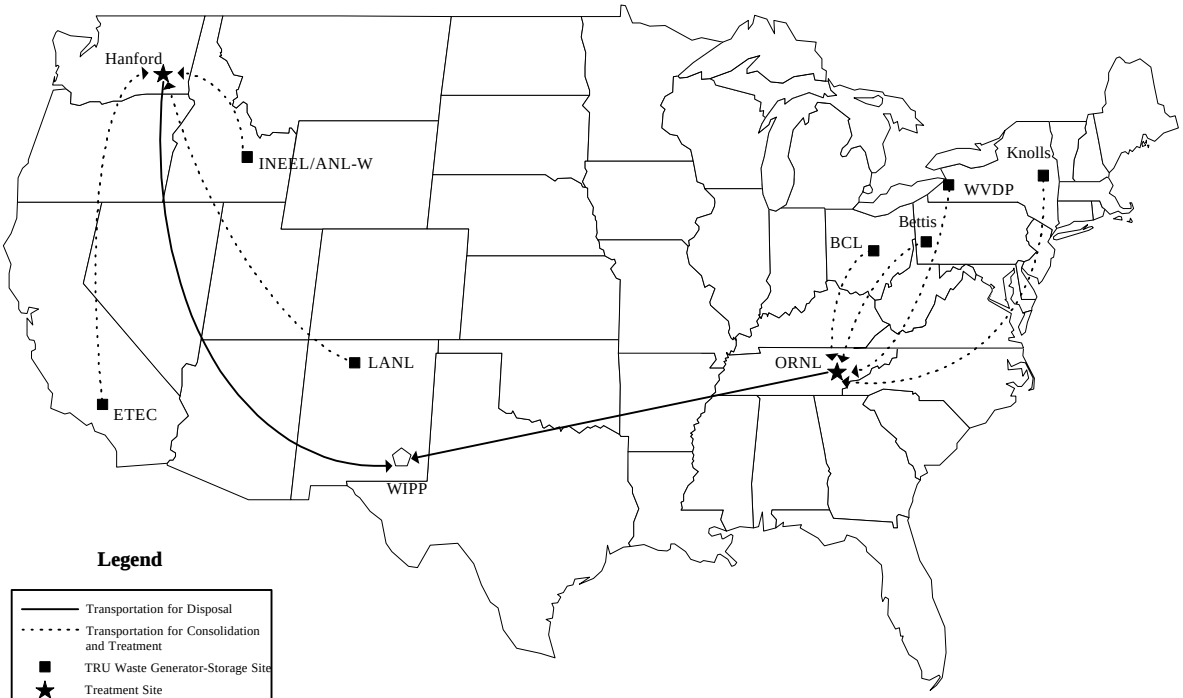
As in the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in the walls of the panels. Because of the increased volume of RH-TRU waste, other RH-TRU waste disposal options may be considered, including horizontal boreholes that could accommodate two canisters and vertical boreholes or trenches in the floors of disposal rooms.

Closure and institutional controls would be the same as those for the Proposed Action except that due to the additional years of operation, the decommissioning and active institutional control period would extend through the year 2270. A berm would be constructed around the perimeter of the site, which would include 395 hectares (976 acres), 375 hectares (927 acres) of which lies above the 75 panel equivalents, 12 hectares (30 acres) of which is for the salt pile, and 8 hectares

CH-TRU Waste



RH-TRU Waste



Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Treatment Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-5
Movement of Waste for Action Alternative 2C [a]
(For complete names of facilities and waste volumes, see Tables 3-8 and 3-9)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

(20 acres) of which is for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities, and, if necessary, any of the area overlying the disposal panel equivalents, although surface disturbance of this area would be minimal.

3.2.3.4 Reducing Operation Time

The overall operation period – including 12 years of construction for offsite thermal treatment facilities (at Hanford, SRS, RFETS, LANL, INEEL, or ORNL) - would be 150 years for all Action Alternative 2 subalternatives. Largely, though, the long operation period is due to the number of panels needed to meet the thermal limit per acre for the RH-TRU waste and an assumption that only one panel would be excavated every two years. This assumption was made to enable all of the SEIS-II alternatives to be easily comparable.

As with Action Alternative 1, stakeholders requested a more detailed understanding of how impacts would change should the Department attempt to shorten the operation time. In response, Chapter 5 of this document includes an assessment of how impacts would change if the excavation of panels were increased to reduce the total operation period to 70 years. For the purposes of the assessment, the discussion of assumptions and description of operations presented above for all of the Action Alternative 2 subalternatives would apply, with the following exceptions:

- WIPP would remain as currently operated for 12 years while thermal treatment facilities were designed and constructed. The 12 years were conservatively estimated; some facilities may begin treatment sooner. No new buildings would be constructed at WIPP because the volume of waste would be reduced by the thermal treatment, but during the first 12 years three additional shafts would be constructed to enable faster excavation and emplacement in the repository. These shafts would be an additional salt handling shaft, an additional air intake shaft, and an exhaust shaft. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.

- Two additional excavation crews would be employed during emplacement operations. These two crews would result in approximately 10 additional WIPP employees. The two crews would enable DOE to increase the excavation rate to three panels every two years and increase the emplacement rate from 8 canisters a week to 24 canisters a week. Overall, the two crews would reduce the period of disposal operations at WIPP from 150 years to 58 years.

- Transportation to WIPP would occur during 58 years.

- Capital construction costs for the three shafts would total $24 million; annual operating costs would remain essentially the same.

3.2.4 Action Alternative 3: Total Inventory (Except PCB-Commingled Waste), Treat by Shred and Grout, Dispose of at WIPP

Action Alternative 3 would involve treating the waste with a shred and grout process. This process would increase the volume by 20 percent. For this alternative, WIPP would accept for disposal all TRU waste, which would include the Basic Inventory and the Additional Inventory without PCB-commingled waste. DOE could not dispose of some of the Additional Inventory waste types at WIPP under the current laws and agreements that regulate WIPP. Table 3-10 presents the

Table 3-10
CH-TRU Waste Volumes for Action Alternative 3 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	121,000	70,000	75,000	146,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	25,000	17,000	42,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	86,000	37,000	68,000	105,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	17,000	6,200	23,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	19,000	---	19,000
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	---	300	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**138,000**	**273,000**	**135,000**	**138,000**	**273,000**	**168,000**	**166,000**	**334,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-6.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is not included.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

CH-TRU waste volumes and Table 3-11 presents the RH-TRU waste volumes for Action Alternative 3. Figure 3-6 shows the flow of TRU waste between sites and shipment to WIPP. DOE would consolidate and treat CH-TRU waste at Hanford, INEEL, LANL, and SRS (RFETS would treat only its own waste). RH-TRU waste would be consolidated and treated at Hanford and ORNL.

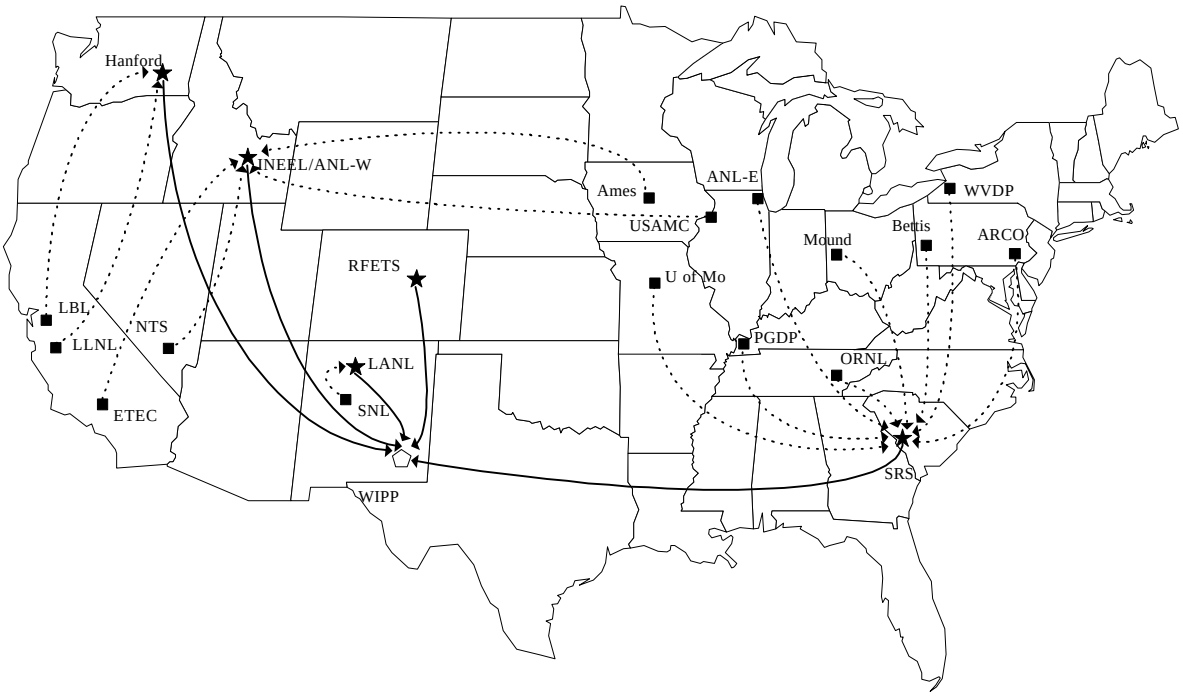
Table 3-11
RH-TRU Waste Volumes for Action Alternative 3 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	54,000	2,700	57,000
Los Alamos National Laboratory. (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	6,300	3,300	10,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**60,000**	**6,000**	**66,000**

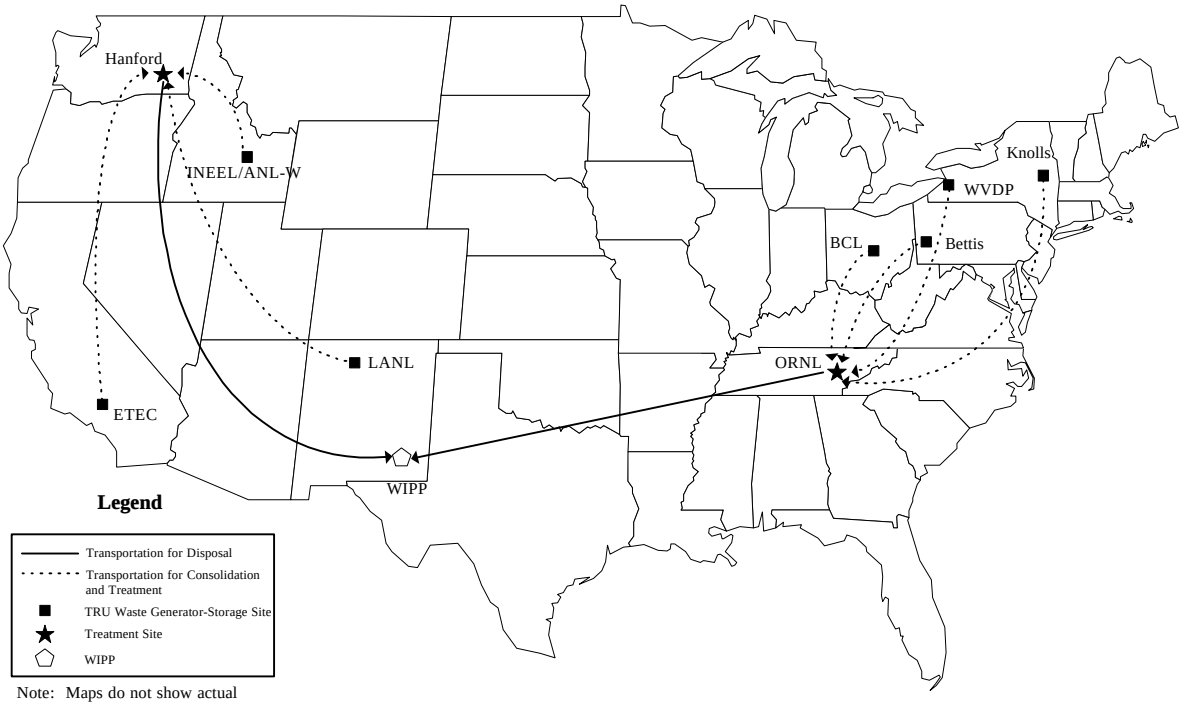
[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

The timeline below presents the approximate schedule for disposal activities under Action Alternative 3. Sites would generate waste for 35 years, beginning in 1998. It would take 12 years to design and construct the treatment facilities for Action Alternative 3. The disposal of TRU waste would begin in 2010 and would continue for 190 years, ending in 2200. The disposal operations duration is based on the time needed to emplace the total volume of RH-TRU waste, assuming a maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996b), and an operating time of 50 weeks per year. Decommissioning activities would last for up to 10 years and would be

CH-TRU Waste



RH-TRU Waste

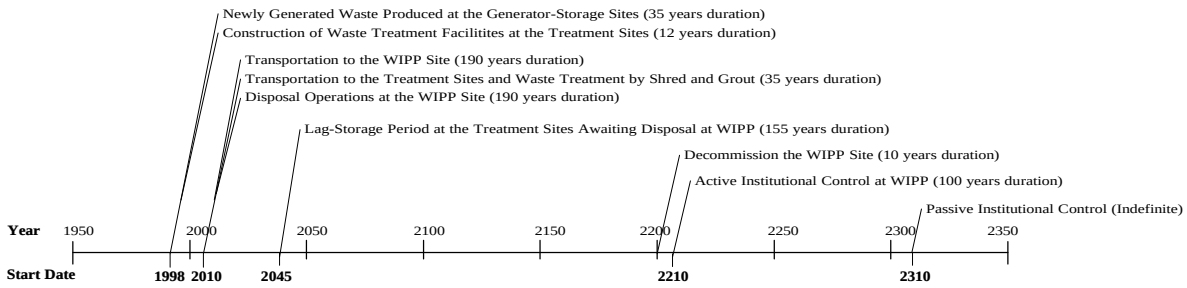


Note: Maps do not show actual transportation routes.

Figure 3-6
Movement of Waste for Action Alternative 3 [a]
(For complete names of facilities and waste volumes, see Tables 3-10 and 3-11)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

followed by an active institutional control period assumed for analyses to last 100 years, ending in 2310. (Section 3.2.4.4 discusses methods that could be used to reduce operations time for this alternative.)



Timeline for the Implementation of Action Alternative 3

3.2.4.1 Activities at the Generator-Storage Sites

The activities at the generator-storage sites are the same as those described for the Proposed Action, with the exceptions that there would be approximately twice as much waste and that treatment sites would use a shred and grout process to treat the waste. It was assumed that all waste treatment facilities would be constructed over a period of 12 years and would be ready for operation in the year 2010. Waste treatment would occur over 35 years, through the year 2045, and lag storage of the TRU waste awaiting shipment would occur for 155 years, through the year 2200. Lag storage would be necessary due to the rate of emplacement of RH-TRU waste. The lag storage would be similar to that described in Section 3.2.2.1. Engineering details of the shred and grout process that would be used have not been finalized. Nevertheless, such a process would consist of shredding the TRU waste to fragments smaller than some limiting size, perhaps 15 centimeters (6 inches); combining the fragments with a cement-based grout; and placing the mixture in disposal drums. Additional information on the TRU waste treatment processes is presented in Chapter 2.

3.2.4.2 Transportation Activities

Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- More than twice as many shipments as needed for the Proposed Action (based on BIR-3) would be required to transport the Basic Inventory and Additional Inventory to WIPP due to a larger pretreatment waste volume and the volume increase resulting from treatment.

- The period of shipping to WIPP would occur for 190 years, through the year 2200.

- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses only trucks, as described under the Proposed Action. The other two use a mix of maximum commercial rail and truck transportation or maximum dedicated rail and truck transportation, as described in Section 3.2.2.2. DOE would not build new rail lines. WIPP already has a rail spur leading to the facility.

3.2.4.3 Activities at WIPP

Under Action Alternative 3, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be the same as for the Proposed Action. This alternative would extend the operations time frame to as late as the year 2200 and would accept a larger total volume of TRU waste at WIPP. Seventy-one panels would be excavated to accommodate the additional waste, with 20 panels to accommodate CH-TRU and RH-TRU waste and 51 panels for RH-TRU waste only. Any expansion of WIPP capacity would require changes to the LWA, the C&C Agreement, and various permits to operate WIPP.

As in the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in the walls of the panels. Because of the increased volume of RH-TRU waste, other RH-TRU waste disposal options may be considered, including horizontal boreholes that could accommodate two canisters and vertical boreholes or trenches in the floors of disposal rooms.

Closure and institutional controls would be the same as those for the Proposed Action, except that decommissioning and assumed active institutional control period would extend through the year 2310 because of the additional years of operation. A berm would be constructed around the perimeter of the site. This berm would include 375 hectares (927 acres), 355 hectares (877 acres) of which would lie above the 71 panel equivalents, 12 hectares (30 acres) of which would be for the salt pile, and 8 hectares (20 acres) of which would be for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities, and, if necessary, any of the area overlying the disposal panels.

3.2.4.4 Reducing Operation Time

The 190 years of total operation time for treatment and emplacement of TRU waste under Action Alternative 3 is due to the large volume of RH-TRU waste to be emplaced, the increase in that volume due to treatment, and the assumptions that only one excavation shift will be used and that only 8 RH-TRU waste canisters will be emplaced per week. These assumptions were made to ensure all of the alternatives were comparable to the Proposed Action and to each other. During the public comment period, though, stakeholders stated that the operation time was too long and that DOE should consider methods of reducing it. Stakeholders also asked that the Final SEIS-II include greater detail on how the impacts would change if the operation time were reduced.

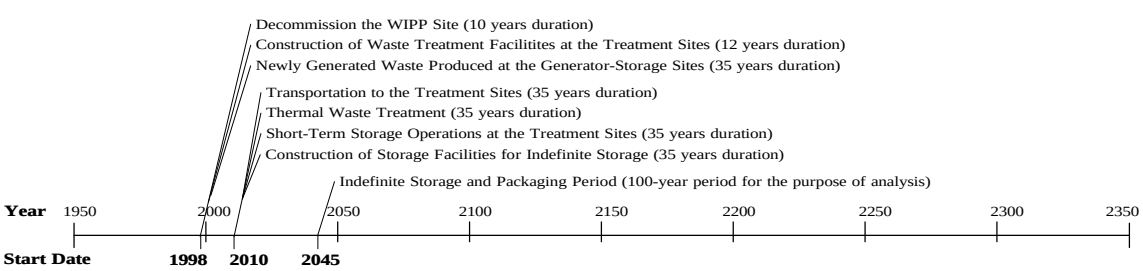
In response, this document includes analyses of impacts should the period of total operation be reduced from 162 years to 75 years by constructing new RH-TRU waste handling facilities and increasing the number of excavation crews. The 75 years would include 12 years to plan, design, and construct treatment facilities and 63 years for emplacement operations. The assumptions and description of operations presented for Action Alternative 3 above would apply, except for the following modifications:

- During the 12 years when treatment facilities would be planned, designed, and constructed, a new RH-TRU waste handling facility would be constructed at WIPP. The additional facility would include two RH-TRU waste handling areas and four new shafts into the facility. The four shafts would include a waste emplacement shaft, a salt removal shaft, an air intake shaft, and a ventilation shaft. Further NEPA review may need to be conducted, as appropriate, before any new facilities would be built.
- Two additional excavation crews would be used to excavate panels for the waste, increasing the excavation rate to three panels every two years. In all, an additional 90 WIPP employees would be hired.
- All transportation to WIPP would be completed in 63 years, following the 12-year period for construction of the treatment facilities.
- The capital cost of the new facility would be about $80 million; annual operating costs would increase by 10 percent.

3.2.5 No Action Alternative 1: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP

Under No Action Alternative 1, no waste would be shipped to WIPP. DOE would consolidate and thermally treat its inventory and would manage the treated waste indefinitely in newly engineered and constructed monitored storage facilities at the consolidation sites. A 65 percent reduction in volume was assumed due to the thermal treatment. The Department would dismantle the existing facilities at WIPP, salvage the equipment for other uses, and close the repository. Agreements and orders between DOE and various states, such as those under the Federal Facility Compliance Act, could require modification because of the extended time frame for storage.

Two waste treatment subalternatives were assumed for No Action Alternative 1. These two subalternatives are referred to as No Action Alternative 1A and 1B, respectively. Table 3-12 presents the CH-TRU waste volumes and Table 3-13 presents the RH-TRU waste volumes for No Action Alternative 1A. Figure 3-7 shows the flow of TRU waste between the sites. DOE would consolidate and treat CH-TRU waste at five sites (Hanford, INEEL, LANL, SRS, and RFETS) and RH-TRU waste at two sites (Hanford and ORNL). Table 3-14 presents the CH-TRU waste volumes and Table 3-15 presents the RH-TRU waste volumes for No Action Alternative 1B. Figure 3-8 shows the flow of TRU waste between sites. DOE would consolidate and treat CH-TRU waste at three sites (Hanford, INEEL, and SRS) and would treat RH-TRU waste at two sites (Hanford and ORNL). The timeline below presents the approximate schedule for No Action Alternatives 1A and 1B. Sites would generate waste for 35 years, beginning in 1998.



Timeline for the Implementation of No Action Alternatives 1A and 1B

Table 3-12
CH-TRU Waste Volumes for No Action Alternative 1A [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Material Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-7.

[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

It would take 12 years to design and construct the treatment facilities for No Action Alternatives 1A and 1B. The waste would be treated for 35 years and stored indefinitely. The treated TRU waste would be placed in and maintained at newly constructed storage facilities. WIPP would be decommissioned immediately. Decommissioning would last 10 years.

Table 3-13
RH-TRU Waste Volumes for No Action Alternative 1A [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-7.

[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.

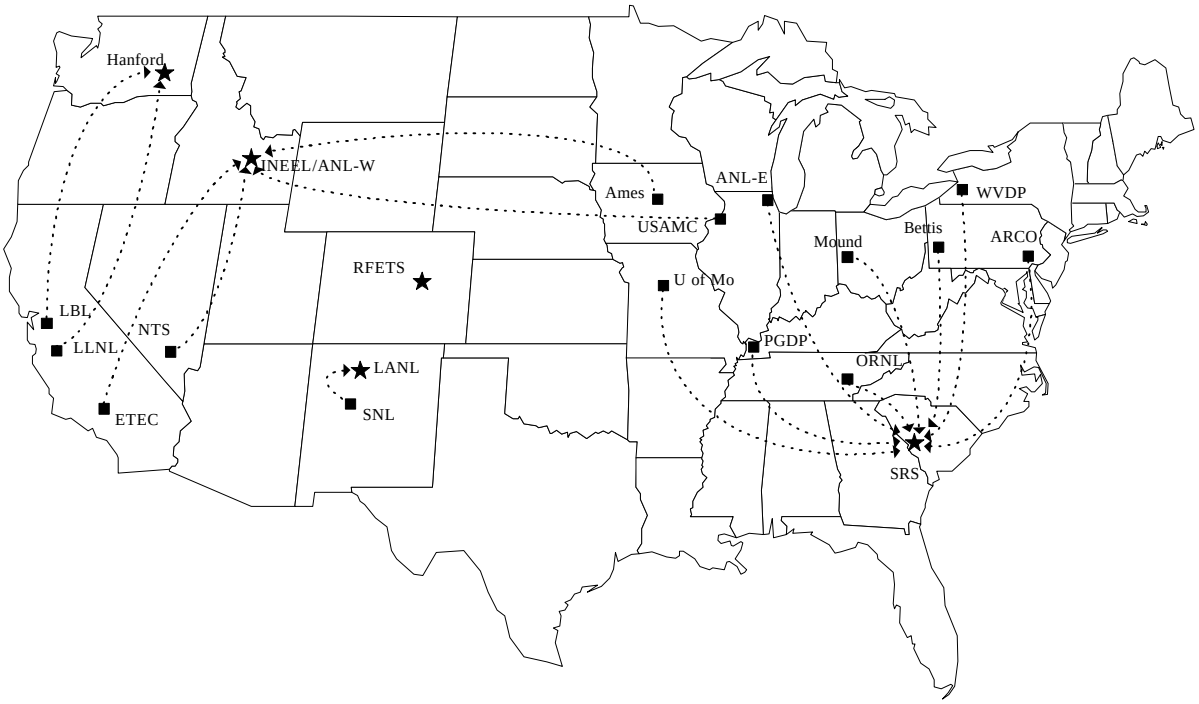
[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste.

[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

CH-TRU Waste



RH-TRU Waste

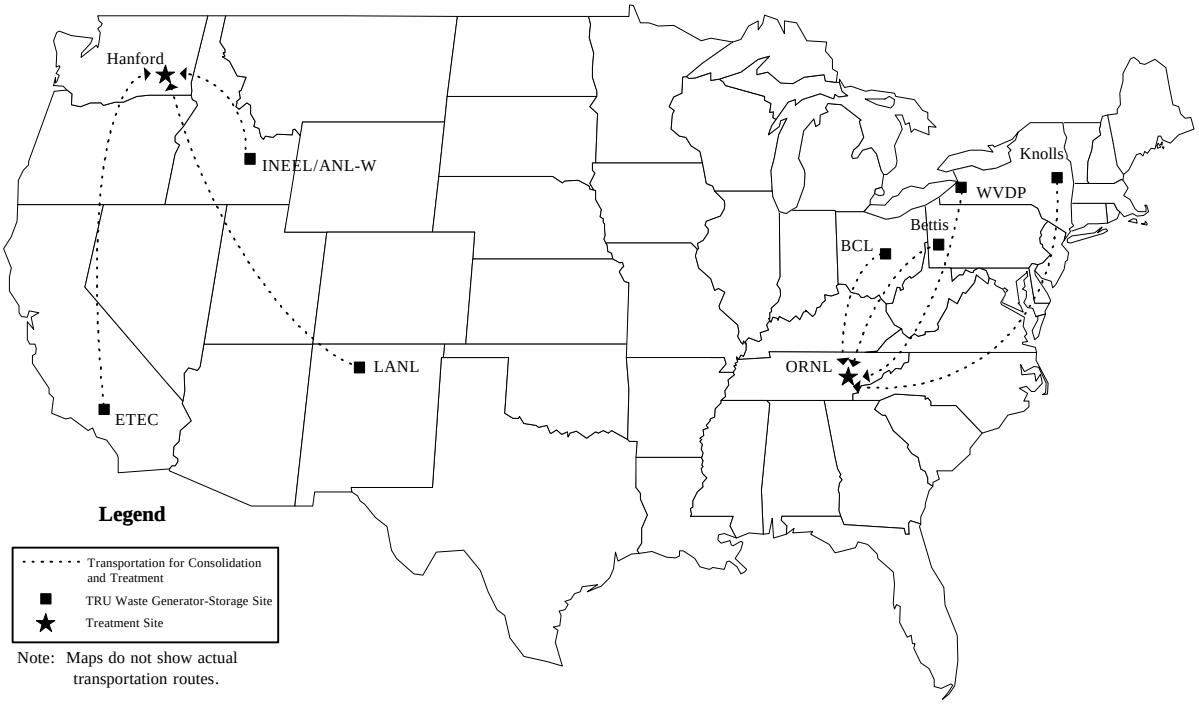


Figure 3-7
Movement of Waste for No Action Alternative 1A [a]
(For complete names of facilities and waste volumes, see Tables 3-12 and 3-13)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

Table 3-14
CH-TRU Waste Volumes for No Action Alternative 1B [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory - West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-8.

[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste.

[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

Table 3-15
RH-TRU Waste Volumes for No Action Alternative 1B [a]

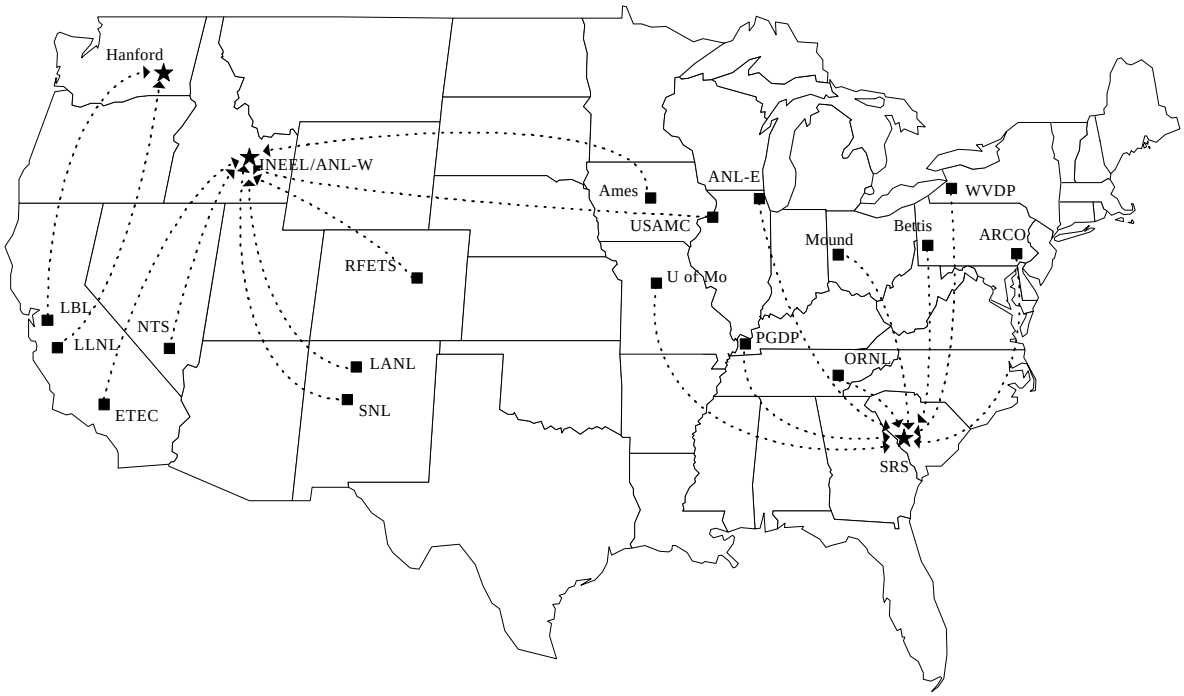
Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,600**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-8.
[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

3.2.5.1 Activities at the Generator-Storage Sites

Consolidation sites would use a thermal treatment process that may involve vitrification. This process would destroy organic matter, thereby reducing the total volume of thermally treated waste. A vitrification process would add silica-based materials that would result in a glass-like product. The volumes shown in Tables 3-12 through 3-15 reflect the currently stored and projected volumes and any thermal treatment. Waste treatment facilities would be constructed over a period of 12 years and would be ready for operation in the year 2010. The treated waste would be managed for an indefinite period of time at the consolidation sites in newly engineered, monitored storage facilities. Though the Department would investigate designing packages with longer minimal shelf-lives than those currently used, to bound the impacts it was assumed for the SEIS-II analyses that CH-TRU waste packaging would be performed every 20 years. Currently used drums and waste boxes have a relatively short design life and would degrade over time due to corrosion. It was further assumed, for purposes of analysis, that the storage facilities themselves would be refurbished or replaced at least every 50 years, although the Department may attempt to design facilities with a longer lifetime under this alternative.

CH-TRU Waste



RH-TRU Waste

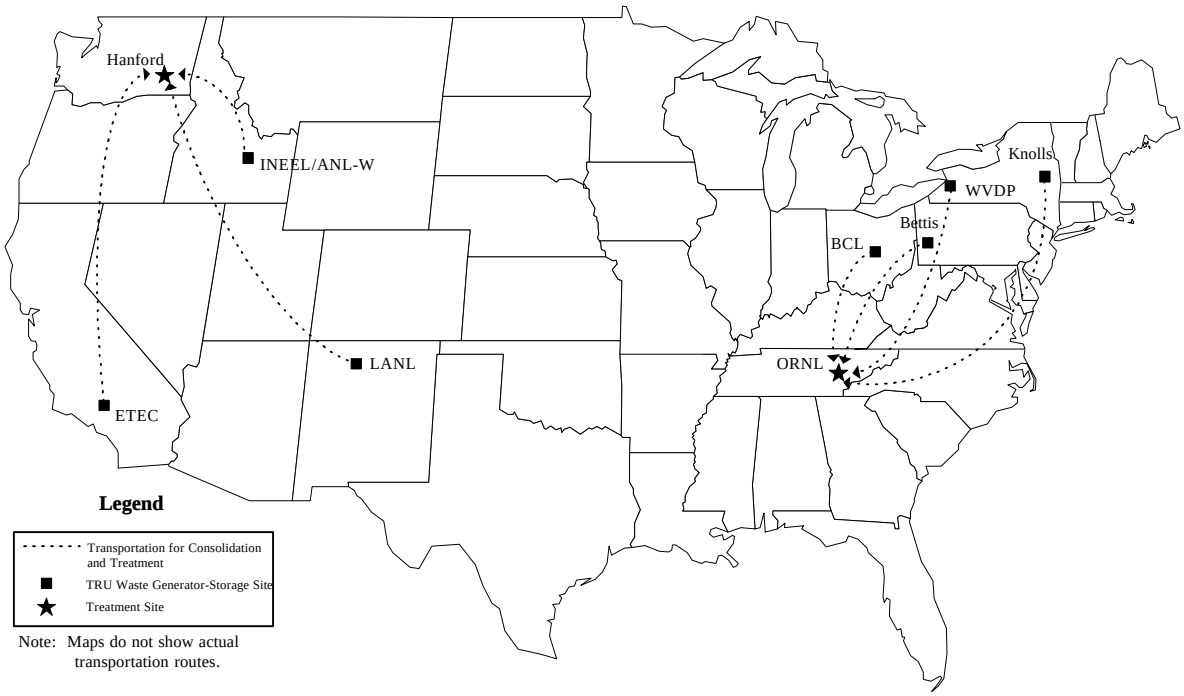


Figure 3-8
Movement of Waste for No Action Alternative 1B [a]
(For complete names of facilities and waste volumes, see Tables 3-14 and 3-15)

[a] Although Pantex currently has no TRU waste, future decisions by the Department may result in TRU waste generation at Pantex.

3.2.5.2 Transportation Activities

Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- No waste would be shipped to WIPP.
- The period of shipping to consolidation sites would begin in the year 2010.
- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses only trucks, as described under the Proposed Action. The other two scenarios use a mix of maximum commercial rail and truck transportation and maximum dedicated rail and truck transportation, as described in Section 3.2.2.2.

3.2.5.3 Activities at WIPP

There would be no disposal activities at WIPP; the Department would terminate its WIPP mission. DOE would fill the shafts with salt from the storage pile and then seal the excavation. The aboveground site would be restored and perhaps returned to the U.S. Bureau of Land Management (BLM). DOE would salvage all usable equipment and dismantle and remove the surface facilities.

3.2.6 No Action Alternative 2: Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP

Activities associated with No Action Alternative 2 are discussed below. There would be no treatment of stored waste, although newly generated waste would be treated to the requirements of WAC for safe storage. There would be no transportation of any of the waste from the generator-storage sites, unless future agreements require such movement.

3.2.6.1 Activities at the Generator-Storage Sites

Under No Action Alternative 2, no waste would be shipped to WIPP. Current TRU waste management practices would continue at all sites, except where DOE has entered into agreements to have waste removed from small quantity sites to facilitate safe long-term storage. In such cases, shipment of TRU waste from a small quantity site to a consolidation site would be by truck. Newly generated TRU waste would be treated to WAC for safe storage. Existing TRU waste in storage would not be treated but would continue to be managed under current practices. Newly generated waste would constitute about 73,000 cubic meters (2,600,000 cubic feet) of the 135,000 cubic meters (4,800,000 cubic feet) of CH-TRU waste and 32,000 cubic meters (1,100,000 cubic feet) of the 35,000 cubic meters (1,200,000 cubic feet) of RH-TRU waste in the Basic Inventory. Table 3-16 presents TRU waste volumes for No Action Alternative 2.

Table 3-16
TRU Waste Volumes for No Action Alternative 2 [a]

Site [b]	Site Volume Through 2033 (cubic meters)		Stored Volume (1995) (cubic meters)		Newly Generated Post-Treatment Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	57,000	29,000	12,000	200	45,000	29,000
Los Alamos National Laboratory (LANL)	21,000	230	11,000	90	10,000	130
Idaho National Engineering and Environmental Laboratory (INEEL) [c]	28,000	220	28,000	220	---	---
Argonne National Laboratory - West (ANL-W)	1,000	1,700	7	20	1,000	1,700
Argonne National Laboratory - East (ANL-E)	200	--- [d]	25	---	180	---
Savannah River Site (SRS)	12,000	---	2,900	---	9,200	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	4,900	---	6,000	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,300	2,500	350	600
Lawrence Livermore National Laboratory (LLNL)	1,200	---	230	---	960	---
Nevada Test Site (NTS)	630	---	620	---	10	---
Mound Plant (Mound)	300	---	300	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	170	9
Sandia National Laboratories - Albuquerque (SNL)	17	---	7	---	10	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	2	6	---	1
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	---
Total	**135,000**	**35,000**	**62,000**	**3,600**	**73,000**	**32,000**

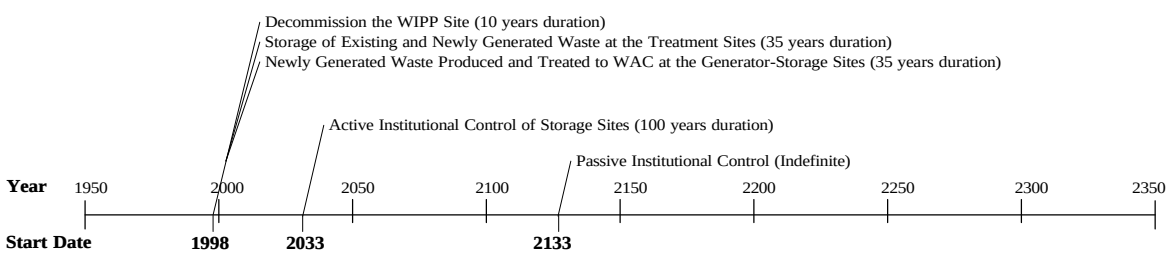
[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites. Waste exceeding 50 ppm of PCBs cannot be disposed of in WIPP unless treated to remove the PCBs first. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Sites in boldface were included in SEIS-I.

[c] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[d] Dashes indicate no waste.

A timeline below presents the approximate schedule under No Action Alternative 2. Sites would continue to generate waste for 35 years and would store the waste. WIPP would be decommissioned beginning immediately.



Timeline for the Implementation of No Action Alternative 2

3.2.6.2 Transportation Activities

The generator-storage sites would only ship waste to the consolidation sites if it were to facilitate safe storage or requirements of future agreements. No waste would be shipped to WIPP.

3.2.6.3 Activities at WIPP

There would be no disposal activities at WIPP; the Department would terminate its WIPP mission. DOE would fill the shafts with salt and then seal the excavation. DOE would restore the aboveground site and perhaps return it to the BLM. DOE would salvage all usable equipment and dismantle and remove the surface facilities according to the WIPP Land Management Plan (DOE 1993).

3.3 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

SEIS-II does not include detailed analyses of several alternatives discussed during the scoping process. These alternatives were not analyzed in detail because — depending on the alternative — they are not technically viable, would not adequately or economically meet DOE's need to safely dispose of TRU waste in a timely manner, involve additional environmental and policy concerns that would need to be accommodated, or are otherwise unreasonable in the present context. The following alternatives are not analyzed in detail.

Transmutation. An accelerator or a reactor could possibly be used to transmute long-lived radionuclides into short-lived or stable nuclides; however, the transmutation process has not been demonstrated for TRU waste. Also, transmutation is a technology that has not yet been proven for production-size facilities. The transmutation process, as well as reactor operations, would result in fission products that would have to be disposed of as radioactive waste by some other method. This alternative was considered and rejected for the same reasons in the 1980 *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980). DOE is not aware of any proven physical or chemical techniques that will neutralize or change the fundamental physical process of radioactive decay. The National Academy of Sciences (NAS) (1996) published a report that evaluated the relative effects, costs, and feasibility of employing separations and transmutation technologies in DOE programs. (These technologies would be used for managing spent nuclear fuel for civilian power reactors and radioactive wastes in tanks at selected existing defense production reactor sites. To DOE's knowledge there has been no similar detailed, independent study with respect to TRU waste.) Based on this research, DOE does not believe that transmutation represents a technically achievable, cost-effective, near-term alternative for the elimination or disposal of TRU waste.

Coprocess with high level waste and vitrify[1]. TRU and high level waste could be combined and mixed with molten glass. This vitrification would produce highly radioactive glass "logs" that would have to be stored in interim storage and eventually buried in a geologic repository (NAS 1994). While the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (DOE 1996c) considered this process to be a reasonable alternative for analysis, it is a much less reasonable alternative for TRU waste. The technical difficulties of thermal loading in a high-level waste repository, the operational difficulties

[1] Vitrification of TRU waste not mixed with high-level waste is considered in SEIS-II.

SEIS-II AND THE WM PEIS ALTERNATIVES

Each SEIS-II alternative reflects an alternative in the WM PEIS in the way consolidation of waste is assumed.

The SEIS-II Proposed Action assumes, for the purposes of analyses, consolidation similar to the WM PEIS Decentralized Alternative, which was the basis for the WM PEIS preferred alternative. As in the WM PEIS Decentralized Alternative, the Proposed Action assumes that TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the 10 facilities with the largest volume of waste to await disposal at WIPP. Those 10 sites are Hanford, LANL, INEEL, ANL-East, SRS, RFETS, ORNL, Lawrence Livermore National Laboratory (LLNL), NTS, and the Mound Plant (Mound). The SEIS-II inventory includes small quantities of TRU waste from several sites that were not considered for the WM PEIS. Waste from these sites would be consolidated at the closest site with larger volumes, if necessary.

The SEIS-II Action Alternative 1 also assumes, for analysis purposes, consolidation similar to the WM PEIS Decentralized Alternative. TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the same 10 facilities as assumed for the Proposed Action. (The major difference between the SEIS-II Proposed Action and the SEIS-II Action Alternative 1 is the amount of waste to be disposed of.)

The three SEIS-II Action Alternative 2 subalternatives assume, for analysis purposes, consolidation similar to the WM PEIS Regionalized 2, Regionalized 3, and Centralized Alternatives. In each, the TRU waste would be consolidated at treatment sites where it would be treated by a thermal process to meet the RCRA LDRs. The three different consolidation options considered under Action Alternative 2 are:

- **Action Alternative 2A:** Assumes for analysis that CH-TRU waste would be treated at Hanford, SRS, RFETS, LANL, and INEEL/ANL-W. Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Regionalized 2 Alternative.
- **Action Alternative 2B:** Assumes for analysis that CH-TRU waste would be treated at Hanford, SRS, and INEEL/ANL-W. Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Regionalized 3 Alternative.
- **Action Alternative 2C:** Assumes for analysis that CH-TRU waste would be treated at WIPP. Assumes that RH-TRU waste would be treated at Hanford and ORNL. The consolidation used for analysis is similar to the WM PEIS Centralized Alternative.

The SEIS-II Action Alternative 3 is similar to the WM PEIS Regionalized 1 Alternative. For both alternatives, TRU waste would be consolidated at regional sites throughout the country and treated by a shred and grout process before shipping the TRU waste to WIPP. CH-TRU waste would be treated at Hanford, LANL, RFETS, SRS, and INEEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

The two SEIS-II No Action Alternative 1 subalternatives are similar to the WM PEIS Regionalized 2 and Regionalized 3 Alternatives. The waste would be treated at the same sites described above for the SEIS-II Action Alternatives 2A, 2B, and 2C. SEIS-II No Action Alternative 1A is similar to the WM PEIS Regionalized 2 Alternative; SEIS-II No Action Alternative 1B is similar to the WM PEIS Regionalized 3 Alternative.

The SEIS-II No Action Alternative 2 is similar to both the WM PEIS Decentralized and No Action Alternatives. The currently stored waste would be left untreated. Newly generated waste would be treated to WAC. All waste would be stored at the sites where it is currently stored or would be generated.

that a large additional volume of TRU waste would cause, and potential legislative clarification or Nuclear Regulatory Commission certification by rule, make this alternative unreasonable.

Disposal in space. This alternative was considered and rejected in the FEIS. The disposal of TRU waste in a low earth orbit would not be sufficient because material in such an orbit would fall back to earth over a time span that is short as compared to the necessary disposal time and decay time of the TRU waste. Therefore, the waste would have to be launched into an orbit around the sun that is unlikely to encounter the earth or be put on a path to fall into the sun or escape the solar system entirely. The type and number of rockets needed for this type of launch would be very expensive, and the rockets would have to be very reliable. Research shows that even with reliable rockets the possibility of a rocket failure exists, and such a failure could result in the waste reentering from space (NAS 1994).

Underground detonation. Such detonations would produce a large amount of hazardous fission products. Research shows that the waste form resulting from a detonation would be somewhat unpredictable and it would be embedded in an underground location not selected for, or designed as, a long-term repository (NAS 1994). Because of the volume of waste to be disposed of, a large number of detonations would be required. Also, the geologic environment around the detonation points would be greatly disturbed. The manufacture of the explosive devices used in the detonations would generate more waste. This alternative would present additional environmental and policy concerns that would have to be addressed.

Subseabed disposal. This alternative was considered and rejected in the FEIS. Subseabed disposal of TRU waste would involve implanting canisters of TRU waste tens of meters into deep ocean sediments by free-fall penetration or other techniques (DOE 1980). In addition, subseabed disposal is prohibited by international treaties, and further development would be required. The U.S. program studying subseabed disposal was canceled in 1986, and no other country is currently pursuing such research.

Deep borehole disposal. This alternative involves drilling or sinking very deep boreholes or shafts (3,000-meters [9,840-feet] or more) and placing TRU waste canisters into these holes. This method relies on the surrounding rock to contain the waste and on the great depths to delay the release and reentry of radioactive material into the biosphere. This disposal method was reviewed in the FEIS (DOE 1980) and was ruled out because of substantial technical challenges in characterizing the geological conditions at the depth of interest, severe engineering problems in excavating deep holes and emplacing waste canisters, and the large number of boreholes (800 to 1,300) estimated to be required. Deep borehole disposal was evaluated as a candidate technology for possible disposal of surplus fissile materials (DOE 1996c). However, the technology may be more practicable for disposal of surplus fissile materials than for disposal of TRU waste because the volume of fissile materials potentially requiring disposal is many times smaller than the volume of TRU waste. Also, because many years of investigation and development would be needed before this method might be available for the disposal of TRU waste, selection of this technology would considerably delay the disposal of TRU waste.

Greater confinement (shallow borehole). This disposal method involves burial of waste in containers engineered to provide multiple barriers in shallow boreholes at a depth of about 100 feet. At many DOE sites, waste buried at this depth would likely interact with groundwater and could eventually pose an environmental and human health hazard. Greater confinement

disposal is being used for some waste types at the NTS, which has a deep water table, and greater confinement disposal of small quantities of TRU waste in this manner might be feasible. The degree of isolation that could be provided by greater confinement disposal over the 10,000-year-plus period WIPP would be expected to isolate waste is unknown, but this relatively shallow burial method offers no apparent advantage over disposal at WIPP. The need to evaluate the ability of any anticipated greater confinement disposal site to isolate waste would further delay disposal of TRU waste by several years. For the volume of waste that DOE proposes to dispose of in WIPP, greater confinement disposal would be a less cost-effective method of disposal.

Geologic repositories at sites other than WIPP. Three general classes of geologic media have been considered in the past for the disposal of radioactive waste (DOE 1980). These geologic media are salt, igneous rocks (granite, basalt, and tuff), and argillaceous rocks (shale). Salt is a favorable disposal media because of its thermal and physical properties and because its very survival for hundreds of millions of years has demonstrated its isolation from circulating groundwater and the stability of the geologic formations in which it is located (DOE 1980).

Alternative Engineered Barriers. Regulations within 40 CFR Part 194 suggest that alternative engineered barriers, including some not specifically examined here (e.g., supercompaction, improved waste canisters, grout and bentonite backfill) should be considered. The Department examined these as alternatives and determined based on the evaluation conducted in the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995b) that they were less effective than the engineered barriers examined in SEIS-II.

Other Suggestions. Zircon technology and changing the state of atoms to "supercold" in order to slow down radionuclide activity were technologies suggested for TRU waste treatment methods during the public scoping process. None of these technologies are currently technically or economically feasible, and their use as treatment or disposal alternatives would require additional research.

3.4 COMPARISON OF THE PROPOSED ACTION AND ALTERNATIVES

Table 3-17 gives a tabular comparison of the major features of the Proposed Action and the alternatives. This table is meant to help the reader understand the differences and similarities among the different courses of action described in SEIS-II. Figures 3-9 and 3-10 provide graphical comparisons of the CH-TRU and RH-TRU post-treatment waste volumes that would be disposed of according to alternative.

Over the life of the campaign, routine operation under the Proposed Action could result in five estimated worker fatalities at waste treatment sites and three worker fatalities at WIPP. Truck transportation under the Proposed Action could result in an estimated additional eight deaths among members of the public and crew. Although highly unlikely, the most severe accident, a severe truck accident with a maximum radionuclide inventory having a frequency of less than 7.5×10^{-7} per accident, could result in an additional 16 deaths. The waste disposed of at WIPP under the Proposed Action would be isolated from the environment for more than 10,000 years unless an intrusion by drilling occurred. If an intrusion occurred, radionuclides could reach the Culebra Dolomite, but impacts would be negligible. Health impacts due to any released waste at the storage sites could vary depending on the population density in the vicinity at the time the waste was released. The Proposed Action would be the least expensive of the action alternatives ($19.03 billion in 1994 dollars, $10.13 billion when the costs are discounted).

Table 3-17
Summary of WIPP SEIS-II Alternatives

Comparison Parameters	*Proposed Action (Preferred Alternative):* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Waste Type	Defense-related, post-1970 TRU waste in retrievable storage and newly generated through the year 2033 (Basic Inventory).	Basic Inventory plus other DOE-owned or controlled waste including non-defense, commercial, previously disposed of waste, and excluding PCB-commingled waste (Additional Inventory).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Basic Inventory plus Additional Inventory (excluding PCB-commingled waste).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Same as Proposed Action.
Post-Treatment Volume[b] to be Disposed of at WIPP, or Stored	CH-TRU: 168,500 m^3 (5,950,000 ft^3) RH-TRU: 7,080 m^3 (250,000 ft^3) Excess Waste[c] RH-TRU 43,000 m^3 (1,500,000 ft^3)	CH-TRU: 281,000 m^3 (9,900,000 ft^3) RH-TRU: 55,000 m^3 (2,000,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 334,000 m^3 (11,800,000 ft^3) RH-TRU: 66,000 m^3 (2,300,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 135,000 m^3 (4,800,000 ft^3) RH-TRU: 35,000 m^3 (1,200,000 ft^3)
Waste Consolidation Locations (assumed for purposes of analyses; actual consolidation would be in accordance with the ROD for the WM PEIS)	18 sites total - WAC treatment of CH-TRU at the largest sites and store at 10 largest sites[d]. Ship to WIPP. - WAC treatment of RH-TRU at Hanford, INEEL/ANL-W, ORNL, and LANL. Ship to WIPP.	22 sites total - Same as Proposed Action except two other sites (LBL, WVDP) consolidate and treat CH-TRU at Mound and Hanford.	22 sites total Action Alternative 2A - LDR treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2B - LDR treatment of CH-TRU at Hanford, INEEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2C - LDR treatment of CH-TRU at WIPP. - LDR treatment of RH-TRU at Hanford and ORNL.	22 sites total - Shred and grout treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - Shred and grout RH-TRU at Hanford and ORNL.	22 sites total No Action Alternative 1A - LDR treatment of CH-TRU at Hanford, INEEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. No Action Alternative 1B - LDR treatment of CH-TRU at Hanford, INEEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL.	Minimal consolidation to ensure safe storage; however, no sites would ship to WIPP.
Waste Treatment	Treat to meet WAC.	Treat to meet WAC.	Thermal treatment to meet the LDRs (including PCB-commingled waste).	Treatment by shred and grout.	Thermal treatment to meet the LDRs (including PCB-commingled waste). Package every 20 years indefinitely.	Newly generated waste treated to WAC.

Table 3-17
Summary of WIPP SEIS-II Alternatives — Continued

Comparison Parameters	*Proposed Action (Preferred Alternative):* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Transportation Mode	Truck. The Preferred Alternative reserves the option of rail transportation.	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[e] commercial rail - Maximum dedicated rail	Truck only.
Disposal Operations	CH-TRU stacked in disposal rooms. RH-TRU placed in horizontal boreholes. RH-TRU disposal would start 6 years after CH-TRU and 7,080 m^3 (250,000 ft^3) of RH-TRU can be disposed of. 10 panel equivalents required at WIPP.[f]	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 68 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 75 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 71 panel equivalents required at WIPP.	No disposal. CH-TRU and RH-TRU would be in newly engineered, monitored storage at treatment sites.	No disposal. CH-TRU and RH-TRU continue to use existing storage.
WIPP Operations Time Frame [g]	Receive and emplace waste beginning 1998 for 35 years. Decommissioning for 10 years and active institutional control for 100 years, ending in 2143.	Same as Proposed Action, lag storage for 125 years and disposal would be for 160 years, until 2158; active institutional control ending in 2268.	Waste disposal and thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Lag storage for 115 years. Disposal would be for 150 years, until 2160. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2270.	Waste disposal and shred and grout treatment would begin in 2010 after treatment facility construction Lag storage for 155 years. Disposal would be for 190 years, until 2200. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2310.	Dismantle and close WIPP in 10 years. Thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Package and manage indefinitely at treatment sites.	Dismantle and close WIPP. Sites generate waste for 35 years beginning in 1998. Storage at the generator-storage sites evaluated for 35 years, ending in 2033. Active institutional control at generator-storage sites until 2133.
WIPP Institutional Control Site Area	70 hectares (175 acres)	360 hectares (890 acres)	395 hectares (976 acres)	375 hectares (927 acres)	20 hectares (50 acres) (Only for 10 years during decommissioning)	20 hectares (50 acres) (Only for 10 years during decommissioning)

[a] New facilities may be constructed in the future pursuant to future NEPA review.

[b] These values correspond to the Post-Treatment Consolidated Volume and Post-Treatment Disposal Volume data in Tables 3-1 through 3-16; differences in the numbers are due to rounding. The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites.

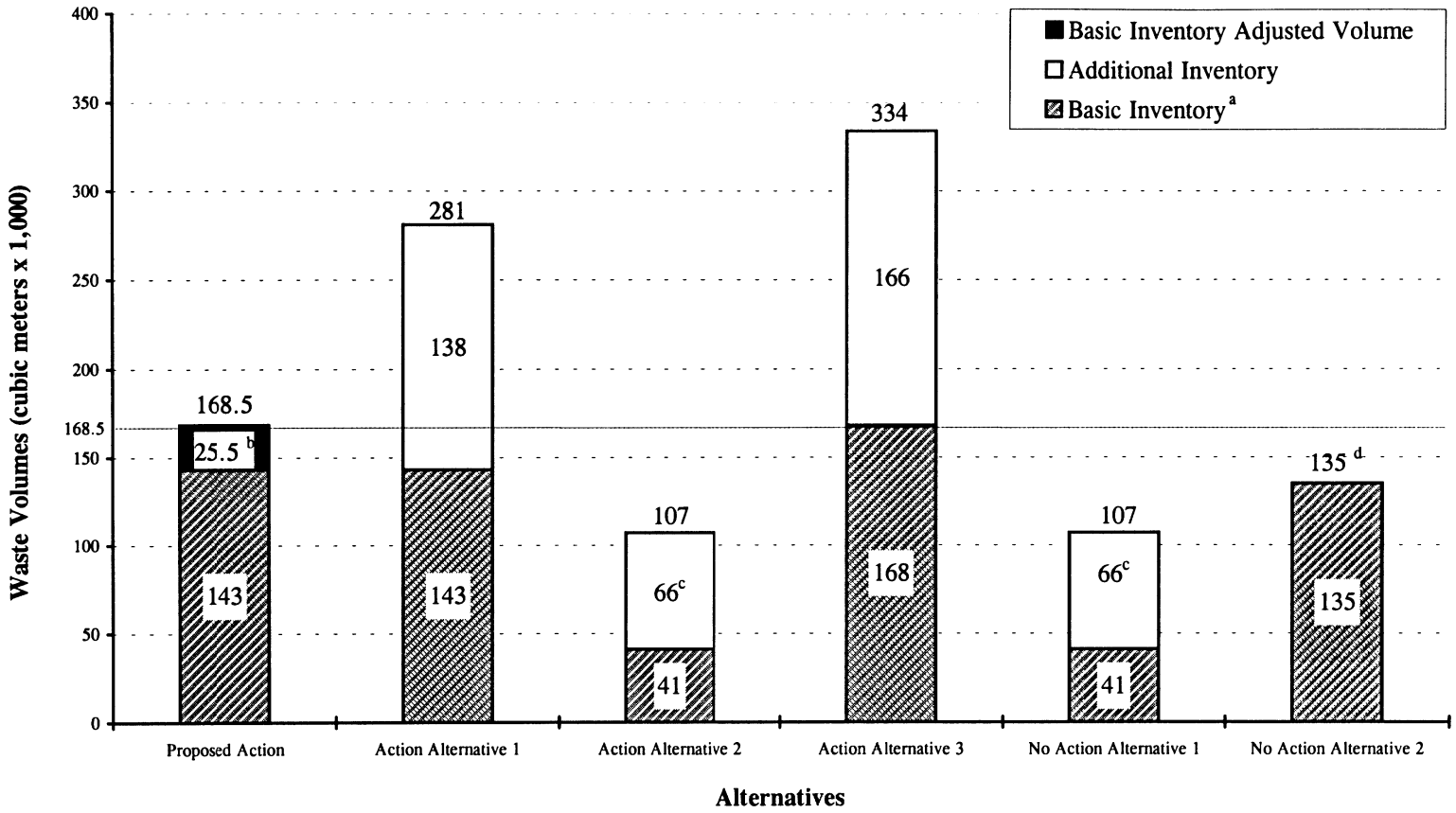
[c] Recent estimates in the *National Transuranic Waste Management Plan* indicate there would be no excess RH-TRU waste; see Appendix J.

[d] The 10 largest generator-storage sites are ANL-E, Hanford, INEEL/ANL-W, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS.

[e] Maximum rail is used to denote that 18 of the 22 sites have rail facilities nearby; the remaining sites would ship by truck. Areas and volumes have been rounded.

[f] Under the Proposed Action, the consequence analysis for RH-TRU waste is based on 7,080 cubic meters (250,000 cubic feet), the maximum disposal volume of RH-TRU waste that is allowable at WIPP under the Consultation and Cooperation Agreement. The disposal strategy is to emplace RH-TRU waste canisters in the panel room walls prior to stacking CH-TRU waste in the rooms. At startup, however, a lag in RH-TRU waste availability is anticipated that would result in only CH-TRU waste initially being disposed of. The actual amount of RH-TRU waste disposed of, therefore, may be as low as 4,300 cubic meters.

[g] These time frames are those presented in the Draft SEIS-II. For reduced time frames, see Sections 3.2.2.4, 3.2.3.4, and 3.2.4.4.



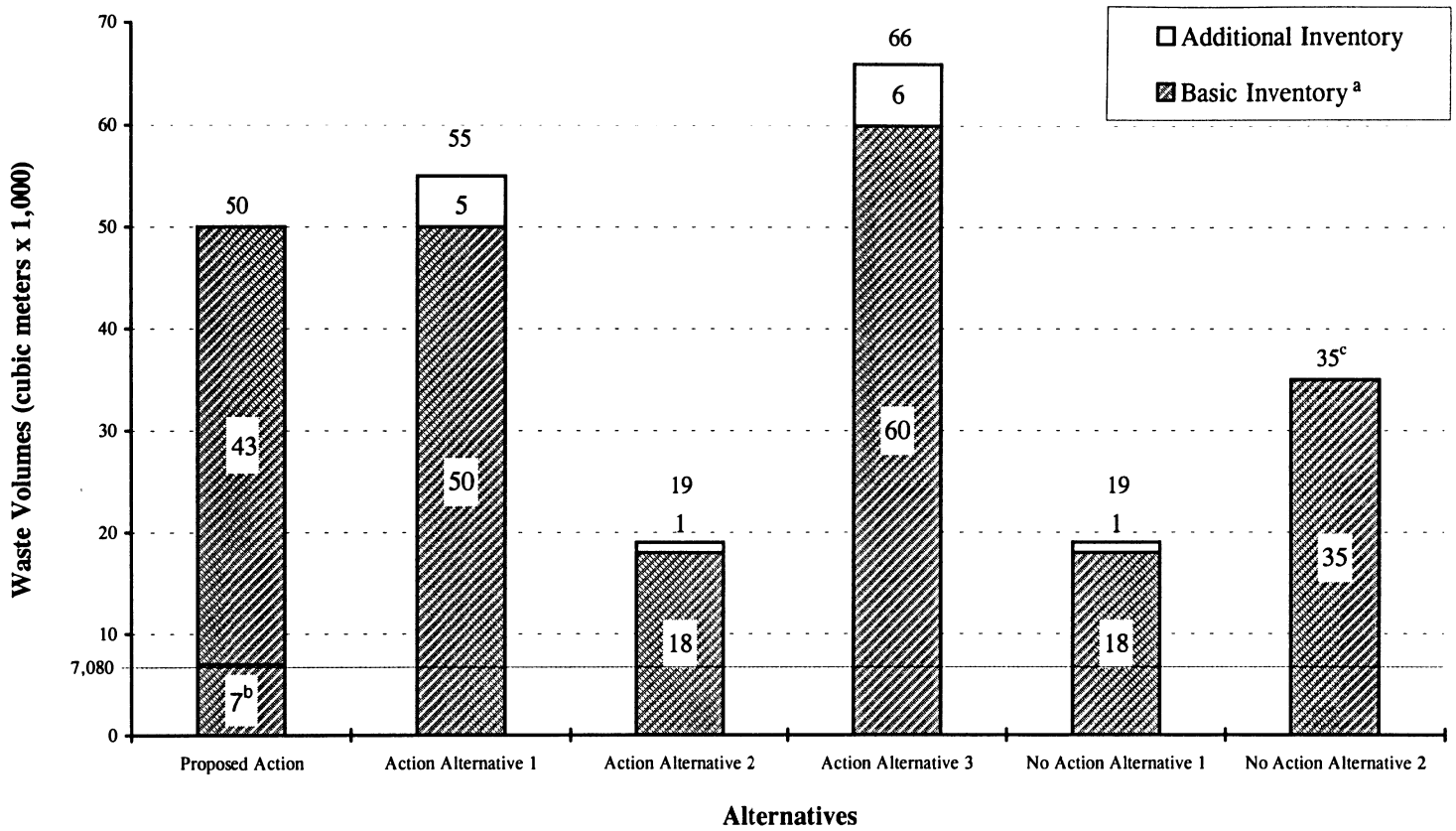
[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] The CH-TRU waste Basic Inventory is adjusted from approximately 143,000 cubic meters to 168,500 cubic meters in order to evaluate the total volume of CH-TRU waste allowable at WIPP under current laws and agreements.

[c] Includes TRU waste commingled with PCBs.

[d] Only 73,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated. Therefore, the post-treatment waste volume of the Basic Inventory is not the same as for the Proposed Action and Action Alternative 1.

Figure 3-9
CH-TRU Post-Treatment Waste Volumes by Alternative



[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] Only 7,080 cubic meters of the Basic Inventory (14 percent of the Basic RH-TRU inventory) was evaluated for WIPP disposal under the Proposed Action because of the WIPP disposal limit established under the C&C Agreement with the State of New Mexico. The excess RH-TRU waste would be treated to WAC and stored at non-WIPP treatment sites.

[c] Only 32,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated. Therefore, the post-treatment waste volume of the Basic Inventory is not the same as for the Proposed Action and Action Alternative 1.

Figure 3-10
RH-TRU Post-Treatment Waste Volumes by Alternative

Action Alternative 1 could result in an estimated six worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 1 could result in an estimated additional 29 deaths (28 among members of the public). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. The waste disposed of at WIPP under Action Alternative 1 would be isolated from the environment for more than 10,000 years, and Action Alternative 1 would effectively isolate all DOE TRU waste generated and expected to be generated over 35 years (except for a small quantity of PCB-commingled waste). Action Alternative 1 costs would be $50.95 billion in 1994 dollars ($16.32 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 2 could result in an estimated seven to twelve worker fatalities at the waste treatment sites and one to two fatalities to the populations in the vicinity of the treatment sites (with subalternatives 2A and 2B having higher impacts than subalternative 2C). An estimated six worker fatalities would result from disposal operations at WIPP under all subalternatives. Truck transportation under Action Alternative 2 could result in an estimated additional 17 to 20 deaths (16 to 19 among members of the public, with Action Alternative 2C having higher transportation impacts than Action Alternatives 2A or 2B). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 480 deaths. The waste disposed of at WIPP under Action Alternative 2 would be isolated from the environment for more than 10,000 years, and Action Alternative 2 would effectively isolate all DOE TRU waste generated and expected to be generated over 35 years. Action Alternative 2 costs would range from $54.01 billion to $57.18 billion in 1994 dollars ($19.56 billion to $21.19 billion when discounted), depending on the subalternative and assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 3 could result in an estimated seven worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 3 could result in an estimated additional 39 deaths (38 among members of the public). The most severe accident under this alternative would be the failure of the WIPP waste hoist (with an annual frequency of 4.5×10^{-7} or less) and could result in an additional 29 deaths. The waste disposed of at WIPP under Action Alternative 3 would be isolated from the environment for more than 10,000 years, and Action Alternative 3 would effectively isolate all DOE TRU waste generated and expected to be generated over 35 years (except for a small quantity of PCB-commingled waste). Action Alternative 3 costs would be $59.67 billion in 1994 dollars ($18.03 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 1 could result in an estimated 10 to 11 worker fatalities at the waste treatment sites and 2 fatalities to the populations in the vicinity of the treatment sites (depending on the subalternative). No worker deaths would be estimated to result from closure activities at WIPP. Truck transportation under No Action Alternative 1 could result in an estimated zero deaths to workers and one death to members of the public. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 480 deaths. No Action Alternative 1 would restrict access for 100 years to all DOE TRU waste generated and expected to be generated over 35 years, at which time the waste would either have to

be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, the thermally treated waste form would restrict migration of the waste initially, but the waste would eventually become more mobile as the vitrified waste form eroded. If the waste were released, deaths to the public over 10,000 years would depend in part on population densities and distributions, but no deaths would be expected based on current densities and distributions. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 1 costs would range from $30.28 to $32.85 billion in 1994 dollars ($17.09 to $18.54 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 2 could result in an estimated two worker fatalities at the waste storage sites and no worker deaths from closure activities at the WIPP site. No transportation is assumed under No Action Alternative 2, and no deaths would result. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. No Action Alternative 2 would restrict access to the currently stored and newly generated portion of DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, estimated deaths would total 800 for the Total Inventory over 10,000 years given current population densities and distributions. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 2 costs would be $2.49 billion in 1994 dollars ($1.68 billion when discounted).

Table 3-18 is a summary table that compares the more notable impacts from within the Proposed Action and the alternatives.

3.5 PREFERRED ALTERNATIVE

The Department's Preferred Alternative is to proceed with WIPP disposal of defense TRU waste treated to planning-basis WAC under the Proposed Action (see Section 3.1). Under the Preferred Alternative, the Department would initially transport waste by truck and would continue to explore the availability of safe and cost-effective commercial rail transportation.

The Department has identified the Proposed Action (reserving the option of future rail transportation) as its Preferred Alternative for a number of reasons, including the following: the Proposed Action would provide long-term isolation of TRU waste from the accessible environment, and the Proposed Action is consistent with DOE's obligations under agreements and court orders and with the LWA.

In contrast, the action alternatives would require amendments to the LWA and/or the C&C Agreement with New Mexico. The no action alternatives would not meet the Department's purpose and need for action, would not meet court orders and treatment plans, and would result in long-term impacts that would be avoided under the Proposed Action.

Table 3-18
Summary of SEIS-II Environmental Impacts

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Land Use and Management									
Treatment Facility Sites	No substantial impacts identified beyond the treatment facilities. Treatment facilities would require no more than 11 hectares, less than 1% of land available at each site for each alternative. Treatment facilities, therefore, could be located in developed areas or areas appropriate for development. Sensitive areas, including wetlands, flood plains, sensitive habitats, and cultural resource areas would be avoided.								No substantial impacts. Only newly generated waste would be treated.
WIPP (during operations)	DOE would occupy the land transferred by the LWA and lease some other land. WIPP would continue to limit drilling and mining activities, and grazing and public access to the site and may acquire oil and gas leases. No other impacts would occur to local land use beyond the site.						Impacts would be minimal because no waste would be emplaced.		
WIPP (area impacted by closure)	70 hectares	360 hectares	395 hectares	395 hectares	395 hectares	375 hectares	20 hectares	20 hectares	20 hectares
Air Quality									
Treatment Facility Sites (As a percentage of the most stringent applicable regulatory standard. Emissions for sites and pollutants not specifically noted would be less than 10% of the most stringent applicable regulatory standard).	RFETS, CO, 17%.		LANL, radionuclides, 134%. RFETS, CO, 24%. INEEL, PM_{10} 10%.	INEEL, radionuclides, 10%. INEEL, PM_{10}, 10%.	WIPP, radionuclides, 137%. WIPP, SO_2, 12%. WIPP, PM_{10}, 25%.	RFETS, CO, 20%.	LANL, radionuclides, 134%. RFETS, CO, 24%, INEEL, PM_{10}, 10%.	INEEL, radionuclides, 10%. SRS, radionuclides, 48%. INEEL, PM_{10}, 10%.	RFETS, CO, 17%.
WIPP Operations (percent of applicable EPA or state standard)	Annual average: negligible increases of O_3 and lead; less than 2% increases in PM_{10}, NO_2, and SO_2. Short-term (24-hour) emission limits: PM_{10} - 57%, NO_2 - 65%, SO_2 - 7%, CO - 3% of standards, releases of lead and ozone would be minimal.						WIPP would not be operated. WIPP would be dismantled.		
Biological Resources									
Treatment Facility Sites	Threatened and endangered species appear at many of the proposed treatment sites and could potentially be impacted. Such species and their critical habitats would be avoided through appropriate consultation, site selection, monitoring, and mitigation measures. Because the treatment sites would require less than 1% of the land available at any site, critical habitats could be avoided at most sites.								No impacts because only minimal treatment would occur.
WIPP (disturbed land area)	Federally- or state-listed or protected, threatened, endangered, and proposed species occur in Eddy County and potentially at the WIPP site, although there have been no threatened, endangered, or proposed species or critical habitats recently observed at the WIPP site by DOE during completion of its recent biennial environmental compliance reports. DOE recently conducted biological surveys at the WIPP site and identified no endangered or threatened species. No impacts to biodiversity or ecosystem balance would be expected. Impacts to other plant and animal species may occur during closure and construction of a berm around the WIPP site. The affected area would differ based on the areas listed above under land use.						Minimal impacts during closure of current facility.		

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Cultural Resources									
Treatment Facility Sites	Although cultural resources are present at many sites, specific treatment facility locations are unknown. Acreage need at any one site is 11 hectares or less. Potential impacts will be avoided or mitigated based on site-specific cultural resource surveys.								No impacts. Treatment would be minimal.
WIPP Resource Sites Potentially Impacted (during operations)	None.						No impacts. WIPP would not be operated.		
WIPP Resource Sites Potentially Impacted (during closure)	Two. Potential impacts would be avoided or mitigated in accordance with the Joint Powers Agreement.	Eleven due to larger surface closure area. Potential impacts would be avoided or mitigated in accordance with the Joint Powers Agreement.					No impacts for the no action alternatives. Closure would only involve the 20 acres on which current facilities have been built.		
Noise									
Treatment Sites	Negligible increase in noise due to waste transportation or treatment facility operation because treatment facilities would probably be placed at industrial-type sites along high-traffic volume corridors. Project-specific impacts to sensitive receptors could occur. Assessment of potential impacts would be conducted in site-wide or project-specific NEPA documentation.								No impacts because transportation would not occur and treatment would be minimal.
WIPP	Negligible increase in noise due to additional daily truck or train traffic. Only 8 trucks per day would travel to WIPP if trucks are used; only 13 to 16 rail cars per week if trains are used.						Not applicable to the no action alternatives. No transportation to WIPP would occur and WIPP would not be operated.		
Water Resources and Infrastructure									
Treatment Sites 1. Water 2. Power 3. Wastewater 4. On-site Transportation	3. Hanford - 5.9% 4. Hanford, INEEL, and LANL - minor impacts		2. INEEL - 6.6% 3. Hanford - 7.8% 4. Hanford, INEEL, and LANL - minor impacts	2. INEEL - 6.6% 3. Hanford - 7.8% 4. Hanford, and INEEL - minor impacts	2. INEEL - 6.6%; WIPP - 50% 3. WIPP - 80% 4. WIPP - 162%; Hanford - minor impacts	2. INEEL - 6.4% 3. Hanford - 7% 4. Hanford, INEEL, and LANL - minor impacts	2. INEEL - 6.6% 3. Hanford - 7.8% 4. Hanford, INEEL, and LANL - minor impacts	2. INEEL - 6.6% 3. Hanford - 7.8% 4. Hanford, and INEEL - minor impacts	No impacts.
Disposal Operations at WIPP	Annual incremental infrastructure impacts at WIPP would be negligible and within capacity for disposal operations.						Decreasing use of resources, none after decommissioning of WIPP.		

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Socioeconomics									
Treatment/Storage Sites									
Life-Cycle Costs (millions of 1994 dollars)	12,140	21,390	27,690	30,550	28,700	24,340	29,360	31,760	1,640
Annual Employment (supported jobs)	11,900	22,500	28,000	28,500	7,200	24,900	29,300	29,800	2,300
Disposal Operations at WIPP									
Life-Cycle Costs (millions of 1994 dollars)	5,300	24,650	23,330	23,330	23,330	28,490	850	850	850
Annual Goods & Services (millions of 1994 dollars)	317	317	317	317	616	317	-317	-317	-317
Annual Employment (supported jobs)	3,538	3,538	3,538	3,538	6,876	3,538	-3,538	-3,538	-3,538
Annual Labor Income (millions of 1994 dollars)	126	126	126	126	245	126	-126	-126	-126
Total Life-Cycle Cost by Mode of Transportation (millions of 1994 dollars); discounted totals using a 4.1 percent annual inflation rate are presented in parentheses									
Total Life-Cycle Costs--Truck	19,030 (10,130)	50,950 (16,320)	54,010 (19,560)	57,180 (21,190)	54,940 (20,100)	59,670 (18,030)	30,280 (17,090)	32,850 (18,520)	No shipments of TRU waste would occur under this alternative. Total life-cycle cost without transportation is 2,490 (1,680).
Total Life-Cycle Costs--Regular Rail	No rail transportation analyzed under Propsed Action; rail transportation reserved under Preferred Alternative.	47,680 (15,800)	52,030 (19,220)	55,020 (20,830)	52,940 (19,760)	55,170 (17,420)	30,240 (17,070)	32,770 (18,470)	
Total Life-Cycle Costs--Dedicated Rail		57,360 (17,330)	57,880 (20,210)	61,360 (21,900)	58,570 (20,720)	68,520 (19,210)	30,460 (17,190)	33,790 (19,040)	
Transportation									
Truck									
Number of Truck Shipments to Consolidation Sites and WIPP	CH - 29,793 RH - 8,915	CH - 41,056 RH - 66,012	CH - 43,313 RH - 30,149	CH - 51,240 RH - 30,149	CH - 41,151 RH - 30,149	CH - 67,844 RH - 82,860	CH - 538 RH - 8,254	CH - 8,466 RH - 8,254	No shipments of TRU waste would occur under this alternative.
Nonradiological Truck Impacts									
Truck Accidents	56	171	109	123	105	239	5	13	
Truck Injuries	39	119	76	86	74	165	4	12	
Truck Fatalities	5	16	10	11	11	22	0.3	1	
Truck Pollution Fatalities	0.1	0.5	0.4	0.5	0.4	0.7	0.03	0.07	

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Radiological Truck Impacts									No shipments of TRU waste would occur under this alternative.
Accident-Free Population Impacts to Crews (LCFs)	0.3	0.7	0.5	0.7	0.5	1.0	0.02	0.07	
Accident-Free Population Impacts to the Public (LCFs)	3.0	11	6	7	6	15	0.4	0.9	
Highest Lifetime Accident-Free Impact to MEIs (probability of an LCF)	8.5E-3	8.6E-3	4.6E-3	4.9E-3	4.5E-3	9.9E-3	Not Analyzed.	Not Analyzed.	
Rail									
Nonradiological Rail Impacts	Transportation by rail not anaylzed under the Proposed Action; rail transportation is reserved under the Preferred Alternative.								
Fatalities Using Regular Rail Service		8	5	6	6	11	0.2	0.5	
Fatalities Using Dedicated Rail Service		112	70	84	84	154	2.8	7	
Radiological Rail Impacts									
Accident-Free Population Impacts to Crews (Regular and Dedicated) (LCFs)		0.03	0.03	0.03	0.03	0.05	8.6E-4	3.7E-3	
Accident-Free Population Impacts to the Public (Regular and Dedicated) (LCFs)		1.5	0.9	1	0.9	2.0	0.07	0.1	
Accidents									
Transportation Accidents (Truck)									
Population Impacts with Conservative Inventory (LCFs)	CH - 16 RH - 16	CH - 16 RH - 16	CH - <1 RH - <1	CH - <1 RH - <1	CH - 16 RH - <1	CH - 16 RH - 16	CH - 16 RH - 16	CH - 16 RH - 16	
Population Impacts with Average Inventory (LCFs)	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - <1 RH - <1	CH - <1 RH - <1	CH - 3 RH - <1	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - 3 RH - 0.04	
MEI Impact with Conservative Inventory (probability of an LCF)	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH – 3E-4 RH - 3E-4	CH – 3E-4 RH – 3E-4	CH – 0.06 RH – 3E-4	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	
MEI Impact with Average Inventory (probability of an LCF)	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 2E-4 RH - 4E-6	CH - 2E-4 RH - 4E-6	CH – 0.04 RH – 4E-6	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	
Aggregate Potential Truck Accident Impacts to Populations Along All Transportation Routes (LCFs)	0.4	0.8	0.7	0.7	0.7	1.2	6.8E-3	0.02	

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Transportation Accidents (Rail)									
Population Impacts with Conservative Inventory (LCFs)	No rail transportation is proposed under the Proposed Action; rail transportation is reserved under the Preferred Alternative.	CH - 32 RH - 32	CH - <1 RH - <1	CH - <1 RH - <1	CH - 32 RH - <1	CH - 32 RH - 32	CH - 32 RH - 32	CH - 32 RH - 32	No shipments of TRU waste would occur under this alternative.
Population Impacts with Average Inventory (LCFs)		CH - 6 RH - 0.08	CH - <1 RH - <1	CH - <1 RH - <1	CH - 6 RH - <1	CH - 6 RH - 0.08	CH - 6 RH - 0.08	CH - 6 RH - 0.08	
MEI Impact with Conservative Inventory (probability of an LCF)		CH - 0.12 RH - 0.12	CH - 3E-4 RH - 3E-4	CH - 3E-4 RH - 3E-4	CH - 0.12 RH - 3E-4	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	
MEI Impact with Average Inventory (probability of an LCF)		CH - 0.08 RH - 1E-4	CH - 2E-4 RH - 4E-6	CH - 2E-4 RH - 4E-6	CH - 0.08 RH - 4E-6	CH - 0.08 RH - 1E-4	CH - 0.08 RH - 1E-4	CH - 0.08 RH - 1E-4	
Aggregate Potential Rail Accident Impacts (LCFs) to Populations Along All Rail Routes		0.8	0.7	0.7	0.7	1.2	6.8E-3	0.02	
Human Health									
Routine Radiological Impacts (LCFs) [a]									
Treatment									
Involved Worker Population	0.8	1.5	1.7	1.3	0.6	1.5	1.7	1.3	0.4
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	7E-6 3E-9	8E-6 8E-9	0.1 5E-5	0.1 2E-4	0.06 2E-4	7E-4 2E-7	0.1 5E-5	0.1 2E-4	8E-5 4E-8
Public Population MEI	2E-4 9E-9	2E-4 1E-9	2.4 3E-5	2.3 5E-5	0.9 2E-4	4E-3 4E-7	2.4 3E-5	2.3 5E-5	1E-3 8E-8
***WIPP Operations* [b] (LCFs) [a]**							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	≤1	≤1	<0.4	<0.4	<0.4	0.3	≤1.1	≤1.1	≤3
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	4E-4 4E-7	5E-4 4E-7	2E-4 2E-7	2E-4 2E-7	2E-4 2E-7	5E-4 3E-7	0.06 1E-6	0.06 1E-6	0.1 4E-5
Public Population MEI	3E-4 3E-7	4E-4 5E-7	5E-5 1E-7	5E-5 1E-7	5E-5 1E-7	3E-4 3E-7	3E-3 2E-7	2E-3 2E-9	0.03 2E-6
Lag Storage[c] Public Population Impacts Lag Storage Noninvolved Worker Population	No lag storage for the Proposed Action.	1E-2 0.05	1E-3 2E-2	8E-4 2E-2	3E-4 1E-3	3E-3 0.07	No lag storage for the no action alternatives.		
Excess RH-TRU Waste Storage Public Population Impacts[d] Excess RH-TRU Waste Storage Noninvolved Worker Population[d]	2E-5 4E-5	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Routine Hazardous Chemical Impacts (Cancer Incidence)									
Treatment at Treatment Sites									
Involved Worker Population	2E-5	3E-5	6E-5	9E-5	8E-5	4E-5	6E-5	9E-5	8E-6
Noninvolved Worker Population	1E-7	2E-7	1E-7	1E-7	1E-7	2E-7	1E-7	1E-7	1E-7
Maximum Exposed Noninvolved Worker	1E-10	2E-10	1E-10	1E-10	1E-10	1E-10	1E-10	1E-10	1E-10
Public Population	4E-7	6E-7	3E-7	3E-7	3E-7	4E-7	3E-7	3E-7	4E-7
Maximum Exposed Individual	2E-11	3E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11	2E-11
WIPP Operations [a]							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	0.01	0.04	No impacts because the TRU waste would be thermally treated.			≤0.01	None because TRU waste would be thermally treated.		≤0.1
Noninvolved Worker Population	1E-4	1E-4				9E-5			6E-3
Maximum Exposed Noninvolved Worker	1E-7	9E-8				5E-8			2E-7
Public Population	2E-5	3E-5				2E-5			6E-3
Maximum Exposed Individual	3E-8	2E-8				1E-8			4E-8
Lag Storage[c] Public Population	No lag storage for the Proposed Action.	5E-3				4E-3	None because there is no lag storage for the no action alternatives.		
Lag Storage Noninvolved Worker Population		0.01				0.02			
Excess RH-TRU Waste Storage Public Population Impacts[d]	3E-4	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							
Excess RH-TRU Waste Storage Noninvolved Worker Population[d]	6E-4								
Selected Facility Accidents [a]									
Treatment Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	0.01	0.01	1	1	1	0.02	1	1	0.01
Maximally Exposed Individual	2E-3	2E-3	1	1	1	5E-3	1	1	2E-3
Public Population	3	3	480	480	28	6	480	480	3
Storage Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	3E-3	1.0	0.05	0.05	0.1	0.04	0.02	0.02	0.7
Maximally Exposed Individual	5E-4	0.1	5E-3	5E-3	0.08	5E-3	0.08	0.08	0.1
Public Population	0.9	300	10	9	2	10	10	10	300
WIPP Disposal (Hoist Failure, frequency of 4.5E-7) LCFs									
Maximally Exposed Noninvolved Worker	0.06	0.06	0.5	0.5	0.5	0.5	No impacts because disposal does not occur under the no action alternatives.		
Maximally Exposed Individual	0.08	0.08	0.6	0.6	0.6	0.6			
Public Population	5	5	29	29	29	29			

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Industrial Safety									
Waste Treatment (fatalities)	4	4	9	7	6	5	9	7	0.7
Construction and Operations (fatalities)	2	6	6	6	6	7	0.8	0.8	0.6
Performance Assessment of Treatment Sites and WIPP									
Treatment Sites - Human Intrusion [e]									
Radiological Impacts (probability of an LCF)									
Driller	4E-4 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the action alternatives, and TRU waste is managed indefinitely under No Action Alternatives 1A and 1B.							1E-6 to 3E-5
Gardener	3E-3 [f]								4E-3 to 0.06
Scavenger	0.01 [f]								6E-4 to 0.02
Family Farm	1 [f]								0.2 to 1
Treatment Sites - Environmental Release									
Radiological Impacts (probability of an LCF)									
MEI (probability of an LCF)	5E-5 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives. For No Action Alternatives 1A and 1B, it was assumed the waste would be managed indefinitely.							3E-6 to 4E-3
Population (LCFs)	3E-4 [f]								4E-5 to 7
Aggregate Population Impacts over 10,000 years	4E-3 [f]	Does not apply to these alternatives because there is no waste at the treatment sites.					8E-4	3E-4	807
Hazardous Chemical Impacts (Cancer Incidence)									
MEI	9E-7 [f]	Does not apply to these alternatives because there is no waste at the treatment sites under the action alternatives, and TRU waste is managed indefinitely under No Action Alternative 1.							1E-7 to 5E-3
Population	5E-6 [f]								5E-7 to 3E-4
WIPP - Human Intrusion (based on the intrusion in the repository scenario)									
Maximum Radiological Impacts Drilling Crew Member (probability of an LCF; dashes indicate no analyses were performed because scenarios are inapplicable)									
CH-TRU Waste Panel	---	4E-4	1E-4	1E-4	1E-4	3E-4	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	---	1E-5	2E-6	2E-6	2E-6	1E-5			
Mixed CH-TRU and RH-TRU Panel	4E-4	4E-4	---	---	---	3E-4			
Maximum Radiological Impacts Site Geologist (probability of an LCF)									
CH-TRU Waste Panel	3E-9	3E-9	7E-9	7E-9	7E-9	2E-9	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	3E-9	5E-9	1E-8	1E-8	1E-8	4E-9			
Environmental Justice									
Treatment sites and WIPP	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.				Impacts are possible at WIPP during treatment.	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.			

Table 3-18
Summary of SEIS-II Environmental Impacts — Continued

Consequence Category	Proposed Action/ Preferred Alternative	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
TRU Waste Retrieval (of one panel of waste before repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	4E-5	4E-5	4E-5	4E-5	4E-5	4E-5			
Public Population	3E-5	3E-5	3E-5	3E-5	3E-5	3E-5			
Transportation									
Accident-Free Population Impacts to Crews (LCFs)	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Accident-Free Population Impacts to the Public (LCFs)	0.3	0.3	0.3	0.3	0.3	0.3			
Traffic-Related Fatalities	0.5	0.5	0.5	0.5	0.5	0.5			
TRU Waste Recovery (of all waste after repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	8	8	8	8	8	8	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	0.3	0.3	0.3	0.3	0.3	0.3			
Public Population	0.2	0.2	0.2	0.2	0.2	0.2			
Transportation									
Accident-Free Population Impacts to Crews (LCFs)	1	1	1	1	1	1	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Accident-Free Population Impacts to the Public (LCFs)	15	15	15	15	15	15			
Vehicle Emission Effects Fatalities	7	7	7	7	7	7			
Traffic-Related Fatalities	185	185	185	185	185	185			

[a] The probability of an LCF occurring to the MEI or maximum exposed noninvolved worker, and the number of LCFs to the populations.
[b] Under the no action alternatives, this category represents impacts from storage.
[c] Lag storage is storage pending shipment to WIPP. Lag storage does not include long-term storage of waste (such as any excess RH-TRU waste under the Proposed Action) that will not be shipped to WIPP.
[d] Recent estimates in the *National Transuranic Waste Management Plan* indicate there would be no excess RH TRU waste; see Appendix J.
[e] People who might intrude upon the stored waste could receive radiation doses that would greatly exceed current regulatory limits.
[f] Impacts from any excess RH-TRU waste. Scaled from No Action Alternative 2.

Note: For details on impacts due to the Additional Inventory (for the Proposed Action) see the text box "The Additional Inventory and the Proposed Action." For information on how impacts would change should WIPP's operations period be reduced to 175 years or less, see the text box "Reducing Operations Periods."

3.6 REFERENCES CITED IN CHAPTER 3

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1993, *Waste Isolation Pilot Plant Land Management Plan*, DOE/WIPP 93-004, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *Remote-Handled Transuranic Waste Study (Draft)*, DOE/CAO-Draft-1095, July, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID-95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP 91-005, Revision 5.2, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Transuranic Materials Transportation Guide*, DOE/CAO-96-1055, March, Carlsbad, New Mexico

DOE (U.S. Department of Energy), 1996c, *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*, DOE/EIS-0229-F, December, Washington, D.C.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

NAS (National Academy of Sciences), 1994, *Management and Disposition of Excess Weapons Plutonium*, March, National Academy Press, Washington D.C.

NRC (U.S. Nuclear Regulatory Commission), 1989, *Safety Evaluation Report, TRUPACT-II Shipping Container, Certificate of Compliance No. 9218*, Rev. 0, Washington, D.C.

NRC (National Research Council), 1996, *Nuclear Waste: Technologies for Separations and Transmutation*, National Academy Press, Washington, D.C.

WID (Westinghouse Waste Isolation Division), 1995, *1995 Long-Term Ground Control Plan for the Waste Isolation Pilot Plant*, Westinghouse Geotechnical Engineering, WIPP/WID-95-2101, June, Carlsbad, New Mexico.

CHAPTER 4
DESCRIPTION OF THE AFFECTED ENVIRONMENTS

This chapter describes the affected environments at the Waste Isolation Pilot Plant (WIPP) site and at the ten major generator-storage sites. The WIPP site is discussed in detail with emphasis on the changes that have occurred and new information that has been determined since the publication of the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) in 1990 (DOE 1990).

4.1 EXISTING ENVIRONMENT AT THE WIPP

The passage of the WIPP Land Withdrawal Act (LWA), results of recent environmental studies, and changes to various aspects of the existing environment have generated new information concerning the environment at the WIPP site. The following sections update Sections 4.1.1 through 4.3.5 of SEIS-I (DOE 1990).

4.1.1 Land Use and Management

The U.S. Department of Energy (DOE or the Department) defines the region of influence (ROI) for land use impacts as WIPP plus ". . . the site and the area immediately adjacent to the site" (DOE 1997b).[1] Thus, for WIPP, the area of consideration for land use includes privately owned ranches and Bureau of Land Management (BLM) lands, including some leased as mineral and grazing lands immediately adjacent to the WIPP site. The *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) states that almost 7,700 hectares (19,000 acres) of land surrounding WIPP were committed to the WIPP project. It notes that the dominant use of the land within 16 kilometers (10 miles) of the site is grazing, with lesser amounts used for oil and gas extraction and potash mining. BLM owns most of this land. Two ranches are located within 16 kilometers (10 miles)

CHANGES IN SITE LAND USE AND MANAGEMENT

Since publication of SEIS-I, DOE has made the following changes in land use. These changes are largely due to the planning-basis WIPP Waste Acceptance Criteria (WAC) and the Land Management Plan.

- *Wildlife Management* - DOE initiated a multi-year research effort to document the population and ecology of several species, and additional seeding of reclamation sites was undertaken.
- *Cultural Resources Management* - DOE created a comprehensive WIPP archeological database.
- *Vegetation Management* - DOE now monitors vegetation for evidence of stress induced by climate and salt tailings.
- *Rights-of-Way* - In 1994, DOE requested and was granted permission by BLM to construct a short access road.
- *Emergency and Facility Security* - DOE has published three plans on emergency and facility security.
- *Groundwater Surveillance* - DOE has installed seven new wells to monitor water quality.

[1] Currently this ROI includes only two working ranches. No towns are included.

of the WIPP site while the closest town, Loving, New Mexico, is 29 kilometers (18 miles) away. The federal government or the State of New Mexico owns most of the land within 50 kilometers (30 miles) of the WIPP site. Within 80 kilometers (50 miles) of the site, there is dryland farming, irrigated farming along the Pecos River, and some forest, wetland, and urban land (see Figure 4-1).

SEIS-I (DOE 1990) notes the release of approximately 4,450 hectares (11,000 acres) of previously restricted land for unrestricted use, allowing exploration for and development of mineral resources and permanent habitation. It describes a land withdrawal boundary, which defines the WIPP site, as encompassing 16 sections (4,146 hectares [10,240 acres]) of federal land in Township 22 South, Range 31 East (Figure 4-2). This boundary was delineated so as to extend at least 1.6 kilometers (1 mile) beyond any WIPP underground development.

The type of land use surrounding WIPP has not changed substantially since the preparation of SEIS-I, although the level of development has increased. The site has been divided into four areas under DOE control (Figure 4-2). A chain-link fence surrounds the innermost "Property Protection Area," which includes the surface facilities. Surrounding this inner area is the "Exclusive Use Area," set off by a barbed-wire fence. Enclosing these areas is the "Off-Limits Area," which is unfenced to allow livestock grazing but, like the other two, is patrolled and posted against trespass or other land uses. Beyond the "Off-Limits Area," but within the 16-section WIPP site, the land is managed under the traditional public land use concept of multiple use. Mining and drilling for purposes other than support of the WIPP project, however, are restricted (DOE 1995d).

On October 30, 1992, the President signed into law the LWA (Public Law 102-579). This Act transferred responsibility for management of the WIPP withdrawal area from the Secretary of the Interior to the Secretary of Energy. The land is permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and is reserved for uses associated with the purposes of WIPP. LWA establishes certain rights and responsibilities, one of which was the preparation of a Land Management Plan published in 1993 (DOE 1993a).

DOE's WIPP Land Management Plan incorporates the restrictions of the LWA and the DOE Memorandum of Understanding (MOU) with the BLM. The Land Management Plan establishes management objectives and planned actions for the use of the withdrawn land until the end of the decommissioning phase. The plan promotes the concept of multiple-use management for the surface area of the withdrawn land and establishes a goal of minimizing land use restrictions where possible. The plan also provides opportunity for participation in the land use planning process by the public, and local, state, and federal agencies.

The Land Management Plan lists 13 areas of concern: wildlife, cultural resources, grazing management, recreation, mining and oil and gas production, rights-of-way, access, emergency and facility security, fire management, water service, groundwater surveillance, salt tailings, and reclamation. The following is a summary of the progress made toward implementing this plan. Details of these actions can be found in the *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994* (DOE 1995d).

Recent efforts in the area of wildlife management include initiating a multi-year research investigation into the ecology and life history of resident raptor populations, with emphasis on the Harris hawk (*Parabuteo unicinctus*); appraisals of populations of small nocturnal mammals; and the additional seeding of reclamation sites to increase soil stabilization.

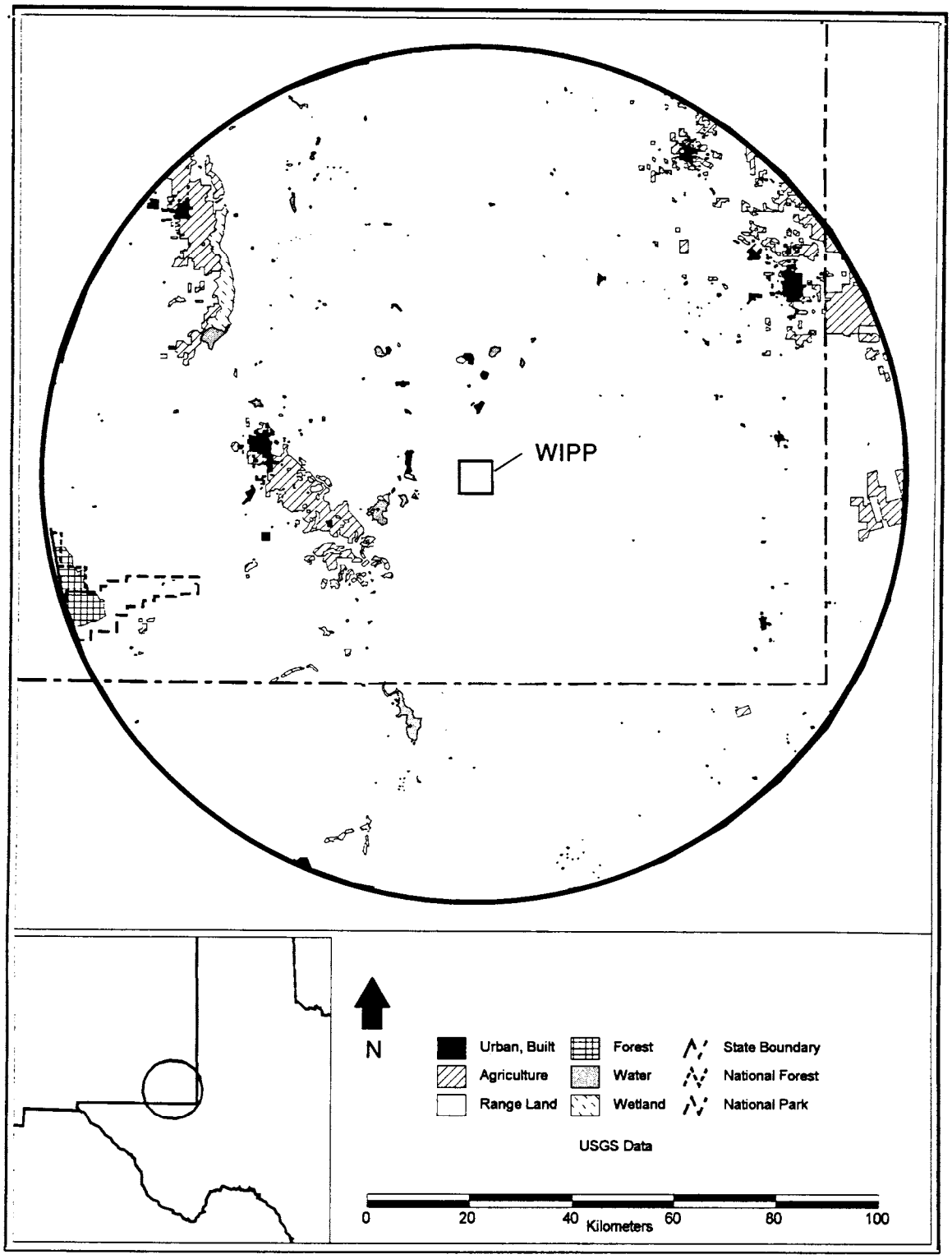


Figure 4-1
Land Use Within 80 Kilometers (50 Miles) of WIPP

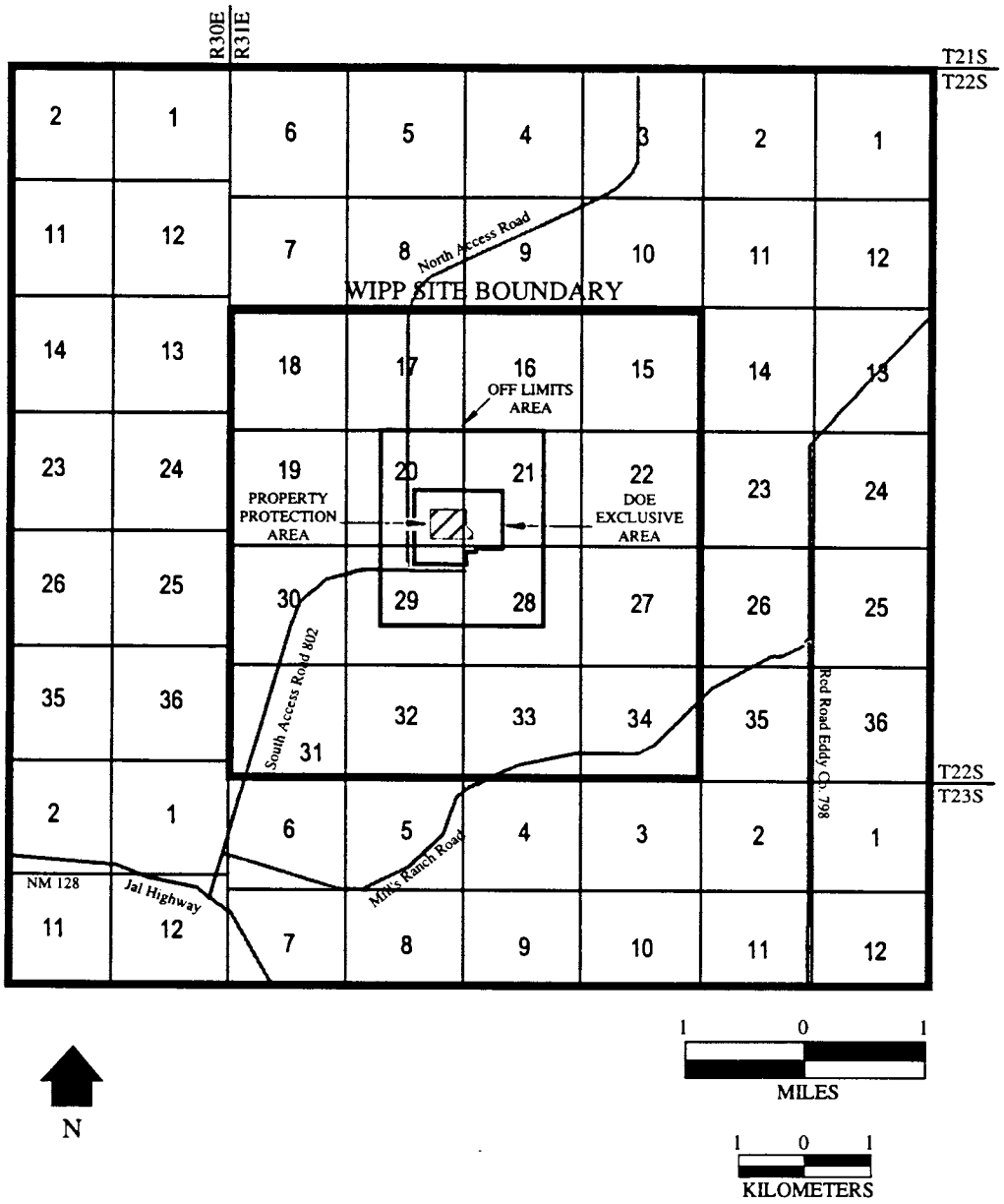


Figure 4-2
WIPP Areas

DOE also recently entered into a Joint Powers Agreement with the State of New Mexico (signed by the State Historic Preservation Officer), pursuant to Sections 106 and 110 of the National Historic Preservation Act and other statutes.

DOE's intent concerning grazing management is to continue current management practices unless a need develops to modify them. To that end, planned actions include continuing vegetative monitoring in the withdrawal area, continuing the management of grazing allotments under the principles of multiple-use management and sustained yield, and continuing range management practices in accordance with appropriate acts and regulations.

DOE intends to maintain recreation resource values and to continue to provide opportunities for individuals to participate in recreational activities within designated parts of the withdrawal area. Planned actions include environmental monitoring of the withdrawal area, regulating off-road vehicle use, and determining the potential effect of anticipated projects or other activities on the visual quality of the landscape. DOE would also allow hunting and trapping in accordance with applicable regulations.

The Land Management Plan incorporates the restrictions of the LWA. The subsurface of the withdrawal area is reserved for exclusive use of WIPP. No surface or subsurface mining unrelated to the WIPP project, including slant drilling from outside the boundary area, is permitted. The exception is two tracts of land within the withdrawal area that are leased from BLM for oil and gas development below 1,829 meters (6,000 feet). In instances where operators seek permits to drill or mine at a location close to the withdrawal boundary, DOE will request drilling information to detect any potential for subsurface encroachment into the WIPP repository. Should there be potential for encroachment, the operator will be required to modify the drilling activity in accordance with existing memorandums of understanding or similar agreements. Two active mining and drilling leases within the Land Withdrawal Area may be purchased by DOE.

BLM administers rights-of-way in coordination with DOE. The objective is to ensure safe and adequate access to WIPP while protecting the security of personnel and facilities. Consideration is also being given to closing parts of some access roads to protect the health and safety of the public. In 1994, DOE requested and was granted permission to construct short access roads from main roadways to the sites of wells.

Changes concerning emergency and facility security preparedness include implementing plans to minimize impacts during emergencies. These plans include the WIPP Emergency Plan (WP 12-9), the WIPP Resource Conservation and Recovery Act (RCRA) Contingency Plan (WP 02-12), and the WIPP Security Plan.

Fire management is concerned with wildfires in the withdrawal area. The Land Management Plan provides for immediate notification of the BLM Carlsbad Fire Control Officer upon detection of a wildfire. WIPP personnel may call upon help from various sources or may opt to have BLM fight a wildfire, if conditions warrant that choice.

Water service for WIPP is provided by a DOE-constructed water line from Carlsbad's system to the WIPP site and is made possible by a contract between DOE and the City of Carlsbad.

The groundwater surveillance program adjusts surveillance activities, if necessary, and plugs and seals wells when they are no longer necessary. In support of this program, seven new wells were installed for water quality sampling.

The Land Management Plan provides for the management of the salt pile in an environmentally sound manner until such time as a determination is made on its disposition. Salt backfill is not required for subsidence control or repository performance but may be placed into the repository for final disposition. Management of the salt pile may include monitoring vegetation for evidence of stress from salt; selling or disposing of unneeded salt under the Materials Act of 1947; ripping, leveling, and adding topsoil to the salt stockpile base; and reseeding with seed mixes reflecting indigenous plant species.

Recent activities in the area of land reclamation have included decommissioning numerous fenced areas, removing rebar from study areas to alleviate safety hazards to personnel and livestock, and carrying out additional reclamation measures in selected problem areas such as drainages and eroded slopes.

4.1.2 Air Quality, Climate, and Noise

The Environmental Protection Agency (EPA) has classified Eddy County, New Mexico, where WIPP is located, as an attainment area for all six of the criteria pollutants under the National Ambient Air Quality Standards (NAAQS). WIPP is also in a Class II Prevention of Significant Deterioration (PSD) area, and any new sources of emissions would have to adhere to the standards for such an area (META/Berger 1995). The Class I PSD areas nearest to WIPP are: Carlsbad Caverns National Park, which is approximately 61 kilometers (38 miles) southwest of WIPP, and Guadalupe Mountains National Park, which is approximately 100 kilometers (62 miles) southwest of WIPP.

The measurement of selected air pollutants at WIPP began in 1976 and was reported in FEIS (DOE 1980). SEIS-I (DOE 1990) stated that seven classes of EPA-regulated atmospheric gases had been monitored since August 27, 1986. These gases are carbon monoxide (CO), hydrogen sulfide (H_2S), ozone (O_3) precursors, oxides of nitrogen (NO_x), and sulfur dioxide (SO_2). Total suspended particulates (TSP) were also monitored in conjunction with the air monitoring programs of EPA's Regulatory and Environmental Surveillance Programs. As reported in SEIS-I, the results of this monitoring program indicated that air quality in the area of WIPP usually met state and federal standards. SEIS-I indicated that, during periods of high wind and blowing sands, the TSP standards were occasionally exceeded, but the ambient air quality standard for sulfur dioxide had been infrequently exceeded.

Air quality monitoring data collected since 1990 are summarized in annual WIPP site

CHANGES IN AIR QUALITY MONITORING

Since publication of SEIS-I, the following changes have occurred:

- *Monitoring of Pollutant Gases* - On October 30, 1994, after DOE notified EPA, monitoring of criteria air pollutants at the WIPP Ambient Air Monitoring Station was discontinued because it was no longer required by regulation.
- *Volatile Organic Compound (VOC) Monitoring Program* - The VOC monitoring program was established at WIPP in 1991 after the EPA determined that air migration of VOC target compounds would be a potential concern during both testing and operations at the facility.

environmental reports (DOE 1992, 1993b, 1994a, 1995d, and 1996d). WIPP has completed inventories of potential pollutants and emissions in accordance with EPA and New Mexico Air Quality Control Regulations (AQCR). Based on these inventories, WIPP has no permitting or reporting requirements at this time except for those applying to two primary backup diesel generators. An AQCR operating permit was issued for the two diesel generators in 1993 (DOE 1995d). These diesel generators are assumed to emit four pollutants (nitrogen dioxide (NO_2), SO_2, CO and particulate matter less than or equal to 10 micrometers in diameter [PM_{10}]) and have strict limits on emissions for these pollutants (see Section C.3.2). On October 30, 1994, DOE, after notifying EPA, ceased to monitor criteria air pollutants at the WIPP Ambient Air Monitoring Station because there was no longer a regulatory requirement to do so. TSP monitoring continues weekly at off-site locations.

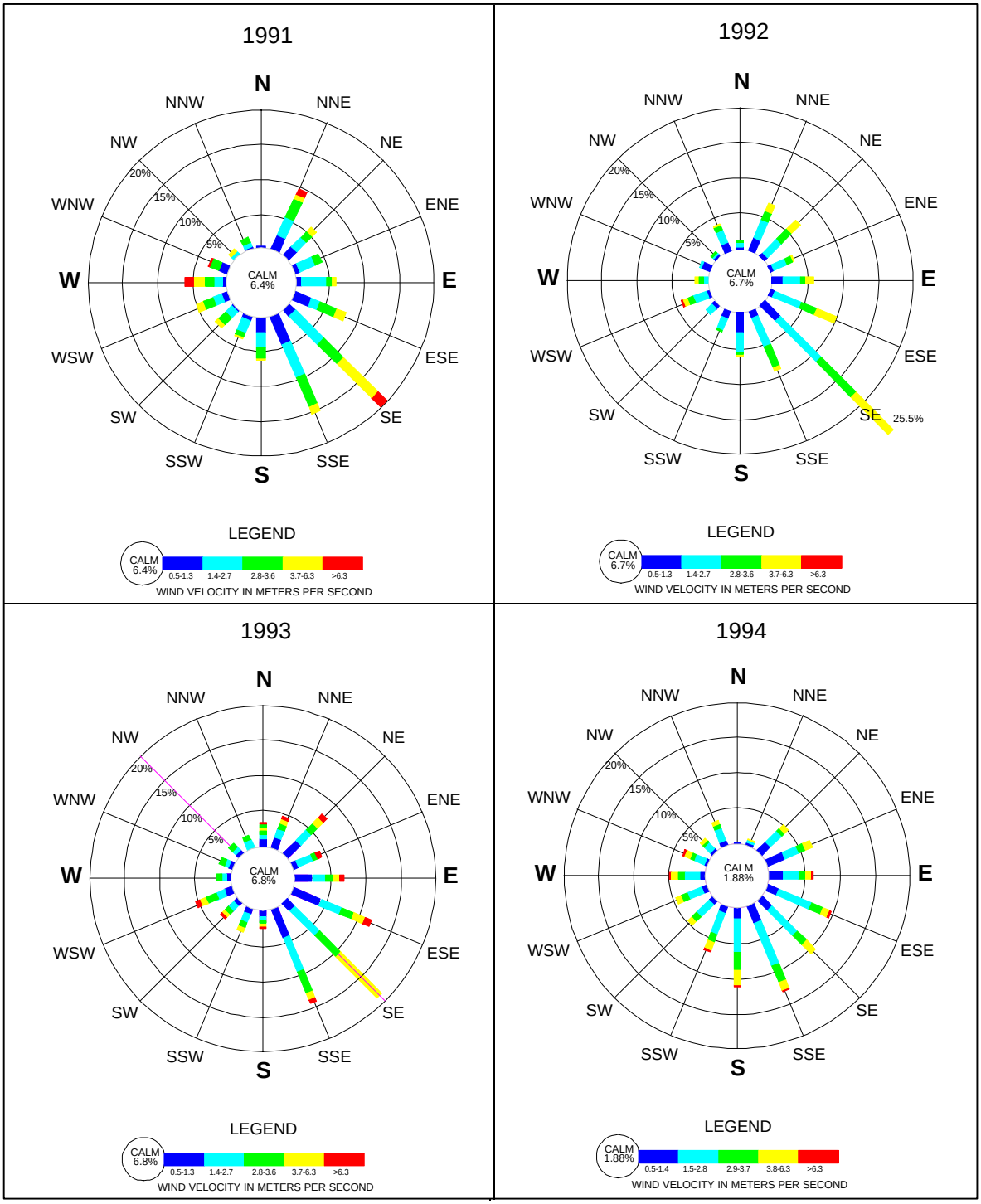
In 1991, after the EPA determined that air migration of VOCs would be a potential concern during testing at the facility, the VOC monitoring program was established at WIPP, and five VOC sampling stations were installed. The VOC monitoring program consisted of monitoring the air pulled from the exhaust shaft for any VOCs released from the test wastes. Samples were regularly analyzed for five target VOCs (carbon tetrachloride, methylene chloride, trichloroethylene, trichloroethane, and freon-113), and for other organics that might be detected.

Background monitoring of target VOCs will continue at three of the five locations. One location will measure the target compounds in the exhaust stream near the top of the exhaust shaft, another will sample the ambient air drawn into the underground facility, and the third will measure the background concentration. By measuring VOCs at the three locations it will be possible to define the variability in VOC concentration due to WIPP operations.

The regional climate is semiarid, with low precipitation and humidity and a high rate of evaporation. Precipitation is unevenly distributed throughout the year, with most occurring during summer thunderstorms. Winds are mostly from the southeast and moderate. In late winter and spring, there are strong west winds and dust storms. Thunderstorms are frequent from June through September, and are often accompanied by hail. Rains are brief but occasionally intense and can result in flash flooding in arroyos and along floodplains. Tornadoes are common throughout the region. From 1955 through 1967, 15 tornadoes were reported in the WIPP site area covered by one degree of latitude and longitude (DOE 1980).

The Carlsbad Air Terminal is the closest meteorological monitoring station and is located approximately 50 kilometers (30 miles) west of WIPP. Because of the relatively flat terrain, meteorological measurements at the airport are considered to be representative of the region. The mean annual temperature is 16 degrees Celsius (60 degrees Fahrenheit), and the mean annual precipitation is about 33 centimeters (13 inches). Drought conditions occurred during 1994. Precipitation for the 1994 calendar year was 31 percent less than that of the 1993 calendar year and 74 percent less than that of the 1992 calendar year.

The predominant wind direction at WIPP during calendar years 1991 through 1993 was from the southeast. However, during the 1994 calendar year, winds during late spring were primarily from the west. Wind speeds categorized as calm (less than 0.5 meters [1.6 feet] per second) usually occur about 7 percent of the time. Wind speeds of 1.4 through 2.7 meters (4.6 through 8.9 feet) per second were the most prevalent in the 1994 calendar year, occurring 25.5 percent of the time. Figure 4-3 displays the 1991 through 1994 wind roses (DOE 1992, 1993b, 1994a, and 1995d).



Source: DOE 1992, 1993b, 1994a, and 1995d

Figure 4-3
Windroses for 1991-1994

These conditions are consistent with long-term averages for the region. For a comprehensive discussion of climatology at the WIPP site, see Section 7.1.1 of the FEIS (DOE 1980). The WIPP site annual environmental reports (DOE 1991, 1992, 1993b, 1994a, 1995d, and 1996d) provide monthly and annual temperatures, precipitation, and wind conditions.

The ambient noise level in the WIPP area prior to construction was 26 to 28 decibels (DOE 1980). DOE requires its facilities to comply with Occupation Safety and Health Administration standards as promulgated in Title 29, of the Code of Federal Regulations (CFR), Section 1910.95. Any WIPP noise sources with the potential to exceed these standards have been mitigated (for example, noise dampers have been installed in the underground air exhausts) and are now in compliance with 29 CFR Section 1910.95.

KEY ELEMENTS CONCERNING GEOLOGY AND HYDROLOGY

Since publication of SEIS-I, additional studies and analyses have provided new information regarding geology and hydrology. These studies have improved the understanding of processes considered in evaluating long-term performance. Several examples are listed below:

- Extensive testing of the Salado Formation's salt beds and interbeds has resulted in confirmation of the Salado's extremely low permeability.
- Recent test data have enabled improved predictions of pressures at which Salado interbeds will likely fracture and relieve elevated gas pressures within the repository.
- Refined modeling of gas generation suggests that elevated gas pressure may slow down or stop brine inflow, thereby slowing gas-generating processes.
- Three-dimensional modeling of groundwater flow in the Rustler Formation suggests a very small amount of vertical flow and a preponderance of horizontal flow within the Culebra Dolomite.
- Recent tests on the Culebra Dolomite have provided new data on contaminant transport in the Culebra and on the Culebra's potential to retard radionuclides.

4.1.3 Geology and Hydrology

The first part of this section summarizes the geological and hydrological features of the WIPP site as well as key factors relevant to the repository's ability to isolate waste (repository performance). The remainder provides a discussion of what has been learned since SEIS-I. For the interested reader, there are several WIPP documents containing detailed, comprehensive, and technical descriptions of WIPP geology and hydrology. These documents have been incorporated by reference. Among them are FEIS (DOE 1980), SEIS-I (DOE 1990), the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* done by Sandia National Laboratories (SNL) (SNL 1992), the *Final No-Migration Variance Petition* (DOE 1996a), the *Waste Isolation Pilot Plant Safety Analysis Report* (DOE 1997a), and the *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1996c). These references are cited throughout this section.

The geophysical, geochemical, and hydrological behavior of various strata believed to be important to WIPP performance has been investigated during almost 20 years as a part of the WIPP program. Since SEIS-I, most of the research performed has centered on improving understanding of groundwater flow and transport processes. This research has primarily dealt with: (1) hydraulic testing of the Salado Formation and characterization of brine flow within the Salado; (2) modeling of the interactions among gas generation, brine flow into the repository, and contaminated brine flow out of the repository; (3) modeling of regional groundwater flow in units above and below the Salado, particularly the Rustler Formation, which overlies the Salado and includes the Culebra

Dolomite; (4) hydraulic testing and tracer testing within the Culebra Dolomite; (5) characterization and modeling of hydrologic and geochemical characteristics of the Culebra; and (6) geophysical characterization of the pressurized brine occurrences in the Castile Formation that underlies the Salado. The following section summarizes results of investigations of WIPP geology and hydrology published since SEIS-I.

4.1.3.1 Geology

No substantive changes have occurred in the understanding of the site and regional geology since SEIS-I. A brief description of surface and subsurface geology and seismicity, both at the WIPP site and the region immediately surrounding the WIPP repository, is presented here. For detailed descriptions, see the references listed above.

Regional Setting and Surface Geology

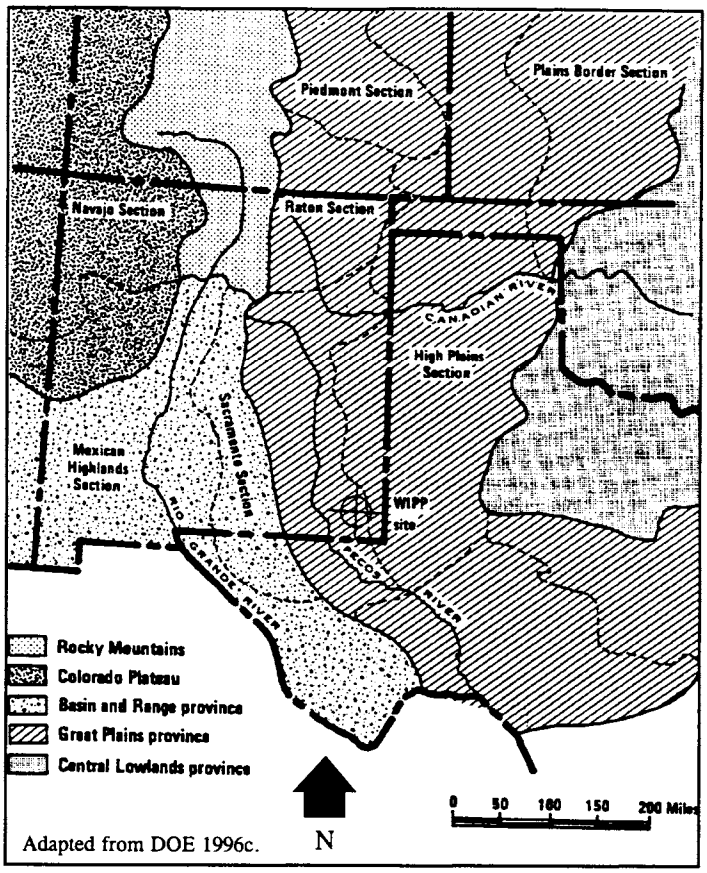
WIPP is located in southeastern New Mexico, in the Pecos Valley Section of the Great Plains Physiographic Province. The terrain throughout the province varies from plains and lowlands to rugged canyons. In the immediate vicinity of WIPP, numerous small mounds formed by wind-blown sand characterize the land surface. A layer enriched in calcium carbonate material, the Mescalero caliche, is typically present beneath the surface layer of sand. This caliche ranges in age from about 510,000 years at the base of the layer to about 410,000 years in the upper part, based on samples within the layer (DOE 1996c, Section 2.1). The caliche layer overlies a 600,000-year old volcanic ash layer (DOE 1996c, Section 2.1). The Mescalero caliche can be found over large portions of the Pecos River drainage area and is generally considered to be an indicator of surface stability (DOE 1980). The site slopes gently from east to west, from an elevation of 1,088 meters (3,570 feet) above sea level at its eastern boundary to 990 meters (3,250 feet) above sea level along its western boundary.

A high plains desert environment characterizes the area. Due to the seasonal nature of the rainfall, most surface drainage is intermittent. The Pecos River, 20 kilometers (12 miles) southwest of the WIPP boundary, is a perennial river and the master drainage for the region. A natural divide lies between the Pecos River and WIPP. As a result, the Pecos drainage system does not currently affect the site. Local physiographic features include Nash Draw and the San Simon Swale (see Figure 4-4).

Subsurface Geology

WIPP is located in the northern portion of the Delaware Basin, a structural basin underlying present-day southeastern New Mexico and western Texas and containing a thick sequence of sandstones, shales, carbonates, and evaporites. The references listed above describe basic characteristics of the stratigraphy (sequence of rock units) of the Delaware Basin.

The WIPP repository is located at a depth of approximately 655 meters (2,150 feet) in rocks of Permian age. The sediments accumulated during the Permian period represent the thickest portion of the sequence in the northern Delaware Basin and are divided into four series. From oldest to youngest, these series are: the Wolfcampian, Leonardian, Guadalupian, and Ochoan. As shown in Figure 4-5, the Ochoan series is divided into four formations. From oldest to youngest, these formations are: Castile, Salado (the lower part of which contains the WIPP repository), Rustler, and Dewey Lake.



Adapted from DOE 1996c.

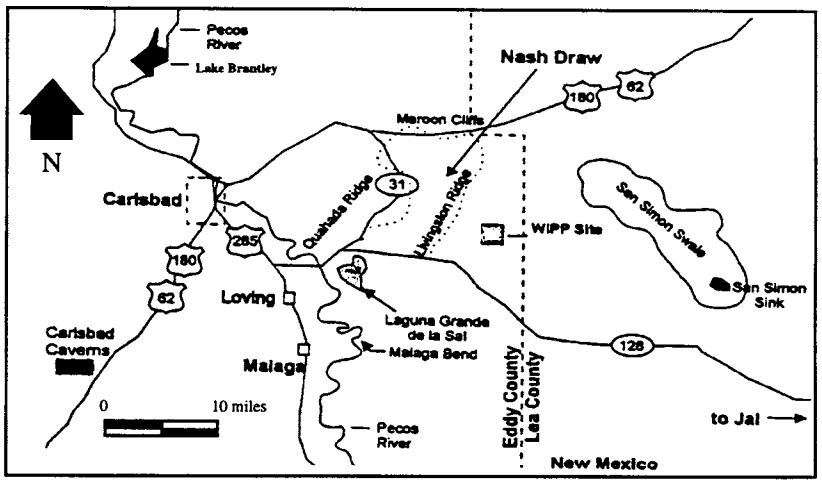


Figure 4-4
WIPP Site Location in Southeastern New Mexico

SYSTEM	SERIES	GROUP	FORMATION	MEMBER	DEPTH AT WIPP WASTE SHAFT meters (feet)
RECENT	RECENT		SURFICIAL DEPOSITS		
QUATER-NARY	PLEISTO-CENE		MESCALERO CALICHE		
			GATUNA		
TRIASSIC		DOCKUM	SANTA ROSA		
					30 (97)
PERMIAN	OCHOAN		DEWEY LAKE		
					164 (538)
			RUSTLER	Forty-niner	
					182 (596)
				Magenta Dolomite	
					189 (621)
				Tamarisk	
					215 (707)
				Culebra Dolomite	
					222 (729)
				lower unnamed	
					257 (844)
			SALADO	upper	
					409 (1,343)
				McNutt Potash	
					526 (1,727)
				lower WIPP	655 (2,150)
					~810 (2,650)
			CASTILE		
					~1,200 (4,000)
	GUADALUPIAN	DELAWARE MOUNTAIN	BELL CANYON		
					~1,550 (5,100)
			CHERRY CANYON		
					~1,900 (6,200)
			BRUSHY CANYON		

Figure 4-5
Regional Geologic Column

The discussion below presents the geologic formations important to understanding the long-term performance of WIPP, including: the host rock for the WIPP repository (the Salado Formation), the formations below the Salado (the Castile and Bell Canyon Formations), and the formations above the Salado (the Rustler and Dewey Lake Formations).

Salado Formation

The Salado Formation is a massive bedded salt formation, predominantly halite (sodium chloride), and is thick and laterally extensive. DOE selected the Salado Formation as the site of the WIPP repository for several geologic reasons (DOE 1980, 1990): (1) the Salado halite units have very low permeability to fluid flow, which impedes groundwater flow into and out of the repository; (2) the Salado is regionally widespread; (3) the Salado includes continuous halite beds without complicated structure; (4) the Salado is deep with little potential for dissolution; (5) the Salado is near enough to the surface that access is reasonable; and (6) the Salado is largely free of mobile groundwater, as compared to existing mines and other potential repository sites.

The Salado Formation is approximately 530 to 610 meters (1,740 to 2,000 feet) thick in the WIPP site area, and the repository is located in the thickest part. The Salado is comprised of three members. From oldest to youngest, these are: the Lower Member, the McNutt Potash Member, and the Upper Member. The WIPP repository is located in the Lower Member. The Salado contains many distinctive and laterally continuous layers composed mostly of anhydrite (a calcium sulfate mineral) and polyhalite (a potassium-magnesium-calcium sulfate mineral). These layers are so continuous that they have been used by geologists as “marker beds” (MB) and numbered to designate vertical position within the Salado Formation. The WIPP repository is located between MB 139 and MB 138.

Castile Formation

The Castile Formation directly underlies the Salado Formation and comprises the base of the Ochoan Series (see Figure 4-5). It is found 244 meters (800 feet) below the level of the repository. The Castile Formation near WIPP typically contains three relatively thick anhydrite/carbonate units and two thick halite units. The thickness of the Castile varies regionally as well as locally beneath WIPP, and there is considerable evidence from borehole data and geophysical surveys that the units of the Castile are deformed. The more brittle anhydrite units of the Castile are probably fractured, and the fracture zones are relatively permeable and act as zones for accumulation of brine originating in the Castile (DOE 1997a). The Castile is exposed at the surface over a considerable area along the western side of the Delaware Basin. In the eastern part of the basin, it is approximately 430 to 460 meters (1,400 to 1,500 feet) thick. At the northern boundary of WIPP, the Castile’s thickness has been measured at 301 meters (989 feet).

Bell Canyon Formation

The Bell Canyon Formation underlies the Castile Formation and is the uppermost formation of the Guadalupian Series (see Figure 4-5). Near WIPP, the Bell Canyon is comprised of a layered sequence of sandstones, shales, siltstones, and limestones approximately 300 meters (1,000 feet) or more in thickness. It is the uppermost target of hydrocarbon exploration in the local area and is known from outcrops on the west side of the Delaware Basin and from oil and gas exploration boreholes (DOE 1996c, Section 2.1).

Rustler Formation

The Rustler Formation directly overlies the Salado Formation and contains five members (see Figure 4-5). From the base of the Rustler, these members are: the Unnamed lower member, the Culebra Dolomite, the Tamarisk, the Magenta Dolomite, and the Forty-niner. The Culebra and Magenta Dolomites are gypsum-bearing dolomites containing numerous cavities (vugs), fractures, and silty zones. The other three members contain various amounts of anhydrite, siltstone, claystone, and halite. The Rustler is the youngest (uppermost) formation in the Delaware Basin and primarily contains evaporite deposits. In the WIPP region, the Rustler can be 152 meters (500 feet) thick, although it ranges from 91 to 107 meters (300 to 350 feet) thick within the WIPP boundary.

Dewey Lake Formation

The Dewey Lake Formation overlies the Rustler Formation at WIPP (see Figure 4-5). Consisting largely of reddish-brown siltstones and claystones with lesser amounts of sandstone, the Dewey Lake Formation is about 30 to 170 meters (100 to 560 feet) thick in the vicinity of WIPP.

Santa Rosa Formation

The Santa Rosa Formation, also called the Dockum Group, overlies the Dewey Lake Formation. Characterized by light reddish-brown sandstones and conglomerates, the Santa Rosa Formation is thin to absent within the WIPP site boundaries, but is thicker (78 meters [255 feet] or greater) to the east (DOE 1996c, Section 2.1).

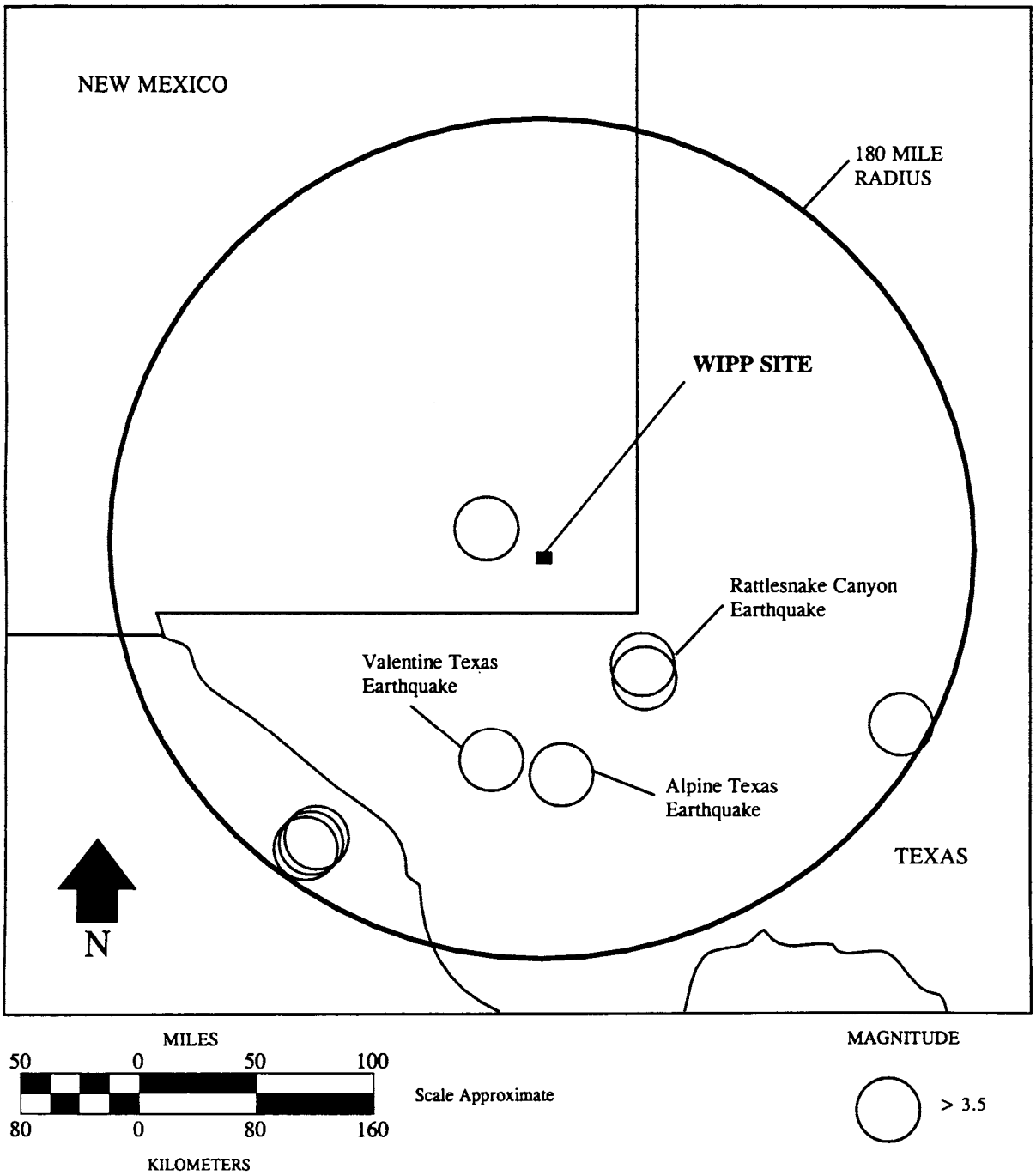
Gatuña Formation

The Gatuña Formation overlies the Santa Rosa Formation and is somewhat similar in lithology and color, although the Gatuña is characterized by a wide range of lithologies (coarse conglomerates to gypsum-bearing claystones). The Gatuña is Pleistocene in age, based on the 600,000-year old volcanic ash layer in the Upper Gatuña (DOE 1996c, Section 2.1). This is the same ash layer used to determine the upper age limit of the Mescalero Caliche that overlies the Gatuña Formation.

Faulting and Seismicity

Understanding of the regional seismicity has changed little since SEIS-I. No surface displacement or faulting younger than early Permian (Wolfcampian) has been reported, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 kilometers (60 miles) west-southwest (DOE 1997a).

The strongest earthquake on record within 290 kilometers (180 miles) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1997a), with an estimated Richter magnitude of 6.4. A Modified Mercalli Intensity V was estimated for this earthquake's groundshaking at WIPP. At Intensity V, groundshaking is felt by nearly everyone, a few instances of cracked plaster occur, and unstable objects are overturned. This is the strongest groundshaking intensity known for the WIPP site. This and other regional earthquakes are shown on Figure 4-6.



NOTES:

LOCATIONS OF SELECTED EARTHQUAKES WITHIN 300 KILOMETERS (180 MILES) OF THE WIPP SITE. FOR DRAFTING CLARITY NO EARTHQUAKE WITH A MAGNITUDE LESS THAN 3.5 IS SHOWN.

Figure 4-6
Regional Earthquake Epicenters Occurring after 1962

Since 1990, at least two seismic events have occurred that were recorded at WIPP. The Rattlesnake Canyon Earthquake occurred approximately 100 kilometers (60 miles) east-southeast of WIPP in January 1992. This event was assigned a Richter magnitude of 5.0 and occurred at a depth of approximately 12 kilometers (7.4 miles). This event had no effect on any of the structures at WIPP, as documented by post-event inspections by WIPP staff and the New Mexico Environment Department (DOE 1997a).

The most recent earthquake recorded at the WIPP site occurred on April 14, 1995, and was located 32 kilometers (20 miles) east-southeast of Alpine, Texas (approximately 240 kilometers [150 miles] south of the site). It was assigned a magnitude of 5.3 and is the largest event within 300 kilometers (185 miles) of the site since the Valentine, Texas, earthquake (Sanford et al. 1995). This event also had no effect on any structures at WIPP.

Based on a probabilistic seismic risk analysis and the region's historic seismicity, the strongest earthquake acceleration expected at WIPP would be 0.075 gravity (7.5 percent of acceleration due to gravity) with an average return period of 1,000 years. The design-basis earthquake (DBE) is conservatively assumed to be 0.1 gravity. Mine experience and studies on earthquake damage to underground facilities show that tunnels, mines, and wells are not damaged at sites having peak surface accelerations below 0.2 gravity (DOE 1997a).

Natural Resource Exploration and Development

Hydrocarbons

Prior to 1970, most commercially related drilling in the WIPP area targeted shallow oil (1,200 to 1,400 meters [4,000 to 4,500 feet] in depth) in the Bell Canyon Formation. Most of the exploratory wells from this period were plugged and abandoned. From 1970 to the mid-1980s, most drilling near WIPP focused on gas exploration in the deeper Morrow and Atoka Formations (approximately 4,000 meters [13,000 feet]). Most drilling for deep gas occurred northeast of WIPP. After parts of the Potash Area were opened to oil and gas exploration in the 1990s, exploration for deep gas in the Morrow and Atoka Formations occurred along the western boundary of the WIPP land withdrawal area (Broadhead et al. 1995).

According to Broadhead et al. (1995), estimates of probable oil and condensate resources within the WIPP Land Withdrawal Area include 12.3 million barrels of oil and gas condensate recoverable by primary production methods and an additional 6.4 million barrels of oil potentially recoverable by secondary recovery and waterfloods. Probable gas resources could total 5.3 billion cubic meters (186 billion cubic feet), 89 percent of which will be produced from the Atoka and Morrow Reservoirs. The remainder of the gas could be produced from shallow reservoirs in the Delaware Mountain Group. Probable resources within an additional 1.6-kilometer-wide (1-mile-wide) study area surrounding the withdrawn acreage include 22.9 million barrels of oil and gas condensate that could be recoverable by primary production methods and an additional 13.8 million barrels of oil that could be recoverable through waterflooding. Probable gas resources in this area could total 4.7 billion cubic meters (168 billion cubic feet), 79 percent of which could be produced from the deep Strawn, Atoka, and Morrow Reservoirs.

Broadhead et al. (1995) also state that possibly significant additional resources of oil, gas, and gas condensate exist beneath the WIPP site and the additional 1.6-kilometer-wide (1-mile-wide) area in untapped sandstones of the Delaware Mountain Group, in largely unexplored and unevaluated

sandstones and carbonates of the Bone Spring Formation, and in carbonate reservoirs in the Wolfcamp and Strawn Group. During the late 1980s and early 1990s, commercial oil was discovered in the Cherry Canyon and Brushy Canyon Formations of the Delaware Mountain Group adjacent to the eastern and northeastern boundary of WIPP, at a depth of approximately 2,100 to 2,400 meters (7,000 to 8,000 feet). These formations are currently the primary exploration and development targets in the Permian Basin, one of the most actively explored areas in the United States (Broadhead et al. 1995).

According to a study of comprehensive well records for nine townships around the WIPP site (Broadhead et al. 1995), 532 wells had been drilled in search of oil and gas by the end of 1993 (Figure 4-7). Few wells had been drilled in the area prior to 1960. Between 1960 and 1989, drilling activity increased but was sporadic and never exceeded 20 wells per year. Since 1990, however, drilling has increased markedly, with annual totals increasing to a maximum of 140 wells in 1993 (Figure 4-8). This increase has been partially attributable to the opening of previously restricted areas of the Potash Area to drilling. Most of these wells were drilled into the Brushy Canyon Formation of the Delaware Mountain Group.

Three commercial wells have been drilled for oil and gas within the boundaries of the WIPP Land Withdrawal Area (see Figure 4-7). Two vertical wells were drilled within the area during the 1970s; neither one became a producing well. A third well was drilled in 1982 from a location outside of the WIPP Land Withdrawal Area. The well was drilled at an angle underneath the area to intercept gas in the Atoka Formation and is currently commercially productive (Broadhead et al. 1995).

Potash

Bedded potash was discovered in Eddy County, New Mexico, in 1925. By 1944, New Mexico was the largest domestic potash producer, representing 85 percent of consumption. Development continued through the 1950s and 1960s, reversed in the 1970s and, for several reasons has declined since (Barker and Austin 1995).

The Carlsbad Potash District, located in southeastern New Mexico near the northeastern border of the Delaware Basin, contains the largest domestic potash reserves. Sylvinite, a mixture of sylvite and halite, is the typical potash ore mined in the Carlsbad Potash District. The only potash mines in the state are located in Eddy and Lea Counties within the soluble potash zone. The WIPP Land Withdrawal Area occupies approximately 41 square kilometers (16 square miles) on the southeastern edge of the Known Potash Leasing Area (or Potash Enclave, administered by BLM) (see Figure 4-9). During the last decade or so, commercial potash mining has continued and the mining front is much closer to the WIPP site, having approached the site boundary on the southwestern side. Future mining is likely to occur there or on the north side of the site (Barker and Austin 1995).

Within the Known Potash Leasing Area, the majority of actively mined and potential resources of potash ore are found in the 37-meter-thick (120-foot-thick) McNutt Member of the Salado Formation, which is the host for 11 ore zones. Horizon Number 1 is at the base of the McNutt Member and Number 11, which is not mined, is at the top. In the vicinity of the withdrawal area, the McNutt Member is found at depths ranging from 400 to 525 meters (1,312 to 1,722 feet) above the repository horizon. An additional ore zone is found in the Upper Member of the Salado.

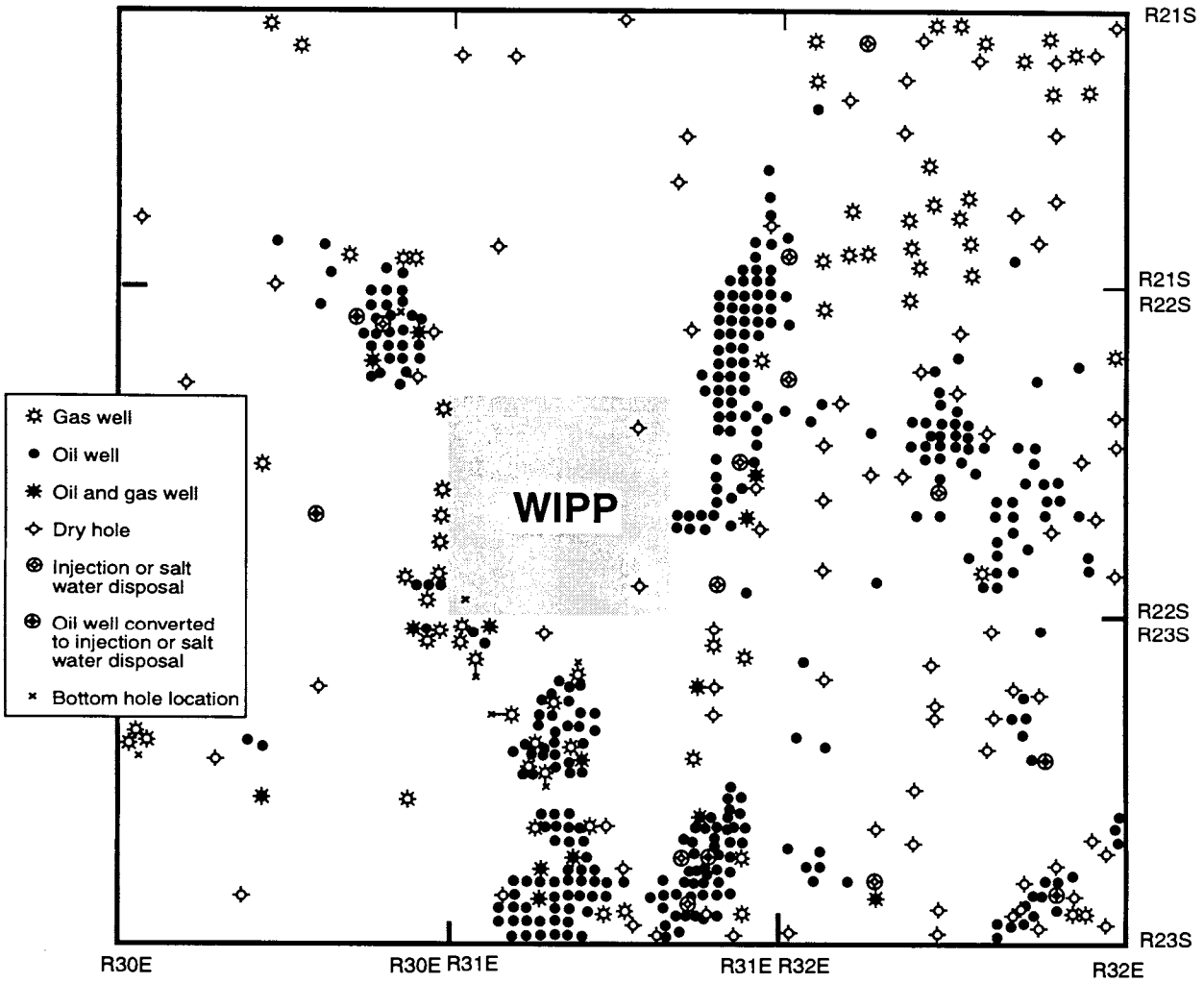


Figure 4-7
Oil, Gas, and Injection Wells in the Nine-Township Area Centered on the WIPP Site

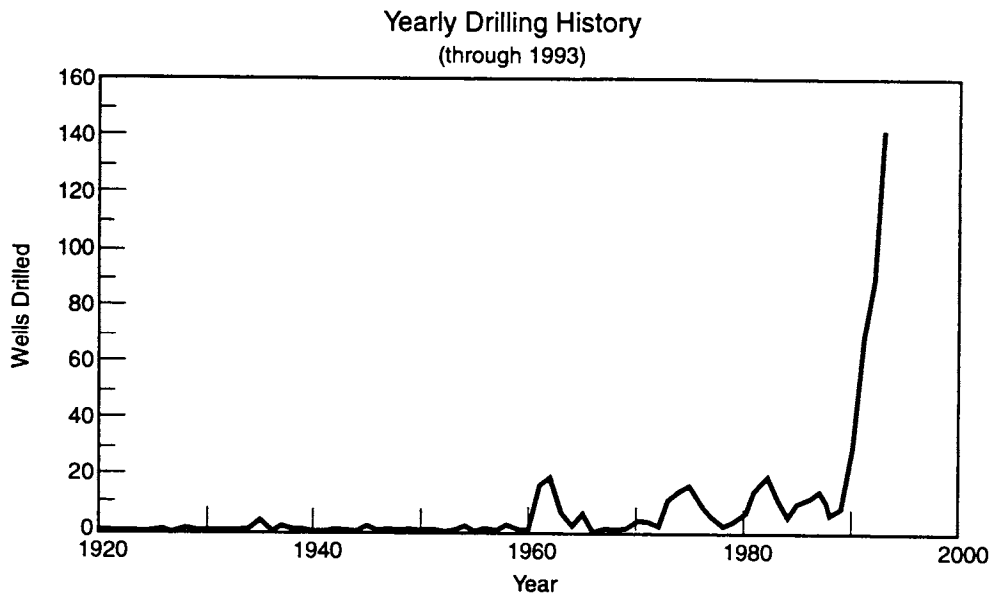


Figure 4-8
Annual Number of Oil and Gas Wells Completed in the Nine-Township Area Centered on the WIPP Site

Potash ore zones are 1 to 3 meters (3 to 10 feet) thick and are laterally consistent except where interrupted by salt horses, collapse features, and igneous dikes (Barker and Austin 1995). Continuous mining equipment that has been adapted from coal mining is used to extract most of the potash ore, although blasting is also used. All mines in the Carlsbad Potash District consist of at least two shafts for safety and ventilation, and older mines may have three or more shafts because working faces are now 5 to 8 kilometers (3 to 5 miles) from the main shafts.

A summary of the current knowledge and estimates of potash mining reserves, based on recent work performed by the New Mexico Bureau of Mines and Mineral Resources in the vicinity of the WIPP site, is provided in Attachment 15-5 of Appendix MASS of the *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (CCA) (DOE 1996c). A summary of current leases indicates that all are held by eight holding companies, five of which are actively mining in the area. No active potash mining leases currently exist within the WIPP controlled area.

4.1.3.2 Hydrology

This section provides a summary of the surface hydrology of the WIPP region, followed by the hydraulic and hydrogeologic characteristics of the geologic formations relevant to WIPP.

Surface Water Hydrology

Understanding of the surface water hydrology in the WIPP vicinity has changed little since SEIS-I. WIPP is located east of the Pecos River and within the Pecos River basin (which represents about one-half of the drainage area of the Rio Grande Water Resources Region). The drainage area of

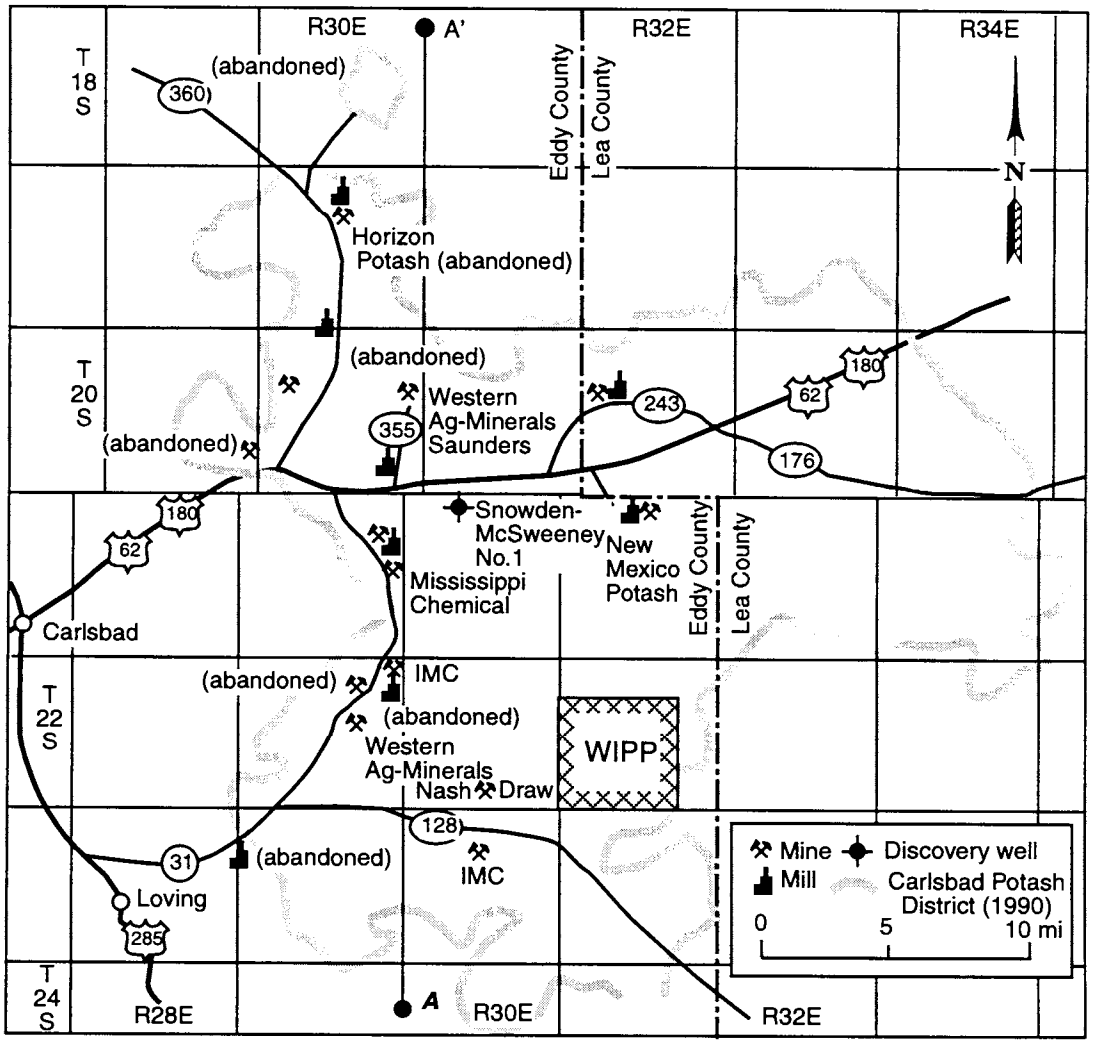


Figure 4-9
Active, Inactive, and Abandoned Potash Facilities in Eddy and Lea Counties, Southeastern New Mexico, Within the Carlsbad Potash District

the Pecos River at this location is 49,200 square kilometers (19,000 square miles). The WIPP site has a few small intermittent creeks, the only westward-flowing tributaries of the Pecos River within 32 kilometers (20 miles) north or south of the site.

The Pecos River is the main surface water resource in the WIPP vicinity. Due to inflow from brine springs (from the Rustler Formation) and slight exceedence of water quality levels of certain heavy metals (DOE 1996a), river water is not used for human consumption. Irrigation and livestock watering are the primary uses of the water from the Pecos.

More than 90 percent of the mean annual precipitation at the site is lost by evapotranspiration. On a mean monthly basis, evapotranspiration at the site greatly exceeds the available rainfall; however, intense local thunderstorms produce runoff and percolation. The maximum recorded flood on the Pecos River occurred on August 23, 1966, near Malaga, about 25 kilometers (15 miles) from WIPP. The maximum elevation of the flood was 90 meters (300 feet) below the elevation of the WIPP surface facility.

Groundwater Hydrology

The WIPP repository is situated in the thick, relatively impermeable Salado Formation salt beds 655 meters (2,150 feet) below the ground surface. The hydrologic and mechanical properties of the salt beds surrounding WIPP are better understood than the regional hydrology. Generally, however, groundwater in the Rustler and Dewey Lake Formations and the units overlying them are essentially isolated from the hydrology of the Salado Formation.

The Rustler Formation includes the Culebra and Magenta Dolomites, two units containing water of low quality (brine to brackish) (DOE 1996c, Section 2.2.1). The Culebra Dolomite, which is the first notable water-bearing unit above the Salado Formation, has been investigated for its potential to transport radionuclides released from the repository resulting from a borehole intrusion. Groundwater flow in the units overlying the Salado Formation has been assumed to occur primarily in the Culebra Dolomite, although it is recognized that regional flow in the Rustler Formation is three-dimensional and occurs to some degree in all Rustler units (DOE 1996c, Section 2.2.1). Flow in the Culebra is generally from north to south. The Dewey Lake Formation overlies the Rustler Formation and in some areas is relatively transmissive, particularly in the south central and southwestern part of the WIPP site (DOE 1996c, Section 2.2.1). The location of the water table is generally considered to be the Dewey Lake.

Only a few locations of groundwater recharge and discharge to and from the Rustler Formation are known. The only documented areas of naturally occurring groundwater discharge in the vicinity of WIPP are the Pecos River near Malaga Bend (Hunter 1985) and, to a lesser extent, the saline lakes in Nash Draw. This local flow associated with Nash Draw is unrelated to groundwater flow at WIPP. The only documented area of groundwater recharge is also near Malaga Bend (Hunter 1985). This location is hydraulically downgradient from the repository, and recharge here has little relevance to flow near WIPP. Recent regional groundwater modeling by Corbet and Knupp (1996) has suggested that groundwater in the Culebra, Magenta, and Dewey Lake and Triassic units originates in areas that are north and northeast of the WIPP site (DOE 1996c).

The following sections discuss the hydraulic and hydrogeologic characteristics of the geologic formations enclosing, underlying, and overlying the WIPP underground facility.

Salado Formation Hydrology

As described above, the Salado Formation has several characteristics which make it a favorable host medium for a repository, including its low permeability to fluids and its relatively low water content. Hydraulic tests from which permeabilities have been derived indicate that the Salado halite has either extremely low or no permeability (no measurable flow occurred during some of the tests). Tests in pure halite indicate permeabilities of less than 1×10^{-23} square meters (1×10^{-22} square feet); permeabilities measured in impure halite range from 1×10^{-23} to 4×10^{-18} square meters (1×10^{-22} to 4×10^{-17} square feet) (DOE 1996c, Section 2.2.1).

There is also indirect evidence of the Salado's low permeability. Measurements in the Salado in the WIPP site region have shown that there are areas of anomalously high and low fluid pressures. If the Salado were relatively permeable, these pressures would likely have equalized relatively quickly; conversely, if the Salado were relatively impermeable, these pressures would probably not equalize, or would do so only over a very long time. Since these pressure differences do exist, it is likely that these areas of anomalous pressures have remained constant over long periods of time because of the relative lack of permeability of the salt (Lappin et al. 1989).

Inflow of brine into the repository excavation has been observed in boreholes and from "weeps," which are localized brine seeps issuing from cracks in the disturbed surfaces of the repository walls, floors, and roofs. The volumes of brine observed from these occurrences have been small, and flow into the repository has ceased within three years of initial observation (DOE 1996c, Appendix MASS). Brine migrates along clay-rich layers and cracks developed in the "disturbed rock zone" (DRZ). Eventually the DRZ heals, thereby cutting off fracture-controlled flow paths into the repository. Nevertheless, for the long-term, it is reasonable and conservative to consider that there may be brine near the repository that would flow toward and into the repository, albeit at a low rate.

Models are available to estimate the amount of brine that would flow into the excavation over time. DOE (1996c) discussed three mechanisms of brine inflow: (1) far-field flow, which is flow from outside the influence of the repository along naturally interconnected pore spaces; (2) redistribution, which is flow within the interconnected fractures of the DRZ; and (3) clay consolidation, which is the squeezing of water out of clay layers which intersect the repository. Of these mechanisms, only the first two are considered crucial (DOE 1996c, Appendix MASS); together, they are capable of contributing approximately 50 to 160 cubic meters (1,785 to 5,712 cubic feet) of brine per disposal room, which has an approximate volume of 3,675 cubic meters (128,700 cubic feet) (DOE 1996c, Appendix MASS).

Brine inflow is a concern in that the brine would provide necessary moisture for the degradation of certain waste material components and gas generation. This could occur from a combination of processes such as microbial activity, canister corrosion, corrosion of metal waste, and radiolysis of brine. If a sufficient supply of brine exists and gas accumulates faster than it can dissipate, it is conceivable that gas pressure could build up to the point that it exceeds lithostatic pressure (approximately 15 million pascals). In this event, fractures would form in the repository walls and provide pathways for contaminants away from the repository.

According to the CCA (DOE 1996c), the total volume of gas that may be generated by corrosion and microbial degradation may be sufficient to result in repository pressures that approach

lithostatic levels. Sustained pressures above lithostatic levels are not physically reasonable within the disposal system, and fracturing of the more brittle anhydrite layers is expected to occur if sufficient gas is present. The permeability and porosity of the anhydrite marker beds (MB 138 and MB 139) will increase rapidly as pore pressure approaches and exceeds lithostatic levels. Pressure-dependent fracturing approximates the hydraulic effect of pressure-induced fracturing and will likely allow gas and brine to move more freely within the marker beds at higher pressures. The interbeds may be expected to serve as conduits for brine flow between the impure halite and the repository. Conceptually, brine flows laterally along higher permeability interbeds toward or away from the repository and vertically between the interbeds and the lower permeability halite. Because the interbeds have a very large contact area with adjacent halite-rich rock, even a very small flux from the halite into the interbeds (for brine inflow) or to the halite from the interbeds (for brine outflow) can accumulate into a significant quantity of brine. In this manner, halite serves as a source or sink for brine in the repository. It is expected that, because of density differences between gas and brine and their stratification within the repository, brine outflow will be dominantly in MB 139, and gas outflow will occur in anhydrite a and b or MB 138.

Interbeds also contain natural fractures that may be partially healed. If high pressure is developed in an interbed, its preexisting fractures may dilate or new fractures may form, altering its porosity and permeability. Pressure-dependent changes in permeability are supported by experiments conducted in the WIPP underground and in the laboratory (Beauheim et al. 1993). To the extent that it occurs, dilation or fracturing of interbeds is expected to increase the transmissivity of interbed intervals. The threshold pressure of dilated or fractured interbeds is expected to be low because apertures of the fractures increase; thus, fluid is expected to be able to flow outward readily if adequate pressure is available to dilate the interbeds.

The Salado salt has such a low permeability that it is difficult to measure with existing technology. Studies of the Salado indicate that the impure halite (greater than 0.5 percent impurities) may exhibit brine flow through pore spaces and along grain boundaries, but measurements on continuous layers of pure halite indicate zero or near-zero permeabilities. The interpretation of flow mechanism is inconclusive. The presence of the pure halite layers suggests that vertical flow through the Salado does not occur (DOE 1996c, Section 2.2.1).

Castile Formation Hydrology

The Castile Formation is dominated by anhydrite and halite zones of low permeability (DOE 1996c, Section 2.2.1.2); however, fracturing in the anhydrite zone of the upper portion of the Castile has generated isolated regions with much greater permeability than the surrounding intact anhydrite. These regions, referred to as brine reservoirs, contain brine at greater than hydrostatic pressure.

Castile brine reservoirs in the northern Delaware Basin contain widely spaced, highly-angled fractures; therefore, a borehole which penetrated through a brine reservoir would be unlikely to intersect a fracture and release brine. Appreciable volumes of brine have been produced from several reservoirs in the Delaware Basin, but there is little direct information on the areal extent of the reservoirs or the interconnection between them (DOE 1996c, Section 2.2.1.2).

Borehole ERDA-6, located 5 kilometers (3 miles) northeast of the WIPP site, and borehole WIPP-12, 1.6 kilometers (1 mile) north of the site center, encountered a zone of pressurized brine within the Castile Formation (DOE 1996c, Section 2.2.1.2). The fluid pressure measured in 1983

in the WIPP-12 borehole was 12.7 megapascals, greater than the nominal hydrostatic pressure of 11.1 megapascals for a column of equivalent brine at that depth. Results of hydraulic tests performed in the ERDA-6 and WIPP-12 boreholes suggest that the extent of the highly permeable portions of the Castile is limited. The vast majority of brine is thought to be stored in low-permeability microfractures, with about 5 percent of the overall brine volume stored in large, open fractures. The volumes of the ERDA-6 and WIPP-12 brine reservoirs were estimated in 1983 to be 100,000 cubic meters (3.5×10^6 cubic feet) and 2.7 million cubic meters (9.5×10^7 cubic feet), respectively.

A geophysical survey using time-domain electromagnetic (TDEM) methods was completed over the WIPP-12 brine reservoir and the waste disposal panels (DOE 1996c, Section 2.2.1.2). The TDEM measurements detected a conductor thought to be the WIPP-12 brine reservoir and also indicated that similar brine reservoirs may be present within the Castile under a portion of the waste disposal panels. In a recent geostatistical analysis, 354 drill holes and 27 Castile brine occurrences were used to establish that there is an 8 percent probability that a hole drilled into the waste panel region would encounter brine in the Castile. This analysis is included in the CCA as Attachment 18-6 in Appendix MASS (DOE 1996c).

The origin of brine in the Castile has been investigated geochemically and reported in the CCA in Section 2.1.6.2 (DOE 1996c). Based on the ratios of major and minor element concentrations in the brine, the report concluded that these fluids originated from ancient seawater and that no evidence exists for fluid contribution from present meteoric waters. The Castile brine chemistries from the ERDA-6 and WIPP-12 reservoirs are distinctly different from each other and from local groundwater samples. The geochemical data indicate that the brine in reservoirs has not mixed to any significant extent with other bodies of water and has not circulated. The brine is saturated, or nearly so, with respect to halite and, consequently, has little potential to dissolve halite.

Bell Canyon Formation Hydrology

The Bell Canyon Formation is considered to form a single hydrostratigraphic unit about 300 meters (1,000 feet) thick. The low-permeability of the Castile Formation that overlies it effectively isolates the fluid flow in the Bell Canyon. In the WIPP vicinity, the brines in the Bell Canyon flow northeasterly and discharge into the Capitan aquifer (DOE 1996c, Section 2.2.1.2).

Rustler Formation Hydrology

The Rustler Formation is the most significant hydrogeologic unit above WIPP because it contains the Culebra Dolomite, the first laterally continuous hydrologic unit above the Salado Formation. In addition to the Culebra, the Rustler Formation also contains four other units: 1) the Unnamed Lower Member, 2) the Tamarisk Member, 3) the Magenta Dolomite Member, and 4) the Forty-Niner Member. The following summary of the most current understanding of all these units draws mainly from discussions in the CCA (DOE 1996c, Section 2.2.1.4).

Unnamed Lower Member

The Unnamed Lower Member makes up a single hydrostratigraphic unit in WIPP models of the Rustler Formation, although its composition varies somewhat (DOE 1996c, Section 2.2.1.4). Overall, it acts as a confining layer: the basal interval of the Unnamed Lower Member, approximately 19.5 meters (64 feet) thick, is composed of siltstone, mudstone, and claystone, and

contains the water-producing zones of the lowermost Rustler. Transmissivity values of 2.9 x 10^{-10} square meters (3.12 x 10^{-9} square feet) per second and 2.4 x 10^{-10} square meters (2.58 x 10^{-9} square feet) per second were reported from tests at well H-16, corresponding to hydraulic conductivities of 1.5 x 10^{-11} meters (4.95 x 10^{-11} feet) per second and 1.2 x 10^{-11} meters (3.96 x 10^{-11} feet) per second. Hydraulic conductivity in the lower portion of the Unnamed Lower Member is believed by DOE to increase to the west in and near Nash Draw, where dissolution at the underlying Rustler-Salado contact has caused subsidence and fracturing of the sandstone and siltstone. The porosity of the Unnamed Lower Member was measured in 1995 as part of the H-19 hydropad testing. Two claystone samples had effective porosities of 26.8 and 27.3 percent, and one anhydrite sample had an effective porosity of 0.2 percent.

The remainder of the Unnamed Lower Member contains mudstones, anhydrite, and variable amounts of halite. The hydraulic conductivity of these lithologies is extremely low; tests of mudstones and claystones in the waste handling shaft gave hydraulic conductivity values varying from 6 x 10^{-15} meters (1.98 x 10^{-14} feet) per second to 1 x 10^{-13} meters (3.28 x 10^{-13} feet) per second (DOE 1996c, Section 2.2.1.4).

Culebra Member

The Culebra Member, also referred to as the Culebra Dolomite, has been the most investigated hydrogeologic unit in the Rustler Formation during the past decade since it is the most transmissive unit at the WIPP site. Because of its hydraulic characteristics, the Culebra is considered the most likely pathway for radionuclide releases from the repository to the accessible environment.

According to the CCA, Culebra flow patterns have been recognized as moving predominantly north to south on the WIPP site and strongly affected by a high transmissivity zone in the southeastern portion of the site. Contours of these water levels suggest that the flow above the WIPP repository is to the south, flow in Nash Draw is to the southwest, and flow south of WIPP is possibly toward the west.

In the past trends in water chemistry along the inferred southerly flow have been an issue in interpretations of local flow conditions in the Culebra Dolomite. Using generally accepted interpretations of flow and chemistry, total dissolved solids would be expected to decrease and the general character of groundwater would be expected to change in the principal direction of groundwater flow. A number of past interpretations of groundwater flow paths and solute chemistry of the Culebra were based on the concept that groundwater flow in the Culebra was a confined system and that rock interactions along the flow path from WIPP must transform the groundwater from a more saline sodium chloride-type water to a more dilute calcium sulfate-type water.

In a recent interpretation by Corbet (1997), the Department has suggested that changes in groundwater chemistry that would be expected for a confined system are complicated by contributions of vertical leakage and regional groundwater recharge that interact with distinctive rock types originating in different areas surrounding the WIPP site. Corbet (1997) concludes that the distributions of solute chemistry observed in the Culebra are consistent with inferred groundwater flow conditions and reflect with a mixing of distinctly different groundwater originating in recharge areas to the east (slowly moving saline groundwater originating from dissolution of the Rustler and/or Salado and moving to the west), southwest (groundwater reacting

with anhydrites of the Rustler and flowing southeast), and north and northeast (meteoric recharge water reacting with Rustler anhydrites and moving south through the WIPP site).

Over the years, both hydraulic and tracer tests have been used to characterize the flow and transport characteristics of the Culebra. The Culebra is a fractured dolomite layer with properties that vary horizontally and vertically. Examination of core and shaft exposures has revealed that there are multiple scales of porosity within the Culebra, including fractures ranging from microscale to potentially large, vuggy (cavity-filled) zones, and interparticle and intercystalline porosity. Measurements of core samples indicate porosities ranging from 0.03 to 0.30 (DOE 1996c, Section 2.2.1.4); this large range in porosity for small samples is expected, given the variety of porosity types within the Culebra. The core measurements indicate that the Culebra has a significant number of porosity connections leading to a limited amount of fluid movement, particularly within interparticle cavities where the porosity and permeability is high, such as in chalky lenses.

The majority of fluid movement in the Culebra occurs within fractures and within vugs connected by fractures (DOE 1996c, Section 2.2.1.4). In some regions, the permeability of the fractures is inferred to be significantly higher than the permeability of the other porosity types; in other regions, there appear to be no fractures of high permeability, which may be due to a lack of large fractures or the result of gypsum fillings in portions of the Culebra.

The hydraulic tests have been designed to yield pressure data that can be used in the interpretation of Culebra transmissivity, permeability, and storativity. The most detailed hydraulic data have been collected from tests at the WIPP hydropads, which generally comprise a network of three or more wells located within close proximity of each other. Long-term pumping tests yielding pressure data over a large area have been conducted at hydropads H-3, H-11, and H-19, and at well WIPP-13. In addition, slug tests and short-term pumping tests conducted at individual wells have provided pressure data that can be used to interpret the transmissivity at those locations. Detailed cross-hole hydraulic tests that yielded data on hydraulic properties have recently been conducted at the H-19 hydropad. The pressure data from long-term pumping tests and the interpreted transmissivity values for individual wells are used to generate the transmissivity fields of the Culebra that were used in performance assessment flow modeling (see DOE 1996c, Appendix TFIELD).

In order to evaluate the transport properties of the Culebra Dolomite, a series of tracer tests was conducted at the H-2, H-3, H-4, H-6, H-11, and H-19 hydropads near the WIPP site. Tests at the first five locations consisted of two-well dipole tests and/or multi-well convergent flow tests and are described in detail in Jones et al. (1992). More recent tracer tests at the H-19 hydropad and additional tracer tests performed at the H-11 hydropad consisted of single-well injection-withdrawal tests and multi-well convergent flow tests and are described in the CCA (DOE 1996c, Section 2.2.1.4). The recent tracer tests were specifically designed to evaluate the importance of horizontal and vertical heterogeneity and diffusion on transport processes.

Tamarisk Member

The Tamarisk Member functions as a confining layer. Attempts were made in two wells, H-14 and H-16, to test a 2.4-meter (7.9-foot) sequence of the Tamarisk that consists of layers of claystone, mudstone, and siltstone sandwiched between layers of anhydrite. The permeability was too low to measure in either well within the time allowed for testing; consequently, the transmissivity of the

claystone sequence was estimated to be less than approximately 2.7 x 10^{-11} square meters (2.9 x 10^{-10} square feet) per second, one or more orders of magnitude less than that of the tested interval in the Unnamed Lower Member. The porosity of the Tamarisk was measured in 1995 as part of testing at the H-19 hydropad. Two claystone samples had an effective porosity of 21.3 to 21.7 percent, and five anhydrite samples had effective porosities of 0.2 to 1.0 percent (DOE 1996c, Section 2.2.1.4).

Magenta Member

The Magenta Member is a conductive, hydrostratigraphic unit about 7.9 meters (26 feet) thick at WIPP. The Magenta is saturated except near outcrops along Nash Draw, and hydraulic data are available from 15 wells. Transmissivity ranges over five orders of magnitude from 1 x 10^{-9} to 4 x 10^{-4} square meters (1.08 x 10^{-8} to 4.30 x 10^{-3} square feet) per second. The porosity of the Magenta was measured in 1995 as part of testing at the H-19 hydropad. Four samples had effective porosities ranging from 2.7 to 25.2 percent (DOE 1996c, Appendix HYDRO).

The hydraulic transmissivities of the Magenta, based on sparse data, show a decrease in conductivity from west to east, with slight indentations of the contours north and south of WIPP that correspond to the topographic expression of Nash Draw. In most locations, the hydraulic conductivity of the Magenta is one to two orders of magnitude less than that of the Culebra. The Magenta does not have hydraulically significant fractures in the vicinity of WIPP. The hydraulic gradient across the site varies from 3 to 4 meters per kilometer (16 to 20 feet per mile) on the eastern side, steepening to about 6 meters per kilometer (32 feet per mile) along the western side near Nash Draw (DOE 1996c, Figure 2-32).

Inferences about vertical flow directions in the Magenta have been made from well data collected by DOE, which reported a downward flow out of the Magenta over the WIPP site, consistent with results of groundwater basin modeling. However, DOE concluded that flow between the Forty-Niner and Magenta would be upward in H-3, H-14, and H-16, three boreholes which yielded reliable pressure data for the Forty-Niner. This conclusion is not consistent with the results of groundwater modeling, and this inconsistency may be the result of local heterogeneity in rock properties that affect flow on a scale that cannot be duplicated in regional modeling. Like the Culebra, groundwater elevations in the Magenta have changed over the period of observation; in fact, the pattern of changes is similar to that observed for the Culebra and is attributed to the same causes (see Section 2.2.1.4 of the CCA, DOE 1996c).

Forty-Niner Member

The Forty-Niner Member is described as a confining hydrostratigraphic layer and consists of low-permeability anhydrite and siltstone about 20 meters (66 feet) thick throughout the WIPP area (DOE 1996c, Section 2.2.1.4). Tests reported in DOE (1996c) for H-14 and H-16 yielded transmissivities of about 3 x 10^{-8} to 8 x 10^{-8} square meters (3.23 x 10^{-7} to 8.61 x 10^{-7} square feet) per second and 3 x 10^{-9} to 6 x 10^{-9} square meters (3.23 x 10^{-8} to 6.46 x 10^{-8} square feet) per second, respectively. The porosity of the Forty-Niner was measured as part of the H-19 hydropad testing. Three claystone samples had effective porosities ranging from 9.1 to 24.0 percent, and four anhydrite samples had effective porosities ranging from 0.0 to 0.4 percent.

Rustler-Salado Contact Zone

The contact between the Rustler and Salado Formations in the vicinity of Nash Draw (see Figure 4-4) is of interest, because it provides evidence of earlier dissolution. It is an unstructured residuum of gypsum, clay, and sandstone created by the dissolution of halite and has been known as the brine aquifer or residuum. The residuum is absent under the WIPP site (DOE 1996c, Section 2.2.1.4).

Robinson and Lang (1938) suggested that the structural conditions that caused the development of Nash Draw might control the occurrence of the brine; thus, the brine aquifer boundary may coincide with the topographic surface expression of Nash Draw. Their studies show brine concentrated along a strip from 3.3 to 13 kilometers (2 to 8 miles) wide and about 43 kilometers (26 miles) long. Data from test holes indicate that the residuum containing the brine ranges in thickness from 3 to 18 meters (10.5 to 60 feet) and averages about 7 meters (24 feet).

Hydraulic properties for the area between Malaga Bend on the Pecos River and Laguna Grande de la Sal were estimated by Hale et al. (1954), who calculated a transmissivity value of 8.6×10^{-3} square meters (9.25×10^{-2} square feet) per second and estimated the potentiometric gradient to be 0.27 meter per kilometer (1.4 feet per mile). The coincident fluctuation of water levels in the area's test holes with pumping rates in irrigation wells along the Pecos River suggest the Rustler-Salado residuum to be part of a continuous hydrologic system.

In the northern half of Nash Draw, the approximate outline of the brine aquifer as described by Robinson and Lang (1938) has been supported by drilling associated with the WIPP hydrogeologic studies. These studies also indicate that the main differences in the aquifer's areal extent occur along the eastern side of Nash Draw where the boundary is very irregular and, in places (test holes P-14 and H-07), extends farther east than previously indicated. The recent studies also found a variability in thickness of residuum present in test holes WIPP-25 through WIPP-29, ranging from 3.3 meters (11 feet) in WIPP-25 to 33 meters (108 feet) in WIPP-29 in Nash Draw, as compared to 2.4 meters (8 feet) in test hole P-14 east of Nash Draw. The specific geohydrologic mechanism that has caused dissolution to be greater in one area than in another is not apparent, although a general increase in chloride concentration in water from the north to the south may indicate the effects of movement down the natural hydraulic gradient in Nash Draw.

The average hydraulic gradient within the residuum in Nash Draw is about 1.9 meters per kilometer (10 feet per mile). In contrast, the average gradient at the WIPP site is 7.4 meters per kilometer (39 feet per mile). This difference reflects the changes in transmissivity, which are as much as five orders of magnitude greater in Nash Draw. The transmissivity determined from aquifer tests in test holes completed in the Rustler-Salado contact residuum of Nash Draw ranges from 2.1×10^{-10} square meters (2.26×10^{-9} square feet) per second at WIPP-27 to 8.6×10^{-6} square meters (9.25×10^{-5} square feet) per second at WIPP-29. This is in contrast to the WIPP site proper, where transmissivities range from 3.2×10^{-11} square meters (3.44×10^{-10} square feet) per second at test holes P-18 and H-5c to 5.4×10^{-8} square meters (5.81×10^{-7} square feet) per second at test hole P-14 (DOE 1996c, Appendix HYDRO). Locations and estimated hydraulic heads of these wells are illustrated in the CCA (DOE 1996c, Figure 2-35).

Hale et al. (1954) believed the residuum discharges to the alluvium near Malaga Bend on the Pecos River. Because the confining beds in this area are probably fractured due to dissolution and

collapse of the evaporites, the brine (under artesian head) moves up through these fractures into the overlying alluvium and then discharges into the Pecos River.

Water in the Rustler-Salado contact residuum in Nash Draw contains the largest concentrations of dissolved solids in the WIPP area, ranging from 41,500 milligrams per liter (5.63 ounces per gallon) in borehole H-1 to 412,000 milligrams per liter (55.9 ounces per gallon) in borehole H-5c (DOE 1996c, Appendix HYDRO). These waters are classified as brines. The dissolved mineral constituents in the brine consist mostly of sulfates and chlorides of calcium, magnesium, sodium, and potassium; the major cations and anions are sodium and chloride. Concentrations of the other major ions vary according to the areal location of the sample, are probably directly related to the interaction of the brine and the host rocks, and reflect residence time within the rocks. Residence time of the brine depends upon the transmissivity of the rock, that is, the presence of large concentrations of potassium and magnesium in water is correlated with minimal permeability and a relatively undeveloped flow system.

Dewey Lake and the Santa Rosa Formation Hydrology

The Dewey Lake and Santa Rosa Formations and surficial soils overlie the Rustler Formation and are the uppermost hydrostratigraphic units considered by DOE (DOE 1996c). A brief description of the main features of these units is provided below.

Dewey Lake Formation

The Dewey Lake Formation, also referred to as the Dewey Lake Redbeds, contains a productive zone of saturation, probably under water table conditions, in the southwestern to south-central portion of the WIPP site and south of the site. Several wells operated by the J.C. Mills Ranch south of the WIPP site produce sufficient quantities of water from the Dewey Lake to supply livestock. Short-term production rates of 5.7 to 6.8 cubic meters (1,500 to 1,800 gallons) per hour were observed in boreholes P-9, WQSP-6, and WQSP-6a (DOE 1996c, Appendix USDW). The saturated zone is typically found in the middle of the Dewey Lake, 55 to 81 meters (180 to 265 feet) below the surface and appears to derive much of its transmissivity from open fractures. The saturated zone may be perched or simply underlain by less transmissive rock. Fractures below the saturated zone tend to be completely filled with gypsum. Open fractures and/or moist (but not fully saturated) conditions have been observed at similar depths north of the saturation zone, at the H-1, H-2, and H-3 boreholes (DOE 1996c, Appendix HYDRO).

DOE estimated the position of the water table in the southern half of the WIPP site from an analysis of drillers' logs from three potash exploration boreholes and five hydraulic test holes. Using log records of the elevation of the first moist cuttings recovered during drilling, the elevation of the water table over the WIPP waste panels was estimated to be about 980 meters (3,215 feet) above sea level. In comparison, the repository lies 385 meters (1,260 feet) above sea level.

Santa Rosa Formation

The Santa Rosa Formation is absent over the western portion of the WIPP site and crops out northeast of Nash Draw. It is present over the eastern half of the WIPP site, where it reaches a thickness of 91 meters (300 feet). Near the WIPP site, the Santa Rosa may have a saturated

thickness of limited extent. Its porosity is estimated at about 13 percent, and it has a specific capacity ranging from 0.029 to 0.041 liters per second per meter (2.3×10^{-3} to 3.3×10^{-3} gallons per second per foot) (DOE 1996c, Appendix HYDRO).

Potential Impacts of Karst and Dissolution Processes

The current understanding of the extent, timing, and features related to dissolution (including a brief history of past project studies related to karst) in the area surrounding WIPP is described in Section 2.1.6.2 of the CCA (DOE 1996c**)**. In summary, these studies and investigations show that the geomorphology of the region, particularly near Nash Draw and to a lesser extent near WIPP, has been influenced by shallow dissolution. Groundwater flow in the Culebra and other units of the Rustler is primarily controlled by fractures that have been affected by shallow dissolution processes. A significant proportion of the fractures within the Culebra are filled with secondary gypsum east of the WIPP; to the west of the site most fractures are open.

Groundwater basin modeling performed in the CCA suggests that the Culebra becomes progressively more confined toward the east, corresponding to an increase in the overburden towards the east. This is also thought to coincide with a decrease in the fracturing associated with dissolution at the Rustler-Salado boundary. Percolating groundwater has caused the lateral dissolution of halite at the top of the Salado, causing collapse of the overlying Rustler with consequent changes in hydrogeological properties. The most prominent lateral dissolution feature in the region is seen at Nash Draw, some 5 miles (8 kilometers) to the west of the WIPP site. Average rates calculated in previous investigations of karst indicate that dissolution at the top of the Salado at the edge of the WIPP site would not take place for some 225,000 years, and an additional 2 to 3 million years would be required for dissolution to reach the repository horizon.

Deep dissolution of salt or other evaporite minerals in formations near the WIPP site is distinguished from shallow and lateral dissolution not only by depth but also by the origin of the water. Groundwater originating from deep brine-bearing zones can lead to the formation of cavities at depths that could potentially cause the collapse of overlying beds. These processes could lead to the formation of collapse breccias if the overlying rocks are brittle or to deformation that causes fracturing if the overlying rocks are ductile. These pipes may reach the surface or pass upwards into fractures and then into cracks that do not extend to the surface. Breccia pipes may also form through the downward percolation of meteoric waters or accelerate contaminant transport from the repository by creating enhanced pathways of vertical flow that bypass low-permeability units in the Rustler. If dissolution occurred within or beneath the waste panels themselves, there could be increased circulation of groundwater through the waste and a breach of the Salado host rock.

Past investigations in the region have identified these types of deep dissolution features within the Delaware Basin; however, their occurrences have been limited to areas along the margins of the basin that are underlain by Capitan Reef. Because of these observations, deep dissolution is not expected to occur sufficiently close to WIPP nor to affect groundwater flow in the immediate region of WIPP during the period of regulatory concern.

Within Nash Draw, extensive fracturing of the Rustler allows more groundwater flow and, therefore, dissolution of the Rustler. East of Livingstone Ridge, there is less fracturing and dissolution in the Rustler. In the CCA, the Department has concluded that the extent of dissolution

at the top of the Salado will not reach the controlled area until long after 10,000 years. Thus, shallow and deep dissolution at the WIPP site were not considered in the CCA performance assessment calculations.

Potential Hydrologic Effects of Natural Resource Exploration and Development Activities

The wide range of natural resource-related activities, which historically have been and will continue to be important in the region, have implications for future site impacts. The following is a brief description of the potential impacts of hydrocarbon exploration and development and potash mining.

Potential Impacts from Oil and Gas Development

Just outside of the WIPP site, oil and gas reserves are accessed by drilling through the Salado Formation and into the underlying oil- and gas-bearing formations. In the early 1990s, the Delaware Basin in the vicinity of the WIPP site experienced a significant increase in oil and gas exploration and development (Broadhead et al. 1995). Current restrictions do not allow any drilling activities within the WIPP controlled area, therefore, no direct impact from drilling activities is expected.

Hydrocarbon exploration and development, as a normal part of operations, also involves the injection of brine into boreholes that are used for brine disposal and enhanced oil recovery. The production of oil and gas is often accompanied by the production of large volumes of reservoir brine. Typically, the unwanted brine is injected back into the subsurface in an approved zone or zones through the use of salt water disposal wells. As oil, gas, and reservoir brine are produced in primary oil production, the natural reservoir energy will be expended and secondary methods such as water flooding are used to enhance crude oil recovery. A successful water flooding operation injects pressurized water through a well borehole into the oil bearing zone, to force additional oil to flow towards the producing well. Without proper management, both primary and secondary recovery methods can have significant hydraulic impact on surrounding geologic media.

In 1988, sudden water level changes were observed in wells completed in the Culebra Dolomite south of the WIPP site. Changes were first observed in Well H-9, about 10 kilometers (6 miles) south of the WIPP site (Figure 4-10). From 1988 through mid-1993, water levels steadily rose almost 5.5 meters (18 feet) before dropping abruptly. Water levels continued to drop until the end of 1995; currently, water levels are on the rise.

Analysis of the water level changes in H-9 and a number of other observation wells in areas north and south of WIPP and in the vicinity of WIPP have suggested that the changes in wells to the south are the result of possible hydraulic impacts of water flooding activities south of the WIPP site. Although there is no direct evidence to conclude which water flooding operation or what specific hydraulic condition is creating the specific water level changes observed near the WIPP site, casing leaks are the most logical pathway for introduction of fluid into the Rustler Formation.

The problem of injected water migrating out of the zone also occurs at other oil fields underlying the Salado Formation in the region.

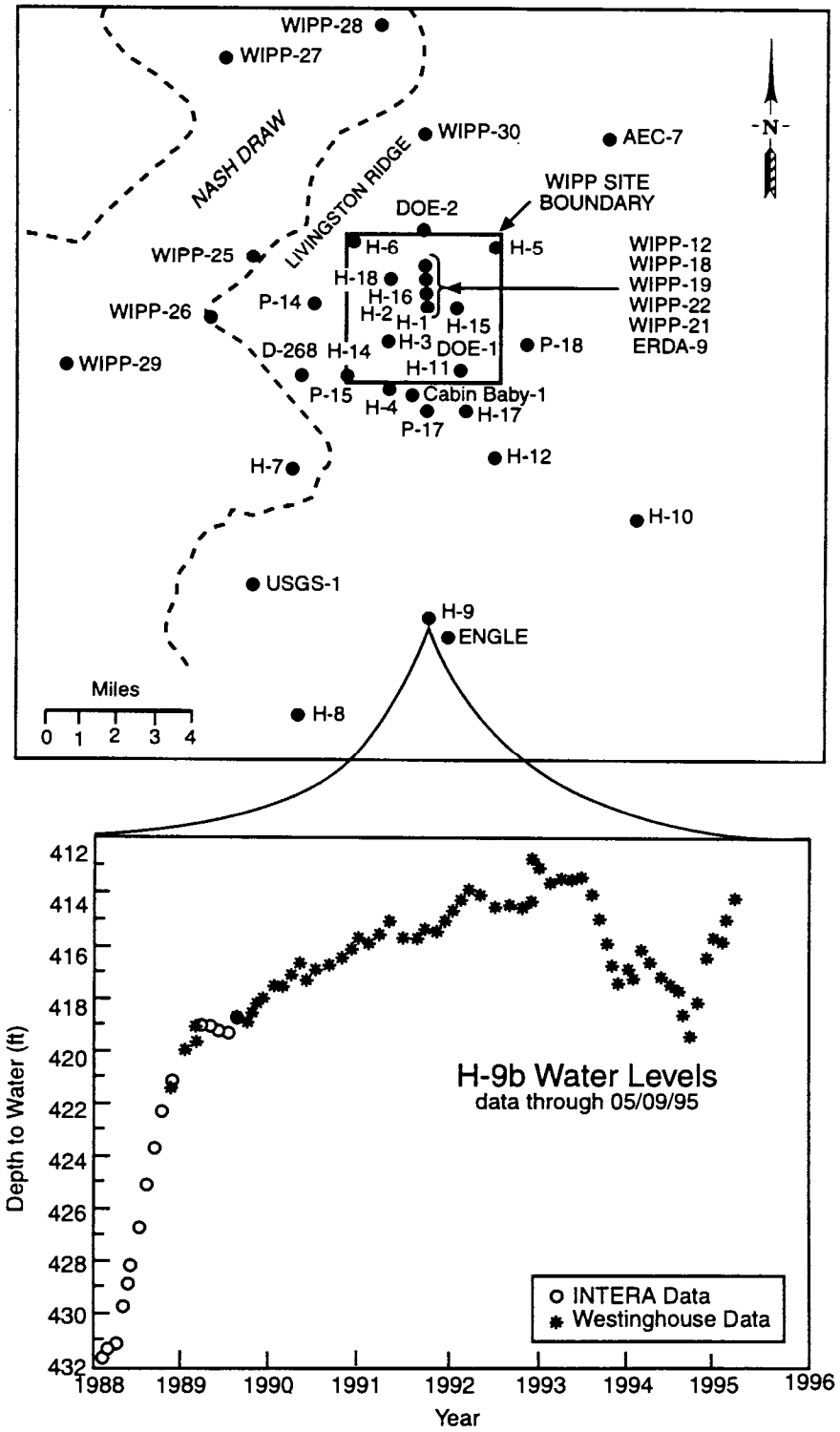


Figure 4-10
Locations of Wells Completed in the Culebra Dolomite in the Vicinity of the WIPP Site and Water-Level Changes in Observation Well H-9b between 1988 and 1996

Another example of potential hydrologic impacts from injection of large volumes of brine occurred in January, 1991 at a site located about 12 kilometers (8 miles) southeast of the WIPP site. In this incident, a borehole was in the process of being drilled through the Salado Formation when a salt water blowout, encountered at depths between 683 and 695 meters (2,240 and 2,280 feet), flowed uncontrollably for five days. In a lawsuit that followed, a claim was made that a nearby water flooding operation allowed large quantities of injected brine to escape out of an approved injection zone (which entered in the overlying Salado Formation) and migrate into the borehole. Evidence presented in the case substantiated the claim that brine injected to depths of about 915 meters (3,000 feet) had migrated out of the injection zone to the Salado Formation. The wells used in the water flooding operation were drilled and completed in the 1940s so the possibility of faulty well completion or failed well casing are potential causes of the out-of-injection zone migration. The potential for this type of incident to occur at WIPP was evaluated by DOE and was viewed as highly unlikely because of differences in geology between the WIPP site and the nearby site, changes in oil-well completion practices since the 1940s, and improved reservoir management practices.

The two examples of impacts noted above and other examples of the potential impacts of brine disposal and water flooding are described in more detail in Silva (1996).

Potential Impacts of Potash Mining

Potash mining has the potential to impact the hydrology of the area near the WIPP site in two ways. One impact involves the potential for mining operations and the development of room and pillar mines to cause weakening and collapse of overlying strata and subsequent subsidence. This may result in the propagation of fractures through both overlying water-bearing unit and potential contaminant pathways (e.g., the Culebra Dolomite), thereby increasing their hydraulic conductivity and potentially damaging petroleum well casings and uncased wells (Neill et al. 1996).

The other potential impact comes from the need of potash mining operations to dispose of brine generated during mining operations. As in the case of oil and gas drilling operations, potash mining requires the use of salt water disposal wells, and the potential exists that out-of-zone migration of brine injected through improperly sealed wells and deteriorating casing could have a potential impact on hydrologic conditions near the WIPP site.

Active and Passive Controls

The Department believes that planned active controls (see DOE 1996c, Chapter 7) will ensure that the prohibition on the drilling of hydrocarbon wells and on potash mining is enforced during the active institutional control period. For the purpose of this analysis, this period of active institutional control is assumed to be 100 years after the disposal operations period and site closure although it is the Department's intention to maintain active institutional control well beyond this period. Beyond the active institutional period, DOE intends to implement a set of passive institutional controls (DOE 1996c, Section 7.3.4) that are expected to significantly deter the possibility of human intrusion for 700 years. Beyond that time, the effectiveness of passive controls is expected to degrade, and the potential exists for drilling or mining activities to encroach into the area of the WIPP site, leading to an intrusion from one or more exploratory boreholes or from mines into the repository and/or underlying possible pressurized brine reservoir. This potential impact was evaluated in the long-term performance assessment analysis described in Chapter 5 and Appendix H.

4.1.4 Biological Resources

SEIS-I (DOE 1990) describes the WIPP site area as characterized by sand dunes. Further, it describes the vegetation as dominated by shinnery oak (*Quercus havardii*), mesquite *(Prosopis grandulosa*), sand sage (*Artemisia filifolia*), dune yucca (*Yucca campestris*), smallhead snakeweed (*Gutierrezia microcephala*), three-awn (*Aristida* spp.), and numerous species of forbs and perennial grasses. The most conspicuous mammals at the site are the black-tailed jack rabbit (*Lepus californicus*) and the desert cottontail (*Sylvilagus auduboni*); other common small mammals include Ord's kangaroo rat (*Dipodomys ordii*), plains pocket mouse (*Perognathus flavescens*), and northern grasshopper mouse (*Onychomys leucogaster*). Large mammals include mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and coyote (*Canis latrans*). Loggerhead shrike (*Lanis ludovicianus*), Pyrrhuloxia (*Cardinalis sinuata*), and black-throated sparrow (*Amphispiza bilineata*) are common resident birds. The Harris hawk (*Parabuteo unicinctus*) is a resident raptor. Aquatic habitats near WIPP, which include stock watering ponds and tanks, may be frequented by yellow mud turtles (*Kinosternon flarescens*) and tiger salamanders (*Ambystoma tigrinum*) (DOE 1992, 1993b, 1994a, 1995d).

Since SEIS-I, ecological monitoring at WIPP has continued. Changes noted in vegetation distribution include an increase in shrub cover and a decrease in grasses such as black grama grass (*Bouteloua eriopoda)* near the salt tailings (due to the colonization of these habitats by salt-tolerant shrub species). No effects from salt-induced physiological stress were seen on the general vegetation of the area. Changes in cover and density during the last few years have been attributed to variations in annual rainfall (DOE 1993b, 1994a, and 1995d).

Wildlife monitoring has indicated increases in some species of birds at the site. This is primarily due to changes in surface conditions such as water availability (DOE 1992) and to increases in oilfield activities in areas surrounding the site which may have disturbed some populations and caused their relocation within the site (DOE 1994a). Surveys taken from 1984 through 1993 have documented 98 species of birds which inhabit or migrate through the area (DOE 1994a).

Mammal populations have fluctuated as a result of changes in natural conditions such as rainfall, temperature, and disease. No differences in mammal population numbers have occurred as a result of WIPP activities (DOE 1995d).

In consultation with the USFWS, the Department concluded in SEIS-I that the following threatened or endangered species occur or have the potential to occur on lands within or outlying the WIPP site: Lee's pincushion cactus (*Coryphantha sneedi* var. *leei*), American peregrine falcon, bald eagle (*Haliaeetus leucocephalus*), and Pecos gambusia (*Notropis simus pecosensis*). DOE stated that it believed the actions described in SEIS-I would have no impacts on any threatened or endangered species because those activities did

CHANGES IN RARE, THREATENED, AND ENDANGERED SPECIES

The threatened, endangered, and candidate species present in Eddy County, New Mexico, have changed since SEIS-I. In 1995, DOE consulted with the U.S. Fish and Wildlife Service (USFWS), the New Mexico Department of Game and Fish (NMDG&F), and the New Mexico Energy, Minerals and Natural Resources Department (NMEMNR) regarding the presence of federally threatened, endangered, and proposed species, state-listed rare and endangered animals, and state-listed rare and endangered plant species, respectively, in Eddy County, New Mexico. Since SEIS-I, more than 60 new state and federal species have been added to these county-wide lists, although no new species have been found at the WIPP site.

not involve any ground disturbance that was not already evaluated in the FEIS (DOE 1980). NMDG&F agreed with the Department that the anticipated WIPP activities would probably not have appreciable impacts on state-listed endangered species in the area. The Department concluded in SEIS-I that there is no critical habitat for terrestrial species identified as endangered by either the USFWS or the NMDG&F at the site (DOE 1990).

In September 1995, DOE contacted the USFWS to determine the occurrence of threatened, endangered, and proposed species at WIPP. The USFWS listed eight endangered, six threatened, and 37 proposed species for Eddy County, New Mexico (USFWS 1995) (see Table 4-1). At that time, DOE also contacted the NMDG&F and NMEMNR regarding the occurrence of state-listed rare, threatened, and endangered plant and animal species in Eddy County. The NMDG&F currently lists 22 threatened and 7 endangered animal species (NMDG&F 1995), and the NMEMNR lists 7 state-endangered and 17 state-sensitive plant species (Sivinski and Lightfoot 1995) (see Table 4-1). There is no designated critical habitat for such species at the WIPP site (NMDG&F 1995, USFWS 1995).

In 1996, DOE conducted another survey on the WIPP Land Withdrawal Area and associated lands to investigate the potential for impact to rare, threatened, endangered, or sensitive plant or animal species as a result of the potential actions presented in SEIS-II. The 1996 survey included an assessment of suitable habitats for these species. No threatened, endangered, or state-listed species were found on the WIPP Land Withdrawal Area during the survey. The data reported in the survey, which support the conclusions of other studies, suggest that dense and permanent populations of these species are not presently established on WIPP lands.

4.1.5 Cultural Resources

This section provides a brief evaluation of recent activities concerning the prehistoric and historic cultural resources at WIPP. FEIS (DOE 1980) summarized background discussions and data, followed by an update in SEIS-I (DOE 1990). More recent summaries of the WIPP cultural resources information are found in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1993a) and the *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994* (DOE 1995d).

CHANGES IN CULTURAL RESOURCES MANAGEMENT

Memorandum of Understanding - In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources in the Land Withdrawal Area to DOE.

Cultural resources investigations at WIPP began in 1976 and have continued to the present. A review of the bibliography of existent WIPP cultural resources reports indicates that at least 24 separate investigations have been conducted. SEIS-I summarized two archeological investigations that provide further insight into the life of the hunter-gatherers who occupied the area of the WIPP site.

The first investigation excavated three sites that had been identified in FEIS that were in areas which could have been disturbed during construction activities. Two of the sites were plant-collecting and processing sites, and one was a base camp used between 1,000 B.C. and 1,400 A.D. The second investigation covered Control Zones III and IV and areas identified for

Table 4-1
Species of Special Concern in Eddy and Lea Counties, New Mexico [a]

Name	FE [b]	FT [c]	FC [d]	SE [e]	ST [f]	SR [g]
Mammals						
Arizona black-tailed prairie dog (*Cynomys ludovicianus arizonensis*)			X			
Big free-tailed bat (*Nyctinomops macrotis*)			X			
Black-footed ferret (*Mustela nigripes*)	X					
Cave myotis (*Myotis velifer*)			X			
Fringed myotis (*Myotis thysanodes*)			X			
Gray-footed chipmunk (*Tamias canipes*)			X			
Guadalupe southern pocket gopher (*Thomomys umbrinus guadalupensis*)			X			
Long-legged myotis (*Myotis volans*)			X			
Occult little brown bat (*Myotis lucifugus occultus*)			X			
Pale Townsend's big-eared bat (*Plecotus townsendii pallescens*)			X			
Pecos river muskrat (*Ondatra zibethicus ripensis*)			X			
Small-footed myotis (*Myotis ciliolabrum*)			X			
Swift fox (*Vulpes velox*)			X			
Yuma myotis (*Myotis yumanensis*)			X			
Birds						
American peregrine falcon (*Falco peregrinus anatum*)	X			X		
Arctic peregrine falcon (*Falco peregrinus tundrius*)		X				
Baird's sparrow (*Ammodramus bairdii*)			X		X	
Bald eagle (*Haliaeetus leucocephalus*)		X			X	
Bell's vireo (*Vireo bellii arizonae*)					X	
Black tern (*Chlidonias niger*)			X			
Broad-billed hummingbird (*Cynanthus latirostris*)					X	
Brown pelican (*Pelecanus occidentalis*)	X			X		
Common ground-dove (*Columbina passerina*)				X		
Ferruginous hawk (*Buteo regalis*)			X			
Gray vireo (*Vireo vicinior*)					X	
Interior least tern (*Sterna antillarum*)	X			X		
Loggerhead shrike (*Lanius ludovicianus*)			X			
Mexican spotted owl (*Strix occidentalis lucida*)		X				
Neotropical cormorant (*Phalacrocorax brasilianus*)					X	
Northern aplomado falcon (*Falco femoralis septentrionalis*)	X			X		
Northern goshawk (*Accipiter gentilis*)			X			
Southwestern willow flycatcher (*Empidonax traillii extimus*)	X				X	
Varied bunting (*Passerina versicolor*)					X	
Western burrowing owl (*Athene cunicularia hypugea*)			X			
White-faced ibis (*Plegadis chihi*)			X			
Reptiles						
Arid land ribbon snake (*Thamnophis proximus*)					X	
Blotched water snake (*Nerodia erythrogaster*)					X	
Dunes sagebrush lizard (*Sceloporus arenicolus*)			X		X	
Mottled rock rattlesnake (*Crotalus lepidus lepidus*)					X	
Texas horned lizard (*Phrynosoma cornutum*)			X			
Western river cooter (*Pseudemys gorzugi*)					X	

[a] Includes federal-endangered, -threatened, and -candidate species, state-endangered and -threatened species, and state-rare and -sensitive species. None of these species have been found during surveys at the WIPP sites. Due to revisions in the lists of endangered and threatened species, only two of the identified federal candidate species (the swift fox and Pecos pupfish) are still listed.

[b] FE = federal-endangered species (USFWS 1995)

[c] FT = federal-threatened species (USFWS 1995)

[d] FC = federal-candidate species (USFWS 1995)

[e] SE = state-endangered species (NMDG&F 1995, Sivinski and Lightfoot 1995)

[f] ST = state-threatened species (NMDG&F 1995)

[g] SR = state-rare and -sensitive species (Sivinski and Lightfoot 1995)

Table 4-1
Species of Special Concern in Eddy and Lea Counties, New Mexico — Continued [a]

Name	FE [b]	FT [c]	FC [d]	SE [e]	ST [f]	SR [g]
Fish						
Bigscale logperch (*Percina macrolepida*)					X	
Blue sucker (*Cycleptus elongatus*)			X	X		
Gray redhorse (*Moxostoma congestum*)					X	
Greenthroat darter (*Etheostoma lepidum*)					X	
Headwater catfish (*Ictalurus lupus*)			X			
Mexican tetra (*Astyanax mexicanus*)					X	
Pecos bluntnose shiner (*Notropis simus pecosensis*)		X			X	
Pecos gambusia (*Gambusia nobilis*)	X				X	
Pecos pupfish (*Cyprinodon pecosensis)*			X		X	
Plains minnow (*Hybognathus placitus*)			X			
Rio Grande shiner (*Notropis jemezanus*)			X			
Invertebrates						
Ovate vertigo (*Vertigo ovata*)			X		X	
Pecos springsnail (*Fontelicella pecosensis*)			X		X	
Texas hornshell (*Popenaias popei*)			X	X		
Plants						
Catchfly gentian (*Eustoma exaltatum*)						X
Chapline's columbine (*Aquilegia chrysantha chaplinei*)						X
Desert parsley (*Pseudocymopterus longiradiatus*)						X
Dune unicorn plant (*Proboscidea sabulosa*)						X
Few-flowered jewelflower (*Streptanthus sparsifloras*)			X			X
Gray sibara (*Sibara grisea*)						X
Guadalupe cliff daisy (*Chaetopappa hersheyi*)			X			X
Guadalupe mescal bean (*Sophora gypsophila guadalupensis*)						X
Guadalupe milkwort (*Polygala rimulicola rimulicola*)						X
Guadalupe penstemon (*Penstemon cardinalis regalis*)						X
Guadalupe rabbitbrush (*Chrysothamnus nauseosus texemsis*)			X			X
Guadalupe smooth aster (*Aster laevis guadalupensis*)			X			
Gypsum milkvetch (*Astragalus gypsodes*)						X
Gypsum wild buckwheat (*Erigonum gypsophilum*)		X		X		
Hitchcock's mockorange (*Philadelphus hitchcockianus*)						X
Kuenzler's hedgehog cactus (*Echinocereus fendleri kuenzleri*)				X		
Lee's pincushion cactus (*Coryphantha sneedii leei*)		X		X		
Lloyd's hedgehog cactus (*Echinocereus lloydii*)	X			X		
McKittrick pennyroyal (*Hedeoma apiculata*)						X
Scheer's pincushion cactus (*Coryphantha scheeri scheeri*)				X		
Shining coral root (*Hexalectris nitida*)			X	X		
Texas tobacco root (*Valeriana texana*)						X
Tharp's bluestar (*Amsonia tharpii*)			X	X		
Waterfall milkvetch (*Astragalus waterfallii*)						X
Wright's water-willow (*Justicia wrightii*)			X			X

[a] Includes federal-endangered, -threatened, and -candidate species, state-endangered and -threatened species, and state-rare and -sensitive species. None of these species have been found during surveys at the WIPP sites. Due to revisions in the lists of endangered and threatened species, only two of the identified federal candidate species (the swift fox and Pecos pupfish) are still listed.

[b] FE = federal-endangered species (USFWS 1995)

[c] FT = federal-threatened species (USFWS 1995)

[d] FC = federal-candidate species (USFWS 1995)

[e] SE = state-endangered species (NMDG&F 1995, Sivinski and Lightfoot 1995)

[f] ST = state-threatened species (NMDG&F 1995)

[g] SR = state-rare and -sensitive species (Sivinski and Lightfoot 1995)

possible land exchange. Sites encountered in the second investigation tended to lack evident or intact features. No definitive structures were identified. Of the 40 new sites identified, 14 were considered eligible for inclusion in the National Register of Historic Places (NRHP). The sites that are eligible or potentially eligible for the NRHP were mapped, and DOE activities have avoided disturbance of these sites. As a result of this past work, about 37 percent of the WIPP withdrawal area (1,551 hectares [3,830 acres]) has been inventoried for cultural resources.

To date, 60 archeological sites have been recorded in the withdrawal area, including 91 isolated occurrences (single or few artifacts, or isolated features). Sites and isolates are almost exclusively prehistoric in origin, and only one site with both prehistoric and historic components has been recorded. Based on the inventory data, and assuming environmental homogeneity and a fairly even distribution of archeological sites, DOE estimates that the WIPP site may contain about 99 archeological sites and 153 locations where isolated artifacts may be found (1993a).

There are no known Native American sacred sites or burials in the Land Withdrawal Area. Prior to the passage of the LWA in 1992, BLM managed the cultural resources on WIPP. In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources to DOE. Cultural resources are currently managed according to guidelines set forth in the WIPP Land Management Plan (DOE 1993a). DOE and the State of New Mexico have signed a Joint Powers Agreement that includes provisions specifying how DOE will satisfy its obligations regarding cultural resources under Sections 106 and 110 of the National Historic Preservation Act.

4.1.6 Socioeconomic Environment

The socioeconomic ROI for WIPP, as defined in FEIS (DOE 1980) and SEIS-I (DOE 1990), is Eddy and Lea counties in southeast New Mexico.[1] Any major changes in future activities undertaken at the WIPP site would have their most immediate socioeconomic effects in the two-county ROI. Principal centers of economic activity in the ROI include Artesia, Carlsbad, Hobbs, and Lovington. The oil and gas extraction and refining industries anchor the economies in both Eddy and Lea counties. Oil and gas mining services, mineral mining, tourism, and business services are the other significant industries of the ROI. The Carlsbad area also is known as a gateway to the Carlsbad Caverns-Guadalupe Mountains National Park complex. Economic impacts associated with WIPP primarily affect the Carlsbad portion of the ROI. Very few WIPP-related expenditures occur outside of the Carlsbad area, and very few direct WIPP employees reside elsewhere within the ROI. Most of the income spent by WIPP employees for local goods and services is spent in the Carlsbad area.

CHANGES IN SOCIOECONOMICS

Since publication in 1990 of SEIS-I, the following changes have occurred:

- *Census Information* - Demographic characteristics in SEIS-II are based on 1990 U.S. Bureau of the Census information as well as more recent data.
- *Economic Characteristics* - SEIS-II uses economic characteristics involving employment and wages covered by unemployment insurance from 1980 through 1990, based on 1994 information provided by the New Mexico Department of Labor and the University of New Mexico Bureau of Business and Economic Research.

[1] Towns in this ROI include Artesia, Atoka, Black River village, Carlsbad, El Paso Gap, Hope, Lakewood, Loco Hills, Loving, Malaga, Riverside, Seven Rivers, and Whites City in Eddy County. It also includes Caprock, Crossroads, Eunice, Hillburn City, Hobbs, Humble City, Jal, Lovington, Maljamar, McDonald, Monument, Nadine, Oil Center, and Tatum in Lea County.

Previous analyses of the socioeconomic impacts of WIPP on southeastern New Mexico occurred in Fiscal Year (FY) 1982 (Adcock et al. 1983), FY 1987 (Lansford et al. 1988), and most recently FY 1988 (Adcock et al. 1989). Socioeconomic analyses were also conducted for SEIS-I (DOE 1990). Employment and wage characteristics for 1994 are based on information provided by the New Mexico Department of Labor (NMDOL 1995) and the Bureau of Business and Economic Research of the University of New Mexico (BBER 1995). Other social and demographic characteristics reported for 1990 are based on 1990 Census information and more recent data compiled by the U.S. Bureau of the Census (1994). Lansford et al. (1994, 1995, 1996) also provide summary economic data relating to WIPP.

4.1.6.1 Background Characteristics

The construction of WIPP had some notable socioeconomic impacts in the ROI from 1981 through 1986. Subsequently, WIPP has had a relatively smaller impact on the socioeconomic characteristics in the ROI relative to changes from the extraction of oil and natural gas, the major industry of Eddy and Lea counties. This industry experienced a loss of almost one-third of its 1980 work force over the decade, substantially dampening the population growth in the ROI (BBER 1995). Correspondingly, WIPP-related activities tended to have a stabilizing effect on the local economy, particularly in Eddy County.

Table 4-2 shows that in 1990, four years after the major WIPP construction effort, the total population in the ROI was 104,370. This population is comprised of approximately 81.9 percent White, 32.4 percent Hispanic (both White and non-White), and 0.5 percent Native American. The ROI has smaller portions of Hispanic and Native American populations when compared to New Mexico as a whole, where the two groups comprise 38.2 percent and 8.9 percent, respectively. About 56 percent of the total ROI population is between the ages of 18 and 65. Overall, 65.4 percent of the ROI population has completed high school, with 11.2 percent attaining a baccalaureate degree or higher.

The ROI experienced slight advances in personal income in spite of the general downturn in oil and natural gas extraction during the 1980s. The median household and per capita income levels shown in Table 4-3 for the ROI were $23,305 and $10,241, respectively. Table 4-3 also shows that 17.4 percent of all families in the ROI were below the national poverty threshold. Poverty thresholds vary by family size and number of related children under 18 years of age. For example, the U.S. Bureau of the Census (1994) defined the national poverty threshold for a family of five persons in 1989 to be $14,900. New additions to the housing stock during 1990 through 1992 were relatively small across the ROI, while vacancy rates for rental units suggested ample availability of rental housing for under $350 per month.

4.1.6.2 Role of WIPP in the Economic Base

Table 4-4 lists recent information on local employment and wage earnings for the ROI. During 1994, a total of 38,094 employees earned $858 million in covered wages (wages covered by unemployment insurance) (NMDOL 1995). The most influential economic sectors in the ROI involved the extractive industries, the trade and service sectors, and government activities.

Given the stability of WIPP funding over the 1990s, the economic base of the ROI has been relatively less sensitive to changes in WIPP activities than to other large-scale enterprises such as the oil and gas industry. Declines in that industry in the 1980s resulted in lower employment and

Table 4-2
1990 Population and Community Characteristics by County in ROI [a]

Characteristic	Eddy	Lea	ROI Total [b]
Total population	48,605	55,765	104,370
Population by Race and Ethnicity			
White (percent)	81.5	82.2	81.9
Black (percent)	1.7	4.7	3.3
Native American (percent)	0.5	0.6	0.5
Asian (percent)	0.4	0.4	0.4
Other or Non-Reporting (percent)	15.9	12.1	13.9
Hispanic [c] (percent)	35.3	29.8	32.4
Population by Age and Education			
Percentage under 18	30.2	33.2	31.8
Percentage 65 and over	15.2	10.6	12.7
Percentage high school	67.3	63.8	65.4
Percentage bachelor degree	10.9	11.5	11.2
Total School Enrollment	13,489	16,457	29,946
College	2,010	2,765	4,775
Elementary or high schools	10,790	12,859	23,649
Community hospitals	2	2	4
Number of beds	156	278	434
Number of physicians	54	40	94

[a] ROI as defined for the socioeconomic environment constitutes a two-county aggregation based on 1990 census information.
[b] ROI percent totals are calculated on the total class level divided by the total ROI population.
[c] Hispanic is an ethnic characterization and consequently persons of Hispanic origin can be of any race.

Source: U.S. Bureau of the Census 1994.

Table 4-3
Income, Poverty, and Housing Characteristics (1989-1992) by County in ROI

Characteristic	Eddy	Lea	ROI Total
Median household income (dollars)	23,418	23,352	23,305
Per capita income (dollars)	10,490	10,025	10,241
Families below poverty line	2,162	2,806	4,968
Percentage of families below poverty line	16.2	18.5	17.4
Persons below poverty line	9,755	12,309	22,064
Percentage of persons below poverty line	20.4	22.4	21.1
Total housing units	20,134	23,333	43,467
Median value of owner-occupied units (dollars)	44,800	39,600	42,200
Median gross rent (dollars)	304	312	308
Vacancy rate	13.2	17.3	15.41
New building permits (1990-1992) as percentage of 1990 housing stock	< 1	< 1	< 1

Source: U.S. Bureau of the Census 1994.

Table 4-4
1994 ROI County Employment and Covered Wages (in Millions of 1994 Dollars)

Sector	Eddy		Lea		ROI Total	
	Employees	Wage	Employees	Wage	Employees	Wage
Agriculture	513	6.9	232	3.0	745	9.9
Mining	2,985	103.1	4,297	132.4	7,282	235.5
Construction	1,006	19.0	1,188	24.6	2,194	43.6
Manufacturing	921	31.0	529	9.8	1,450	40.8
Transportation and Utilities	1,628	52.2	1,487	51.7	3,115	103.9
Trade	3,798	51.4	4,891	77.9	8,689	129.3
F.I.R.E. [a]	614	13.7	529	12.1	1,143	25.8
Services [b]	3,753	62.9	3,668	65.9	7,421	128.8
Government						
Federal	425	15.7	123	4.2	548	19.9
State	420	8.9	238	5.6	658	14.5
Local	2,162	49.2	2,687	56.8	4,849	106
Totals	18,225	414	19,869	444	38,094	858
Unemployed percent	6.8		5.5		6.1	

[a] Finance, Insurance, and Real Estate
[b] The New Mexico Department of Labor classifies WIPP employees under the service sector industry, SIC 87.

Source: NMDOL 1995 and U.S. Bureau of the Census 1994.

wage earnings, while upturns in the 1990s have resulted in higher employment and wage earnings. Future growth and diversification of the economic base in the ROI would tend to diminish the economic impact of future changes in WIPP activities. WIPP, however, continues to play a role in the economic diversification of the Carlsbad economy, and several private ventures related to WIPP science and technology have started operations in Carlsbad. Depending on the extent to which they are reliant on the WIPP budget for their revenue, such businesses will be directly affected by alternatives considered in SEIS-II. Therefore, the more independent of WIPP these businesses become, the less they will be affected by federal actions at WIPP.

The direct economic impact of the anticipated WIPP operations reflects the levels of wage and salary payments to WIPP employees and the size of business and government procurement associated with WIPP construction and operations activities. At the time of the FY 1988 study, $24.3 million was paid in direct WIPP wages and salaries to 661 site personnel, while nonsalary expenditures were estimated to be $95.3 million (Adcock et al. 1989). By 1994, WIPP-related employment and annual wages had risen to 1,005 jobs and $44.56 million, respectively. This accounted for 2.6 percent of the total employment and approximately 5.2 percent of covered wage earnings in Eddy and Lea counties in 1994 (Landsford et al. 1995). In 1995, WIPP-related employment and covered wages dropped slightly to 952 jobs and annual wages of approximately $43.48 million (Landsford et al. 1996).

Nonsalary expenditures are mainly for regional support services, materials, capital equipment, and construction. However, WIPP outlays are also used to pay for business and government expenditures, including grants, community assistance, and out of region expenditures made through or by the local WIPP project office (DOE 1990).

The indirect economic impact of the anticipated WIPP operations is reflected by the subsequent spending and creation of new jobs that follow initial WIPP outlays in any given year. To assess the economic impacts of changes in the funding at the WIPP site, Adcock et al. (1989) estimated an economic activity multiplier value of 2.19 for FY 1988. That is, for every $1.00 spent by WIPP on materials, labor, benefits, equipment and services, another $1.19 worth of goods and services was generated in the ROI for a total impact of $2.19.

Relative to the $24.3 million of direct salaries and wages paid in FY 1988, an estimated additional $26.2 million of indirect wages and salaries were paid in the ROI in FY 1988 in support of 1,153 indirect jobs (Lansford et al. 1988). Meanwhile, the direct nonsalary expenditures of $95.3 million were estimated to generate an additional $113.6 million of indirect nonsalary expenditures in the local economy.

4.1.6.3 Environmental Justice

Environmental justice in the context of this document refers specifically to the potential for minority and low-income populations to bear a disproportionate share of high and adverse environmental impacts from activities at WIPP under the various SEIS-II alternatives. The environmental justice ROI covers all populations within an 80-kilometer (50-mile) radius of the reservation boundary of WIPP.[1] This region includes parts of three counties in New Mexico (Chaves, Eddy, and Lea) and parts of seven counties in Texas (Andrews, Culberson, Gaines, Loving, Reeves, Ward, and Winkler). Seventy-five percent of the ROI lies within New Mexico, and the remaining 25 percent lies within Texas.

The following population data are derived from the 1990 Census of Population and Housing (U.S. Bureau of the Census 1994). Within the Environmental Justice ROI, the total population of 101,129 persons includes 4.1 percent non-White, 32.6 percent Hispanic, and 36.8 percent minority (all except White non-Hispanic persons). In addition, 21.5 percent of the total population had 1989 incomes below the poverty level, as defined by the U.S. Bureau of the Census. There are no Native American reservations in the ROI. Figures 4-11and 4-12 display maps of the distribution of minority and low-income populations according to the percentage of the block group population in the environmental justice ROI. Block grouping is a division of territory, the size of which varies according to population density, that has approximately 400 households.

The proportion of Hispanic, minority, and low-income persons in the ROI are all greater than in the United States as a whole. Also, the proportion of low-income persons in the ROI is greater than in both New Mexico and Texas. Finally, the proportion of Hispanic persons in the ROI is smaller than in New Mexico but greater than in Texas.

[1] Towns in this ROI include Artesia, Atoka, Black River village, Carlsbad, El Paso Gap, Hope, Lakewood, Loco Hills, Loving, Malaga, Riverside, Seven Rivers, and Whites City in Eddy County, New Mexico and Eunice, Hobbs, Humble City, Jal, Lovington, Maljamar, Monument, Nadine, and Oil Center in Lea County, New Mexico. This ROI also includes Mentone in Loving County, Texas, and both Arno and Orla in Reeves County, Texas. The other counties in New Mexico and Texas that are part of this ROI have no communities within the 80-kilometer radius.

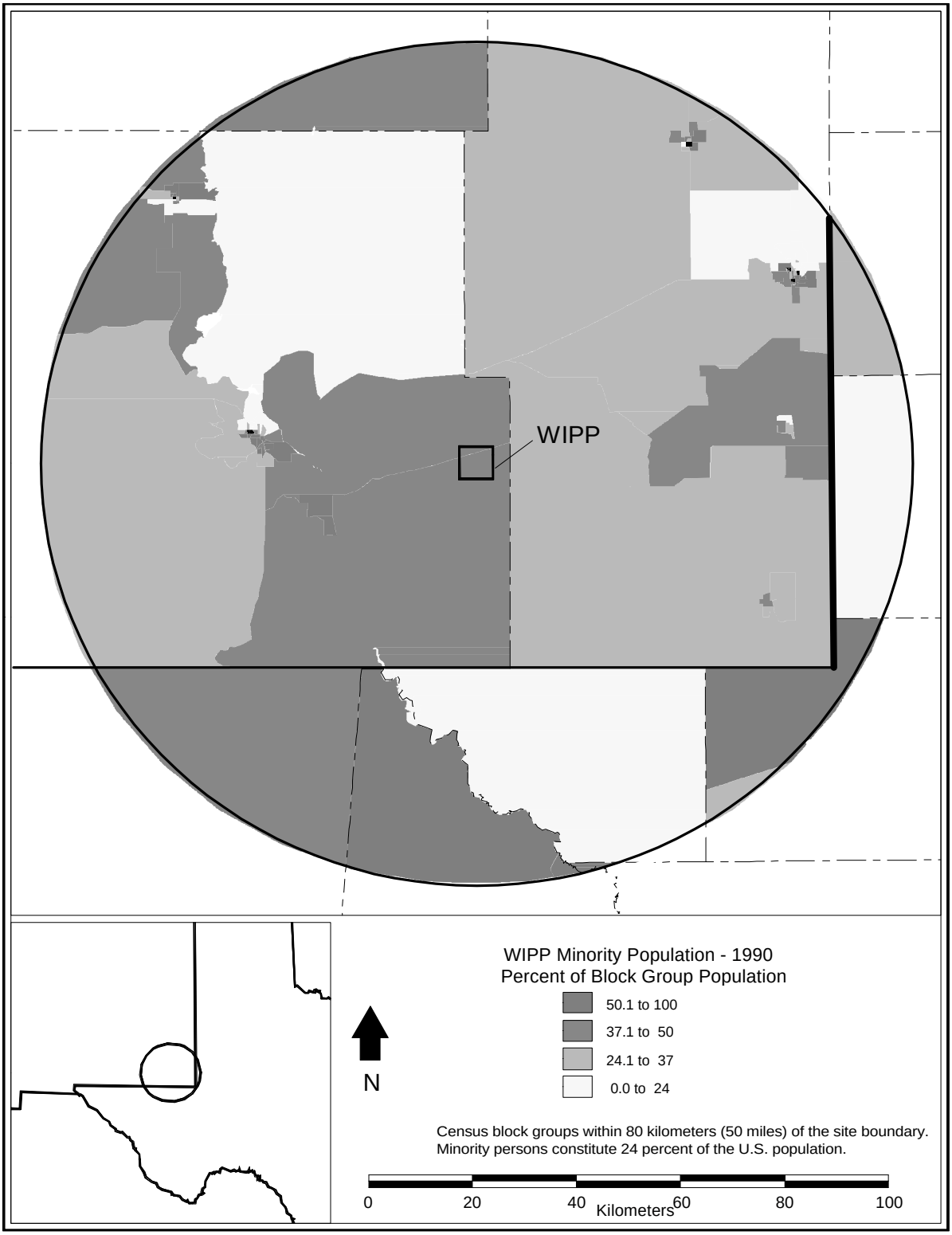


Figure 4-11
Minority Population

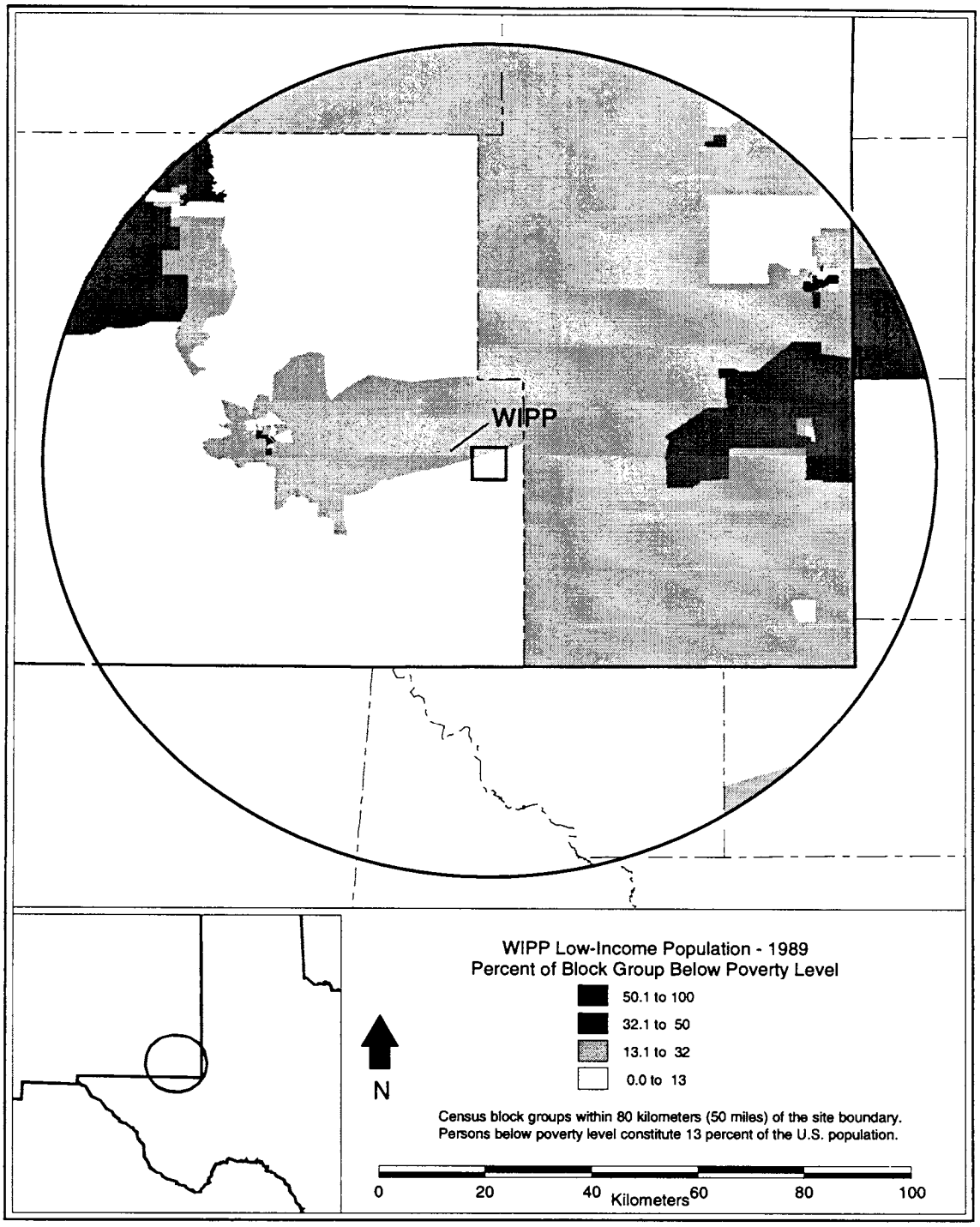


Figure 4-12
Low-Income Population

4.1.7 Transportation

SEIS-I briefly describes the transportation routes leading to WIPP. The site can be reached by rail or highway. DOE has constructed a rail spur to the site from the Burlington Northern and Santa Fe Railroad 10 kilometers (6 miles) west of the site. The site can also be reached from the north and south access roads constructed for the WIPP project. The north access road intersects U.S. Highway 62/180 (U.S. 62/180) 21 kilometers (13 miles) north of WIPP. The south access road intersects New Mexico Highway 128 6.5 kilometers (4 miles) to the southwest of WIPP. Transportation routes from principal DOE sites and facilities are shown in Appendix E, which also presents additional information on transportation methods and routes.

4.1.8 Background Radiation

The background radiation conditions in the vicinity of WIPP are influenced by natural sources of radiation, fallout from nuclear tests, and Project Gnome, a local research project (DOE 1990).

DOE established long-term radiological monitoring programs in southeastern New Mexico prior to the WIPP project, to determine the widespread impacts of nuclear tests at the Nevada Test Site (NTS) and to evaluate the effects of Project Gnome. The background radiation levels measured at WIPP from 1976 to 1979 are discussed in FEIS (DOE 1980).

The WIPP Radiological Baseline Program (RBP) was initiated in 1985 to describe background levels of radiation and radionuclides in the WIPP environment prior to the underground emplacement of radioactive waste (DOE 1990). The RBP consists of five subprograms: (1) atmospheric baseline, (2) ambient radiation (gamma radiation), (3) terrestrial baseline (soils), (4) hydrologic baseline (surface water, bottom sediments, and groundwater), and (5) biotic baseline (radiological parameters in key organisms along potential radionuclide-migration pathways). Mean gross alpha activity in airborne particulates has shown little variation and is within the range of 1 to 3 x 10^{-15} microcuries per milliliter. Mean gross beta activity in airborne particulates fluctuates but is typically within the range of 1 to 4 x 10^{-15} and 1 to 4 x 10^{-14} microcuries per milliliter. The average level of gamma radiation in the environment is approximately 66 millirem per year. On average, a person in the United States receives an effective dose equivalent of about 350-360 millirem per year from all sources of radiation (DOE 1997b, 1995g). Radionuclide concentrations in soil, surface water, sediment samples, and key organisms fall within expected ranges and do not indicate any unexpected environmental concentrations (DOE 1990).

In 1994, atmospheric particulates, ambient radiation, soil, surface water and sediment, groundwater, and biota (vegetation, fish, rabbit, and deer) samples were collected throughout the year from a number of locations and analyzed radiologically. Table 4-5 highlights the radionuclides sampled in the WIPP vicinity. An estimated annual dose of approximately 65 millirem was determined, indicating that no unusual levels of environmental radioactivity exist at WIPP (DOE 1995d).

RADIOLOGICAL ENVIRONMENT

Background Radiation - Since publication of SEIS-I, the WIPP Radiological Baseline Program (RBP) has shown that there has been little variation in mean gross alpha, beta, and gamma levels in airborne particulates. Radionuclide concentrations in soil, surface water, sediment samples, and key organisms have fallen within the expected ranges and have not indicated any excessively high environmental concentrations.

Table 4-5
Radionuclides Sampled in the Vicinity of WIPP

Name	Symbol	Particulate	Soil	Surface-water/ Sediment	Groundwater	Biota
Actinium-228	^{228}Ac			X		X
Beryllium-7	^{7}Be	X				
Potassium-40	^{40}K	X	X	X	X	X
Cobalt-60	^{60}Co	X	X	X	X	X
Strontium-90	^{90}Sr	X	X	X	X	X
Cesium-137	^{137}Cs	X	X	X	X	X
Radium-226/228	$^{226/228}Ra$	X	X	X	X	X
Thorium-228/230/232	$^{228/230/232}Th$	X	X	X	X	X
Uranium-233/234/235/238	$^{233/234/235/238}U$	X	X	X	X	X
Plutonium-238/239/240/241	$^{238/239/240/241}Pu$	X	X	X	X	X
Americium-241	^{241}Am	X	X	X	X	X
Lead-210	^{210}Pb	X	X	X	X	X
Polonium-210	^{210}Po	X	X	X	X	X

As discussed in FEIS (DOE 1980) and SEIS-I (DOE 1990), Project Gnome resulted in a nuclear device being detonated underground approximately 14 kilometers (9 miles) south-southwest of the WIPP site in 1961 as part of the Plowshare Program sponsored by the Atomic Energy Commission. In 1972, the EPA established a program to monitor radionuclide levels in surface water and groundwater in areas potentially affected by Project Gnome. EPA (1989) published the results in its "Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Test Areas, Calendar Year 1988." In June 1995, the Environmental Evaluation Group (EEG) conducted a limited radiological survey of the Project Gnome area (EEG 1995) as well as a radiochemical analyses with a commercial laboratory. The results indicated that there were elevated levels of plutonium-238 (Pu-238), plutonium-239 (Pu-239), plutonium-240 (Pu-240), and americium-241 (Am-241) in localized surface soils at the Gnome site. Although the results indicated measurable transuranic (TRU) contamination at the Gnome site, EEG reported that the levels did not appear to present any immediate health and safety concern.

4.2 EXISTING ENVIRONMENT AT THE TEN MAJOR GENERATOR-STORAGE SITES

The following sections briefly summarize the existing environments at the 10 major generator-storage sites listed in Chapter 1. Maps showing the locations of the sites can be found in Chapter 3.

4.2.1 Argonne National Laboratory-East (ANL-E)

ANL-E occupies 690 hectares (1,700 acres) in northeast Illinois, in DuPage County, approximately 35 kilometers (22 miles) southwest of downtown Chicago, Illinois. The site is north of the Des Plaines River valley, south of Interstate-55, and west of Illinois Highway 83. Comprised of several buildings, ANL-E is a multi-program laboratory that conducts basic and applied research in the areas of reactor development, physical sciences, and life and environmental sciences. Technology commercialization and science education are also ANL-E missions (META/Berger 1995).

Regional land use surrounding ANL-E is characterized by high concentrations of urban development, including commercial, industrial, public, and residential usage. Several large forest preserves are east and southeast of the site. The site itself is in a suburban area. ANL-E uses only 80 hectares (200 acres) of the site for DOE activities, devoting the rest to forest and landscape areas (META/Berger 1995).

Four on-site wells provide the water supply for ANL-E. An average of 3,000 to 3,400 cubic meters (800,000 to 900,000 gallons) of water is pumped from the wells each day. ANL-E is now in the process of converting from local groundwater supplies to a municipal supply obtained from Lake Michigan (Holdren et al. 1995). The current site load for electricity is 23 megawatts (META/Berger 1995).

The ANL-E is located in a Class II designated PSD air quality area. The nearest Class I designated PSD area is the Seney National Wildlife Refuge located approximately 525 kilometers (325 miles) north of the site in Seney, Michigan. The EPA classifies the site and the surrounding counties as severe nonattainment areas for the criteria pollutant ozone. All other surrounding counties and areas are in attainment of the remaining NAAQS criteria pollutants except for Lyons Township in southeast Chicago, which is listed as a moderate nonattainment area for PM_{10} (META/Berger 1995).

There are no known active tectonic features within 100 kilometers (62 miles) of the site. Several areas of considerable seismic activity are present at moderate distances from ANL-E, including the New Madrid fault zone in southeastern Missouri (a fault zone along the southern Illinois-Indiana border) and one in western Ohio. Horizontal accelerations greater than 0.1 gravity are estimated to occur on the site approximately once in 600 years (META/Berger 1995).

ANL-E is on the northern margin of the Des Plaines River valley. The largest on-site stream is Sawmill Creek, which originates north of the site and enters the Des Plaines River about 2 kilometers (1.25 miles) southeast from the center of the site. ANL-E is located approximately 46 meters (150 feet) above the Des Plaines River and thus is not subject to major flooding (META/Berger 1995). Sawmill Creek is currently the receiving body for effluent from ANL-E treatment facilities. The quality of waters in both Sawmill Creek and the Des Plaines River is poor. The Des Plaines River is used for neither agricultural nor domestic supplies for more than 100 kilometers (62 miles) downstream of ANL-E (Holdren et al. 1995).

ANL-E uses two principal aquifers for its water supply. The upper aquifer is about 60 meters (200 feet) thick and supplies potable water. The other aquifer is below the first, lying between 150 and 460 meters (500 and 1,500 feet) beneath the surface. The two aquifers are not directly connected and pumpage from the upper aquifer does not appear to affect the lower aquifer. No aquifers in the ROI are considered sole source aquifers under Safe Drinking Water Act regulations (META/Berger 1995).

Federal-listed threatened or endangered species are not known to reside on the ANL-E site. The site is known to contain one state-listed endangered bird. Six federally- or state-threatened or endangered species reside in the area and may possibly reside on the site (META/Berger 1995).

As of 1994, a complete survey of ANL-E revealed 43 prehistoric and 6 historic archeological properties, but no sites listed with the NRHP or designated as National Historic Landmarks. Three sites are potentially eligible for the NRHP, 20 sites are not considered eligible, and 26 sites have

not been evaluated. The potential of ANL-E to contain traditional cultural resources of interest to Native American groups has also not been evaluated (META/Berger 1995).

The counties of DuPage, Cook, Kane, and Will, in Illinois comprise the economic ROI in which 95.4 percent of all ANL-E's employees reside. About 4,500 persons were employed at ANL-E. The ROI total population in 1992 was 6,568,800, of which approximately 98 percent was urban. Within the ROI, Whites comprise approximately 68.5 percent of the population, Blacks comprise 21.2 percent, and Hispanics comprise 12.1 percent. In 1989, about 9 percent of all families were below the poverty level. The dominant industries in the ROI include manufacturing, finance, insurance, real estate, and government (META/Berger 1995).

The ANL-E ROI is served by Interstate Highways 55, 80, 294, and 355. In addition, U.S. Routes 34 and 45/20 and Illinois Route 83 provide local access. The Chicago metropolitan area has a number of rail lines which can be accessed by truck from ANL-E. The nearest major airport is Chicago's O'Hare International Airport (META/Berger 1995).

Radionuclide sampling at ANL-E is carried out for soil, water, and air. The 1990 data indicated no substantial difference between on-site and off-site radionuclide concentrations in soil samples. In 1993, measurable levels of several radionuclides were detected in Sawmill Creek downstream from the wastewater treatment plant outfall. The concentrations of all these radionuclides were only a small fraction of the DOE-derived concentration guides for water. In 1993, elevated levels of Am-241, cesium-137 (Cs-137), cobalt-60 (Co-60), and Pu-239 were found in sediments below the outfall and are attributed to past releases. Radionuclides found in groundwater include Cs-137, strontium-90 (Sr-90), and tritium (H-3). In 1993, all radionuclide monitoring results were less than the limits established by the Safe Drinking Water Act. Airborne particulates and other airborne sources added to the background radiation in the ANL-E area.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 3×10^{-3} latent cancer fatalities (LCFs). The population within this area was 7,900,000. The annual dose from airborne radionuclides to the maximally exposed individual (MEI) during 1994 would result in a 8×10^{-9} probability of an LCF. The corresponding dose is below the National Emission Standard for Hazardous Air Pollutants (NESHAP) limit.

4.2.2 Hanford Site (Hanford)

Hanford covers about 1,450 square kilometers (560 square miles) of the southeastern part of the state of Washington in parts of Benton, Grant, and Franklin Counties. The nearest city, Richland, Washington, borders the site on its southeast corner. The site is bounded on the east by the Columbia River, on the west by the Rattlesnake Hills, and on the north by Saddle Mountain. The site has a number of facilities including retired plutonium production reactors, operating reactors, waste management and spent nuclear fuel processing facilities, and nuclear research and development laboratories (DOE 1995a).

Land on the Hanford site is used primarily by DOE. However, there are also areas used as a wildlife refuge and for game management. The land adjacent to the site is either urban, commercial, or agricultural. Agricultural areas include irrigated and dry-land farming and grazing. The Columbia River adjacent to the site is heavily used for recreation (DOE 1995a).

The Columbia River is the principal source of water for Hanford. In 1992, the site consumed approximately 15 million cubic meters (4 billion gallons) of water. The Bonneville Power Administration provides electricity. In 1992, electricity consumption at the site was approximately 340,000 megawatt-hours, with a power demand of 57 megawatts (DOE 1995a).

Air quality in the Hanford region is well within the State of Washington and EPA standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the PM_{10} standard (DOE 1995a). Hanford is in a Class II air quality area (META/Berger 1995). The Class I areas nearest to the site are Goat Rocks Wilderness Area and Mount Rainier National Park, both about 145 kilometers (90 miles) away. Two other Class I areas are within 175 kilometers (110 miles) of the site (DOE 1995a).

The climate of the area is semiarid, with hot, dry summers and cool winters. Temperatures range from an average high of 2 degrees Celsius (36 degrees Fahrenheit) in January to an average high of 35 degrees Celsius (95 degrees Fahrenheit) in July (DOE 1995a). On average, thunderstorms occur 11 days per year, mostly in summer. The annual average precipitation is 16 centimeters (6.3 inches). The prevailing wind is from the west and the monthly average wind speeds range from 3 meters per second (7 miles per hour) in the winter to 4 meters per second (9 miles per hour) in the summer (META/Berger 1995). Tornadoes are extremely rare, occurring within 160 kilometers (100 miles) of the site about once every three years. The estimated probability of a tornado striking a point on the site is 9.6×10^{-6} per year.

Hanford is on a low-lying, modified plain of the Columbia River. Recent alluvial or windblown sands comprise the surface of the plain, with basaltic lava flows and various layers of gravel, silts, and clays underneath (DOE 1995a).

Earthquake activity in the area of Hanford has historically been low-to-moderate. The site is in a Uniform Building Code Seismic Risk Zone 2B. The largest shock recorded near the site was approximately 4.5 to 5.0 on the Richter scale (Modified Mercalli Intensity of V) in Corfu, 35 kilometers (22 miles) north of the site, in 1918. Another Modified Mercalli Intensity V quake occurred in the area in 1973. The site often experiences low intensity earthquakes occurring in clusters over a short period of time. Volcanic hazards are low as the site is located approximately 160 kilometers (100 miles) east of the Cascade Range, which includes several volcanic vents. Foreseeable volcanic effects at the site are limited to windborne volcanic ash (DOE 1995a).

The Columbia River passes through the northern part of Hanford and forms part of the eastern boundary. The Yakima River is located near the southern portion of the site. There are also two intermittent creeks. Upstream dams control potential flooding from the Columbia River. Minor flooding away from on-site facilities occurs from the other watercourses. The water quality of the Columbia River is high, and the river contributes to the water supply for the site and for nearby cities. Radiological monitoring shows low levels of radionuclides in the river, considerably below concentration guidelines established by EPA drinking water standards. Wastewaters are discharged to several ponds on the site and the Columbia River. Nonradiological contaminant concentrations are within Washington State Water Quality Standards (DOE 1995a).

There are unconfined aquifers located beneath Hanford (DOE 1995a). No aquifers are considered sole-source aquifers (META/Berger 1995). In 1993, several radionuclides and nonradioactive chemicals were detected at levels exceeding EPA drinking water standards and/or DOE derived

concentration guides (DOE 1995a). Preliminary investigations have identified four major groundwater contaminant plumes that have been found to enter the Columbia River in at least three locations (META/Berger 1995). Groundwater beneath the site is not used for human consumption or food production, except for one well used for drinking at one of the facilities. Above-background levels of radionuclides have been detected in this well; however, the levels are considerably below EPA drinking water standards (DOE 1995a).

Hanford, a shrub-steppe environment dominated by cheatgrass and sagebrush, includes 10 different types of plant communities. Deer and elk are the major large animals, and coyotes are the main large predators (DOE 1995a). Wetlands existing along the Columbia River and other streams and seeps support extensive stands of various types of vegetation as well as the waterfowl that use them for nesting. The river supports 44 species of fish, including salmon and trout, which use it as a spawning area (META/Berger 1995). A 310-square-kilometer (120-square-mile) area of the site set aside for ecological studies, a wildlife refuge, and a game management area comprises the Arid Land Ecology Reserve.

The entire Hanford site has been designated a National Environmental Research Park (NERP) (DOE 1995a). There are six federal- or state-threatened or endangered species of birds on the Hanford site. One state-endangered mammal and four state-threatened or endangered plant species are also found. In addition, there are 12 other species of animals which are federal- or state-classified as species of concern (META/Berger 1995).

As of 1992, 248 prehistoric archeological sites were recorded, 48 of which are on the NRHP (DOE 1995a). In addition, 11 historic archeological sites and 11 other properties are also listed on the NRHP (META/Berger 1995). Archeological sites include the remains of villages, campsites, cemeteries, monuments, hunting sites, and quarries. Several Native American groups retain traditional secular and religious ties to the region. Some native plant and animal foods used in religious ceremonies can be found on the Hanford site (DOE 1995a).

The primary socioeconomic impact area includes the tri-cities (Richland, Kennewick, and Pasco) and the counties of Franklin and Benton in Washington state. The estimated population for this area in 1992 was about 160,000. The larger economic ROI includes eight other counties in both Washington and Oregon. The estimated population for this ROI in 1992 was about 550,000. The primary economies of the economic ROI, each employing about 40,000 to 50,000 people, include agriculture/fishing/lumbering, manufacturing, trade, services, and government (DOE 1995a). The environmental justice ROI, which is the area within an 80-kilometer (50-mile) radius from the site, contains about 380,000 people. This ROI population includes 20 percent minority, 18 percent low-income (DOE 1995a), and 19 percent Hispanic (META/Berger 1995). The site employs about 14,200 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties. These two counties also account for approximately 93 percent of site employees (META/Berger 1995).

DOE has entered into agreements with the tribal governments representing the Yakama Indian Nation, Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. These agreements pertain to the core environmental programs and the emergency preparedness and response program.

U.S. Highways 12 and 395, Interstate-82, and State Route 240 run through the Hanford site. Two railroads also connect the area with much of the rest of the nation.

High-level radioactive waste has been accumulating at Hanford since 1944. Before 1970, TRU waste was disposed of on-site in unlined trenches; since 1970, however, Hanford has stored TRU waste in aboveground storage facilities. Besides high-level radioactive waste, the site also has low-level waste, mixed waste, and hazardous waste stored in large amounts. Hanford is included on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List.

In 1993, radiation workers at the site were monitored and found to have average annual doses resulting in an 8×10^{-6} probability of an LCF per individual (DOE 1995a). The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-4} LCFs. The population within this area was 380,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-9} probability of an LCF. The corresponding dose is below the NESHAP limit. About 50 cancer deaths could be projected by the total public radiation dose from Hanford activities since 1944. Essentially all of these would have been the result of radiation exposures received during 1945 (DOE 1995a).

4.2.3 Idaho National Engineering and Environmental Laboratory (INEEL)

INEEL encompasses 230,000 hectares (568,000 acres) within five counties in southeastern Idaho. The site is located 44 kilometers (27 miles) west of Idaho Falls, Idaho, on the Eastern Snake River Plain in the Basin and Range Province of North America. The site is bordered by mountain ranges and volcanic buttes (DOE 1995a).

Land at INEEL is used for DOE operations, recreation, grazing, and environmental research. About 2 percent of the total INEEL site area (4,600 hectares [11,400 acres]) is used for facilities and operations. Recreational uses include public tours of general facility areas and controlled hunting. Between 121,000 and 142,000 hectares (300,000 and 350,000 acres) are used for cattle and sheep grazing. BLM does not allow grazing within 3 kilometers (2 miles) of any nuclear facility, and, to avoid the possibility of milk contamination by long-lived radionuclides, does not permit dairy cattle anywhere on the site. BLM also manages some of the undeveloped areas for wildlife habitat. No mineral exploration or development is allowed on INEEL land (DOE 1995a).

Site activities at INEEL withdraw an average of 7.4 million cubic meters (1.9 billion gallons) of groundwater per year. The peak demand on the INEEL electric system from 1990 to 1993 was about 40 megawatts, and the average usage was approximately 200,000 megawatt-hours per year (DOE 1995a).

The Craters of the Moon National Monument is 25 kilometers (15 miles) southwest of INEEL's western boundary and is in a designated Wilderness Area for which Class I air quality standards must be maintained. Concentrations of criteria pollutants at the site are below the NAAQS, state, and PSD standards and limits. The estimated on-site concentrations of most toxic air pollutants are well below levels established for protection of workers. The maximum short-term benzene concentration slightly exceeds the standard at the highest predicted location. For off-site conditions, all toxic air pollutant levels are below reference levels (DOE 1995a).

INEEL has an arid climate, with low relative humidity, wide daily temperature fluctuations, and large variations in annual precipitation. Thunderstorms occur 2-3 days per month during the

summer; otherwise, severe weather is uncommon. No tornadoes were reported on-site from 1950 to 1988. The mean annual temperature is 5.6 degrees Celsius (42 degrees Fahrenheit) and the mean annual precipitation is 22 centimeters (8.7 inches) (DOE 1995a). Notable variations in wind direction and speed are characteristic of the INEEL site. The prevailing wind direction ranges from west-southwest to north, and the average wind speed is about 3.2 meters per second (7.2 miles per hour) (Holdren et al. 1995).

The surface at the INEEL site is comprised primarily of basaltic lava flows ranging in age from about 2,000 years to over 1 million years. The site also contains wind-blown loess and sand and floodplain sediments. Volcanic hazards at INEEL can come from sources inside or outside the boundary of the site. Regional major volcanic activity has occurred at Craters of the Moon National Monument as recently as 2,100 years ago and at Yellowstone National Park (160 kilometers [100 miles] away) three times within the past 2 million years. The probability that volcanism would affect an INEEL site facility is less than 2.5×10^{-5} per year (DOE 1995a).

There are volcanic rift zones lying across INEEL, and the surrounding basin and range landscape also has frequent earthquakes (DOE 1995a). Two major earthquakes, of magnitude 7.3 and 7.5, have occurred within 100 miles of the site during the last 35 years (DOE 1996b). However, based on the seismic history and geologic conditions, earthquakes greater than magnitude 5.5 are unlikely within the site, though moderate to strong ground shaking from earthquakes within the nearby basin and range areas can affect the site (DOE 1995a).

The INEEL site is covered with wind-blown sediments generally less than 2.1 meters (7 feet) deep (DOE 1995a). These soils have a low-to-moderate water erosion hazard and a moderate-to-high wind erodibility (DOE 1995g).

INEEL is located in the Mud Lake-Lost River Basin, a closed drainage basin that includes three main tributaries (the Big and Little Lost Rivers and Birch Creek) which together drain approximately 753,000 hectares (1,860,000 acres). The Big Lost River crosses the site to an area of playas, or sinks, where water is discharged during an unusually wet year. However, surface water from this river, as well as the Little Lost River, does not usually reach the site. Water from Birch Creek flows into the site during the winter and infiltrates into channel gravels, where it recharges a local aquifer (DOE 1995a). During most years, all surface waters in the Little Lost River and Birch Creek are diverted to irrigation before entering the site (Holdren et al. 1995). Local flooding can occur at the site when the ground is frozen and runoff from melting snow is combined with heavy spring rains (DOE 1995a).

Chemical and radioactive parameters measured in the three rivers have not exceeded applicable drinking water quality standards. INEEL site activities do not directly affect the quality of surface water outside the site because surface water does not flow directly off-site. Discharges from facilities are made to manmade seepages and evaporation basins, rather than natural surface water bodies (DOE 1995a).

INEEL overlies the Snake River Plain Aquifer, the largest in Idaho, designated as a sole-source aquifer. This aquifer is also the source of all water used at INEEL. The depth to groundwater from the surface ranges from approximately 60 meters (200 feet) to over 270 meters (900 feet). Groundwater quality is affected by natural water chemistry and contaminants originating at INEEL facilities. Concentrations of radionuclides in the aquifer have decreased over time, primarily due to reduced discharges, adsorption, radioactive decay, and improved waste management practices.

Inside the site boundary, several radionuclide concentrations have exceeded the EPA maximum contaminant levels for drinking water. Outside the site boundary, all contaminant levels measured have been below the EPA levels (DOE 1995a). INEEL is included on the CERCLA National Priorities List.

INEEL site vegetation includes saltbrush deserts, juniper woodlands, native grasslands, big and low sagebrush, and riparian communities. Big sagebrush is dominant, covering approximately 80 percent of INEEL (DOE 1996b). The USFWS National Wetlands Inventory maps show over 130 potential wetlands, most found near the rivers and associated playas. As of December 1994, at least one area at the Big Lost River sinks was found to meet the criteria for jurisdictional wetland delineation by the United States Army Corps of Engineers (DOE 1995a). In 1975, DOE designated most of INEEL as a NERP (DOE 1995g).

Several migratory species use the INEEL site for part of the year. Two federal-endangered and nine federal species of concern were identified as potentially occurring on the site. Two state-protected and ten state species of special concern also potentially occur on the site. No federal- or state-listed plant species were identified as potentially occurring. Eight plant species considered sensitive, rare, or unique are known to occur (DOE 1995a).

INEEL contains paleontological fossil sites and numerous prehistoric archeological sites. As of June 1994, more than 100 cultural resource surveys have been conducted, and over 1,500 archeological resources have been identified. Over 700 of these resources are considered to be potentially eligible for NRHP. The Experimental Breeder Reactor-I is a national historic landmark. INEEL contains many resources culturally important to the Shoshone-Bannock Tribes. These include not only cultural sites but also features of the natural landscape. In accordance with federal laws and in consideration of DOE's Native American policy, DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes of the nearby Fort Hall Indian Reservation and is developing procedures for consultation and coordination at INEEL (DOE 1995a).

The socioeconomic ROI is a 7-county area where over 95 percent of INEEL's approximate 6,400 employees reside (DOE 1996b). The ROI labor force was 104,654 in 1991, and the 1990 population was 219,713 (DOE 1995a). About 2.5 percent of this population was Native American, and 5.5 percent was Hispanic (META/Berger 1995). The population within an 80-kilometer (50-mile) circle centered at Argonne National Laboratory-West (on the INEEL site) contains 7 percent minority and 14 percent low-income. Retail trade and educational services are the two largest employment sectors in the ROI, accounting for 17.6 percent and 11.4 percent of employment, respectively (DOE 1995a). In 1990, the per capita income for the ROI was $14,622 (META/Berger 1995).

DOE has entered into an agreement with the tribal governments representing the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation. This agreement is designed to enhance Tribal technical and scientific capability in the areas of environmental restoration, emergency preparedness and response, and management of cultural resources.

About 144 kilometers (90 miles) of paved public highway run through the INEEL site. Railroads also serve the area, and a rail line into INEEL connects the towns of Arco and Blackfoot.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-4} LCFs. The population within this area was 120,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-9} probability of an LCF. The corresponding dose is below the NESHAP limit. In addition, DOE estimates no adverse health effects from any noncarcinogenic chemical contaminants (DOE 1995a).

4.2.4 Lawrence Livermore National Laboratory (LLNL)

LLNL includes the Livermore site, the adjoining Sandia National Laboratories, California site (SNL-CA), and the LLNL experimental test site (Site 300). The Livermore site is approximately 64 kilometers (40 miles) east of San Francisco, California, and about 5 kilometers (3 miles) east of Livermore, California. The SNL-CA site is located next to and south of the Livermore site. Site 300 is about 24 kilometers (15 miles) southeast of Livermore in the sparsely populated hills of the Diablo Range. Today, the major programs at LLNL include defense and related programs, laser fusion, laser isotope separation, biomedical and environmental research, and environmental restoration and waste management (META/Berger 1995).

The Livermore and SNL-CA sites are at the southeast end of Livermore Valley in southern Alameda County. Site 300 is in a mostly rural area of San Joaquin County. Land adjacent to LLNL is predominantly private and consists of agricultural, residential, and light/industrial lands, with a smaller portion of public lands (META/Berger 1995).

The water supply for LLNL is provided by San Francisco's Hetch Hetchy water system. The current site load for water is 2,714,000 liters (717,000 gallons) per day and the maximum capacity is 9.54 million liters (2.52 million gallons) per day. The Pacific Gas and Electric Company and the Western Area Power Administration supply power to LLNL. The current site load is 61 megawatts. The maximum capacity is 100 megawatts (META/Berger 1995).

The Livermore site is in the San Francisco Bay Area Interstate Air Quality Control Region. This region has been classified as a nonattainment area for two criteria pollutants: CO and O_3. The Livermore site is in a Class II area, and any new sources of emissions must adhere to the increment standards for a Class II area (META/Berger 1995). Site 300 is located within the San Joaquin Valley Unified Air Pollution Control District. This area is classified as a nonattainment area for O_3 and PM_{10}. Several PSD Class I areas have been designated in the vicinity of LLNL, including Point Reyes National Wilderness Area, approximately 89 kilometers (55 miles) northwest of the Livermore site; Desolation National Wilderness Area; Mokelumne National Wilderness Area; Emigrant National Wilderness Area; Hoover National Wilderness Area; and Yosemite National Park. Since the promulgation of the PSD regulations in 1977, no PSD permits have been required for any emission source at the Livermore site (DOE 1996b).

The climate at LLNL and the surrounding region is classic Mediterranean with hot dry summers and cold wet winters. The average annual temperature is 12.5 degrees Celsius (54.5 degrees Fahrenheit). The temperature range at Site 300 is more extreme than at the Livermore site because of the higher elevation and pronounced relief (DOE 1996b). Annual precipitation at the SNL-CA ranges from 30 to 38 centimeters (12 to 15 inches) (META/Berger 1995).

All three sites lie within Seismic Zone 4 (DOE 1996b). The San Andreas fault system, the Sur-Nacimiento fault system, and the Coast Range thrust fault system are the major fault systems in the area. Along with local faults, these major regional faults are potential sources of ground motion at LLNL. In January 1980, an earthquake sequence on a local fault produced two earthquakes of magnitudes 5.5 and 5.6. These earthquakes caused structural damage at the Livermore and SNL-CA sites. Larger earthquakes on more distant faults, such as the San Andreas, do not substantially affect the hazard estimation for LLNL. The potential for surface faulting within the Livermore site is very low. Surface faulting at Site 300 in areas adjacent to the active Carnegie fault is possible (META/Berger 1995).

The main surface water features at the Livermore site are the Arroyo Las Positas and Arroyo Seco. Both stream channels are dry for most of the year. Two areas on the Livermore site are within the 100-year floodplains of these two streams; however, no existing on-site structures are within the 100-year floodplain. There are no perennial streams at or near Site 300. The canyons that dissect the hills and ridges at Site 300 drain into intermittent streams. The majority of these on-site streams drain to the south into Corral Hollow Creek, also intermittent, which flows east along the southern boundary of Site 300 in San Joaquin Valley. In addition to these streams, 24 springs and 2 vernal pools exist on-site. Some surface water discharge occurs from cooling towers and other process runoff areas (DOE 1996b).

Groundwater in the vicinity of the Livermore site is generally suitable as a domestic, municipal, agricultural, and industrial supply, with the exception of groundwater less than 90 meters (300 feet) deep. This groundwater is routinely monitored for radioactive and nonradioactive parameters. In 1993, the maximum concentrations of gross alpha, nitrate/nitrite, trichloroethylene, and tritium were above their water quality criteria or standard. The maximum concentrations found for tritium are in one local on-site well and pose no threat to water supplies. VOCs have also been detected in the on-site groundwater and in the area around the Livermore site. All site practices known to contribute VOCs to groundwater have been discontinued. LLNL is working with EPA and the State of California to identify appropriate remedial measures (DOE 1996b).

Two regional aquifers have been identified at Site 300. These are an upper water table aquifer of the Neroly Formation and a deeper confined aquifer also in the Neroly Formation (META/Berger 1995). At Site 300, groundwater is sampled quarterly from inactive and active water supply wells and monitoring wells, and analyzed for radioactive and nonradioactive parameters. Maximum concentrations of arsenic, gross alpha, nitrate/nitrite, trichloroethylene, tritium, and uranium were above their water quality criteria or standard at least once in 1993. LLNL is included on the CERCLA National Priorities List. LLNL is investigating and identifying characteristics of groundwater contamination at Site 300. Several plumes of VOCs and tritium have been identified in shallow and deeper bedrock aquifers in this area and several adjacent off-site areas. LLNL is working with the EPA and the State of California to remediate these plumes (DOE 1996b).

Fifty-nine federal- and state-listed threatened, endangered, and other special status species may be found on and in the vicinity of the Livermore site. Ten of these species have been observed on the site, including the federal-listed bald eagle (*Haliaeetus leucocephalus*). Thirty federal- and state-listed threatened, endangered, and other special status species have been observed on Site 300, and an additional 32 may be found on and in the vicinity of the site. These species include the federal-listed San Joaquin kit fox (*Vulpes macrotis mutica*), American peregrine falcon (*Falco peregrinus anatum*), large-flowered fiddleneck (*Amsinckia grandiflora*) and bald eagle; and the

federal-proposed Alameda whipsnake (*Masticophis lateralis euryxanthus*) and California red-legged frog (*Rana aurora draytoni*). Although suitable habitats for several of the other listed species exist on-site at LLNL, potential occurrence of most of the other species is minimal due to the lack of suitable habitat (DOE 1996b). No critical habitat for threatened or endangered species exists at LLNL (META/Berger 1995).

Since 1974, several archeological investigations have taken place at the Livermore site and Site 300. No prehistoric sites have ever been located at the Livermore site. A preliminary investigation at the Livermore site in 1992 explored the historic significance of World War II-era buildings and developed a potential context for initial consideration of the distinguished technical and scientific resources of LLNL. Cultural resource investigations at Site 300 have resulted in the discovery of 7 prehistoric sites, 21 historic sites, and 1 with elements of each. Of these, 24 are officially recorded, but no evaluations to determine site significance have been performed. Sacred and important Native American resources that might be found in the vicinity of LLNL include burials, cremations, vision quest sites, and traditional-use areas. Initial consultation with Native American groups to determine important resources has begun (DOE 1996b).

Four counties comprise the ROI in which 97.2 percent of the approximately 7,850 Livermore site and Site 300 employees reside. In 1990, the population in the ROI was 2,952,000. The population in the ROI is predominantly White (69 percent), and approximately 8.4 percent of the families were living below the poverty level in 1989. In 1991, the unemployment rate for the ROI was 9.3 percent. The 1990 per capita income in the ROI was $21,099. The dominant industries in the ROI include services, government, manufacturing, and retail, which account for 68.8 percent of total earnings (META/Berger 1995).

LLNL is serviced by Interstate-580, Interstate-5, and Interstate-680. South Vasco Road and Greenville Road, both of which are accessed from Interstate-580, service the Livermore site from the north. Patterson Avenue and East Avenue provide access to the Livermore site from the east and west. The Southern Pacific Railroad and the Western Pacific Railroad are the primary providers of rail service to the LLNL region (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 4×10^{-4} LCFs. The population within this area was 6,300,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit. The impact to the LLNL worker population from operations in 1994 was estimated to be 7.3×10^{-3} LCF (DOE 1996b).

4.2.5 Los Alamos National Laboratory (LANL)

LANL is located in north-central New Mexico, 97 kilometers (60 miles) north-northeast of Albuquerque, New Mexico, and 40 kilometers (25 miles) northwest of Santa Fe, New Mexico. The 11,300-hectare (28,000-acre) LANL site and adjacent communities are situated on the Pajarito Plateau (DOE 1995e). Since its inception in 1943, LANL's primary mission has been nuclear weapons research and development and related projects (META/Berger 1995). The land surrounding LANL is largely undeveloped, and large tracts of federal land surrounding the site are managed by the United States Forest Service, BLM, National Park Service, and Los Alamos County.

Three DOE-operated well fields provide an average of 15.5 million liters (4.1 million gallons) per day for LANL. Electricity usage in 1993 was 68 megawatts (META/Berger 1995).

LANL and its surrounding counties are considered attainment areas with respect to applicable NAAQS. The criteria pollutants make up approximately 79 percent of the stationary source emissions at LANL. Toxic and other hazardous pollutants represent the remaining 21 percent of the stationary source emissions. One PSD Class I area, Bandelier National Monument's Wilderness Study Area, borders LANL to the south. Since promulgation of regulations, no PSD permits have been required for any emissions source at LANL (DOE 1996b).

Los Alamos has a semiarid, temperate mountain climate. The annual average temperature at LANL is 8.9 degrees Celsius (48.1 degrees Fahrenheit) (META/Berger 1995). The average annual precipitation is 48 centimeters (18.7 inches) but is quite variable from year to year. Approximately 36 percent of the annual precipitation normally occurs from thunderstorms during July and August (DOE 1995e).

LANL is located on the Pajarito Plateau, which lies between the Jemez Mountains on the west and the Rio Grande on the east. Deep southeast-trending canyons, separated by long, narrow mesas, dissect the surface of the plateau (DOE 1995e). Studies have determined that the area has three active faults. The strongest earthquake in the past 100 years within a 80-kilometer (50-mile) radius had an estimated magnitude of 5.5 to 6 measured on the Richter scale and a Modified Mercalli Intensity of VII (META/Berger 1995). The site lies within Seismic Zone 2 (DOE 1996b), as established by the Uniform Building Codes.

All groundwater and surface water drainages from the Pajarito Plateau flow toward the Rio Grande. On-site tributaries to the Rio Grande include 14 drainage areas that pass through or start at LANL. Three of the canyons receive treated industrial or sanitary effluent. Surface water in these canyons is principally ephemeral and is not a source of municipal, industrial, or agricultural water supply. Regional, perimeter, and on-site surface waters are monitored to provide routine surveillance on the effect of LANL operations on water quality (META/Berger 1995). Surface water in the Los Alamos area principally occurs as short-lived or intermittent reaches of streams. The overall flood risk to LANL is low because nearly all the structures are located on the mesa tops, from which runoff drains rapidly into the deep canyons (DOE 1996b).

Groundwater in the LANL area occurs in four modes: shallow alluvium in canyons, perched water, the unsaturated zone between the surface and the main aquifer, and the main aquifer (DOE 1995e). Nearly all groundwater used at LANL originates from deep wells that produce water from the main aquifer. Under LANL are Class II aquifers, which provide current sources of drinking water and have other beneficial uses. Most of the wells in the Pajarito Plateau yield fresh water (total dissolved solids less than 500 milligrams per liter), although some wells east of the site have a higher total dissolved solids content (1,000 milligrams per liter or more). The primary, secondary, and radiochemical groundwater quality, as measured from wells and springs in the main aquifer, are below the DOE derived concentration guides or the New Mexico standards applicable to a DOE drinking water system. LANL and the nearby communities are entirely dependent on groundwater for their water supply (DOE 1996b).

The predominant vegetative communities at LANL are ponderosa pine, piñon-juniper, and juniper-grassland. LANL was designated a NERP in 1976 (META/Berger 1995). Most LANL wetlands occur in canyons. Wetlands have developed in the vicinity of some outfalls serving

LANL facilities. Thirty-four federal- or state-listed threatened, endangered, and other special status species may be found in the vicinity of LANL. Five of these species have been observed at LANL, but only one has been found to nest there and occupy the site year-round. Critical habitat for the Mexican spotted owl (*Strix occidentalis lucida*), a federally threatened species, exists at LANL and in areas bordering the northern and western boundaries of LANL (DOE 1996b).

Approximately 75 percent of LANL has been inventoried for cultural resources. More than 1,000 prehistoric sites have been recorded, and approximately 95 percent of these sites are considered eligible or potentially eligible for inclusion in the NRHP. Two areas in the vicinity of LANL have been established as NRHP sites or districts: Bandelier National Monument and Puye Cliffs Historical Ruins. Many of these cultural resources are of special importance to Native Americans in the area. Consultations with local Native Americans to identify any such cultural resources have been conducted in the past and are ongoing. More than 40 historic resources have been recorded at LANL, and about 90 percent of the resources are considered eligible or potentially eligible for the NRHP, based on their association with the broad historic theme of the Manhattan Project and initial nuclear production (DOE 1996b).

Three counties comprise the economic ROI in which 94.7 percent of LANL's 9,700 employees reside. In 1990, the population in the ROI was 152,300. The population in the ROI is predominantly White (79.8 percent) and 12.1 percent of the families are below the poverty level (META/Berger 1995). The 1994 unemployment rate in the ROI was 6.2 percent, and the per capita income in 1993 was $17,689. The service sector accounts for 31 percent of the nonfarm private sector employment in the ROI (DOE 1996b).

DOE has entered into an agreement with Tribal governments representing the Pueblos of Santa Clara, Cochiti, Jemez, and San Ildefonso. The purpose of this agreement is to build Tribal technical and scientific capability in environmental restoration and waste management and to assist the Tribes in participating in DOE decision making.

LANL is served by U.S. 84 and U.S. 285, which link Los Alamos to Santa Fe, New Mexico. U.S. 502, which can be accessed by U.S. 285 from Santa Fe, also services LANL. The nearest railway access is south of Santa Fe in Lamy, New Mexico (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-3} LCFs. The population within this area was 220,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 4×10^{-6} probability of an LCF. The corresponding dose is below the NESHAP limit. Two epidemiological studies have recently been conducted in the LANL area. The most recent study presented an increased incidence of thyroid cancer in residents of Los Alamos county compared to the rest of New Mexico (DOE 1996b).

4.2.6 Mound Plant (Mound)

Mound is located in west-central Ohio, in Montgomery County, within the city limits of Miamisburg, Ohio, about 16 kilometers (10 miles) south-southwest of Dayton, Ohio (Holdren et al. 1995). Mound occupies about 124 hectares (306 acres) (DOE 1979) and is situated on the highlands overlooking the Great Miami River. Until December 1991, Mound manufactured nonnuclear components and tritium-containing components for nuclear weapons. Mound's current mission is environmental restoration and economic development (DOE 1994b). Land use and

cover within the vicinity of the Mound site is primarily residential and woodland, and on the site itself there are heavily wooded areas (Holdren et al. 1995).

The Air Quality Control Region comprising the facility has been classified as attainment of the NAAQS for NO_2, SO_2, and lead. However, EPA lists Montgomery County as nonattainment for O_3 and TSP (DOE 1995c). Operations at Mound emitted a wide variety of nonradioactive contaminants, such as organic solvents, acids, and metals (DOE 1989). Various radioactive contaminants such as Pu-238 and tritium were also released. The site is also a source of radionuclides due to resuspension of contaminated soils related to past practices. Recorded levels of these contaminants are well below DOE guidelines (DOE 1995c).

Tornadoes may touch down along short and narrow paths, but are infrequent in the region. Tornado wind speeds of 146 kilometers (90 miles) per hour or greater have an annual probability of occurrence of one in one thousand. Tornadoes with wind speeds exceeding 368 kilometers (227 miles) per hour have an annual probability of one in one million (DOE 1995c).

The major surface water feature in the area is the Great Miami River, located approximately 450 to 600 meters (1,500 to 2,000 feet) west of the site. The tributary valley between the two main hills contains a drainage ditch, the only perennial stream within Mound boundaries (Holdren et al. 1995). Surface water quality in the vicinity of Mound is satisfactory, with radioactivity levels far below established limits (DOE 1995b).

The major aquifer in the area, the Buried Valley Aquifer (also called the Great Miami Aquifer), is the major source of the area's potable water. Typically, groundwater occurs 6 to 8 meters (20 to 26 feet) below ground surface in the valley. The bedrock also contains groundwater but cannot provide a reliable source. The glacial tills overlying the bedrock may also contain perched water zones but are generally too thin to act as a water supply (Holdren et al. 1995). There has been minor contamination of the groundwater by Mound activities. Tritium and plutonium have been detected in the Miamisburg water supply at levels far below regulatory limits. Some on-site groundwater VOCs exceed EPA levels; however, off-site concentrations are far lower, with none exceeding EPA levels (DOE 1995b).

The site lies within the range of the Indiana bat (*Myotis sodalis*), a federally-listed endangered species. However, the bat has not been seen on-site, and habitats hosting the bat are not present at the site. A single specimen of the Inland rush (*Juncas interior weig*), a state-endangered plant species, was found but it is not considered a viable breeding population. No other rare or endangered species have been found on the site (DOE 1995b).

The only historic landmark in the vicinity of the site is the Miamisburg Mound, an ancient mound located 120 meters (390 feet) east-southeast of the site. It is believed to be a burial place of a member of the Adena culture of Mound Builders which inhabited the Ohio region in prehistoric times (DOE 1979). The site itself does not contain any properties listed or eligible for the NRHP (DOE 1995b).

The city of Miamisburg is largely residential, with limited commercial and industrial development. The 1990 population of the city was 17,770. Within an 8-kilometer (5-mile) radius of the site, the population is estimated to be 76,061, based on 1988 figures (DOE 1995b). The population rises to several hundred thousand within a 16-kilometer (10-mile) radius and to over one million within a

32-kilometer (20-mile) radius. The facility employs about 1,200 people, the majority of whom live either in Miamisburg or in immediately adjacent areas (DOE 1979).

Area routes include the Dayton-Cincinnati Pike, 0.6 kilometers (0.4 miles) west of Mound; State Route 725, 1.4 kilometers (0.9 miles) to the north; and Interstate-75, 5 kilometers (3 miles) to the east. The tracks of the Penn Central Railroad roughly parallel the western boundary of the site at distances ranging from approximately 15 to 60 meters (50 to 200 feet) (DOE 1979).

Mound is included on the CERCLA National Priorities List. There are 22 known radioactively contaminated soil areas on-site and one area off-site. Sediments in the Great Miami River also contain levels of radioactive material that are higher than background levels for the surrounding area. There are also approximately 100 areas on-site that are either known or suspected to be contaminated with nonradioactive hazardous substances (DOE 1989).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 1×10^{-3} LCFs. The population within this area was 3,000,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit.

4.2.7 Nevada Test Site (NTS)

NTS occupies 3,500 square kilometers (1,350 square miles) of desert valley and Great Basin mountain terrain in southern Nevada, 105 kilometers (65 miles) northwest of Las Vegas, Nevada. Limited access areas, including the Nellis Air Force Base Bombing and Gunnery Range and the Tonopah Test Range, surround the site. The NTS has been the primary location for testing the nation's nuclear explosive devices since 1951 (META/Berger 1995).

Fourteen on-site wells supply an average of 5.15 million liters (1.36 million gallons) of water per day. The Nevada Power Company supplies electricity to NTS. The current site load is 30 megawatts (META/Berger 1995).

NTS is designated as an attainment or unclassified area with respect to all applicable NAAQS. Two PSD Class I areas in the vicinity of NTS are Grand Canyon National Park, Arizona, approximately 193 kilometers (120 miles) to the southeast and Sequoia National Park, California, located approximately 169 kilometers (105 miles) to the west-southwest of the site. Since promulgation of regulations, no PSD permits have been required for any emissions source at NTS (DOE 1996b).

NTS is in an area of moderate historic seismicity on the southern margin of the Southern Nevada East-West Seismic Belt in Seismic Zones 2 and 3. Since about 1848, more than 4,000 earthquakes have been recorded within a 242-kilometer (150-mile) radius of NTS. Most of these were minor events with Richter magnitudes of less than 5.5 (DOE 1995g). The Yucca fault is the only active fault on NTS within the underground nuclear testing area. The Rock Valley fault near the southern boundary of NTS has been the most active fault since 1990. (META/Berger 1995).

There are no continuously flowing streams at NTS, but there are permanent on-site water bodies, including natural springs and water-well overflow ponds, that are not associated with wastewater disposal. Sanitary wastewater influents to ponds and lagoons are regulated under a series of state

permits. Surface water bodies at NTS are routinely monitored for radioactive and nonradioactive parameters, and off-site surface water bodies and springs are also monitored for radionuclides (META/Berger 1995).

NTS has three general water-bearing units, and all are classified as Class IIA or Class IIB aquifers. Groundwater is the only source of drinking water in the NTS area. On-site wells are routinely monitored for radioactive and nonradioactive parameters, as required by the Safe Drinking Water Act, State of Nevada regulations, and DOE orders. Off-site groundwater is routinely monitored at 22 locations for radionuclides. Only three locations have evidenced detectable tritium levels on a consistent basis. In all three cases, the tritium activity has been less than 2 percent of the primary maximum contaminant level for tritium (20,000 picocuries per liter) (META/Berger 1995).

Thirteen federal- and state-listed threatened, endangered, and other special status species are present in the vicinity of NTS. The peregrine falcon is the only known species at NTS that is on the federal endangered species list. No critical habitat for threatened or endangered species exists on NTS (DOE 1996b).

Approximately 6 percent of NTS has been inventoried for cultural resources, and over 1,200 prehistoric sites have been recorded (DOE 1996b). Many of these sites may be eligible for listing on the NRHP. The only historic site that is currently listed is the Sedan Crater, which was created as part of the Plowshare Program to identify peaceful uses for nuclear explosions. Native American resources include ceremonial sites, petroglyphs, and traditional-use areas. Native Americans view many natural resources at NTS as cultural resources (DOE 1995g).

Two counties comprise the economic ROI in which 97 percent of the 1,600 NTS employees live. The ROI population totaled 865,144 in 1992 (DOE 1996b). The population in the ROI is predominantly White (81.5 percent), and in 1989, 7.5 percent of the population was below the poverty level (META/Berger 1995). During 1994, unemployment in the ROI was 6.1 percent. The 1993 per capita income in the ROI was $20,561. The service sector is the major economic sector in the ROI, with over half of the region's nonagricultural activity (DOE 1996b).

DOE has entered into two separate agreements with Consolidated Group of Tribes and Organizations to foster a government-to-government relationship and to encourage involvement in programs associated with NTS operations. This group is composed of 17 Tribes representing three ethnic groups (Western Shoshone, Owens Valley Paiute, and Southern Paiute) from Arizona, California, Nevada, and Utah, with cultural or historic ties to NTS.

Vehicular access to NTS is provided by U.S. Route 95 from the south and off-road access via State Route 375 from the northeast (DOE 1995a). Interstate-15 is the major transportation route in the region (META/Berger 1995). The major railroad in the area is the Union Pacific, which runs through Las Vegas and is located approximately 80 kilometers (50 miles) east of the NTS.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-4} LCFs. The population within this area was 33,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit. Epidemiologic studies on groups surrounding NTS have concentrated on health effects in

soldiers and children associated with aboveground nuclear testing rather than operational emissions. Results are contradictory regarding the observed leukemia incidence and deaths in exposed children (DOE 1996b).

4.2.8 Oak Ridge National Laboratory (ORNL)

ORNL is part of the 13,980-hectare (34,545-acre) Oak Ridge Reservation (ORR) located 32 kilometers (20 miles) west of Knoxville, Tennessee, in the rolling terrain between the Cumberland Mountains and Great Smoky Mountains. The primary mission of ORNL is basic and applied research, technology development, and special DOE research. ORR also contains the Y-12 plant whose missions include dismantling nuclear weapons components, maintaining nuclear production capability and stockpile support, and providing storage for nuclear materials; and the K-25 site, which presently serves as an operations center for environmental restoration and waste management programs. The K-25 site formerly provided enriched uranium for United States nuclear weapons (DOE 1995g). The land surrounding ORR is primarily rural, dominated by agricultural and residential land (Holdren et al. 1995).

The Clinch River provides an average of 69.3 million liters (18.3 million gallons) of water per day to ORNL and ORR. The Tennessee Valley Authority provides electric power. The current site load is 116 megawatts (META/Berger 1995).

As of 1991, the area within the Air Quality Control Region was designated as attainment with respect to all NAAQS for criteria pollutants. The Great Smoky Mountains National Park is the only PSD Class I area in the vicinity of ORNL. Since the promulgation of regulations, no PSD permits have been required for any emissions source at ORNL (DOE 1995g).

Winters are generally mild and summers are warm, with few extremes in precipitation, temperature, or winds (DOE 1995g). Summer thunderstorms are frequent. Tornado occurrence in the general region averages about 0.5 per year (DOE 1995f). The annual average temperature is 14.2 degrees Celsius (57.5 degrees Fahrenheit). The annual average precipitation is 139 centimeters (55 inches) (DOE 1995g).

The topography, primarily ridge-and-valley, is part of the Tennessee Valley and Ridge Province of the Southern Appalachian fold and thrust belt (Holdren et al. 1995). There is no evidence of active faulting in the immediate area, although many inactive faults are present at ORNL (DOE 1995g). Regionally, earthquake frequency averages 1-2 per year (META/Berger 1995). Since 1812, at least 26 earthquakes with a Modified Mercalli Intensity of II to VI have been recorded in the area (DOE 1995f). ORNL lies within Seismic Zone 2, indicating that the probability of future seismic damage is low to moderate (META/Berger 1995). The site lies on moderately-well to well-drained soils. Soil erosion has ranged from light to severe, and the present erosion potential is high in some areas (DOE 1995g). The typical soil in the area is a reddish-brown clay (DOE 1997b).

The Clinch River and its tributaries are the major surface water features of the area (Holdren et al. 1995). ORR streams receive effluents from treated sanitary wastewater, industrial discharges, cooling water blowdown, stormwater, surface water runoff, and groundwater. Substantial cleanup activities are required both on-site and off-site (DOE 1995g).

Although groundwater occurs in all formations that outcrop at ORNL and ORR, three major hydrologic units are present. Mechanisms and rates of flow appear to be controlled by topography,

structure, and lithology (Holdren et al. 1995). There are no Class I sole-source aquifers beneath the site. Very little groundwater is used; only one supply well exists on ORR. Background groundwater quality is generally good in surface and bedrock aquifer zones and poor at depths greater than 305 meters (1,000 feet) due to high total dissolved solids. Hazardous chemicals and radionuclides from weapons production process activities have contaminated groundwater in some areas. The contaminated sites include past waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities (DOE 1995g). ORR is included on the CERCLA National Priorities List.

ORR is heavily forested, with pine and pine-hardwood forest being the most extensive plant community, followed by oak-hickory forest (DOE 1995g). Approximately 20 percent of the site consists of wetlands; half of this is bottomland forest and half is pothole wetlands (META/Berger 1995). Approximately 5,500 hectares (13,590 acres) has been designated as a NERP (DOE 1995f). There are 88 federal- and state-listed threatened, endangered, and other special status species that have been identified on or in the vicinity of ORR. However, no critical habitat for threatened or endangered species exists on ORR (DOE 1995g).

More than 20 cultural resource surveys have been conducted on ORR. Over 45 prehistoric sites have been recorded, one site has been included in the NRHP, and several more are considered eligible. More than 240 historic resources have been recorded, and 50 of those sites may be eligible for the NRHP. The Graphite Reactor is a National Historic Landmark. There are also some resources that may be sensitive to Native American groups, including historic burial mounds, camps, quarries, chipping stations, limited activity locations, and shell scatters (DOE 1995g).

Four counties comprise the economic ROI in which about 92 percent of ORR employees live. The 1990 population of this ROI was about 489,000 (DOE 1995a). Minorities comprised 8.4 percent of this population, while 10.6 percent was below the poverty level (META/Berger 1995). The unemployment rate was 5.9 percent in 1991, and the per capita income was almost $17,000 (DOE 1997b). Major economic sectors include services, with over 26 percent of the region's total private sector nonagricultural activity; manufacturing (19 percent); and retail trade (17 percent) (DOE 1996b).

Interstate-40, located 2.4 kilometers (1.5 miles) south of the ORR boundary, provides the main access to the cities of Nashville and Knoxville, Tennessee. Interstate-75, located 24 kilometers (15 miles) south of the site serves as a major route to the north and south. Several state routes provide local access and form interchanges with Interstate-40. Railroad service is also available in the area (DOE 1995a).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-2} LCFs. The population within this area was 940,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 9×10^{-7} probability of an LCF. The corresponding dose is below the NESHAP limit.

4.2.9 Rocky Flats Environmental Technology Site (RFETS)

RFETS covers almost 17 square kilometers (7 square miles) in northern Jefferson County, Colorado. The site is located east of the foothills of the Rocky Mountains, approximately 25 kilometers (16 miles) northwest of Denver, Colorado. RFETS is situated in a generally rural

area with some ranches and industrial facilities nearby. Before January 1992, RFETS's primary mission was to produce nuclear weapon components from plutonium and other metals. The mission has now changed to decontamination and decommissioning, and the primary focus of the activities at RFETS is currently on environmental remediation and waste and materials management (META/Berger 1995).

The Denver Water Board from the Ralston and Gross Reservoirs provides the water supply for RFETS. Water is treated on-site at a plant with a maximum capacity of 3.8 million liters (1 million gallons) per day. The current site load for the treatment plant is 1.03 million liters (272,000 gallons) per day. The Public Service Company of Colorado supplies power to RFETS. The current site load for electricity is 18.3 megawatts (META/Berger 1995).

RFETS is located in an Air Quality Control Region that is a nonattainment area for the NAAQS criteria pollutants CO, O_3, and PM_{10} and an attainment area for the remaining criteria pollutants, SO_2, NO_2, and lead. Because the site is in a Class II PSD area, any new emission sources would have to adhere to the increment standards for a Class II area. The nearest Class I PSD area is Rocky Mountain National Park, approximately 50 kilometers (30 miles) northwest of RFETS (META/Berger 1995).

The climate in the area is semiarid. July is the warmest month, with daily maximum and minimum temperatures averaging 31 degrees Celsius (88 degrees Fahrenheit) and 15 degrees Celsius (59 degrees Fahrenheit), respectively. January is the coolest month, with daily maximum and minimum temperatures averaging 6 degrees Celsius (43 degrees Fahrenheit) and -9 degrees Celsius (16 degrees Fahrenheit), respectively. Annual precipitation is approximately 39 centimeters (15 inches), with about 80 percent falling from April through September (Holdren et al. 1995).

The topography at RFETS is generally flat except for areas along three creeks. Seismic activity in the area is low. An earthquake with a maximum horizontal acceleration of 0.21 gravity has an annual probability of occurrence of 1 in 5,000. The surface soils at the site are moderately deep, well-drained clay, cobbly clay, and sandy loams, with moderate-to-low permeability. Twenty-nine on-site locations monitor soil for plutonium contamination (META/Berger 1995).

There are five ephemeral streams at RFETS that form a west-to-east surface drainage pattern. The primary source of flood potential is from flash flooding in these streams; however, most facilities are located outside the 500-year floodplain. The site has seven National Pollutant Discharge Elimination System (NPDES) permitted outfalls, three of which discharge to surface waters that flow off-site. In 1992, only one case was reported in which the NPDES permit limits were exceeded, and this was for low pH at the wastewater treatment plant. Surface water is also monitored for radioactive and nonradioactive parameters in 3 on-site detention ponds. Monitoring of local drinking water supplies was discontinued in October 1992 (META/Berger 1995).

Groundwater systems at RFETS consist of a shallow, unconfined system in the Rocky Flats Alluvium and valley fill, and a confined system in the deeper sandstone units within the underlying bedrock. Recharge is from rainfall, snowmelt, leakage from other aquifers, and percolation from streams, ditches, and reservoirs. Discharge is by seeps, springs, base flow to streams, and evapotranspiration. Groundwater also leaves the area as subsurface flow. No aquifers in the area are sole source aquifers under the Safe Drinking Water Act regulations. The results of 1992

groundwater quality monitoring indicate that the groundwater in the area contains elevated levels of several VOCs, several radionuclides, and other contaminants (META/Berger 1995).

The major terrestrial communities at RFETS are mesic-mixed and xeric-mixed grassland (mixed tall- and short-grass communities), reclaimed grassland, riparian woodland, complex deciduous woodland and bottomland shrubland, tall upland shrubland, tall marsh, short marsh, and wet meadow. Wetlands represent 3.9 percent of the plant communities at RFETS and comprise a total of 100 hectares (250 acres). There are 40 federal- and state-listed threatened, endangered, proposed, candidate, and other special status species that are known to occur or may occur at RFETS (META/Berger 1995); in addition, the Preble's Meadow Jumping Mouse *(Zapus hudsonius preblei*) was recently proposed for federal listing.

RFETS has no properties designated as National Historic Landmarks or listed in the NRHP. According to the Colorado Historic Society, portions of the site have been the subject of at least three cultural resource investigations. The historic cultural resources in the area are archeological sites or standing structures associated with homesteads and ranching. Many Native American groups historically occupied or traversed the foothills area around RFETS. Important sites, such as burials or vision quest locations, and several unidentified rock features and alignments that have been recorded on RFETS may be of concern to Native American groups (META/Berger 1995).

Five counties comprise the economic ROI in which 92.5 percent of the site's 3,500 employees reside. In 1990, the ROI population was 1,790,600. The population was predominantly White (86.2 percent) with 7.2 percent of the total population living below the poverty level. In 1991, the unemployment rate for the ROI was 4.5 percent, and the per capita income in 1990 was $20,961. The dominant industries in the ROI include services, manufacturing, government, transportation and public utilities. These account for 68.1 percent of total earnings (META/Berger 1995).

The site is well served by both road and rail. Interstate-70, Interstate-25, and State Highways 72 and 93 serve the area. The city of Denver is a major railway hub in the Rocky Mountain region. A Southern Pacific line, approximately 1.6 kilometers (1 mile) south of the site, is the rail line nearest the plant and provides access to Denver. The nearest major airport is in Denver (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 1×10^{-4} LCFs. The population within this area was 2,100,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 1×10^{-9} probability of an LCF. The corresponding dose is below the NESHAP limit. Radiological monitoring of animals shows no notable uptake of radionuclides in deer and no ecologically appreciable quantities of plutonium or americium in small animals (META/Berger 1995).

4.2.10 Savannah River Site (SRS)

SRS is located approximately 20 kilometers (12 miles) south of Aiken, South Carolina, bordering the State of Georgia at the Savannah River. DOE activities conducted at SRS involve tritium recycling, support for the nation's space program missions, storage of plutonium on an interim basis, processing of backlog targets and spent nuclear fuel, waste management, and research and development (DOE 1995g).

Land use at SRS, which comprises 80,200 hectares (198,200 acres), is generally categorized as forest, water, or developed facility locations. A total of 77,400 hectares (191,300 acres) of SRS are undeveloped, of which 72 percent are forested. A majority of the woodlands, comprising 53 percent of the total site, are in revenue producing, managed timber production. DOE designated the entire SRS as a NERP, which allows the scientific study of the cypress swamp, southeastern pine, and hardwood forest ecosystems (DOE 1995g).

On-site wells provide an average of 6.1 million liters (1.6 million gallons) of water per day. The capacity of the system is 19 million liters (5 million gallons) per day. Both on-site and public supply sources provide electrical power. The existing site load is 130 megawatts (META/Berger 1995).

SRS is located near the center of the Augusta-Aiken Interstate Air Quality Control Region. The EPA classifies the areas within SRS and its surrounding counties as attainment areas with respect to the NAAQS for criteria pollutants. There are no known PSD Class I areas in the vicinity of SRS (DOE 1995g).

The SRS region is in a temperate climate with short, mild winters and long, humid summers. The average annual temperature is 19 degrees Celsius (66 degrees Fahrenheit); average daily temperatures vary from 3 degrees Celsius (38 degrees Fahrenheit) in January to 33 degrees Celsius (91 degrees Fahrenheit) in July. The average annual precipitation is 126 centimeters (50 inches) (DOE 1995g). Prevailing winds at SRS are from the southwest through west-northwest and from the northwest and east-northeast. The average annual wind speed is 5.7 meters per second (12.8 miles per hour) (DOE 1995g).

SRS is located in the Aiken Plateau portion of the Upper Atlantic Coastal Plain east of the Fall Line, a major physiographic and structural feature that separates the Piedmont from the Coastal Plain, in southeastern South Carolina. The soils at the site are mainly sandy and sandy loams. The site lies within a Seismic Zone 2 and is in an area where earthquakes capable of producing structural damage are not likely to occur. Probabilistic seismic hazard curves were developed for all DOE sites in the 1980s, and the results for SRS indicated that a peak acceleration of 0.19 gravity was associated with a probability of 2×10^{-4} per year (5,000-year return period). Since 1985, only three earthquakes, all of Richter magnitude 3.0 or less, have occurred in the immediate area of SRS (DOE 1995g).

The primary surface water feature is the Savannah River, which borders the site for approximately 32 kilometers (20 miles) to the southwest. There are six major streams that flow through SRS into the Savannah River, and approximately 190 Carolina bays scattered throughout the site. Carolina bays are naturally occurring land depressions that can hold water. The Savannah River and on-site streams are classified as fresh water suitable for primary and secondary contact recreation, as a source for drinking water supply following conventional treatment, fishing, and industrial and agricultural uses (DOE 1995g).

The most shallow aquifer at SRS is commonly referred to as the water table. Below the water table is the Congaree aquifer, and below it is the Cretaceous aquifer. Although there are variations, groundwater in the Cretaceous aquifer discharges predominantly along the Savannah River. The Cretaceous aquifer is an abundant and important water resource for the SRS region. Some of the local cities, such as Aiken, also obtain groundwater from the Cretaceous, but most of the rural population in the SRS region gets its water from the Congaree or water table. Groundwater quality

ranges from excellent (soft and slightly acidic) to poor (exceeding EPA drinking water standards for several constituents) in the vicinity of some waste sites. The Cretaceous aquifer is generally unaffected except for a relatively small portion of the site near existing waste treatment, storage, and disposal facilities that is contaminated with trichloroethylene. The Congaree aquifer is contaminated with trichloroethylene over a relatively small portion of the site in the northeast part of SRS and low levels of tritium in the General Separation areas. The water table is contaminated with solvents, metals, or low levels of radionuclides at several waste sites and facilities (DOE 1995g). SRS is included on the CERCLA National Priorities List.

There have been five major plant communities identified at SRS. The loblolly-longleaf-slash pine community is the dominant community covering approximately 65 percent of the site. Swamp forests and bottomland hardwood forests are found along the Savannah River. SRS supports a diverse and abundant wildlife community, including 43 amphibian, 58 reptile, 213 bird, and 54 mammal species. SRS contains approximately 19,850 hectares (49,030 acres) of wetlands, most of which are associated with floodplains, streams, and impoundments. Sixty-one federal- and state-listed threatened, endangered, and other special status species have been identified at SRS. There is potential habitat in some areas for the Red Cockaded Woodpecker (*Dendrocopus borealis*).

More than 60 percent of SRS has received some level of cultural resources evaluation. More than 800 prehistoric sites have been identified, although fewer than 8 percent have been evaluated for eligibility to the NRHP. Approximately 400 historic sites have been identified within SRS, ten of which are eligible for the NRHP. Literature reviews and consultations with Native American representatives reveal that there are some concerns related to the American Indian Religious Freedom Act within the central Savannah River valley.

Four counties in which 87 percent of all SRS employees reside compose the economic ROI. SRS currently employs approximately 16,300 persons (4.6 percent of the total regional economic area employment) (DOE 1995g). The total population in the ROI in 1990 was 460,028 with approximately 37 percent minority and 14 percent below poverty level. The ROI unemployment rate was 8.4 percent in 1991 (META/Berger 1995).

Interstate-20 is located approximately 29 kilometers (18 miles) northeast of SRS, providing the nearest interstate access to the site. State Routes 19, 64, and 125 are used by 40, 10, and 50 percent of the SRS commuters, respectively. SRS is served by more than 200 miles of primary roads on-site. Railroad service is also available through SRS (DOE 1995g).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 8×10^{-3} LCFs. The population within this area was 620,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-8} probability of an LCF. The corresponding dose is below the NESHAP limit.

4.3 REFERENCES CITED IN CHAPTER 4

Adcock, L., E.J. Nowak, and J. Myers, 1983, *The Socioeconomic Impact Review, Waste Isolation Pilot Plant Project*, Kirscher Associates, Inc., Carlsbad, New Mexico.

Adcock, L., et al., 1989, *The Social and Economic Impact of the Waste Isolation Pilot Plant (WIPP) on Southeastern New Mexico, FY 1988,* Report #ATD-89-1, United States Department of Energy Albuquerque Operations Office, Albuquerque, New Mexico.

Barker, J. M., and G.S. Austin, 1995, "Overview of the Carlsbad Potash District, New Mexico," *in: Evaluation of Mineral Resources at the Waste Isolation Pilot Plant (WIPP) Site,* Westinghouse Electric Corporation, Waste Isolation Division, Carlsbad, New Mexico.

Beauheim, R.L., et al., 1993, *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report*, SAND92-0533, Sandia National Laboratories, Albuquerque, New Mexico.

Broadhead, R.F., F. Luo, and S.W. Speer, 1995, "Oil and Gas Resource Estimates," in: *Evaluation of Mineral Resources at the Waste Isolation Pilot Plant (WIPP) Site*, Westinghouse Electric Corporation, Waste Isolation Division, Carlsbad, New Mexico.

BBER (Bureau of Business and Economic Research, University of New Mexico), 1995, *The Census in New Mexico, Vol. IV: Social and Economic Characteristics for the State and Counties from the 1980 and 1990 Censuses*, Albuquerque, New Mexico.

Corbet, T.F. and P.M. Knupp, 1996, *The Role of Regional Groundwater Flow in the Hydrogeology of the Culebra Member of the Rustler Formation at the Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico,* SAND96-2133, Sandia National Laboratories, Albuquerque, New Mexico.

Corbet T., 1997, *Integration of Hydrogeology and Geochemistry of the Culebra Member of the Rustler Formation in Vicinity of the Waste Isolation Pilot Plan,* Sandia National Laboratories, Expedited CCA Activity, WPO# 43215, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1979, *Mound Facility, Miamisburg, Ohio, Final Environmental Impact Statement,* DOE/EIS-0014, June, Washington, D.C.

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant,* DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1989, *Tiger Team Assessment of the Mound Plant, Miamisburg, Ohio,* DOE/EH-0117, December, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant,* DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1991, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1990*, DOE/WIPP 91-008, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1992, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1991*, DOE/WIPP 92-007, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1993a, *Waste Isolation Pilot Plant Land Management Plan*, DOE/WIPP 93-004, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1993b, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1992*, DOE/WIPP 93-017, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994a, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1993*, DOE/WIPP 94-2033, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994b, *Environmental Assessment for Commercialization of the Mound Plant*, DOE/EA-1001, October, Miamisburg, Ohio.

DOE (U.S. Department of Energy), 1995a, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*, DOE/EIS-0203-F, April, Washington, D.C.

DOE (U.S. Department of Energy), 1995b, *Environmental Assessment for Mound Plant Decontamination and Decommissioning Projects*, DOE/EA-0683, May, Miamisburg, Ohio.

DOE (U.S. Department of Energy), 1995c, *Environmental Assessment for the Operation of the Glass Melter Thermal Treatment Unit at the U.S. Department of Energy's Mound Plant, Miamisburg, Ohio*, DOE/EA-0821, June, Miamisburg, Ohio.

DOE (U.S. Department of Energy), 1995d, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994*, DOE/WIPP 95-2094, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995e, *Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement*, DOE/EIS-0228, August, Washington, D.C.

DOE (U.S. Department of Energy), 1995f, *Disposition of Surplus Highly Enriched Uranium Draft Environmental Impact Statement*, DOE/EIS-0240-D, October, Washington, D.C.

DOE (U.S. Department of Energy) 1995g, *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling*, DOE/EIS-0161, October, Washington, D.C.

DOE (U.S. Department of Energy), 1996a, *Final No-Migration Variance Petition*, DOE/CAO-96-2160, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, September, Washington, D.C.

DOE (U.S. Department of Energy), 1996c, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1995*, DOE/WIPP 96-2182.

DOE (U.S. Department of Energy), 1997a, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997b, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

EEG (Environmental Evaluation Group), 1995, *Radionuclide Baseline in Soil Near Project Gnome and the Waste Isolation Project Plant*, EEG-58, July, Albuquerque, New Mexico.

EPA (U.S. Environmental Protection Agency), 1989, *Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Test Areas, CY-1988*, EPA-600/4-89-019, May, Washington, D.C.

Hale, W. E., Hughes, L. S., and Cox, E. R., 1954, *Possible Improvement of Quality of Water of the Pecos River By Diversion of Brine At Malaga Bend, Eddy County, New Mexico:* Pecos River Commission, p 43.

Holdren, G.R., et al., 1995, *Environmental Settings for Selected U.S. Department of Energy Installations- Support Information for the Programmatic Environmental Impact Statement and the Baseline Environmental Management Report*, PNL-10550, Pacific Northwest Laboratory, Richland, Washington.

Hunter, R. L., 1985, *A Regional Water Balance for the Waste Isolation Pilot Plant (WIPP) Site and Surrounding Area*, SAND84-2233, Sandia National Laboratories, Albuquerque, New Mexico.

Jones, T.L., V.A. Kelley, J.F. Pickens, D.T. Upton, R.L. Beauheim, and P.B. Davies, 1992, *Integration of Interpretation Results of Tracer Tests Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant Site*, SAND92-1579, Sandia National Laboratories, Albuquerque, New Mexico.

Lansford, R., et al., 1988, *The Economic Impact of the Waste Isolation Pilot Plant on Southeastern New Mexico, FY 1987*, Special Report 82, Draft, New Mexico State University, Las Cruces, New Mexico.

Lansford, R., et al., 1994, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1993*, Albuquerque Operations Office, Department of Energy, July, 1994, Albuquerque, New Mexico.

Lansford, R., et al., 1995, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1994*, Albuquerque Operations Office, Department of Energy, July, 1995, Albuquerque, New Mexico.

Lansford, R., et al., 1996, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1995*, Albuquerque Operations Office, Department of Energy, August, 1996, Albuquerque, New Mexico.

Lappin, A.R., et al., 1989, *Systems Analysis, Long-Term Radionuclide Transport, and Dose Assessments, Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico: March 1989*, SAND89-0462, Sandia National Laboratories, Albuquerque, New Mexico.

META/Berger, 1995, *Technical Report on Affected Environment for the DOE Sites Considered in the DOE Waste Management Programmatic Environmental Impact Statement*, M/B SR-01, Gaithersburg, Maryland.

Neill, R.H., et al., 1996, *Review of WIPP Draft Application to Show Compliance with EPA Transuranic Waste Disposal Standards*, EEG-61, March, Environmental Evaluation Group, Albuquerque, New Mexico.

NMDG&F (New Mexico Department of Game and Fish), 1995, letter from Andrew V. Sandoval to Harold Johnson, Document Manager, U.S. Department of Energy, October 12, 1995, Santa Fe, New Mexico.

NMDOL (New Mexico Department of Labor), 1995, *Covered Employment and Wages, Fourth Quarter 1994*, October, Santa Fe, New Mexico.

Robinson, T.W., and W.B. Lang, 1938, *Geology and Ground-water Conditions of the Pecos River Valley in the Vicinity of Laguna Grande de la Sal, New Mexico, with Special Reference to the Salt Content of the River Water*, Twelfth and Thirteenth Biennial Reports of the State Engineer of New Mexico, pp. 77-118.

Sanford, A., K. Lin, and L. Jaksha, 1995, *A Report on the Seismicity of the WIPP Site for the Period April 1, 1995 Through June 30, 1995*, WD:95:02158, Westinghouse Electric Corporation, Carlsbad, New Mexico.

Silva, Matthew K., 1996, *Fluid Injection for Salt Water Disposal and Enhanced Oil Recovery as a Potential Problem for the WIPP: Proceedings of a June 1995 Workshop and Analysis*, EEG-62, Environmental Evaluation Group, August, Albuquerque, New Mexico.

Sivinski, R. and K. Lightfoot, eds., 1995, *Inventory of the Rare and Endangered Plants of New Mexico, Third Edition*, Miscellaneous Publication No. 4, August, New Mexico Forestry and Resources Conservation Division, Energy, Minerals, and Natural Resources Department.

SNL (Sandia National Laboratories), 1992, *Preliminary Performance Assessment for the Waste Isolation Pilot Plant*, December, Volume 1-5, SAND92-070013, Sandia National Laboratories, Albuquerque, New Mexico.

U.S. Bureau of the Census, 1994, *County and City Data Book: 1994*, Washington, D.C.

USFWS (U.S. Fish and Wildlife Service), 1995, Letter from Jennifer Fowler-Propst, Field Supervisor, Albuquerque, New Mexico, to Harold Johnson, Document Manager, U.S. Department of Energy, October 12, 1995, Carlsbad, New Mexico.

This page intentionally left blank.

CHAPTER 5
ENVIRONMENTAL IMPACTS

This chapter presents the results of environmental impact analyses for the Proposed Action, the three action alternatives, and the two no action alternatives. Environmental impacts of each alternative are discussed separately.

The environmental impacts that could result should the Proposed Action or any of the alternatives be implemented have been divided into four categories:

- Those impacts that would occur at the treatment sites due to the treatment and storage of transuranic (TRU) waste (for all alternatives), those that would occur both during and after long-term storage (for all alternatives except the Proposed Action), and those due to transporting the waste for treatment (for all alternatives except No Action Alternative 2)

- Those impacts that would occur due to transporting TRU waste from the treatment sites to the Waste Isolation Pilot Plant (WIPP) (except for the two no action alternatives)

- Those impacts that would occur due to waste handling, disposal, and decommissioning at WIPP (for the Proposed Action and all of the action alternatives) and the decommissioning of WIPP (for the no action alternatives)

- Those impacts that would occur due to releases associated with closure of the repository, long-term disposal of the waste, and any retrieval and recovery of the waste (for the Proposed Action and action alternatives)

As noted in Chapter 1, the Record of Decision (ROD) that followed the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) stated that an analysis of the impacts of processing and handling TRU waste at the treatment sites would be conducted. The U.S. Department of Energy (DOE or the Department) has analyzed TRU waste processing and handling at its sites in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997). Because estimates of TRU waste volumes and radionuclide and hazardous chemical inventories have been updated since those used in the WM PEIS were developed (as reported in Appendix A), a revised analysis of those impacts is included in this chapter. The following points highlight how impacts due to treatment and handling were assessed for this supplemental environmental impact statement (SEIS-II).

- WM PEIS annual air quality impacts at the treatment sites have been incorporated by reference and summarized in SEIS-II. The impacts assessed in the WM PEIS were considered appropriate because the facilities assumed in the WM PEIS analysis would be the same number, type, and size as those assumed in SEIS-II. Though additional waste would be treated under some SEIS-II alternatives, the assumed treatment period is 35 years rather than the 10 years assumed in the WM PEIS; therefore, the annual rate of treatment and annual air impacts would not increase.

- Estimated total life-cycle costs for the treatment and transportation of TRU waste to potential consolidation sites used the methods developed for the cost analysis in the WM PEIS. Total life-cycle costs for TRU waste treatment for the entire DOE Complex have been reported. Additional details on the estimated costs and the methods used for estimating these costs are presented in Appendix D.

- The impacts that may occur due to transporting TRU waste from the treatment sites to WIPP are based upon the alternatives presented in the WM PEIS. The impacts were based upon the updated TRU waste volumes and radionuclide and hazardous chemical inventories reported in SEIS-II. Similarly, the impacts due to waste handling at WIPP also were based on these updated inventories. Details on the transportation analyses are presented in Appendix E.

- Industrial safety impacts due to treatment facility construction and operation were adjusted from those in the WM PEIS. The adjustments were based upon the increased construction and operations time estimated under the SEIS-II alternatives. The WM PEIS anticipated 10 years of planning and construction followed by 10 years of operations. SEIS-II analyses anticipated 35 years of operation for all alternatives. Those SEIS-II alternatives requiring shred and grout facilities or thermal treatment facilities also included a 12-year planning and construction period.

- Impacts to water resources and infrastructure (including wastewater, power, and roadways) may occur due to construction and operation of treatment and storage facilities. The potential impacts presented in the WM PEIS are incorporated by reference and summarized in the following sections. No annual increases to these potential impacts would be anticipated due to differences between the inventories used for the WM PEIS and SEIS-II. As decisions are made regarding the specific location of TRU waste treatment and storage facilities, site-specific National Environmental Policy Act (NEPA) reviews will be conducted, as appropriate.

- Impacts to ecological resources, land use, and cultural resources may occur due to construction and operation of treatment and storage facilities. The WM PEIS reported that "major impacts to the resources at the sites are unlikely" because they can be avoided. The treatment facilities would need less than 1 percent of available land at proposed treatment site locations. Also, as decisions are made regarding the location of TRU waste treatment and storage facilities, site-specific NEPA reviews will be conducted, as appropriate.

ENVIRONMENTAL ANALYSES

The potential environmental impacts presented throughout Chapter 5 rely on information gathered during extensive site characterization and experimental programs and on the various scientific and engineering analyses performed by DOE since investigation of the WIPP site began in the late 1970s. Analyses used throughout SEIS-II are designed to provide conservative estimates of the reasonably foreseeable impacts that may occur.

Where appropriate, conservative assumptions are employed; thus, the analyses have a tendency to overestimate impacts. Typically, the analytical methods employed are examined in the appendices. A summary of the reasonably foreseeable impacts and key assumptions considered are presented throughout this chapter.

COMPARING ALTERNATIVES

When comparing the impacts and costs of SEIS-II alternatives, it is important to recognize that disposal at WIPP would isolate waste for more than 10,000 years, while continuing storage in facilities would isolate waste for a maximum of 100 years before reconstruction or disposal (at WIPP or some other location) would be necessary. SEIS-II alternatives that would dispose of the largest amount of waste at WIPP would isolate more waste for a longer period of time than those alternatives that would dispose of less waste while storing the rest. The differences in the degree of waste isolation that DOE would achieve for a given set of costs and impacts should be considered by the reader when comparing alternatives because these differences, in some cases, are noteworthy.

For purposes of comparison, each alternative presents the impacts that potentially would occur (1) at treatment sites due to waste treatment and storage, (2) as a result of transporting TRU waste among the sites and to WIPP for disposal, (3) at WIPP from TRU waste handling and disposal operations, and (4) as a result of long-term releases from the closed repository or storage facilities.

As appropriate, potential environmental impacts are further identified as either resulting from the Basic Inventory or the Additional Inventory, each of which is composed of contact-handled (CH) TRU waste and remote-handled (RH) TRU waste (see Table 3-18 for a summary of the results).

- Human health impacts from TRU waste treatment were adjusted from the impacts presented in the WM PEIS. Additional details on the methods used for adjusting these results are presented in Appendix B.

Potential environmental impacts from waste treatment, waste storage, transportation, disposal, and releases following WIPP closure are presented below for the Basic Inventory and the Additional Inventory, each of which includes contact-handled (CH)-TRU and remote-handled (RH)-TRU waste. These results are presented to facilitate comparisons within and between alternatives (see Table 3-18 for a summary of the results). Sums and products of numbers in this chapter may not appear consistent because of rounding.

5.1 IMPACTS OF THE PROPOSED ACTION (PREFERRED ALTERNATIVE, RESERVING RAIL TRANSPORTATION FOR FUTURE CONSIDERATION)

The environmental impacts associated with implementation of the Proposed Action are detailed within this section. The Proposed Action would continue with the phased development of WIPP by disposing of TRU waste at the facility. Under the Proposed Action, WIPP would accept only newly generated defense TRU waste and that post-1970, defense TRU waste in retrievable storage. Throughout this document this inventory is referred to as the Basic Inventory. Waste would be treated to meet the Waste Acceptance Criteria (WAC); for purposes of analysis, the current planning-basis WAC were used (DOE 1996c). Any consolidation under the Proposed Action would occur in the manner described in the ROD to be issued for the WM PEIS. For the purposes of analysis in SEIS-II, consolidation was assumed at 10 sites for CH-TRU waste and four sites for RH-TRU; the sites are shown in Figure 3-1 in Chapter 3. (The impacts should consolidation not occur, or limited consolidation as in the WM PEIS preferred alternative occur, are presented in a text box at the end of Section 5.1). Treatment at the sites and disposal at WIPP would occur over a 35-year operating period, through the year 2033. A more detailed description of the Proposed Action is given in Section 3.1.

5.1.1 Land Use and Management

DOE found in the WM PEIS that the facilities needed to manage and treat TRU waste under the Proposed Action would require less than 1 percent of the land available for such activities at each proposed treatment site. In calculating the percentage, DOE removed from consideration any acreage with known cultural resource areas, sensitive habitats (including wetlands and wildlife management areas), prohibitive topographic features, and surface water. As a result, the WM PEIS states that DOE would "have considerable flexibility in locating those facilities and impacts to on-site land use would probably be minimal." The Department would be able to minimize impacts to on-site land use and avoid conflicts with any off-site land use plans (DOE 1997). The Department also would locate treatment facilities such that sensitive or inappropriate areas would be avoided. These sensitive or inappropriate areas would include flood plains, wetlands, known cultural resource areas, and the habitats of threatened or endangered species.

No substantial changes in this finding due to differences between the WM PEIS and SEIS-II were determined. The WM PEIS also assumed that the facilities would be large enough to treat all of the TRU waste in 10 years (for consistency of analysis across waste types); for SEIS-II, it was assumed that treatment would be completed within 35 years, as the waste is generated. Although the SEIS-II operations time would be three and one-half times longer than that anticipated under the WM PEIS, the size and number of the treatment facilities needed for this SEIS-II alternative would be the same as those analyzed for the WM PEIS. The specific location of treatment and waste management facilities within each site would be selected following additional site-wide or project-level NEPA reviews (for an explanation of tiered NEPA reviews, see Appendix B).

Under the Proposed Action, DOE would continue to occupy the land transferred to it by the WIPP Land Withdrawal Act (LWA). DOE would exercise its easements on land outside the WIPP withdrawal area for such uses as groundwater surveillance pads, signs, and transportation and utility corridors. The total aboveground disturbed area is estimated to be 20 hectares (50 acres), equal to the area of the current aboveground facilities. Additional construction at WIPP would be limited to its underground disposal area. During the closure period when a berm and permanent markers would be constructed over the underground disposal area, a total of 70 hectares (173 acres) would be disturbed.

Local WIPP land use includes grazing, recreation, and mining (Section 4.1.1). Currently, an area of 120 hectares (300 acres) is fenced and posted to prevent grazing, trespassing, or other uses. Other grazing areas within the withdrawn area are managed pursuant to the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996a). Access to a 590-hectare (1,454-acre) area of the WIPP site (the "Off Limits Area") is currently restricted to grazing (see Figure 4-2). Other areas are open to the public; however, various resources in the withdrawn area are protected. The LWA prohibits any surface or subsurface mining unrelated to the WIPP project, with the exception of two hydrocarbon leases. No activity is occurring under these leases, and the Department may acquire these leases in the future. The Proposed Action would continue these restrictions and land use management practices throughout the disposal and post-closure periods.

5.1.2 Air Quality

For TRU waste treatment, the only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be carbon

monoxide (CO) at the Rocky Flats Environmental Technology Site (RFETS) (17 percent) (see Appendix C). RFETS, Lawrence Livermore National Laboratory (LLNL), Nevada Test Site (NTS), and Argonne National Laboratory-East (ANL-E) are in nonattainment areas for some of the pollutants. In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the Prevention of Significant Deterioration (PSD) of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations. No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard during normal accident-free treatment (DOE 1997). Particulate matter less than or equal to 10 microns in diameter (PM_{10}) levels may increase during construction.

For SEIS-II, air quality impacts from operation of WIPP under the Proposed Action have been updated from those contained in Section 9.4.5 of the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and referenced in SEIS-I (DOE 1990). SEIS-II air quality analyses also include information on the salt pile fugitive dust emissions (Tillman 1988b), emissions of particulates from the ventilation system (Tillman 1988a) not included in SEIS-I, and reflect fewer salt pile releases from bulldozer activity and fewer emissions from mining and support equipment because they would be smaller, electric, or would be used less often (Hollen 1996) than reported in the FEIS or SEIS-I.

The four criteria pollutants considered at WIPP were nitrogen dioxide (NO_2), sulfur dioxide (SO_2), CO, and PM_{10}. Volatile organic compounds (VOC), as ozone precursors, were also considered. Potential impacts were determined using the methods described in Appendix C. There would be only negligible releases of two other criteria pollutants, ozone and lead, under the Proposed Action. Principal emission sources of particulates from operation of WIPP under the Proposed Action are (1) exhaust from underground mining, (2) surface salt handling, (3) wind erosion of the salt pile, and (4) fuel combustion from two back-up diesel generators and mining and support equipment. Fuel combustion would be the principal source of NO_2, SO_2, and CO.

Estimates of criteria pollutant air quality impacts from WIPP disposal operations under the Proposed Action are provided in Table 5-1. WIPP would remain an attainment area for all criteria pollutants, and there would be no impact to nearby national parks (Carlsbad Caverns and Guadalupe Mountains) which are Class I attainment areas. Increases in annual concentrations of each analyzed pollutant would be small (less than 2 percent of the regulatory limit). Some 24-hour impacts could be, on a short-term basis, as high as 65 percent of regulatory limits (for NO_2) due primarily to use of backup generators. These estimates represent an upper limit to the 24-hour impacts owing to the conservative assumptions used in the modeling. These conservative assumptions included that low-velocity wind would blow directly at a receptor under stable atmospheric conditions, thus minimizing dispersion and maximizing concentrations. Calculated VOC releases (an ozone precursor) were compared to the New Mexico PSD regulation (Air Quality Control Regulation [AQCR] 707), a major source screening criteria for ozone (40 tons per year). Calculated VOC emissions (an ozone precursor) from waste disposed of in WIPP would not exceed 2 percent of this level. Radionuclide releases would be less than 0.1 percent of the limit specified in the National Emissions Standard for Hazardous Air Pollutants (NESHAP) (40 Code of Federal Regulations [CFR] 61, Subpart H).

Table 5-1
Impacts on Air Quality at WIPP for the Proposed Action

Criteria Pollutant	Averaging Time	Concentration at Maximally Impacted Point of Unrestricted Public Access (μg per cubic meter)	Regulatory Limit (μg/cubic meter)	Percent of Regulatory Limit
PM_{10}	Annual	0.67	50 [a]	1.3
	24-hour	85	150 [a]	57
NO_2	Annual	0.28	84 [b]	0.3
	24-hour	110	168 [b]	65
SO_2	Annual	0.02	47 [b]	0.05
	24-hour	8.5	234 [b]	3.6
	3-hour	77	1,170 [c]	6.6
CO	8-hour	110	8,900 [b]	1.3
	1-hour	410	13,400 [b]	3.1

[a] National primary ambient air quality standard (40 CFR Part 50).
[b] New Mexico ambient air quality standard (AQCR 201) corrected for altitude.
[c] National secondary ambient air quality standard (40 CFR Part 50) corrected for altitude.

The plans for decommissioning WIPP under the Proposed Action are described in Section 3.1.3.5. Potential air quality impacts could result from the construction of berms around and permanent markers in the surface area overlying the underground disposal area, dismantling all the aboveground structures on the site, and reclaiming the salt pile. Specifically, air quality impacts would be the result of fugitive dust and emissions from heavy-duty construction equipment typical of a large construction project. Reclaimed salt may be used to either close the shafts or as a base for the berm. Excess salt may be sold for other purposes and transported off-site by private carrier. Decommissioning would produce temporary increases in dust and other criteria pollutants but no substantial long-term impacts.

5.1.3 Biological Resources

Analyses conducted during the WM PEIS determined that construction and operation of TRU waste treatment facilities should not have major adverse effects on populations of nonsensitive plant and animal species for two reasons: (1) no more than 11 hectares (28 acres) would be disturbed at any site, and (2) the habitats for these species are well established regionally near the proposed treatment sites. Site activities are not expected to affect ecosystem balance or biodiversity. Also, because so little land would be required for the waste management and treatment facilities, DOE would be able to locate the new facilities to avoid impacts to sensitive habitat areas (see Section 5.1.1).

Threatened and endangered species appear at all of the proposed treatment sites and could potentially be impacted; however, whether there would be impacts depends on the actual location of the facility at a particular site. Such species and their critical habitats would be avoided, and appropriate consultation, monitoring, and mitigation measures would be undertaken. Site selection would be conducted following site-wide or project-level NEPA review during which such impacts would be assessed. The WM PEIS analyses also determined that terrestrial wildlife species were unlikely to be affected by airborne emissions from waste management or treatment facilities, or from spills of TRU waste into aquatic environments due to traffic accidents. These findings of the

WM PEIS also are applicable to SEIS-II, though a larger inventory would be treated under the Proposed Action than that considered for the WM PEIS because the size and number of facilities would be the same.

Federally listed, threatened and endangered, and state-listed species occur in Eddy and Lea counties and potentially at WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE recently completed a biological survey, during which no threatened, endangered, or state-listed species were identified at the WIPP site, and the results are being shared with the U.S. Fish and Wildlife Service.

At WIPP, vegetation-monitoring data from 1989 through 1993 were consistent with those reported in SEIS-I (DOE 1990), which indicated no salt-related stress in vegetation except for that directly near the salt pile. At the salt pile, based on past observations, increased shrub cover near the salt cuttings is anticipated due to colonization by saline-tolerant species such as the fourwing saltbush (*Atriplex canescens*) (DOE 1995c). Throughout the WIPP site, however, no change in foliage was occurring at the time of SEIS-I, and recent environmental reports indicate that this is still the case (DOE 1991, 1992, 1993, 1994b, and 1995c). SEIS-I also reported a salt buildup in the soil below 75 centimeters (30 inches) but stated that it was not affecting the vegetation and that the buildup was not expected to continue. During disposal operations, the salt pile is anticipated to stabilize as a 12-hectare (30-acre) working pile, which would not affect the ecosystem balance. Salt tolerant plant species would replace less saline-tolerant species such as the black grama grass (*Bouteloua eriopoda*) and are not expected to affect site ecosystem balance or biodiversity (DOE 1994b).

Over 10 years of avian survey data at WIPP (from 1984 through 1994) have revealed no discernible impacts on densities and distributions of breeding birds due to activities in the areas adjacent to the surface facilities. The Cooperative Raptor Research and Management Program has reported no adverse effects to raptors from WIPP activities. In addition, no adverse effects to small mammals from WIPP operations have been reported (DOE 1995c). Negligible impact to plant and animal communities near the WIPP site would be expected because almost all of the proposed operations would be conducted underground or in areas already developed.

Decommissioning and closure of the WIPP site would result in the dismantling of all aboveground structures and reclamation of the area. These activities would affect approximately 70 hectares (175 acres), resulting in the loss of much of the plant community and avian and small mammal habitats within and near the area. DOE would return decommissioned lands used in the operation of WIPP to a stable ecological condition and maintain or enhance the ecological condition of wildlife habitat within the WIPP Land Withdrawal Area (DOE 1996a).

5.1.4 Cultural Resources

Because cultural resources at many of the treatment sites are eligible or potentially eligible for the National Register of Historic Places (NRHP), construction and operation of TRU waste management and treatment facilities could have an adverse effect. Site-level cultural resource surveys would be conducted and protection measures established, where necessary, when specific facility locations are proposed (DOE 1997). These surveys would be part of site-wide or project-level NEPA reviews. Any Native American sacred sites and burial grounds would be avoided and appropriate consultation would be undertaken.

At WIPP, disposal surface activities and salt pile maintenance would take place within already disturbed areas of the Property Protection Area. Because no new construction of surface features would occur, impacts to cultural resource properties are not anticipated as part of the shipping, waste handling, or emplacement operations. Previous research of the site cultural resources has identified and evaluated individual properties and mitigated, as necessary, potential impacts from the construction of surface features in the Property Protection Area. No Native American sacred sites or burial grounds have been identified to date.

Activities undertaken in conjunction with closure and decommissioning under the Proposed Action, may have potentially adverse impacts on cultural resources, depending on the ultimate design of the permanent marking system and the berm. Two prehistoric archaeological sites, LA33179 and LA33180, are located within the proposed surface closure area. Both sites were evaluated as being potentially eligible for inclusion on the NRHP (DOE 1995c). Site LA33179 was subjected to surface collection of artifacts and subsurface testing in 1981 (DOE 1996a). Site LA33180 appears to be partially buried and may require testing and mitigation activities if important subsurface cultural deposits are present.

Measures for ensuring protection of known archaeological and historic resources, or others that may be inadvertently discovered during ground-disturbing activities, are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996a). These measures include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the maximum extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed under the recently signed Joint Powers Agreement with the State of New Mexico.

5.1.5 Noise

According to the WM PEIS, treatment facilities would probably be placed at industrial-type sites along high traffic volume corridors; therefore, treatment should not substantially increase ambient noise levels. Still, the WM PEIS notes that sensitive receptors may be impacted. Site-specific noise impacts will be assessed in a site-wide or project-specific NEPA document when siting treatment facilities. Noise impacts due to waste transportation to or from the treatment sites would be less than noise levels near the WIPP site (discussed below). Under this alternative, all waste would travel to WIPP but only a portion of the waste would travel to or from each treatment facility.

Noise impacts at the WIPP site were initially evaluated in the FEIS (DOE 1980) which provided a qualitative evaluation of operational impacts that remains accurate for SEIS-II. The FEIS determined that an overall sound pressure level of 50 decibels might occur 120 meters (400 feet) from the Waste Handling Building due to normal operations. The noise should not be heard at the nearest residence. The FEIS also indicated that should all of WIPP's equipment be operated at once or its emergency generators tested simultaneously, the noise level may increase. However, the FEIS also states that the levels would typically be within acceptable limits as established by the U.S. Department of Housing and Urban Development (DOE 1980).

Under the Proposed Action, all truck transportation of TRU waste would travel through Carlsbad, New Mexico (see figures in Appendix E for routes). Waste from all of the sites east of the Mississippi River would arrive from the south on U.S. 285. Waste from all other sites would come from the north on U.S. 285, passing through Vaughn, Roswell, and Artesia, New Mexico,

prior to arriving at Carlsbad. Trucks would arrive at random times throughout two WIPP working shifts. Impacts were estimated based on a maximum throughput of 50 TRUPACT-IIs and eight RH-72Bs per week, corresponding to a maximum of eight trucks per day. Data from the New Mexico State Highway and Transportation Department (NMSH&TD 1997) showed annual average daily traffic at the intersection of Canal and Greene streets in Carlsbad to be approximately 7,700 in 1994. In 1996, estimated daily traffic was approximately 7,900. The increase in noise associated with the Proposed Action's additional truck traffic would be negligible compared to the background noise level associated with existing automobile and truck traffic in Carlsbad and along the transportation corridors.

5.1.6 Water Resources and Infrastructure

Negligible impacts on water resources are expected at the treatment sites due to the Proposed Action. The WM PEIS assessed water availability issues by identifying whether water needs during construction and operation of treatment facilities would increase by more than 1 percent at the DOE facilities proposed as treatment locations. Under this alternative, only Idaho National Engineering and Environmental Laboratory (INEEL), LLNL, and RFETS would have such increases. The increases would be 1.2, 2.8, and 2.1 percent, respectively, and could be accommodated by existing water supplies.

Although no off-site annual infrastructure impacts would be expected at the treatment sites, proposed TRU waste activities would affect on-site activities. The affected infrastructure elements analyzed were on-site transportation and the capacity of on-site water, power, and wastewater systems. Water and power were evaluated for both construction and operations; wastewater treatment was evaluated only for operations because construction wastewater was assumed to be negligible (DOE 1997).

Under the Proposed Action, only the Hanford Site (Hanford) would show an increase in on-site demand for wastewater treatment that would exceed 5 percent of current demand (5.9 percent). Major impacts to water resources at the sites would be unlikely for treatment of TRU waste (DOE 1997).

Minor impacts to the on-site transportation infrastructure under the Proposed Action might occur. These impacts would be the result of an increase in on-site employment of 6 percent at Hanford and INEEL and 7 percent at Los Alamos National Laboratory (LANL). Impacts to the off-site transportation infrastructure are not anticipated because population increases would not exceed five percent (DOE 1997).

Disposal operations at WIPP would result in increased vehicle traffic from both the site work force and waste transport vehicles, but no new construction of roads or rail lines by DOE for waste transport is anticipated. Negligible annual infrastructure impacts would be expected at WIPP under the Proposed Action. Existing water supply and sewer capabilities, and existing and planned power and roadway resources would be able to accommodate proposed disposal operations.

5.1.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts under the Proposed Action are presented in the following subsections.

5.1.7.1 Life-Cycle Costs

Life-cycle costs under the Proposed Action are presented in Table 5-2 for three areas: waste treatment facilities, waste transportation, and WIPP disposal operations. Waste treatment facility costs include construction, operations and maintenance (O&M), and decontamination and decommissioning (D&D) at the TRU waste treatment sites. These sites would process, treat, and package waste over a period of 35 years to meet planning-basis WAC. The waste treatment facility costs, excluding storage costs for any excess RH-TRU waste, are estimated to be $11.83 billion, or an annualized cost of $340 million (in 1994 dollars). The waste transport costs include the costs of consolidating waste volumes at the 10 sites and then shipping the treated volumes to WIPP for disposal over the 35-year period. The waste transport costs are estimated to be $1.59 billion, or an average of $45 million per year. Finally, the WIPP site life-cycle costs are projected to be $5.3 billion, or $150 million per year. The WIPP site life-cycle costs cover a 35-year waste emplacement period followed by a 10-year decommissioning period. The total life-cycle cost of the Proposed Action is $19.03 billion or $10.13 billion when discounted. More details regarding life-cycle costs may be found in Appendix D. The cost impacts would be essentially the same should waste not be consolidated.

DOE is restricted by the Consultation and Cooperation Agreement (C&C) to disposal of a maximum of 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste at WIPP. Thus, there is approximately 43,000 cubic meters (1,530,000 cubic feet) of RH-TRU waste under the Proposed Action that could not be disposed of at WIPP and that would require long-term storage at the treatment facilities.[1] Based on WM PEIS storage cost estimates presented in the site data tables for Hanford and Oak Ridge National Laboratory (ORNL), the additional life-cycle cost of storing the excess RH-TRU waste for 35 years would be approximately $310 million (in 1994 dollars) or $170 million when discounted. (These costs are included in the total life cycle costs for the Proposed Action.) The need for this type of storage is not necessary under the action alternatives because the action alternatives assume that all TRU waste would be disposed of at WIPP.

Table 5-2
Life-Cycle Costs for the Proposed Action
(in millions of 1994 dollars) [a]

Cost Information	Basic Inventory CH-TRU Waste	Basic Inventory RH-TRU Waste	Basic Inventory CH-TRU and RH-TRU Waste	Discounted Basic Inventory CH-TRU and RH-TRU Waste
Treatment Facilities	8,850	2,980	11,830	6,560
Transport by Truck	1,260	330	1,590	880
Disposal at WIPP	4,200	1,100	5,300	2,500
Excess RH-TRU Waste Storage	---	310	310	170
Total Life-Cycle Cost	14,310	4,720	19,030	10,130

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Totals may differ due to rounding.

[1] The most recent volume estimates for RH-TRU waste are much lower than those used in SEIS-II. Those estimates indicate all currently stored post-1970, defense RH-TRU waste and waste to be generated could be disposed of in WIPP. See Appendix J.

LIFE-CYCLE COSTS AND DISCOUNTING

A life-cycle is the entire life of a project from conceptual design to completion (through decommissioning). For these analyses, life-cycle costs at WIPP comprise waste management and disposal costs at the WIPP facility from the beginning of the disposal phase through decommissioning. At the treatment facilities, the life-cycle costs include all activities from conceptual design through closure. Total life-cycle costs also include transportation costs.

To allow for more consistent program evaluations relative to the various WM PEIS estimates, the SEIS-II estimates are presented in 1994 dollars. Moreover, to allow for more consistent program evaluations relative to the various SEIS-II alternatives the life-cycle cost estimates are also presented in present value terms. The practice of discounting future costs gives more weight to money that is spent in the near future compared to money spent in the distant future. The justification for discounting future dollar values stems from the desire to know the equivalent, present-day values. For example, if $100,000 of expenses are anticipated during the 50th year of a project and the discount value is 5 percent per year, the equivalent present-day value would be $8,208.50, assuming that the $8,208.50 was reinvested continuously for 50 years with 5 percent compound interest. Thus, the process of discounting future dollar values reflects the common-sense understanding that money at the present time is worth more than money at a future time, as it takes only $8,208.50 today to produce $100,000 in 50 years.

The present value of the life-cycle costs was estimated using a 1996, inflation-adjusted annual discount rate of 4.1 percent. Economic impact estimates are based on life-cycle cost estimates and are not discounted further. These estimates represent annual effects over the life of the alternative.

5.1.7.2 Economic Impacts

TRU waste treatment activities would support direct, indirect, and induced jobs. The Proposed Action would support approximately 11,900 jobs in the regions of influence (ROI) of the 10 major treatment sites (ANL-E, Hanford, INEEL, LANL, LLNL, the Mound Plant [Mound], NTS, ORNL, RFETS, Savannah River Site [SRS]).

Estimates of the impacts of the Proposed Action on employment, income, and the production of goods and services within the WIPP ROI are presented in Table 5-3. These regional impacts are estimated using an average project budget of $180 million per year over a 35-year period of waste disposal operations. Over this period, the WIPP facility would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 project personnel annually. The operation of WIPP (from 1998 through 2033) would annually support 2,443 indirect and induced jobs in the ROI work force. The estimates of total WIPP-induced employment within the ROI reflect the sum of these direct, indirect, and induced employment levels. In percentage terms, the Proposed Action could result in supporting as much as 7.9 percent of all employment in the ROI. Appendix D provides details regarding these estimations and impacts specific to the local Carlsbad economy.

Table 5-3
Economic Impacts Within the WIPP ROI for the Proposed Action

Economic Effects	Total Output of Goods and Services (in millions of 1994 dollars)	Total Employment (Full- and Part-Time Jobs)	Total Labor Income (in millions of 1994 dollars)	Carlsbad Output of Goods and Services (in millions of 1994 dollars)	Carlsbad Employment (Full- and Part-Time Jobs)	Carlsbad Labor Income (in millions of 1994 dollars)
Direct – Annual	113	1,095	52	95	979	46
Indirect & Induced – Annual	204	2,443	75	172	2,185	67
Total – Annual	317	3,538	126	267	3,164	113
Total - Operations (35 years)	11,079	123,830 [a]	4,411	9,345	110,740 [a]	3,955

[a] Job-years (number of annual jobs supported multiplied by the number of years in the project).

Because the projected annual budget is close to levels observed from 1988 to 1996, the Proposed Action is not expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection) nor should it require major capital investments in public infrastructure within the ROI. For this same reason, the Proposed Action is not expected to impact the local real estate market or result in major changes in the work force population. (Discussion of the economic impacts resulting from WIPP's closure is in the discussion of No Action Alternative 1.)

5.1.8 Transportation

This section examines the potential environmental impacts of transporting TRU waste in accordance with the consolidation, treatment, and disposal methods described for the Proposed Action in Chapter 3. The results shown here update the results of SEIS-I. SEIS-II uses essentially the same methods for assessing transportation impacts as were used for SEIS-I. The major differences between the two sets of analyses are the following:

- SEIS-II analyses use 1990 Census data for population impacts. These data were not available for SEIS-I.
- SEIS-II analyses include transportation of TRU waste from several sites that are storing small quantities of the waste. Transportation of this waste was not considered in SEIS-I.
- SEIS-II analyses use a larger TRU waste inventory.
- SEIS-II analyses consider three transportation risk assessments prepared since SEIS-I was published. They are the *Comparative Study of WIPP Transportation Alternatives* (DOE 1994a), the WM PEIS (DOE 1997), and the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995d).

In assessing the impacts of transporting TRU waste, several measures were used. The most fundamental of these was the number of traffic accidents, fatalities, and injuries likely to occur as a result of transportation unrelated to the waste type. Another impact assessed was that caused by vehicle emissions (diesel exhaust); this impact is termed pollution health effects. A third measure, termed accident-free radiological impacts, is associated with the external radiation present around a TRUPACT-II or RH-72B container as it is being shipped. The general public and transportation workers would be exposed to very low levels of radiation during shipment. The final measure is

associated with accidents that are severe enough to breach the waste packages and release some of the radioactive and hazardous material being shipped.

The first step in all of these analyses was to determine the highway routes that would be used for transporting waste to WIPP. All of the impacts are a function of route characteristics, the number of shipments via each route, and, for the accident risks, the accident environment associated with a particular mode of transportation and the behavior of the waste form and packaging in that accident environment. Therefore, a major focus of this section is to summarize important route characteristics, the waste shipment volumes using each route, and the impacts of potential accidents.

The following sections estimate the impacts of shipping TRU waste to WIPP. The first subsection is devoted to developing the data needed. It is followed by subsections devoted to analyzing the various transportation impacts associated with transporting waste. Each section also presents the impacts for transporting waste from sites with smaller quantities to the treatment sites. The results of the truck transportation analyses to WIPP were adjusted to account for the additional miles and shipments between these sites.

5.1.8.1 Route Characteristics and Shipment Projections

Under the Proposed Action, waste destined for WIPP would originate at 18 sites around the United States. Many of these sites have generated small quantities of TRU waste and are no longer generating waste. The waste present at these sites could be shipped to one of 10 sites with larger TRU waste volumes (see Chapter 3 for tables and maps detailing the consolidation). The number of CH-TRU and RH-TRU waste shipments from each of these 10 sites to WIPP under the Proposed Action are shown in Table 5-4. The number of TRU waste shipments is primarily dependent on limitations concerning weight, gas generation, plutonium-239 equivalent curies (PE-Ci), and thermal power limits that are incorporated into the planning-basis WAC. The methods used to determine the number of shipments are outlined in Appendix A.

Table 5-4
Number of Truck Shipments to WIPP for the Proposed Action [a]

Waste Treatment Site	CH-TRU Waste	RH-TRU Waste
Argonne National Laboratory-East	28	0
Hanford Site	13,666	3,178
Idaho National Engineering and Environmental Laboratory & Argonne National Laboratory-West	5,782	3,136
Lawrence Livermore National Laboratory	162	0
Los Alamos National Laboratory	5,009	367
Mound Plant	59	0
Nevada Test Site	86	0
Oak Ridge National Laboratory	251	1,276
Rocky Flats Environmental Technology Site	2,485	0
Savannah River Site	2,238	0
Total	**29,766**	**7,957**

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. There would be 27 CH-TRU waste shipments and 958 RH-TRU waste shipments. Impacts from the transportation of TRU waste to the major treatment sites (see Appendix E) are small relative to impacts from shipment between the major treatment sites and WIPP.

The HIGHWAY code (Johnson et al. 1993) was used to estimate trip lengths from the 10 major treatment facilities to WIPP and to estimate the corresponding population density fractions along the routes. Built into the HIGHWAY code are the routes that were selected by the states and accepted by the Department of Transportation for the shipment of route-controlled quantities of radioactive materials. Not all shipments to WIPP will fall within the definition of a highway route-controlled quantity (HRCQ) (49 CFR Part 173.403(l)), DOE, as a matter of policy, has determined that all shipments, whether they are empty or full and whether or not they meet the definition of HRCQs, will use the U.S. Department of Transportation (DOT) preferred routes as defined in 49 CFR Part 397 Subpart D. Selected routes, shown in Appendix E, generally follow interstate highways. The major exception to this is New Mexico, where the state has selected U.S. Highway 285 as the primary northern route between Interstate-25 near Santa Fe, New Mexico, and WIPP, and the southern route between Interstate-20 at Pecos, Texas, and WIPP. Table 5-5 presents the total miles from the 10 major treatment sites to WIPP and the total miles along the route for rural, suburban, and urban population zones for potential shipments to WIPP under the Proposed Action.

Table 5-5
Mileage for Shipping TRU Waste by Truck to WIPP for the Proposed Action [a]

Origination Site	Total One-Way Truck Mileage	Miles in Each Population Zone		
		Rural	Suburban	Urban
Argonne National Laboratory-East	1,696	1,412	259	25
Hanford Site	1,807	1,645	144	18
Idaho National Engineering and Environmental Laboratory & Argonne National Laboratory-West	1,392	1,263	114	15
Lawrence Livermore National Laboratory	1,452	1,304	100	48
Los Alamos National Laboratory	341	318	21	2
Mound Plant	1,764	1,359	382	23
Nevada Test Site	1,214	1,137	64	13
Oak Ridge National Laboratory	1,439	1,160	265	14
Rocky Flats Environmental Technology Site	704	619	71	14
Savannah River Site	1,535	1,203	315	17

[a] The mileage from sites with small quantities of waste to the treatment sites can be found in Appendix E.

5.1.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

Although the transportation of TRU waste cannot be made entirely impact free, reasonable planning and control strategies can usually reduce impacts to a level below that of comparable shipments (for example, commercial shipments of hazardous materials such as gasoline). WIPP would use such strategies to reduce impacts. A complete picture of the planning and control strategies are presented in Appendix C, Appendix L, and Appendix M of SEIS-I, and Appendix E of this document. Appendix C of SEIS-I summarizes emergency response training, procedures, and plans for the WIPP shipping campaign. Appendix L of SEIS-I summarizes the design, certification, and operation of the TRUPACT-II shipping container for CH-TRU waste and the NuPac 72B shipping cask for RH-TRU waste (the RH-72B is very similar in design to the NuPac 72B). Appendix M of SEIS-I (and Section 3.1.2.1 of this document) summarizes a trucking contract, including qualification standards and training requirements for drivers, and quality assurance standards applicable to operational activities. The qualifications and quality assurance standards are essentially unchanged since SEIS-I.

As outlined in the *Transuranic Materials Transportation Guide* (DOE 1996b), the trucking contractor is responsible for the routing of shipments in accordance with federal, state, Tribal, and local regulations. DOE, on behalf of the contractor, has coordinated these routes with the affected states. The DOE Carlsbad Area Office (CAO) is responsible for providing a plan (DOE 1995a) for responding to emergencies involving TRU waste transportation. The plan has been completed and is available upon request. The level of response to an accident would be determined by the DOE Albuquerque Office, based on the type of accident as outlined in the CAO emergency response plan. The levels are defined as 0 through III, with 0 representing the lowest severity (a minor accident), I representing potential penetration of TRU waste packaging, II representing definite penetration, and III representing a definite release or the need for repackaging.

Once the appropriate level of response has been established, a team would respond with the necessary equipment. The team would also coordinate with the carrier to expedite recovery of TRU waste and the packaging. Personnel would be on call 24 hours a day when shipments are en route.

For the SEIS-II analyses of accidents, injuries, and fatalities, truck accident statistics compiled for each state by highway type were used to determine route-specific accident, injury, and fatality rates (Saricks and Kvitek 1994). The route mileage through each state, obtained using HIGHWAY, was multiplied by the state traffic accident, injury, or fatality rates. The products were then summed for the route, and the sums were divided by the total route mileage. With the exception of the State of New Mexico, the accident rate data for federally aided interstate highways were used. For New Mexico, because much of the waste would travel on U.S. Highway 285, the rate for federally aided primary roads was used.

Once the route-specific accident, injury, and fatality rates per route were obtained, they were multiplied by the number of shipments along each route to obtain the estimated number of accidents, injuries, and fatalities. These impacts were estimated using round-trip mileage and adjusted to account for the small number of shipments between the 10 sites with small amounts of waste and the 10 major treatment sites.

For the Proposed Action, 56 accidents, 39 injuries, and 5 traffic-related fatalities were estimated over the transportation period of 35 years. Though rail transportation was not analyzed under the Proposed Action, use of rail transportation is reserved for future consideration under the Preferred Alternative; if rail transportation were used, impacts are expected to be lower. The results are shown in Table 5-6.

Table 5-6
Nonradiological Impacts of Transporting TRU Waste by Truck for the Proposed Action [a]

Impact	CH-TRU Waste	RH-TRU Waste	Total Impact
Number of Accidents	43	13	56
Number of Traffic Injuries	30	9	39
Number of Traffic Fatalities	4	1	5
Pollution Health Effects (fatalities)	0.1	0.04	0.1

[a] All numbers include the impacts from potential transportation between sites with small volumes of waste and the 10 major treatment sites.

Similarly, the estimated pollution health effects due to diesel exhaust are shown in Table 5-6. These are potential cancer fatalities attributed to exposure to diesel exhaust. This health effect is based upon the total miles traveled in urban areas and a factor that estimates vehicle exhaust impacts on the public, 9.9×10^{-8} latent cancer fatalities (LCF) per kilometer (1.6×10^{-7} LCF per mile) (Rao et al. 1982). Urban areas have greater concentrations of vehicle exhaust. These areas sometimes have air quality concerns as well. Urban areas were assumed to have the largest mean population density (3,861 persons per square kilometer [10,000 persons per square mile]). The impacts would be smaller for rural areas, as in much of New Mexico.

5.1.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during the routine transportation of radioactive material and result from direct public and worker exposure to radiation at levels allowed by transportation regulations. While the TRUPACT-II and RH-72B packaging provides radiation shielding, workers, vehicle crew members, and the public along the transportation routes would be exposed to radiation at very low dose rates during transportation. The RADTRAN code (Neuhauser and Kanipe 1992) was used to estimate the impacts due to this radiation. The following categories of accident-free occupational and nonoccupational exposures were estimated (the nomenclature provided in RADTRAN is presented in parentheses):

- ***Along Route*** *(Off Link Exposure):* Exposure to individuals adjacent to routes of travel
- ***Sharing Route*** *(On Link Exposure):* Exposure to individuals sharing the right of way
- ***Stops*** *(Stops):* Exposure to individuals while shipments are at rest stops
- ***Occupational*** *(Occupational Exposure):* Exposure to waste transportation crews

The sum of the first three items in the above list equals the total nonoccupational exposure. The important RADTRAN input parameters related to TRU waste shipment characteristics are the transportation index (TI), which is the exposure rate at 1 meter (3.3 feet) from the container (in mrem per hour); the frequency of vehicle stops; the number of people exposed and their distances from the container; and the speed of the vehicle.

The TI for a TRUPACT-II or RH-72B shipment is a function of the radionuclide content of the waste being shipped. Typically, the radionuclide content of the waste is different for each generator site. For WIPP shipments, an average radionuclide inventory was developed for each site (see Appendix A). The TIs were then calculated. Because of the uncertainty of the TRU waste radionuclide inventory, a conservative TI of 4 (4 mrem per hour at 1 meter) was chosen for all CH-TRU waste shipments and a TI of 10 (10 mrem per hour at 1 meter) for all RH-TRU waste shipments. All of the calculated TIs were less than those used to estimate impacts (for details on the process used to calculate the TIs, see Appendix E).

ESTIMATING RADIOLOGICAL IMPACTS

Estimation of potential human health impacts involves a series of calculations that indicate the potential health consequence of a particular action or accident, and the probability that the action or accident would occur. Impacts can be calculated both for individuals and for a population. The probability of occurrence for routine actions is 1.0, meaning the action (e.g., chronic release from a permitted exhaust point) will occur at regular intervals, typically daily, over a year of operations. The probability of occurrence for accidents, therefore, is between zero and 1.0, indicating that the nonroutine event might be expected to occur at some random point in time over the entire operations period.

The health effect of concern from low levels of radiation exposure is a radiation-induced cancer fatality. To quantify the radiological impact, the radiation dose must be calculated. The dose is a function of the exposure pathway (external, inhalation, or ingestion) and the type and quantity of radionuclides involved. After the dose is estimated, the health impact is calculated from current internationally recognized risk factors. For this document, potential radiological impacts are based on a scenario that includes prudently conservative release, exposure, and risk factor estimates. Because of the use of conservative assumptions, the impact estimates bound any that would be expected.

The unit of radiation dose for an individual is the rem. A millirem (mrem) is 1/1,000 of a rem. The unit of dose for a population is person-rem and is determined by summing the individual doses of an exposed population. Dividing the person-rem estimate by the number of people in the population would indicate the average dose to a single individual. The impacts from a small dose to a large number of people can be approximated by the use of population (i.e., collective) dose estimates.

To estimate the human health impact from radiation dose, a dose-to-risk factor that indicates the potential for a latent cancer fatality, or LCF, is used. An LCF is a fatality resulting from a cancer that was originally induced by radiation, but which may occur years after the exposure. The dose-to-risk factor for low (less than 20 rem) annual doses is 0.0005 LCF per person-rem for the general public, which includes the very young and the very old, and 0.0004 for the worker population. For example, a population dose of 2,000 person-rem is estimated to result in one additional cancer fatality (0.0005 x 2,000 = 1) in the general public. The dose-to-risk factor for an individual is doubled if the individual dose is greater than 20 rem/year (20,000 mrem per year).

The average individual in the United States receives a dose of 0.3 rem (300 mrem) each year from background radiation. Background radiation sources include radon that has concentrated in homes from foundation soil sources, uranium found in rocks used as building materials, and cosmic radiation from the earth's atmosphere. The average lifetime chance or probability of cancer to a member of the public from a 70-year exposure due to background radiation is 0.01 (70 x 0.3 x 0.0005). That is, the best current radiation risk estimates are that one in 100 people will die from cancer due to background radiation.

The accident-free radiological impacts are presented in Table 5-7. These impacts were estimated using factors of 4×10^{-4} LCF per person-rem for occupational exposures and 5×10^{-4} LCF per person-rem for nonoccupational exposures (ICRP 1991). Table 5-7 also summarizes the impacts to those living along routes, those in vehicles sharing the routes, and those exposed during stops for both CH-TRU and RH-TRU waste shipments. The accident-free impacts for transporting TRU waste under the Proposed Action include the impacts associated with the potential consolidation of TRU waste from those sites with smaller quantities of waste. These impacts contribute approximately 1 percent to the total accident-free transportation impacts under the Proposed Action.

Table 5-7
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for the Proposed Action (LCFs) [a]

Exposure Category	CH-TRU Waste	RH-TRU Waste	Total
Occupational	0.3	0.03	0.3
Nonoccupational			
Stops	2	0.8	2.8
Sharing Route	0.1	0.05	0.2
Along Route	0.04	0.02	0.06
Nonoccupational Total	2.1	0.9	3.0

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments.

A total of 3.0 nonoccupational LCFs are estimated due to routine transportation under the Proposed Action. However, default parameters of the RADTRAN code substantially overestimate impacts due to WIPP shipments. Because WIPP shipments would use two-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, because they are not near population centers, the actual impacts from stops would be much lower.

Accident-free radiological impacts include the probability of incurring an LCF for maximally exposed individuals (MEI). The assumptions and scenarios used to determine the MEIs were as follows:

- *Individual stuck in traffic next to a truck transporting TRU waste*. For this assessment, it was assumed that the individual would have an exposure distance of 1 meter (3.3 feet) for an exposure time of 30 minutes. The individual was assumed to be exposed only once.

- *An inspector of trucks ready for departure*. For this assessment, it was assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for 30 minutes, that the inspector would work at the same job for 10 years, and that there would be three shifts working the same job. The number of shipments inspected would depend on the total number of shipments to be shipped from the site and the rate at which they would be shipped. In actuality, in accordance with current DOE administrative requirements, such an inspector's dose would be limited through radiation monitoring, and the inspector would be rotated into a new job should his or her dose climb to the administrative limit. In order to be conservative, this administrative requirement was not taken into consideration for SEIS-II analyses.

- *A person who performs state vehicle safety inspections*. For this assessment, it was assumed that the individual would inspect 20 percent of the TRU waste shipments, that the inspector would work at the same job for 10 years, and that the average exposure distance would be approximately 1 meter (3.3 feet) for 1 hour. To bound the state inspector's dose, it was assumed that the individual would work on the route on which the majority of the waste enters New Mexico. Again, in actuality this person's dose would be limited by administrative rules and the inspector would be rotated into a new position. In order to be conservative, this was not taken into consideration for SEIS-II analyses.

UNDERSTANDING SCIENTIFIC AND EXPONENTIAL NOTATION

Scientific notation is used in this document to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10	**Negative Powers of 10**
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
$10^6 = 1{,}000{,}000$ (or 1 million)	$10^{-6} = 0.000001$ (or 1 in 1 million)

A power of 10 is also commonly expressed as "E", where "E" means "x 10". For example, 3×10^5 can also be written as 3E+5, and 3×10^{-5} is equivalent to 3E-5. Therefore, 3E+5=300,000 and 3E-5 = 0.00003. This is called exponential notation.

The data tables in this section use exponential notation for numbers that are either very large or very small. The text uses scientific notation to convey these numbers.

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3E-6 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

- *Individual residing along a shipment route*. For this assessment, it was assumed that the individual would have an exposure distance of 30 meters (100 feet) over a 70-year period.

- *Individual who is a rest stop employee*. For this assessment, it was assumed that all trucks stop at the same location, that there are three shifts working at the truck stop, and that the individual works at the truck stop for 10 years. It was estimated that the individual would be exposed to 20 percent of all TRU waste shipments sent to WIPP over a 10-year period. The individual was assumed to be exposed over a 2-hour stop duration at a distance of 20 meters (66 feet).

Table 5-8 summarizes the maximum probability of incurring an LCF for these individuals. The departure and state inspectors would have the highest probability of health effects due to the performance of their responsibilities associated with TRU waste shipments.

Table 5-8
Lifetime Accident-Free Radiological Impacts to MEIs from Truck Transportation for the Proposed Action (Probability of an LCF)

MEI	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to TRU waste shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	2.4E-3	1.6E-3	4.0E-3
State Vehicle Inspector	4.6E-3	3.9E-3	8.5E-3
Residing adjacent to access route	2.5E-4	1.5E-4	4.0E-4
Rest stop employee	1.5E-4	3.5E-4	5.0E-4

5.1.8.4 Radiological Impacts from Truck Transportation Accidents

As part of the U.S. Nuclear Regulatory Commission (NRC) package certification process, computer simulations are used to model the behavior of packaging in a series of tests that are internationally recognized to represent a severe accident. These simulations are followed by physical tests. By comparing the results of the physical tests with the simulation results, it is possible to conclude, with a high degree of confidence, that a properly constructed and maintained package will not be breached in all but a small number of accidents in which forces imposed on the packaging are much more severe than the tests. This section looks at the impacts associated with the small fraction of severe accidents that would cause the release of radioactive material.

Two types of analyses were conducted for SEIS-II radiological impacts from accidents. For the first type of analysis, the RADTRAN code was used to estimate the radiological impact from accidents during transport from each of the assumed 10 major treatment sites to WIPP. For this analysis, a conservative radionuclide inventory was used; it was assumed every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowable by the planning-basis WAC. The first type of analysis took into account eight different severity categories of accidents, their probabilities of occurrence, the distance from each site, and the number of shipments. The total accident risk from each of the 10 sites was obtained by summing the risks calculated for the severity categories. A complete discussion of these analyses is included in Appendix E.

Assumptions for these analyses included the following:

- Release fractions increase with the severity category.
- Because the TRUPACT-II and RH-72B must endure severity category I and II accidents without a breach, no release was calculated for these two severity categories.
- Only one of the TRUPACT-IIs in a shipment would be breached in an accident of any of the severity categories. This assumption is based on studies that indicate hard targets along roadways are too few or are of the wrong orientation to cause the breach of more than one TRUPACT-II (see Appendix E).

FRACTIONAL LCFs

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers, and, especially in environmental applications, may yield numbers less than 1.0. For example, if each member of a population of 100,000 were exposed to a total dose of 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons x 0.001 rem x 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers).

How should one interpret a nonintegral number of latent cancer fatalities, such as 0.05? The answer is to interpret the result as a statistical estimate. That is, 0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. For most groups, no one would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The *average* number of deaths over all of the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is ¼ or 0.25). The most likely outcome is 0 latent cancer fatalities.

ESTIMATING ACCIDENT RISK

Assessing the radiological or hazardous chemical impact due to accidents is typically done by estimating the probability that such an accident might occur and, for a selection of accidents, by estimating the accident's consequences. The probability, or chance, that the accident will occur, and the consequences of the accident are multiplied together to determine the total risk of the accident.

Accident probability is usually determined by historical information on accidents of a similar type or severity. Determining accident consequences requires estimation of the quantity of radionuclides or hazardous chemicals likely to be released, the exposure pathways that will bring the radionuclides or hazardous chemicals into contact with people, and the environmental transport mechanisms. Because of the many variables in these calculations, conservative or bounding assumptions are commonly used and risks tend to be overestimated.

- Only one RH-72B is transported per truck. That one cask would be breached.
- The population densities used to estimate impacts were six persons per square kilometer (16 per square mile) for rural areas, 719 persons per square kilometer (1,863 per square mile) for suburban areas, and 3,861 persons per square kilometer (10,000 per square mile) for urban areas.
- The analyses assumed that stable atmospheric conditions predominated, maximizing impacts.
- Impacts were calculated using a resuspension particle half-life of 365 days.

The results for the first type of accident analysis, route-specific accidents summed over the entire shipping campaign, are presented in Table 5-9.

Table 5-9
Aggregate Radiological Impacts from Potential Truck Transportation Accidents for the Proposed Action (LCFs) [a]

Waste Origin	CH-TRU Waste	RH-TRU Waste	Total
Argonne National Laboratory-East	5.0E-4	---	5.0E-4
Hanford Site	0.3	4.0E-3	0.3
Idaho National Engineering and Environmental Laboratory & Argonne National Laboratory-West	0.08	2.6E-3	0.08
Lawrence Livermore National Laboratory	1.5E-3	---	1.5E-3
Los Alamos National Laboratory	3.5E-3	1.5E-5	3.5E-3
Mound Plant	1.0E-3	---	1.0E-3
Nevada Test Site	5.0E-4	---	5.0E-4
Oak Ridge National Laboratory	3.0E-3	1.0E-3	4.0E-3
Rocky Flats Environmental Technology Site	8.0E-3	---	8.0E-3
Savannah River Site	0.02	---	0.02
Total	**0.42**	**7.6E-3**	**0.43**

[a] Includes both probability of the accident and consequences.

A 1987 NRC study estimated that only 0.6 percent of truck and rail accidents involving Type B containers or casks could cause a radiation hazard to the public (Fischer et al. 1987). There are 56 potential accidents under the Proposed Action, and only half of these accidents are expected to occur when the canister or cask is loaded. Therefore, of the approximately 28 potential transportation accidents estimated to occur under the Proposed Action when the canister or cask is loaded, none would be expected to result in package failure. Still, the second type of analysis was an assessment of four bounding accidents: two assumed a breach of a TRUPACT-II and two assumed a breach of an RH-72B cask. The accidents were assumed to occur under conditions that would maximize, within reasonable bounds, the impacts to exposed population groups. Assumptions for these analyses included the following (see Appendix E for details):

- During the accidents, one TRUPACT-II or RH-72B cask would be breached.
- Each accident would occur in an urban area with a population density of 3,861 persons per kilometer (10,000 persons per square mile), under stable atmospheric conditions that would maximize exposure to nearby populations.
- Two types of inventories were considered for the four accidents: a conservative inventory similar to that used for the first type of analysis above and an inventory based on the average concentrations of radionuclides and hazardous chemicals at Hanford (for RH-TRU waste) and SRS (for CH-TRU waste). The conservative inventory was determined by maximizing the concentrations of radionuclides and hazardous chemicals to the limits allowed by the planning-basis WAC.
- Breach of the TRU waste packaging would result in 0.02 percent of the radioactive material being released to the environment in a respirable form (DOE 1990).
- Impacts were calculated using a resuspension particle half-life of 365 days.

The results for the second type of accident analysis follow. The probability of an accident that would breach a Type B package is 7.5×10^{-7} per accident.

- For the accident with the conservative inventory in a breached TRUPACT-II, the estimated dose would result in 16 LCFs in the exposed population. The estimated maximum individual dose would result in a 0.06 probability of an LCF. The estimated population doses were dominated by inhalation contributions (initial or from resuspension).
- For the accident with a conservative inventory in a breached RH-72B, the estimated dose would result in 16 LCFs in the exposed population. The estimated maximum individual dose would result in a 0.06 probability of an LCF.
- For the accident with average concentrations of radionuclides and hazardous chemicals in a breached TRUPACT-II, the dose estimated would result in 3 LCFs in the exposed population. The estimated maximum individual dose would result in a 0.04 probability of an LCF.
- For the accident with average concentrations of radionuclides and hazardous chemicals in a breached RH-72B, the total population dose estimated would result in a 0.04 LCF in the exposed population. The estimated maximum individual dose would result in a 7×10^{-4} probability of an LCF.

TRANSPORTATION IMPACTS OF THE SANTA FE BYPASS

The Santa Fe Bypass route is an established New Mexico Highway and Transportation Department project that provides for alternative routing for radioactive materials around the Santa Fe, New Mexico urban area. It is a route 22.24 kilometers (13.82 miles) long and connects US-285 north of Santa Fe with I-25 southwest of Santa Fe. The location study was completed in 1985 and adopted by the city on January 8, 1986. To date, approximately two-thirds of the route has been completed; the final one-third has been designed and was originally scheduled for late 1997. However, negotiations are being conducted at this time for the right-of-way for the final phase.

To compare the impacts of using St. Francis Drive to access I-25 through Santa Fe or the Santa Fe bypass under the Proposed Action, the impacts of shipping TRU waste from LANL to WIPP was reevaluated using the Santa Fe bypass route. By this method, the total number of miles traveled would increase from approximately 550 kilometers (342 miles) to 575 kilometers (357 miles). Using the bypass eliminates about 3.2 kilometers (2 miles) of travel in an urban population zone and 7.2 kilometers (4.5 miles) in a suburban population zone along St. Francis Drive. Using the bypass adds approximately 29 kilometers (18 miles) of travel in a suburban population zone and 6.4 kilometers (4 miles) in a rural population zone. The additional 29 kilometers (18 miles) includes 13 kilometers (8 miles) along federally aided interstate (I-25) and 16 kilometers (10 miles) along federally aided primary road (the bypass). The rural miles are along the bypass and are classified as federally aided primary road. The road classifications (federally aided interstate and federally aided primary road) are identified because the accident rates are based upon state-specific data for those road types (Saricks and Kvitek 1994). The following table compares the impacts of shipping TRU waste from Los Alamos to WIPP using the Santa Fe bypass or St. Francis Drive.

Impact	Santa Fe Bypass	St. Francis Drive
Nonradiological		
Accidents	3.3	2.8
Injuries	3.1	2.7
Fatalities	0.5	0.4
Radiological Accident-Free		
Dose, in rem (LCFs in parentheses)		
Occupational	32.1 (0.013)	30.7 (0.012)
Non-occupational	201.2 (0.101)	192.6 (0.096)

5.1.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

This section estimates the impacts associated with exposure to hazardous constituents (as defined by the Resource Conservation and Recovery Act [RCRA]) during the transportation of TRU mixed waste to WIPP. Hazardous chemicals in TRU waste include VOCs and certain metals listed as hazardous chemicals in RCRA. During routine transportation of TRU mixed waste, exposures to hazardous chemicals would not occur because the TRUPACT-II and RH-72B packagings are not vented, and the hazardous chemical components in the waste are completely contained. No impacts to human health would be posed by the hazardous constituents under routine transportation conditions. Impacts due to accidents, however, are possible. It is those impacts that are evaluated in this section.

Hazardous chemical inventories were developed as described in Appendix A. For those VOCs where maximum allowable levels are stipulated in the planning-basis WAC, those levels were assumed to be in the container being transported during an accident. Where no maximum level was specified in the planning-basis WAC, the highest level found during waste drum sampling was

selected to ensure that the typical concentration is bounded. For heavy metals, the concentration was assumed to be the average of those found during sampling (see Section A.5).

It was assumed that CH-TRU waste hazardous chemical accident scenarios would bound any impacts from RH-TRU waste shipments; therefore, no hazardous chemical accidents were analyzed for RH-TRU shipments. The bases for this assumption included the relative shipment capacity (hazardous chemical inventory) of 14 CH-TRU waste drums or 2.91 cubic meters (103 cubic feet)

ESTIMATING HAZARDOUS CHEMICAL IMPACTS

Hazardous chemical exposures can pose two types of health effects, carcinogenic (causing cancer) and noncarcinogenic (for example, respiratory problems or skin irritation). Some hazardous chemicals can potentially produce both carcinogenic and noncarcinogenic health effects. Health effect analyses require knowledge of the exposure pathway and intake (typically by inhalation, but also by ingestion), and use of health effect risk factors that allow estimated intakes to be converted to estimates of health effects.

Carcinogenic Risk

Carcinogenic risk is probabilistic; that is, every intake carries with it some probability of cancer incidence regardless of how small the intake is. The risk varies linearly with exposure, and there is assumed to be no threshold below which an effect would not occur. The U.S. Environmental Protection Agency (EPA) has published carcinogenic risk factors to be used for estimating potential impacts from chronic (long-term) exposure to hazardous chemicals. The “slope factor” of a hazardous chemical is used to convert chronic hazardous chemical intakes to the probability of cancer incidence. The chronic exposure is assumed to last for a 70-year lifetime. Slope factors are specified as the risk per average daily intake over that 70-year period.

No standard method exists to calculate the carcinogenic risk from an acute (one-time or short-term) intake. The method selected for SEIS-II analyses used the chronic-exposure slope factors and assumed the total acute intake was averaged over the 70-year lifetime. In practice then, slope factors were used but specified as the risk per total acute intake.

Noncarcinogenic Health Effects

In contrast to carcinogenic health effects, noncarcinogenic health effects are deterministic, not probabilistic; that is, these effects are assumed to have an exposure threshold, and unless that threshold is reached no health effect would occur. EPA “reference doses” were used to estimate the potential noncarcinogenic health effects from chronic exposure to hazardous chemicals. Reference doses are specified as the chronic daily intake that would be required for the health effect to occur.

As was the case for acute exposures to carcinogenic hazardous chemicals, no standard method exists for estimating the noncarcinogenic health effects from acute exposures to hazardous chemicals. The method selected for SEIS-II analyses used the National Institute of Occupational Safety and Health (NIOSH) immediately dangerous to life or health (IDLH) values, or calculated IDLH-equivalent intakes. IDLH values are the air concentrations that would result in serious or life-threatening health effects if an individual were to be exposed at that concentration for 30 minutes. IDLH-equivalent intakes were calculated using the IDLH parameters to estimate potential impacts from exposure times less than 30 minutes. The IDLHs are air concentrations with units of milligrams per cubic meter (mg/cubic meter) or parts per million (ppm) of the hazardous chemical in air. IDLH-equivalent values are in mass quantities of intake, such as milligrams (mg).

of waste compared to the capacity of an RH-72B cask or 0.89 cubic meters (32 cubic feet) of waste. A TRUPACT-II, therefore, is likely to hold nearly three times the hazardous chemicals that an RH-72B would hold. For the purpose of analysis, it was assumed that the RH-TRU waste hazardous chemical inventory is the same as the CH-TRU hazardous chemical inventory.

The approach used to assess human health effects from hazardous chemical exposures during transportation accidents was similar to that used for SEIS-I. The assessment criteria used were the immediately dangerous to life or health (IDLH) values provided by the National Institute of Occupational Safety and Health (NIOSH). Each chemical was considered separately; the impacts from each chemical are not additive. As long as the ratio of possible intake to IDLH value was less than 1, the risk of health impact was considered zero, and there was no need to further evaluate an exposure. The hazardous constituents that were analyzed are presented in Table 5-10.

Hazardous chemical impacts were evaluated for a bounding, severity category VIII accident. The accident would breach one of the three TRUPACT-IIs. The entire TRUPACT-II inventory of VOCs was assumed to be released (release fraction = 1.0), and heavy metals would be released as particulates with a release fraction of 2×10^{-4} (DOE 1990). The receptor was assumed to be a public MEI located 1,000 meters (3,300 feet) downwind from the accident, exposed at the centerline of the released plume of chemicals for two hours under stable meteorological conditions and low wind speed. Table 5-10 presents the hazardous chemicals analyzed and impacts to the MEI as a fraction of the chemical-specific IDLH value. For all chemicals analyzed, the concentration to which the MEI would be exposed would be no more than about 1/10,000th of the chemical's IDLH value. Therefore, no human health effects would be expected from acute exposure to hazardous chemicals released from a severe transportation accident.

Table 5-10
Hazardous Chemical Impacts for a Severe Truck Transportation Accident for the Proposed Action [a]

Chemical	IDLH (parts per million)	IDLH (milligrams per cubic meter)	Receptor Concentration (milligrams per cubic meter)	Fraction of IDLH Value
Carbon Tetrachloride	200	1,278	5.4E-04	4.2E-07
Chloroform	500	2,480	3.1E-05	1.3E-08
Methylene Chloride	2,300	8,119	1.1E-03	1.3E-07
1,1,2,2-Tetrachloroethane	100	700	1.4E-03	2.0E-06
Chlorobenzene	1,000	4,680	2.0E-04	4.4E-08
Methyl Ethyl Ketone	3,000	9,000	4.0E-04	4.5E-08
Toluene	500	1,915	1.3E-04	7.0E-08
1,2-Dichloroethane	50	206	1.1E-04	5.1E-07
Beryllium	---	4	5.5E-03	1.4E-03
Cadmium	---	9	8.8E-05	9.8E-06
Lead	---	100	2.2E-01	2.2E-03
Mercury	---	10	9.4E-02	9.4E-03

[a] Assumes a severity category VIII accident of a CH-TRU waste shipment.

5.1.9 Human Health Impacts from Waste Treatment and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment and waste disposal operations under the Proposed Action. Throughout this section, the potential impacts from treating waste to planning-basis WAC and from the disposal operations at WIPP are reported separately.

Impacts from waste treatment under the Proposed Action were adjusted from those presented in the WM PEIS (DOE 1997); a description of this adjustment is provided in Appendix B. Treatment of the waste may result in the release of radioactive materials or hazardous chemicals, impacting the public and workers who would not directly handle waste (noninvolved workers).

Direct radiation from the waste would present potential radiological impacts for workers who would handle waste (involved workers) at the treatment sites. The public MEI impact is presented for the site with the highest estimated impact of all sites evaluated in the WM PEIS. Population impact estimates from waste treatment are the sum of all population impact estimates for all treatment sites.

UNCERTAINTIES IN TRANSPORTATION IMPACT ANALYSES

To account for inherent uncertainties in the data, conservative assumptions were made so that reported impacts would bound potential impacts. The following are descriptions of the sources of uncertainty.

Waste Inventory and Characterization

The physical form and radionuclide content of TRU waste were considered when estimating both the external dose rate during accident-free transport and the dose to exposed individuals from transportation accidents. Therefore, conservative assumptions were applied consistently to the waste data to limit potential differences between sites and across alternatives.

Route Determination

Although highway infrastructure and demographics may change considerably over the next 35 to 190 years, representative routes were established for all origin and destination sites in each of the alternatives. The routes were determined using current guidelines, regulations, and practices.

Radiation Doses

Based on the natural variability of key physical processes (i.e., atmospheric dispersion of radioactive material), conservative assumptions were made regarding radiation dose assessment for transportation activities. Parameter values were selected that would provide reasonable upper limits or, in some cases, bounding estimates of potential impacts. Because parameters and assumptions were applied consistently to all alternatives, the relative comparisons between alternatives would not be affected.

For TRU waste shipments, the largest dose contributors were found to be: (1) accident-free dose to members of the public at stops; (2) accident-free dose to transportation crew members; (3) accident-free dose to members of the public sharing the route; (4) accident-free dose to members of the public living along the route; (5) accident dose risk to members of the public in an urban population zone (mean density of 3,861 persons per kilometer). Approximately 80 percent of the estimated public dose would be incurred at stops, 15 percent would be incurred by the members of the public sharing the route, and 5 percent would be incurred by members of the public living along the route.

Potential impacts from WIPP waste handling and emplacement operations were calculated for the public living near WIPP, for WIPP noninvolved workers, and for WIPP involved workers. Potential impacts from routine releases of VOCs and radioactive gases were calculated because each waste drum or waste box would be vented to reduce gas buildup. Both workers and the public may be exposed to these releases. No release of particulate hazardous chemicals during routine operations would occur at WIPP because the vents on the drums have filters, and the drums would not be opened. For the involved workers, potential impacts also were calculated for exposure to direct radiation from waste container contents. Direct radiation impacts for others at WIPP were not calculated because of the distances between where the drums would be unloaded and emplaced and other work areas. The impacts from the disposal operations were calculated for releases occurring after waste is unloaded from the TRUPACT-II or RH-72B. The detailed methods and assumptions used to calculate the potential impacts are described in Appendix F.

The types and concentrations of VOCs in the TRU mixed waste were estimated from past sampling of CH-TRU waste containers (see Appendix A). Emissions from CH-TRU and RH-TRU waste containers were assumed to have similar concentrations of VOCs. Although an estimated 60 percent of the TRU waste is mixed waste, all TRU waste was considered TRU mixed waste for human health analyses. Weighted average headspace concentrations (concentrations in the void area of a drum) were estimated for waste at each treatment site and were used to estimate impacts from waste emplaced underground at WIPP. More conservative estimates of VOC emissions were used to estimate impacts to workers in the Waste Handling Building. The limited number of drums (or drum-equivalents if the waste is in other containers) that could be present in the Waste Handling Building were assumed to release quantities of VOCs based on weighted maximum headspace concentrations; this assumption was made to bound the potential impacts to a worker in this facility.

Radiological impacts are presented as the estimated number of LCFs in a population, and, for individuals, as the probability of an LCF. As with the transportation analyses, the International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991) dose-to-risk factors of 5×10^{-4} LCF per person-rem for the general public and 4×10^{-4} LCF per person-rem for the worker population were used to convert radiation dose to LCFs.

Impacts resulting from chronic exposure to hazardous chemicals may be either carcinogenic or noncarcinogenic. Carcinogenic impacts are presented as the estimated cancer incidence (number of cancers occurring) in a population and, for MEIs, as the probability of cancer occurring. The Environmental Protection Agency's (EPA) slope factors were used to estimate cancer incidence from chronic exposure to hazardous chemicals. Noncarcinogenic health effects were evaluated using a hazard index (HI), which is the ratio of the

RADIOLOGICAL IMPACTS OTHER THAN LCFs

For SEIS-II, the impact reported from a radiation dose is the number of LCFs that may occur in a population, and the probability of an LCF occurring in a maximally exposed individual. Other radiological impacts could result from exposure, such as a nonfatal cancer or hereditary effects (physical deformities). The risk of an LCF, however, is the dominant risk.

For the general public, consideration of nonfatal cancers would increase the impact estimate by 20 percent and, for severe hereditary effects, the impact estimate would increase by another 20 percent. For workers, consideration of nonfatal cancers would increase the impact estimate by 20 percent and for severe hereditary effects, by an additional 26 percent (ICRP 1991).

estimated annual intake of a specific chemical divided by the EPA reference dose for that chemical (see the "Estimating Hazardous Chemical Impacts" text box). An HI greater than 1 would predict the occurrence of the chemical-specific noncarcinogenic health effect. Estimates of the HI for involved workers for some prospective cases (such as WIPP waste handling) were done very conservatively, and resulted in an HI greater than 1. In these cases additional evaluations were made.

The air concentration to which the worker would be exposed was conservatively calculated and compared to the Occupational Safety and Health Administration's (OSHA) permissible exposure limit (PEL) values. The PELs are, typically, time-weighted averages that must not be exceeded during any 8-hour work shift or a 40-hour work week. A few hazardous chemicals that may be present in waste accepted at WIPP have PEL values that must not be exceeded over any time period; they are chloroform, methylene chloride, and beryllium. If the air concentration of the hazardous chemical of concern did not exceed the PEL, no worker noncarcinogenic health effects would occur for the scenario evaluated. Evaluation of the potential for noncarcinogenic health effects in waste treatment workers may be expressed as an exposure index, rather than an HI. This methodology was used in the WM PEIS and is based on the ratio of the exposure level divided by an occupational exposure limit, rather than by the reference dose.

5.1.9.1 Public

Impacts to public populations and to the MEIs under the Proposed Action are presented in this section; results are presented in Table 5-11. Impacts from waste treatment and from WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment would take place at multiple DOE sites that would not include WIPP, while disposal operations would take place only at WIPP. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of each treatment facility and WIPP. The MEI from waste treatment is presented for the highest individual waste treatment site, while the MEI from disposal operations would be near the WIPP site. See Chapter 3 for information on where potential treatment could occur.

Table 5-11
Lifetime Human Health Impacts to the Public
from Waste Treatment and WIPP Disposal Operations for the Proposed Action

Category	Waste Treatment Impacts [a]		WIPP Disposal Operations Impacts	
	Radiological (LCF) [b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF) [b]	Hazardous Chemical (Cancer Incidence)
MEI [c, d]				
CH-TRU Waste	2E-9 (R)	2E-12 (X)	3E-7	3E-8
RH-TRU Waste	6E-11 (L)	2E-11 (O)	3E-10	1E-9
Total Waste	2E-9 (R)	2E-11 (O)	3E-7	3E-8
Population [c]				
CH-TRU Waste	2E-4	1E-7	3E-4	2E-5
RH-TRU Waste	1E-6	4E-7	4E-7	9E-7
Total Waste	2E-4	4E-7	3E-4	2E-5

[a] Adapted from the WM PEIS (DOE 1997).
[b] The probability of an LCF occurring in the MEI, and number of LCFs occurring in the exposed population.
[c] The MEI and populations evaluated for treatment impacts and WIPP disposal operations impacts are different.
[d] L = LANL, O = ORNL, R = RFETS, X = LLNL

Waste Treatment

No radiation-related LCFs (2×10^{-4} LCFs) or cancer incidence (4×10^{-7} cancers) would be expected in the total population around the waste treatment sites. The MEIs with the greatest impact would be at RFETS for radiological impacts (2×10^{-9} probability of an LCF) and at ORNL for hazardous chemical impacts (2×10^{-11} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the MEI would be 3×10^{-10}, and no health effect is predicted unless the HI is 1 or higher.

WIPP Disposal Operations

No LCFs would be expected in the population around WIPP from radiation exposure (3×10^{-4} LCFs). VOC releases were estimated by assuming that a single panel, fully emplaced with RH-TRU and CH-TRU waste (4.5 percent and 95.5 percent of panel waste volume, respectively) would release VOCs continuously throughout all 35 years of WIPP disposal operations. Because each panel would be filled over a 2.5-year period and then closed, reducing VOC releases, the assumption of a full panel continuously releasing VOCs is conservative. Still, no cancer incidence (2×10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 3×10^{-7} probability of an LCF from radiation exposure, and a 3×10^{-8} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum HI for the MEI would be 7×10^{-5}, and no health effect is predicted unless the HI is 1 or higher.

5.1.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under the Proposed Action are presented in this section; results are presented in Table 5-12. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling or disposal of waste. Impacts from waste treatment and from WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment would take place at multiple DOE sites that would not include WIPP, while disposal operations would take place only at WIPP. Noninvolved worker population impacts were estimated for the total of all treatment sites, and for WIPP. The impact to the maximally exposed noninvolved worker from waste treatment is presented for the highest individual waste treatment site, while the maximally exposed noninvolved worker from disposal operations was assumed to work continuously at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was assumed to be 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

No LCFs (7×10^{-6} LCFs) would be expected in the total noninvolved worker population at the waste treatment sites, and no cancer incidence (1×10^{-7} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at RFETS for radiological impacts (3×10^{-9} probability of an LCF)

Table 5-12
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and WIPP Disposal Operations for the Proposed Action

Category	Waste Treatment Impacts [a]		WIPP Disposal Operations Impacts	
	Radiological (LCF) [b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF) [b]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker [c, d]				
CH-TRU Waste	3E-9 (R)	6E-12 (X)	4E-7	1E-7
RH-TRU Waste	3E-11 (L)	1E-10 (O)	7E-10	5E-9
Total Waste	3E-9 (R)	1E-10 (O)	4E-7	1E-7
Population Noninvolved Worker [c]				
CH-TRU Waste	7E-6	2E-8	4E-4	1E-4
RH-TRU Waste	7E-8	1E-7	7E-10	5E-6
Total Waste	7E-6	1E-7	4E-4	1E-4

[a] Adapted from the WM PEIS (DOE 1997).
[b] The probability of an LCF occurring in the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] The individuals and populations evaluated for treatment impacts and operations impacts are different.
[d] R = RFETS, O = ORNL, L = LANL, X = LLNL

and at ORNL for hazardous chemical impacts (1×10^{-10} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the maximally exposed noninvolved worker would be 3×10^{-9}, and no health effect is predicted unless the HI is 1 or higher.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (4×10^{-4} LCFs). VOC release estimates were the same as for the public. No cancer incidence (1×10^{-4} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 4×10^{-7} probability of an LCF from radiation exposure and a 1×10^{-7} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum HI for the maximally exposed noninvolved worker was found to be 6×10^{-4}, and no health effect is predicted unless the HI is 1 or higher.

Appendix F provides additional information on the methods used to determine impacts to noninvolved workers from WIPP disposal.

5.1.9.3 Involved Workers

Impacts to the involved worker populations under the Proposed Action are presented in this section; results are presented in Table 5-13. Involved workers are those directly involved in day-to-day waste treatment, disposal, and management activities. At the waste treatment facilities, such workers would include those who are in direct contact with waste during treatment or packaging to meet planning-basis WAC. At WIPP, they would include workers in the Waste

Table 5-13
Lifetime Human Health Impacts to Involved Workers from Waste Treatment and WIPP Disposal Operations for the Proposed Action

Category	Waste Treatment Impacts [a]		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Involved Worker Population [b]			(36 workers)	(36 workers)
CH-TRU Waste	0.7	8E-6	0.4 to 0.5	9E-3
RH-TRU Waste	0.02	7E-6	≤0.5	5E-4
Total Waste	0.8	2E-5	≤1	< 0.01

[a] Adapted from the WM PEIS (DOE 1997).
[b] The involved worker populations evaluated for treatment impacts and WIPP disposal operations impacts are different.

Handling Building and those who would emplace waste underground. All worker exposures to radiation and hazardous chemicals would be controlled to as low as reasonably achievable (ALARA) levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Waste Treatment

An estimated 0.8 radiation-related LCFs could occur in the worker population, while no cancer incidence (2×10^{-5} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health impacts are predicted. The maximum exposure index for a waste treatment worker would be 2×10^{-4}. Impacts from waste treatment under the Proposed Action were adjusted from those presented in the WM PEIS (DOE 1997); a description of this adjustment is provided in Appendix B.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 1 LCF, and hazardous chemical impacts would be less than 0.01 cancers. No noncarcinogenic health effects would occur. External radiation doses would be the primary source of potential radiological impacts to involved workers; there would be negligible impact from intakes of radioactive material. Worker population impacts were estimated using a total of 36 involved workers (32 Waste Handling Building workers and four underground workers).

The drum vent filters prevent the release of particulates, although small quantities of radioactive gases would be released from containers. Workers would be exposed to external radiation from radioactive decay of radionuclides in the waste and receive an external dose. Worker doses are administratively limited at WIPP to 1 rem per year for the whole-body and 50 rem per year for any extremity (DOE 1995e). CH-TRU waste containers are limited to external dose rates of 200 mrem per hour at the surface of the container. The majority of routine worker doses would result from the disposal of CH-TRU waste rather than RH-TRU waste because of the greater throughput volume of CH-TRU waste and the use of RH-TRU waste remote disposal operations. Estimates of worker whole-body doses were made assuming that the worker would be exposed at 1 meter (3.3 feet) from the CH-TRU waste, 2 hours per workday, 4 workdays per week.

The range of WIPP involved worker radiological impacts were estimated assuming 25 to 35 years of exposure. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would be less than the impact from handling CH-TRU waste.

Workers may routinely be exposed to VOCs released from the waste containers. Worker impacts are related to the quantity of VOCs released and the ventilation rate of the area where they work. Involved workers in the Waste Handling Building were assumed to be exposed to VOC emissions from the maximum number of drums or drum-equivalents that could be stationed in the Waste Handling Building at any one time (42 CH-TRU waste drums and 3 RH-TRU waste drum equivalents). All of the drums were assumed to continuously contain concentrations of VOCs equal to the weighted maximum headspace concentrations. A low ventilation rate was assumed for the Waste Handling Building.

An involved worker underground at WIPP was assumed to be exposed to the VOCs released from a nearby panel filled with CH-TRU and RH-TRU waste containers. A low ventilation rate was assumed for the underground area. Underground workers would normally be upwind of the ventilation air that passes over the waste containers. The potential carcinogenic impacts would be greater for the individual underground worker than for a Waste Handling Building worker, but no cancer incidence would be expected (0.01 cancers). Workers were assumed to be exposed for 35 years.

Noncarcinogenic health effects also were estimated for WIPP workers who would handle waste. The initial maximum HI estimates were 2 for the Waste Handling Building worker and 6 for the underground worker, so further evaluation was conducted for those constituents that had an HI near or greater than 1: (1) carbon tetrachloride for the Waste Handling Building (HI of 2) and the underground (HI of 6); and (2) methylene chloride for the Waste Handling Building (HI of 0.9). The air concentrations to which workers would be exposed were calculated and then compared with the PELs. For the VOCs noted above, the air concentrations would be at least three orders of magnitude below the PELs, well within permissible exposure limits, so no noncarcinogenic health effects would be expected.

5.1.9.4 Storage of Excess RH-TRU Waste

Under the Proposed Action, using the conservative RH-TRU waste volume estimates of Baseline Inventory Report, Revision 3 (BIR-3), a portion of the RH-TRU waste at Hanford and ORNL would not be disposed of at WIPP. (Under more recent waste volumes projected in *The National Transuranic Waste Management Plan* (DOE 1996f), all post-1970, defense RH-TRU waste could be disposed of at WIPP [see Appendix J].) The impacts of surface storage of 39,000 cubic meters (1.4 million cubic feet) of RH-TRU waste at Hanford and 4,000 cubic meters (141,000 cubic feet) of RH-TRU waste at ORNL were evaluated. The waste was assumed to be stored in RH-TRU waste canisters packaged to meet the planning-basis WAC. Radiological impacts would result from the release of gaseous radionuclides from the waste containers. The only gaseous radionuclide identified was carbon-14 in RH-TRU waste at ORNL, and no carbon-14 or radium-226 inventories are known for Hanford RH-TRU waste. Impacts from container VOC releases were estimated using the average weighted headspace concentration from waste packaged to the planning-basis WAC.

OVERVIEW OF UNCERTAINTIES IN HUMAN HEALTH IMPACT ESTIMATES

The results of any human health assessment are conditional estimates based on multiple assumptions about exposure, toxicity, release of contaminants into the environment, human behavior patterns, and other variables. Therefore, the uncertainties accompanying the analysis should be evaluated to place these risk estimates in proper perspective. Uncertainties can be classified into three broad categories: model uncertainty, scenario uncertainty, and parameter uncertainty. Each of the SEIS-II analyses has associated uncertainties that fall into each of these categories.

Model uncertainty can result from the general limitations of mathematical models. Modeling involves trying to simulate a process that is inherently complex using a fixed and relatively small number of variables. Model uncertainty is usually estimated in the verification and validation phase of model development. Model uncertainty can also result from the inappropriate application of a model to a particular scenario (for instance, in situations for which no model has been specifically designed, and existing models must be adapted for use).

Scenario uncertainty may result from a generalized or incorrect conceptualization of a contaminant release or an exposure scenario. For example, there may be errors in the generalized assumptions concerning the amount of contaminants released, the spatial distribution of potential receptors, and the intake parameters considered for the receptors. Uncertainty is introduced because of the prospective nature of the scenarios, involving actions that may be take sometime in the future. For example, the performance of facilities not yet designed or built is unknown and is therefore based on current facilities and specifications. Scenarios do not consider major hypothetical technological advances or global changes, such as a cure for cancer, global nuclear war, or a new ice age.

Parameter uncertainty may result from sampling errors, natural variability of the parameter, or the use of generic data (data that are not site-specific). The fate and transport models used to estimated risks require large amounts of data, including meteorological measurements, hydrogeologic settings, and release parameters. Actual data are used where possible, but generic data are often substituted where site-specific data are unavailable.

The WIPP SEIS-II evaluates the absolute and relative magnitude of potential human health impacts. Evaluating the absolute magnitude of human health impacts involves estimating the actual but unknown impact. The approach taken in SEIS-II was to make assumptions and employ methods that would yield reasonably conservative absolute estimates of impacts (i.e., estimates that tend to overestimated rather than underestimate impacts) using the best available data and state-of-the-art models. Impacts estimated for the various alternatives may be compared (relative impacts). Many of the uncertainties associated with the WIPP SEIS-II impact estimates are “systematic;” that is, modeling and scenario assumptions such as the population distribution around a particular site, the inhalation rate, and the way in which a population may be exposed were applied consistently (i.e., systematically) throughout the analysis. The relative differences in impact estimates among alternatives should not be greatly affected by errors associated with systematically applied assumptions. For example, if inhalation of contaminants by the off-site population was overestimated for one alternative, it was similarly overestimated for all other alternatives.

Impacts from long-term storage of the RH-TRU waste are shown in Table 5-14. Impacts to involved workers would be less than those shown for RH-TRU waste treatment in Table 5-13. Exposure of involved workers to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-14
Impacts from Storage of Excess RH-TRU Waste for the Proposed Action

Impact Area	Radiological	Hazardous Chemical	
	LCFs [a]	Cancer incidence	Maximum HI
Public [b]			
Population	2E-5	3E-4	N/A
MEI	1E-9 (O)	4E-8 (O)	1E-5 (O)
Noninvolved Worker			
Population	4E-5	6E-4	N/A
Maximally Exposed Noninvolved Worker	1E-8 (O)	4E-8 (H)	1E-4 (H)

[a] The probability of an LCF occurring in the ORNL MEI or maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] H = Hanford, O = ORNL

N/A = Not Applicable

5.1.10 Facility Accidents

This section describes potential consequences of facility accidents at the generator-storage sites from treatment of waste to the planning-basis WAC, at two of the generator-storage sites from waste storage after treatment, and at WIPP during waste management and disposal operations. Consequences from treatment accidents were evaluated for the six major generator-storage sites (Hanford, LANL, INEEL, SRS, RFETS, and ORNL) that would treat about 98 percent of the total CH-TRU and RH-TRU waste under the Proposed Action.

Inhalation is the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological consequences are potentially much greater than hazardous chemical consequences and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used in the accident analyses and complete accident scenario descriptions are provided in Appendix G.

5.1.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated under the Proposed Action; they are presented in Table 5-15. Results are presented only for accidents involving CH-TRU waste. The results from these accidents would be greater than the results for similar accidents involving RH-TRU waste because CH-TRU waste contains greater concentrations of transuranic radionuclides, which are the dominant contributors to dose from the inhalation pathway (see Tables G-23 and G-24). The potential accident consequences at the five sites that would treat the greatest volume of CH-TRU waste were evaluated in detail; these sites would be Hanford, INEEL, LANL, RFETS and SRS. Potential accident consequences at ORNL, Hanford, INEEL, and LANL were evaluated for RH-TRU waste treatment separately. Consequences at LLNL, NTS, Mound, ANL-E, and other smaller sites were not evaluated because these sites would treat relatively small quantities of CH-TRU waste. Because of the small quantities, these sites would be expected to treat this waste (treatment to WAC is required prior to transportation) in small batches (e.g., 1 to 2 drum quantities at some sites). This treatment would not be expected to result in substantial consequences (i.e., no LCFs).

Table 5-15
Treatment Accident Scenarios for the Proposed Action

Accident Scenarios	Annual Occurrence Frequency	Description
Waste Spill (Accident Scenario T1)	0.01	Drum is mispositioned causing waste to spill onto the floor.
Drum Fire (Accident Scenario T2)	1E-4	Pyrophoric material inside a drum causes drum contents to burn.
Earthquake (Accident Scenario T3)	1E-5 or less	An earthquake stronger than that for which the building was designed (beyond-design-basis earthquake) (or other natural event) collapses the roof of the building, causing drums to rupture and high efficiency particulate air (HEPA) filters to fail.

Treatment accident scenarios analyzed included a high-frequency/low-consequence operational accident expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a low-frequency/high-consequence beyond-design-basis accident involving a building collapse. Such an accident could potentially be precipitated by an earthquake, a plane crash, or a tornado; for the purposes of analysis in SEIS-II, the accident was assumed to be an earthquake. Accident analysis information is presented in Appendix G. The accidents analyzed are believed to be representative of the spectrum of potential accidents; different or additional accidents may be analyzed in past, ongoing, or future NEPA reviews or safety analysis reports.

A beyond-design-basis earthquake was chosen as the most severe accident. Other natural disasters such as tornadoes, floods, and fires would not be expected to produce more severe consequences. While the annual occurrence frequency of a beyond-design-basis earthquake varies for DOE sites across the country (1×10^{-3} or less), the frequency of a beyond-design-basis earthquake that would result in loss of confinement and collapse the building has been estimated at 1×10^{-5} or less for purposes of these analyses. The analyses were conducted to estimate the difference in consequences among the types of waste treatment and not to make decisions regarding specific treatment sites.

Estimated radiological consequences are presented in the text as the number of LCFs in the exposed population and the probability of an LCF occurring in MEIs. Carcinogenic and noncarcinogenic consequences from hazardous chemicals, both VOCs and heavy metals, also were estimated. Carcinogenic consequences are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic consequences from exposure to VOCs and heavy metals were estimated by two different methods for the waste spill accident scenario (Accident Scenario T1) and drum fire scenario (Accident Scenario T2): IDLH-equivalent ratios and Emergency Response Planning Guideline (ERPG) ratios. The potential noncarcinogenic consequences identified by ERPG ratios would be of minor importance during a beyond-design-basis earthquake and its consequent site-operations upheaval.

In general, potential radiological consequences would be higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-16. Consequences to the maximally exposed involved worker were addressed qualitatively.

Table 5-16
Radiological Consequences of Treatment Accidents for the Proposed Action [a]

Accident Scenarios		Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
CH-TRU Waste	Waste Spill (Accident Scenario T1)	Maximum: 3E-4 (RFETS)	Maximum: 1E-7 (LANL)	Maximum: 4E-7 (Hanford)
	Drum Fire (Accident Scenario T2)	Maximum: 3E-4 (RFETS)	Maximum: 1E-7 (LANL)	Maximum: 4E-7 (Hanford)
	Earthquake (Accident Scenario T3)	Hanford: 3 INEEL: 0.1 LANL: 1 RFETS: 3 SRS: 0.2	Hanford: 1E-3 INEEL: 8E-5 LANL: 2E-3 RFETS: 2E-4 SRS: 3E-5	Hanford: 9E-3 INEEL: 0.01 LANL: 9E-3 RFETS: 5E-3 SRS: 6E-3
RH-TRU Waste	Waste Spill (Accident Scenario T1)	Maximum: 1E-8 (ORNL)	Maximum: 1E-11 (ORNL)	Maximum: 1E-11 (ORNL)
	Drum Fire (Accident Scenario T2)	Maximum: 2E-6 (ORNL)	Maximum: 2E-9 (ORNL)	Maximum: 6E-9 (INEEL)
	Earthquake (Accident Scenario T3)	Hanford: 6E-5 INEEL: 3E-6 LANL: 2E-5 ORNL: 1E-4	Hanford: 3E-8 INEEL: 1E-9 LANL: 3E-8 ORNL: 1E-7	Hanford: 2E-7 INEEL: 2E-7 LANL: 1E-7 ORNL: 3E-7

[a] The site with the greatest consequences is shown in parentheses. Complete information about accident scenarios T1 and T2 for all sites is contained in Appendix G.

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

The potential radiological consequences from RH-TRU waste treatment accidents would be the greatest at the ORNL site for all accident scenarios and receptors; however, they would be four to five orders of magnitude less than the consequences from CH-TRU waste treatment accidents.

Public

Population consequences from treatment accidents were estimated for the exposed populations around the six major treatment sites. Potential consequences to the population and MEIs at the six sites vary over a wide range because population distributions, the distances to the MEIs, and atmospheric dispersion factors differ among the sites. No LCFs would be expected in the exposed population from the waste spill or drum fire scenarios (Accident Scenarios T1 and T2, respectively), but 3 LCFs were estimated to occur due to the earthquake (Accident Scenario T3) at RFETS and Hanford. One LCF was estimated for LANL. The radiological consequences were estimated to be the highest to the MEI at LANL for all three accident scenarios. For the earthquake scenario (Accident Scenario T3), consequences to the MEI were estimated to range from a 3×10^{-5} (at SRS) to 2×10^{-3} (at LANL) probability of an LCF.

Depending on the treatment site, carcinogenic consequences from VOCs would be two to five orders of magnitude greater than consequences from heavy metals for the waste spill and earthquake scenarios (Accidents T1 and T3, respectively) (see Appendix G). Heavy metals would

account for all carcinogenic consequences from the drum fire scenario (Accident Scenario T2) because VOCs would be consumed by the fire. No cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum probability of developing cancer would be 2×10^{-9} to the MEI from any of the accidents. The Hanford and LANL MEI could develop irreversible or severe noncarcinogenic health effects from exposure to hazardous chemicals as a result of the events in the earthquake scenario (Accident Scenario T3).

CRITICALITY

Criticality is defined as a state in which a self-sustaining nuclear chain reaction is achieved. The fissile material in the TRU waste that would be disposed of at WIPP would have to achieve a critical mass (the smallest mass of fissionable material that will support a self-sustaining nuclear chain reaction) in order to drive such a reaction. The minimum critical mass of a fissile material is the amount that can be made critical in a spherical geometry with optimum conditions. These conditions are considered incredible in the WIPP repository environment. Although TRU waste does contain fissile and fissionable material such as Pu-239, Pu-241, U-233, and U-235, DOE safety analysis reports for packaging for the TRUPACT-II (Revisions 0 and 16) and the RH-72B found that a criticality event is not a credible scenario. Indeed, the planning-basis WAC has established nuclear criticality criteria for both CH-TRU and RH-TRU waste that define the maximum allowable quantity of fissile material. These limits are defined in terms of Pu-239 fissile-gram equivalents (FGE) and include a factor allowing for two times the measurement error when the waste packages are assayed. The planning-basis WAC allows up to 200 FGE for a 55-gallon drum and 325 Pu-239 FGE for the RH-72B cask, TRUPACT-II, ten drum overpack, and standard waste box. DOE intends to revise the planning-basis WAC to allow waste transport in pipe overpacks containing up to 2,800 FGEs per TRUPACT-II. NRC has approved use of these overpacks in the TRUPACT-II container. Assumptions regarding use of these overpacks in the SEIS-II transportation analysis are included in a text box in Section A.2.1.4.

The primary difference between CH-TRU waste and RH-TRU waste is the inclusion of other radionuclides, Cs-137 and its decay product Ba-137m, Am-241, Sr-90, and Co-60. These radionuclides, present in sufficient quantities, give a TRU waste container or cask a higher surface dose rate and, thus, the need to handle the waste container or cask remotely for worker protection. However, these radionuclides cannot support self-sustaining nuclear chain reaction and are not factors when determining the potential for criticality. In general, the radionuclides that affect criticality are present in higher concentrations in CH-TRU waste than in RH-TRU waste. Therefore, criticality concerns associated with CH-TRU waste would provide bounding conditions for RH-TRU waste. Therefore, a criticality event involving RH-TRU waste is also considered incredible, although this type of accident is being further investigated.

The portion of the TRU waste Total Inventory that has a noteworthy concentration of radionuclides of concern is the RFETS plutonium residue waste. On average, a drum of RFETS plutonium residue waste would contain 8.6 curies of Pu-239 and 50.5 curies of Pu-241 per drum which represents approximately 139 FGEs in a drum. These concentrations indicate that only two drums of RFETS plutonium residue waste could be shipped in a TRUPACT-II without exceeding the 325 FGE limit for a TRUPACT-II. Other drums could be transported as long as the FGEs remained within the limits of the WAC. Proposed treatment being considered in the ***Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site Environmental Impact Statement (Draft in Preparation)*** could also reduce the FGE concentrations in this waste. No other source of TRU waste contains higher concentrations of fissile or fissionable radionuclides. Assumptions regarding RFETS plutonium residue waste in the SEIS-II transportation analysis are included in a text box in Section A.2.1.4.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest consequence outside of the waste treatment building. The consequences to the noninvolved worker were estimated to vary over one order of magnitude across the five sites. Radiological consequences to the maximally exposed noninvolved worker would result in a 4×10^{-7} probability of an LCF from the events of the waste spill scenario (Accident Scenario T1), a 4×10^{-7} probability of an LCF from the events of the drum fire scenario (Accident Scenario T2), and up to a 0.01 probability of an LCF (at INEEL) from the beyond-design-basis earthquake (Accident Scenario T3).

No cancer incidence would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest probability of cancer would be 7×10^{-9} (see Appendix G). If the events of the earthquake scenario should occur (Accident Scenario T3), noninvolved workers at all sites would have chances of developing noncarcinogenic irreversible or severe health effects, but none of them would be life threatening. These effects would be expected from exposure to heavy metals and VOCs.

Maximally Exposed Involved Worker

No consequences to the maximally exposed involved worker would be anticipated from the events in either the waste spill or drum fire scenarios (Accident Scenarios T1 and T2, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the events. Substantial consequences would be possible from the events of the earthquake scenario (Accident Scenario T3), ranging from workers killed by debris from collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated. Intakes of radionuclides, VOCs, and heavy metals would also be likely.

5.1.10.2 Excess RH-TRU Waste Storage Accident

Under the Proposed Action, excess RH-TRU waste could potentially be stored at Hanford and ORNL, regardless of whether waste is consolidated. (New estimates indicate all post-1970, defense RH-TRU waste could be disposed of at WIPP; see Appendix J.)

Should excess RH-TRU waste need to be stored, lower transuranic radionuclide activity in RH-TRU waste (lower PE-Ci levels, see Table G-23 and Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) would all combine to limit potential consequences from excess RH-TRU waste accidents.

Operational accidents involving storage of excess RH-TRU waste were estimated to have no or negligible consequences, so only the bounding case accident, a beyond-design-basis earthquake (with an assumed annual accident frequency of 1×10^{-5} or less), was examined. The beyond-design-basis earthquake was assumed to collapse the RH-TRU waste storage facility. Twenty-five percent of the RH-TRU waste canisters were assumed to be breached, and 5 percent of the contents in the drums inside were assumed to spill. The respirable airborne fraction of the spilled contents was assumed to be 5×10^{-6}, and 50 percent of this fraction was assumed to escape the debris of the storage structure. In subsequent facility accident sections for the other alternatives, this accident scenario is designated Accident Scenario S3.

Radiological consequences would be much greater than hazardous chemical consequences and are shown in Table 5-17. Consequences would be greater at Hanford than at ORNL in all cases. Exposed populations could experience 3 x 10^{-3} (at ORNL) to 0.9 (at Hanford) LCFs, the MEI could have up to a 5 x 10^{-4} probability of an LCF (at Hanford), and the maximally exposed noninvolved worker could have up to a 3 x 10^{-3} probability of an LCF (Hanford).

Table 5-17
Radiological Consequences of an Excess RH-TRU Waste Storage Accident for the Proposed Action

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Earthquake (Accident Scenario S3)	Hanford: 0.9 ORNL: 3E-3	Hanford: 5E-4 ORNL: 3E-6	Hanford: 3E-3 ORNL: 6E-6

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

No cancer would be expected to occur from hazardous chemical exposure. The highest estimate of cancer in the population would be 1 x 10^{-4} from VOCs and 4 x 10^{-7} from heavy metals near Hanford. The MEI near Hanford would have the highest probability of cancer occurring, 7 x 10^{-8} from exposure to VOCs and 2 x 10^{-10} from exposure to heavy metals. The maximally exposed noninvolved worker would be located at Hanford as well, with a 4 x 10^{-7} probability of cancer from exposure to VOCs and a 2 x 10^{-9} probability of cancer from exposure to heavy metals. No noncarcinogenic consequences would be expected.

Catastrophic destruction of the RH-TRU waste storage facility due to an earthquake could result in death or serious injury to the maximally exposed involved worker, principally from falling accident debris and radiation doses.

5.1.10.3 WIPP Disposal Accidents

Eight potential accidents at WIPP during disposal operations were evaluated; they are shown in Table 5-18. Six of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W5 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for consequences from both CH-TRU and RH-TRU waste (Accident Scenario W6).

Potential radiological consequences to the public and maximally exposed noninvolved worker are substantially higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-19.

Public

Population consequences from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the City of Carlsbad. The population in this sector is 25,629 and would be affected greater than any other section in the surrounding 80-kilometer (50-mile) region.

Table 5-18
WIPP Disposal Accident Scenarios for the Proposed Action

Accident Scenarios	Annual Occurrence Frequency	Description
Drums Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	0.01	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drum Drop, Puncture, Lid Failure in Waste Handling Building (Accident Scenario W2)	0.01	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drums Drop, Lid Failure in Underground (Accident Scenario W3)	0.01	Same as accident W1, but it occurs in the underground.
Drum Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.01	Same as accident W2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	1E-4 (<8 PE-Ci) <1E-6 (>8 PE-Ci)	Contents of a drum in an underground disposal room spontaneously combusts prior to panel closure.
Hoist Failure (Accident Scenario W6)	<1E-6	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	0.01, Panel 1 <1E-6, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing container breaches.
RH-TRU Canister Breach (Accident Scenario W8)	1E-4 to 1E-6	RH-TRU waste canister is breached during Waste Handling Building operations.

Table 5-19
Radiological Consequences of WIPP Disposal Accident Scenarios for the Proposed Action

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9E-3	1E-4	1E-4	0.03
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	0.02	2E-4	2E-4	0.06
Drop, Lid Failure in Underground (Accident Scenario W3)	9E-3	1E-4	1E-4	0.03
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.02	2E-4	2E-4	0.06
Container Fire (Accident Scenario W5)	0.3	4E-3	3E-3	N/A
Hoist Failure (CH-TRU, RH-TRU) (Accident Scenario W6)	CH-TRU: 5 RH-TRU: 2	CH-TRU: 0.08 RH-TRU: 0.03	CH-TRU: 0.06 RH-TRU: 0.02	See Footnote a
Roof Fall (Accident Scenario W7)	0.2	2E-3	2E-3	See Footnote a
RH-TRU Canister Breach (Accident Scenario W8)	5E-3	7E-5	5E-5	0

[a] These impacts could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris)

N/A = Not Applicable

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Consequences to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use Area boundary and the least atmosphere dispersion of facility exhaust ventilation air, which would be the location of maximum consequence. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for high-efficiency particulate air (HEPA) filtration of estimated accident releases from either the Exhaust Filter Building or the Waste Handling Building.

Radiological consequences from accidents would be higher than consequences from hazardous chemicals. The accident with the largest potential radiological consequence to the population and the MEI would be the failure of a fully loaded waste hoist (Accident Scenario W6), which has a 95th percentile probability of occurrence of 4.5×10^{-7} per year (Greenfield and Sargent 1995). Up to 5 LCFs could occur in the exposed population, and the MEI could experience a 0.08 probability of an LCF. The roof fall accident (Accident Scenario W7) would result in the highest potential carcinogenic hazardous chemical consequence, with an estimated 1×10^{-6} cancers occurring in the exposed population and an estimated 2×10^{-8} probability of cancer for the MEI. No fatalities due to toxicological effects would be expected, with the MEI estimated to inhale no more than of 2×10^{-3} percent of an IDLH-equivalent intake of any hazardous chemical under either the hoist failure or roof fall accidents. However, based on ERPG ratios, an extreme circumstance where the hoist fails while carrying a full load of drums, all with bounding methylene chloride concentrations and beryllium content, might result in serious health consequences. High concentrations of 1,1,2,2-tetrachloroethane and heavy metals could also produce serious, although not life-threatening, consequences from a hoist failure or roof fall accident.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological consequences shown in Table 5-19 may be slightly lower than those for the MEI because of the small difference in the radiation dose-to-LCF conversion factors for workers and members of the public. The hazardous chemical consequences would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest consequences to an involved worker would be underground, from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These consequences could range from negligible (workers not present or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological consequences of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-19. The consequences from the drop, puncture, and lid failure accidents (Accident Scenarios W2 and W4), would be a 0.06 probability of an LCF. The highest hazardous chemical carcinogenic consequences to an involved worker were estimated to be from the accidental breach of three drums, with a 3×10^{-7} probability of cancer due to

inhalation of VOCs. No fatalities due to toxicological effects would be expected, with the highest ratio of the IDLH-equivalent intake being 5×10^{-4} for the breach of three drums (Accident Scenarios W2 and W4).

Based on ERPG analyses and conservative exposure assumptions, the involved worker might experience a life-threatening effect from exposures to high concentrations of methylene chloride from drum breaches (Accident Scenarios W1 through W4); irreversible, but not life-threatening consequences from high 1,1,2,2-tetrachloroethane and methylene chloride concentrations.

5.1.11 Industrial Safety

Under the Proposed Action, four fatalities would occur during the waste treatment period from industrial accidents at all treatment sites. This result was found by adjusting the physical-hazard fatality estimate of the WM PEIS.

At WIPP, the management and operating contractor has been awarded the star status in the DOE Voluntary Protection Program. This star status recognizes as "exemplary" the safety culture at the WIPP site. It is reciprocal with OSHA's Voluntary Protection Program star recognition. This star status indicates that the WIPP work force tends to have far fewer accidents and injuries than those at other DOE facilities. Regardless, estimates of potential industrial safety impacts to workers for proposed operations at WIPP were made using the average DOE occupational injury/illness and fatality rates shown in Table 5-20. DOE as a whole is well below the national average with respect to accident rates. DOE's average total recordable case (TRC) rate for 1988 to 1992 was 0.032 accidents per worker-year. The average TRC rate for private industry from 1983 to 1992 was 0.084 accidents per worker-year.

Table 5-20
Average Occupational Injury/Illness and Fatality Rates (per worker-year) [a]

Category	All Labor Categories (Operations)		Construction Worker (Excavation and Decommissioning)	
	Total Injury/Illness	Fatalities	Total Injury/Illness	Fatalities
DOE and Contractors [b]	0.032	3.2E-5	0.062	1.1E-4
Private Industry [c]	0.084	9.7E-5	0.13	3.4E-4

[a] Taken from DOE 1995b, Vol 2, Table F-4-7
[b] 1988-1992 averages from DOE (U.S. Department of Energy), 1993, "Occupational Injury and Property Damage Summary, January-March 1993," DOE/EH/015370-H2, March, Washington, D.C.
[c] 1983-1992 averages from NSC (National Safety Council), 1993, "Accident Facts," Itasca, New York.

For the purpose of estimating impacts, salt excavation activities were considered to be equivalent to construction activities, which have a higher rate of injury and illness than all other labor categories combined, and all other WIPP operations activities were considered jointly under all labor categories.

During the 35-year WIPP disposal operations period under the Proposed Action, the work force was assumed to remain constant at 1,095. Salt excavation would be undertaken by a crew of 10, with the remaining 1,085 workers employed in other operational activities. At the conclusion of

operations, there would be a 10-year decommissioning period. For the purpose of estimating industrial safety impacts during this 10-year period, it was assumed that the work force would decrease by 10 percent each year and that half of the work force would be involved in decommissioning activities equivalent to construction activities.

The estimated number of injuries/illnesses and fatalities among workers from operations, excavation, and decommissioning are shown in Table 5-21. Fewer than two worker fatalities would be expected from industrial-related occurrences during the 45 years of operations and decommissioning. Oversight and inspections by the Mining Safety and Health Administration (MSHA) and adherence to OSHA regulations would likely reduce actual occurrences below these estimated values.

Table 5-21
Industrial Safety Impacts from Operations and Decommissioning of WIPP for the Proposed Action

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2033	22	1,225	1,247	0.035	1.2	1.3
Decommissioning 2033-2043	187	96	283	0.3	0.1	0.4
Operations & Decommissioning Total	209	1,321	1,530	0.4	1.3	1.7

5.1.12 Long-Term Performance

This section presents the potential impacts associated with the long-term performance of the WIPP repository for the Proposed Action evaluated for the 10,000-year period after the site is closed. These impacts were estimated based on computer simulations that predicted radionuclide and heavy metal releases from TRU waste in the repository under undisturbed and disturbed conditions.

The conceptual and computational models used in the analyses were based on models and tools used by the Department in current regulatory compliance analyses. The WIPP Program has been conducting analyses of long-term performance as a part of regulatory compliance with RCRA regulations and certification under 40 CFR Part 191 and 40 CFR Part 194. Although SEIS-II does not directly address these regulatory requirements, the scenarios analyzed in SEIS-II were chosen to represent the types of analyses that are being conducted for regulatory compliance applications.

The results presented here are consistent with those in the *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1996g). SEIS-II results were determined using the same computer codes employed for the regulatory compliance documents.

Analysis of the long-term impacts of WIPP was previously performed in SEIS-I. New analyses were deemed necessary in SEIS-II for the following reasons: (1) the current alternatives are different from those analyzed for SEIS-I in 1990, (2) the waste volumes and inventories for the Proposed Action and action alternatives are different from those used for SEIS-I in 1990, (3) new

data have been collected for use in performance assessment models since 1990, and (4) substantial improvements have been made in the WIPP performance assessment approaches and computational tools (DOE 1996g). A discussion of developments since SEIS-I is provided in Appendix H.

For the purposes of analyses, the CH-TRU waste volumes were assumed to be 168,500 cubic meters (5.95 million cubic feet). Because of limits on the amount of RH-TRU waste currently permitted at WIPP, only 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste were assumed to be emplaced with the Proposed Action. The radionuclide inventory was adjusted, using the ratio derived from these volume changes, to 5.8×10^6 Ci in CH-TRU waste and 4.3×10^5 Ci in RH-TRU waste. Additional information on waste volumes and inventories is presented in Chapter 3 and in Appendix A.

The approach for SEIS-II had five major elements:

- The computational approach used a selected set of computer simulations rather than a full probabilistic analysis to represent the broad range of impacts that could be expected from long-term undisturbed and disturbed performance.
- Performance analyses were conducted using both median and 75th percentile values for model parameters.
- Both undisturbed and disturbed (i.e., human intrusion) conditions were analyzed.
- Numerical evaluation of performance was done using codes developed for WIPP.
- Results for long-term performance assessment were provided for the first 10,000 years after repository closure.

Though many parameters are employed for long-term performance assessment, only a small number have a potential impact on the estimate of contaminants released. Some of the important parameters include the solubility of contaminants in the waste form, sorption of contaminants on salt, hydraulic conductivity of the salt beds near the repository, volume and pressure of the hypothetical brine reservoir in the event of an intrusion, and underground water travel times.

Estimates were made for expected performance conditions and for degraded performance. Expected performance was analyzed using median values of the statistical distributions that describe the input parameters for the full probabilistic analysis required by 40 CFR Part 194. Degraded performance was analyzed using the 75th percentile parameter values from the statistical distributions of the input parameters.

The use of median parameter values means that the results would be expected to fall in the middle of the results produced from a full probabilistic analysis. A model run using all median parameters would not yield the same result as the median output. Use of the 75th percentile parameter values would produce a conservative result, yielding model results that should fall in the upper tail of a full probabilistic analysis. They are not expected to yield higher impacts than the highest impact calculated from a full probabilistic analysis.

Both undisturbed and disturbed repository conditions were considered. Undisturbed conditions examined repository performance for 10,000 years post-closure with no human intrusion. Two release and exposure scenarios for disturbed conditions were considered:

- Surface release caused by drilling into the repository. Drilling into the repository may cause a direct release of drill cuttings containing waste material to the land surface, exposing individuals involved in the drilling processes to radioactive material and heavy metals.

- Drilling through the repository and into a pressurized brine reservoir in the Castile Formation below the repository. This condition may allow brine in the pressurized reservoir to come into contact with waste in the repository. The brine could then move further up the borehole to the more permeable units lying above the repository horizon, like the Culebra Dolomite in the Rustler Formation, allowing migration of radionuclides and heavy metals into the accessible environment. Impacts of two different mining conditions were considered: partial mining that would remove all potash reserves outside the Land Withdrawal Area and full mining that would remove all potash reserves both outside and inside the Land Withdrawal Area.

Drilling intrusions analyzed in SEIS-I considered a family farm scenario that was assumed to be located 500 meters (1,640 feet) from the discarded drill cuttings. Currently, no farms exist near the WIPP site. Agricultural use of land in the region is limited mainly to cattle grazing due to poor soil conditions, a limited supply of stock-potable water, and no source of water for farming. Even if water were available, saline soil conditions make farming unlikely. For these reasons, the family farm scenario was not considered in SEIS-II analyses of drilling intrusion impacts.

The four cases below were analyzed for the Proposed Action:

- Case 1 considered undisturbed repository conditions. Median parameter values were used for input variables where probability distributions have been defined.

- Case 2 considered disturbed conditions resulting from a borehole assumed to pass through the repository and intercept a pressurized brine reservoir in the Castile Formation. Median parameters values were used for input variables where probability distributions have been defined.

- Case 3 was the same as Case 1 but used 75th percentile parameter values for input variables where probability distributions have been defined.

- Case 4 was the same as Case 2 but used 75th percentile parameter values for input variables where probability distributions have been defined.

5.1.12.1 Impacts of Undisturbed Conditions

The NUclide Transport System (NUTS) code was used to simulate radionuclide and heavy metal transport using the time-varying brine and gas flow fields computed by BRAGFLO. The two-dimensional modeling domain extended 23.3 kilometers (14.5 miles) laterally in each direction from the edge of the repository and vertically from the Castile Formation below the repository to the ground surface.

The extent of radionuclide and heavy metal (lead, mercury, beryllium, and cadmium) migration for undisturbed conditions at 10,000 years after closure for Case 3 (using 75th percentile parameter values) over the model domain is presented in Figure 5-1. Case 3 resulted in slightly more extensive migration than Case 1. Figure 5-1 shows the locations in the modeled region where the

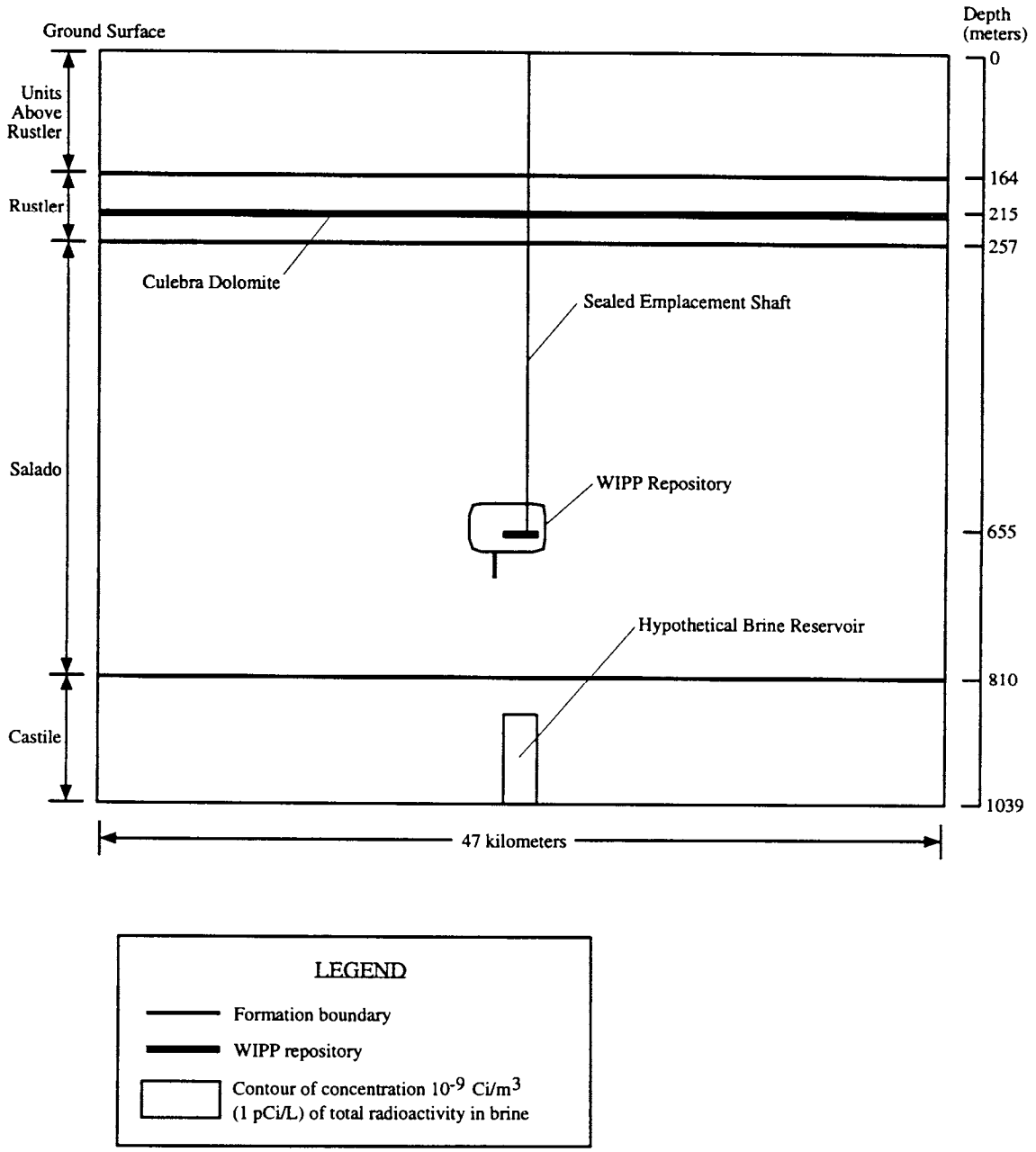


Figure 5-1
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) for the Proposed Action

concentration of total radionuclide activity in the brine, summed over 30 radionuclides, is equal to 1 picocurie (pCi) per liter (1 x 10^{-9} Ci per cubic meter). Total heavy metal concentration of one part per billion (1 x 10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration.

The total vertical scale of the modeled region is 1,039 meters (3,409 feet). The horizontal extent of the modeled region represented in Figure 5-1 is approximately 47 kilometers (29 miles). The vertical scale is greatly exaggerated so the extent of vertical migration can be seen in the figure. For the Proposed Action, total radionuclide activity concentrations of one pCi per liter would extend about 60 meters (200 feet) below the repository, 40 meters (130 feet) above the repository, and about 1,900 meters (6,200 feet) laterally from the south edge of the repository.

Analysis of undisturbed repository conditions (Cases 1 and 3) during the first 10,000 years showed that no radionuclides or heavy metals would be released to the Culebra Dolomite. No total radionuclide activity concentrations greater than 1 pCi per liter or heavy metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. There would be no release to the accessible environment and therefore no human health impact. Additional information is provided in Appendix H.

5.1.12.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for the disturbed conditions of the Proposed Action.

Surface Release Caused by Drilling into the Repository

In this scenario, a drilling operation penetrates a waste panel in the repository. The analysis here is for only one event, although DOE recognizes that during a 10,000-year period more than one borehole could penetrate the repository. The drilling operation was assumed to bring waste originating in the repository to the land surface through a number of physical processes. These processes create cuttings (created by the cutting action of the drill bit), cavings (waste introduced into the borehole is eroded as drilling fluids move up or down the borehole), and spallings (waste and brine caused by the movement of repository gas to the low pressure conditions existing in the borehole). The generation of spallings in a borehole could be affected by very high-pressure repository conditions, causing waste to move into the borehole under blowout or direct gas erosion conditions.

The quantity of waste released would be dependent on repository gas- and brine-pressure conditions and the overall waste characteristics (primarily porosity and permeability) at the time the repository is breached by the borehole.[1] The relationship of repository pressure and these release processes has been quantified and provides the basis for calculations of direct waste releases for the CUTTINGS_S computer code. The values of brine and gas pressure in the repository and the permeability of the waste used to determine the release process under this model were obtained from the fluid flow simulations performed with the BRAGFLO computer code. Simulated brine and gas pressures were derived for undisturbed conditions calculated for Cases 1 and 3 (the

[1] For a multiple-intrusion scenario, the maximum impact would be seen in the first intrusion; less material would be released at any one borehole following the first intrusion because gas pressure would likely dissipate after the first intrusion.

pressure history in the repository is the same until the time of intrusion, so the pressure encountered for any given intrusion time is represented by the analagous undisturbed case). The calculations of direct waste releases for the simulated BRAGFLO conditions were carried out using the CUTTINGS_S code.

Human health impacts would be limited to individuals involved in the drilling operation. No population impacts were calculated because only small amounts of radioactive material would be brought to the surface, remain in a wet, relatively nondispersable form, and would remain localized. Impacts were estimated for two types of exposed individuals:

- A member of a drilling crew directly involved in the borehole drilling. This individual was assumed to be exposed to external radiation from materials at the drill head and in the drill cutting pond and to inadvertently ingest 100 milligrams per day of borehole material. This individual was assumed to be exposed for 168 hours (8 hours per day for a 21-day working period).

- A well-site geologist involved in the periodic examination of cuttings generated by the drilling process. This individual would be exposed to external radiation through the direct handling of an exhumed fragment of waste. The concentration of radionuclides in the exhumed waste fragment was assumed to be the emplacement concentration decayed to the time of intrusion. The geologist was assumed to pick up a cylindrical waste fragment 5 centimeters (2 inches) in radius with a volume of 524 cubic centimeters (32 cubic inches). An exposure time of one hour was assumed.

The drilling intrusions were timed to maximize the estimated health impacts to exposed individuals. The earliest time that intrusion could occur was assumed to be 100 years after repository closure, the end of the active institutional control period. Because results of BRAGFLO calculations showed a steady increase in brine pressures in the repository (approximately 5 to 14 MPa) over the initial 2,000 years following repository closure, the potential impact of repository pressure conditions on the release of materials up the borehole was examined. Radiation dose calculations were performed for intrusions 100, 200, 300, 400, 500, 800, 1,200, and 2,000 years after closure. These calculations showed that an intrusion event at 400 years after closure for Case 2 (median parameter values) and an intrusion event at 300 years after closure for Case 4 (75th percentile parameter values) would lead to the greatest potential health impacts. As a result, impact analysis of the drilling intrusion under the Proposed Action (and all other action alternatives) assumed the intrusion occurred at these respective times. Additional information on this analysis is presented in Appendix H.

The estimated activity of radionuclides released to the ground surface during the drilling event for Case 2 (median parameter values) was 3.1 Ci, consisting mainly of Am-241, Pu-239, and Pu-238. For Case 4 (75th percentile parameter values), the release was 4.5 Ci, again consisting mainly of Am-241, Pu-239, and Pu-238. Heavy metal releases were 24 kilograms (53 pounds) of lead and 2 kilograms (4 pounds) of mercury for Case 2 and 31 kilograms (68 pounds) of lead and 3 kilograms (7 pounds) of mercury for Case 4.

Radiological impacts to a member of the drilling crew for Case 2 (median parameter values) would be a 2×10^{-4} probability of an LCF. For Case 4 (75th percentile parameter values), the impacts

would be slightly higher with a 4×10^{-4} probability of an LCF. The impact in these cases would be primarily due to the inadvertent ingestion of drill cuttings. The radionuclide with the greatest impact contribution (approximately 97 percent) was Am-241.

The drilling crew member may also ingest heavy metals (lead, beryllium, cadmium, and mercury) in the drill cuttings. There would be a 2.2×10^{-8} probability of a cancer incidence to the drill crew member from heavy metal ingestion. There would be no noncarcinogenic impacts expected from the ingestion of the metals because all hazard indices would be much less than one. Impacts of exposure to VOCs were not analyzed (see Appendix H) but were expected to be bounded by impacts of VOC exposure for WIPP disposal accidents (see Appendix G). There would be a 3×10^{-7} probability of a cancer incidence. Some short-term toxicological effects from inhalation of VOCs could occur (see Appendix G) under these assumptions.

Radiological impacts to a well-site geologist from external radiation exposure for Case 2 (median parameter values) would be a 3×10^{-9} probability of an LCF from CH-TRU waste and a 9×10^{-10} probability of an LCF from RH-TRU waste. For Case 4 (75th percentile parameter values), the radiological impacts would be a 3×10^{-9} probability of an LCF from CH-TRU waste and a 3×10^{-9} probability of an LCF from RH-TRU waste. The major dose contributors from CH-TRU waste were Am-241 and U-234, while Sr-90 and Cs-137 were major dose contributors from RH-TRU waste.

Drilling Through the Repository into a Pressurized Brine Reservoir

In this scenario, a borehole would be drilled through the repository into a pressurized brine reservoir, introducing a high permeability (relative to the permeability of the intact salt) groundwater pathway from the repository to the Culebra Dolomite. Contaminants could migrate up the borehole and move laterally through the Culebra Dolomite.

Because current drilling practices are to plug all deep boreholes in the Delaware Basin (Thompson et al. 1996), it was assumed for SEIS-II analyses that all deep intrusion boreholes would be plugged. Boreholes were assumed to have two low permeability concrete plugs that would degrade after 200 years. Additional information on the hydrologic properties of the plugged borehole are given in Appendix H.

The extent of radionuclide migration at 10,000 years after closure for Case 4 (75th percentile parameter values) is presented schematically in Figure 5-2. Total radionuclide activity concentrations of one pCi per liter are shown. Simulations showed radionuclides migrated upward and downward into the borehole and penetrated into rocks directly in contact with the borehole for a limited distance. For Case 4 at 10,000 years, migration extends upward into the Culebra Dolomite. Migration also extends downward in the borehole (for both Cases 2 and 4) to the Castile Formation and into the brine reservoir. This would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole. A total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration. Predicted brine pressures and additional modeling information is provided in Appendix H.

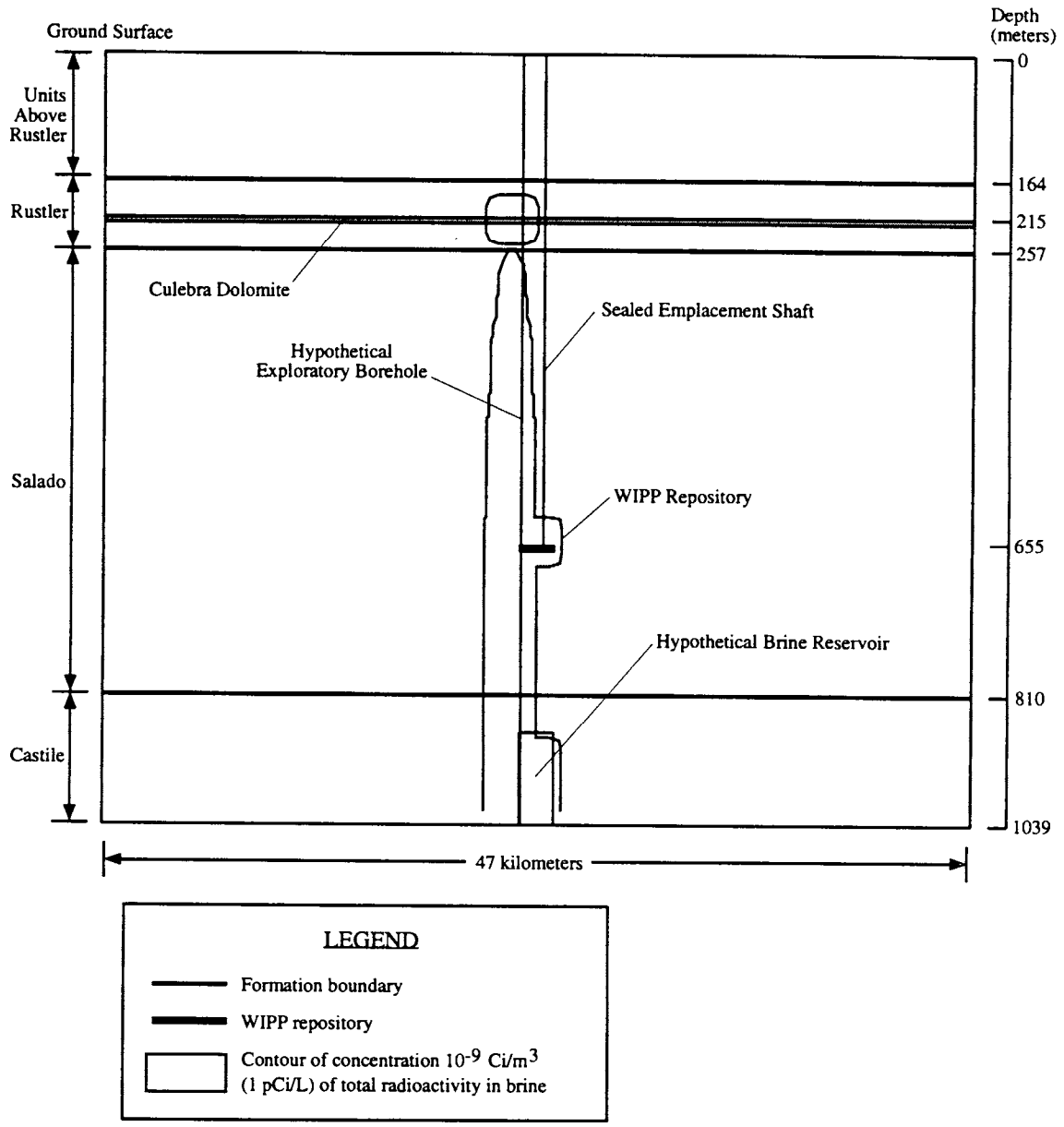


Figure 5-2
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) for the Proposed Action

THE PROPOSED ACTION AND THE ADDITIONAL INVENTORY

During the public comment period that followed publication of the Draft SEIS-II, several stakeholders requested that the Additional Inventory be included in the Proposed Action. The Additional Inventory, as defined in Chapter 2, is largely TRU waste disposed of prior to 1970 by near surface burial at sites throughout the DOE Complex. The Department currently has no plans to excavate all of this waste and would do so only following Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or RCRA investigations and possibly following additional NEPA review. The Additional Inventory, therefore, is still not a part of the Proposed Action. This text box, though, is provided to assist those wishing a general understanding of the impacts of this waste under four scenarios. The scenarios and their impacts follow:

All Additional Inventory would be left as currently stored or buried: The impacts for this scenario would be similar to the Additional Inventory impacts of No Action Alternative 2. Because no treatment or transportation of this waste would occur, no treatment or transportation impacts would occur. Most of the waste would remain buried, so no biological, cultural, infrastructure, water, land use, or socioeconomic impacts would occur due to the Additional Inventory. Approximately 13 LCFs are estimated at the sites where the waste is currently stored should it be left in place for 10,000 years and no intrusion occur. The principal sites where these impacts are estimated are INEEL (at 7.6 LCFs) and LANL (at 5.6). For additional results, see the Additional Waste columns on each table of Section 5.6, later in this chapter.

All Additional Inventory would be excavated, treated to WAC, and stored where currently located for approximately 70 years: During the 70 years, the Department, would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory storage impacts presented for treatment and storage under Action Alternative 1. No transportation would occur, so no transportation impacts are expected. No impacts to the public or noninvolved workers from treatment and storage of this waste are expected. Involved worker impacts would include up to 2 LCFs for treatment and 3 LCFs for storage. For additional results, see the Additional Waste columns of Section 5.2, immediately following this section.

All Additional Inventory would be excavated, shipped to six thermal treatment facilities, treated, and then stored for approximately 70 years: During the 70 years, the Department, would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory impacts for treatment and storage under Action Alternative 2A and No Action Alternative 1A. As noted in No Action Alternative 1A, transportation only to treatment facilities would result in no estimated accidents, injuries, or fatalities. No impacts to the public or noninvolved workers due to storage would be expected; about 1 LCF would be expected to involved workers. For treatment, 1 LCF is estimated for the involved workers. For additional results, see the Additional Waste columns concerning Action Alternative 2A and No Action Alternative 1A on each table of Sections 5.3 and 5.5.

All Additional Inventory would be excavated, shipped to four thermal treatment facilities, treated, and then stored for 70 years: During the 70 years, the Department, Congress, and the nation would look for a disposal solution. The impacts for this scenario would be very similar to the Additional Inventory impacts presented for treatment and storage under Action Alternative 2B and No Action Alternative 1B. As noted in No Action Alternative 1B, transportation for treatment would result in two transportation accidents resulting in two injuries. An estimated 1 LCF each would be expected to the population and involved workers due to treatment. No impacts due to storage would be expected to the population or noninvolved workers; about 1 LCF would be expected to the involved workers. For additional results, see the Additional Waste columns concerning Action Alternative 2B and No Action Alternative 1B on each table of Sections 5.3 and 5.5.

THE WM PEIS PREFERRED ALTERNATIVE

For the purposes of analysis in the Draft SEIS-II Proposed Action, the Department assumed that TRU waste treatment would be partially consolidated in accordance with the Decentralized Alternative of the WM PEIS. Since publication of the Draft SEIS-II, the Final WM PEIS identified a preferred alternative which was a combination of the WM PEIS Alternatives. If TRU waste were treated at the locations identified in the WM PEIS preferred alternative, there would be a slight impact on the analysis set forth in SEIS-II, although there would be no changes in health and other impacts. The modifications to impacts, should the Department select the WM PEIS preferred alternative, are shown below.

RH-TRU waste from SRS would be consolidated at ORNL before disposal at WIPP.

For purposes of analysis of this potential consolidation, the waste volumes used for the WM PEIS have been used. The inventory used for other SEIS-II analyses shows no RH-TRU waste at SRS. The WM PEIS inventory includes up to 21 cubic meters [700 cubic feet] of RH-TRU waste, nearly all of it to be generated during the next 20 years. The number of shipments of RH-TRU waste involved would be approximately 23. The additional miles would also be small because SRS is east of ORNL (the waste would travel west, then south to WIPP). The overall additional impacts (when added to the impacts of the 7,957 shipments in the Basic Inventory) would be small (0.03 additional accidents, 0.03 additional injuries, and 0.004 additional fatalities). Radiological impacts to the occupational population would be 1×10^{-4} LCFs and for nonoccupational populations would be 3×10^{-3} LCFs. (If this waste went directly to WIPP, the impacts would be the same as those presented for the Proposed Action.)

The CH-TRU waste at ORNL would be consolidated at SRS before disposal at WIPP.

A total of 1,700 cubic meters (60,000 cubic feet) or 251 shipments of waste would be transported. The additional transportation would result in 0.1 additional accidents, 0.1 additional injuries, and no additional fatalities. Additional radiological impacts to the occupational population would be 4×10^{-4} LCFs. The radiological impacts to the public would decrease slightly (by 5×10^{-5} LCFs) because of a difference in accident rates along the roadways. The number of shipments would be spread over 35 years, averaging less than 10 shipments per year. Because CH-TRU waste at SRS would be transported to WIPP during the same 35-year period, only small additional impacts to the cost and risk from storage would occur.

Some RFETS CH-TRU waste would be shipped to INEEL for treatment before shipment to WIPP.

Recent estimates are that about 1,000 cubic meters (35,000 cubic feet) of RH-TRU waste would be shipped to INEEL for treatment before shipment to WIPP. For purposes of analysis, the number of shipments was conservatively estimated at 250, though would probably be lower. Additional impacts from this transportation would be 0.25 additional accidents, 0.06 additional injuries, and 0.1 additional fatalities.

Waste from small generator sites (with the exception of Sandia) would be shipped directly to WIPP instead of being consolidated before shipment to WIPP. Waste from Sandia would be consolidated at LANL.

Approximately 25 shipments of CH-TRU waste at the small generator sites would be directly shipped to WIPP under either the WM PEIS preferred alternative (or scenarios where there is no consolidation), and the number of shipments from the potential consolidation sites would probably be reduced. Although routes from the small generator sites have not been proposed, impacts from the additional miles, if any, to be traveled by so few shipments (when compared to the 29,766 shipments for the total campaign) would be so small that the results from the total shipping campaign would not change. For RH-TRU waste, 958 shipments (931 of them from Battelle Columbus Laboratory) would transport waste directly to WIPP, and there would be a one for one reduction in the number of RH-TRU waste shipments from the consolidation sites (because RH-TRU waste would not be repackaged at the potential consolidation sites). The mileage when shipping directly to WIPP would be nearly the same as when first consolidating that waste. Therefore, it is unlikely that there would be additional impacts during the shipping campaign.. Therefore, it is unlikely that there would be additional impacts during the shipping campaign.

Impacts of radionuclide and heavy metals migration were evaluated for Case 4 (75th percentile parameter values) since a release of contaminants into the Culebra Dolomite was indicated for this case only. The potential human health impacts were evaluated at a stock well assumed to be located 3 kilometers (2 miles) downgradient from the borehole (point of intrusion). It was assumed that this well would provide contaminated water to stock ponds used by cattle. Direct uses by humans were not considered because of the high salinity of groundwater in the area. Beef cattle were assumed to drink 50 liters (13.2 gallons) of water per day from the well. Beef from cattle using this water was assumed to be consumed by an individual such as a cattle rancher at a rate of 42 kilograms (93 pounds) annually (about 4 ounces per day) over a 70-year lifetime.

Both partial potash mining (mining only outside the Land Withdrawal Area boundary) and full potash mining (mining inside and outside the Land Withdrawal Area boundary only) conditions were evaluated. Partial mining would result in a 7×10^{-28} probability of an LCF to an individual ingesting beef from cattle using the water from this well over the individual's lifetime. Full mining would result in a 4×10^{-41} probability of an LCF to this individual. The probability of a cancer incidence from ingesting heavy metals would not exceed 3×10^{-27} and 3×10^{-37} for partial and full mining, respectively. No noncarcinogenic impacts would be expected because the estimated hazard index would not exceed 1×10^{-20}. Additional information is presented in Appendix H.

5.1.12.3 Long-Term Storage of Excess RH-TRU Waste

DOE may continue to store excess defense RH-TRU waste beyond the WIPP authorized disposal capacity at Hanford and ORNL under the Proposed Action. (The most recent estimates indicate all post-1970, defense RH-TRU waste can be disposed of at WIPP; see Appendix J.)

Continued storage of excess waste, should it be necessary, would result in less than two worker deaths for each 100 years of storage. If institutional control were lost and the waste were released, it would be expected to cause about 0.02 aggregate deaths over a 10,000-year period, assuming current population distributions.

5.2 IMPACTS OF ACTION ALTERNATIVE 1

This section describes the environmental impacts associated with implementation of Action Alternative 1. This alternative proposes treating waste to WAC[1], consolidating the waste at the same sites discussed under the Proposed Action, and disposing of the waste at WIPP. In addition to the Basic Inventory, WIPP would accept nearly all other DOE-controlled waste (i.e., the Additional Inventory without the polychlorinated biphenyl (PCB) commingled waste). The treatment time frame would remain 35 years. Though additional waste would be treated under this alternative, the treatment time period would be three and a half times that assessed in the WM PEIS. The total consolidated volume of waste to be treated under this alternative is 312,000 cubic meters (11 million cubic feet) (see Tables 3-2 and 3-3), less than three times the 110,000 cubic meters (3.9 million cubic feet) assessed in the WM PEIS. The WIPP operational time frame would extend to the year 2158 (160 years) so that the additional waste could be emplaced. (See Section 5.2.13 for discussion of how the impacts change should the operational time frame be reduced to 60 years.)

[1] For purposes of analysis, the current planning-basis WAC was used.

FACTORS TO CONSIDER IN COMBINING ALTERNATIVES

When considering whether to implement a combination of alternatives, it is important to identify factors that lead to differences in impacts. How impacts change in relation to several factors is examined here.

WASTE VOLUME: In general, impacts (particularly treatment and transportation impacts) vary directly according to waste volume. The greater the waste volume, the greater the impacts. Preliminary figures from recent data indicate that projected waste volumes through 2033 could be lower than BIR-3 projections through 2022 by about 30,000 cubic meters for CH-TRU waste (which translates to a decrease of about 34,000 cubic meters from SEIS-II 2033 CH-TRU waste projections) and about 20,000 cubic meters for RH-TRU waste (which translates to a decrease of about 25,000 cubic meters from the SEIS-II 2033 RH-TRU waste projections). The accuracy of these projections depends, in part, on remediation decisions that would be made in the future and the effect these decisions could have on the timing of TRU waste generation. Much of this potential decrease could result if DOE were to decide to leave some of the instrumentation and machinery related to facilities with high radiation levels (such as instrument trees, and mixer pumps in the Hanford high-level waste tanks, which are projected to be RH-TRU waste when removed from the tanks) in place at those facilities until the facilities themselves are remediated, thus resulting in reduced TRU waste generation through 2033. This decrease would not affect waste volumes proposed to be disposed of under the Proposed Action and would not affect the analysis of the impacts of that action, except that impacts from storage of excess RH-TRU waste would decrease. The waste volumes for alternatives that involve disposing of all of the waste have changed (see Appendix J). Impacts directly related to waste volume may be reduced for the action alternatives that consider disposing of all DOE TRU waste, including impacts from transportation and routine waste treatment operations. The need to dispose of a lower volume of TRU waste could reduce operational time periods for the alternatives by about 50 (Alternative 2) to about 75 years (Alternative 3) and would also reduce the land area above the repository that would be impacted by closure activities. The annual probability of an accident occurring would be the same, but the number of years during which an accident could occur would be reduced. The lower waste volumes would not affect the ability of WIPP to isolate the waste once it is disposed of.

WASTE TREATMENT: Health impacts related to treatment for both workers and the public in the short-term increase as the complexity of waste treatment increases. Treatment to planning-basis WAC has the least impact, followed by shred and grout treatment, with thermal treatment having the highest treatment related impacts of the three treatment alternatives examined.

WASTE MANAGMENT: The long-term impacts of disposal at WIPP are lower than the long-term impacts of the waste storage. This is particularly true when loss of institutional control of the waste is assumed. Also, industrial accidents could lead to substantial impacts if waste were stored for long time periods.

WASTE TYPE (CH-TRU or RH-TRU): Transportation of RH-TRU waste would have relatively greater transportation impacts than CH-TRU waste primarily because of the smaller volume of RH-TRU waste per shipment which increases the number of shipments required to move the RH-TRU waste. Otherwise, on a per unit volume basis, the impacts from treatment and storage of RH-TRU waste are less than those for CH-TRU waste.

TRANSPORTATION MODE: Overall, regular rail transportation would have the least impacts, truck transportation impacts would have about 2 to 3 times that of regular rail service, and dedicated rail service would be about 23 times those of regular rail transportation.

DURATION OF ALTERNATIVE: Longer durations would spread the impacts out over more generations, exposing more people to potential impacts; the risk to each population therefore, would be less. Shorter durations would expose fewer people to potential impacts, the risk to each population would be slightly higher.

As appropriate, analyses include assessment of the impacts of storage of treated TRU waste before disposal. For the purposes of this document, this storage is called lag storage. Analyses in Action Alternative 1 also include a qualitative assessment of the impacts of rail transportation. A detailed description of Action Alternative 1 is given in Section 3.2.2.

5.2.1 Land Use and Management

At the treatment sites, land use impacts under Action Alternative 1 would be the same as those under the Proposed Action. The type, size, and number of treatment and consolidation facilities needed under this alternative would be comparable to those for the Proposed Action. The Department would be able to minimize impacts to on-site land use and avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate areas, including cultural resource areas, the habitats of threatened or endangered species, wetlands, and flood plains. Before treatment facilities would be constructed, further NEPA reviews would be undertaken at a site-wide or project-specific level.

At WIPP, land use impacts on the surface during disposal operations under Action Alternative 1 would be similar to those under the Proposed Action discussed in Section 5.1.1. These impacts would be similar because the surface facilities would be the same as those for the Proposed Action. One difference from the Proposed Action would occur during the decommissioning and closure process; approximately 360 hectares (890 acres) would be affected due to an increased underground waste disposal area. This area would be included in the bermed and permanently marked area once closure was begun. Like the Proposed Action, the rest of the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure. Restrictions on slant drilling would continue.

5.2.2 Air Quality

At the treatment sites, the potential annual air quality impacts would not differ substantially from those presented for the Proposed Action in Section 5.1.2. The only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be CO at RFETS (17 percent), the same as for the Proposed Action. RFETS, LLNL, NTS, and ANL-E are in nonattainment areas for some pollutants. In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations. No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard (DOE 1997). Potential minor emissions of PM_{10} may occur during construction.

At WIPP, the potential annual air quality impacts under Action Alternative 1 would be the same as those anticipated under the Proposed Action. Although the increased waste disposal volume would increase the duration of disposal activities, there would be no substantial differences in the rates of pollutant emissions on an annual or short-term basis.

Potential air quality impacts due to decommissioning of WIPP under Action Alternative 1 would be similar to those anticipated under the Proposed Action. Because the waste disposal area would increase, the construction of berms and permanent markers and other decommissioning activities

would take longer, although these activities would still be within the 10-year decommissioning period. Thus, there would be no substantial difference in the rate of pollutant emissions.

5.2.3 Biological Resources

The potential impacts on biological resources at the treatment sites under Action Alternative 1 would be the same as those under the Proposed Action described in Section 5.1.3. Threatened and endangered species may be present at all of the proposed treatment sites and could potentially be impacted; however, whether there would be impacts depends on the actual location of the facility at a particular site. Site selection would be conducted following site-wide or project-level NEPA review during which such impacts would be assessed and mitigated as necessary. Endangered, threatened, or proposed species and all critical habitats would be avoided and appropriate consultation, monitoring, and mitigation measures would be undertaken as necessary. The longer treatment period proposed for Action Alternative 1 is not expected to have any additional impact to species over the life of the campaign. Analyses also determined that terrestrial wildlife species would not be affected by airborne emission from waste management or treatment facilities nor from spills of TRU waste into aquatic environments due to traffic accidents (DOE 1997).

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE recently completed a site-specific biological survey, during which no endangered, threatened, or state-listed species were identified.

At WIPP, the potential impacts on biological resources under Action Alternative 1 would be similar to those under the Proposed Action (described in Section 5.1.3) except for impacts resulting from the increased underground waste disposal area. A total of 360 hectares (890 acres) of aboveground area would be disturbed during salt pile reclamation and construction of berms and permanent markers during closure. These activities would disturb avian and small mammal habitat. These areas would be attractive after natural vegetation recolonizes.

5.2.4 Cultural Resources

At the treatment sites, the potential impacts on cultural resources are expected to be the same under Action Alternative 1 as for the Proposed Action. This is because the size and number of the facilities would be the same as those assessed for the Proposed Action. The construction and operation of TRU waste treatment facilities could adversely affect cultural resources; however, site-level cultural resource surveys would be conducted and protection measures would be established, where necessary, when specific facility construction locations are proposed (DOE 1997). These surveys would be part of site-wide or project-level NEPA reviews. Sacred sites and burials would be avoided when siting the facilities, and appropriate consultation would be undertaken during the reviews.

At WIPP, all of the surface area included under Action Alternative 1 has been inventoried for cultural resources as part of the initial survey of the 1,040-hectare (4-square mile) central WIPP site. Eleven prehistoric archaeological sites (LA14307, LA14308, LA33155, LA33156, LA33157, LA33159, LA33160, LA33163, LA33170, LA33179, and LA33180) are located in the previously surveyed areas within Sections 28 and 29, T. 22S, R. 31E. Each of these sites was evaluated by the original investigators as being potentially eligible for inclusion in the NRHP (DOE 1995c).

TRU waste shipping and operational activities at WIPP would not have an impact on these or other archaeological sites. Depending on final project design, some of these archaeological sites could be affected by closure and decommissioning-related activities. Surface ground disturbance for construction of long-term decommissioning features such as various types of markers, earthen berms, and informational centers could impact some archaeological sites.

Measures for ensuring protection of known archaeological and historic resources (or others that may be inadvertently discovered during ground-disturbing activities) are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996a). These measures include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed under the Joint Powers Agreement between DOE and the State of New Mexico.

5.2.5 Noise

Treatment facilities would probably be located in industrial areas along high-volume roadways, and, therefore, ambient noise levels would not increase substantially (DOE 1997). Sensitive receptors, however, may be impacted. Further analysis has been reserved for site-wide or project-level NEPA review (DOE 1997). Because all waste would travel to WIPP but only a portion of the waste would travel to or from each treatment facility under this alternative, the greatest impacts due to transportation noise would be near the WIPP site and are discussed below.

At WIPP, potential noise impacts under Action Alternative 1 for truck transportation and operations would be similar to those described under the Proposed Action in Section 5.1.5. This is because the throughput rate was assumed to remain the same (50 TRUPACT-IIs and eight RH-72B casks per day). The trucks would still arrive at random times throughout the day.

Unlike the Proposed Action, Action Alternative 1 examines rail transportation. All rail transportation of TRU waste destined for WIPP would travel through Carlsbad, New Mexico, to Loving, New Mexico, where it would be diverted to WIPP via a dedicated spur. Rail noise may be disruptive to certain public and private institutions. The commercial rail noise impact would result from the addition of rail cars carrying TRUPACT-IIs or RH-72Bs to existing commercial trains. A single rail car may carry up to six TRUPACT-IIs or two RH-72Bs. The noise impact would be a slight increase in the duration of propagated noise resulting from trains passing through the affected communities. The estimated impact would depend on the speed of the rail car and the total number of rail cars. Use of dedicated trains would result in increased rail traffic through Carlsbad and Loving and would be potentially more disruptive than use of commercial rail. Assuming each dedicated train contained three fully loaded rail cars, four additional trains could pass through these cities each week, averaging less than one additional train per day. Therefore, the overall noise impact would be negligible.

5.2.6 Water Resources and Infrastructure

Because the SEIS-II operations time would be three and a half times longer and the volume of waste treated less than three times higher than that anticipated under the WM PEIS, the size of the treatment facilities needed for Action Alternative 1 would be comparable, if not smaller, than those analyzed for the WM PEIS. Therefore, the incremental impacts to site infrastructure are estimated to be the same as those reported in the WM PEIS.

Although no off-site infrastructure impacts are expected to occur, proposed TRU waste activities at the treatment sites would affect on-site activities, including the capacities of on-site water, power, and wastewater systems, and on-site transportation. The impacts would be the same as those for the Proposed Action. Only Hanford would show an increase in on-site demand for wastewater that would exceed five percent of current demand (5.9 percent). Major impacts to water resources at the treatment sites would be unlikely (DOE 1997).

Minor impacts to the on-site transportation infrastructure are expected under Action Alternative 1. These impacts are a result of an increase in on-site employment of 6 percent at Hanford and INEEL and 7 percent at LANL. Impacts to the off-site transportation infrastructure are not anticipated because population increases do not exceed 5 percent (DOE 1997).

At WIPP, negligible annual infrastructure impacts would be expected under Action Alternative 1. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.2.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for Action Alternative 1 are presented in the following subsections.

5.2.7.1 Life-Cycle Costs

Life-cycle costs under Action Alternative 1 are presented in Table 5-22 for three areas: treatment facilities, waste transport, and WIPP disposal operations. Waste treatment facility costs include construction, O&M, and D&D at the treatment sites. For the purposes of SEIS-II analyses, it was assumed that the treatment sites would process, treat, and package waste to planning-basis WAC over a period of 35 years (as in the Proposed Action, but for larger waste volumes). Correspondingly, sites with large volumes (INEEL, Hanford, and ORNL) would be required to store portions of the treated waste volumes over some or all of the 160-year disposal operations period, mainly due to RH-TRU waste throughput limitations at WIPP. The waste treatment facility life-cycle costs would be $21.39 billion (in 1994 dollars).

Table 5-22
Life-Cycle Costs for Action Alternative 1 (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	8,430	3,120	11,550	8,860	980	9,840	21,390	11,860
Transport by Truck	1,200	2,690	3,890	750	270	1,020	4,910	778
Transport by Regular Rail	400	890	1,300	250	90	340	1,640	260
Transport by Dedicated Rail	2,760	6,200	8,960	1,740	620	2,360	11,320	1,790
Disposal at WIPP	10,600	2,700	13,300	11,100	250	11,350	24,650	3,680
Total Life-Cycle Cost (Truck Transport)	20,230	8,510	28,740	20,710	1,500	22,210	50,950	16,320
Total Life-Cycle Cost (Regular Rail)	19,430	6,720	26,150	20,210	1,320	21,530	47,680	15,800
Total Life-Cycle Cost (Dedicated Rail)	21,790	12,020	33,810	21,700	1,850	23,550	57,360	17,330

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

Action Alternative 1 considers three waste transportation options from the treatment sites to WIPP: (1) trucks only, as in the Proposed Action, (2) trucks with maximum regular (commercial) rail service, and (3) trucks with maximum dedicated rail service. Under transportation options 2 and 3, rail routes would be used to the greatest extent practical. LANL and NTS would be the two exceptions because there are no rail routes to these sites; thus, their waste would be entirely transported by truck. Under these options, the transportation costs reflect consolidation of the waste volumes at the treatment sites and shipment of the treated volumes via truck or rail to WIPP for emplacement. The waste transport life-cycle costs would be $4.91 billion by truck, $1.64 billion by regular rail, and $11.32 billion by dedicated rail.

The WIPP life-cycle costs would be $24.65 billion. The total life-cycle costs for the Total Inventory under Action Alternative 1 would be $50.95 billion ($16.32 billion when discounted) using truck transportation, $47.68 billion ($15.80 billion when discounted) using regular rail transportation, or $57.36 billion ($17.33 billion when discounted) using dedicated rail transportation.

5.2.7.2 Economic Impacts

Treatment activities would support direct, indirect, and induced jobs. Action Alternative 1 would support approximately 22,500 annual jobs in the ROIs of the 10 major treatment sites (ANL-E, Hanford, INEEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, SRS).

Within the WIPP ROI, estimates of the impacts of Action Alternative 1 on employment, income, and the production of goods and services are presented in Table 5-23. These regional impacts are estimated using an annual average project budget of $180 million per year over a 160-year period of disposal operations. During this extended period of waste emplacement operations, the WIPP facility would remain a stable federal employer in the ROI economy by providing direct employment for 1,095 project personnel annually. Indirectly, the operation of WIPP (from 1998 through 2158) would annually support 2,443 jobs in the ROI work force. Total annual WIPP-induced employment within the ROI would be 3,538.

Because the projected average annual project budget is close to historical levels, Action Alternative 1 would not be expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection) nor require major capital investments in public infrastructure within the ROI. For this same reason, Action Alternative 1 would not be expected to impact the local real estate markets nor result in major changes in the work force population.

Table 5-23
Economic Impacts within the ROI for Action Alternative 1

Economic Effects	Total Output of Goods and Services (in millions of 1994 dollars)	Total Employment (Full- and Part-Time Jobs)	Total Labor Income (in millions of 1994 dollars)	Carlsbad Output of Goods and Services (in millions of 1994 dollars)	Carlsbad Employment (Full- and Part-Time Jobs)	Carlsbad Labor Income (in millions of 1994 dollars)
Direct – Annual	113	1,095	52	95	979	46
Indirect & Induced – Annual	204	2,443	75	172	2,185	67
Total – Annual	317	3,538	126	267	3,164	113
Total - Operations (160 years)	50,720	566,080 [a]	20,160	42,720	506,240 [a]	18,080

[a] Job-years (number of annual jobs supported multiplied by the number of years in the project).

5.2.8 Transportation

This section presents the transportation impacts for Action Alternative 1. Treatment and consolidation of TRU waste and the radionuclide and hazardous chemical concentrations in the waste are the same for truck transportation in the Proposed Action and Action Alternative 1; therefore, the differences between the transportation impacts are due solely to the increased number of shipments under Action Alternative 1. Rail transportation impacts for both regular and dedicated train options for Action Alternative 1 are presented at the end of this section.

5.2.8.1 Route Characteristics and Shipment Projections

The methods used to determine route characteristics and the number of shipments were identical to the approach as presented in Section 5.1.8.1. Table 5-24 presents the number of shipments required under Action Alternative 1. Because the consolidation and treatment of waste would be the same for the Proposed Action and Action Alternative 1, the mileage for each route would also be the same (see Table 5-5).

Table 5-24
Number of Truck Shipments to WIPP for Action Alternative 1 [a]

Waste Treatment Site	CH-TRU Waste			RH-TRU Waste		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Argonne National Laboratory - East	24	---	24	---	---	---
Hanford Site	11,562	7,167	18,729	47,156	1,651	48,807
Idaho National Engineering and Environmental Laboratory/ANL-W	4,892	6,474	11,366	3,136	711	3,847
Lawrence Livermore National Laboratory	137	---	137	---	---	---
Los Alamos National Laboratory	4,238	1,590	5,828	367	190	557
Mound Plant	50	23	73	---	---	---
Nevada Test Site	73	---	73	---	---	---
Oak Ridge National Laboratory	212	8	220	5,875	3,076	8,951
Rocky Flats Environmental Technology Site	2,102	---	2,102	---	---	---
Savannah River Site	1,893	558	2,451	---	---	---
Total	**25,183**	**15,820**	**41,003**	**56,534**	**5,628**	**62,162**

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. There would be 53 CH-TRU waste shipments and 3,850 RH-TRU waste shipments. Impacts from the transportation of TRU waste to the treatment sites is small relative to the 10 major generator-storage sites above (see Appendix E).

5.2.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

The total number of accidents, injuries, and fatalities over the transportation period of 160 years for Action Alternative 1 are shown in Table 5-25. For Action Alternative 1, a total of 171 accidents, 119 injuries, and 16 traffic-related fatalities were estimated. Also shown in Table 5-25 are the estimated cancer fatalities attributed to diesel exhaust (pollution health effects).

Table 5-25
Nonradiological Impacts of Transporting
TRU Waste by Truck for Action Alternative 1

Impact	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Number of Accidents	36	25	62	100	9	109	136	34	171
Number of Injuries	26	17	43	68	8	76	94	25	119
Number of Fatalities	4	2	6	9	1	10	13	3	16
Pollution Health Effects (fatalities)	0.1	0.08	0.2	0.3	0.04	0.3	0.4	0.1	0.5

These effects are based upon the total miles traveled in an urban area and 9.9×10^{-8} LCFs per kilometer (1.6×10^{-7} per mile) (Rao et al. 1982). The impacts of shipping waste from the small quantity sites to the larger treatment sites are included in Table 5-25.

5.2.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during routine transportation and are the result of public and worker exposure to direct radiation at levels allowed by transportation regulations. The methods used to determine accident-free radiological impacts for Action Alternative 1 were identical to those described for the Proposed Action.

Table 5-26 presents a summary of the accident-free population radiological impacts for Action Alternative 1. Approximately 0.7 occupational LCFs and 10.5 nonoccupational LCFs would be expected in the exposed population groups. The accident-free radiological impacts of shipping waste from the small quantity sites to the larger treatment sites to consolidate TRU waste are included in the results in Table 5-26.

Table 5-26
Aggregate Accident-Free Population Radiological Impacts
from Truck Transportation for Action Alternative 1 (LCFs) [a]

Exposure Category	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Occupational	0.2	0.2	0.4	0.3	0.03	0.3	0.5	0.2	0.7
Nonoccupational									
Stops	1.7	1.1	2.8	6.3	0.7	7.0	8.0	1.8	9.8
Sharing Route	0.09	0.06	0.2	0.4	0.04	0.4	0.5	0.1	0.6
Along Route	0.04	0.02	0.06	0.1	0.02	0.1	0.1	0.04	0.2
Nonoccupational Total	1.8	1.2	3.0	6.8	0.7	7.5	8.6	1.9	10.5

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use two-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

Table 5-27 summarizes the impacts to MEIs who might be exposed to radiation because of traffic jams, lifestyles, or occupations. The discussion in Section 5.1.8.3 presents the methods used to determine the impacts presented in Table 5-27. The state vehicle inspector was estimated to have the highest potential impact with an 8.6 x 10^{-3} probability of an LCF.

Table 5-27
Radiological Impacts to MEIs from Truck Transportation for Action Alternative 1 (Probability of an LCF)

Individual	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	4.4E-4	5.5E-3	5.9E-3
State Vehicle Inspector	1.5E-3	7.1E-3	8.6E-3
Residing adjacent to access route	1.5E-4	6.0E-4	7.5E-4
Rest stop employee	1.0E-4	3.0E-4	4.0E-4

5.2.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts from accidents. The first type of analysis determined the radiological impact from accidents during transportation from each of the 10 treatment sites to WIPP. This analysis took into account eight different severities of accidents, the number of miles from each site, and the number of shipments. The methods used were the same as those presented in Section 5.1.8.4.

The results of the analyses for route-specific accidents for the entire shipping campaign are presented in Table 5-28. The aggregate radiological impact was estimated to be 0.8 LCF.

Table 5-28
Aggregate Radiological Population Impacts from Truck Transportation Accidents for Action Alternative 1 (LCFs)

	CH-TRU Waste			RH-TRU Waste			Total		
Originating Site	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Argonne National Laboratory-East	4.0E-4	---	4.0E-4	---	---	---	4.0E-4	---	4.0E-4
Hanford Site	0.3	0.2	0.5	0.06	2.0E-3	0.07	0.4	0.2	0.6
Idaho National Engineering and Environmental Laboratory & Argonne National Laboratory – West	0.07	0.09	0.2	2.5E-3	5.0E-4	3.0E-3	0.07	0.09	0.2
Lawrence Livermore National Laboratory	1.5E-3	---	1.5E-3	---	---	---	1.5E-3	---	1.5E-3
Los Alamos National Laboratory	3.0E-3	1.0E-3	4.0E-3	1.5E-5	5.0E-6	2.0E-5	3.0E-3	1.0E-3	4.0E-3
Mound Plant	1.0E-3	0	1.0E-3	---	---	---	1.0E-3	---	1.0E-3
Nevada Test Site	5.0E-4	0	5.0E-4	---	---	---	5.0E-4	---	5.0E-4
Oak Ridge National Laboratory	2.5E-3	5.0E-4	3.0E-3	4.5E-3	2.5E-3	7.0E-3	7.0E-3	3.0E-3	0.01
Rocky Flats Environmental Technology Site	7.0E-3	---	7.0E-3	---	---	---	7.0E-3	---	7.0E-3
Savannah River Site	0.02	6.0E-3	0.03	---	---	---	0.02	6.0E-3	0.03
Total LCFs							**0.5**	**0.3**	**0.8**

The second type of analysis was an assessment of four conservative, bounding accident scenarios: two involving the breach of a TRUPACT-II, and two involving the breach of an RH-72B. Methods of estimating impacts from bounding case accidents are presented in Appendix E and Section 5.1.8.4. For Action Alternative 1, the potential radiological impacts from the bounding case accidents would be the same as those presented for the Proposed Action in Section 5.1.8.4. For both alternatives, TRU waste would be treated to planning-basis WAC.

5.2.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

As with the Proposed Action, the hazardous chemical releases from a severe accident would present negligible hazard to the exposed population. Though the inventory for Action Alternative 1 is larger than that for the Proposed Action, the concentration of VOCs and metals in each TRUPACT-II or RH-72B would be the same. Hazardous chemical impacts from accidents would be the same as those presented for the Proposed Action in Table 5-10.

5.2.8.6 Impacts from Rail Transportation

This section presents a summary of potential impacts due to transportation by both regular and dedicated rail service. Rail service would be used to the fullest extent practical (called maximum rail), whereas truck transportation would be used only for the two sites with no rail service, LANL and NTS. SEIS-II rail impacts were determined by adjusting the SEIS-II impacts from truck transportation presented earlier in this section. Overall, these adjustments were based on the similarities and differences between the two transportation modes based on models presented in RADTRAN (Neuhauser and Kanipe 1992) and truck and rail accident statistics (Saricks and Kviteck 1994). The similarities and differences are presented in Appendix E. Some key differences are noted below:

- Overall, rail cars move slower than trucks. When vehicles move slower, those individuals living or traveling along a route are exposed for longer periods of time.

- Six TRUPACT-IIs would be put on each rail car instead of the three transported per truck. Two RH-72Bs would be put on each rail car instead of the one transported per truck.

- Each train can include many rail cars. For the purpose of SEIS-II analyses, it was assumed that a train transporting TRU waste would include three rail cars loaded with TRUPACT-IIs or RH-72Bs. For dedicated rail service, it was assumed that each train would only have the three rail cars. For regular rail service, it was assumed that the three rail cars of TRU waste would be included in a train of 70 rail cars (the average number of cars in regular rail service trains).

- When a train stops at a rail yard, there typically are other rail cars there. These other rail cars provide shielding for the potential radiation coming from TRU waste packaging.

- While many people would share a roadway with a truck transporting TRU waste, very few people would travel along a rail route at the same time as a train transporting TRU waste.

These differences result in the following adjustments to truck transportation results:

- The slower average train speed would increase the radiation dose to individuals living along rail routes by 1.5 times over that for individuals living along truck routes.

- When a shipment stops, the individual dose would be one-tenth of the dose to individuals near a stopped truck. This difference is due to the shielding provided by the other rail cars when the shipment stops in a railyard.

- When these two factors are considered together, accident-free radiological impacts are greatly reduced for rail transportation compared to truck transportation. Accident-free radiological impacts from truck or rail transportation were dominated by radiation doses received at stops.

Rail accident statistics typically include the number of trains and the number of accidents and fatalities. The statistics do not typically include information concerning the number of fatalities per rail car. For the purpose of SEIS-II analyses, it is important to understand the number of accidents and fatalities per rail car, because a commercial train has the same probability of being in an accident whether it contains rail cars with TRU waste or not. The standard method of calculating the number of accidents and fatalities per commercial train is to divide the number of accidents or fatalities per train by the average number of rail cars per train, which is 70. Therefore, when a train of 70 cars is in an accident that results in one death, that fatality would count as 1/70th of a fatality for each rail car. If that train included three rail cars of TRU waste, 3/70ths of that fatality would be apportioned to rail cars of TRU waste.

There are no statistics on the average number of cars in dedicated trains; as a result, making such adjustments becomes more difficult. The assumption for SEIS-II is that each dedicated train would only have three rail cars carrying TRU waste. Should a dedicated train be involved in an accident that results in a fatality, that fatality would be apportioned as 1/5 a fatality for each rail car. This number could be changed a great deal, though, by increasing the number of rail cars per train.

Differences in impacts between regular and dedicated rail service would be primarily due to the differences in apportioning fatalities to rail cars. For SEIS-II, it was estimated that the fatality rate for dedicated rail would be 14 times greater than for regular rail.

Table 5-29 presents the impacts of transportation by regular and dedicated rail for Action Alternative 1. The impacts presented in this table represent three rail cars of TRU waste in either regular or dedicated rail transport. Further details on the estimation of rail impacts can be found in Appendix E.

Radiological impacts from rail transportation accidents were estimated relative to impacts presented for truck transportation accidents. As described under Action Alternative 1, two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first estimated impacts over the entire shipping campaign and the second estimated impacts from four bounding case accidents.

Table 5-29
Impacts from Rail Transportation
for Action Alternative 1

Aggregate Traffic-Related Fatalities	
Regular Rail	8
Dedicated Rail	112
Aggregate Accident-Free Radiological Impacts (LCFs)	
CH-TRU Waste	
Occupational	0.02
Nonoccupational	
Stops	0.3
Sharing Route	1.6E-3
Along Route	0.09
Nonoccupational Total	0.4
RH-TRU Waste	
Occupational	0.01
Nonoccupational	
Stops	0.8
Sharing Route	3.9E-3
Along Route	0.2
Nonoccupational Total	1.1
Total CH-TRU and RH-TRU Waste	
Occupational	0.03
Nonoccupational	
Stops	1.2
Sharing Route	5.5E-3
Along Route	0.3
Nonoccupational Total	1.5
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)	
CH-TRU Waste	0.7
RH-TRU Waste	0.08
Total CH-TRU and RH-TRU Waste	0.8

For the first analysis, the impacts were estimated based on the number of shipments, the accident frequency for each route, and the eight accident severity categories presented in RADTRAN. Because the number of miles traveled are similar between truck and rail and the rail car accident frequency is less than the truck accident frequency, it was conservatively estimated that the aggregate radiological impacts for rail transportation would be the same as those reported for truck transportation.

The estimation of radiological impacts for bounding truck accidents was done assuming that only one TRUPACT-II or RH-72B would fail in an impact event. The basis for this assumption was Fischer et al. (1987), which states that impact with a hard target, such as a bridge abutment, could potentially breach one container per shipment. To breach the container, though, it must strike a hard target head on.

For rail shipments, it was assumed that each train would include three rail cars of TRU waste. Each rail car would carry six TRUPACT-IIs or two RH-72Bs. It was also assumed that for the bounding case accidents two TRUPACT-IIs or RH-72Bs could potentially be breached. The accidents would be derailments where two rail cars would strike bridge abutments on either side of the tracks. Although other TRUPACT-IIs or RH-72B casks might experience impact forces, it was

assumed that the forces would be insufficient to breach the containers. The estimated population doses would be dominated by inhalation contributions (initial or from resuspension). The impacts are presented below:

- For the accident with the conservative inventory in two breached TRUPACT-IIs, the total population dose would result in 32 LCFs in the exposed population. The estimated maximum individual dose would result in a 0.12 probability of a cancer fatality.

- For the accident with a conservative inventory in two breached RH-72Bs, the total population dose would result in 32 LCFs in the exposure population. The estimated maximum individual dose would result in a 0.12 probability of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached TRUPACT-IIs, approximately 6 LCFs in the exposed population would be expected. The estimated maximum individual dose would result in a 0.08 probability of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached RH-72Bs, the total population dose would result in an expectation of 0.08 LCF in the population. The estimated maximum individual dose would result in a 1.4×10^{-4} probability of a cancer fatality.

As in the case for truck transportation, there would be negligible impacts from hazardous chemical releases in a rail transportation severe accident.

5.2.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and waste disposal operations under Action Alternative 1. The methods and assumptions used were similar to those used for the Proposed Action and described in Section 5.1.9, except that the inventory to be disposed of would include the Total Inventory (except for the PCB-commingled waste).

Impacts from waste treatment were adjusted from those presented in the WM PEIS, and a description of this adjustment is provided in Appendix B. Action Alternative 1 also includes analysis of potential impacts from TRU waste in lag storage (waste that would be treated and stored awaiting shipment to WIPP for disposal). Lag storage impact estimates were made assuming the waste would be at the lag storage site for the same lifetime exposure periods as for WIPP disposal operations: 70 years for an MEI, 35 years for the surrounding population, and 35 years for noninvolved and involved workers. The shorter exposure time for the population reflects population turnover resulting from deaths, immigration, and emigration. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.2.9.1 Public

Impacts to the populations and to the MEIs under Action Alternative 1 are presented in this section; results are presented in Table 5-30. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at multiple DOE sites but not WIPP, while disposal operations would take place only at WIPP. Population impacts

were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment and lag storage are presented for the highest individual waste treatment sites, while the MEI from disposal operations is near the WIPP site. See Chapter 3 for additional information on where treatment and storage would occur under Action Alternative 1.

Table 5-30
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1

	Waste Treatment Impacts		Lag Storage Impacts [a]		WIPP Disposal Operations Impacts	
Category	Radiological (LCF) [b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [b]	Hazardous Chemical (Cancer Incidence) [c]
MEI [d, e]						
Basic Inventory						
CH-TRU Waste	1E-9 (R)	2E-12 (X)	2E-6 (O)	6E-8 (L)	3E-7	1E-8
RH-TRU Waste	6E-11 (L)	2E-11 (O)	1E-9 (O)	5E-8 (O)	8E-10	2E-9
Total Waste	1E-9 (R)	2E-11 (O)	2E-6 (O)	6E-8 (L)	3E-7	1E-8
Total Inventory						
CH-TRU Waste	1E-9 (R)	2E-12 (X)	2E-6 (O)	1E-7 (L)	5E-7	2E-8
RH-TRU Waste	1E-10 (L)	3E-11 (O)	2E-9 (O)	7E-8 (O)	7E-10	2E-9
Total Waste	1E-9 (R)	3E-11 (O)	2E-6 (O)	1E-7 (L)	5E-7	2E-8
Population [d]						
Basic Inventory						
CH-TRU Waste	1E-4	1E-7	1E-2	2E-3	2E-4	2E-5
RH-TRU Waste	1E-6	4E-7	3E-5	4E-4	1E-6	9E-7
Total Waste	1E-4	4E-7	1E-2	2E-3	2E-4	2E-5
Total Inventory						
CH-TRU Waste	2E-4	1E-7	1E-2	2E-3	3E-4	2E-5
RH-TRU Waste	2E-6	5E-7	4E-5	5E-4	9E-7	9E-7
Total Waste	2E-4	6E-7	1E-2	3E-3	3E-4	2E-5
Aggregate Total	2E-4	6E-7	1E-2	5E-3	4E-4	3E-5

[a] These sites would have the maximum impacts.
[b] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[c] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were released at a constant rate, the MEI lifetime risk from the CH-TRU waste would be 5E-8.
[d] The MEI and populations evaluated for treatment, storage, and operations impacts are different.
[e] R = RFETS, L = LANL, O = ORNL, X = LLNL

Waste Treatment

No LCFs (2×10^{-4} LCFs) would be expected in the total population around the waste treatment sites, and no cancer incidence (6×10^{-7} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at RFETS for radiological impacts (1×10^{-9} probability of an LCF) and at ORNL for hazardous chemical impacts (3×10^{-11} probability of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for the MEI would be 4×10^{-10}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

No LCFs (1×10^{-2} LCFs) would be expected in the total population around the lag storage sites, and no cancer incidence (3×10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at ORNL for radiological impacts (2×10^{-6} probability of an LCF) and at LANL for hazardous chemical impacts (1×10^{-7} probability

of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the MEI would be 6×10^{-4}, and no health effect is predicted unless the HI is 1 or higher.

The aggregate total indicated in Table 5-30 refers to the impacts to the public expected over the entire operational period under Action Alternative 1. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 42 years for CH-TRU waste and 160 years for RH-TRU waste. No LCFs (1×10^{-2} LCFs) or cancer incidence (5×10^{-3} cancers) would be expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials under incident-free operations.

WIPP Disposal Operations

No LCFs (3×10^{-4} LCFs) would be expected in the population around WIPP from radiation exposure, or cancer incidence (2×10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 5×10^{-7} probability of an LCF from radiation exposure and a 2×10^{-8} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects are predicted. The maximum HI for the MEI was estimated to be 7×10^{-5}, and no health effect is predicted unless the HI is 1 or higher.

The aggregate total indicated in Table 5-30 refers to the impacts to the public expected over the entire operational period. The operations period for the disposal of the Total Inventory is expected to be 42 years for CH-TRU waste and 160 years for RH-TRU waste. Under Action Alternative 1, no LCFs (4×10^{-4} LCFs) or cancer incidence (3×10^{-5} cancers) would be expected over the several generations of exposure to the estimated releases.

5.2.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternative 1 are presented in this section; results are presented in Table 5-31. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling, or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at multiple DOE sites but would not include WIPP. Disposal operations would take place only at WIPP. The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites, while the maximally exposed noninvolved worker from disposal operations was assumed to work at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was assumed to be 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Table 5-31
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence) [b]
Maximally Exposed Noninvolved Worker [c, d]						
Basic Inventory						
CH-TRU Waste	3E-9 (R)	6E-12 (X)	8E-6 (O)	2E-7 (I)	2E-7	5E-8
RH-TRU Waste	3E-11 (L)	1E-10 (O)	1E-8 (O)	4E-8 (H)	2E-9	4E-9
Total Waste	3E-9 (R)	1E-10 (O)	8E-6 (O)	2E-7 (I)	2E-7	5E-8
Total Inventory						
CH-TRU Waste	8E-9 (R)	6E-12 (X)	8E-6 (O)	5E-7 (I)	4E-7	9E-8
RH-TRU Waste	5E-11 (L)	2E-10 (O)	4E-9 (O)	4E-8 (H)	2E-9	4E-10
Total Waste	8E-9 (R)	2E-10 (O)	8E-6 (O)	5E-7 (I)	4E-7	9E-8
Population Noninvolved Worker [c]						
Basic Inventory						
CH-TRU Waste	6E-6	2E-8	3E-2	4E-3	2E-4	5E-5
RH-TRU Waste	7E-8	1E-7	6E-5	7E-4	2E-6	4E-6
Total Waste	6E-6	1E-7	3E-2	5E-3	2E-4	5E-5
Total Inventory						
CH-TRU Waste	8E-6	3E-8	4E-2	9E-3	4E-4	1E-4
RH-TRU Waste	1E-7	2E-7	9E-5	8E-4	2E-6	4E-7
Total Waste	8E-6	2E-7	4E-2	5E-3	4E-4	1E-4
Aggregate Total	8E-6	2E-7	0.05	0.01	5E-4	1E-4

[a] The probability of an LCF occurring to the maximally exposed noninvolved worker and the number of LCFs in the population.
[b] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were released at a constant rate, the noninvolved worker lifetime risk from CH-TRU waste would be 5E-8.
[c] The noninvolved workers considered for treatment impacts and operations impacts are different.
[d] R = RFETS, L = LANL, O = ORNL, X = LLNL, I = INEEL, H = Hanford

Waste Treatment

No LCFs (8×10^{-6} LCFs) or cancer incidence (2×10^{-7} cancers) would be expected in the total noninvolved worker population around the waste treatment sites. The maximally exposed noninvolved worker would be at RFETS for radiological impacts (8×10^{-9} probability of an LCF) and at ORNL for hazardous chemical impacts (2×10^{-10} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the maximally exposed noninvolved worker would be 3×10^{-9}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Radiological impacts from lag storage would be somewhat greater than nonradiological impacts to noninvolved workers under Action Alternative 1. No LCFs would be expected in the total noninvolved worker population at the lag storage sites (4×10^{-2} LCFs), and no cancer incidence (5×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at ORNL for radiological impacts (8×10^{-6} probability of an LCF) and at INEEL for hazardous chemical impacts (5×10^{-7} probability of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for any maximally exposed noninvolved worker would be 4×10^{-3}.

The aggregate total indicated in Table 5-31 refers to the impacts to noninvolved worker population at the lag storage sites expected over the entire operational period under Action Alternative 1. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 42 years for CH-TRU waste and 160 years for RH-TRU waste. No LCFs (0.05 LCFs) or cancer incidence (0.01 cancers) would be expected in the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials under incident-free operations.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (4×10^{-4} LCFs). VOC release estimates were the same as for the public. No cancer incidence (1×10^{-4} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 4×10^{-7} probability of an LCF from radiation exposure, and a 9×10^{-8} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects are predicted. The maximum HI for the maximally exposed noninvolved worker would be 6×10^{-4}, and no health effect is predicted unless the HI is 1 or higher.

The aggregate total to noninvolved workers at the WIPP site indicated in Table 5-31 shows that no LCFs (5×10^{-4} LCFs) or cancer incidence (1×10^{-4} cancers) would be expected during the entire disposal operations period under Action Alternative 1.

5.2.9.3 Involved Workers

Impacts to involved workers who would handle waste during treatment, lag storage, and WIPP disposal operations under Action Alternative 1 are presented in this section. Results are presented in Table 5-32. The methods used to estimate impacts from waste treatment and WIPP disposal operations are described at the beginning of Section 5.1.9 and in Section 5.1.9.3. Additional information is presented in Appendix F. In actuality, all worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Waste Treatment

Radiological impacts to the involved worker population from waste treatment would be greater than nonradiological impacts. A maximum of 1.5 radiation-related LCFs could occur in the worker population, while no cancer incidence (3×10^{-5} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health effects are predicted. The maximum exposure index for a waste treatment worker would be 3×10^{-4}, and no health effect is predicted unless the HI is 1 or higher. Additional information is presented in Appendix F.

Table 5-32
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 1 [a]

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population					(36 workers)	(36 workers)
Basic Inventory						
CH-TRU Waste	0.7	8E-6	0.5	0.02	0.3	0.01
RH-TRU Waste	0.02	7E-6	≤0.5	≤0.02	≤0.3	1E-3
Total Waste	0.8	2E-5	≤1	≤0.04	≤0.6	0.01
Total Inventory						
CH-TRU Waste	1.5	2E-5	0.5	0.02	0.5	0.03
RH-TRU Waste	0.03	1E-5	≤0.5	≤0.02	≤0.5	1E-3
Total Waste	1.5	3E-5	≤1	≤0.04	≤1	0.03
Aggregate Total	1.5	3E-5	≤1	≤0.1	≤1	0.04

[a] The involved worker populations considered for treatment impacts and operations impacts are different.

Lag Storage

Radiological impacts to the involved worker population from lag storage would be less than or equal to 1 LCF, and hazardous chemical impacts would be less than 0.04 cancers. No noncarcinogenic health effects would occur. Involved worker lag storage impacts would be larger from CH-TRU waste storage operations than from RH-TRU waste storage operations because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Therefore, no specific RH-TRU waste lag storage impact estimates were made. Impacts were assumed to be less than or equal to those for CH-TRU waste.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers. The workers were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over the 35 years, and all sites were assumed to monitor 20 percent of the Total Inventory annually.

The aggregate total indicated in Table 5-32 refers to the impacts to the involved worker population at the lag storage sites over the entire operational period under Action Alternative 1. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 42 years for CH-TRU waste and 160 years for RH-TRU waste. Less than 1 LCF and no cancer incidence (less than 0.1 cancers) would be expected over the several generations of involved workers that would be exposed externally or via inhalation of hazardous chemicals from lag storage operations. The radiological impact estimates reflect the aggregate impacts analyses presented in detail in Appendix F. The hazardous chemical impacts were estimated in the same manner as the public and noninvolved worker estimates.

WIPP Disposal Operations

Workers would be exposed under the same circumstances as described for the Proposed Action in Section 5.1.9.3. Radiological impacts to the involved worker population from disposal operations

at WIPP would be less than 1 LCF. WIPP involved worker radiological impact estimates were made assuming each involved worker handled the CH-TRU waste for 400 hours per year. The operational period was determined by assuming that 2.5 years of disposal operations were required to fill each panel. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste.

Hazardous chemical impacts to the involved worker population would be 0.03 cancers, and no noncarcinogenic health effects would occur. Involved worker exposures to VOCs were evaluated in the Waste Handling Building and underground, as was done for the Proposed Action. The potential carcinogenic impacts would be greatest for the individual underground worker. Noncarcinogenic health effects were also estimated. The same methods and assumptions were used as for the Proposed Action (Section 5.1.9.3). Workers were assumed to be exposed for 35 years. The results were the same as those presented for the Proposed Action.

The aggregate total indicated in Table 5-32 refers to the impacts to the involved worker population at WIPP over the entire disposal operations period under Action Alternative 1. Less than 1 LCF and 0.04 cancers are expected from external radiation or hazardous chemical exposures, respectively, over the several generations of involved workers at WIPP. Radiological impacts over the entire operational period would be approximately twice the number of impacts estimated for the individual during the first 35 years of CH-TRU waste disposal operations at WIPP. Radiological decay would reduce the radiological impacts to each generation of WIPP workers. Hazardous chemical impacts were conservatively estimated by assuming continuous exposure to the same releases over the entire disposal operations period.

5.2.10 Facility Accidents

Impacts under Action Alternative 1 would be the same as those for the Proposed Action for treatment and WIPP disposal accidents. However, there would be lag storage of CH-TRU and RH-TRU waste under Action Alternative 1; therefore, impacts resulting from storage accidents are discussed for the six sites under evaluation (Hanford, LANL, INEEL, SRS, RFETS, and ORNL). Impacts of storage accidents were evaluated for storage at these six sites because they would store about 99 percent of the CH-TRU and RH-TRU waste under Action Alternative 1.

5.2.10.1 Waste Treatment Accidents

The impacts from waste treatment accidents under Action Alternative 1 would be the same as those under the Proposed Action (see Section 5.1.10.1).

5.2.10.2 Waste Storage Accidents

Three potential waste storage accidents were evaluated for Action Alternative 1 (see Table 5-33). The results are presented only for accidents involving CH-TRU waste because they would be greater than the results for similar accidents involving RH-TRU waste. (The impacts from failure of RH-TRU storage facilities as a result of an earthquake are presented in Appendix G). Lower transuranic radionuclide activity in RH-TRU waste (lower PE-Ci levels, see Table G-23 and

Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) would all combine to limit potential impacts from RH-TRU waste accidents. Waste would be consolidated at 10 sites for lag storage under Action Alternative 1.

Table 5-33
Storage Accident Scenarios Evaluated for Action Alternative 1

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop, and Lid Failure (Accident Scenario S1)	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destabilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2)	1E-4 to 1E-6 (<8 PE-Ci) <1E-6 (>8 PE-Ci)	A fire spontaneously erupts in a waste drum.
Earthquake (Accident Scenario S3)	1E-5 or less	A beyond-design-basis earthquake (or other natural event) occurs, causing the storage building to collapse.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. For Accident Scenarios S1 and S2, CH-TRU waste involved in the accidents was assumed to have the highest levels of radionuclides (80 PE-Ci per drum) permitted by the planning-basis WAC, conservative concentrations of VOCs (based on CH-TRU waste sampling and planning-basis WAC limits) and conservative concentrations of heavy metals. Accident Scenario S3 involves a large number of waste containers; therefore, site-specific drum PE-Ci values and average hazardous chemical concentrations were used in the analyses. Additional details on the accident analyses are presented in Appendix G.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and as the probability of an LCF occurring in MEIs. Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and heavy metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and heavy metals were estimated by two different methods for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the earthquake scenario (Accident Scenario S3). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-34.

Table 5-34
Radiological Consequences from Storage Accidents for Action Alternative 1 [a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Drum Puncture and Lid Failure (Accident Scenario S1)	Maximum: 5E-4 (RFETS)	Maximum: 3E-7 (ORNL)	Maximum: 4E-7 (Hanford)
Drum Fire (Accident Scenario S2)	Maximum: 2E-3 (RFETS, ORNL)	Maximum: 1E-6 (ORNL)	Maximum: 2E-6 (Hanford, LANL, ORNL)
Earthquake (Accident Scenario S3-CH)	Hanford: 200 INEEL: 6 LANL: 50 RFETS: 300 ORNL: 6 SRS: 38	Hanford: 0.1 INEEL: 3E-3 LANL: 0.1 RFETS: 0.02 ORNL: 6E-3 SRS: 4E-3	Hanford: 1 INEEL: 0.6 LANL: 0.6 RFETS: 0.6 ORNL: 0.01 SRS: 1

[a] The site with the greatest impact is shown in parentheses.

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Public

Population impacts from storage accidents were estimated for the exposed populations around the six major treatment sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because of different population distributions, distances to the MEIs, and atmospheric dispersion factors among the sites. No LCFs would be expected in the exposed population from drum puncture or drum fire accidents (Accident Scenarios S1 and S2, respectively), but LCFs were estimated to occur from the earthquake accident (Accident Scenario S3) at all sites. The number of LCFs ranged from 6 (at ORNL and INEEL) to 300 (at RFETS). The radiological impacts were estimated to be the highest to the MEI at ORNL for the drum puncture and drum fire accidents (Accident Scenarios S1 and S2). Impacts from the earthquake accident (Accident Scenario S3) were estimated to range from 3×10^{-3} to 0.1 probability of an LCF to the MEI.

Carcinogenic impacts from VOCs would be one to six orders of magnitude greater than impacts from heavy metals for the drum puncture and earthquake scenarios (Accident Scenarios S1 and S3, respectively). Heavy metals account for all carcinogenic impacts from the drum fire accident (Accident Scenario S2) because VOCs would be consumed by the fire. No cancer was estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum probability of cancer to an MEI would be 9×10^{-10} for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively). The maximum probability of cancer to the MEI would be 9×10^{-7} for the earthquake accident (Accident Scenario S3). No noncarcinogenic impacts would be expected for any of the three accidents evaluated.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste storage facility. The impacts to the noninvolved worker would vary over a narrow range across the six sites evaluated. The range was narrow because similar conditions were assumed to exist at the six sites.

Radiological impacts to the maximally exposed noninvolved worker would result in a 4×10^{-7} probability of an LCF (at Hanford) from events of the drum puncture scenario (Accident Scenario S1), a 2×10^{-6} probability of an LCF (at Hanford, LANL, or ORNL) from the events of the drum fire scenario (Accident Scenario S2), and up to a probability of 1 of an LCF (at Hanford and SRS) from the beyond-design-basis earthquake (Accident Scenario S3).

Hazardous chemical impacts would be relatively minor in comparison to the radiological impacts. The maximum probability of cancer to the maximally exposed noninvolved worker from VOC and heavy metal intakes would be 1×10^{-9} for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively). The corresponding impact for the earthquake scenario (Accident Scenario S3) would be a 5×10^{-6} probability of cancer. A Hanford noninvolved worker could experience a minor noncarcinogenic health effect from drum puncture releases (Accident Scenario S1) of 1,1,2,2-tetrachloroethane.

Maximally Exposed Involved Worker

The involved worker would be the individual most seriously impacted by the events of the drum puncture and earthquake scenarios (Accident Scenarios S1 and S3, respectively) because of close proximity to the accidents. Impacts were quantitatively estimated for the drum puncture scenario (Accident Scenario S1). The maximally exposed involved worker could have a 0.06 probability of an LCF as a result of the radionuclide intake from this accident. The analysis assumed the instantaneous radioactive material releases from the three containers, expanding in a uniform hemisphere of 5 meters (16 feet) in radius. The worker was assumed to inhale this air for 1 minute prior to exiting to a fresh air source.

The involved worker could have a 7×10^{-8} probability of contracting cancer from estimated hazardous chemical intakes due to the events of the drum puncture scenario (Accident Scenario S1). Noncarcinogenic impacts could be irreversible but would not be life-threatening under the assumed exposure assumptions. These impacts could result from the potential releases of 1,1,2,2-tetrachloroethane, and methylene chloride. Mild impacts might result from lead and mercury releases.

Impacts from the drum fire scenario (Accident Scenario S2) would be serious if the worker happened to be adjacent to the drum when the fire began. However, a worker's actions are not required to initiate the accident; therefore the probability of exposure of a worker adjacent to the fire is small. The smoke being released from the drum would alert workers to the incident, and it can be reasonably assumed that workers would avoid exposure to the smoke.

Catastrophic destruction of the storage facility during an earthquake or other natural events (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker due to a falling ceiling or other debris and radiation doses.

5.2.10.3 WIPP Disposal Accidents

The impacts from accidents during WIPP disposal operations under Action Alternative 1 would be the same as those under the Proposed Action (see Section 5.1.10.3).

5.2.11 Industrial Safety

A total of four fatalities from industrial accidents would occur under Action Alternative 1 during waste treatment at all treatment sites. This result was determined by adjusting the physical-hazard fatality estimate of the WM PEIS.

Under Action Alternative 1, the WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 160 years rather than 35 years. Decommissioning activities would be the same as under the Proposed Action. Estimated industrial safety impacts to workers under Action Alternative 1 are presented in Table 5-35. Oversight and inspections by the MSHA and adherence to OSHA regulations would probably reduce actual occurrences below these estimated values.

Table 5-35
Industrial Safety Impacts from WIPP
Operations and Decommissioning for Action Alternative 1

Years	Injuries/Illnesses			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2158	99	5,600	5,699	0.2	5.6	5.8
Decommissioning 2159-2168	187	96	283	0.3	0.1	0.4
Total	286	5,696	5,982	0.5	5.7	6.2

5.2.12 Long-Term Performance

This section presents the potential impacts associated with the long-term performance of the WIPP repository for Action Alternative 1 over the 10,000-year period after the site is closed. These impacts were estimated based on computer simulations that predicted radionuclide and heavy metal releases from TRU waste in the repository under undisturbed and disturbed conditions. Analyses were conducted using the same methods as for the Proposed Action and other action alternatives; additional information is presented in Appendix H. The waste volume emplaced would be 281,000 cubic meters (9.9 million cubic feet) of CH-TRU waste and 55,000 cubic meters (1.9 million cubic feet) of RH-TRU waste. The repository size was increased from the 10 panels of the Proposed Action to 68 panels to accommodate the increased waste volume. The radionuclide inventory was increased to 7.3×10^6 Ci in CH-TRU waste and 5.1×10^6 Ci in RH-TRU waste. There were similar increases in heavy metal inventories. Detailed information on the radionuclide and heavy metal inventories is provided in Appendix A.

The four cases below were analyzed for Action Alternative 1. The cases are the same as the Proposed Action and other action alternatives but include alternative-specific differences, such as repository size and radionuclide and heavy metal inventories.

- Case 6 considered undisturbed repository conditions. Median parameter values were used for input variables where probability distributions have been defined.

- Case 7 considered disturbed conditions resulting from a borehole assumed to pass through the repository and intercept a pressurized brine reservoir in the Castile Formation. Median parameters values were used for input variables where probability distributions have been defined.

- Case 8 was the same as Case 6 but used 75th percentile parameter values for input variables where probability distributions have been defined.

- Case 9 was the same as Case 7 but used 75th percentile parameter values for input variables where probability distributions have been defined.

5.2.12.1 Impacts of Undisturbed Conditions

Radionuclide and heavy metal (predominantly lead) migration for undisturbed conditions at 10,000 years after closure for Case 8 (75th percentile parameter values) is presented in Figure 5-3. Case 8 resulted in slightly more extensive migration than Case 6 (median parameter values). Figure 5-3 shows the locations in the modeled region where the concentration of total radionuclide activity in the brine, summed over 30 radionuclides, is equal to 1 pCi per liter (1×10^{-9} Ci per cubic meter). A total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration.

Approximately the same vertical and lateral migration of radionuclides and heavy metals would occur for Action Alternative 1 as for the Proposed Action. Total radionuclide concentrations of one pCi per liter would extend about 20 meters (65 feet) below the repository, 40 meters (130 feet) above the repository, and about 1,900 meters (6,200 feet) laterally.

Analysis of undisturbed repository conditions (Cases 6 and 8) during the first 10,000 years showed that no radionuclides or heavy metals would be released to the Culebra Dolomite. No total radionuclide activity concentrations greater than 1 pCi per liter or heavy metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. There would be no release to the accessible environment and therefore no human health impact. Additional information is provided in Appendix H.

5.2.12.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of Action Alternative 1.

Surface Release Caused by Drilling into the Repository

The human health impacts of drilling into the repository (Case 7 and Case 9) were evaluated for a drilling crew member and a well-site geologist. These individuals were assumed to be exposed to waste material brought to the land surface by drilling, as described in Section 5.1.12.2 and Appendix H. Under Action Alternative 1, 17 repository panels would hold both CH-TRU and RH-TRU waste, and 51 waste panels would hold only RH-TRU waste, so a drilling event could contact CH-TRU, RH-TRU, or both CH-TRU and RH-TRU waste.

The estimated radionuclide releases to the ground surface for Case 7 (median parameter values) would be 2.6, 0.1, and 2.7 Ci, respectively, from CH-TRU waste, RH-TRU waste, and both

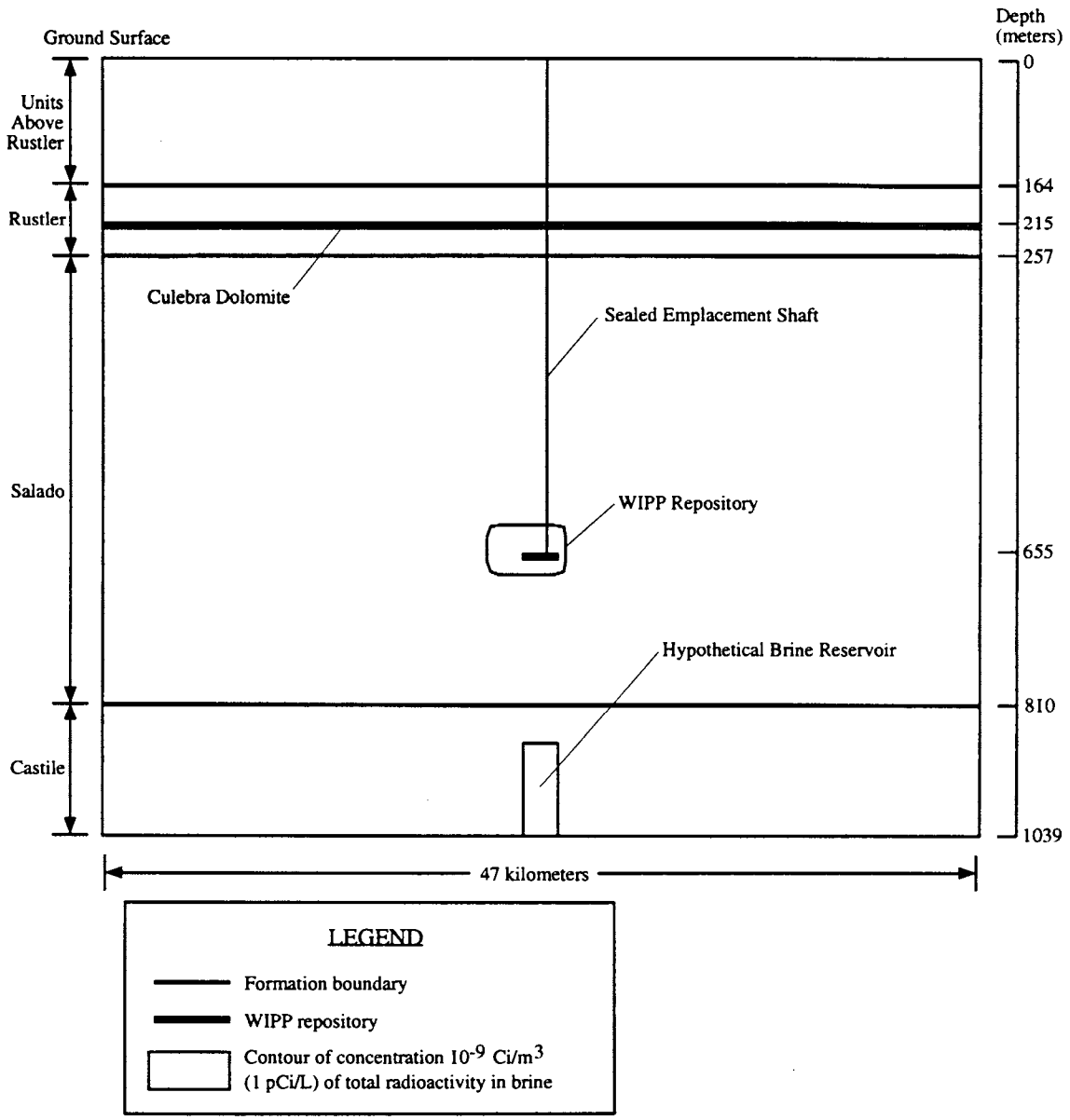


Figure 5-3
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) for Action Alternative 1

CH-TRU and RH-TRU waste. For Case 9 (75th percentile parameter values), the releases would be 3.5 Ci from CH-TRU waste, 0.15 Ci from RH-TRU waste, and 3.6 Ci from CH-TRU and RH-TRU waste. The releases would consist mainly of Pu-238, Pu-239, and Am-241 for all these events. Heavy metal releases from these drilling intrusions would be 6, 22, and 23 kilograms (13, 49, and 50 pounds), respectively, from CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste for Case 7 (median parameter values). For Case 9 (75th percentile parameter values), the releases would be 8 kilograms (18 pounds) from CH-TRU waste, 30 kilograms (65 pounds) from RH-TRU waste, and 31 kilograms (67 pounds) from both CH-TRU and RH-TRU waste. Additional information is provided in Appendix H.

The radiological impacts to a drilling crew member for Case 7 (median parameter values) would be a 2×10^{-4}, 7×10^{-6}, and 2×10^{-4} probability of an LCF, respectively, from drilling intrusions of CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. For Case 9 (75th percentile parameter values), the impacts would be higher with a 4×10^{-4}, 1×10^{-5}, and 4×10^{-4} probability of an LCF for the same respective waste type intrusions. Most of the impact would be due to the inadvertent ingestion of drill cuttings (ranging from 83 percent to about 100 percent), with less impact from external radiation dose. Americium-241 would be the major dose contributor. Ingestion of heavy metals for this scenario would result in a 1.7×10^{-8}, 1.0×10^{-9}, and 1.8×10^{-8} probability of cancer incidence, respectively. There would be no noncarcinogenic impacts expected from the ingestion of the metals because all hazard indices would be much less than one. Impacts of exposure to VOCs were not analyzed (see Appendix H) but were expected to be bounded by impacts of VOC exposure under WIPP disposal accidents (see Appendix G). There would be a 3×10^{-7} probability of a cancer incidence. Some short-term toxicological effects from inhalation of VOCs could occur under these assumptions (see Appendix G).

Radiological impacts to the well-site geologist from external radiation exposure for Case 7 (median parameter values) would result in a 2×10^{-9} probability of an LCF from CH-TRU waste and a 2×10^{-9} probability of an LCF from RH-TRU waste. For Case 9 (75th percentile parameter values), the radiological impacts would be a 3×10^{-9} probability of an LCF from CH-TRU waste and a 5×10^{-9} probability of an LCF from RH-TRU waste. Am-241 and U-234 were major external dose contributors in CH-TRU and RH-TRU waste for Case 7 and in CH-TRU waste for Case 9, while Sr-90 and Cs-137 were the major external dose contributors in RH-TRU waste for Case 9.

Drilling through the Repository into a Pressurized Brine Reservoir

Impacts of drilling through the repository into a pressurized brine reservoir were analyzed as described in Section 5.1.12.2 and in Appendix H, using information specific to Action Alternative 1 where appropriate. Analysis of radionuclide and heavy metal migration for this scenario at 10,000 years after closure for Case 7 (median parameters values) showed there would be no radionuclide or heavy metal releases into the Culebra Dolomite or the accessible environment.

The extent of radionuclide (predominantly Pu-238, Pu-239, and Am-241) migration for disturbed conditions at 10,000 years after closure for Case 9 (75th percentile parameters values) is presented schematically in Figure 5-4. Total radionuclide activity concentrations of one pCi per liter are shown. Simulations showed radionuclides migrated upward and downward into the borehole and penetrated into rocks directly in contact with the borehole for a limited distance. For Case 9 only, migration extends upward into the Culebra Dolomite at 10,000 years. Migration also extends downward in the borehole (for both Cases 7 and 9) to the Castile Formation and into the brine

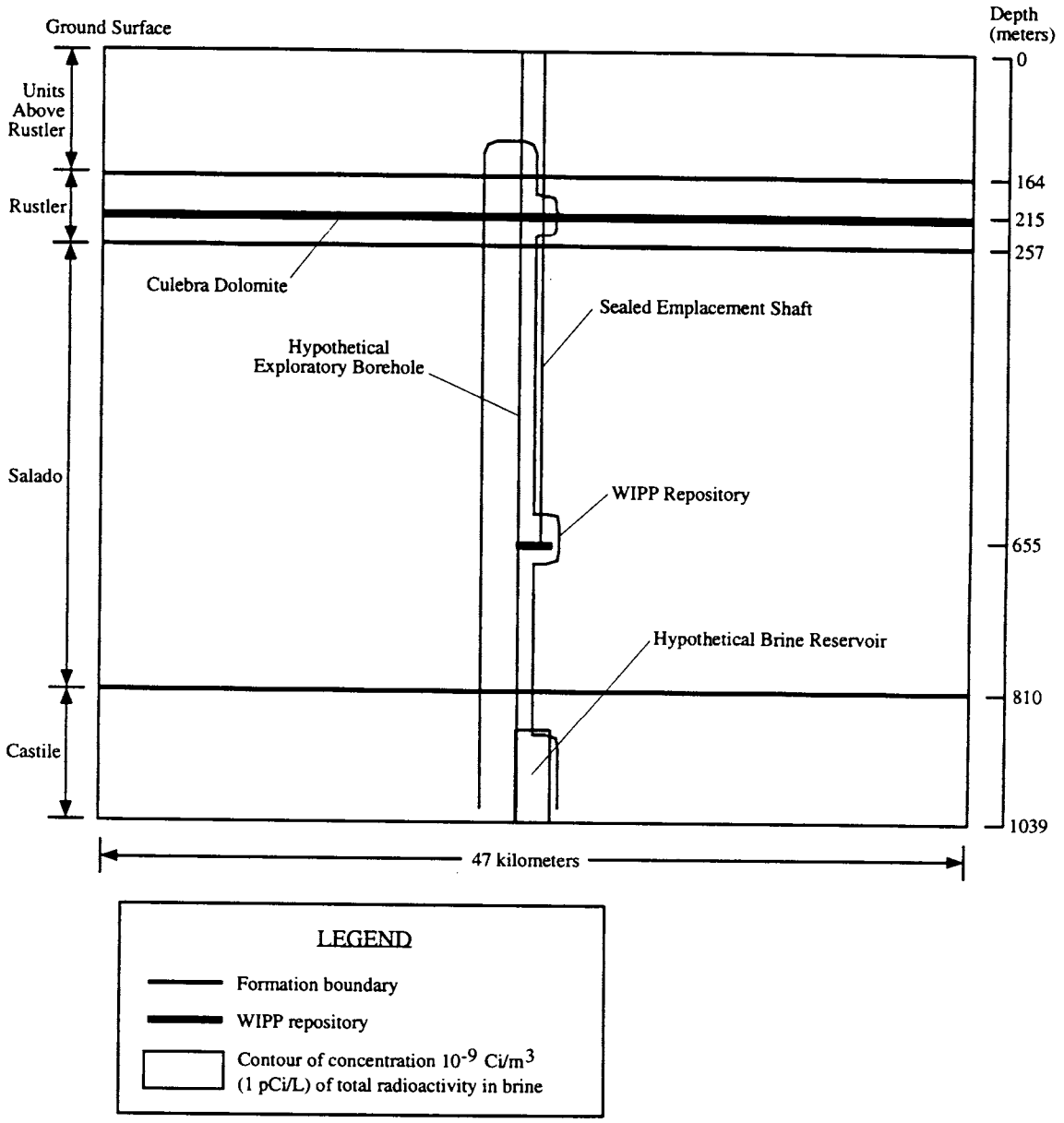


Figure 5-4
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 9) for Action Alternative 1

reservoir. This would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole. Total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration. Predicted brine pressures and additional modeling information is provided in Appendix H.

Impacts of radionuclide and heavy metal migration to the accessible environment were evaluated for Case 9 (75th percentile parameter values) since a release of contaminants into the Culebra Dolomite was indicated for this case only. The exposure scenario was the same as that evaluated for the Proposed Action and other action alternatives, with an individual consuming beef from cattle using the water from a stock well 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions since calculated impacts for full mining conditions were significantly lower (see Section H.8.2). Radiological impacts would be negligible, with a 2×10^{-27} probability of an LCF. The dominant dose contributor was Pu-239. Ingestion of heavy metals from consumption of contaminated beef was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-27}. No noncarcinogenic impacts would be expected. Additional information is presented in Appendix H.

5.2.13 Reducing WIPP Operations for Action Alternative 1

As noted in Chapter 3, stakeholders requested a discussion in greater detail of the changes to impacts should the Department reduce the period of operations for WIPP under Action Alternative 1. The period of operations is 160 years, but it could be reduced to 60 years by constructing an additional waste handling building for RH-TRU waste, constructing four new shafts, and tripling the number of excavation and emplacement crews. Additional costs would total $80 million in capital costs and $165 million in annual operating costs.

No additional impacts would be expected at treatment facilities because the facilities and their periods of operation would be identical to those discussed earlier.

The time to ship to WIPP from the treatment facilities would decrease from 160 years to 53 years. The aggregate nonradiological impacts would be the same as those described earlier, except that they would occur within the shorter time period. The accident-free radiological impacts to occupational and nonoccupational populations were reported as aggregate impacts over the entire shipping campaign. Therefore, no increase in impacts would be noted. However, because the MEIs would be exposed to more shipments, the estimated exposure to MEIs would triple. All accident impacts would be identical to those described earlier.

Because the size of the WIPP underground facility would remain the same and because the new facility would be constructed within the footprint of the repository, land use, biological resource, and cultural resource impacts would be similar to those described earlier in this section. Construction of the new waste handling building would increase the air quality impacts slightly for the period of construction. Other air quality impacts would be negligible. Noise impacts would triple because the rate of shipments through Carlsbad would triple. Water quality and infrastructure impacts may be impacted by the new facilities and additional work crews.

Human health impacts would decrease for lag storage. The impacts to the public, noninvolved workers, and involved workers over the entire operations period would remain the same, but be

compressed into about a third of the time. Impacts to the MEIs would triple because triple the waste would be emplaced during a lifetime. Industrial safety impacts would decrease by approximately 50 percent, considering the reduced operation times, construction of new facilities, and the increased number of workers. There would be no change in long-term performance assessment results.

The greatest change in Action Alternative 1 results would be in life-cycle costs, which would drop from $50.95 billion in 1994 dollars ($16.32 billion discounted) to $35.80 billion ($13.24 billion discounted) should only trucks be used. Life-cycle costs should regular rail transportation be used would decrease from $47.68 billion ($15.80 billion discounted) to $32.53 billion ($12.03 billion discounted), and life-cycle costs should dedicated rail transportation be used would decrease from $57.36 billion ($17.33 billion discounted) to $42.21 billion ($15.62 billion discounted).

5.3 IMPACTS OF ACTION ALTERNATIVE 2

This section describes the environmental impacts associated with the implementation of the subalternatives of Action Alternative 2. Under each subalternative, WIPP would accept the Basic Inventory and the Additional Inventory including PCB-commingled TRU waste. All TRU waste would be thermally treated to meet Land Disposal Restrictions (LDR). SEIS-II analyzed three different consolidation and treatment subalternatives, Action Alternatives 2A, 2B and 2C. Action Alternative 2C includes treatment of all CH-TRU waste at WIPP.[1] Each subalternative is described in Section 3.2.3.

The total consolidated, pretreatment volume of waste to be treated under this alternative would be 313,000 cubic meters (11 million cubic feet) (see Tables 3-4 through 3-9). The type, size, and number of treatment facilities needed under this alternative would be comparable to those assessed in the thermal treatment alternatives of the WM PEIS. Treatment under each subalternative would continue for 35 years. The waste would be stored at the treatment facilities until disposal (this storage is called lag storage). The WIPP operational time frame under this alternative would extend to the year 2148 (150 years).

5.3.1 Land Use Management

Land use impacts at the treatment sites for each of the Action Alternative 2 subalternatives would be similar to those under the Proposed Action discussed in Section 5.1.1. Additional waste would be treated under this alternative, but the treatment time period would be extended to 35 years. Though the SEIS-II Action Alternative 2 subalternatives propose treating TRU waste at various DOE locations, in no case would the treatment facilities require more than 1 percent of the available land at those DOE locations. The Department would have a great deal of flexibility when determining the locations of such facilities (DOE 1997). The Department would be able to minimize impacts to on-site land use and would be able to avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate land areas (including wetlands, flood plains, cultural resource areas, and the habitats of endangered and threatened species) (DOE 1997). Before treatment facilities would be constructed, further NEPA review would be undertaken at a site-wide or project-specific level.

[1] If the Department decides, based on the WM PEIS analyses, to centralize treatment at WIPP, the Department would prepare further project-specific NEPA review for any proposed treatment facility. Such review would be tiered from SEIS-II.

Land use impacts during disposal operations at WIPP under Action Alternatives 2A, 2B, and 2C would be similar to those under the Proposed Action, discussed in Section 5.1.1. A difference from the Proposed Action would occur during decommissioning and closure, when approximately 395 hectares (976 acres) would be affected due to an increased underground waste disposal area. Like the Proposed Action, the rest of the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure.

5.3.2 Air Quality

For Action Alternative 2A, the levels of criteria pollutants exceeding 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be those for CO at RFETS (24 percent) and PM_{10} at INEEL (10 percent). For Action Alternative 2B, the levels of criteria pollutants exceeding 10 percent would be PM_{10} at INEEL (10 percent). For Action Alternative 2C, the levels of criteria pollutants exceeding 10 percent would be PM_{10} (25 percent) and SO_2 (12 percent) at WIPP (DOE 1997) (see Appendix C for additional detail). Minor increases in PM_{10} levels may occur during construction.

RFETS, LLNL, NTS, and ANL-E are in nonattainment areas for some of the pollutants. In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations.

Of hazardous or toxic air pollutant releases, only radionuclide releases would exceed 10 percent of the applicable regulatory standard. For Action Alternative 2A, treatment-related releases could reach 134 percentof the regulatory standard at LANL. For Action Alternative 2B, treatment-related releases could reach 10 percent of the regulatory standard at INEEL. For Action Alternative 2C, releases could reach 137 percent of the regulatory standard at WIPP. Postulated waste treatment-related releases above the regulatory standard would require mitigation measures, such as HEPA filtration, to ensure they remained below the allowable limit.

The potential air quality impacts from the operation of WIPP for disposal under Action Alternatives 2A, 2B, and 2C would be the same as those anticipated under the Proposed Action. Although the increased waste disposal volume at WIPP would increase the duration of disposal activities, there would be no substantial difference in the rate of pollutant emissions on either an annual or a short-term basis.

Potential air quality impacts due to the decommissioning of WIPP under Action Alternative 2 would be similar to those under the Proposed Action. Construction of the berm and permanent markers and other decommissioning activities would last longer than under the Proposed Action and other alternatives, but would probably produce negligible increases in annual pollutant emissions compared to the other alternatives.

5.3.3 Biological Resources

The biological impacts at the treatment sites (including WIPP) for Action Alternatives 2A, 2B, and 2C would be the same as those for the Proposed Action. Though additional waste would be treated using a different treatment method, the size, type, and number of the treatment facilities would be

comparable to those assessed in the WM PEIS, which determined that construction and operation of the treatment facilities should not affect populations of nonsensitive plant and animal species. Also, terrestrial wildlife species probably would not be affected by airborne emissions nor by spills into aquatic environments due to traffic accidents (DOE 1997). Threatened and endangered species may be present at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following appropriate Endangered Species Act consultation and site-wide or project-level NEPA review during which such impacts would be assessed and mitigated, if necessary. The critical habitats of species listed by the state and federal governments as endangered, threatened or candidates would be avoided.

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE recently completed a site-specific biological survey yet to be published, during which no endangered, threatened, or state-listed species were identified.

At WIPP, potential impacts on biological resources for disposal operations would be similar to those under the Proposed Action, described in Section 5.1.3. The increased underground waste disposal area, though, would lead to greater impacts during closure and post-closure activities. Approximately 395 hectares (976 acres) of aboveground area would be affected by decommissioning, salt pile reclamation, and closure construction of berms and permanent markers. These activities would disturb avian and small mammal habitat within and near the area. These disturbed areas would be attractive as habitat after natural vegetation recolonizes.

5.3.4 Cultural Resources

The impacts to cultural resources at the treatment sites under Action Alternatives 2A, 2B, and 2C would be the same as those for the Proposed Action. Construction and operation of treatment facilities (including that proposed for WIPP under Action Alternative 2C) could adversely affect cultural resources, but site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed. These surveys would be part of site-wide or project-level NEPA reviews.

Waste shipment and disposal activities at WIPP would not have an impact on archaeological sites; however, some sites could be affected by expansion of the disposal area and closure- and decommissioning-related activities. The land that would be disturbed due to closure and decommissioning under Action Alternatives 2A, 2B, and 2C covers a substantially larger area (395 hectares [976 acres]) than that under the Proposed Action.

Since publication of SEIS-I in 1990, additional cultural resource surveys have been conducted at WIPP. Based on inventory data, and assuming environmental homogeneity and a fairly even distribution of archaeological sites, DOE estimates that the WIPP site may contain about 99 archaeological sites and 153 locations where isolated artifacts may exist. There are no known Native American sacred sites or burials in the Land Withdrawal Area.

Measures for ensuring protection of known archaeological and historic resources, or others that may be inadvertently discovered during ground-disturbing activities, are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996a). DOE will avoid, to the extent

possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed under the Joint Powers Agreement with the State of New Mexico.

5.3.5 Noise

Treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially, although some sensitive receptors may be affected (DOE 1997). Further assessment of these impacts was reserved until actual siting of treatment facilities is proposed in a site-wide or project-specific NEPA document. Under each Action Alternative 2 subalternative, all waste would travel to WIPP, but only a portion of the waste would travel from or to each treatment facility; therefore, the greatest impacts due to transportation noise would be near the WIPP site.

Disposal operations at WIPP would result in noise impacts similar to those discussed for the Proposed Action in Section 5.1.5. Potential noise impacts at WIPP from truck transportation also would be similar to those under the Proposed Action (Section 5.1.5). Estimated rail noise from transportation would be similar to those under Action Alternative 1 (Section 5.2.5).

5.3.6 Water Resources and Infrastructure

The following sections discuss the water resource and infrastructure impacts of the three Action Alternative 2 subalternatives.

Action Alternative 2A

Although no off-site infrastructure impacts would be expected to occur; proposed TRU waste activities may affect on-site activities. The affected infrastructure elements analyzed were on-site transportation and the capacity of on-site water, power, and wastewater systems. For Action Alternative 2A, on-site demand for wastewater at Hanford would exceed 5 percent of current demand (7.8 percent) and at INEEL, an increase in the on-site demand for power of 6.6 percent would occur.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2A. These impacts would result from an increase in on-site employment of 9 percent at Hanford and INEEL and 7 percent at LANL. Impacts to the off-site transportation infrastructure would not occur because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts would be expected at WIPP under Action Alternative 2A. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

Action Alternative 2B

For Action Alternative 2B, Hanford would have an increase in on-site demand for wastewater that would exceed 5 percent of current demands (7.8 percent) and INEEL would have an increase in the on-site demand for power by 6.6 percent.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2B. These impacts would result from an increase in on-site employment of 9 percent at

Hanford and 11 percent at INEEL. Impacts to the off-site transportation infrastructure would not occur because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts at WIPP would be expected under Action Alternative 2B for disposal operations. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

Action Alternative 2C

The greatest incremental impacts to infrastructure would occur under Action Alternative 2C due to treatment activities at the WIPP site. Expected impacts under Action Alternative 2C include INEEL increasing on-site demand for power by 6.6 percent and WIPP increasing wastewater treatment demand by approximately 80 percent and power by 50 percent. The increase in wastewater treatment demand at WIPP could exceed the current system capacity by approximately 60 percent. The increase in power demand at WIPP would not cause total power demand to exceed 90 percent of current capacity.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2C. These impacts result from an increase in on-site employment of 6 percent at Hanford and 162 percent at WIPP. Impacts to the off-site transportation infrastructure would not be anticipated because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts would be expected at WIPP under Action Alternative 2C for disposal operations. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.3.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for the Action Alternative 2 subalternatives are presented in the following subsections.

5.3.7.1 Life-Cycle Costs

The life-cycle costs of the three Action Alternative 2 subalternatives are presented in the following subsections.

Life-Cycle Costs for Action Alternative 2A

Table 5-36 shows the life-cycle costs under Action Alternative 2A. Waste treatment facility costs reflect construction, O&M, and D&D at the waste treatment sites, which would thermally treat waste to meet the LDRs and package the waste over a period of 35 years. In addition, Hanford, which has the largest volume, would store portions of the treated waste over a period of 150 years because of WIPP emplacement limitations. Life cycle costs include an additional $700 million to account for treatment to planning-basis WAC of waste that would be shipped for thermal treatment. The waste treatment facility life-cycle costs would be $27.69 billion (in 1994 dollars).

Table 5-36
Life-Cycle Costs for Action Alternative 2A (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	11,000	4,500	15,500	11,340	850	12,190	27,690	15,360
Transport by Truck	870	920	1,790	1,100	100	1,200	2,990	510
Transport by Regular Train	290	310	600	370	30	400	1,010	170
Transport by Dedicated Train	2,010	2,100	4,110	2,530	220	2,750	6,860	1,160
Disposal at WIPP	10,000	2,600	12,600	10,500	230	10,730	23,330	3,700
Total Life-Cycle Cost (Truck)	21,870	8,020	29,890	22,940	1,180	24,120	54,010	19,560
Total Life-Cycle Cost (Regular Train)	21,290	7,410	28,700	22,210	1,110	23,320	52,030	19,220
Total Life-Cycle Cost (Dedicated Train)	23,010	9,200	32,210	24,370	1,300	25,670	57,880	20,210

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

Life-cycle costs also include one of three options for TRU waste transportation between consolidation sites and WIPP: (1) trucks, as explained under the Proposed Action, (2) truck and rail using commercial rail as explained under Action Alternative 1, and (3) truck and rail using dedicated rail, also as explained in Action Alternative 1. Rail routes would be used to the greatest extent practicable. Under these options, transportation costs include the consolidation of waste volumes at the treatment sites and shipment via truck or rail to WIPP for emplacement. The waste transport life-cycle costs would be about $2.99 billion by truck, $1.01 billion by regular rail, and $6.86 billion by dedicated rail.

The WIPP life-cycle costs would be $23.33 billion. The total life-cycle costs of Action Alternative 2A would be $54.01 billion ($19.56 billion when discounted) using truck, $52.03 billion ($19.22 billion when discounted) using regular rail, or $57.88 billion ($20.21 billion when discounted) using dedicated rail transportation.

Life-Cycle Cost for Action Alternative 2B

The life-cycle costs of Action Alternative 2B are presented in Table 5-37. This alternative would involve the same combined CH-TRU and RH-TRU waste volumes considered under Action Alternative 2A. However, the waste management facility costs include waste treatment at fewer TRU waste treatment sites. Again, due to WIPP emplacement limitations, the site with the largest volume (Hanford) would incur additional storage costs over the life of the project. Life-cycle costs include an additional $3.8 billion to account for treatment to planning-basis WAC of waste that would be shipped for thermal treatment. The waste treatment facility life-cycle costs at the treatment sites would be $30.55 billion (in 1994 dollars).

Table 5-37
Life-Cycle Costs for Action Alternative 2B (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	12,150	4,960	17,110	12,500	940	13,440	30,550	16,940
Transport by Truck	960	1,010	1,970	1,220	110	1,330	3,300	560
Transport by Regular Train	330	350	680	420	40	460	1,140	190
Transport by Dedicated Train	2,190	2,290	4,480	2,760	240	3,000	7,480	1,260
Disposal at WIPP	10,000	2,600	12,600	10,500	230	10,730	23,330	3,700
Total Life-Cycle Cost (Truck)	23,110	8,570	31,680	24,220	1,280	25,500	57,180	21,190
Total Life-Cycle Cost (Regular Train)	22,480	7,910	30,390	23,420	1,210	24,630	55,020	20,830
Total Life-Cycle Cost (Dedicated Train)	24,340	9,850	34,190	25,760	1,410	27,170	61,360	21,900

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

As under Action Alternative 2A, three options for waste transportation between consolidation sites and WIPP were examined: (1) trucks, as in the Proposed Action, (2) truck and rail using commercial rail as in Action Alternative 1, and (3) truck and rail using dedicated rail service, also as in Action Alternative 1. Rail routes would be used to greatest extent practicable. Transportation costs reflect consolidating the waste volumes at the treatment sites, and then shipping the waste to WIPP for emplacement. The life-cycle waste transport costs would be about $3.30 billion by truck, $1.14 billion by regular rail, and $7.48 billion by dedicated rail.

The WIPP life-cycle costs would be $23.33 billion. The total life-cycle costs of Action Alternative 2B would be $57.18 billion ($21.19 billion when discounted) using truck, $55.02 billion ($20.83 billion when discounted) using regular rail, or $61.36 billion ($21.90 billion when discounted) using dedicated rail transportation.

Life-Cycle Costs for Action Alternative 2C

The life-cycle costs for Action Alternative 2C are presented in Table 5-38. The same combined CH-TRU and RH-TRU waste volumes were considered for this subalternative as were considered under the other Action Alternative 2 subalternatives. Life-cycle costs include an additional $18.5 billion to account for treatment of waste to planning-basis WAC so the waste can be shipped for thermal treatment. Waste treatment facility costs include the activities at Hanford and ORNL for RH-TRU waste and WIPP for CH-TRU waste. The largest site (Hanford) would incur additional storage costs over the 150-year period due to WIPP emplacement limitations. The waste treatment facility life-cycle costs would be $28.7 billion (in 1994 dollars).

The RH-TRU waste transportation costs reflect consolidation of the RH-TRU waste volumes at Hanford and ORNL for treatment and shipment to WIPP. The CH-TRU transportation costs reflect consolidation of CH-TRU waste volumes at WIPP. Transportation modes analyzed included truck, regular rail service, and dedicated rail service. The life-cycle waste transportation costs would be about $2.91 billion by truck, $910 million by regular rail, and $6.54 billion by dedicated rail.

Table 5-38
Life-Cycle Costs for Action Alternative 2C (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste and RH-TRU Waste
Treatment Facilities [b]	8,330	9,630	17,960	8,730	2,010	10,740	28,700	15,910
Transport by Truck	1,160	910	2,070	740	100	840	2,910	490
Transport by Regular Train	360	290	650	230	30	260	910	150
Transport by Dedicated Train	2,610	2,050	4,660	1,660	220	1,880	6,540	1,100
Disposal at WIPP	10,000	2,600	12,600	10,500	230	10,730	23,330	3,700
Total Life-Cycle Cost (Truck)	19,490	13,140	32,630	19,970	2,340	22,310	54,940	20,100
Total Life-Cycle Cost (Regular Rail)	18,690	12,520	31,210	19,460	2,270	21,730	52,940	19,760
Total Life-Cycle Cost (Dedicated Rail)	20,940	14,280	35,220	20,890	2,460	23,350	58,570	20,720

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] All CH-TRU waste treatment occurs at the WIPP site under this subalternative.

The WIPP life-cycle disposal costs would be $23.33 billion. The total life-cycle costs of Action Alternative 2C would be $54.94 billion ($20.10 billion when discounted) using truck, $52.94 billion ($19.76 billion when discounted) using regular rail or $58.57 billion ($20.72 billion when discounted) using dedicated rail transportation.

5.3.7.2 Economic Impacts

TRU waste treatment activities would support direct, indirect, and induced jobs. Action Alternative 2A would support approximately 28,000 jobs in the ROIs of the six treatment sites (Hanford, INEEL, LANL, ORNL, RFETS, and SRS). Action Alternative 2B would support approximately 28,500 jobs in the ROIs of the four treatment sites (Hanford, INEEL, ORNL, and SRS). Action Alternative 2C would support approximately 7,200 jobs in the ROIs of the three treatment sites (Hanford, ORNL, and WIPP).

Estimates of the impacts of Action Alternatives 2A, 2B, and 2C on employment, income, and the production of goods and services within the WIPP ROI are presented in Table 5-39. For Action Alternatives 2A and 2B, these impacts were estimated using an average annual budget of $180 million per year (in 1994 dollars) over a 150-year period of waste disposal operations. Over this period, the WIPP facility would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 site personnel annually. Indirectly, the operation of WIPP as a waste emplacement facility (from 1998 through 2148) would annually support 2,443 indirect and induced jobs in the ROI work force. The total WIPP-induced employment within the ROI is estimated to be 3,538 per year reflecting the sum of these direct and indirect employment levels.

Table 5-39
Economic Impacts within the WIPP ROI for Action Alternatives 2A, 2B, and 2C

Economic Effects	Total Output of Goods and Services (in millions of 1994 dollars)	Total Employment and Part-Time Jobs)	Total Labor Income (in millions of 1994 dollars)	Carlsbad Output of Goods and Services (in millions of 1994 dollars)	Carlsbad Employment (Full- and Part-Time Jobs)	Carlsbad Labor Income (in millions of 1994 dollars)
Action Alternatives 2A and 2B						
Direct – Annual	113	1,095	52	95	979	46
Indirect & Induced – Annual	204	2,443	75	172	2,185	67
Total – Annual	317	3,538	126	267	3,164	113
Total - Operations (150 years)	47,550	530,700	18,900	40,050	474,600	16,950
Action Alternative 2C						
Direct – Annual	220	2128	100	185	1903	90
Indirect & Induced – Annual	396	4748	145	334	4246	130
Total – Annual	616	6876	245	519	6148	220
Total - Operations (150 years)	92,400	1,031,400[a]	36,750	77,850	922,200 [a]	33,000

[a] Job-years (number of annual jobs supported multiplied by the number of years in the project).

Action Alternatives 2A and 2B would not be expected to result in any socioeconomic impacts in the WIPP ROI beyond those associated with WIPP disposal operations, such as additional government-provided goods or services (schools, police, fire protection, and health protection), or major capital investments in public infrastructure within the ROI. Action Alternatives 2A and 2B would not be expected to impact the local real estate market, nor result in major changes in WIPP ROI work force population.

Under Action Alternative 2C, however, the economic impacts were estimated using an average annual budget of $350 million per year over a 150-year period. Because of the relatively larger scope of operations, Action Alternative 2C would have relatively larger economic impacts in the WIPP ROI, and Carlsbad, in particular. The combination of treatment and emplacement operations is estimated to provide direct employment for 2,128 site personnel annually. The combined operations would annually support 4,748 indirect and induced jobs in the ROI work force. The total WIPP-related employment impact within the ROI is estimated to be 6,876 per year, reflecting the sum of these direct and indirect employment levels.

Action Alternative 2C may have a relatively large economic impact in WIPP ROI due to the projected budget of $350 million per year, almost twice the levels observed during the 1988-1996 period. The relatively larger budget reflects waste treatment and storage costs for the CH-TRU waste inventory. Given the relatively larger scope of activities at the WIPP site, Action Alternative 2C has the potential of increasing the demand for government-provided goods and services (schools, police, fire protection, and health protection) within the ROI, as well as requiring additional capital investments in public infrastructure. Similarly, this subalternative would have the potential of increasing the level of activity within the local real estate market due to resulting changes in the WIPP ROI population and work force characteristics.

5.3.8 Transportation

This section describes the transportation impacts associated with the implementation of Action Alternatives 2A, 2B, and 2C. Descriptions of these alternatives are provided in Chapter 3.

Detailed results are presented for truck transportation. Rail transportation impacts adjusted from truck transportation results are presented in the final subsection for both the regular and dedicated rail options.

5.3.8.1 Route Characteristics and Shipment Projections

The methods used to determine route characteristics and the number of shipments for this alternative were identical to those presented in Section 5.1.8.1. Table 5-40 presents the number of shipments required under Action Alternatives 2A, 2B, and 2C.

Although the consolidation and treatment of waste would be different under each Action Alternative 2 subalternative than under the Proposed Action, those sites that would ship to WIPP would use the same routes. The one-way mileages from the treatment sites to WIPP, therefore, are the same as those presented for the Proposed Action in Table 5-5.

Table 5-40
Number of Truck Shipments to WIPP for Action Alternatives 2A, 2B, and 2C [a]

Waste Treatment Site	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	22	---	22
Hanford Site	8,230	8,813	17,043	8,230	8,813	17,043	11,562	7,194	18,756
Idaho National Engineering and Environmental Laboratory/ANL-West	4,178	12,388	16,566	8,653	14,335	22,988	4,892	6,639	11,531
Lawrence Livermore National Laboratory	---	---	---	---	---	---	137	---	137
Los Alamos National Laboratory	2,952	1,947	4,899	---	---	---	4,236	1,590	5,826
Mound Plant	---	---	---	---	---	---	50	3	53
Nevada Test Site	---	---	---	---	---	---	73	---	73
Oak Ridge National Laboratory	---	---	---	---	---	---	192	8	200
Rocky Flats Environmental Technology Site	1,524	---	1,524	---	---	---	2,102	---	2,102
Savannah River Site	2,020	723	2,743	2,020	723	2,743	1,893	558	2451
Total CH-TRU Waste	18,904	23,871	42,775	18,903	23,871	42,774	25,159	15,992	41,151
RH-TRU Waste									
Hanford Site	17,730	1,031	18,761	17,730	1,031	18,761	17,730	1,031	18,761
Oak Ridge National Laboratory	2,057	1,077	3,134	2,057	1,077	3,134	2,057	1,077	3,134
Total RH-TRU Waste	19,787	2,108	21,895	19,787	2,108	21,895	19,787	2,108	21,895

[a] The total number of shipments under any of the subalternatives presented here do not include shipments from the generator sites to the consolidation sites. The number of consolidation shipments are: Subalternative 2A – 538 (CH-TRU waste), 8,254 (RH-TRU waste); Subalternative 2B – 8,466 (CH-TRU waste), 8,254 (RH-TRU waste); Subalternative 2C – 0 (CH-TRU waste), 8,254 (RH-TRU waste).

5.3.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

The following subsections present the number of nonradiological accidents, injuries, and fatalities expected under Action Alternatives 2A, 2B, and 2C. Table 5-41 presents a summary of these impacts as well as the pollution health effects (in fatalities), which are based upon the total miles traveled in urban areas and 9.9 x 10^{-8} fatalities per kilometer (1.6 x 10^{-7} per mile) (Rao et al. 1982). Also included in the results of Table 5-41 are the impacts due to TRU waste consolidation prior to thermal treatment. For additional details on the adjustment process, see Appendix E.

For Action Alternative 2A, the total number of nonradiological accidents, injuries and fatalities over the entire shipping campaign were estimated to be 109, 76, and 10, respectively. For Action Alternative 2B, the total numbers were 123 accidents, 86 injuries, and 11 fatalities. For Action Alternative 2C, the total numbers were 105 accidents, 74 injuries, and 11 fatalities, respectively.

Table 5-41
Nonradiological Impacts of Transporting TRU Waste by Truck for Action Alternatives 2A, 2B, and 2C

	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
Impact	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Number of Accidents	28	38	66	38	42	80	36	26	62
Number of Injuries	20	25	45	27	28	55	26	17	43
Number of Fatalities	3	3	6	4	4	8	4	3	7
Pollution Health Effects (fatalities)	0.09	0.1	0.2	0.1	0.1	0.2	0.1	0.08	0.2
RH-TRU Waste									
Number of Accidents	38	6	43	38	6	43	38	6	43
Number of Injuries	26	5	31	26	5	31	26	5	31
Number of Fatalities	4	1	4	4	1	4	4	1	4
Pollution Health Effects (fatalities)	0.1	0.03	0.1	0.1	0.03	0.1	0.1	0.03	0.2
Total									
Number of Accidents	66	44	109	76	48	123	74	32	105
Number of Injuries	46	30	76	53	33	86	51	22	74
Number of Fatalities	6	4	10	6	5	11	7	4	11
Pollution Health Effects (fatalities)	0.2	0.1	0.4	0.2	0.1	0.5	0.2	0.1	0.4

5.3.8.3 Accident-Free Radiological Impacts from Truck Transportation

The methods used to determine accident-free radiological impacts for Action Alternatives 2A, 2B, and 2C were identical to those used for the Proposed Action.

Table 5-42 presents a summary of the accident-free radiological impacts. For Action Alternative 2A, the total occupational and nonoccupational population doses would result in 0.5 LCF and 6.2 LCFs, respectively. For Action Alternative 2B, the total occupational and nonoccupational population doses estimated would result in 0.7 LCF and 6.9 LCFs, respectively. For Action Alternative 2C, the total occupational and nonoccupational population doses estimated would result in 0.5 LCF and 6.0 LCFs, respectively.

Table 5-42
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for Action Alternatives 2A, 2B, and 2C (LCFs) [a]

Impact	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Occupational	0.2	0.2	0.4	0.3	0.3	0.6	0.2	0.2	0.4
Nonoccupational									
Stops	1.3	1.7	3.0	1.8	1.9	3.7	1.6	1.1	2.7
Sharing Route	0.07	0.09	0.2	0.1	0.1	0.2	0.09	0.06	0.2
Along Route	0.03	0.03	0.06	0.04	0.04	0.08	0.04	0.02	0.06
Nonoccupational - Total	1.4	1.8	3.2	1.9	2.0	3.9	1.8	1.2	3.0
RH-TRU Waste									
Occupational	0.1	0.02	0.1	0.1	0.02	0.1	0.1	0.02	0.1
Nonoccupational									
Stops	2.4	0.4	2.8	2.4	0.4	2.8	2.4	0.4	2.8
Sharing Route	0.1	0.03	0.1	0.1	0.03	0.1	0.1	0.03	0.1
Along Route	0.05	0.02	0.07	0.05	0.02	0.07	0.05	0.02	0.07
Nonoccupational - Total	2.6	0.5	3.0	2.6	0.5	3.0	2.6	0.5	3.0
Total CH-TRU and RH-TRU Waste									
Occupational	0.3	0.2	0.5	0.4	0.3	0.7	0.3	0.2	0.5
Nonoccupational									
Stops	3.7	2.1	5.8	4.2	2.3	6.5	4.0	1.5	5.5
Sharing Route	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.09	0.3
Along Route	0.08	0.05	0.1	0.09	0.06	0.2	0.09	0.04	0.1
Nonoccupational - Total	4.0	2.3	6.2	4.5	2.5	6.9	4.4	1.7	6.0

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use two-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

As in Table 5-41, Table 5-42 includes the impacts from consolidation prior to the thermal LDR treatment. For details on the adjustment method, see Appendix E.

Table 5-43 summarizes the radiological impacts to maximally exposed individuals for TRU waste shipments under Action Alternatives 2A, 2B, and 2C. Section 5.1.8.3 and Appendix E describe the methods used to estimate the impacts presented in Table 5-43. The results in Table 5-43 indicate that the departure inspectors and state inspectors would have the greatest probability of an LCF.

Table 5-43
Radiological Impacts to MEIs from Truck Transportation for Action Alternatives 2A, 2B, and 2C (Probability of an LCF)

Individual	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C
CH-TRU Waste			
Stuck in traffic next to shipment	2.5E-6	2.5E-6	2.5E-6
Departure Inspector	6.8E-4	6.8E-4	7.6E-4
State Vehicle Inspector	1.7E-3	2.0E-3	1.6E-3
Residing adjacent to access route	1.5E-4	1.5E-4	1.5E-4
Rest stop employee	1.0E-4	1.0E-4	1.0E-4
RH-TRU Waste			
Stuck in traffic next to shipment	5.0E-6	5.0E-6	5.0E-6
Departure Inspector	2.2E-3	2.2E-3	2.2E-3
State Vehicle Inspector	2.9E-3	2.9E-3	2.9E-3
Residing adjacent to access route	2.0E-4	2.0E-4	2.0E-4
Rest stop employee	1.0E-4	1.0E-4	1.0E-4
Total CH-TRU and RH-TRU Waste			
Stuck in traffic next to shipment	7.5E-6	7.5E-6	7.5E-6
Departure Inspector	2.9E-3	2.9E-3	3.0E-3
State Vehicle Inspector	4.6E-3	4.9E-3	4.5E-3
Residing adjacent to access route	3.5E-4	3.5E-4	3.5E-4
Rest stop employee	2.0E-4	2.0E-4	2.0E-4

5.3.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first type of analysis determined the radiological impact due to accidents during transportation from treatment or generator-storage sites to WIPP. This analysis took into account eight different severities of accidents, the number of miles from each site, and the number of shipments. The results of the analyses for route-specific accidents summed over the entire shipping campaign are presented in Table 5-44.

The second type of analysis was an assessment of four conservative, bounding accident scenarios. Two involving the breach of a TRUPACT-II, and two involving the breach of an RH-72B cask. Details on the estimation of impacts from these bounding case accidents are presented in Appendix E and in Section 5.1.8. For Action Alternatives 2A and 2B, the potential radiological releases from bounding case accidents that would occur after treatment would be smaller than those presented for the Proposed Action, with less than 1 LCF estimated. Those during consolidation for treatment would be similar to those presented for the Proposed Action. For Action Alternative 2C, the transportation impacts for RH-TRU waste that has been treated would be similar to those for Action Alternatives 2A and 2B. All of the impacts due to CH-TRU waste and due to consolidation of RH-TRU waste for treatment would be similar to the impacts presented for the Proposed Action.

Although the radionuclide inventory concentration for waste that is thermally treated increases by a factor of about 2.8, the thermal treatment of the waste reduces the release fraction for a bounding accident by a factor greater than 1,000. A release fraction is the quantity of material that would be released in an accident. The assumptions and methods used for these analyses are presented in Appendix E.

Table 5-44
Aggregate Radiological Population Impacts
by Truck for Action Alternatives 2A, 2B, and 2C (LCFs)

Origin	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Argonne National Laboratory-East	-----	-----	-----	-----	-----	-----	3.5E-4	-----	3.5E-4
Hanford Site	0.2	0.2	0.4	0.2	0.2	0.4	0.3	0.2	0.5
Idaho National Engineering and Environmental Laboratory/ANL-W	0.06	0.2	0.3	0.1	0.2	0.3	0.07	0.09	0.2
Lawrence Livermore National Laboratory	-----	-----	-----	-----	-----	-----	1.5E-3	-----	1.5E-3
Los Alamos National Laboratory	2.0E-3	1.5E-3	3.5E-3	-----	-----	-----	3.0E-3	1.0E-3	4.0E-3
Mound Plant	-----	-----	-----	-----	-----	-----	1.0E-3	5.0E-5	1.0E-3
Nevada Test Site	-----	-----	-----	-----	-----	-----	5.0E-4	-----	5.0E-4
Oak Ridge National Laboratory	-----	-----	-----	-----	-----	-----	2.5E-3	1.0E-4	2.5E-3
Rocky Flats Environmental Technology Site	5.0E-3	-----	5.0E-3	-----	-----	-----	7.0E-3	-----	7.0E-3
Savannah River Site	0.02	8.0E-3	0.03	0.02	8.0E-3	0.03	0.02	6.0E-3	0.03
RH-TRU Waste									
Hanford Site	0.02	1.5E-3	0.03	0.02	1.5E-3	0.03	0.02	1.5E-3	0.03
Oak Ridge National Laboratory	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3
Total CH-TRU and RH-TRU Waste									
Argonne National Laboratory-East	-----	-----	-----	-----	-----	-----	3.5E-4	-----	3.5E-4
Hanford Site	0.2	0.2	0.4	0.2	0.2	0.4	0.3	0.2	0.5
Idaho National Engineering and Environmental Laboratory/ANL-W	0.06	0.2	0.3	0.1	0.2	0.3	0.07	0.09	0.2
Lawrence Livermore National Laboratory	-----	-----	-----	-----	-----	-----	1.5E-3	-----	1.5E-3
Los Alamos National Laboratory	2.0E-3	1.5E-3	3.5E-3	-----	-----	-----	3.0E-3	1.0E-3	4.0E-3
Mound Plant	-----	-----	-----	-----	----	-----	1.0E-3	5.0E-5	1.0E-3
Nevada Test Site	-----	-----	-----	-----	-----	-----	5.0E-4	-----	5.0E-4
Oak Ridge National Laboratory	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3	4.0E-3	1.0E-3	5.0E-3
Rocky Flats Environmental Technology Site	5.0E-3	-----	5.0E-3	-----	-----	-----	7.0E-3	-----	7.0E-3
Savannah River Site	0.02	8.0E-3	0.03	0.02	8.0E-3	0.03	0.02	6.0E-3	0.03
Total	0.3	0.4	0.7	0.3	0.4	0.7	0.4	0.3	0.7

5.3.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents to WIPP

During a severe accident, hazardous chemical releases under Action Alternatives 2A, 2B, and 2C would not pose a threat because the waste would have been thermally treated before being transported. Thermal treatment would eliminate the presence of all VOCs and greatly reduce the release fraction for heavy metals.

5.3.8.6 Impacts from Rail Transportation

This section presents a summary of transportation impacts for both the regular and dedicated rail transportation options. These impacts were estimated by scaling the transportation impacts from truck transportation to the impacts for rail transportation. In Appendix E, each of the impact parameters are identified, and the differences between truck and rail transportation are explained. Table 5-45 presents the estimated rail impacts for Action Alternatives 2A, 2B, and 2C.

Table 5-45
Impacts from Rail Transportation
for Action Alternatives 2A, 2B, and 2C

	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C
Aggregate Traffic-Related Fatalities			
Regular Rail	5	6	6
Dedicated Rail	70	84	84
Aggregate Accident-Free Radiological Impacts (LCFs)			
CH-TRU Waste			
Occupational	0.02	0.03	0.02
Nonoccupational			
Stops	0.4	0.4	0.3
Sharing Route	1.7E-3	2.0E-3	1.6E-3
Along Route	0.09	0.1	0.09
Nonoccupational -Total	0.5	0.6	0.4
RH-TRU Waste			
Occupational	5.7E-3	5.7E-3	5.7E-3
Nonoccupational			
Stops	0.3	0.3	0.3
Sharing Route	1.6E-3	1.6E-3	1.6E-3
Along Route	0.1	0.1	0.1
Nonoccupational - Total	0.4	0.4	0.4
Total CH-TRU and RH-TRU Waste			
Occupational	0.03	0.03	0.03
Nonoccupational			
Stops	0.7	0.8	0.7
Sharing Route	3.3E-3	3.7E-3	3.2E-3
Along Route	0.2	0.2	0.2
Nonoccupational - Total	0.9	1.0	0.9
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)			
CH-TRU Waste	0.7	0.7	0.7
RH-TRU Waste	0.03	0.03	0.03
Total CH-TRU and RH-TRU Waste	0.7	0.7	0.7

The analyses of bounding case accidents assumed similar accidents to those described in Section 5.2.8.6. For that waste treated thermally before shipment by train, the release fraction would be reduced by a factor of 1,000. However, thermal treatment increases the concentration of radionuclides by approximately a factor of 2.8. The combination of these two factors reduces the impacts for rail accidents to the following:

- For the accident with the conservative inventory in two breached TRUPACT-IIs, the total population dose under Action Alternatives 2A and 2B would result in 0.09 LCF in the exposed population. The estimated maximum individual dose would result in a 3×10^{-4} probability of a cancer fatality. Impacts for Action Alternative 2C would be the same as those presented for Action Alternative 1.

- For the accident with a conservative inventory in two breached RH-72Bs, the total population dose would result in 0.09 LCF in the exposed population. The estimated maximum individual dose would result in a 3×10^{-4} probability of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached TRUPACT-IIs, approximately 0.02 LCF in the exposed population would be expected under Action Alternatives 2A and 2B. The estimated maximum individual dose under these two subalternatives would result in a 2×10^{-4} probability of a cancer fatality. Impacts for Action Alternative 2C would be the same as those presented for Action Alternative 1.

- For the accident with average concentrations of radionuclides in two breached RH-72B casks, the total population dose would result in an expectation of 2×10^{-4} LCF in the population. The estimated maximum individual dose would result in a 4×10^{-6} probability of a cancer fatality.

5.3.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and WIPP disposal operations under Action Alternatives 2A, 2B, and 2C. Impacts from waste treatment were adjusted from those presented in the WM PEIS, and a description of this adjustment is provided in Appendix B. Impacts from lag storage at the treatment sites (including WIPP under Action Alternative 2C) and WIPP disposal operations were estimated using the general methods and assumptions used for the human health analyses of the Proposed Action and Action Alternative 1. Action Alternative 2 is the only action alternative that eliminates the risk from storage of PCB-commingled TRU waste at the three sites known to store such waste (242 cubic meters [8,550 cubic feet] at Hanford, 461 cubic meters [16,300 cubic feet] at INEEL, and 19 cubic meters [670 cubic feet] at Mound). All VOCs in the waste under these subalternatives would be destroyed during thermal treatment, and all heavy metals would be immobilized. Therefore, no routine releases of hazardous chemicals would occur in subsequent lag storage or WIPP disposal operations. Thermal treatment also concentrates the waste and radionuclides into a smaller, more dense volume. Denser waste matrices tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.3.9.1 Public

Impacts to the populations and to the MEIs under Action Alternatives 2A, 2B, and 2C are presented in this section; results are presented in Table 5-46. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites under Action Alternative 2A, four sites under Action Alternative 2B, and three sites (including WIPP) under Action Alternative 2C. Waste disposal operations would take place only at WIPP.

Table 5-46
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternatives 2A, 2B, and 2C

	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
Category	**Radiological (LCF)** [a]	**Hazardous Chemical (Cancer Incidence)**	**Radiological (LCF)** [a]	**Hazardous Chemical (Cancer Incidence)**	**Radiological (LCF)** [a]	**Hazardous Chemical (Cancer Incidence)**
MEI [b, c]						
Basic Inventory						
2A CH-TRU Waste	3E-5 (R)	3E-13 (L)	1E-7 (L)	0	5E-8	0
2B CH-TRU Waste	2E-5 (H)	3E-13 (I)	5E-9 (S)	0	5E-8	0
2C CH-TRU Waste	1E-4 (W)	3E-13 (W)	5E-8 (W)	0	5E-8	0
RH-TRU Waste	4E-7 (O)	1E-11 (O)	1E-9 (H)	0	7E-10	0
2A Total Waste	3E-5 (R)	1E-11 (O)	1E-7 (L)	0	5E-8	0
2B Total Waste	2E-5 (H)	1E-11 (O)	5E-9 (S)	0	5E-8	0
2C Total Waste	1E-4 (W)	1E-11 (O)	5E-8 (W)	0	5E-8	0
Total Inventory						
2A CH-TRU Waste	3E-5 (R)	5E-13 (I)	2E-7 (L)	0	1E-7	0
2B CH-TRU Waste	5E-5 (H)	6E-13 (I)	1E-8 (S)	0	1E-7	0
2C CH-TRU Waste	2E-4 (W)	5E-13 (W)	1E-7 (W)	0	1E-7	0
RH-TRU Waste	6E-7 (O)	2E-11 (O)	2E-9 (H)	0	8E-10	0
2A Total Waste	3E-5 (R)	2E-11 (O)	2E-7 (L)	0	1E-7	0
2B Total Waste	5E-5 (H)	2E-11 (O)	1E-8 (S)	0	1E-7	0
2C Total Waste	2E-4 (W)	2E-11 (O)	1E-7 (W)	0	1E-7	0
Population [c]						
Basic Inventory						
2A CH-TRU Waste	2.2	5E-9	7E-4	0	2E-5	0
2B CH-TRU Waste	1.1	2E-9	4E-4	0	2E-5	0
2C CH-TRU Waste	0.4	7E-10	2E-5	0	2E-5	0
RH-TRU Waste	0.02	2E-7	3E-5	0	9E-7	0
2A Total Waste	2.2	2E-7	7E-4	0	2E-5	0
2B Total Waste	1.1	2E-7	4E-4	0	2E-5	0
2C Total Waste	0.4	2E-7	5E-5	0	2E-5	0
Total Inventory						
2A CH-TRU Waste	2.3	9E-9	1E-3	0	5E-5	0
2B CH-TRU Waste	2.3	4E-9	6E-4	0	5E-5	0
2C CH-TRU Waste	0.9	1E-9	5E-5	0	5E-5	0
RH-TRU Waste	0.02	3E-7	5E-5	0	1E-6	0
2A Total Waste	2.4	3E-7	1E-3	0	5E-5	0
2B Total Waste	2.3	3E-7	6E-4	0	5E-5	0
2C Total Waste	0.9	3E-7	1E-4	0	5E-5	0
Aggregate Total						
2A	2.4	3E-7	1E-3	0	5E-5	0
2B	2.3	3E-7	8E-4	0	5E-5	0
2C	0.9	3E-7	3E-4	0	5E-5	0

[a] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[b] H = Hanford, L = LANL, S = SRS, O = ORNL, R = RFETS, W = WIPP, I = INEEL
[c] The MEI and populations evaluated for treatment, storage, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact occurs.

Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment and lag storage are presented for the highest individual waste treatment sites, while the impacts to the MEI from disposal operations are presented for an individual near WIPP. See Chapter 3 for additional information on where treatment and storage would occur.

Waste Treatment

Radiological impacts to the public from waste treatment under Action Alternatives 2A, 2B, and 2C would be 2.4, 2.3 and 0.9 LCFs, respectively, in the total population around the waste treatment sites. No cancer incidence would be expected in the total population from hazardous chemical exposure (3×10^{-7} cancers) under Action Alternatives 2A, 2B, and 2C. For radiological impacts, the MEI would be at RFETS under Action Alternative 2A (3×10^{-5} probability of an LCF), at Hanford under Action Alternative 2B (5×10^{-5} probability of an LCF), and at WIPP under Action Alternative 2C (2×10^{-4} probability of an LCF). Hazardous chemical impacts would not exceed a 2×10^{-11} probability of a cancer incidence at any site. No noncarcinogenic health effects are predicted. The maximum HIs for the MEIs would be 2×10^{-8} under Action Alternative 2A, 5×10^{-9} under Action Alternative 2B, and 1×10^{-7} under Action Alternative 2C, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Only radiological impacts would result from lag storage because VOCs would be removed by thermal treatment under Action Alternatives 2A, 2B, and 2C. No LCFs would be expected in the total population around the lag storage sites under any of the alternatives, with 1×10^{-3}, 6×10^{-4}, and 1×10^{-4} LCFs expected under Action Alternatives 2A, 2B, and 2C, respectively. The MEI would be at LANL for Action Alternative 2A (2×10^{-7} probability of an LCF), at SRS for Action Alternative 2B (1×10^{-8} probability of an LCF), and at WIPP for Action Alternative 2C (1×10^{-7} probability of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

The aggregate total indicated in Table 5-46 refers to the impacts to the public expected over the entire operational period under Action Alternative 2. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 22 years for CH-TRU waste and 150 years for RH-TRU waste. No LCFs (a maximum of 1×10^{-3} LCFs under Action Alternative 2A) are expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials.

WIPP Disposal Operations

Only radiological impacts would result from disposal operations at WIPP because VOCs would be removed by thermal treatment. No LCFs would be expected in the population around WIPP from radiation exposure, with 5×10^{-5} LCFs expected under all three of the subalternatives.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 1×10^{-7} probability of an LCF from radiation exposure under all three subalternatives. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

The aggregate total indicated in Table 5-46 refers to the impacts expected over the entire operational period to the public residing within 80 kilometers (50 miles) at the WIPP site. The operational period for the disposal of the Total Inventory is expected to be 22 years for CH-TRU waste and 150 years for RH-TRU waste. No LCFs (5×10^{-5} LCFs) are expected to result from exposure to the estimated releases over the several generations.

5.3.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternatives 2A, 2B, and 2C are presented in this section; results are presented in Table 5-47. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites under Action Alternative 2A, four sites under Action Alternative 2B, and three sites (including WIPP) under Action Alternative 2C. Waste disposal operations would take place only at WIPP.

The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites. The maximally exposed noninvolved worker from disposal operations would be at the WIPP site and was assumed to work continuously at the location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

No LCFs would be expected in the total noninvolved worker population at the waste treatment sites, with 0.1, 0.1, and 0.06 LCFs under Action Alternatives 2A, 2B, and 2C, respectively. No cancer incidence would be expected in the total noninvolved worker population from hazardous chemical exposure, with 1×10^{-7} cancers under each of the three subalternatives. The maximally exposed noninvolved worker for radiological impacts would be at RFETS under Action Alternative 2A (5×10^{-5} probability of an LCF), at Hanford under Action Alternative 2B (2×10^{-4} probability of an LCF), and at WIPP under Action Alternative 2C (2×10^{-4} probability of an LCF). Hazardous chemical impacts would not exceed a 1×10^{-10} probability of a cancer incidence at any site. No noncarcinogenic health effects are predicted. The maximum HIs for the maximally exposed noninvolved worker would be 2×10^{-7} under Action Alternative 2A, 1×10^{-7} under Action Alternative 2B, and 8×10^{-7} under Action Alternative 2C, and no health effects are predicted unless the HI is 1 or higher.

Lag Storage

Only radiological impacts would result from lag storage because VOCs would be removed by thermal treatment. No LCFs would be expected in the total noninvolved worker population at the lag storage sites under any of the alternatives, with 2×10^{-2}, 2×10^{-2}, and 4×10^{-4} LCFs expected under Action Alternatives 2A, 2B, and 2C, respectively. The maximally exposed noninvolved worker would be at SRS for Action Alternatives 2A and 2B (1×10^{-6} probability of an LCF), and at WIPP for Action Alternative 2C (1×10^{-7} probability of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

Table 5-47
Lifetime Human Health Impacts
to Noninvolved Workers from Waste Treatment, Lag Storage,
and WIPP Disposal Operations for Action Alternatives 2A, 2B, and 2C

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker [b, c]						
Basic Inventory						
2A CH-TRU Waste	5E-5 (R)	1E-12 (I)	8E-7 (S)	0	8E-8	0
2B CH-TRU Waste	7E-5 (H)	2E-12 (I)	8E-7 (S)	0	8E-8	0
2C CH-TRU Waste	1E-4 (W)	2E-12 (W)	8E-8 (W)	0	8E-8	0
RH-TRU Waste	3E-7 (O)	6E-11 (O)	1E-8 (H)	0	2E-9	0
2A Total Waste	5E-5 (R)	6E-11 (O)	8E-7 (S)	0	8E-8	0
2B Total Waste	7E-5 (H)	6E-11 (O)	8E-7 (S)	0	8E-8	0
2C Total Waste	1E-4 (W)	6E-11 (O)	8E-8 (W)	0	8E-8	0
Total Inventory						
2A CH-TRU Waste	5E-5 (R)	4E-12 (I)	1E-6 (S)	0	2E-7	0
2B CH-TRU Waste	2E-4 (H)	4E-12 (I)	1E-6 (S)	0	2E-7	0
2C CH-TRU Waste	2E-4 (W)	3E-12 (W)	1E-7 (W)	0	2E-7	0
RH-TRU Waste	5E-7 (O)	1E-10 (O)	2E-9 (H)	0	2E-9	0
2A Total Waste	5E-5 (R)	1E-10 (O)	1E-6 (S)	0	2E-7	0
2B Total Waste	2E-4 (H)	1E-10 (O)	1E-6 (S)	0	2E-7	0
2C Total Waste	2E-4 (W)	1E-10 (O)	1E-7 (W)	0	2E-7	0
Population [c]						
Basic Inventory						
2A CH-TRU Waste	0.09	3E-9	2E-2	0	9E-5	0
2B CH-TRU Waste	0.06	3E-9	2E-2	0	9E-5	0
2C CH-TRU Waste	0.03	3E-10	7E-5	0	9E-5	0
RH-TRU Waste	4E-4	7E-8	2E-4	0	2E-6	0
2A Total Waste	0.09	7E-8	2E-2	0	9E-5	0
2B Total Waste	0.06	7E-8	2E-2	0	9E-5	0
2C Total Waste	0.03	7E-8	3E-4	0	9E-5	0
Total Inventory						
2A CH-TRU Waste	0.1	7E-9	2E-2	0	2E-4	0
2B CH-TRU Waste	0.1	6E-9	2E-2	0	2E-4	0
2C CH-TRU Waste	0.06	7E-10	2E-4	0	2E-4	0
RH-TRU Waste	6E-4	1E-7	2E-4	0	2E-6	0
2A Total Waste	0.1	1E-7	2E-2	0	2E-4	0
2B Total Waste	0.1	1E-7	2E-2	0	2E-4	0
2C Total Waste	0.06	1E-7	4E-4	0	2E-4	0
Aggregate Total						
2A	0.1	1E-7	2E-2	0	2E-4	0
2B	0.1	1E-7	2E-2	0	2E-4	0
2C	0.06	1E-7	1E-3	0	2E-4	0

[a] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] H = Hanford, I = INEEL, L = LANL, O = ORNL, R = RFETS, S = SRS, W = WIPP, I = INEEL
[c] The noninvolved workers considered for treatment, lag storage, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

The aggregate total indicated in Table 5-47 refers to the impacts to noninvolved workers expected over the entire operational period under Action Alternative 2. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 22 years for CH-TRU waste and 150 years for RH-TRU waste. No LCFs (a maximum of 0.02 LCFs under Action Alternatives 2A and 2B) are expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials under incident-free operations.

WIPP Disposal Operations

Only radiological impacts would result from disposal operations at WIPP because VOCs would be removed by thermal treatment. No LCFs would be expected in the noninvolved worker population at WIPP from radiation exposure, 2×10^{-4} LCFs under all three subalternatives. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker. The maximally exposed noninvolved worker would have a 2×10^{-7} probability of an LCF from radiation exposure under all three subalternatives. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

The aggregate total indicated in Table 5-47 shows that no LCFs (2×10^{-4} LCFs) are expected in the multiple noninvolved worker populations that would be exposed to potential radioactive releases over the entire WIPP disposal operations period under Action Alternative 2.

5.3.9.3 Involved Workers

Impacts to involved workers under Action Alternatives 2A, 2B and 2C are presented in this section. Results are presented in Table 5-48, and additional information is presented in Appendix F. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Waste Treatment

Under Action Alternative 2, radiological impacts to the involved worker population from waste treatment would be greater than nonradiological impacts. A maximum of 1.7, 1.3, and 0.6 radiation-related LCFs could occur in the worker population under Action Alternatives 2A, 2B, and 2C, respectively, while no cancer incidence (6×10^{-5}, 9×10^{-5}, and 8×10^{-5} cancers, respectively) would be expected from hazardous chemical exposure. No noncarcinogenic health effects are predicted because the maximum exposure index for a waste treatment worker under any of the subalternatives would be 6×10^{-3} under Action Alternatives 2A and 2B and 5×10^{-3} under Action Alternative 2C, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Lag storage would take place under all three subalternatives. Assuming 35 years of management of the entire inventory, radiological impacts to the lag storage involved worker population would be less than 0.4 LCF under each subalternative. No hazardous chemical impacts, either carcinogenic or noncarcinogenic, would occur because of the removal of VOCs from the waste during thermal treatment. Involved worker lag storage impacts would be larger from CH-TRU

Table 5-48
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for the Action Alternative 2 Subalternatives [a]

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population						
Basic Inventory					(36 workers)	(36 workers)
2A CH-TRU Waste	0.7	2E-5	0.09	0	0.1	0
2B CH-TRU Waste	0.5	4E-5	0.08	0	0.1	0
2C CH-TRU Waste	0.02	3E-5	0.08	0	0.1	0
RH-TRU Waste	0.2	9E-6	≤0.09	0	≤0.1	0
2A Total Waste	0.9	3E-5	≤0.2	0	≤0.2	0
2B Total Waste	0.7	5E-5	≤0.2	0	≤0.2	0
2C Total Waste	0.3	4E-5	≤0.2	0	≤0.2	0
Total Inventory					(36 workers)	(36 workers)
2A CH-TRU Waste	1.4	5E-5	0.2	0	0.2	0
2B CH-TRU Waste	1.1	8E-5	0.2	0	0.2	0
2C CH-TRU Waste	0.3	1E-5	0.2	0	0.2	0
RH-TRU Waste	0.3	1E-5	≤0.2	0	≤0.2	0
2A Total Waste	1.7	6E-5	≤0.4	0	≤0.4	0
2B Total Waste	1.3	9E-5	≤0.4	0	≤0.4	0
2C Total Waste	0.6	8E-5	≤0.4	0	≤0.4	0
Aggregate Total						
2A	1.7	6E-5	0.01	0	< 0.4	0
2B	1.3	9E-5	0.02	0	< 0.4	0
2C	0.6	8E-5	0	0	< 0.4	0

[a] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

waste storage operations than from RH-TRU waste storage operations. Impacts from RH-TRU waste lag storage operations would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Lag storage impacts would be assessed in future site-wide or project-specific NEPA reviews.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years and 20 percent of the Total Inventory were assumed to be monitored annually.

The aggregate total indicated in Table 5-48 refers to the impacts to involved workers at the lag storage sites over the entire operational period under Action Alternative 2. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 22 years for CH-TRU waste and 150 years for RH-TRU waste. Fewer than 0.4 LCFs would be expected over the several generations of involved workers that would be exposed externally from lag storage operations. The radiological impact estimates reflect the aggregate impacts analyses presented in detail in Appendix F.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 0.4 LCF for each subalternative. WIPP involved worker radiological impact estimates were made assuming each involved worker handled the CH-TRU waste for 400 hours per year. The operational period was determined by assuming that 2.5 years of disposal operations were required to fill each panel. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste. No hazardous chemical impacts, either carcinogenic or noncarcinogenic, would occur because of the removal of VOCs from the waste during thermal treatment.

The aggregate total indicated in Table 5-48 refers to the impacts to WIPP involved workers from incident-free operations over the entire disposal operations period under Action Alternative 2. Fewer than 0.4 LCFs from external radiation exposures would be expected over several generations of involved workers at WIPP. Radiological impacts over the entire operational period would be approximately twice the number of impacts estimated for the maximally exposed population during the first 35 years of CH-TRU waste disposal operations. Radiological decay would reduce the radiological impacts to each generation of WIPP workers.

5.3.10 Facility Accidents

This section describes potential consequences of facility accidents at the treatment sites from thermal treatment of waste, from waste storage after treatment but before shipment to WIPP, and at WIPP from waste management and disposal. Consequences of treatment and storage were evaluated at seven treatment sites (Hanford, LANL, INEEL, SRS, RFETS, ORNL, and WIPP); these seven sites would treat and store all of the CH-TRU and RH-TRU waste under the Action Alternative 2 subalternatives. The difference between Action Alternatives 2A and 2B is that no CH-TRU waste treatment and storage (and no consequences) would occur at LANL and RFETS under Action Alternative 2B. CH-TRU waste treatment and storage would occur only at WIPP under Action Alternative 2C.

Inhalation would be the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological consequences are potentially much greater than hazardous chemical consequences and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used and complete accident descriptions and results are provided in Appendix G.

5.3.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated for the Action Alternative 2 subalternatives; they are shown in Table 5-49. The results are presented only for accidents involving CH-TRU waste. The results from these accidents would be greater than results on similar accidents involving RH-TRU waste because CH-TRU waste contains a higher concentration of transuranic radionuclides.

Table 5-49
Treatment Accident Scenarios Evaluated
for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Failure (Accident Scenario T4)	0.01	Cover block falls on a drum filled with hot glass causing shattering of glass.
Steam Explosion (Accident Scenario T5)	1E-4	Steam explosion in glass melter causes fragmentation of glass.
Earthquake (Accident Scenario T6)	1E-5 or less	A beyond-design-basis earthquake (or other natural event) collapses the roof, causing drums to rupture and HEPA filters to fail.

The potential accident consequences under Action Alternatives 2A and 2B were evaluated in detail for the five major sites that would treat and store the greatest volume of CH-TRU waste: Hanford, INEEL, LANL, RFETS, SRS for Action Alternatives 2A and 2B. Under Action Alternative 2C, consequences were evaluated at WIPP for the treatment of CH-TRU waste.

Treatment accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. Accident analysis information is presented in Appendix G.

Estimated radiological consequences are presented as the number of LCFs in the exposed population and the probability of an LCF occurring in MEIs. Carcinogenic and noncarcinogenic consequences from hazardous chemicals, both VOCs and heavy metals, were estimated. Carcinogenic consequences are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic consequences from exposure to VOCs and heavy metals were estimated by two different methods for the drum failure and steam explosion scenarios (Accident Scenarios T4 and T5, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic treatment facility failure of the earthquake (Accident Scenario T6). The potential noncarcinogenic consequences identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological consequences were found to be higher than hazardous chemical consequences, which would be very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-50. Consequences to the maximally exposed involved worker are addressed qualitatively.

The potential radiological consequences from RH-TRU waste treatment accidents are greatest at the ORNL site for all accident scenarios and receptors; however, they are four to five orders of magnitude less than the consequences from CH-TRU waste treatment accidents.

Table 5-50
Radiological Consequences of Treatment Accidents for the Action Alternative 2 Subalternatives

Accident Scenarios		Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
CH-TRU Waste	Drum Failure (Accident Scenario T4)	Maximum: 1E-3 (RFETS)	Maximum: 5E-7 (LANL)	Maximum: 1E-6 (Hanford)
	Steam Explosion (Accident Scenario T5)	Maximum: 0.2 (RFETS)	Maximum: 8E-5 (LANL)	Maximum: 2E-4 (Hanford/LANL)
	Earthquake (Accident Scenario T6)	Hanford: 440 INEEL: 25 LANL: 180 RFETS: 480 SRS: 42 WIPP: 28	Hanford: 0.4 INEEL: 0.01 LANL: 0.6 RFETS: 0.03 SRS: 5E-3 WIPP: 1	Hanford: 1 INEEL: 1 LANL: 1 RFETS: 1 SRS: 1 WIPP: 1
RH-TRU Waste	Drum Failure (Accident Scenario T4)	Maximum: 4E-8 (ORNL)	Maximum: 3E-11 (ORNL)	Maximum: 4E-11 (ORNL)
	Steam Explosion (Accident Scenario T5)	Maximum: 7E-6 (ORNL)	Maximum: 5E-9 (ORNL)	Maximum: 6E-9 (ORNL)
	Earthquake (Accident Scenario T6)	Hanford: 1E-2 ORNL: 2E-2	Hanford: 5E-6 ORNL: 2E-5	Hanford: 3E-5 ORNL: 5E-5

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Public

Under Action Alternatives 2A and 2B, population consequences from treatment accidents were estimated for the exposed populations around the six treatment sites. Potential consequences to the population and MEIs at the six sites vary over a wide range because of differences in the population distributions, distances to MEIs, and atmospheric dispersion factors among the sites. No LCFs would be expected in the exposed population from the drum failure or steam explosion scenarios (Accident Scenarios T4 or T5, respectively), but 480 and 440 LCFs were estimated to occur from the earthquake (Accident Scenario T6) at RFETS and Hanford, respectively. Due to the events of the earthquake scenario, 180, 42, and 25 LCFs were estimated at LANL, SRS, and INEEL, respectively. The radiological consequences to the MEI were estimated to be the highest at LANL for all three accidents. Consequences to the MEI due to the earthquake or other natural phenomenon (Accident Scenario T6) were found to range from a 5×10^{-3} (at SRS) to 0.6 (at LANL) probability of an LCF.

Under Action Alternative 2C, population consequences from treatment accidents were estimated for the exposed population around the WIPP site. The radiological population consequences for the drum failure, steam explosion, and earthquake scenarios (Accident Scenarios T4, T5, and T6, respectively) would be 5×10^{-5}, 9×10^{-3}, and 28 LCFs, respectively. Consequences to the MEI due to the earthquake (Accident Scenario T6) were estimated to be 1 probability of an LCF to the MEI at the WIPP site.

For the Action Alternative 2 subalternatives, all carcinogenic consequences from the drum failure or steam explosion (Accident Scenarios T4 and T5, respectively) would be attributable to heavy metals because VOCs would be consumed by the fire or thermal treatment. Under Action Alternatives 2A and 2B, no cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum probability of cancer to the MEI would be 4×10^{-9} from any of the three treatment accidents. The MEIs at all sites could develop irreversible or severe health effects from both metals (lead and mercury) and VOCs (1,1,2,2-tetrachlorethane) released during the earthquake. Life threatening effects could be expected at all sites but SRS from beryllium. Under Action Alternative 2C, no cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The probability of cancer to the WIPP MEI would be 2×10^{-7} from hazardous chemical releases during the earthquake.

Under Action Alternatives 2A, 2B, and 2C, RH-TRU waste would be treated at Hanford and ORNL. Consequences under Accident Scenarios T4, T5, and T6 would be bounded by those presented for CH-TRU waste treatment. The maximum population consequence (20 LCFs) would be expected at ORNL under Accident Scenario T6. The maximum probability of an LCF (0.02) would also be at ORNL. No cancer incidents would be expected in the population as a result of exposure to hazardous chemicals from any accident scenarios. Irreversible or severe health effects would be expected for both the ORNL and Hanford MEI as a result of the earthquake.

Maximally Exposed Noninvolved Worker

Under Action Alternatives 2A and 2B, the maximally exposed noninvolved worker was assumed to be at the location of greatest consequence outside of the waste treatment building. The estimated consequences to the noninvolved worker would not vary significantly across the six sites. Radiological consequences to the maximally exposed noninvolved worker would result in a 1×10^{-6} probability of an LCF from the events of the drum failure scenario (Accident Scenario T4), a 2×10^{-4} probability of an LCF from the events of the steam explosion scenario (Accident Scenario T5), and a maximum probability of 1 LCF (at all sites) from the events caused by the beyond-design-basis earthquake (Accident Scenario T6).

No cancers would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest probability of cancer would be 2×10^{-8}. During the earthquake (Accident Scenario T6), the noninvolved workers at all of the sites have a chance of developing noncarcinogenic irreversible or severe health effects, and life threatening effects were estimated for all sites INEEL. These effects would be expected from exposures to both VOCs and heavy metals. Under Action Alternative 2C, the only effects due to hazardous chemicals or metals were estimated under the earthquake accident (Accident Scenario T6) where the noninvolved worker would develop irreversible health effects from exposure to 1,1,2,2-tetrachloroethane, mercury, and lead and may expect life threatening effects from beryllium, mercury and lead.

Under Action Alternative 2, RH-TRU waste would be processed at ORNL and Hanford. The maximum consequence from RH-TRU waste treatment would be about 2 percent of that listed for CH-TRU waste treatment. The radiological consequence to the noninvolved worker would be a 0.04 probability of an LCF for Accident Scenario T6. Consequences from hazardous chemicals would be equal to those described above in the discussion for CH-TRU waste treatment.

Maximally Exposed Involved Worker

For all of the Action Alternative 2 subalternatives, no consequences to the maximally exposed involved worker would be anticipated from either the drum failure or steam explosion accidents (Accident Scenarios T4 or T5, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the events. Substantial consequences would be possible from the earthquake (Accident Scenario T6), including workers killed by debris from collapsing treatment facilities and radiation doses from TRU waste being treated. Intakes of VOCs, and heavy metals would also be expected.

5.3.10.2 Waste Storage Accidents

Two potential waste storage accidents were evaluated under the Action Alternative 2 subalternatives and are described in Table 5-51. The drum fire (Accident Scenario S2) analyzed under Action Alternative 1 is not credible for thermally treated waste because waste treatment would remove all combustible components. The results are presented only for accidents involving CH-TRU waste because the would be greater than the results for similar accidents involving RH-TRU waste. However, the consequences from catastrophic failure of an RH-TRU waste storage facility as a result of an earthquake are presented in Appendix G.

Table 5-51
Storage Accident Scenarios Evaluated
for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop, and Lid Failure (Accident Scenario S1) [a]	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destabilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2)	---	Not credible for thermally treated waste.
Earthquake (Accident Scenario S3)	1E-5 or less	A beyond design-basis earthquake (or other natural event) occurs, causing the collapse of the building.

[a] Occurrence frequency for Accident Scenario S1 was taken from reference documents applicable to waste packaged to meet the planning-basis WAC. The quantity of waste handled would be lower under this alternative and frequency of occurrence would likely be lower as well.

Lower transuranic radionuclide activity in RH–TRU waste (lower PE-Ci levels, see Table G-23 and Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) all combine to limit potential consequences from RH-TRU waste accidents. Waste would be stored at Hanford, INEEL, RFETS, ORNL (RH-TRU waste only), and SRS under Action Alternative 2A; at Hanford, INEEL, ORNL (RH-TRU waste only) and SRS under Action Alternative 2B; and at WIPP, ORNL (RH-TRU waste only), and Hanford (RH-TRU waste only) under Action Alternative 2C. Consequences at a particular site were analyzed only for the subalternative that would result in the greatest potential consequences.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design (Accident Scenario S1) and a beyond-design-basis natural disaster accident (Accident Scenario S3). For Accident Scenarios S1 and S2, CH-TRU waste involved in the accidents was assumed to have the maximum radionuclide levels allowable under the planning-basis WAC (80 PE-Ci per drum), conservative concentrations of VOCs (based on CH-TRU sampling and WAC limits), and conservative concentrations of heavy metals. Accident Scenario S3 involves a large number of waste containers; therefore, site-specific drum PE-Ci values and average hazardous chemical concentrations were used in the analyses. Additional details on the accident analyses are presented in Appendix G.

Estimated radiological consequences are presented as the number of LCFs in the exposed population and the probability of an LCF occurring in the MEI. Carcinogenic and noncarcinogenic consequences from heavy metals were estimated. Carcinogenic consequences are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic consequences from exposure to heavy metals were estimated by two different methods for the drum puncture (Accident Scenario S1): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic storage facility failure of the earthquake (Accident Scenario S3). The potential noncarcinogenic consequences identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological consequences would be higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-52.

Table 5-52
Radiological Consequences of Storage Accidents for the Action Alternative 2 Subalternatives [a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Drum Puncture and Lid Failure (Accident Scenario S1)	Maximum: 3E-5 (RFETS)	Maximum: 1E-8 (WIPP)	Maximum: 2E-8 (Hanford, LANL)
Earthquake (Accident Scenario S3)	Hanford: 9 INEEL [b]: 0.8 LANL [c]: 2 RFETS [c]: 10 SRS: 2 WIPP [d]: 2	Hanford: 5E-3 INEEL [b]: 4E-4 LANL [c]: 4E-3 RFETS [c]: 7E-4 SRS: 2E-4 WIPP [d]: 0.08	Hanford: 0.03 INEEL [b]: 0.05 LANL [c]: 0.02 RFETS [c]: 0.02 SRS: 0.04 WIPP [d]: 0.1

[a] The site with the greatest consequence is shown in parentheses.
[b] Consequences are greatest at INEEL under Action Alternative 2B.
[c] CH-TRU waste is stored at LANL and RFETS only under Action Alternative 2A.
[d] CH-TRU waste is stored at WIPP only under Action Alternative 2C.

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Public

Population consequences from storage accidents were estimated for the exposed populations around the six treatment sites. Potential consequences to the population and MEIs at the six sites vary over a wide range because the population distributions, distances to MEIs, and atmospheric dispersion factors vary from site to site. No LCFs would be expected in the exposed population from the drum puncture accident (Accident Scenario S1), but LCFs were estimated to occur from the earthquake (Accident Scenario S3) at almost all sites; the LCFs would range from 0.8 (at INEEL) to 10 (at RFETS). The radiological consequences to the MEI would be highest for the WIPP MEI under the drum puncture scenario (Accident Scenario S1), with a 1×10^{-8} probability of an LCF. Consequences from the earthquake scenario (Accident Scenario S3) were estimated to range from a 2×10^{-4} (at SRS) to 0.08 (at WIPP) probability of an LCF to the MEI.

No cancers would be expected in the exposed population from the heavy metal releases of any accident. The maximum probability of cancer incidence to the MEI from the heavy metal releases of either accident would be 2×10^{-7} (Accident Scenario S3 at WIPP). No noncarcinogenic consequences would be expected from either accident.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest consequence outside of the waste storage facility. The consequences to the noninvolved worker were estimated to vary over a narrow range. The range was narrow because of the uniform release heights assumed and the close distances considered for all noninvolved workers.

Radiological consequences to the maximally exposed noninvolved worker would result in a 2×10^{-8} probability of an LCF from the events of the drum puncture scenario (Accident Scenario S1) and up to a 0.05 probability of an LCF (at INEEL under Action Alternative 2B) from the events of the beyond-design-basis earthquake scenario (Accident Scenario S3).

For hazardous chemical consequences, the maximum probability of cancer to the maximally exposed noninvolved worker from heavy metal intakes would be 5×10^{-16} from the drum puncture scenario (Accident Scenario S1). The corresponding consequence for the earthquake scenario (Accident Scenario S3) would be 2×10^{-8} probability of cancer. No noncarcinogenic consequences would be expected from any accident release.

Maximally Exposed Involved Worker

The involved worker would be the individual most seriously affected by the two accidents analyzed. Consequences were quantitatively estimated for the drum puncture scenario (Accident Scenario S1). The maximally exposed involved worker could potentially have a 3×10^{-3} probability of an LCF as a result of the radionuclide intake due to the events of the drum puncture scenario. The analysis assumed the instantaneous radioactive material releases from the three containers, expanding in a uniform hemisphere 5 meters (16 feet) in radius. The worker was assumed to inhale this air for 1 minute prior to exiting to a fresh air source. The involved worker could have a 6×10^{-11} probability of cancer from estimated hazardous chemical intakes due to the drum puncture accident (Accident Scenario S1). No noncarcinogenic consequences would be expected.

Catastrophic destruction of the storage facility due to an earthquake (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker due to falling debris and releases from stored waste.

5.3.10.3 WIPP Disposal Accidents

Seven potential accidents at WIPP during disposal operations were evaluated for the Action Alternative 2 subalternatives; they are shown in Table 5-53. Because thermal treatment would eliminate the combustibility of the waste, Accident Scenario W5, a drum fire, is not credible and was not evaluated. Five of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W4 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for consequences from CH-TRU and RH-TRU waste (Accident Scenario W6). Annual accident frequencies are one-half those of other alternatives because of the smaller waste volumes and the limited amount of waste that could be placed in each panel due to the thermal power limitation of the WIPP underground.

Potential radiological consequences are substantially higher than consequences from heavy metals, which are very small for all accident cases. There would be no VOCs in thermally treated waste, and VOCs were the primary contributors to hazardous chemical consequences (though small) under the Proposed Action and Action Alternative 1. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below.

Table 5-53
WIPP Disposal Accident Scenarios
for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	5E-3	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	5E-3	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drop, Lid Failure in Underground (Accident Scenario W3)	5E-3	Same as accident W1, but it occurs in the underground.
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	5E-3	Same as accident 2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	---	Not credible for thermally treated waste.
Hoist Failure (Accident Scenario W6)	<1E-6	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	5E-3, Panel 1 <1E-6, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing lid seal failures.
RH-TRU Canister Breach (Accident Scenario W8)	5E-5 to 5E-7	RH-TRU waste canister is breached during Waste Handling Building operations.

With the exception of the waste hoist failure (Accident Scenario W6), the consequences of postulated accidents under the Action Alternative 2 subalternatives would be less than those under the Proposed Action by at least a factor of ten. Thermal treatment also eliminates potential consequences of an RH-TRU container breach (Accident Scenario W8). In such an event, thermally treated waste would be less likely to release particles of respirable size. However, in the event of a hoist failure, the more uniform, brittle waste matrix (as compared to waste treated to planning-basis WAC) is more likely to shatter upon impact into respirable particles. The thermal treatment also concentrates the heavy metals in the waste form, which also increases the potential consequences. Consequences of the hoist failure are approximately five to seven times higher than those estimated for waste treated to planning-basis WAC under the Proposed Action and Action Alternative 1. Radiological consequences of accidents under the Action Alternative 2 subalternatives are shown in Table 5-54.

Public

Population consequences from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the City of Carlsbad. The population in this sector is 25,629 and would be affected greater than any other section in the surrounding 80-kilometer (50-mile) region. Consequences to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use Area boundary and the least atmosphere dispersion of facility exhaust ventilation air, which would be the location of maximum consequence. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for HEPA filtration of accident releases from either the Exhaust Filter Building or the Waste Handling Building.

Table 5-54
Radiological Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9E-4	1E-5	1E-5	3E-3
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	9E-4	1E-5	1E-5	3E-3
Drop, Lid Failure in Underground (Accident Scenario W3)	9E-4	1E-5	1E-5	3E-3
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	9E-4	1E-5	1E-5	3E-3
Container Fire (Accident Scenario W5)	Not Credible	Not Credible	Not Credible	Not Credible
Hoist Failure (both CH-TRU and RH-TRU waste) (Accident Scenario W6)	CH-TRU: 29 RH-TRU: 9	CH-TRU: 0.6 RH-TRU: 0.1	CH-TRU: 0.5 RH-TRU: 0.1	See Footnote a
Roof Failure (Accident Scenario W7)	0.02	2E-4	2E-4	See Footnote a
RH-TRU Waste Canister Breach (Accident Scenario W8)	0	0	0	0

[a] These consequences could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris)

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Radiological consequences from accidents would be higher than consequences from heavy metals. The accident with the largest potential radiological consequence to the population and the MEI would be the failure of a fully loaded waste hoist (Accident Scenario W6). Up to 29 LCFs could occur in the exposed population, and the MEI could experience a 0.6 probability of an LCF. The hoist failure accident would also result in the highest potential carcinogenic heavy metal consequence, with an estimated 4×10^{-7} cancers occurring in the exposed population and an estimated 5×10^{-9} probability of cancer for the MEI. No fatalities due to hazardous chemical effects would be expected under any accident scenario.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological consequences (shown in Table 5-54) may be slightly lower than those for the MEI because of the small different in the radiation dose-to-LCF conversion factors for workers and members of the public. Consequences from exposure to heavy metals would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest consequences to an involved worker would be underground, from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These consequences could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological consequences of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-54. Consequences would come from the drop and lid failure (Accident Scenarios W1 and W3) and drum puncture accidents (Accident Scenarios W2 and W4), all with a 3×10^{-3} probability of an LCF. The highest heavy metal carcinogenic consequences to an involved worker were estimated to be a 6×10^{-11} probability of a cancer incidence. No fatalities due to toxicological effects would be expected.

5.3.11 Industrial Safety

A total of nine, seven, and six fatalities would occur under Action Alternatives 2A, 2B, and 2C, respectively, from industrial accidents during waste treatment at all treatment sites. These estimates were adjusted from the physical-hazard fatality estimates of the WM PEIS.

Under Action Alternatives 2A, 2B and 2C, WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 150 years rather than 35 years. Decommissioning activities would be the same as those for the Proposed Action. Estimated industrial safety impacts to workers under Action Alternatives 2A, 2B, and 2C are presented in Table 5-55. Oversight and inspections by the MSHA and adherence to OSHA regulations would likely reduce actual occurrences below these estimated values.

Table 5-55
Industrial Safety Impacts from WIPP Operations and Decommissioning for the Action Alternative 2 Subalternatives

Years	Injury/Illness			Fatalities		
	Excavation	Operations	Total	Excavation	Operations	Total
Operations 1998-2148	93	5,250	5,343	0.2	5.2	5.4
Decommissioning 2148-2158	187	96	283	0.3	0.1	0.4
Total	280	5,346	5,626	0.5	5.3	5.8

5.3.12 Long-Term Performance

This section presents the potential impacts associated with the long-term performance of the WIPP repository for Action Alternative 2 evaluated for the 10,000-year period after the site is closed. These impacts were estimated based on computer simulations that predicted radionuclide and heavy metal releases from TRU waste in the repository under undisturbed and disturbed conditions. Analyses were conducted using the same methods as for the Proposed Action and other action alternatives; additional information is presented in Appendix H. The waste volume emplaced would be 107,000 cubic meters (3.8 million cubic feet) of CH-TRU waste and 19,000 cubic meters (671,000 cubic feet) of RH-TRU waste. The repository size was increased from the 10 panels of the Proposed Action to 75 panels to accommodate the increased waste volume. The radionuclide inventory was increased to 7.3 x 10^6 Ci in CH-TRU waste and 5.1 x 10^6 Ci in RH-TRU waste, essentially the same as the inventories of Action Alternatives 1 and 3. There were similar increases in heavy metal inventories. Detailed information on the radionuclide and heavy metal inventories is provided in Appendix A.

The four cases below were analyzed for Action Alternative 2. The cases are the same as the Proposed Action and other action alternatives but include alternative-specific differences, such as repository size and radionuclide and heavy metal inventories.

- Case 11 considered undisturbed repository performance. Median parameter values were used for input variables where probability distributions have been defined.

- Case 12 considered disturbed conditions resulting from a borehole assumed to pass through the repository and intercept a pressurized brine reservoir in the Castile Formation. Median parameter values were used for input variables where probability distributions have been defined.

- Case 13 was the same as Case 11 but used 75th percentile parameter values for input variables where probability distributions have been defined.

- Case 14 was the same as Case 12 but used 75th percentile parameter values for input variables where probability distributions have been defined.

5.3.12.1 Impacts of Undisturbed Conditions

Radionuclide and heavy metal (predominantly lead) migration for undisturbed conditions at 10,000 years after closure for Case 13 (75th percentile parameter values) is presented in Figure 5-5. Case 13 resulted in slightly more extensive migration than Case 11 (median parameter values). Figure 5-5 shows the locations in the modeled region where the concentration of total radionuclide activity in the brine, summed over 30 radionuclides, is equal to 1 pCi per liter (1×10^{-9} Ci per cubic meter). A total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration.

Approximately the same vertical and lateral migration of radionuclides and heavy metals would occur for Action Alternative 2 as for the Proposed Action. Total radionuclide concentrations of one pCi per liter would extend about 20 meters (65 feet) below the repository, about 40 meters (130 feet) above the repository, and about 1,900 meters (6,200 feet) laterally.

Analysis of undisturbed repository conditions (Cases 11 and 13) during the first 10,000 years showed that no radionuclides or heavy metals would be released to the Culebra Dolomite. No total radionuclide activity concentrations greater than 1 pCi per liter or heavy metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. There would be no release to the accessible environment and therefore no human health impact. Additional information is provided in Appendix H.

5.3.12.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of Action Alternative 2**.**

Surface Release Caused by Drilling into the Repository

The human health impacts of drilling into the repository (Case 12 and Case 14) were evaluated for a drilling crew member and a well-site geologist. These individuals were assumed to be exposed to waste material brought to the land surface by drilling, as described in Section 5.1.12.2 and Appendix H. For Action Alternative 2, 12 waste panels would hold only CH-TRU waste and 63 panels would hold only RH-TRU waste, so a drilling event could contact either CH-TRU waste or RH-TRU waste but not both.

The estimated radionuclide release to the ground surface for Case 12 (median parameter values) totaled 0.8 and 0.02 Ci for intrusions into CH-TRU waste and RH-TRU waste, respectively. For Case 14 (75th percentile parameter values), the estimated radionuclide releases totaled 1.0 Ci and 0.02 Ci, respectively. The releases would consist mainly of Pu-238, Pu-239, and Am-241 for all of these events. For Case 12, total heavy metal releases would be 1.9 and 3.4 kilograms (4.2 and 7.5 pounds) from CH-TRU waste and RH-TRU waste, respectively. For Case 14, the releases would be 2.3 and 4.2 kilograms (5.1 and 9.3 pounds), respectively. Additional information is provided in Appendix H.

The radiological impacts to a drilling crew member for Case 12 (median parameter values) would be a 5×10^{-5} and 1×10^{-6} probability of an LCF, respectively, from drilling intrusions of CH-TRU waste and RH-TRU waste. For Case 14 (75th percentile parameter values), the probability of an

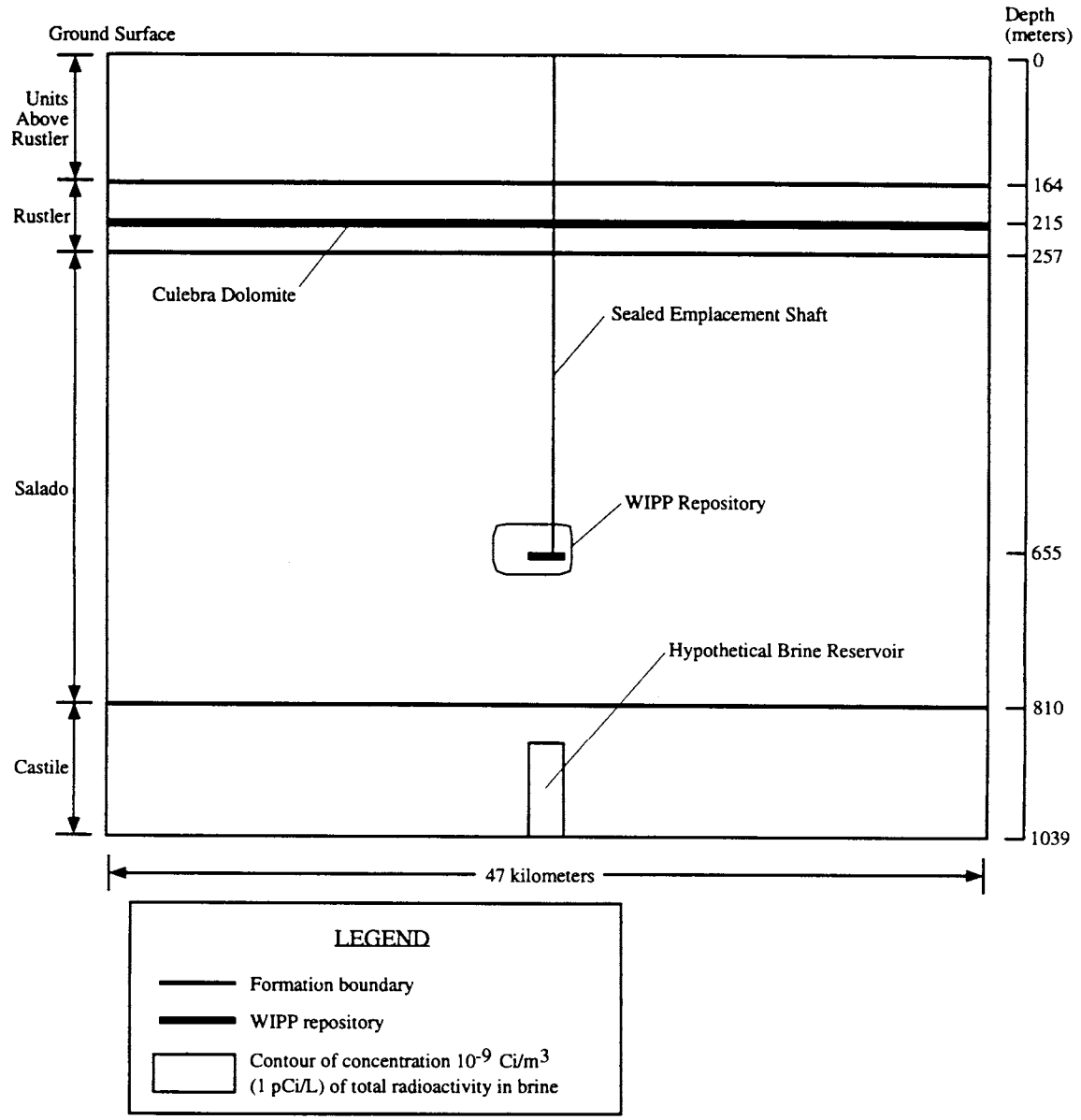


Figure 5-5
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) for Action Alternative 2

LCF would be 1 x 10^{-4} and 2 x 10^{-6} for the same respective intrusions. The majority of the impacts would be due to the inadvertent ingestion of drill cuttings (ranging from about 90 to 99 percent), with lesser impact from external radiation dose. Americium-241 would be the major dose contributor. Ingestion of heavy metals for this scenario would result in a 3.2 x 10^{-8} and 8.5 x 10^{-10} probability of cancer incidence for intrusions in CH-TRU waste and RH-TRU waste, respectively. There would be no noncarcinogenic impacts expected from the ingestion of the metals because all hazard indices would be much less than one. There would be no VOCs in waste disposed of under Action Alternative 2 and thus no impacts.

Radiological impacts to the well-site geologist from external radiation exposure for Case 12 (median parameter values) would result in a 6 x 10^{-9} probability of an LCF from CH-TRU waste and a 4 x 10^{-9} probability of an LCF from RH-TRU waste. For Case 13 (75th percentile parameter values), the radiological impacts would be a 7 x 10^{-9} probability of an LCF from CH-TRU waste and a 1 x 10^{-8} probability of an LCF from RH-TRU waste. Am-241 and U-234 were major external dose contributors in CH-TRU and RH-TRU waste for Case 12 and in CH-TRU waste for Case 14, while Sr-90 and Cs-137 were the major external dose contributors in RH-TRU waste for Case 14.

Drilling through the Repository into a Pressurized Brine Reservoir

Impacts of drilling through the repository into a pressurized brine reservoir were analyzed as described in Section 5.1.12.2 and in Appendix H, using information specific to Action Alternative 2 where appropriate. Analysis of radionuclide and heavy metal migration for this scenario within 10,000 years after closure for Case 12 (median parameter values) showed there would be no radionuclide or heavy metal releases into the Culebra Dolomite or the accessible environment.

The extent of radionuclide (predominantly Pu-238, Pu-239, and Am-241) migration for disturbed conditions at 10,000 years after closure for Case 14 (75th percentile parameters values) is presented schematically in Figure 5-6. Total radionuclide activity concentrations of 1 pCi per liter are shown. Simulations showed radionuclides migrated upward and downward into the borehole and penetrated into rocks directly in contact with the borehole for a limited distance. For Case 14 only, migration extends upward into the Culebra Dolomite at 10,000 years. Migration also extends downward in the borehole (for both Cases 12 and 14) to the Castile Formation and into the brine reservoir. This would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole. A total heavy metal concentration of one part per billion (1 x 10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the 1 pCi per liter level of total radionuclide activity concentration. Predicted brine pressures and additional modeling information is provided in Appendix H.

Impacts of radionuclide and heavy metal migration to the accessible environment were evaluated for Case 14 (75th percentile parameter values) since a release of contaminants into the Culebra Dolomite was indicated for this case only. The exposure scenario was the same as evaluated for the Proposed Action and other action alternatives, for an individual consuming beef from cattle using the water from a stock well 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions, since calculated impacts for full mining conditions were significantly lower (see Section H.8.2). Radiological impacts would be negligible, with a 7 x 10^{-28} probability of an LCF. The dominant dose contributor was Pu-239. Ingestion of heavy

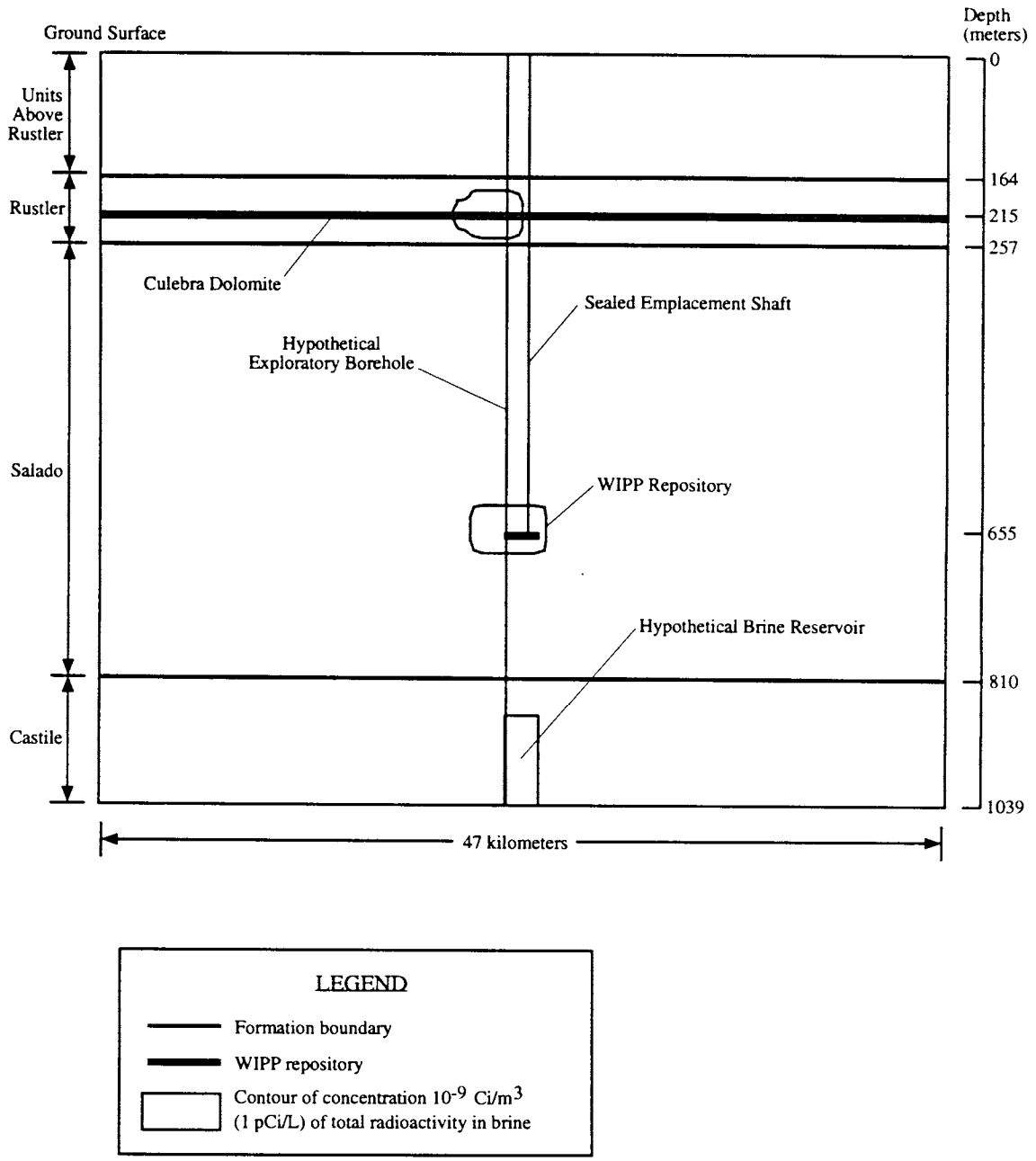


Figure 5-6
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 14) for Action Alternative 2

metals from consumption of contaminated beef was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-27}. No noncarcinogenic impacts would be expected. There would be no VOCs in waste disposed of under Action Alternative 2 and thus no impacts. Additional information is presented in Appendix H.

5.3.13 Reducing WIPP Operations for Action Alternative 2

As noted in Chapter 3, stakeholders requested a discussion in greater detail of the changes to impacts should the Department reduce the period of operations for WIPP under Action Alternative 2. The period of operations is 150 years, but it could be reduced to 70 years by constructing three new shafts and tripling the number of excavation and emplacement crews. Additional costs would total $24 million in capital costs and $155 million in annual operating costs.

As with Action Alternative 1, no additional impacts would be expected at treatment facilities because the facilities and their periods of operation would be identical to those discussed earlier. The time to ship to WIPP from the treatment facilities would decrease from 150 years to 58 years. The aggregate nonradiological impacts would be the same as those described earlier, except that they would occur within the shorter time period. The accident-free radiological impacts to occupational and nonoccupational populations were reported as aggregate impacts over the entire shipping campaign; therefore, no increase in impacts would be noted. However, because the MEIs would be exposed to more shipments, the estimated exposure to MEIs would increase by a factor of 2.6. All accident impacts would be identical to those described earlier.

Because the size of the WIPP underground facility would remain the same, land use, biological resource, air quality, and cultural resource impacts would be similar to those described earlier in this section. Noise impacts would triple because the rate of shipments through Carlsbad would triple. Water quality and infrastructure impacts may be impacted by the additional work crews.

Human health impacts would decrease for lag storage. The impacts to the public, noninvolved workers, and involved workers over the entire operations period would remain the same, but they would be compressed into one-third of the time. Impacts to the MEIs would triple because the waste that would be emplaced during a lifetime would triple. Industrial safety impacts would decrease by 40 percent, considering the reduced operation time, construction of the shafts, and the increased number of workers. There would be no change in long-term performance assessment results.

Life-cycle cost impacts would change the most. Should only trucks be used, life-cycle costs would drop from a low of $54.01 billion for Action Alternative 2A and a high of $57.18 billion for Action Alternative 2B in 1994 dollars ($19.56 billion and $21.19 billion discounted) to $41.11 billion and $44.27 billion, respectively ($13.46 billion and $14.50 billion discounted). Should regular rail transportation be used, life-cycle costs would decrease for these alternatives from $52.03 billion and $55.02 billion ($19.22 billion and $20.83 billion discounted) to $39.13 billion and $42.11 billion ($12.81 billion and $13.79 billion discounted). Should dedicated rail transportation be used, life-cycle costs would decrease for these alternatives from $57.88 billion and $61.36 billion ($20.21 billion and $21.90 billion discounted) to $44.98 billion and $48.45 billion ($14.73 billion and $15.87 billion discounted).

5.4 IMPACTS OF ACTION ALTERNATIVE 3

This section describes the environmental impacts associated with the implementation of Action Alternative 3. Under this alternative, WIPP would accept the Additional Inventory (except for PCB-commingled waste) as well as the Basic Inventory for disposal, and all of the waste would be treated by a shred and grout process. The total volume of waste to be treated under this alternative would be 312,000 cubic meters (11 million cubic feet) (see Tables 3-10 and 3-11). The operational time frame would extend to the year 2200 (190 years). A detailed description of Action Alternative 3 is given in Section 3.2.4.

5.4.1 Land Use and Management

Land use impacts at the treatment sites for Action Alternative 3 would be similar to those under the Proposed Action, discussed in Section 5.1.1. Additional waste would be treated under this alternative, but the treatment time period would be extended to 35 years, and the land requirements for the number and size of the treatment facilities would be about the same as for the Proposed Action. Treatment facilities would be located to avoid sensitive and inappropriate areas (including flood plains, known cultural resource areas, and the habitats of endangered or threatened species) (DOE 1997). Before treatment facilities would be constructed, further NEPA reviews would be undertaken at a site-wide or project-specific level.

Surface land use impacts during disposal operations under Action Alternative 3 would be similar to those under the Proposed Action, as discussed in Section 5.1.1 because the size of the surface facilities would be similar to those for the Proposed Action. A difference from the Proposed Action would be noted for decommissioning and closure; approximately 375 hectares (927 acres) would be affected due to an increased underground waste disposal area. As in the Proposed Action, the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure.

5.4.2 Air Quality

From TRU waste treatment, the only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be CO at RFETS (20 percent) (DOE 1997). RFETS, LLNL, NTS, and ANL-E are in nonattainment areas for some of the pollutants. In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations. No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard during normal treatment operations (DOE 1997). Potential minor emissions of PM_{10} may occur during construction.

At WIPP, potential air quality impacts from disposal operations under Action Alternative 3 would be similar to those anticipated under the Proposed Action. Although the volume of waste disposed of under this alternative would increase the duration of disposal activities, there would be no substantial difference in the rate of pollutant emissions on either an annual or short-term basis.

Potential air quality impacts due to the decommissioning of WIPP would be similar to those under the Proposed Action. Construction of the berm and permanent markers and other decommissioning

activities would last longer than under the Proposed Action but would probably produce no substantial increase in annual pollutant emissions.

5.4.3 Biological Resources

The biological impacts at the treatment sites under Action Alternative 3 would be the same as those for the Proposed Action. Additional waste would be treated, but the size and type of the treatment facilities would be similar to those discussed in Section 5.1.3. Also, construction and operation of the treatment facilities should not affect populations of nonsensitive plant and animal species. Terrestrial wildlife species probably would not be affected by airborne emissions or spills into aquatic environments due to traffic accidents (DOE 1997). Threatened and endangered species may be present at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following site-wide or project-level NEPA review and appropriate Endangered Species Act consultation, during which impacts would be assessed and mitigated, if necessary. During site selection critical habitats of species listed as threatened, endangered, or candidates would be avoided.

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE recently completed a site-specific biological survey, during which no endangered, threatened, or state-listed species were identified.

At WIPP, a total of 375 hectares (927 acres) of aboveground area would be affected by decommissioning, salt pile reclamation, closure, and construction of berms and permanent markers. These activities would disturb avian and small mammal habitat. The disturbed areas would probably be attractive as habitat after natural vegetation recolonizes.

5.4.4 Cultural Resources

At the treatment sites, cultural resource impacts are expected to be the same for this alternative as for the Proposed Action. Construction and operation of TRU waste management and treatment facilities could adversely affect cultural resources, but site-level cultural resource surveys would be conducted and protection measures established, where necessary, when specific facility construction locations are proposed. These surveys would be part of site-wide or project-level NEPA reviews.

At WIPP, TRU waste shipping and operational activities would not have an impact on the archaeological sites on the disturbed land; however, some sites could be affected by closure- and decommissioning-related activities. Measures for ensuring protection of known archaeological and historic resources (or others that may be inadvertently discovered during ground-disturbing activities) are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996a). They include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the maximum extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed under the Joint Powers Agreement in consultation with the State Historic Preservation Office, Advisory Council on Historic Preservation, and the Bureau of Land Management (BLM).

5.4.5 Noise

The WM PEIS stated that treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially. Still, some sensitive receptors may be affected (DOE 1997). Site-specific noise impacts will be assessed in site-wide or project-specific NEPA documents. Because all waste would travel to WIPP but only a portion of the waste would travel from or to each treatment facility, the greatest noise impacts due to transportation noise would be near the WIPP site.

At WIPP, potential noise impacts under Action Alternative 3 would be similar to those under Action Alternative 1 (Section 5.2.5). Like Action Alternative 1, the increase in noise associated with this alternative would be negligible when compared to the background noise level associated with normal automobile, truck, and rail traffic in Carlsbad, New Mexico.

5.4.6 Water Resources and Infrastructure

At the treatment sites, proposed TRU waste activities might affect on-site infrastructures although no off-site infrastructure impacts would be expected. The infrastructure elements analyzed were the capacity of on-site water, power, and wastewater systems, and on-site transportation. For Action Alternative 3, Hanford would have an increased on-site demand for wastewater treatment that would exceed 5 percent of the current demand (7 percent), and INEEL would have an increase in on-site demand for power by 6.4 percent (DOE 1997).

Minor impacts to the on-site transportation infrastructure under Action Alternative 3 may occur. These impacts would result from an increase to on-site employment of 7 percent at Hanford and INEEL and 8 percent at LANL. Impacts to the off-site transportation infrastructure are not anticipated because population increases would not exceed 5 percent. On-site increases could be accommodated by existing and anticipated water supplies, power, water treatment, and transportation systems (DOE 1997).

Negligible annual infrastructure impacts would occur at WIPP under Action Alternative 3. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.4.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for Action Alternative 3 are presented in the following subsections.

5.4.7.1 Life-Cycle Costs

The life-cycle costs of Action Alternative 3 are presented in Table 5-56 and are discussed below. Six TRU waste treatment sites would process, treat, and package waste over a period of 35 years. In addition, the largest sites (INEEL, Hanford, and ORNL) would be required to store portions of their treated waste volumes over some or all of the 190-year period of disposal operations because of WIPP emplacement limitations. Life-cycle costs include an additional $640 million to account for treatment to planning-basis WAC of waste that would be shipped for treatment. The waste treatment facility life-cycle costs at these six sites would be $24.34 billion (in 1994 dollars).

Table 5-56
Life-Cycle Costs for Action Alternative 3 (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	9,550	4,380	13,930	9,940	470	10,410	24,340	13,500
Transport by Truck	2,330	3,270	5,600	910	330	1,240	6,840	910
Transport by Regular Train	800	1,120	1,920	310	110	420	2,340	310
Transport by Dedicated Train	5,340	7,500	12,840	2,100	750	2,850	15,690	2,100
Disposal at WIPP	12,300	3,100	15,400	12,800	290	13,090	28,490	3,610
Total Life-Cycle Cost (Truck)	24,180	10,750	34,930	23,560	1,090	24,740	59,670	18,030
Total Life-Cycle Cost (Regular Train)	22,650	8,600	31,250	23,050	870	23,920	55,170	17,420
Total Life-Cycle Cost (Dedicated Train)	27,190	14,980	42,170	24,840	1,510	26,350	68,520	19,210

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

Waste transport costs include one of three transportation options between the six consolidation sites and the WIPP site: (1) trucks, as in the Proposed Action, (2) trucks with maximum practical commercial rail, and (3) trucks with maximum practical dedicated rail. Under these options, transportation costs include the consolidation of the waste volumes at the six large sites, and then shipment to WIPP via truck or rail for emplacement. The waste transport costs would be about $6.84 billion by truck, $2.34 billion by regular rail, and $15.69 billion by dedicated rail.

The WIPP site life-cycle costs of the project would be projected to be $28.49 billion. The total life-cycle costs of Action Alternative 3 would be $59.67 billion ($18.03 billion when discounted) using trucks, $55.17 billion ($17.42 billion when discounted) using regular rail, and $68.52 billion ($19.21 billion when discounted) using dedicated rail.

5.4.7.2 Economic Impacts

TRU waste treatment activities would support direct, indirect, and induced jobs. Action Alternative 3 would support approximately 24,900 jobs in the ROIs of the six treatment sites (Hanford, INEEL, LANL, ORNL, RFETS, and SRS).

Estimates of the impacts of Action Alternative 3 on employment, income, and the production of goods and services within the ROI are presented in Table 5-57. These regional impacts were estimated using an annual average project budget of $180 million per year over a 190-year period of waste disposal operations. Over this extended period of waste emplacement operations, WIPP would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 site personnel annually. Indirectly, the operation of WIPP as a waste emplacement facility (from 2010 through 2200) would annually support 2,443 jobs in the ROI work force.

Table 5-57
Economic Impacts within the WIPP ROI for Action Alternative 3

Economic Effects	Total Output of Goods and Services (in millions of 1994 dollars)	Total Employment (Full- and Part-Time Jobs)	Total Labor Income (in millions of 1994 dollars)	Carlsbad Output of Goods and Services (in millions of 1994 dollars)	Carlsbad Employment (Full- and Part-Time Jobs)	Carlsbad Labor Income (in millions of 1994 dollars)
Direct – Annual	113	1,095	52	95	979	46
Indirect & Induced – Annual	204	2,443	75	172	2,185	67
Total – Annual	317	3,538	126	267	3,164	113
Total - Operations (190 years)	60,230	672,220 [a]	23,940	50,730	601,160 [a]	21,470

[a] Job-years (number of annual jobs supported multiplied by the number of years in the project).

Because the projected average annual project budget would be close to historical levels, Action Alternative 3 would not be expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection), nor require major capital investments in public infrastructure within the ROI. For this same reason Action Alternative 3 would not be expected to impact the local real estate market, nor result in major changes in WIPP ROI work force population.

5.4.8 Transportation

This section presents the transportation impacts for Action Alternative 3.

5.4.8.1 Route Characteristics and Shipment Projections

The methods used to estimate route characteristics and the number of shipments for Action Alternative 3 were the same as those presented in Section 5.1.8.1. Table 5-58 presents the number of shipments that would be required.

Table 5-58
Number of Truck Shipments to WIPP for Action Alternative 3 [a]

Waste Treatment Site	CH-TRU Waste			RH-TRU Waste		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	24,531	8,600	33,131	60,789	3,076	63,865
Idaho National Engineering and Environmental Laboratory Argonne/National Laboratory-West	10,386	7,769	18,155	---	---	---
Los Alamos National Laboratory	7,628	1,907	9,535	---	---	---
Oak Ridge National Laboratory	---	---	---	7,050	3,691	10,741
Rocky Flats Environmental Technology Site	2,897	---	2,897	---	---	---
Savannah River Site	2,885	706	3,591	---	---	---
Total	48,327	18,982	67,309	67,839	6,767	74,606

[a] The total number of shipments presented here do not include shipments from the generator sites to the consolidation sites. The number of consolidation shipments are 535 for CH-TRU waste and 8,254 for RH-TRU waste.

5.4.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

Table 5-59 presents a summary of the nonradiological impacts for Action Alternative 3. The fatalities due to the pollution-related health effects of diesel fuel and the impacts due to transporting the waste to treatment sites are also presented. The number of pollution-related fatalities was based upon the total miles traveled in urban areas and a conversion factor of 9.9×10^{-8} LCFs per kilometer (1.6×10^{-7} LCFs per mile) (Rao et al. 1982). For Action Alternative 3, the total number of accidents, injuries, and fatalities over the entire shipping campaign were estimated to be 239, 165, and 22, respectively. Details on the methods used are presented in Appendix E.

Table 5-59
Nonradiological Impacts of Transporting
TRU Waste by Truck for Action Alternative 3

Category	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Number of Accidents	73	31	104	124	12	135	197	43	239
Number of Injuries	51	20	71	85	10	94	136	30	165
Number of Fatalities	7	3	10	11	1	12	18	4	22
Pollution Health Effects (fatalities)	0.2	0.09	0.3	0.4	0.05	0.4	0.6	0.1	0.7

5.4.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during routine transportation and are the result of public and worker exposure to direct radiation at levels allowed by transportation regulations. The methods used to estimate accident-free radiological impacts for Action Alternative 3 were identical to those described for the Proposed Action.

Table 5-60 presents a summary of the accident-free radiological impacts for Action Alternative 3. It includes the impacts due to transporting waste to the treatment sites for treatment (see Appendix E). The total occupational and nonoccupational impacts were estimated to be 1 LCF and 14.5 LCFs, respectively.

Table 5-61 summarizes the radiological impacts to MEIs for accident-free shipments by truck under Action Alternative 3.

Table 5-60
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation for Action Alternative 3 (LCFs) [a]

Exposure Category	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Occupational	0.5	0.2	0.7	0.3	0.04	0.4	0.8	0.2	1.0
Nonoccupational									
Stops	3.3	1.4	4.7	7.8	.9	8.7	11.1	2.3	13.4
Sharing Route	0.2	0.08	0.3	0.4	0.05	0.5	0.6	0.1	0.8
Along Route	0.07	0.03	0.1	0.2	0.03	0.2	0.3	0.06	0.3
Nonoccupational - Total	3.6	1.5	5.1	8.4	1.0	9.4	12.0	2.5	14.5

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use two-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

Table 5-61
Radiological Impacts to MEIs from Truck Transportation for Action Alternative 3 (Probability of an LCF)

Individual	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	1.0E-3	6.0E-3	7.0E-3
State Vehicle Inspector	2.1E-3	7.8E-3	9.9E-3
Residing adjacent to access route	2.0E-4	6.0E-4	8.0E-4
Rest stop employee	1.0E-4	3.0E-4	4.0E-4

5.4.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to traffic accidents. The first analysis determined the radiological impacts due to accidents occurring from each of the principal treatment sites to WIPP. The results for route-specific accidents summed over the entire shipping campaign are presented in Table 5-62.

The second analysis assessed four bounding accident scenarios, two involving the breach of a TRUPACT-II and the other two involving the breach of an RH-72B cask. These assessments were to estimate the maximum potential impacts posed by a severe transportation accident. Details on the methods used to estimate impacts from bounding case accidents are presented in Section 5.1.8.4 and Appendix E.

Table 5-62
Aggregate Radiological Population Impacts
for Truck Transportation Accidents for Action Alternative 3 (LCFs)

Originating Site	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory-East	---	---	---	---	---	---	---	---	---
Hanford Site	0.6	0.2	0.8	0.08	4.0E-3	0.09	0.7	0.2	0.9
Idaho National Engineering and Environmental Laboratory/ANL-W	0.1	0.1	0.2	3.0E-3	5.0E-4	3.5E-3	0.1	0.1	0.2
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	5.0E-3	1.5E-3	6.5E-3	2.0E-5	1.0E-5	3.0E-5	5.0E-3	1.5E-3	6.5E-3
Oak Ridge National Laboratory	---	---	---	5.0E-3	3.0E-3	8.0E-3	5.0E-3	3.0E-3	8.0E-3
Rocky Flats Environmental Technology Site	0.01	---	0.01	---	---	---	0.01	- - -	0.01
Savannah River Site	0.03	7.5E-3	0.04	---	---	---	0.03	7.5E-3	0.04
Total LCFs							**0.9**	**0.3**	**1.2**

For Action Alternative 3, the potential radiological releases from the bounding case accidents were assumed to be the same as those presented under the Proposed Action (a maximum of 16 LCFs to the population and 0.06 probability of cancer to the maximally exposed individual.) The shred and grout treatment process used for treating TRU waste under Action Alternative 3 would reduce the void space in the drums, but increase the waste volume by approximately 20 percent. It was assumed that the release fraction for waste treated using a shred and grout process would be the same as for waste treated under the Proposed Action. The bounding accident consequences therefore, are assumed to be the same as those for the Proposed Action (see Section 5.1.8.4).

5.4.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

Exposures to hazardous chemical releases from a severe accident would present a negligible hazard to the exposed population under Action Alternative 3. Although the TRU waste for Action Alternative 3 would be treated using a shred and grout process and the inventory for Action Alternative 3 is larger than that for the Proposed Action, the bounding concentrations of VOCs and metals in the TRUPACT-II or RH-72B cask and the release fractions in an accident were estimated to be the same, and so potential impacts would be the same as for the Proposed Action.

5.4.8.6 Impacts from Rail Transportation

This section presents a summary of transportation impacts for both regular and dedicated rail transportation. These impacts were determined by scaling the transportation impacts for truck shipments to estimate the impacts for rail. In Section 5.2.8.6 and Appendix E, the impact parameters are identified, and the differences between truck and rail transportation are explained. Table 5-63 presents the rail impacts under Action Alternative 3.

Table 5-63
Impacts from Rail Transportation
for Action Alternative 3

Aggregate Traffic Related Fatalities	
Regular Rail	11
Dedicated Rail	154
Aggregate Accident-Free Radiological Impacts (LCFs)	
CH-TRU Waste	
Occupational Exposure	0.03
Nonoccupational	
Stops	0.6
Sharing Route	2.6E-3
Along Route	0.1
Nonoccupational Exposure - Total	0.7
RH-TRU Waste	
Occupational Exposure	0.02
Nonoccupational	
Stops	1.1
Sharing Route	4.9E-3
Along Route	0.3
Nonoccupational Exposure - Total	1.3
Total CH-TRU and RH-TRU Waste	
Occupational Exposure	0.05
Nonoccupational	
Stops	1.6
Sharing Route	7.5E-3
Along Route	0.4
Nonoccupational Exposure - Total	2.0
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)	
CH-TRU Waste	1.1
RH-TRU Waste	0.1
Total CH-TRU and RH-TRU Waste	1.2

The bounding case accident analyses for rail transportation were based on assumptions presented in Section 5.2.8.6. Though the waste would be treated by a shred and grout process, the impacts would be similar to those presented for the Action Alternative 1 rail accident analyses. The greatest impacts were found for the two accidents in which conservative inventories were assumed, 32 LCFs to the exposed population and a 0.12 probability of a cancer fatality for the maximally exposed individual.

5.4.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and WIPP disposal operations under Action Alternative 3. As for other action alternatives, impacts from waste treatment were adjusted from those presented in the WM PEIS; a description of the adjustments is provided in Appendix B.

Impacts from lag storage at the treatment sites and WIPP disposal operations were estimated using the general methods and assumptions used for the human health analyses of Proposed Action and Action Alternative 1. Action Alternative 3 includes the Total Inventory (except for PCB-commingled waste). PCB-commingled TRU waste is known to exist at three sites: 242 cubic meters (8,550 cubic feet) at Hanford, 461 cubic meters (16,300 cubic feet) at INEEL, and 19 cubic meters (670 cubic feet) at Mound.

The major distinction of this alternative for human health analyses is the shred and grout treatment method. Shred and grout treatment of waste reduces gas generation and changes the quantity of

VOCs emitted from the waste containers; it also results in a net waste volume increase of about 20 percent overall. The increase in volume would reduce the concentration of the radionuclides in the waste, which decreases the estimated average container dose rates. Denser waste matrices, such as grout, tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.4.9.1 Public

Impacts to the populations and to the MEIs under Action Alternative 3 are presented in this section; results are presented in Table 5-64. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites; none of them WIPP. Waste disposal operations would take place only at WIPP. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment and lag storage are presented for the highest individual waste treatment sites; the MEI from disposal operations is near the WIPP site. See Chapter 3 for additional information on where treatment and storage would occur under Action Alternative 3.

Table 5-64
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence) [b]
MEI [c, d]						
Basic Inventory						
CH-TRU Waste	2E-7 (L)	4E-13 (L)	2E-7 (L)	1E-7 (L)	2E-7	5E-9
RH-TRU Waste	7E-12 (O)	1E-11 (O)	1E-9 (O)	4E-8 (H)	7E-10	9E-10
Total Waste	2E-7 (L)	1E-11 (O)	2E-7 (L)	1E-7 (L)	2E-7	6E-9
Total Inventory						
CH-TRU Waste	4E-7 (L)	7E-13 (I)	3E-7 (L)	2E-7 (L, H)	3E-7	1E-8
RH-TRU Waste	1E-11 (O)	2E-11 (O)	2E-9 (O)	4E-8 (H)	8E-10	9E-10
Total Waste	4E-7 (L)	2E-11 (O)	3E-7 (L)	3E-7 (H)	3E-7	1E-8
Population [b]						
Basic Inventory						
CH-TRU Waste	3E-3	5E-9	1E-3	2E-3	1E-4	5E-6
RH-TRU Waste	3E-7	3E-7	3E-5	2E-4	9E-7	5E-7
Total Waste	3E-3	3E-7	1E-3	2E-3	1E-4	6E-6
Total Inventory						
CH-TRU Waste	4E-3	1E-8	2E-3	2E-3	2E-4	1E-5
RH-TRU Waste	4E-7	4E-7	5E-5	2E-4	1E-6	5E-7
Total Waste	4E-3	4E-7	2E-3	2E-3	2E-4	1E-5
Aggregate Total	4E-3	4E-7	3E-3	4E-3	3E-4	2E-5

[a] The probability of an LCF to the MEI, and the number of LCFs in the population
[b] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were emitted at a constant rate, the MEI lifetime risk from the CH-TRU waste would be 2E-8.
[c] I = INEEL, L = LANL, H = Hanford, O = ORNL.
[d] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

Waste Treatment

No LCFs (4×10^{-3} LCF) or cancer incidence (4×10^{-7} cancers) would be expected in the total population around the waste treatment sites. The MEI would be at LANL for radiological impacts (4×10^{-7} probability of an LCF), and impacts at all sites would not exceed a 2×10^{-11} probability of a cancer incidence. The maximum HI for the MEI would be 7×10^{-10}.

Lag Storage

No LCFs would be expected in the total population around the lag storage sites (2×10^{-3} LCFs); no cancer incidence (2×10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at LANL for radiological impacts (3×10^{-7} probability of an LCF) and at Hanford for hazardous chemical impacts (also 3×10^{-7} probability of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for any MEI would be 9×10^{-4}.

The aggregate total indicated in Table 5-64 refers to the impacts expected over the entire operational period under Action Alternative 3. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 57 years for CH-TRU waste and 190 years for RH-TRU waste. No LCFs (3×10^{-3} LCFs) or cancer incidence (4×10^{-3} cancers) would be expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials.

WIPP Disposal Operations

No LCFs would be expected in the population around WIPP from radiation exposure (2×10^{-4} LCF). No cancer incidence (1×10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 3×10^{-7} probability of an LCF from radiation exposure and a 1×10^{-8} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the MEI would be 1×10^{-4}.

The aggregate total indicated in Table 5-64 refers to the impacts expected over the entire operational period. The operational period for the disposal of the Total Inventory is expected to be 57 years for CH-TRU waste and 190 years for RH-TRU waste. No LCFs (3×10^{-4} LCFs) or cancer incidence (2×10^{-5} cancers) would be expected over the several generations of exposure to the estimated releases.

5.4.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternative 3 are presented in this section; results are presented in Table 5-65. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling, or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage

Table 5-65
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemicals (Cancer Incidence)
Maximally Exposed Noninvolved Worker [b, c]						
Basic Inventory						
CH-TRU Waste	1E-7 (L)	2E-12 (I)	8E-7 (S)	2E-7 (H)	2E-7	3E-8
RH-TRU Waste	6E-12 (O)	9E-11 (O)	1E-8 (O)	8E-8 (H)	2E-9	2E-9
Total Waste	1E-7 (L)	9E-11 (O)	8E-7 (S)	3E-7 (H)	2E-7	3E-8
Total Inventory						
CH-TRU Waste	2E-7 (L)	6E-12 (I)	2E-6 (S)	3E-7 (H)	3E-7	5E-8
RH-TRU Waste	9E-12 (O)	1E-10 (O)	2E-8 (O)	9E-8 (H)	2E-9	2E-9
Total Waste	2E-7 (L)	1E-10 (O)	2E-6 (S)	4E-7 (H)	3E-7	5E-8
Population [c]						
Basic Inventory						
CH-TRU Waste	5E-4	4E-9	0.02	4E-3	2E-4	3E-5
RH-TRU Waste	9E-9	9E-8	2E-4	1E-3	2E-6	2E-6
Total Waste	5E-4	1E-7	0.02	5E-3	2E-4	3E-5
Total Inventory						
CH-TRU Waste	7E-4	9E-9	0.04	8E-3	3E-4	5E-5
RH-TRU Waste	1E-8	1E-7	2E-4	1E-3	2E-6	2E-6
Total Waste	7E-4	1E-7	0.04	9E-3	3E-4	5E-5
Aggregate Total	7E-4	1E-7	0.07	0.02	5E-4	9E-5

[a] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] L = LANL, H = Hanford, I = INEEL, O = ORNL, S = SRS
[c] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

would take place at six DOE sites not including WIPP, while disposal operations would take place only at WIPP. Noninvolved worker population impacts were estimated as the total for all treatment sites, for all lag storage facilities, and at WIPP. The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites. The maximally exposed noninvolved worker from disposal operations was assumed to work continuously at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

Under Action Alternative 3, radiological impacts to the noninvolved workers from waste treatment would be somewhat greater than nonradiological impacts. No LCFs (7×10^{-4} LCFs) or cancer incidence (2×10^{-7} cancers) would be expected in the total noninvolved worker population at the waste treatment sites. The maximally exposed noninvolved worker would be at LANL for radiological impacts (2×10^{-7} probability of an LCF) and at ORNL for hazardous chemical impacts

(1×10^{-10} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the maximally exposed noninvolved worker would be 8×10^{-9}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

No LCFs would be expected in the total noninvolved worker population at the lag storage sites (4×10^{-2} LCF); no cancer incidence (9×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at SRS for radiological impacts (2×10^{-6} probability of an LCF) and at Hanford for hazardous chemical impacts (4×10^{-7} probability of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for the maximally exposed noninvolved worker would be 4×10^{-3}.

The aggregate total indicated in Table 5-65 refers to the impacts to the noninvolved worker population at the lag storage sites expected over the entire operational period under Action Alternative 3. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 57 years for CH-TRU waste and 190 years for RH-TRU waste. No LCFs (0.07 LCFs) or cancer incidence (0.02 cancers) would be expected in the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials under incident-free operations.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (3×10^{-4} LCF). VOC release estimates were the same as for the public. No cancer incidence (5×10^{-5} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 3×10^{-7} probability of an LCF from radiation exposure and a 5×10^{-8} probability of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the maximally exposed noninvolved worker would be 1×10^{-3}.

The aggregate total indicated in Table 5-65 shows that no LCFs (5×10^{-4} LCFs) or cancer incidence (9×10^{-5} cancers) would be expected to the noninvolved workers at the WIPP site during the entire disposal operations period under Action Alternative 3.

5.4.9.3 Involved Workers

Impacts to involved workers who would handle waste during treatment, lag storage, and WIPP disposal operations under Action Alternative 3 are presented in this section. Results are presented in Table 5-66, and additional information is presented in Appendix F and Appendix B for waste treatment impacts. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-66
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations for Action Alternative 3 [a]

Category	Waste Treatment Impacts		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)
Population					(36 workers)	(36 workers)
Basic Inventory						
CH-TRU Waste	0.7	1E-5	0.2	0.03	0.05	4E-3
RH-TRU Waste	9E-3	6E-6	≤0.2	≤0.03	≤0.05	4E-4
Total Waste	0.7	2E-5	≤0.4	≤0.06	≤0.1	≤4E-3
Total Inventory						
CH-TRU Waste	1.5	3E-5	0.3	0.06	0.1	7E-3
RH-TRU Waste	0.01	9E-6	≤0.3	≤0.06	≤ 0.1	4E-4
Total Waste	1.5	4E-5	≤0.6	≤0.1	≤ 0.2	≤7E-3
Aggregate Total	1.5	4E-5	0.6	≤0.4	0.3	≤0.01

[a] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

Waste Treatment

A maximum of 1.5 radiation-related LCFs could occur in the involved worker population, while no cancer incidence (4×10^{-5} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health effects are predicted. The maximum exposure index for a waste treatment worker would be 3×10^{-4}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Assuming 35 years of management of the entire inventory, radiological impacts to the lag storage involved worker population would be less than 0.6 LCF, and hazardous chemical impacts would be less than 0.1 cancers. No noncarcinogenic health effects would occur. Involved worker lag storage impacts would be larger from CH-TRU waste storage operations than from RH-TRU waste storage operations. Impacts from RH-TRU waste lag storage operations would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. No specific RH-TRU lag storage impact estimates were made because specific RH-TRU waste handling configurations and procedures are unknown. RH-TRU waste lag storage impacts would be assessed in greater detail in future site-wide or project-specific NEPA reviews.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years, and 20 percent of the Total Inventory was assumed to be monitored annually.

The aggregate total indicated in Table 5-66 refers to the impacts to the involved worker population at the lag storage sites over the entire operational period under Action Alternative 3. Lag storage impact estimates conservatively assume that the lag storage period is equivalent to the disposal operations period, which is estimated to be 57 years for CH-TRU waste and 190 years for RH-TRU waste. A maximum of 0.6 LCFs and less than 0.4 cancers would be expected over the several generations of involved workers that would be exposed externally or via inhalation of hazardous chemicals during lag storage operations. The radiological impact estimates reflect the aggregate impacts analyses presented in detail in Appendix F. The hazardous chemical impacts were estimated in the same manner as the public and noninvolved worker estimates.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 0.2 LCF. WIPP involved worker radiological impacts would be from external radiation dose, and it was assumed that each involved worker who handled CH-TRU waste for 400 hours per year. The operational period was determined by assuming that 2.5 years of disposal operations were required to fill each panel. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste.

Hazardous chemical carcinogenic impacts to the involved worker population would be less than 7×10^{-3} cancers. Involved worker exposures to VOCs were evaluated for workers in the Waste Handling Building and underground. The potential carcinogenic impacts would be greatest for the individual underground worker. Noncarcinogenic health effects were also estimated for WIPP workers who would handle waste. The same methods were used as for the Proposed Action (Section 5.1.9.3).

No hazardous chemical noncarcinogenic health effects would occur. The initial maximum HI estimates for involved workers were from carbon tetrachloride, with values of 2 and 10, respectively, for workers in the Waste Handling Building and the underground. Further evaluation was conducted by comparing the worker exposure air concentration to the PEL for carbon tetrachloride. The worker air concentrations would be, at a minimum, two orders of magnitude below the PEL, so no noncarcinogenic health effects would occur. Workers were assumed to be exposed for a working lifetime of 35 years.

The aggregate total indicated in Table 5-66 refers to the impacts to the involved worker population at WIPP over the entire disposal operations period under Action Alternative 3. No LCFs (0.3 LCFs) or cancer incidence (less than 0.01 cancers) would be expected over the several generations of involved workers at WIPP. Total radiological impacts would be approximately twice the number of impacts estimated for the individual during the first 35 years of CH-TRU waste disposal operations at WIPP. Radiological decay would reduce the radiological impacts to each generation of WIPP workers. Hazardous chemical impacts were conservatively estimated by assuming continuous exposure to the same releases over the entire disposal operations period.

5.4.10 Facility Accidents

This section describes potential consequences of facility accidents at the treatment sites from the shred and grout treatment of waste, at the treatment sites from waste storage after treatment but before shipment to WIPP, and at WIPP during waste management and disposal operations. Consequences of treatment and storage accidents were evaluated at the six treatment sites (Hanford, LANL, INEEL, SRS, RFETS, and ORNL) that would handle all of the CH-TRU and RH-TRU waste under Action Alternative 3.

Inhalation is the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological consequences are potentially much greater for members of the public and the noninvolved workers than hazardous chemical consequences and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used and complete accident descriptions are provided in Appendix G.

5.4.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated under Action Alternative 3; they are presented in Table 5-67. Results are presented only for accidents involving CH-TRU waste. They would be greater than similar accidents involving RH-TRU waste. Treatment accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. For the purposes of analyses, an earthquake was assumed to be the initiating event the beyond-design-basis accident for analysis (rather than a plane crash or tornado, for instance). Accident analysis information is presented in Appendix G.

Table 5-67
Treatment Accident Scenarios Evaluated for Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Waste Spill (Accident Scenario T7)	0.01	Wet grout is spilled onto facility floor before it is placed in a drum.
Fire (Accident Scenario T8)	1E-4	Pyrophoric material inside a shredder causes shredder contents to burn.
Earthquake (Accident Scenario T9)	1E-5 or less	A beyond-design-basis earthquake (or other natural event) collapses the roof, causing drums to rupture and HEPA filters to fail.

Estimated radiological consequences are presented as the number of LCFs in the exposed population and the probability of an LCF occurring in MEIs (in tables the probability of an LCF is presented for MEIs). Carcinogenic and noncarcinogenic consequences from hazardous chemicals, both VOCs and heavy metals, were estimated. Carcinogenic consequences are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic consequences from exposure to VOCs and heavy metals were estimated by two different methods: IDLH-equivalent ratios and ERPG ratios.

In general, potential radiological consequences would be higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the

Table 5-68
Radiological Consequences of Treatment Accidents for Action Alternative 3 [a]

Accident Scenarios		Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
CH-TRU Waste	Waste Spill (Accident Scenario T7)	Maximum: 1E-4 (RFETS)	Maximum: 6E-8 (LANL)	Maximum: 2E-7 (Hanford)
	Fire (Accident Scenario T8)	Maximum: 6E-3 (RFETS)	Maximum: 3E-6 (LANL)	Maximum: 8E-6 (Hanford)
	Earthquake (Accident Scenario T9)	Hanford: 6 INEEL: 0.3 LANL: 2 RFETS: 6 SRS: 0.5	Hanford: 3E-3 INEEL: 2E-4 LANL: 5E-3 RFETS: 4E-4 SRS: 6E-5	Hanford: 0.02 INEEL: 0.02 LANL: 0.02 RFETS: 0.01 SRS: 0.01
RH-TRU Waste	Waste Spill (Accident Scenario T7)	Maximum: 5E-9 (ORNL)	Maximum: 4E-12 (ORNL)	Maximum: 4E-12 (ORNL)
	Fire (Accident Scenario T8)	Maximum: 3E-7 (ORNL)	Maximum: 2E-10 (ORNL)	Maximum: 2E-10 (ORNL)
	Earthquake (Accident Scenario T9)	Hanford: 1E-4 ORNL: 3E-4	Hanford: 7E-8 ORNL: 3E-7	Hanford: 4E-7 ORNL: 7E-7

[a] The site with the greatest consequence is shown in parentheses.

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-68. Consequences to the maximally exposed involved worker were addressed qualitatively.

Public

Population consequences from treatment accidents were estimated for the exposed populations around the six treatment sites. Potential consequences to the population and MEIs at the five sites vary over a wide range because population distributions, distances to MEIs, and atmospheric dispersion factors differ among sites. No LCFs would be expected in the exposed population from the waste spill accident or fire in a waste shredder accident (Accident Scenario T7 and T8). Up to 6 LCFs were estimated to occur from the earthquake (Accident Scenario T9) at RFETS and Hanford. The radiological consequences were estimated to be the highest to the MEI at LANL for all three accidents. Consequences due to the earthquake (Accident Scenario T9) were estimated to range from a 6×10^{-5} (at SRS) to 5×10^{-3} (at LANL) probability of an LCF to the MEI.

Carcinogenic consequences from VOCs would be one to five orders of magnitude greater than consequences from heavy metals for the waste spill and earthquake accidents (Accident Scenarios T7 and T9, respectively). Heavy metals would account for all carcinogenic consequences from the fire accident (Accident Scenario T8) because VOCs would be consumed by the fire. No cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum probability of cancer to the MEI would be 6×10^{-9} from any of the three treatment accidents. The ORNL, Hanford, LANL, and RFETS MEIs could all develop irreversible or severe noncarcinogenic health effects from exposure to hazardous chemicals as a result of the earthquake.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest consequence outside of the waste treatment building. The consequences to the noninvolved worker were estimated to not vary significantly across the five sites. Radiological consequences to the

maximally exposed noninvolved worker would result in a 2 x 10^{-7} probability of an LCF from the waste spill accident (Accident Scenario T7 at Hanford), 8 x 10^{-6} probability of an LCF from the fire accident (Accident Scenario T8 at Hanford), and up to 0.02 probability of an LCF (at Hanford, INEEL, and LANL) from the beyond-design-basis earthquake (Accident Scenario T9).

No cancer incidents would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest probability of cancer would be 2 x 10^{-8}. Under the earthquake scenario (Accident Scenario T9), the maximally exposed noninvolved worker at all the sites would have a chance of developing irreversible or severe noncarcinogenic health effects, and could develop life threatening effects. These effects would be because of exposures to heavy metals and VOCs.

Maximally Exposed Involved Worker

No consequences to the maximally exposed involved worker would be anticipated from either the waste spill or fire accidents (Accident Scenarios T7 or T8, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial consequences would be possible due to the events of the earthquake scenario (Accident Scenario T9), ranging from workers killed by debris from collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated. Intakes of radionuclides, VOCs, and heavy metals would also occur.

5.4.10.2 Waste Storage Accidents

Three potential waste storage accidents were evaluated for Action Alternative 3; they are presented in Table 5-69. CH-TRU waste would be consolidated at five sites for lag storage under Action Alternative 3. The potential accident consequences at the five sites were evaluated in detail; the sites would be Hanford, INEEL, LANL, RFETS, and SRS. A sixth site, ORNL, would store only for RH-TRU waste under Action Alternative 3. Only CH-TRU accident consequences are presented in this section; the consequences of an RH-TRU storage facility failure in the event of an earthquake are presented in detail in Appendix G.

Table 5-69
Storage Accident Scenarios Evaluated for Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop and Lid Failure (Accident Scenario S1) [a]	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destablilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2) [a]	1E-4 to 1E-6	A fire spontaneously erupts in a waste drum.
Earthquake (Accident Scenario S3)	1E- 5 or less	A beyond-design-basis earthquake (or other natural event) occurs, causing the collapse of the storage buildings.

[a] Occurrence frequencies for Accident Scenarios S1 and S2 were taken from reference documents applicable to waste packaged to meet the planning-basis WAC. The same range of frequencies were assumed to apply to grouted waste. In reality, the frequency of occurrence of Accident Scenario S2 would probably be substantially lower for the grouted waste than for the waste treated to planning-basis WAC.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident (an earthquake). For Accident Scenarios S1 and S2, CH-TRU waste involved in the accidents was assumed to have the maximum radionuclide content allowable under the planning-basis WAC (80 PE-Ci per drum), conservative concentrations of VOCs (based on CH-TRU sampling and WAC limits), and conservative concentrations of heavy metals. Accident Scenario 3 involves a large number of waste containers; therefore, average site-specific drum PE-Ci values and average hazardous chemical concentrations were used in the analyses. Additional details on the accident analyses are presented in Appendix G.

Estimated radiological consequences are presented as the number of LCFs in the exposed population and the probability of an LCF occurring in MEIs. Carcinogenic and noncarcinogenic consequences from hazardous chemicals, both VOCs and heavy metals, were estimated. Carcinogenic consequences are presented as the number of cancers in the exposed population and the probability of cancer for MEIs. Noncarcinogenic consequences from exposure to VOCs and heavy metals were estimated by two different methods for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic storage facility failure due to the earthquake (Accident Scenario S3). The potential noncarcinogenic consequences identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological consequences would be higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-70.

Public

Population consequences from storage accidents were estimated for the exposed populations around the five CH-TRU waste treatment sites. Potential consequences to the population and MEIs at the five sites vary over a wide range because the population distributions, distances to MEIs, and

Table 5-70
Radiological Consequences of Storage Accidents for Action Alternative 3 [a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Puncture and Lid Failure (Accident Scenario S1)	Maximum: 3E-5 (RFETS)	Maximum: 8E-9 (LANL)	Maximum: 2E-8 (Hanford, LANL)
Drum Fire (Accident Scenario S2)	Maximum: 5E-5 (RFETS)	Maximum: 2E-8 (LANL)	Maximum: 5E-8 (Hanford)
Earthquake (Accident Scenario S3)	Hanford: 9 INEEL: 0.3 LANL: 2 RFETS: 10 SRS: 2	Hanford: 5E-3 INEEL: 1E-4 LANL: 4E-3 RFETS: 6E-4 SRS: 2E-4	Hanford: 0.03 INEEL: 0.02 LANL: 0.02 RFETS: 0.02 SRS: 0.04

[a] The site with the greatest consequence is shown in parentheses.

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

atmospheric dispersion factors differ among sites. No LCFs would be expected in the exposed population due to the drum puncture or drum fire scenarios (Accident Scenarios S1 and S2, respectively), but LCFs were estimated to occur due to the earthquake scenario (Accident Scenario S3) at most sites. The consequences due to the earthquake ranged from 0.3 (at INEEL) to 10 (at RFETS) LCFs. The radiological consequences were estimated to be the highest to the MEI at LANL for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2). Consequences due to the earthquake scenario (Accident Scenario S3) were estimated to range from a 1×10^{-4} (at INEEL) to 5×10^{-3} probability of an LCF to the MEI.

Carcinogenic consequences from VOCs would be two to seven orders of magnitude greater than consequences from heavy metals for the drum puncture and earthquake accidents (Accident Scenarios S1 and S3, respectively). Heavy metals would account for all carcinogenic consequences from the drum fire (Accident Scenario S2) because VOCs would be consumed by the fire. No cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum probability of cancer to the MEI would be 3×10^{-10} from the drum puncture or drum fire scenarios (Accident Scenarios S1 and S2). The maximum probability of cancer to the MEI would be 6×10^{-7} for the earthquake scenario (Accident Scenario S3 at Hanford). No noncarcinogenic consequences would be expected for any of the three accidents evaluated.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest consequence outside of the waste storage facility. The consequences to the noninvolved worker were estimated to vary over a narrow range. The range was narrow because of the uniform release height and close distances considered.

Radiological consequences to the maximally exposed noninvolved worker would result in a 2×10^{-8} probability of an LCF from the drum puncture scenario (Accident Scenario S1), 5×10^{-8} probability of an LCF from the events of the drum fire scenario (Accident Scenario S2), and up to a 0.04 probability of an LCF (at SRS) from the beyond-design-basis earthquake (Accident Scenario S3). Hazardous chemical consequences would be relatively minor in comparison to radiological consequences. The maximum probability of cancer to the maximally exposed noninvolved worker from VOC and heavy metal intakes would be 8×10^{-10} for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2). The corresponding consequence for the earthquake (Accident Scenario S3) would be 3×10^{-6} probability of cancer. No noncarcinogenic consequences to the noninvolved worker would be expected to result from the hazardous chemical releases for the accidents evaluated.

Maximally Exposed Involved Worker

The maximally exposed involved worker would be the individual most seriously affected by the events of the drum puncture scenario or earthquake (Accident Scenarios S1 and S3, respectively) because of close proximity to the accident. Consequences were quantitatively estimated for Accident S1 and qualitatively for Accident Scenarios S2 and S3. The worker could potentially have a 3×10^{-3} probability of an LCF as a result of the radionuclide intake during the events of the drum puncture scenario (Accident Scenario S1). The analysis assumed instantaneous radioactive material release from the three containers, expanding in a uniform hemisphere 5 meters (16 feet) in radius. The worker was assumed to inhale this air for 1 minute prior to exiting to a fresh air

source. The involved worker could have a 5 x 10^{-8} probability of contracting cancer from hazardous chemicals inhaled following the drum puncture (Accident Scenario S1). Noncarcinogenic consequences would include consequences to the maximally exposed involved worker from methylene chloride and would be irreversible, although not life-threatening.

Consequences due to the drum fire (Accident Scenario S2) would be serious if the worker happened to be adjacent to the drum when the fire began. However, a worker's actions are not required to initiate the accident; therefore, the probability of exposure of a worker adjacent to the fire is small. The smoke released from the drum would alert workers to the incident, and it, therefore, can be reasonably assumed that workers would avoid exposure to the smoke.

Catastrophic destruction of the storage facility during an earthquake (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker.

5.4.10.3 WIPP Disposal Accidents

Eight potential accidents at WIPP during disposal operations were evaluated; they are presented in Table 5-71. Six of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W5 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for consequences from CH-TRU and RH-TRU waste (Accident Scenario W6). The drum fire accident (Accident Scenario W5) that was evaluated under the Proposed Action and Action Alternative 1 may not be relevant for the relatively noncombustible shred-and-grout waste matrix evaluated under Action Alternative 3. Accident consequences were nevertheless estimated, and the same annual occurrence frequency for the accident under the Proposed Action and Action Alternative 1 was conservatively applied. Annual occurrence frequencies are the same in all cases as those indicated for the Proposed Action and Action Alternative 1.

Table 5-71
WIPP Disposal Accident Scenarios for Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	0.01	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drop, Puncture Lid Failure in the Waste Handling Building (Accident Scenario W2)	0.01	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drop, Lid Failure in Underground (Accident Scenario W3)	0.01	Same as Accident Scenario W1, but it occurs in the underground.
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.01	Same as Accident Scenario W2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	1E-4 (<8 PE-Ci) <1E-6 (>8 PE-Ci)	Contents of a drum in an underground disposal room spontaneously combusts prior to panel closure.
Hoist Failure (Accident Scenario W6)	<1E-6	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	0.01, Panel 1 < 1E-6, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing lid seal failures.
RH-TRU Waste Canister Breach (Accident Scenario W8)	1E-4 to 1E-6	RH-TRU waste canister is breached Waste Handling Building operations.

Potential radiological consequences would be substantially higher than hazardous chemical consequences, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below.

The greatest radiological consequences of facility accidents under Action Alternative 3 would be the same as the greatest consequences under the Action Alternative 2 subalternatives because characteristics of the thermally-treated and grouted waste forms were assumed to be the same. However, average radionuclide concentrations in the treated waste under the Action Alternative 2 subalternatives would realistically be two to five times higher than that of Action Alternative 3 waste. Therefore, average accident consequences for the Action Alternative 2 subalternatives would be higher than those for Action Alternative 3. For the disposal room roof failure (Accident Scenario W7), the consequences of postulated accidents under Action Alternative 3 would be less than those under the Proposed Action and Action Alternative 1 by at least a factor of ten. The grout treatment increases waste volume by 20 percent overall, and therefore reduces average concentrations by 20 percent, as well. The grouted waste is less likely to release particles of respirable size in the event of a container breach caused by a minor accident. However, in the event of a hoist failure, the more uniform, grouted waste matrix (as compared to waste treated to planning-basis WAC) is more likely to shatter upon impact into respirable particles. Consequences of the hoist failure would be approximately five to seven times higher than those estimated for waste treated to planning-basis WAC under the Proposed Action and Action Alternative 1. Radiological consequences of accidents under Action Alternative 3 are shown in Table 5-72.

Table 5-72
Radiological Consequences of WIPP Disposal Accidents for Action Alternative 3

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9E-4	1E-5	1E-5	3E-3
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	9E-4	1E-5	1E-5	3E-3
Drop, Lid Failure in Underground (Accident Scenario W3)	9E-4	1E-5	1E-5	3E-3
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	9E-4	1E-5	1E-5	3E-3
Container Fire (Accident Scenario W5)	5E-3	7E-5	6E-5	Not Credible
Hoist Failure (CH-TRU, RH-TRU) (Accident Scenario W6)	CH-TRU: 29 RH-TRU: 9	CH-TRU: 0.6 RH-TRU: 0.1	CH-TRU: 0.5 RH-TRU: 0.1	See Footnote a
Roof Failure (Accident Scenario W7)	0.02	2 E-4	2 E-4	See Footnote a
RH-TRU Canister Breach (Accident Scenario W8)	0	0	0	0

[a] These consequences could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris)

Note: This table presents estimates of the consequences of accident scenarios and does not reflect the frequency (or probability) of the accident occurring.

Public

Population consequences from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the city of Carlsbad. The population in this sector is 25,629 and would be affected greater than any other section in the surrounding 80-kilometer (50-mile) region. Consequences to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use Area boundary and the least atmospheric dispersion of facility exhaust ventilation air, which would be the location of maximum consequence. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for HEPA filtration from either the Exhaust Filter Building or the Waste Handling Building.

Radiological consequences from accidents would be higher than consequences from hazardous chemicals. The accident with the largest potential radiological consequence to the population and the MEI would be the failure of a fully loaded waste hoist carrying CH-TRU waste (Accident Scenario W6). Up to 29 LCFs could occur in the exposed population, and the MEI could experience a 0.6 probability of an LCF. The roof fall accident (Accident Scenario W7) would result in the highest potential carcinogenic hazardous chemical consequence, with an estimated 7×10^{-7} cancers occurring in the exposed population and an estimated 1×10^{-8} probability of cancer for the MEI. No fatalities due to toxicological effects would be expected. Noncarcinogenic consequence analyses based on ERPGs indicated potentially life-threatening exposures to methylene chloride and beryllium from a hoist failure accident and less serious consequences from lead, mercury, and carbon tetrachloride exposures. Consequences of the roof fall could involve serious, but not life-threatening exposures to 1,1,2,2,-tetrachloroethane releases and less serious consequences from carbon tetrachloride releases.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological consequences shown in Table 5-72 may be slightly lower than those for the MEI because of the small difference in the radiation dose-to-LCF conversion factors for workers and members of the public. The hazardous chemical consequences would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest consequences to an involved worker would be underground from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These consequences could range from negligible (workers not present or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological consequences of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-72. The highest radiological consequences would come from an accident causing three drums to breach (Accident Scenarios W1-W4), both with a 3×10^{-3} probability of an LCF. No fatalities due to hazardous chemical effects would be expected.

These same accidents, however, evaluated by ERPG ratios, might result in irreversible, non-life-threatening consequences from methlyene chloride and 1,1,2,2-tetrachloroethane exposure.

5.4.11 Industrial Safety

Five fatalities from industrial accidents would occur under Action Alternative 3 during waste treatment at all treatment sites. This result was estimated by adjusting the physical-hazard fatality estimate of the WM PEIS.

Under Action Alternative 3, WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 190 years rather than 35 years. Decommissioning activities would be the same as those for the Proposed Action. Estimated industrial safety impacts to WIPP workers under Action Alternative 3 are presented in Table 5-73. Oversight and inspections by the MSHA and adherence to OSHA regulations would probably reduce actual occurrences below these estimated values.

Table 5-73
Industrial Safety Impacts from WIPP
Operations and Decommissioning for Action Alternative 3

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2200	118	6,650	6,768	0.2	6.6	6.8
Decommissioning 2200-2210	187	96	283	0.3	0.1	0.4
Total	305	6,746	7,051	0.5	6.7	7.3

5.4.12 Long-Term Performance

This section presents the potential impacts associated with long-term performance of the WIPP repository for Action Alternative 3 evaluated for the 10,000-year period after the site is closed. These impacts were estimated based on computer simulations that predicted radionuclide and heavy metal releases from TRU waste in the repository under undisturbed and disturbed conditions. Analysis was conducted using the same methods as those used for the Proposed Action and other action alternatives; additional information is presented in Appendix H. The waste volume emplaced would be 334,000 cubic meters (11.8 million cubic feet) of CH-TRU waste and 66,000 cubic meters (2.3 million cubic feet) of RH-TRU waste. The repository size was increased from the 10 panels of the Proposed Action to 71 panels to accommodate the increased waste volume. The radionuclide inventory was increased to 7.3×10^6 Ci in CH-TRU waste and 5.1×10^6 Ci in RH-TRU waste, essentially the same as the inventories of Action Alternatives 1 and 2. There were similar increases in heavy metal inventories. Additional information on the radionuclide and heavy metal inventories is provided in Appendix A.

The four cases below were analyzed for Action Alternative 3. The cases are the same as the Proposed Action and other action alternatives but include alternative-specific differences, such as repository size and radionuclide and heavy metal inventories.

- Case 16 considered undisturbed repository conditions. Median parameter values were used for input variables where probability distributions have been defined.

- Case 17 considered disturbed conditions resulting from a borehole assumed to pass through the repository and intercept a pressurized brine reservoir in the Castile Formation. Median parameters values were used for input variables where probability distributions have been defined.

- Case 18 was the same as Case 16 but used 75th percentile parameter values for input variables where probability distributions have been defined.

- Case 19 was the same as Case 17 but used 75th percentile parameter values for input variables where probability distributions have been defined.

5.4.12.1 Impacts of Undisturbed Conditions

For Action Alternative 3, the extent of radionuclide (predominantly Pu-238, Pu-239, and Am-241) migration for undisturbed conditions 10,000 years after closure for Case 18 (75th percentile parameter values) would be very similar to that shown for Case 8 of Action Alternative 1 in Figure 5-3. Figure 5-3 shows the locations in the modeled region where the concentration of total radionuclide activity in the brine, summed over 30 radionuclides, is equal to 1 pCi per liter (1×10^{-9} Ci per cubic meter). A total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration.

Approximately the same vertical and lateral migration of radionuclides and heavy metals would occur under Action Alternative 3 as for the Proposed Action and other action alternatives. Total radionuclide concentrations of one pCi per liter would extend about 20 meters (65 feet) below the repository, 40 meters (130 feet) above the repository, and about 1,900 meters (6,200 feet) laterally.

Analysis of undisturbed repository conditions (Cases 16 and 18) during the first 10,000 years showed that no radionuclides or heavy metals would be released to the Culebra Dolomite. No total radionuclide activity concentrations greater than 1 pCi per liter or heavy metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. There would be no release to the accessible environment and therefore no human health impact. Additional information is provided in Appendix H.

5.4.12.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions for Action Alternative 3.

Surface Release Caused by Drilling into the Repository

The human health impacts of drilling into the repository (Case 17 and Case 19) were evaluated for a drilling crew member and a well-site geologist. These individuals were assumed to be exposed to waste material brought to the land surface by drilling, as described in Section 5.1.12.2 and Appendix H. Under Action Alternative 3, 20 repository panels would hold both CH-TRU and

RH-TRU waste and 51 waste panels would hold only RH-TRU waste; therefore, a drilling event could contact CH-TRU, RH-TRU, or both CH-TRU and RH-TRU waste.

The estimated radionuclide releases to the ground surface from a drilling intrusion for Case 17 (median parameter values) would be 2.2, 0.1, and 2.3 Ci, respectively, for CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. For Case 19 (75th percentile parameter values), the estimated radionuclide releases would be 3.0, 0.15, and 3.0 Ci, respectively, for CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. The releases would be mainly of Pu-238, Pu-239 and Am-241 for all events. Heavy metal releases from these drilling intrusions would be 5, 22, and 18 kilograms (11, 49, and 39 pounds) from CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste for Case 17. For Case 19, the heavy metal releases would be 7, 30, and 23 kilograms (15, 65, and 52 pounds) from CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. Additional information is provided in Appendix H.

The radiological impacts to a drilling crew member for Case 17 (median parameter values) would be a 1×10^{-4}, 7×10^{-6}, and 1×10^{-4} probability of an LCF, respectively, from CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. For Case 19 (75th percentile parameter values), the probability of an LCF would be a 3×10^{-4}, 1×10^{-5}, and 3×10^{-4} probability of an LCF for the same respective panel types. Most of the impact would be due to the inadvertent ingestion of drill cuttings (ranging from 83 percent to about 96 percent), with less impact from external radiation dose. Americium-241 would be the major dose contributor. Ingestion of heavy metals under this scenario would result in a 1.5×10^{-8}, 1.0×10^{-9}, and 1.5×10^{-8} probability of cancer incidence, respectively, for intrusions into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. There would be no noncarcinogenic impacts expected from ingestion of the metals becaues all hazard indices would be much less than one. Impacts of exposure to VOCs were not analyzed (see Appendix H), but were expected to be bounded by impacts of VOC exposure under WIPP disposal accidents (see Appendix G). There would be a 2×10^{-7} probability of a cancer incidence. Some short-term toxicological effects from inhalation of VOCs could occur under these assumptions (see Appendix G).

Radiological impacts to the well-site geologist from external radiation exposure for Case 17 (median parameter values) would be a 2×10^{-9} probability of an LCF from CH-TRU waste and a 1×10^{-9} probability of an LCF from RH-TRU waste. For Case 19 (75th percentile parameter values), the radiological impacts would be a 2×10^{-9} probability of an LCF from CH-TRU waste and a 4×10^{-9} probability of an LCF from RH-TRU waste. Am-241 and U-234 were major external dose contributors in CH-TRU and RH-TRU waste for Case 17 and in CH-TRU waste for Case 19, while Sr-90 and Cs-137 were the major external dose contributors in RH-TRU waste for Case 19.

Drilling through the Repository into a Pressurized Brine Reservoir

Impacts of drilling through the repository into a pressurized brine reservoir were analyzed as described in Section 5.1.12.2 and in Appendix H, using information specific to Action Alternative 3 where appropriate. Analysis of radionuclide and heavy metal migration for this scenario 10,000 years after closure for Case 17 (median parameter values) showed there would be no radionuclide or heavy metal releases into the Culebra Dolomite or the accessible environment.

The extent of radionuclide (predominantly Pu-238, Pu-239, and Am-241) migration for disturbed conditions at 10,000 years after closure for Case 19 (75th percentile parameters values) were very similar to the results of Case 9 (also 75th percentile parameter values) for Action Alternative 1 and are presented schematically in Figure 5-4. Total radionuclide activity concentrations of one pCi per liter are shown. Simulations showed radionuclides migrated upward and downward into the borehole and penetrated into rocks directly in contact with the borehole for a limited distance. For Case 19 only (not Case 17), migration extends upward into the Culebra Dolomite at 10,000 years. Migration also extends downward in the borehole (for both Cases 17 and 19) to the Castile Formation and into the brine reservoir. This would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole. A total heavy metal concentration of one part per billion (1×10^{-3} milligrams per cubic meter) showed approximately the same extent of migration from the repository as the one pCi per liter level of total radionuclide activity concentration in Figure 5-4. Predicted brine pressures and additional modeling information is provided in Appendix H.

Impacts of radionuclide and heavy metal migration to the accessible environment were evaluated for Case 19 (75th percentile parameter values) since a release of contaminants into the Culebra Dolomite was indicated for this case only. The exposure scenario was the same as that evaluated for the Proposed Action and other action alternatives, for an individual consuming beef from cattle using the water from a stock well 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions since calculated impacts for full mining conditions were significantly lower (see Section H.8.2). Radiological impacts would be negligible, with a 2×10^{-27} probability of an LCF. The dominant dose contributor was Pu-239. Ingestion of heavy metals from consumption of contaminated beef was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-25}. No noncarcinogenic impacts would be expected. Additional information is presented in Appendix H.

5.4.13 Reducing WIPP Operations for Action Alternative 3

As noted in Chapter 3, stakeholders requested that the Department discuss in greater detail the changes to impacts should the Department reduce the period of operations for WIPP under Action Alternative 3. The period of operations is 190 years, but it could be reduced to 75 years by constructing an additional waste handling building for RH-TRU waste, constructing four new shafts, and tripling the number of excavation and emplacement crews. Additional costs would total $80 million in capital costs and $165 million in annual operating costs.

No additional impacts would be expected at treatment facilities because the facilities and their periods of operation would be identical to those discussed earlier.

The time to ship to WIPP from the treatment facilities would decrease from 190 years to 63 years. The aggregate nonradiological impacts would be the same as those described earlier, except that they would occur within the shorter time period. The accident-free radiological impacts to occupational and nonoccupational populations were reported as aggregate impacts over the entire shipping campaign; therefore, no increase in impacts would be noted. However, because the MEI would be exposed to more shipments, the estimated exposure to the MEI would be three times higher. All accident impacts would be identical to those described earlier.

Because the size of the WIPP underground facility would remain the same, and because the new facility would be constructed within the footprint of the repository, land use, biological resource,

and cultural resource impacts would be similar to those described earlier in this section. Construction of the new waste handling building would increase the air quality impacts slightly for the period of construction. Other air quality impacts would be negligible. Noise impacts would triple because the rate of shipments through Carlsbad would triple. Water quality and infrastructure impacts may be impacted by the new facilities and additional work crews.

Human health impacts would decrease for lag storage. The impacts to the public, noninvolved workers, and involved workers over the entire operations period would remain the same, but they would be compressed into about one-third of the time. Impacts to the MEIs would triple because the waste emplaced during a lifetime would triple. Industrial safety impacts would decrease by approximately 50 percent, considering the shorter operations period, construction of facilities, and an increase in the number of workers. There would be no change in long-term performance assessment results.

The greatest change in Action Alternative 3 results would be in life-cycle costs, which would drop from $59.67 billion in 1994 dollars ($18.03 billion discounted) to $43.02 billion ($13.30 billion discounted) should only trucks be used. Life-cycle costs should regular rail transportation be used would decrease from $55.17 billion ($17.42 billion discounted) to $38.52 billion ($11.91 billion discounted), and life-cycle costs should dedicated rail transportation be used would decrease from $68.52 billion ($19.21 billion discounted) to $51.87 billion ($16.04 billion discounted).

5.5 IMPACTS OF NO ACTION ALTERNATIVE 1

This section describes the environmental impacts associated with the implementation of No Action Alternative 1. Two subalternatives are included, one similar to Action Alternative 2A and the other similar to Action Alternative 2B. Under this alternative, the Basic Inventory and the Additional Inventory (including the PCB-commingled waste) would be shipped to treatment sites for treatment using a thermal process, but no waste would be shipped to WIPP for disposal. Instead, under No Action Alternative 1A, waste would remain at six sites in aboveground, retrievable storage. These sites are Hanford, INEEL, LANL, SRS, RFETS, and ORNL. Under No Action Alternative 1B, waste would remain at four sites in aboveground, retrievable storage. These sites are Hanford, INEEL, SRS and ORNL. The total consolidated, pretreatment volume of waste to be treated under this alternative would be 313,000 cubic meters (11 million cubic feet) (see Tables 3-12 through 3-15). A detailed description of No Action Alternative 1 is given in Section 3.2.5.

5.5.1 Land Use and Management

Land use impacts due to treatment under No Action Alternatives 1A and 1B would be similar to those under the Proposed Action discussed in Section 5.1.1. The WM PEIS estimated that treatment facilities would not require more than 1 percent of the available land, and the Department would have a great deal of flexibility when determining the locations of such facilities (DOE 1997). The Department would be able to minimize impacts to on-site land use and would be able to avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate habitats, including flood plains, wetlands, known cultural resource areas, and the habitats of threatened or endangered species. Before the sites for the treatment facilities would be selected, site-wide or project level NEPA reviews would be conducted.

Land use requirements due to storing the waste for an indefinite period of time would probably increase the land use impacts at the treatment and storage sites. The storage facilities, though, are not likely to increase the amount of land needed for overall operations at these sites to more than 1 or 2 percent of that available. Land use needs for the storage facilities, therefore, are not likely to conflict with other planned activities or impact sensitive or inappropriate areas.

At WIPP, under No Action Alternatives 1A and 1B, decommissioning and closure would begin immediately. No surface marking system would be necessary because no waste would be disposed of underground. Decommissioning, therefore, would be less extensive than under the Proposed Action and Action Alternatives 1, 2A, 2B, 2C, and 3. Surface structures in the Property Protection Area would be dismantled and removed, and the existing salt pile would either be returned to the underground, sold, or disposed of. The disturbed areas, estimated not to exceed 20 hectares (50 acres), would be returned to pre-WIPP condition to the extent possible. The restrictions of the LWA would probably be lifted and the land returned to BLM.

5.5.2 Air Quality

Air quality impacts from TRU waste treatment at the sites would be similar to those presented for Action Alternatives 2A and 2B in Section 5.3.2. For No Action Alternative 1A, the levels of criteria pollutants exceeding 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be those for CO at the RFETS (24 percent) and PM_{10} at INEEL (10 percent) (See Appendix C for details) (DOE 1997). Under No Action Alternative 1B, the levels of criteria pollutants exceeding 10 percent would be PM_{10} at INEEL (10 percent). RFETS, LLNL, NTS, and ANL-E, are in nonattainment areas for some pollutants (See Appendix C for details) (DOE 1997). In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations.

Of hazardous or toxic air pollutant releases, only radionuclide releases could exceed 10 percent of the applicable regulatory standard. For No Action Alternative 1A, treatment-related radiological releases could reach 134 percent of the NESHAP standard at LANL. For No Action Alternative 1B, treatment-related releases could reach 10 percent at INEEL (DOE 1997). Postulated waste treatment-related releases above the regulatory standard would require mitigation measures, such as HEPA filters, to ensure they remained below the allowable limit.

At WIPP, potential air quality impacts due to decommissioning activities under No Action Alternatives 1A and 1B would be similar to those under the Proposed Action for decommissioning of the aboveground structures. There would be no construction of berms and permanent markers, so overall air quality impacts at WIPP would be less than for the Proposed Action. This alternative would also require building retrievable storage facilities at six DOE sites for the consolidation, treatment, and storage of TRU waste. Any impacts from construction of the storage facility would be from fugitive dust and equipment emissions. PM_{10} emissions may occur due to such construction; dust suppression would be used to limit these short-term impacts.

5.5.3 Biological Resources

The biological impacts at the treatment sites under No Action Alternatives 1A and 1B would be the same as those for Action Alternatives 2A and 2B. Construction and operation of the treatment and

storage facilities should not affect populations of nonsensitive plant and animal species. Terrestrial wildlife species probably would not be affected by airborne emissions nor by spills into aquatic environments due to traffic accidents (DOE 1997). Threatened and endangered species appear at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following appropriate Endangered Species Act consultation and site-wide or project-level NEPA review during which such impacts would be assessed and mitigated, if necessary. Critical habitats and the habitats of endangered, threatened, and proposed species would be avoided, and appropriate consultation, monitoring, and mitigation measures would be undertaken, as necessary.

At WIPP, No Action Alternatives 1A and 1B would entail beginning the immediate decommissioning of the site, including dismantling all aboveground structures and closing all shafts. No waste would be disposed of, so there would be no permanent aboveground marking of the underground waste disposal area. Only about 20 hectares (50 acres) would be disturbed. Therefore, decommissioning and closure at the WIPP site would have less potential impact than the Proposed Action.

5.5.4 Cultural Resources

At the treatment sites, cultural resource impacts would be the same for this alternative as for the Proposed Action. Construction and operation of TRU waste treatment and storage facilities could adversely affect cultural resources, but site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed. Appropriate Native American tribes would be consulted, if necessary. These surveys would be in conjunction with site-wide or project-specific NEPA reviews.

At WIPP, no impacts to known cultural resource properties are anticipated under this alternative.

5.5.5 Noise

The WM PEIS stated that treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially. Still, the WM PEIS states that some sensitive receptors may be affected. Assessment of these impacts would be conducted in site-wide or project-specific NEPA documents when the treatment facilities are proposed. Noise impacts due to transportation of waste to or from the treatment sites also was not evaluated in the WM PEIS. Overall, though, less transportation would be conducted under this alternative because no waste would leave the treatment sites for disposal at WIPP. The transportation noise impacts, therefore, would be negligible.

There would be no impacts from truck or rail transportation to WIPP because waste transportation activities to WIPP would not be initiated.

5.5.6 Water Resources and Infrastructure

Water resource and infrastructure impacts at the treatment and storage sites under No Action Alternatives 1A and 1B would be the same as under Action Alternatives 2A and 2B (See Section 5.3.6). During decommissioning at WIPP, there would be a decreasing need and use of water, power, and wastewater systems and a decreasing demand on-site transportation infrastructure. There would be no demand or use of these resources following decommissioning.

5.5.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for No Action Alternatives 1A and 1B are presented in the following subsections.

5.5.7.1 Life-Cycle Costs

Under No Action Alternatives 1A and 1B, WIPP would not receive waste. All waste volumes would remain indefinitely at the sites where treated. The CH-TRU waste portion of the waste inventory would be packaged every 20 years. Impacts from this packaging were evaluated over a 100-year period. No Action Alternatives 1A and 1B include the same waste treatment sites and the same waste volumes as those in Action Alternatives 2A and 2B. Cost for storage facilities are included with the cost of the treatment facilities. The WIPP site costs reflect a 10-year period of decommissioning. The waste transport costs reflect shipments between small sites and the treatment sites.

The transportation options include using trucks, regular rail, and dedicated rail services. Life-cycle costs for No Action Alternative 1A and 1B include additional costs of $700 million and $3.8 billion, respectively, to account for treatment to planning-basis WAC of waste to be shipped for treatment. These costs were based on dual treatment (WAC and thermal) of 34 percent and 18.4 percent, respectively, of the total waste volume. The total life-cycle cost of No Action Alternative 1A (shown in Table 5-74) vary slightly with mode of transportation: $30.28 billion ($17.09 billion when discounted) for truck, $30.24 billion ($17.07 billion when discounted) for regular-class rail service, and $30.46 billion ($17.19 billion when discounted) for dedicated-class rail service.

Table 5-74
Life-Cycle Costs for No Action Alternative 1A (in millions of 1994 dollars) [a]

Life-Cycle Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment and Storage Facilities	12,670	3,280	15,950	13,040	370	13,410	29,360	16,280
Transport by Truck	30	10	40	30	0	30	70	40
Transport by Regular Train	10	0	10	20	0	20	30	20
Transport by Dedicated Train	110	30	140	110	0	110	250	140
WIPP Decommissioning [b]	N/A	N/A	N/A	N/A	N/A	N/A	850	770
Total Life-Cycle Cost (Truck)	12,700	3,290	15,990	13,070	370	13,440	30,280	17,090
Total Life-Cycle Cost (Regular Rail)	12,680	3,280	15,960	13,060	370	13,430	30,240	17,070
Total Life-Cycle (Dedicated Rail)	12,780	3,310	16,090	13,150	370	13,520	30,460	17,190

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] The WIPP decommissioning cost of $850 million is applied to the total column only because it is not attributed to storage of CH-TRU or RH-TRU waste but must be considered in the life-cycle cost of the alternative.

N/A = Not Applicable

The total life-cycle costs of No Action Alternative 1B (shown in Table 5-75) vary slightly depending on the mode of transportation, ranging from $32.77 billion ($18.47 billion when discounted) for regular-class rail service to $33.79 billion ($19.04 billion when discounted) for dedicated-class rail service.

Table 5-75
Life-Cycle Costs for No Action Alternative 1B (in millions of 1994 dollars) [a]

Life-Cycle Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment and Storage Facilities	13,700	3,550	17,250	14,100	350	14,450	31,760	17,610
Transport by Truck	100	30	130	110	0	110	240	130
Transport by Regular Train	70	20	90	70	0	70	160	90
Transport by Dedicated Train	510	130	640	530	10	540	1,180	650
WIPP Decommissioning	N/A	N/A	N/A	N/A	N/A	N/A	850	770
Total Life-Cycle Cost (Truck)	13,800	3,580	17,380	14,210	350	14,560	32,850	18,520
Total Life-Cycle Cost (Regular Rail)	13,770	3,570	17,340	14,170	350	14,520	32,770	18,470
Total Life-Cycle Cost (Dedicated Rail)	14,210	3,680	17,890	14,630	350	14,990	33,790	19,040

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

N/A = Not Applicable

5.5.7.2 Economic Impacts

TRU waste treatment activities would support direct, indirect, and induced jobs. No Action Alternative 1A would support approximately 29,300 jobs in the ROIs of the six treatment sites (Hanford, INEEL, LANL, ORNL, RFETS, and SRS). No Action Alternative 1B would support approximately 29,800 jobs in the ROIs of four treatment sites (Hanford, INEEL, ORNL, and SRS).

Estimates of the impacts of No Action Alternative 1 on employment, income, and the production of goods and services within the WIPP ROI are presented in Table 5-76. These regional impacts are estimated on the basis of a constant declining operating budget over a 10-year decommissioning period (from 1998 to 2008). Over this 10-year period, direct employment at the WIPP facility would be reduced at an annual rate of 10 percent of the 1998 employment level of 1,095 workers, or 110 workers per year. Accordingly, the WIPP site would employ about half its present work force by the year 2003. It is possible, however, that a more aggressive (front-loaded) downsizing could result in equivalent job losses within a two-year period, assuming an exponentially declining WIPP budget. Compared to WIPP operations levels assumed for all action alternatives, approximately 3,500 jobs (1,095 direct and 2,443 indirect) could be lost in the WIPP ROI, over a period of about 10 years. The accompanying annual reduction in labor income and output of goods and services in the ROI could be $126 million and $317 million, respectively, from those which could occur were waste disposal operations to take place. These impacts would be concentrated in the Carlsbad area of the ROI.

Table 5-76
Economic Impacts Within the WIPP ROI for No Action Alternative 1

Economic Effects	Total Output of Goods and Services (in millions of 1994 dollars)	Total Employment and Part-Time Jobs	Total Labor Income (in millions of 1994 dollars)	Carlsbad Output of Goods and Services (in millions of 1994 dollars)	Carlsbad Employment (Full- and Part-Time Jobs)	Carlsbad Labor Income (in millions of 1994 dollars)
Direct – Average Annual	51	493	23	43	441	21
Indirect & Induced – Average Annual	92	1,099	34	77	983	30
Total – Average Annual	143	1,592	57	120	1,424	51
Total – Operations (10 years)	1,427	15,921 [a]	572	1,202	14,238 [a]	509

[a] Job-years (number of annual jobs supported multiplied by the number of years in the project).

5.5.8 Transportation

The transportation impacts presented in this section for No Action Alternatives 1A and 1B are the impacts due to transporting the waste to the treatment sites (details are included in Appendix E).

5.5.8.1 Route Characteristics and Shipment Projections

The number of shipments was estimated to be 538 and 8,466 CH-TRU waste shipments for No Action Alternatives 1A and 1B, respectively. The number of RH-TRU waste shipments were estimated to be 8,254 for both No Action Alternatives 1A and 1B. The methods used to estimate the number of shipments were the same as those presented in Section 5.1.8.1. The total estimated one-way mileage for consolidation of TRU waste under No Action Alternatives 1A and 1B is presented in Table 5-77.

Table 5-77
One-Way Waste Transportation Miles for No Action Alternative 1

Alternative	CH-TRU Waste	RH-TRU Waste	Total
No Action Alternative 1A	292,000	4,900,000	5,192,000
No Action Alternative 1B	8,545,000	4,900,000	13,445,000

5.5.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects

The population impacts for No Action Alternatives 1A and 1B are presented in Table 5-78. For No Action Alternative 1A, the total number of accidents, injuries, and fatalities over the entire shipping campaign were estimated to be 5, 4 and 0.3, respectively. Similarly, for No Action Alternative 1B, the accidents, injuries, and fatalities were estimated to be 13, 12, and 1, respectively. Also presented in Table 5-78 are the pollution-related health effects.

Table 5-78
Population Impacts from Truck Transportation for No Action Alternative 1

Category	No Action Alternative 1A	No Action Alternative 1B
Nonradiological Impacts		
Number of Accidents	5	13
Number of Injuries	4	12
Number of Fatalities	0.3	1
Pollution Health Effects (fatalities)	0.03	0.07
Accident-Free Radiological Impacts (LCFs)		
Occupational	0.02	0.07
Nonoccupational		
Stops	0.4	0.8
Sharing Route	0.02	0.05
Along Route	0.01	0.02
Nonoccupational (LCFs) - Total	0.4	0.9
Aggregate Radiological Population Impacts for Truck Transportation Accidents (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02

5.5.8.3 Accident-Free Radiological Impacts from Truck Transportation

The method used to calculate the accident-free radiological impacts under No Action Alternatives 1A and 1B was based on the consolidation of waste at the treatment sites. Table 5-78 presents a summary of the accident-free radiological impacts under No Action Alternatives 1A and 1B.

5.5.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first estimated impacts over the entire shipping campaign, and the second estimated impacts from four bounding case accidents. For the first analysis, the impacts were estimated based on the number of shipments and the eight accident severity categories presented in RADTRAN. For No Action Alternatives 1A and 1B, the radiological impacts from accidents summed over all shipments are presented in Table 5-78.

For the bounding case accidents, it was estimated that the impacts would be the same as those reported for truck transportation under the Proposed Action (see Section 5.1.8.4). The analyses were based on an assumption that only one TRUPACT-II or RH-72B would be breached in a bounding case accident. Though the waste would be treated thermally under No Action Alternatives 1A and 1B, the treatment would not occur until after the transportation.

5.5.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

As reported previously in Section 5.1.8.5, exposures to hazardous chemical releases from a severe truck transportation accident would present negligible impacts to the exposed population.

5.5.8.6 Impacts from Rail Transportation

Table 5-79 presents a summary of the transportation impacts for both regular and dedicated rail under No Action Alternatives 1A and 1B. The rail transportation impacts were estimated by adjusting the transportation impacts for truck shipments as described in Section 5.2.8.6 and Appendix E.

Table 5-79
Impacts of Rail Transportation for No Action Alternative 1

Impact Category	No Action Alternative 1A	No Action Alternative 1B
Aggregate Traffic Related Fatalities		
Regular Rail	0.2	0.5
Dedicated Rail	2.8	7
Aggregate Accident-Free Radiological Impacts (LCFs)		
Occupational	8.6E-4	3.7E-3
Nonoccupational		
Stops	0.05	0.09
Sharing Route	2.3E-4	4.6E-4
Along Route	0.02	0.04
Nonoccupational - Total	0.07	0.1
Aggregate Radiological Population Impacts for Rail Transportation Accidents (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02

Radiological accident impacts from shipping by rail summed over all shipments for No Action Alternatives 1A and 1B are presented in Table 5-79 along with traffic-related fatalities and accident-free radiological impacts.

The impacts from bounding case accidents were estimated to be the same as those reported for Action Alternative 1 rail accident analyses, where it was assumed that two TRUPACT-IIs or RH-72Bs would be breached in an accident. The greatest impact was found when a conservative inventory was assumed, 32 LCFs in the population and a 0.12 probability of an LCF to the MEI.

5.5.9 Human Health Impacts from Waste Treatment and Storage Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment and 100 years of managed storage under No Action Alternatives 1A and 1B. The estimates include the impacts from overpacking CH-TRU waste storage containers every 20 years. There would be no disposal of waste at WIPP under this alternative.

No Action Alternative 1 eliminates the risk from PCB-commingled TRU waste at the three sites known to store such waste: 242 cubic meters (8,550 cubic feet) at Hanford, 461 cubic meters (16,300 cubic feet) at INEEL, and 19 cubic meters (670 cubic feet) at Mound. Under No Action Alternative 1, PCBs in the waste would be destroyed during treatment.

Impacts from waste treatment were adjusted from those presented in the WM PEIS; a description of these adjustments is provided in Appendix B. Like Action Alternatives 2A and 2B, No Action Alternatives 1A and 1B include thermal treatment of the Total Inventory. The VOCs in the waste

would be destroyed during thermal treatment, and heavy metals would be immobilized. Therefore, no routine releases of hazardous chemicals would occur in the subsequent waste storage operations. Thermal treatment also concentrates the waste and radionuclides into a smaller, denser volume. Denser waste matrices tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts presented in this section.

5.5.9.1 Public

Impacts to the populations and to the MEIs under No Action Alternatives 1A and 1B are presented in this section; results are presented in Table 5-80. Impacts from waste treatment and managed storage operations are presented separately to show their relative impact contribution. Waste treatment and storage would take place at six DOE sites under No Action Alternative 1A and at four sites under No Action Alternative 1B. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites and all lag storage sites. The impacts to the MEIs from waste treatment and managed storage operations are presented for the highest individual waste treatment and storage sites. See Chapter 3 for additional information on where treatment and managed storage would occur under the subalternatives of No Action Alternative 1.

Waste Treatment

Radiological impacts to the public from waste treatment would be 2.4 and 2.3 LCFs under No Action Alternatives 1A and 1B, respectively. No cancer incidence would be expected in the total population from hazardous chemical exposure, with 3×10^{-7} cancers expected under both subalternatives. For radiological impacts, the MEI with the greatest impact would be at RFETS under No Action Alternative 1A (3×10^{-5} probability of an LCF) and at Hanford under No Action Alternative 1B (5×10^{-5} probability of an LCF). Impacts from hazardous chemicals in CH-TRU waste would not exceed a 2×10^{-11} probability of a cancer incidence at any site. No noncarcinogenic health effects are predicted. The maximum HIs for the MEI would be 2×10^{-8} (under No Action Alternative 1A) and 5×10^{-9} (under No Action Alternative 1B), and no health effect is predicted unless the HI is 1 or higher.

Long-Term Managed Storage

Only radiological impacts would result from long-term managed storage because VOCs would be removed by thermal treatment under No Action Alternative 1. No LCFs would be expected in the total population around the storage sites under any of the alternatives, with 1×10^{-3} and 7×10^{-4} LCFs expected under No Action Alternatives 1A and 1B, respectively. The MEI with the greatest impact would be at LANL for No Action Alternative 1A (2×10^{-7} probability of an LCF) and at ORNL for No Action Alternative 1B (2×10^{-9} probability of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

Table 5-80
Lifetime Human Health Impacts to the Public from Waste Treatment and Storage Operations for No Action Alternatives 1A and 1B

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemicals (Cancer Incidence)
MEI [b, c]				
Basic Inventory				
1A CH-TRU Waste	3E-5 (R)	3E-13 (L)	2E-7 (L)	0
1B CH-TRU Waste	2E-5 (H)	3E-13 (I)	5E-9 (S)	0
RH-TRU Waste	4E-7 (O)	1E-11 (O)	1E-9 (O)	0
1A Total Waste	3E-5 (R)	1E-11 (O)	2E-7 (L)	0
1B Total Waste	2E-5 (H)	1E-11 (O)	5E-9 (S)	0
Total Inventory				
1A CH-TRU Waste	3E-5 (R)	5E-13 (I)	2E-7 (L)	0
1B CH-TRU Waste	5E-5 (H)	6E-13 (I)	1E-9 (S)	0
RH-TRU Waste	6E-7 (O)	2E-11 (O)	2E-9 (O)	0
1A Total Waste	3E-5 (R)	2E-11 (O)	2E-7 (L)	0
1B Total Waste	5E-5 (H)	2E-11 (O)	2E-9 (O)	0
Population [b]				
Basic Inventory				
1A CH-TRU Waste	2.2	5E-9	7E-4	0
1B CH-TRU Waste	1.1	2E-9	4E-4	0
RH-TRU Waste	0.02	2E-7	3E-5	0
1A Total Waste	2.2	2E-7	7E-4	0
1B Total Waste	1.1	2E-7	4E-4	0
Total Inventory				
1A CH-TRU Waste	2.3	9E-9	1E-3	0
1B CH-TRU Waste	2.3	4E-9	6E-4	0
RH-TRU Waste	0.02	3E-7	5E-5	0
1A Total Waste	2.4	3E-7	1E-3	0
1B Total Waste	2.3	3E-7	7E-4	0
Aggregate Total				
1A	2.4	3E-7	3E-3	0
1B	2.3	3E-7	2E-3	0

[a] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[b] The MEI and populations evaluated for treatment and storage operations impacts are different.
[c] H = Hanford, L = LANL, O = ORNL, R = RFETS, S = SRS, I = INEEL

The aggregate total indicated in Table 5-80 refers to the impacts to the public expected over a 100-year operational period under No Action Alternative 1. The estimates reflect the impacts under the management of the Total Inventory of CH- and RH-TRU waste. No LCFs (3×10^{-3} LCFs) would be expected over the several generations exposed to the small potential routine releases of radioactive materials under incident-free operations.

5.5.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under No Action Alternatives 1A and 1B are presented in this section; results are presented in Table 5-81. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, or handling of waste. Impacts from waste treatment and long-term managed storage are presented separately to show the relative contributions of these activities.

Noninvolved worker population impacts were estimated as the total for all treatment sites and all managed storage facilities. The impacts to the maximally exposed noninvolved worker from waste treatment and managed storage are presented for the highest individual waste treatment sites.

Table 5-81
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations for No Action Alternative 1

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker [b, c]				
Basic Inventory				
1A CH-TRU Waste	5E-5 (R)	1E-12 (I)	8E-7 (S)	0
1B CH-TRU Waste	7E-5 (H)	2E-12 (I)	8E-7 (S)	0
RH-TRU Waste	3E-7 (O)	6E-11 (O)	1E-8 (O)	0
1A Total Waste	5E-5 (R)	6E-11 (O)	8E-7 (S)	0
1B Total Waste	7E-5 (H)	6E-11 (O)	8E-7 (S)	0
Total Inventory				
1A CH-TRU Waste	5E-5 (R)	4E-12 (I)	1E-6 (S)	0
1B CH-TRU Waste	2E-4 (H)	4E-12 (I)	1E-6 (S)	0
RH-TRU Waste	5E-7 (O)	1E-10 (O)	2E-8 (O)	0
1A Total Waste	5E-5 (R)	1E-10 (O)	1E-6 (S)	0
1B Total Waste	2E-4 (H)	1E-10 (O)	1E-6 (S)	0
Population [b]				
Basic Inventory				
1A CH-TRU Waste	0.09	3E-9	0.02	0
1B CH-TRU Waste	0.06	2E-9	0.02	0
RH-TRU Waste	4E-4	7E-8	2E-4	0
1A Total Waste	0.09	7E-8	0.02	0
1B Total Waste	0.06	7E-8	0.02	0
Total Inventory				
1A CH-TRU Waste	0.1	7E-9	0.02	0
1B CH-TRU Waste	0.1	6E-9	0.02	0
RH-TRU Waste	6E-4	1E-7	2E-4	0
1A Total Waste	0.1	1E-7	0.02	0
1B Total Waste	0.1	1E-7	0.02	0
Aggregate Total				
1A	0.1	1E-7	0.06	0
1B	0.1	1E-7	0.06	0

[a] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] The MEI and populations evaluated for treatment and storage operations impacts are different.
[c] H = Hanford, I = INEEL, L = LANL, O = ORNL, R = RFETS, S = SRS

Waste Treatment

No radiation-related LCFs would be expected in the total noninvolved worker population at the waste treatment sites, with 0.1 LCFs under both subalternatives. No cancer incidence would be expected in the total noninvolved worker population from hazardous chemical exposure, with a 1×10^{-7} probability of a cancer incidence under both of the subalternatives. The maximally exposed noninvolved worker for radiological impacts would be at RFETS under No Action Alternative 1A (5×10^{-5} probability of an LCF) and at Hanford under No Action Alternative 1B (2×10^{-4} probability of an LCF). Impacts would not exceed a 1×10^{-10} probability of cancer incidence at any site. No noncarcinogenic health effects are predicted. The maximum HIs for the maximally exposed noninvolved worker would be 2×10^{-7} (under No Action Alternative 1A) and 1×10^{-7} (under No Action Alternative 1B), and no health effect is predicted unless the HI is 1 or higher.

Long-Term Managed Storage

Only radiological impacts would result from managed storage because VOCs would be removed by thermal treatment. No LCFs would be expected in the total noninvolved worker population during the 35-year working lifetime assumed for workers at the managed storage sites (0.02 LCFs would be expected under both subalternatives). The maximally exposed noninvolved worker would be at SRS for both subalternatives; a 1 x 10^{-6} probability of an LCF was calculated. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

The aggregate total indicated in Table 5-81 refers to the impacts to the noninvolved worker population expected over the 100-year operational period under No Action Alternative 1. The estimates reflect the impacts under the management of the Total Inventory of CH- and RH-TRU waste. No LCFs (0.06 LCFs) would be expected over the several generations exposed to the small potential routine releases of gaseous radionuclides under incident-free operations.

5.5.9.3 Involved Workers

Potential impacts to involved workers from waste treatment and storage operations are presented in Table 5-82. Up to 1.7 and 1.3 LCFs could occur in involved worker populations from radiation exposure during waste treatment under No Action Alternatives 1A or 1B, respectively. No cancer incidence would be expected to occur from hazardous chemical exposure (6 x 10^{-5} cancers for No Action Alternative 1A and 9 x 10^{-5} cancers for No Action Alternative 1B), and no noncarcinogenic health effects would occur (maximum exposure index of 6 x 10^{-3}).

No impacts from radiation exposure would be expected from waste storage during the 100-year storage period evaluated (≤0.4 LCF) under either subalternative. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-82
Lifetime Human Health Impacts to Involved Workers from Waste Treatment and Storage Operations for No Action Alternative 1 [a]

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)
Population				
Basic Inventory				
1A CH-TRU Waste	0.7	2E-5	0.09	0
1B CH-TRU Waste	0.5	4E-5	0.08	0
RH-TRU Waste	0.2	9E-6	≤0.09	0
1A Total Waste	0.9	3E-5	≤0.2	0
1B Total Waste	0.7	5E-5	≤0.2	0
Total Inventory				
1A CH-TRU Waste	1.4	5E-5	0.2	0
1B CH-TRU Waste	1.1	8E-5	0.2	0
RH-TRU Waste	0.3	1E-5	≤0.2	0
1A Total Waste	1.7	6E-5	≤0.4	0
1B Total Waste	1.3	9E-5	≤0.4	0
Aggregate Total				
1A	1.7	6E-5	≤1.1	0
1B	1.3	9E-5	≤1.1	0

[a] The workers considered for treatment impacts and storage impacts are different.

Different populations of involved workers would be involved in routine surveillance and monitoring activities and in waste overpacking operations. All sites were assumed to overpack 5 percent of the CH-TRU waste Total Inventory annually during the 100 years of storage evaluated. Each CH-TRU waste container would be overpacked every 20 years, although if this alternative were selected the Department would probably begin efforts to design longer lasting CH-TRU waste containers.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from storage activities were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years. The first 35 years of packaging operations would be the period of greatest potential impact because radioactive decay would reduce the radioactivity of the waste over time. Table 5-83 shows how potential annual radiological impacts to involved worker populations would decrease over the storage period because of radioactive decay.

Overpacking of RH-TRU waste containers was not considered during the 100-year storage period because of the greater RH-TRU waste container integrity. Impacts from RH-TRU waste storage would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Therefore, no specific RH-TRU waste storage impact estimates were made. Storage impacts under this alternative would be assessed in future site-wide or project-specific NEPA reviews.

The aggregate totals indicated in Table 5-82 refer to the impacts to the involved worker population expected over the 100-year operational period under No Action Alternatives 1A and 1B. Less than 1.1 LCFs would be expected in the several generations of involved workers exposed via external exposures from storage operations. The radiological impact estimates reflect the results of the aggregate impacts analyses presented in detail in Appendix F.

Table 5-83
Annual Involved Worker Population Impacts from CH-TRU Waste Overpacking Operations for No Action Alternatives 1A and 1B (LCFs)

Location	Worker Population	Years Since Operations Began					
		1	20	40	60	80	100
No Action Alternative 1A							
Hanford	14	9E-3	6E-3	4E-3	3E-3	2E-3	1E-3
INEEL	14	4E-3	3E-3	3E-3	3E-3	3E-3	3E-3
LANL	4	6E-4	6E-4	5E-4	5E-4	4E-4	4E-4
RFETS	1	3E-3	3E-3	2E-3	2E-3	2E-3	2E-3
SRS	2	1E-4	1E-4	1E-4	1E-4	9E-5	9E-5
No Action Alternative 1B							
Hanford	14	9E-3	6E-3	4E-3	3E-3	2E-3	1E-3
INEEL	19	7E-3	7E-3	6E-3	6E-3	6E-3	6E-3
SRS	2	1E-4	1E-4	1E-4	1E-4	9E-5	9E-5

5.5.10 Facility Accidents

This section describes potential impacts of facility accidents at the treatment sites from thermal treatment of waste and from indefinite waste storage after treatment under No Action Alternatives 1A and 1B. The difference between No Action Alternatives 1A and 1B is that no CH-TRU waste would be treated or stored at LANL and RFETS under No Action Alternative 1B. No waste would be disposed of under the two No Action Alternative 1 subalternatives; therefore, no WIPP disposal accidents were analyzed.

5.5.10.1 Waste Treatment Accidents

The impacts of waste treatment accidents under both No Action Alternative 1 subalternatives would be the same as those under Action Alternatives 2A and 2B (see Section 5.3.10.1). In both cases, the waste would be treated thermally at the same sites.

5.5.10.2 Waste Storage Accidents

Potential facility accident impacts under both No Action Alternative 1 subalternatives would be very similar to those presented in Section 5.3.10.2 for Action Alternatives 2A and 2B because stored waste would have been thermally treated. Because WIPP would not be an indefinite storage site under either No Action Alternative 1 subalternative some of the maximum values reported for the MEI in Section 5.3.10.2 would change. These differences are as follows:

- The maximum radiological impacts to the MEI from the drum puncture accident (Accident Scenario S1) would occur at LANL with an 8×10^{-9} probability of an LCF. Maximum impacts from the earthquake or other natural event (Accident Scenario S3) would also be at LANL, with a 4×10^{-3} probability of an LCF.

- The maximum heavy metal carcinogenic impacts to the MEI from the drum puncture accident (Accident Scenario S1) would occur at LANL, with a 1×10^{-16} probability of cancer. The maximum heavy metal carcinogenic impacts to the MEI from the earthquake or other natural event (Accident Scenario S3) would occur at Hanford, with a 1×10^{-9} probability of cancer.

Additional accident analysis information is presented in Appendix G.

As waste would be maintained in storage over long periods of time, the accident risk would be expected to change. Radioactive decay would reduce the amount of radioactivity in the waste. Impacts from a drum puncture (Accident Scenario S1) would be expected to decrease because of reduced radioactivity and overpacking reducing the potential amount of particulates spilled from the waste container in the event of a breach. Impacts from an earthquake (Accident Scenario S3) may decrease because of overpacking or may remain stable because of deterioration of the waste form over time. The deterioration may result in an increase in the amount of particulates released in the event that containers are breached.

5.5.11 Industrial Safety

Nine and seven fatalities would occur from industrial accidents during waste treatment at all treatment sites under No Action Alternatives 1A and 1B, respectively. These estimates were adjusted from the physical-hazard fatality estimates of the WM PEIS.

Under No Action Alternatives 1A and 1B, industrial safety impacts could occur as a result of decommissioning the WIPP site and from constructing and operating long-term TRU waste storage facilities at the treatment sites. Results are presented in Table 5-84. WIPP decommissioning activities would be the same as those discussed under the Proposed Action, except that activities would begin in 1998. In all likelihood, the initial work force would be smaller and the decommissioning period shorter, resulting in fewer injuries and illnesses. No fatalities would be projected.

Table 5-84
Industrial Safety Impacts from WIPP Decommissioning and Site Storage for No Action Alternative 1

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
WIPP Decommissioning 1998-2008	187	96	283	0.3	0.1	0.4
Indefinite Storage at Sites (packaging and monitoring for 100-year period)	124	213	337	0.2	0.2	0.4

Long-term storage impacts were evaluated for a 100-year period. It was assumed that CH-TRU waste storage facilities would be constructed. Waste would be moved to new facilities every 50 years. RH-TRU waste storage facilities would necessarily be more robust to provide therequired shielding and would be constructed only once during the period and would last 100 years. CH-TRU waste would be repackaged every 20 years (5 percent per year), while RH-TRU waste, stored in drums inside welded steel canisters, would not be repackaged during the 100-year period. Each year approximately 20 percent of the CH-TRU waste and 5 percent of the RH-TRU waste would be monitored in a manner requiring worker attention to individual containers (e.g., smearing the exterior of containers for contamination and checking lid seals or welds). These activities would be accomplished remotely for RH-TRU waste. No fatalities would occur during the 100-year storage period.

5.5.12 Long-Term Performance

Under No Action Alternatives 1A and 1B, TRU waste would continue to be generated and put into monitored, retrievable storage. There would be no shipment of waste to WIPP, and no long-term radiological or hazardous chemical impacts to the environment or human health would occur at the WIPP site. DOE would indefinitely maintain institutional control and provide long-term monitoring and maintenance of storage facilities. As a consequence, adverse health effects for the general public while DOE maintained control would be minimal, and the principal adverse effects, which also would be small, would be related to occupational activity at the facility. Health effects would continue at such levels for the indefinite future.

The Department realizes that loss of institutional control is a possibility for any long-term storage alternative. Therefore, an analysis of the potential impacts from long-term environmental release under No Action Alternative 1A and 1B was conducted. The analysis was similar to that presented in Appendix I for No Action Alternative 2; however, the waste form generated by the thermal treatment process would substantially reduce those potential impacts. Radionuclides and heavy

metals would be incorporated into a more dense and durable waste form that would limit the release of waste into the accessible environment. It was assumed that the glass waste form uniformly reduced the infiltration release rate by a factor of 1×10^{-4}. This factor is based on studies conducted on the dissolution rate of glass waste forms and their effect on contaminant releases to the environment. VOCs would be removed in the treatment process and would not be present in emplaced waste. Once waste containers degrade, direct release from a thermally-treated waste form (e.g., metal slag or glass) would depend on the rate of corrosion and dissolution of metal or glass and natural forces responsible for erosion rather than leaching.

No radiological or hazardous chemical impacts to individuals or populations would be expected over 10,000 years. The number of aggregate LCFs for all sites over 10,000 years was estimated to be less than 8×10^{-4} LCFs for No Action Alternative 1A and 3×10^{-4} LCFs for No Action Alternative 1B for the Total Inventory. [1]

5.6 IMPACTS OF NO ACTION ALTERNATIVE 2

This section describes the environmental impacts associated with the implementation of No Action Alternative 2. If No Action Alternative 2 were implemented, WIPP would be closed, newly generated waste would be treated to planning-basis WAC, all other waste would be left as is, and all of the waste would remain at the sites where it is currently located or would be generated. A detailed description of No Action Alternative 2 is presented in Section 3.2.6.

5.6.1 Land Use and Management

Construction of treatment facilities under this alternative would be minimal. Only newly generated waste would be treated. All other waste would continue to be stored as it has been to date. Therefore, minimal land use impacts would be expected.

At WIPP, land use impacts under No Action Alternative 2 would be similar to those for WIPP under No Action Alternative 1, discussed in Section 5.5.1.

5.6.2 Air Quality

Very limited treatment would be done under No Action Alternative 2. Only newly generated waste would be treated. All other waste would be left as it has been stored to date. Also, any treatment conducted would be to planning-basis WAC; no thermal or shred and grout treatment would be conducted. For TRU waste treatment, the only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be CO at RFETS (17 percent). No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard during normal accident-free treatment (DOE 1997). At WIPP, potential air quality impacts due to decommissioning activities under No Action Alternative 2 would be similar to those under No Action Alternative 1 described in Section 5.5.2.

5.6.3 Biological Resources

Because very limited treatment would be done under No Action Alternative 2 and because current storage facilities would be used, minimal biological impacts would be expected due to construction

[1] People who might intrude upon the stored waste could receive radiation doses that would greatly exceed current regulatory limits.

and operation of treatment and storage facilities. Potential impacts on biological resources at WIPP under No Action Alternative 2 would be similar to those under No Action Alternatives 1A and 1B, described in Section 5.5.3.

5.6.4 Cultural Resources

Because very limited treatment would be done under this alternative, minimal cultural resource impacts, if any, would be expected. Also, no potential cultural resources impacts at WIPP would be expected under this alternative.

5.6.5 Noise

Potential noise impacts under No Action Alternative 2 would be negligible. No waste would be transported and only newly generated waste would be treated.

5.6.6 Water Resources and Infrastructure

Under No Action Alternative 2 there would be minimal incremental infrastructure impacts from water, wastewater, and power usage due to treatment to planning-basis WAC and storage. During decommissioning at WIPP, there would be a decreasing need and use of water, power, and wastewater systems and on-site transportation infrastructure. There would be no demand or use of these resources following decommissioning.

5.6.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for No Action Alternative 2 are presented in the following subsections.

5.6.7.1 Life-Cycle Costs

The life-cycle costs of No Action Alternative 2 are reported in Table 5-85. Under No Action Alternative 2, WIPP would not be used as a waste disposal site. Closure of the WIPP site would follow a 10-year period of decommissioning, beginning in 1998 and ending in 2008. There would be no waste transportation under No Action Alternative 2. Waste generator sites would treat and store CH-TRU and RH-TRU waste inventories for 35 years. Waste treatment operations at these sites cover only newly generated waste. Current waste management practices would continue. The total life-cycle costs of the No Action Alternative 2 would be $2.49 billion ($1.68 billion when discounted), reflecting life-cycle costs at the treatment sites and decommissioning costs at the WIPP site.

5.6.7.2 Economic Impacts

TRU waste treatment activities would support direct, indirect, and induced jobs. Under No Action Alternative 2, only the newly generated defense waste would be treated, and approximately 2,300 jobs would be supported throughout the ROIs of the ten major generator sites (ANL-E, Hanford, INEEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS).

The economic impacts at the WIPP site would be the same as those for No Action Alternatives 1A and 1B, presented in Section 5.5.7.2.

Table 5-85
Life-Cycle Costs for No Action Alternative 2 (in millions of 1994 dollars) [a]

Cost Information	Basic Inventory			Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment of Newly Generated Waste	880	380	1,260	700
Storage of all Waste	270	110	380	210
WIPP Decommissioning [b]	N/A	N/A	850	770
Total Life-Cycle Cost	1,150	490	2,490	1,680

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] The WIPP decommissioning cost of $850 million is applied to the total column only because it is not attributed to either CH-TRU or RH-TRU waste at the storage sites but must be considered in the life-cycle cost of this alternative.

N/A = Not Applicable

5.6.8 Transportation

No waste would be transported under No Action Alternative 2, so there would be no transportation impacts.

5.6.9 Human Health Impacts from Waste Treatment and Management Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from treatment of newly generated TRU waste to meet the planning-basis WAC and from continuation of current waste management practices (aboveground waste storage) under No Action Alternative 2. There would be no disposal of waste at WIPP under this alternative. Impacts from waste treatment were adjusted from those presented in the WM PEIS. A description of these adjustments is provided in Appendix B.

5.6.9.1 Public

Impacts to the populations and to the MEIs under No Action Alternative 2 are presented in this section; results are presented in Table 5-86. Impacts from treatment of newly generated waste and continued waste management/storage operations are presented separately to show their relative contribution to the total impact. Waste treatment and management/storage would take place at multiple DOE sites. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites and all management/storage sites. The impacts to the MEIs from waste treatment and waste management/storage operations are presented for the highest individual sites. See Chapter 3 for additional information on where treatment and management/storage would occur under No Action Alternative 2.

Waste Treatment

No LCFs (1×10^{-3} LCF) or cancer incidence (4×10^{-7} cancers) would be expected in the total population around the waste treatment sites. The MEI with the greatest impact would be at LANL for radiological impacts (8×10^{-8} probability of an LCF) and at ORNL for hazardous chemical impacts (2×10^{-11} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the MEI would be 8×10^{-11}, and no health effect is predicted unless the HI is 1 or higher.

Table 5-86
Lifetime Human Health Impacts to the Public
from Waste Treatment and Storage Operations Under No Action Alternative 2

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)
MEI [b, c]				
Basic Inventory				
CH-TRU Waste	8E-8 (L)	2E-12 (X)	2E-6 (O)	4E-8 (L)
RH-TRU Waste	1E-10 (L)	2E-11 (O)	2E-9 (O)	2E-8 (O)
Total Waste	8E-8 (L)	2E-11 (O)	2E-6 (O)	4E-8 (L)
Population [b]				
Basic Inventory				
CH-TRU Waste	1E-3	7E-8	0.01	2E-3
RH-TRU Waste	1E-6	4E-7	3E-5	3E-4
Total Waste	1E-3	4E-7	0.01	2E-3
Aggregate Total	1E-3	4E-7	0.01	2E-3

[a] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[b] The MEI and populations considered for treatment impacts and storage impacts are different.
[c] L = LANL, O = ORNL, X = LLNL

Continued Management/Storage

No LCFs would be expected in the total population around the lag storage sites (1×10^{-2} LCF); no cancer incidence (2×10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI with the greatest impact would be at ORNL for radiological impacts (2×10^{-6} probability of an LCF) and at LANL for hazardous chemical impacts (4×10^{-8} probability of a cancer incidence). No noncarcinogenic health effects would occur. The maximum HI for any MEI would be 4×10^{-4}.

The aggregate total indicated in Table 5-86 refers to the impacts to the public expected over the 100-year operational period under No Action Alternative 2. The estimates reflect the impacts under the management of the Total Inventory of CH- and RH-TRU waste. No LCFs (0.03 LCFs) or cancer incidence (6×10^{-3} cancers) would be expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous materials under incident-free operations.

5.6.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under No Action Alternative 2 are presented in this section; results are presented in Table 5-87. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, management, or storage of waste. Impacts from waste treatment and management/ storage are presented separately to show the relative impact contribution of these activities. Waste treatment and management/storage would take place at multiple DOE sites. Noninvolved worker population impacts were estimated as the total for all treatment sites and all management/storage sites. The impacts to the maximally exposed noninvolved worker from waste treatment and management/storage are presented for the highest individual waste treatment sites.

Table 5-87
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations Under No Action Alternative 2

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF) [a]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker [b, c]				
Basic Inventory				
CH-TRU Waste	4E-8 (L)	5E-12 (X)	8E-6 (O)	2E-7 (I)
RH-TRU Waste	5E-11 (L)	1E-10 (O)	3E-5 (O)	3E-8 (H)
Total Waste	4E-8 (L)	1E-10 (O)	4E-5 (O)	2E-7 (I)
Population [b]				
Basic Inventory				
CH-TRU Waste	8E-5	2E-8	0.04	4E-3
RH-TRU Waste	8E-8	1E-7	8E-5	5E-4
Total Waste	8E-5	1E-7	0.04	2E-3
Aggregate Total	8E-5	1E-7	0.04	2E-3

[a] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] The noninvolved workers considered for treatment impacts and operations impacts are different.
[c] H = Hanford, I = INEEL, L = LANL, O = ORNL, X = LLNL

Waste Treatment

No LCFs (8×10^{-5} LCF) or cancer incidence (1×10^{-7} cancers) would be expected in the total noninvolved worker population at the waste treatment sites. The maximally exposed noninvolved worker would be at LANL for radiological impacts (4×10^{-8} probability of an LCF) and at ORNL for hazardous chemical impacts (1×10^{-10} probability of a cancer incidence). No noncarcinogenic health effects are predicted. The maximum HI for the maximally exposed noninvolved worker would be 8×10^{-10}, and no health effect is predicted unless the HI is 1 or higher.

Continued Management/Storage

No LCFs would be expected in the total noninvolved worker population at the management/storage sites (4×10^{-2} LCF); no cancer incidence (2×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at ORNL for radiological impacts (4×10^{-5} probability of an LCF) and at INEEL for hazardous chemical impacts (2×10^{-7} probability of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for any maximally exposed noninvolved worker would be 1×10^{-3}.

The aggregate total indicated in Table 5-87 refers to the impacts to the noninvolved worker population expected over the 35-year operational period under No Action Alternative 2. No LCFs (0.1 LCFs) or cancer incidence (6×10^{-3} cancers) would be expected over the several generations that would be exposed to the small potential routine releases of radioactive or hazardous chemicals under incident-free operations.

5.6.9.3 Involved Workers

Potential impacts to involved workers from treatment of newly generated waste and storage operations under No Action Alternative 2 are presented in Table 5-88. No LCFs (0.4) would

occur in the total involved worker population from radiation exposure during waste treatment. No cancer (8×10^{-6} cancers) would be expected from hazardous chemical exposure, and no noncarcinogenic health effects would occur (maximum exposure index of 5×10^{-5}). Less than 1 radiation-related LCF, and less than 0.04 cancers from hazardous chemical exposure would be expected in the involved worker population from continued waste management and storage operations. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-88
Lifetime Human Health Impacts to Involved Workers from Waste Treatment and Storage Under No Action Alternative 2

Category	Waste Treatment Impacts		Storage Operations Impacts	
	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population				
Basic Inventory				
CH-TRU Waste	0.3	8E-7	0.5	0.02
RH-TRU Waste	0.02	7E-6	≤0.5	≤0.02
Total Waste	0.4	8E-6	≤1	≤0.04
Aggregate Total	0.4	8E-6	≤1	≤0.04

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from storage activities were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years. Impacts from RH-TRU waste storage would be less than those for CH-TRU waste storage because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste.

The aggregate total indicated in Table 5-88 refers to the impacts to the involved worker population at the storage sites expected over the 35-year period (for operations) under No Action Alternative 2. Storage worker population impact estimates indicate that less than 3 LCFs and less than 0.1 cancers are expected over the several generations of involved workers exposed externally or via inhalation of hazardous chemicals.

5.6.10 Facility Accidents

Very limited treatment of waste would occur under No Action Alternative 2. Only newly generated waste would be treated, and that waste would be treated only to the planning-basis WAC. Also, no consolidation of waste would occur. Storage would be continued for an indefinite period of time. No waste would be disposed of at WIPP. WIPP disposal accidents, therefore, were not assessed for this alternative.

5.6.10.1 Waste Treatment Accidents

The impacts of waste treatment accidents under No Action Alternative 2 would be the same as those under the Proposed Action (see Section 5.1.10.1) because the small portion of waste that would be treated, would be treated to planning-basis WAC.

5.6.10.2 Waste Storage Accidents

Potential storage accident impacts under No Action Alternative 2 would be similar to those presented in Section 5.2.10.2 for Action Alternative 1 because that waste that would be treated at all would be treated to planning-basis WAC prior to storage. For that portion of the No Action Alternative 2 waste that would not be treated to planning-basis WAC, accident frequencies and potential impacts could be somewhat higher than those presented in Section 5.2.10.2.

5.6.11 Industrial Safety

At the waste generator sites less than one fatality (0.7) would occur from industrial accidents under No Action Alternative 2 during waste treatment at all generator sites. This result was estimated by adjusting the physical-hazard fatality estimate of the WM PEIS.

Under No Action Alternative 2, industrial safety impacts could occur as a result of decommissioning the WIPP site and from continued management of TRU waste at the generator-storage sites. Estimated impacts are presented in Table 5-89. WIPP decommissioning activities were assumed to be the same as discussed under the Proposed Action except that activities would begin in 1998. In all likelihood, the initial work force would be smaller and the decommissioning period shorter, resulting in fewer injuries and illnesses. No fatalities would be projected. Current waste practices were assumed to continue at the generator-storage sites for the 35-year operations period. No industrial fatalities were projected from continued waste storage at the sites.

Table 5-89
Industrial Safety Impacts from WIPP Decommissioning and Site Waste Management Under No Action Alternative 2

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
WIPP Decommissioning 1998-2008	187	96	283	0.3	0.1	0.4
Waste at Sites 1998-2033	N/A	190	190	N/A	0.2	0.2

N/A = Not Applicable

5.6.12 Long-Term Performance

No Action Alternative 2 was included among those alternatives considered in the FEIS and SEIS-I. The FEIS and SEIS-I analyzed the environmental consequences of No Action Alternative 2 under several different assumptions and conditions. In general, it was estimated that if DOE would

provide effective monitoring and maintenance of storage facilities, adverse health effects for the general public would be quite small, and the principal adverse effects, also small, would be related to occupational activity at the facilities. These health effects would continue at such levels for the indefinite future under the hypothesis of DOE control.

However, if DOE were to lose institutional control of storage facilities, it was estimated that intruders could receive substantial radiation doses, a situation that could persist for the indefinite future. In addition, contaminants in TRU waste stored in shallow burial trenches and surface storage facilities would eventually be released and would persist in the surrounding environments at the treatment sites exposing on-site and off-site populations to chronic health impacts.

The ROD for the FEIS, published on January 28, 1981, determined as part of the basis for decision that the No Action Alternative was "unacceptable." This determination was made at the time because of the potential impacts of natural, low probability events and human intrusion at storage facilities after governmental control of the site is lost. In SEIS-I, a summary of the FEIS analysis was provided and the same conclusion was reached in its ROD, published on June 21, 1990.

The long-term impacts of continuing current TRU waste management practices and loss of institutional control were reexamined under No Action Alternative 2 for SEIS-II. The effect of human intrusion was reexamined because of the changed estimated volumes and inventories of future generated TRU waste (see Appendix A). This analysis also examined the long-term impacts

INTRUSION AT WIPP AND AT GENERATOR-STORAGE SITES

The intrusion scenarios and potential impacts for the WIPP repository evaluated under the Proposed Action and Action Alternatives 1, 2, and 3 are very different from those for the generator-storage sites evaluated under No Action Alternatives 1 and 2.

Intrusion into TRU waste at WIPP is limited by the repository's 655-meter (2,150-foot) depth below the surface and remote location. The most likely direct intrusion scenario is penetration of the repository by hydrocarbon drilling. DOE has estimated the most likely number of intrusions into WIPP to be 5, with a probability of about 0.17 over a 10,000-year evaluation period. A limited amount of waste would be brought to the surface (less than 1 cubic meter) and would impact only a few members of the public directly associated with the drilling activity. This scenario, evaluated in SEIS-II, showed only a slight risk to the MEI. WIPP intrusion could result in the possibility of contamination migrating from the repository to the accessible environment through the borehole. Indirect intrusion, such as a well drilled for stock water (water in the vicinity of WIPP is not suitable for drinking or irrigation), would result in very low impacts to people eating stock exposed to this water.

In contrast, waste in surface facilities or shallow-buried storage would be easily accessible in the event of loss of institutional control, under the no action alternatives. There are multiple DOE sites that currently store TRU waste, some near population centers. Direct intrusion could occur through such common mechanisms as basement or building excavation, road building, pipeline or utility emplacement, scavenging, and casual intrusion. Indirect intrusion into contamination dispersed by any of the above activities or natural processes could be by gardening or farming activities. SEIS-II has evaluated potential impacts of intrusion and release of material under the no action alternatives. Under No Action Alternative 1, people who might intrude upon stored waste could receive radiation doses that would greatly exceed current regulatory limits. For waste in unconsolidated waste forms, evaluated under No Action Alternative 2, long-term and repeated intrusion activities could result in thousands of radiation-related LCFs over a 10,000-year evaluation period.

of environmental releases of contaminants from stored TRU waste at the major generator-storage sites. No TRU waste would be transported to WIPP and current WIPP operations would cease after a short decommissioning period. Thus, no long-term radiological or hazardous chemical impacts to the environment or human health would occur at the WIPP site under this alternative.

This section provides a summary of long-term impacts from stored TRU waste at the major generator-storage sites for 10,000 years following the loss of institutional control. The analysis of human health impacts estimated the impacts of TRU waste as a source of direct exposure and as a contaminant source for release to surface and subsurface exposure points in the environment. Scenarios analyzed included exposure to waterborne and airborne releases of contaminants from waste stored in shallow earth-covered trenches or covered by earthen berms and to waste stored in exposed surface pads or in surface enclosures and buildings.

Impacts to human health from waste intrusion and long-term environmental release were estimated using methods outlined in Appendix I and in a technical supporting document (Buck et al. 1997). This analysis focused on the impacts of waste at seven of the 10 major sites because the majority (99 percent) of the waste is stored at these sites. Estimates for RH-TRU waste impacts were only made at sites storing RH-TRU waste which are Hanford, INEEL, LANL, and ORNL. For buried waste, no estimates of impacts were made for either CH-TRU or RH-TRU waste at LLNL and RFETS because neither of these sites currently store waste in buried configurations.

Exposure scenarios evaluated included acute exposures to intruders and chronic exposures to settlers. These exposures were assumed to occur at the site of the original waste storage location, with little dispersion of contamination prior to exposure. Exposure scenarios evaluated for buried waste included an acute exposure of a driller intruder and the chronic exposure of a gardener who was assumed to subsequently settle at the drilling site. Exposure scenarios evaluated for surface-stored waste included the acute exposure of a scavenger intruder and the chronic exposure of a farm family settling on the site of the former waste storage area.

Impacts were also evaluated for the long-term environmental release of stored waste over 10,000 years. Evaluated were scenarios for chronic exposure of a MEI and the population living within 80 kilometers (50 miles) of the former waste storage sites. This individual and population could be exposed from releases from both buried and surface-stored waste. The MEI was assumed to be located 300 meters (980 feet) away from the waste storage site, in the direction of groundwater flow. The distribution of the off-site populations were assumed to be characteristic of current populations around the sites.

Descriptions of these exposure scenarios for intruders and settlers and long-term environmental releases are provided in AppendixI.

Impacts of Exposure Scenarios

With the loss of institutional control, individuals could come into direct contact or be inadvertently exposed to waste that had been stored in shallow burial or surface storage facilities. The following sections describe the impacts that could result from exposure to radionuclides and hazardous chemicals in CH-TRU and RH-TRU waste for exposure scenarios, where individuals were assumed to be exposed at the original storage locations. Individuals were assumed to be exposed immediately after the loss of institutional control, minimizing reduction of impact through radioactive decay.

Impacts from Exposure to Buried Waste

The driller scenario is one where an individual was assumed to drill a well at the site of the waste storage locations and be exposed over a 5-day work week to waste material brought to the land surface by the drilling process.

Radiological impacts to a hypothetical driller exposed acutely for 5 days (1 work week) from CH-TRU waste would range from a 1×10^{-6} to 5×10^{-6} probability of an LCF for the five sites with buried CH-TRU waste. Impacts to the driller from RH-TRU waste would range from a 1×10^{-6} to 3×10^{-5} probability of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be INEEL and ORNL for CH-TRU waste and Hanford for RH-TRU waste. These results are presented in Table 5-90. Health impacts from hazardous chemicals would be significant. The RH-TRU waste concentration for lead could be up to 3,000 times the PEL.

The gardener scenario is one in which an individual was assumed to prepare a garden at the drilling site and grow produce in soil containing waste material brought to the surface by the drilling. This individual was assumed to ingest produce grown in the contaminated soil for a period of 30 years and be exposed while working in the garden.

Table 5-90
Radiological Impacts to Inadvertent Intruders Following Loss of Institutional Control for Seven Major Generator-Storage Sites (probability of an LCF)

	Hanford	INEEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Impacts							
Buried Waste							
Driller (acute)	1E-6	5E-6	N/A	2E-6	5E-6	N/A	4E-6
Gardener (chronic)	0.01	0.01	N/A	0.02	0.01	N/A	0.06
Surface Waste							
Scavenger (acute)	2E-03	2E-03	6E-04	3E-03	3E-03	0.02	0.01
Family Farm (chronic)	0.6	0.8	0.2	1	1	1	1
RH-TRU Waste Impacts							
Buried Waste							
Driller (acute)	3E-5	5E-6	N/A	1E-6	3E-6	N/A	N/A
Gardener (chronic)	0.04	9E-3	N/A	4E-3	7E-3	N/A	N/A
Surface Waste							
Scavenger (acute)	0.01	2E-03	N/A	7E-04	1E-03	N/A	N/A
Family Farm (chronic)	1	1	N/A	0.3	1	N/A	N/A

N/A = Not Applicable

Radiological impacts to a hypothetical gardener would range from a 0.01 to 0.06 probability of an LCF for the five sites with buried CH-TRU waste. Impacts to the gardener from RH-TRU waste would range from a 4×10^{-3} to 0.04 probability of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be SRS for CH-TRU waste and Hanford for RH-TRU waste. These results are also presented in Table 5-90. The hazard index for mercury and lead are 77 and 3,900, respectively, for the gardener for RH-TRU waste. The lead hazard index is 36 for CH-TRU waste.

Impacts from Exposure to Surface-Stored Waste

The scavenger scenario is one where an individual was assumed to come into direct contact with the TRU waste on the surface for a 24-hour period. This intruder was assumed to be exposed by inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil while at the site.

Radiological impacts to a hypothetical scavenger from CH-TRU waste would range from a 6×10^{-4} to 0.02 probability of an LCF; all seven sites would have surface-stored CH-TRU waste. Impacts to the scavenger from RH-TRU waste would range from a 7×10^{-4} to 0.01 probability of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be RFETS for CH-TRU waste and Hanford for RH-TRU waste. These results are presented in Table 5-90. Significant impacts would be seen from heavy metals. The concentration of heavy metals ranges from 5 times to 1,400 times the PEL for CH-TRU waste and up to 160,000 times the PEL for RH-TRU waste.

The farmer scenario is one in which a hypothetical framer lives and farms on a plot of land at the location of the surface-stored waste. The waste was assumed to have degraded to a point where it was indistinguishable from the surrounding land and soil. The maximally exposed farmer was assumed to be exposed by ingestion of contaminated food crops grown in the contaminated soil, inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil. Under this scenario, the members of the family would receive very high radiation doses in the first year of farming. The probability of an LCF would range from 0.2 to 1 for CH-TRU waste, with three of the seven sites evaluated having a probability of 1 in the first year. The probability of an LCF would range from 0.3 to 1 for RH-TRU waste, with 3 of 4 sites having a probability of 1. These results are presented in Table 5-90. Noncarcinogenic effects such as radiation pneumenitis in the lungs could also occur. Health impacts from hazardous chemicals would be significant as well. The hazard index ranges from 10 to 100,000 for CH-TRU waste and up to 5,200,000 for RH-TRU waste.

Impacts of Long-Term Environmental Release

For TRU waste stored in shallow burial trenches and surface storage facilities at generator-storage sites, contaminants would eventually be released to the surrounding environments after loss of institutional control. Contaminants within the buried or surface-stored waste would be leached and released to underlying soils and aquifer systems at depth. At most sites contaminants would eventually reach groundwater and migrate laterally to a downgradient receptor location. Contaminants might also eventually be discharged into nearby surface water bodies. Once in these surface-water systems, the public would be exposed to dilute concentrations of the contaminants in public water supplies.

Waste stored in surface facilities would also degrade and disperse contaminants in the environment by the processes of direct water and air erosion, deposition onto soils surrounding the site, and resuspension of contaminated soils in air. The surrounding populations would be exposed to these contaminants as they were redistributed into the environment by these cyclic and ongoing processes.

Radiological and chemical impacts were evaluated for MEIs and the populations surrounding seven major generator-storage sites (Hanford, INEEL, LANL, LLNL, ORNL, RFETS, and SRS).

Additional information is provided in Appendix I. Impacts to the MEI were evaluated for a groundwater exposure scenario and an air pathway exposure scenario. Under the groundwater exposure scenario, the MEI was assumed to be a member of a farm family living 300 meters (980 feet) downgradient of the waste storage areas at each of the sites. It was assumed that the family would engage in farming activities such as growing and consuming its own crops and livestock and would use contaminated groundwater as a source of drinking water and for watering the crops and animals. Under the air pathway exposure scenario the MEI was assumed to live at the point of maximum airborne contaminant concentration. This individual could be exposed via inhalation of resuspended contamination, ingestion of contaminated food crops grown in the contaminated soil, external exposure to the soil, and inadvertent ingestion of contaminated soil.

Impacts to off-site populations were also evaluated from long-term environmental releases to surface water and to air. For analyses of buried waste releases, all CH-TRU and RH-TRU waste was combined into a single waste disposal unit, and only the groundwater pathway was considered. For analyses of surface-stored waste releases, all CH-TRU and RH-TRU waste was combined into a single waste storage unit and was allowed to be released to all pathways.

Impacts to the MEIs for the maximum 70-year lifetime over 10,000 years of environmental release of contaminants are presented in Table 5-91 for the seven major generator-storage sites. Radiological impacts to the MEI would range from a 3×10^{-6} probability of an LCF at ORNL to a 4×10^{-3} probability of an LCF at INEEL. Carcinogenic hazardous chemical impacts to the MEI would range from a 1×10^{-7} probability of cancer incidence at LANL to a 5×10^{-3} probability of cancer incidence at INEEL. Noncarcinogenic hazardous chemical impacts were estimated using an HI and are presented in Table 5-92. No noncarcinogenic health effects would occur for an HI less than 1, and only at SRS, with an estimated HI of 2 for the MEI from ingestion of mercury in groundwater, would any noncarcinogenic impacts be expected.

Table 5-91
Maximum Lifetime MEI and Population Impacts
for Seven Major Generator-Storage Sites Under No Action Alternative 2

	Radiological Impacts		Chemical Carcinogenic Impacts	
Major Sites	**Lifetime LCF [a]**	**Dominant Pathway**	**Lifetime Cancer Incidence**	**Dominant Pathway**
MEI Impacts				
Hanford	1E-04	Inhalation	2E-06	Groundwater Ingestion
INEEL	4E-03	Groundwater Ingestion	5E-03	Groundwater Ingestion
LANL	5E-05	Inhalation	1E-07	Resuspended Soil Ingestion
LLNL	7E-06	Inhalation	5E-06	Groundwater Ingestion
ORNL	3E-06	Groundwater Ingestion	6E-07	Groundwater Ingestion
RFETS	2E-03	Inhalation	3E-07	Groundwater Ingestion
SRS	7E-04	Groundwater Ingestion	4E-04	Groundwater Ingestion
Population Impacts				
Hanford	7E-04	Resuspended Soil Ingestion	2E-06	Surface Water Ingestion
INEEL	0.07	Inhalation	3E-06	Resuspended Soil Ingestion
LANL	0.08	Inhalation	2E-04	Resuspended Soil Ingestion
LLNL	0.02	Inhalation	3E-07	Resuspended Soil Ingestion
ORNL	4E-05	Inhalation	3E-07	Surface Water Ingestion
RFETS	7.1	Inhalation	3E-04	Resuspended Soil Ingestion
SRS	0.09	Inhalation	6E-05	Surface Water Ingestion

[a] Probability of an LCF for the MEIs; number of LCFs for the populations.

Table 5-92
Noncarcinogenic Hazardous Chemical Impacts to MEIs at Seven Major Generator-Storage Sites for No Action Alternative 2

Major Generator/Storage Sites	HI [a]	Key Chemical	Dominant Pathway
Hanford	0.2	Mercury	Groundwater Ingestion
INEEL	0.3	Carbon Tetrachloride	Groundwater Ingestion
LANL	2E-03	Mercury	Resuspended Soil Ingestion
LLNL	5E-04	Carbon Tetrachloride	Resuspended Soil Ingestion
ORNL	3E-04	Mercury	Groundwater Ingestion
RFETS	6E-05	Lead	Inhalation
SRS	1.5	Mercury	Groundwater Ingestion

[a] No noncarcinogenic impacts would occur for an HI less than 1.

Impacts to populations for the maximum 70-year lifetime over 10,000 years of environmental release of contaminants are also presented in Table 5-91 for the seven major generator-storage sites. Exposures from the air and groundwater to surface water pathways were included.

Radiological impacts to populations would range from 4×10^{-5} LCFs at ORNL to 7.1 LCFs at RFETS. Carcinogenic hazardous chemical impacts would range from 1×10^{-7} cancers at LLNL to 3×10^{-4} cancers at RFETS.

The aggregate number of LCFs that could occur in off-site populations around the seven sites over 10,000 years (approximately 142 70-year lifetimes) from release of the No Action Alternative 2 inventory was estimated. The aggregate number of LCFs for all sites was estimated to be 794 LCFs, with 98 percent of the estimated LCFs (781) occurring in the population around RFETS. In addition to the impact from release of the No Action Alternative 2 inventory, the number of aggregate LCFs at the seven sites was estimated for the Additional Inventory of Action Alternative 1 (see Tables 3-2 and 3-3) which would also remain in place at the sites under the No Action Alternative 2. An additional 13 aggregate LCFs were estimated to occur from release of the Additional Inventory. Release of the combined inventories would result in about 800 LCFs. Estimates of site-specific and total aggregate LCFs are presented in Table 5-93. The aggregate hazardous chemical impact over 10,000 years was estimated to be about 0.002 cancers. These

Table 5-93
Aggregate LCFs over 10,000 Years for Seven Major Generator-Storage Sites After Loss of Institutional Control for No Action Alternative 2

Site	Aggregate LCFs from Basic Inventory	Aggregate LCFs from Additional Inventory	Aggregate LCFs from Combined Inventory
Hanford	0.01	0.01	0.02
INEEL	3.8	7.7	11.4
LANL	8.5	5.6	14.1
LLNL	0.4	0	0.4
ORNL	6E-04	3E-04	9E-04
RFETS	781	0	781
SRS	0.3	0.1	0.4
Total	**794**	**13**	**807**

impacts were estimated based on current population distributions. These distributions may change substantially, creating the potential for significant increases over these estimates of aggregate LCFs.

5.7 RETRIEVAL AND RECOVERY

Waste "retrieval," as defined by the WIPP LWA, is "the removal of TRU waste and the container in which it has been retained, and any material contaminated by such waste from the underground repository at WIPP." For the purposes of analyses, SEIS-II distinguishes between waste "retrieval" and waste "recovery." Retrieval is the removal of intact (unbreached) waste containers. Retrieval is presumed to occur prior to the closure of WIPP before salt reconsolidation (rock creep) begins to crush CH-TRU waste drums and standard waste boxes or RH-TRU waste canisters. Waste "recovery" assumes that the waste containers would be breached through the process of salt reconsolidation and would include the removal of waste, waste containers, and any material contaminated by such waste. The analysis of waste removal at some future time is based on the following general assumptions: (1) the reason for removing the waste would be known; (2) the transportation mode, destination, and end use would be known; (3) waste removal would be based on future available technologies and future regulations.

The consequence analysis presented in the following subsections is intended to bound the impacts that could occur in the unlikely event that waste would need to be removed from the WIPP repository. If one or more panels of waste were removed after the panels had been closed but prior to repository closure, the impacts of waste removal would be proportional to the number of panel equivalents removed. In general, worker impacts would increase in proportion to the number of waste containers that have been breached.

5.7.1 Waste Retrieval

The retrieval of waste from WIPP prior to closure would conceptually be the reverse of the initial disposal. Because the facility would not have been closed, it was assumed that (1) the surface facilities, equipment, and shafts would be intact and operational, (2) access to the waste would be available via the access tunnels, (3) panel rooms would not have collapsed, and (4) the waste containers would be unbreached and intact. For this analysis, it was assumed that one panel of waste (17,560 cubic meters [620,000 cubic feet]) would be removed. This is equal to 10 percent of the Basic Inventory, the total of which is proposed for disposal in ten panel equivalents. If more than one panel were retrieved, the impacts would be proportional to the number of panel equivalents retrieved.

5.7.1.1 Operational Impacts of Waste Retrieval

Operational impacts of retrieving CH-TRU and RH-TRU waste from one panel-equivalent would be essentially the same as the impacts of emplacing that waste. Approximately 40 workers would be involved with removing the waste from the panel on a daily basis for a period of 2 years. The worker-population dose for this operation would not exceed 80 person-rem, based on WIPP administrative limits of 1 rem total effective dose equivalent (TEDE) per year, and would probably be much smaller. The number of LCFs in the worker population from this exposure would be about 0.03. The potential of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 5×10^{-6}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected.

Impacts to the public and to noninvolved workers would be expected to be smaller, by at least an order of magnitude, than the values for WIPP operations under the Proposed Action (Tables 5-11 and 5-12). The estimated number of LCFs in the general population from radiation exposure was 3×10^{-5}, while cancer incidence from hazardous chemical exposure was about 2×10^{-6}. The MEI would have a 3×10^{-8} probability of an LCF from radiation exposure and about a 3×10^{-9} probability of a cancer incidence. The noninvolved worker population would have an estimated 4×10^{-5} LCF from radiation exposure and cancer incidence from hazardous chemical exposure would be about 1×10^{-5}. The maximally exposed noninvolved worker would have a 5×10^{-7} probability of an LCF from radiation exposure, and about a 1×10^{-8} probability of a cancer incidence. No noncarcinogenic health effects would be expected, with HIs not exceeding those under the Proposed Action and no larger than 6×10^{-5}.

5.7.1.2 Transportation Impacts of Waste Retrieval

Transportation impacts from the retrieval of one panel of waste would be the same for transporting the waste to WIPP for disposal. The impact of transporting waste is primarily based on the number of shipments required and the shipping destination distances. Because the amount of waste would be the same as originally disposed of, and the waste would be shipped back to the origination site, the number of shipments and shipping destinations would be the same, making the transportation impact the same. The estimated impacts of transporting one panel of TRU waste removed from WIPP to the waste origination site would be less than one vehicle-related fatality and less than one nonoccupational LCF (see Appendix E).

5.7.2 Waste Recovery

Recovery of waste from WIPP could occur during operations or after closure. Recovery after closure would require the sinking of new shafts and the excavation of new drifts. For this analysis it was assumed that standard mining techniques would be used until excessive contamination or radiation fields are encountered. In contaminated areas, currently available remote-controlled excavation equipment or equipment modified with off-the-shelf systems may be used. Where practical, waste removal operations and support operations, such as radiation and air quality monitoring, and geotechnical surveying, would be performed remotely. Contaminated and uncontaminated equipment and materials would be segregated, and maintenance operations would use separate ventilation systems.

Excavated waste materials would be placed in appropriately designed waste containers. The surfaces of the containers would be decontaminated, if necessary, prior to being transported aboveground. Aboveground facilities would include a control center where all remote operations would be coordinated and a decontamination area where waste containers would undergo additional decontamination if necessary. The waste containers would be staged aboveground for transportation to a pre-determined location or end use. A control center in the underground would provide the interface between the aboveground control center and underground operational activities.

The excavation and waste removal operations would be designed to reduce the amount of contamination and radiation exposure, and to allow limited human access for assessments, equipment retrieval, and equipment repairs. Operations would be designed to reduce direct human involvement to the extent practicable. Radiological work would be performed using standard industry practices and approved procedures.

Standard mining equipment would be used to sink the shafts and to excavate the drifts and support rooms. After the underground support areas have been completed, the waste would be removed. Reduced scale mining equipment would be used to remove the waste. A reduction in scale would enable the vehicles and supporting equipment to be remotely controlled and to handle waste materials not usually associated with mining activities. The CH-TRU and RH-TRU waste would be retrieved in separate operations. The RH-TRU waste would be removed as intact as possible. Because the RH-TRU waste poses a greater external radiation hazard, RH-TRU waste removal activities would require more rigorous measures to limit personnel exposure.

It is anticipated that a long time period would be needed to complete the removal of waste, but no time limit would be specified. The removal approach would minimize the overall hazards.

After the waste has been removed from the repository, the facility would be decommissioned in accordance with the regulatory requirements applicable at that time. Closure may include partial backfilling of the repository and support areas. The entire repository would not be backfilled, however. The intent would be to dispose of uncontaminated excavated salt and other materials removed from the underground during the initial mining operations. The shafts may be sealed; surface facilities would be decontaminated and decommissioned. All decontamination waste could be packaged and shipped in the same fashion as the waste removed.

The analysis for the recovery of waste after closure was based on the assumptions that (1) the repository has been closed for a period of time sufficient for total encapsulation of the waste and reconsolidation of the salt, (2) waste containers have been breached, and (3) waste characterization requirements and the process/equipment that meet these requirements are known and are based on regulations current at the time of removal.

A volume of 400,000 cubic meters (14 million cubic feet) of CH-TRU and RH-TRU waste was assumed to have been disposed of. This volume, which is the volume of waste disposed of under Action Alternative 3 (the maximum under any alternative), would be emplaced in 71 waste panels. To recover the disposed of waste, the materials that would be removed from the repository would include 3,370,000 cubic meters (119 million cubic feet) of contaminated material and 570,000 cubic meters (20 million cubic feet) of uncontaminated material. These volumes include uncontaminated materials from newly excavated repository shafts and access drifts and contaminated materials from the waste panel rooms and drifts, plus an additional 10 percent to include contaminated materials that may have penetrated into the disposal panel or drift floors or walls.

5.7.2.1 Operational Impacts of Waste Recovery

Operational impacts of recovering emplaced CH-TRU and RH-TRU waste from the entire repository 100 years after closure would be substantially greater than the impacts of emplacing the waste. In addition to excavation of waste, containers, and surrounding contaminated salt, there would be substantial effort involved in packaging the material for safe shipment. Packaging of recovered waste and contaminated salt was assumed to take place underground. It was assumed that engineered contamination controls, such as a HEPA-filtered ventilation system typical of DOE facilities that handle radioactive material, would be put into place. DOE believes that such controls would maintain releases and radiation exposures below the current regulatory levels. Therefore, all releases and radiation exposures to the public and workers were assumed to be limited to current regulatory standards, and the MEI would receive no more than 10 mrem per year, the

NESHAP limit for radionuclides in 40 CFR Part 61. Workers would be subject to the WIPP administrative dose limit of 1 rem per year.

The number of workers required for excavation and packaging activities was estimated to be about 100. The time period needed to remove the waste was estimated to be about the same as that required for emplacement, about 200 years, based on 5 years to excavate and package each panel containing CH-TRU and RH-TRU waste, and 2 years to excavate and package each panel containing only RH-TRU waste. Assuming a 35-year work period per worker, the accumulated worker-population dose over the entire 200-year recovery period would be 20,000 person-rem. The maximum accumulated LCFs in the involved worker population would be about 8. The accumulated potential of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 1×10^{-3}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected.

The impact to the MEI receiving 10 mrem per year (the NESHAP radionuclide limit) would be approximately 1,000 times the calculated impact to the MEI from WIPP disposal operations under Action Alternative 3 (Tables 5-64 and 5-65). This ratio was used to estimate the potential impacts to the public and noninvolved workers from waste recovery, adjusting Action Alternative 3 impacts upward by a factor of 1,000. The estimated number of LCFs in the general population from radiation exposure would be 0.3, while cancer incidence from hazardous chemical exposure would be 0.02. The MEI would have a 3×10^{-4} probability of an LCF from radiation exposure, and about a 1×10^{-5} probability of a cancer incidence from exposure to hazardous chemicals. The noninvolved worker population would have an estimated 0.5 LCF from radiation exposure, and cancer incidence from hazardous chemical exposure would be about 0.09. The maximally exposed noninvolved worker would have a 3×10^{-4} probability of an LCF from radiation exposure, and about a 5×10^{-5} probability of a cancer incidence. No noncarcinogenic health effects would be expected, with the HIs not exceeding those under Action Alternative 3 and no larger than 1×10^{-3}.

5.7.2.2 Transportation Impacts of Waste Recovery

The transportation impacts of recovering the waste would be substantially greater than for its disposal because there would be a much greater volume of recovered waste (3.4 million cubic meters [121 million cubic feet]). It is assumed that the recovered waste would be transported to the treatment sites using the transportation consolidation described for Action Alternative 3. Because contaminated salt would be treated as waste, each generator site would receive more waste than it originally shipped for disposal.

The large volume of contaminated salt would increase the number of shipments by a factor of 8.5, increasing the transportation impact by approximately the same factor. This impact estimate is conservative because, in the time between disposal and recovery, the radionuclides with short half-lives would have decayed sufficiently to reduce accident-free radiological impacts to a large extent. Also, because much of the recovered waste would have a large salt component, the salt would provide shielding for the radioactive component. This self-shielding effect would further reduce accident-free impacts. The bounding accident impacts, however, would be about the same as that calculated for Action Alternative 3 (3 LCFs for CH-TRU waste average radionuclide concentration scenario) because the half-life of the alpha emitting radionuclides, which contribute most to internal dose, have relatively long half-lives. After 100 years, these radionuclides would not have decayed sufficiently enough to substantially reduce impacts. The maximum radiological populations impacts calculated to occur from nonoccupational accident-free exposures is estimated

to be the same as Action Alternative 3 (15 LCFs). Vehicle-related traffic fatalities would increase to 185 due to a proportional increase in waste and transportation miles (see the related discussion in Appendix E for complete estimated transportation impacts).

5.8 ENVIRONMENTAL JUSTICE

DOE is in the process of developing environmental justice guidance, pursuant to Executive Order 12898. This guidance will be finalized after stakeholder comments, concerns, and opinions are received, reviewed, and incorporated, as appropriate.[1] The approach taken in this SEIS-II analysis may depart somewhat from the guidance that is eventually issued or from the approach taken in other documents. Information concerning minority populations for New Mexico as a whole is included in this section in response to public comments.

For purposes of this analysis, a high and adverse human health or environmental impact is a significant deleterious human health or environmental impact. A disproportionate impact to a minority or low-income population is one that substantially exceeds, or is likely to exceed, the same type of impact in the larger community. A disproportionately high and adverse human health or environmental impact would occur when the adverse human health or environmental effects are significant, and the risk or rate to a minority or low-income population from exposure (or multiple exposures) to the environmental or health hazard(s) substantially exceeds, or is likely to exceed, the risk or rate to the general population.

The SEIS-II environmental justice analysis for the vicinity of WIPP addresses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations within an 80-kilometer (50-mile) area of the WIPP site. The shaded areas in Figures 4-11 and 4-12 show the percentage of minority populations and low-income populations, respectively, in census blocks around the WIPP site. Minorities comprise about 36.8 percent of the population in the 80-kilometer (50-mile) area around WIPP, and low-income individuals about 21.5 percent of this population.

Approximately 38 percent of New Mexico's population is Hispanic. Approximately 9 percent of New Mexico's population is Native American.

The populations within an 80-kilometer (50-mile) area of the non-WIPP treatment sites are described in Chapter 4 of SEIS-II. SEIS-II also incorporates by reference the maps of the census tracts containing greater than 50 percent minority and low-income populations within the 80-kilometer (50-mile) area of treatment sites that are included in Appendix C of the WM PEIS. Of note for environmental justice assessments are LANL and SRS, where minorities constitute greater than 55 percent and 35 percent, respectively, of the total populations within the 80-kilometer (50-mile) area.

For treatment, potentially high and adverse human health effects could occur during normal, accident-free treatment operations at some treatment sites as a result of TRU waste management activities under the three Action Alternative 2 subalternatives. Several areas in the vicinity of WIPP contain a greater percentage of minorities than some other areas within the 80-kilometer (50-mile) area of WIPP and the population of the United States as a whole. It is possible, therefore, that adverse health impacts (estimate of 1 fatality) from routine or accident-free thermal

[1] The Council on Environmental Quality has also developed draft "Guidance for Addressing Environmental Justice Under the National Environmental Policy Act."

treatment of waste at WIPP under Action Alternative 2C would disproportionately affect the minority populations in the vicinity of WIPP. The prevailing winds at both SRS and LANL would direct treatment releases away from the concentrations of minority and low-income populations that exist around those sites.

At all treatment sites, treatment accidents would be unlikely so that accidents would not be expected to impact off-site populations; also, the impacts from treatment accidents would depend on meteorological conditions at the time of the accident. For these reasons, it is not likely that adverse environmental or human health impacts would disproportionately affect the minority or low-income populations at any of the treatment sites.

Potentially high and adverse impacts as defined above may occur as a result of waste transportation activities. Because all TRU waste would travel through New Mexico, residents of the State could be affected by transportation activities, although impacts would be spread throughout the transportation corridors. Routine truck transportation could cause between 3 (under the Proposed Action) and 15 (under Action Alternative 3) public fatalities over the life of the project from radiation exposure. These impacts are likely to be much lower because of conservative assumptions used in the analysis (e.g., assuming more stops than would actually occur). For the Proposed Action, less than 5 percent of the radiological impacts would be to those living along the highways. The ethnic and income distribution of travelers and workers at rest stops, where the impacts would primarily occur, would vary over time and by location. Thus, potential high and adverse impacts from routine transportation would not be likely to disproportionately affect minority or low-income populations.

Under the action alternatives, there could be from 5 (using truck transportation under the Proposed Action) to 264 fatalities (using dedicated rail under Action Alternative 3) from traumatic injuries sustained in accidents involving transportation vehicles. For truck transportation, accidents not involving a release of radioactivity are most likely to affect those traveling along the same route; for rail transportation, such accidents are most likely to affect those traveling near railroad crossings. Accidents would be random events that could occur on any segment of the transportation routes. Whether such travelers are minorities or low-income individuals cannot be predicted. Therefore, any high and adverse impacts from transportation accidents are not likely to disproportionately affect minority or low-income populations.

Severe transportation accidents that breach the transport package could result in up to 16 LCFs (from release of radioactive material) under any of the action alternatives. Accidents involving a release of radioactive material are most likely to affect residents and travelers along the transportation corridors, although the probability that an accident would involve a release of radioactive material is low (1.5×10^{-5} per accident). As noted above, accidents would be random events that could occur on any segment of the transportation routes. Whether the affected people would be minorities or low-income individuals cannot be predicted. Therefore, any high and adverse impacts from transportation accidents are not likely to disproportionately affect minority or low-income populations.

For disposal at WIPP, normal accident-free operations would not cause significant adverse human health or environmental impacts, and thus there would be no such impacts that could disproportionately affect minority or low-income populations. For disposal accidents, the most severe accident (the waste hoist failure) could cause up to 4 public fatalities for the Proposed Action and up to 24 fatalities for Action Alternative 3. However, the annual probability of this

accident is 4.5 x 10^{-7}. Therefore, although possible, disproportionately high and adverse effects on minority or low-income populations would not be expected.

5.9 CUMULATIVE IMPACTS

This section focuses on the cumulative impacts that could result once the incremental impacts of the SEIS-II Proposed Action (its Preferred Alternative) and action alternatives are added to the impacts of other past, present, and reasonably foreseeable future actions. Throughout this section, the cumulative impacts discussion in the Final WM PEIS is incorporated by reference. This assessment of cumulative impacts also considers a number of other NEPA documents, including those listed in Table 5-94.

5.9.1 Cumulative Impacts in the Vicinity of WIPP

The WIPP site was withdrawn in the LWA for the purpose of TRU waste disposal and related activities, and DOE has no plans to dispose of other types of waste at WIPP nor to conduct any other type of activity there.

Future mining and drilling to extract mineral resources known to exist within the Land Withdrawal Boundary in the vicinity of WIPP would be prohibited by the LWA in the foreseeable future. Activity on two existing leases near the WIPP site would be allowed only if EPA found that such activity would not affect WIPP performance; otherwise, DOE would acquire those leases. The SEIS-II long-term performance assessment (presented both in this chapter and in Appendix H) takes into account the potential impacts of mining and drilling activities that might result after WIPP closure and the period of active institutional control.

DOE is also exploring the possibility of obtaining a Toxic Substances Control Act (TSCA) permit to dispose of the small amount (less than 700 cubic meters [25,000 cubic feet] as estimated in BIR-3) of PCB-commingled TRU waste without treatment. This waste was included in the CH-TRU waste Additional Inventory and was analyzed in SEIS-II.

DOE may propose to treat low-level alpha mixed waste at INEEL with a thermal process that would reduce the waste volume and concentrate TRU radionuclides. If DOE decides to use such a treatment process at INEEL, all or a portion of the resulting waste form could become CH-TRU waste after treatment. The thermally treated low-level alpha mixed waste would have characteristics similar to the other CH-TRU waste examined in the SEIS-II analyses, and disposal of this waste at WIPP would have impacts similar to the disposal of any other equivalent volume of CH-TRU waste. The volume of this waste is estimated to be about 27,000 cubic meters (930,000 cubic feet), which after treatment would occupy most of the projected unused CH-TRU waste disposal capacity of WIPP. While the CH-TRU waste capacity that was assumed to be emplaced for the SEIS-II Proposed Action (its Preferred Alternative) was adjusted up for the purpose of bounding the analyses to this disposal limit, the results of the analyses for the Proposed Action would have been essentially the same had the treated low-level mixed waste been included in the TRU waste inventory and assumed to take up the additional volume. Likewise, addition of this relatively small volume of treated TRU waste to the waste volumes examined under any of the SEIS-II action alternatives would not substantially affect the environmental impacts of disposal.

Table 5-94
Documents Describing Other Activities Included in the Cumulative Impact Analysis

Title	Applicable Sites
Final Environmental Impact Statement, Defense Waste Processing Facility	SRS
Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility	SRS
Savannah River Site Waste Management Final Environmental Impact Statement	SRS
Final Environmental Impact Statement, Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley	West Valley Demonstration Project
Final Environmental Impact Statement, Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington	Hanford
Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement	Hanford, INEEL, SRS
Storage and Disposition of Weapons-Usable Fissile Materials, Environmental Impact Statement	Hanford, INEEL, NTS, ORR, Pantex, SRS
Medical Isotopes Production Project: Molybdenum-99 and Related Isotopes Environmental Impact Statement	LANL, SNL
Dual Axis Radiographic Hydrodynamic Test Facility, Final Environmental Impact Statement	LANL
Final Environmental Impact Statement for the Tank Waste Remediation System	Hanford
Plutonium Finishing Plant Stabilization Final Environmental Impact Statement	Hanford
Programmatic Environmental Impact Statement for Stockpile Stewardship and Management	LLNL, LANL, NTS, ORR, Pantex, SRS
The Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada	NTS
Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure or Long-Term Management of Facilities at the Western New York Nuclear Services Center	WVDP
Final F-Canyon Plutonium Solutions Environmental Impact Statement	SRS
Proposed Interim Storage of Enriched Uranium Above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee	ORR
Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling	INEEL, NTS, ORR, Pantex, SRS
Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada	NTS
Savannah River Site Waste Management Final Environmental Impact Statement	SRS
Final Environmental Impact Statement for Continued Operations of Lawrence Livermore National Laboratory and Sandia National Laboratories	LLNL, SNL-CA
Disposition of Surplus Highly Enriched Uranium, Environmental Impact Statement	ORR, SRS
Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling	SRS
Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components	Pantex
Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan	Hanford
Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class and Los Angeles Class Naval Nuclear Plants	Hanford
Nonnuclear Consolidation Environmental Assessment	LANL, ORR, RFETS, SNL, SRS
Proposed 7-GeV Advanced Photon Source Environmental Assessment	ANL-E
Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories	SNL

DOE also is considering whether to classify some stabilized plutonium residues (with less than 20 percent plutonium by weight) as TRU waste. These residues are not usable for weapons and are stored primarily at Hanford, INEEL, LANL, LLNL, RFETS, and SRS. Residues with less than 20 percent plutonium by weight at RFETS were reported as TRU waste volumes in BIR-3, and the impacts of disposal of the RFETS residues were examined as part of the SEIS-II Proposed Action and the action alternatives. The Department will prepare additional site-specific NEPA analyses, as appropriate, concerning management and stabilization of the residues before decisions are made concerning disposal at WIPP.

Other DOE decisions may result in generation of TRU waste that could ultimately be destined for WIPP. The ROD for the *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (DOE 1996e) has little impact on TRU waste generation potential. The ROD for the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996h) may potentially have a greater impact on TRU waste generation. The Department decided to pursue a dual strategy for disposing of excess weapons-usable plutonium that would immobilize some (and potentially all) of the inventory in a glass or ceramic material and allow the burning of some of the surplus plutonium as mixed oxide fuel in existing reactors, depending upon subsequent decisions. The Department is preparing a *Surplus Plutonium Disposition Environmental Impact Statement* (Notice Of Intent, May 22, 1997, 62 FR 28009). The disposition of surplus weapons-usable plutonium (a fissile material) could produce approximately 4,500 cubic meters (158,000 cubic feet) to 7,000 cubic meters (245,000 cubic feet) of additional TRU waste for disposal at WIPP.

5.9.2 Cumulative Transportation Impacts

The cumulative effects of transporting low-level, low-level mixed, high-level, hazardous, and TRU wastes are presented in the Final WM PEIS (DOE 1997). For the following discussion, the information in the Final WM PEIS, which examined 20 years of transportation for all waste types except high-level waste (for which 40 years of transportation was analyzed), has been incorporated and supplemented by information in SEIS-II (which examined 35 years of transportation).

The totals in the Final WM PEIS show that transporting all waste types between generator, treatment, storage, and disposal sites by truck would result in an aggregate total of between 12 fatalities (under one of the regionalized alternatives for TRU waste considered in the WM PEIS) and 69 fatalities (under the decentralized alternative for TRU waste considered in the WM PEIS). The total for the SEIS-II Proposed Action (over 35 years) would increase to about 15 fatalities for transportation of TRU waste by truck to WIPP. Approximately 6 of these 15 fatalities would result from radiation exposure, with the remainder due to injuries induced by physical trauma.

Cumulatively, transportation of all waste types by rail would result in 11 fatalities (for SEIS-II Action Alternative 1) to 15 fatalities (for SEIS-II Action Alternative 3). Rail transportation impacts were not examined for the SEIS-II Proposed Action. Transportation by rail would result in a reduction of both radiological and physical trauma impacts as compared to truck transportation.

If the potential impacts from other DOE and non-DOE transportation activities are included, approximately 175 radiation-related LCFs may occur in the general population and an additional 140 radiation-related LCFs may occur among workers from past, present, and reasonably foreseeable transportation activities (including transportation to WIPP) (DOE 1997).

5.9.3 Cumulative Impacts at Treatment Sites

The Final WM PEIS (DOE 1997) examined the impacts of storage and treatment of TRU waste at major storage or treatment sites and found the potential for TRU waste management activities to affect health or to exceed applicable air quality standards. It also found cumulative impacts as a result of combined activities at those sites. These cumulative impacts are presented in the Final WM PEIS.

The Final WM PEIS did not examine cumulative impacts at Mound. However, the bounding analysis in the *Environmental Assessment for Commercialization of the Mound Plant* (DOE 1994c) does not project the generation of any TRU waste or any impacts associated with TRU waste at Mound.

The cumulative impacts of the SEIS-II Proposed Action (Preferred Alternative) and Action Alternative 1 during the 10 years analyzed by the Final WM PEIS would be virtually identical to those of the Final WM PEIS preferred alternative. Those impacts are presented below. For SEIS-II Action Alternatives 2 and 3, treatment was assumed to begin after the 10-year period examined in the Final WM PEIS, because it would take an estimated 12 years to design, build, and obtain permits for the treatment facilities. Treatment, therefore, would not begin until after the 10-year period assessed in the Final WM PEIS.

For the cumulative impacts for time periods beyond the 10-year period, as examined below, the impacts from TRU waste (as noted in this chapter for a 35-year period) would be added to those impacts from other actions that are foreseeable or ongoing at that time. DOE has not attempted to predict the cumulative impacts beyond 10 years, because many of the actions that might contribute to those impacts are not reasonably foreseeable at this time. The following discussion focuses on human health impacts and presents the impacts of the Final WM PEIS preferred alternative. Other cumulative impacts due to construction and operation of storage and treatment facilities would also be similar or identical to those presented in the Final WM PEIS.

Hanford Site

No off-site public radiation cancer fatalities (0.14 LCF) and 11 worker radiation fatalities (11.1 LCFs) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at Hanford.

Idaho National Engineering and Environmental Laboratory

No off-site public radiation cancer fatalities (0 LCF) and 2 worker radiation fatalities (2.04 LCFs) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at INEEL.

Los Alamos National Laboratory

No off-site public radiation cancer fatalities (0 LCF) and 2 worker radiation fatalities (2.11 LCFs) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at LANL.

Nevada Test Site

No off-site public radiation cancer fatalities (0 LCF) and 3 worker radiation fatalities (2.87 LCFs) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at NTS.

Oak Ridge National Laboratory

No off-site public radiation cancer fatalities (0.23 LCF) and 2 worker radiation fatalities (1.6 LCF) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at ORNL.

Rocky Flats Environmental Technology Site

No off-site public radiation cancer fatalities (0 LCF) and no worker radiation fatalities (0 LCF) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at RFETS.

Savannah River Site

Approximately 1 off-site public radiation cancer fatality (1.48 LCF) and 8 worker radiation fatalities (8.0 LCF) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at SRS.

Lawrence Livermore National Laboratory

No off-site public radiation cancer fatalities (0.18 LCF) and no worker radiation fatalities (0.16 LCF) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at LLNL.

Argonne National Laboratory – East

No off-site public radiation cancer fatalities (0 LCF) and no worker fatalities (0 LCF) would result from ongoing operations, waste management activities, and other reasonably foreseeable future actions at ANL-E.

5.10 MITIGATION MEASURES

Analyses of potential environmental impacts in SEIS-II did not identify the need for any additional mitigation measures above those described in the FEIS (DOE 1980) and SEIS-I (DOE 1990). Most of the previously identified mitigation commitments have been fulfilled at WIPP for construction and predisposal phases or were intended to apply to underground tests at WIPP using TRU waste that never took place. DOE will reevaluate ongoing mitigation measures from the FEIS and SEIS-I and mitigation proposals for the disposal phase in light of SEIS-II analyses. Most of the following mitigation measures are included as part of each alternative and would be implemented by DOE to reduce potential impacts. DOE will specify the mitigation measures to be implemented for the action selected in the Record of Decision.

Air quality impacts may be mitigated by activities to reduce generation of criteria pollutants at WIPP, including the use of proper, low-contaminant fuels; paving heavily trafficked areas; and

spraying water on dusty roads to minimize fugitive dust emissions. Similar measures may also be taken during decommissioning to minimize air quality impacts. The HEPA filtration systems are already in place and can be used to mitigate any potential releases of radionuclides from the WIPP waste handling facilities. The use of radiation monitors to activate HEPA filtration of underground exhaust air (a mitigation commitment made in SEIS-I) may be reevaluated.

Biological resource impacts would be mitigated by avoiding unnecessary damage to vegetation, wildlife, and soil by controlling traffic, minimizing the areas of disturbance, controlling runoff, and cleaning up spills. Any temporary facilities such as haul roads, stockpiles, and work areas may be restored by regarding, reseeding, and fencing as activities requiring these facilities are completed. Environmental monitoring is ongoing and could continue, as necessary, to provide early warning of affects on the biological environment so that specific mitigative measures could be developed and implemented. DOE plans to return decommissioned land used in the operation of WIPP to a stable ecological condition and maintain or enhance the ecological condition of wildlife habitat within the Land Withdrawal Area (DOE 1996a). Disturbed areas would be restored as soon as possible after decommissioning, using methods of soil replacement and revegetation conducive to soil stabilization and wildlife needs.

Cultural resource impacts could be mitigated by performing additional surveys of areas that could be disturbed by surface activities, including those during decommissioning. DOE would attempt to avoid potential cultural and historic sites to the extent possible; if avoidance is not possible, specific mitigation measures would likely be developed in consultation with the State Historic Preservation Office, the Advisory Council on Historic Preservation, and the BLM.

Some socioeconomic impact was mitigated when DOE eliminated the former “Control Zone IV” in the 1980's, releasing the area of this zone that was outside the current Land Withdrawal Boundary and making available an estimated 50 million tons of potash for mining and opening the area for oil and gas recovery. In the event that either of the no action alternatives were selected, DOE may mitigate impacts to the regional economy by staging worker layoffs over the course of the decommissioning period. DOE could also assist laid-off workers by offering such services as worker training and reeducation programs, and providing relocation services for finding jobs elsewhere in the DOE complex.

Transportation impacts would be mitigated in a variety of ways in addition to using approved routes and transportation packages. Transportation routes can be selected to meet federal and state regulations. Trucks (and rail cars) transporting TRU waste would be inspected and maintained on a regular basis. Drivers would be required to meet strict selection and training criteria. The TRANSCOM system would be used to monitor truck movement at all times when transporting waste to WIPP. Extensive emergency response capability exists and would be maintained at DOE, the trucking contractor, and in communities along the transportation routes to respond in the event of an accident. In addition, DOE will consider maintaining spill control equipment to protect the environment from fuel spills, should a transportation accident occur.

Human health impacts to the public and noninvolved worker may be mitigated by using HEPA filtration systems to reduce potential releases of radionuclides or heavy metals from the WIPP waste handling facilities. Worker safety programs are currently in place at WIPP and could continue, with particular emphasis on the physical hazards of underground operations. Mitigation measures for potential radiological impacts to involved workers include adhering to the ALARA philosophy, area and personnel monitoring, and using shielding and remote-handling equipment

when handling high dose rate waste containers. Panel seals would be constructed to reduce operational exposures to VOCs emanating from emplaced waste.

The long-term performance of the repository could be enhanced by taking mitigation measures that include emplacing a chemical backfill with waste in the repository and using plugs and seals in the repository panels, access drifts, and shafts. The performance assessment calculations assumed the use of these mitigation measures. To protect the repository from inadvertent intrusion, hydrocarbon drilling and potash mining would continue to be limited by the BLM and DOE.

The need for specific mitigation measures at the treatment sites would be determined in NEPA reviews performed for the construction and operation of treatment facilities. For example, mitigation of human health impacts from atmospheric releases of radionuclides during treatment operations would be evaluated where treatment impacts warrant such mitigation.

5.11 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The LWA prohibits the extraction of mineral and hydrocarbon resources from the 41-square-kilometer (16-square-mile) Land Withdrawal Area during the period of WIPP disposal operations and for perpetuity. After decommissioning and permanent marking, the aboveground area of the WIPP site would be restored by contouring, grading, seeding, and other methods to return it to its natural condition.

5.12 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The irreversible and irretrievable commitments of resources associated with the operation of WIPP have not changed substantially from those presented in Section 9 of the FEIS and Section 11 of SEIS-I. Land use for the salt storage pile is currently planned as 12 hectares (30 acres) rather than 24 hectares (60 acres). Although this area would be remediated when the WIPP site is closed, residual salt would probably make growth of any but salt-tolerant species unlikely. Retrieval or recovery activities, discussed in Section 5.7, would probably result in additional use of resources. Retrieval usage would probably equal normal operating uses for the period these activities were under way, while recovery activities would probably be greater than normal operating usage.

Use of diesel fuel for transportation of waste would be more than estimated previously. The FEIS estimate was about 380 cubic meters (100,000 gallons) per year, or about 9,460 cubic meters (2.5 million gallons) for the original WIPP operating period of 25 years. While annual fuel consumption would not be greatly different from the FEIS estimates, total fuel consumption would be 2 to 5 times higher under the Proposed Action.

5.13 CHANGES DUE TO OTHER TRU WASTE VOLUME ESTIMATES

Since the completion of the analyses in the Draft SEIS-II, DOE has continued to update the estimates of stored and to-be-generated TRU waste volumes at the various generator sites. In particular, the *National Transuranic Waste Management Plan* includes updated estimates of the stored and projected volumes of TRU waste at the generator sites. SEIS-II analyses are based on the TRU waste volumes published in BIR-3, although the updated *National Transuranic Waste Management Plan* estimates and associated impacts are also presented in SEIS-II (see Appendix J).

Overall, the *National Transuranic Waste Management Plan* has 5,662 cubic meters (199,951 cubic feet) more CH-TRU waste than the SEIS-II Basic Inventory (before adjustment to the

168,500 cubic meters [5,950,000 cubic feet] allowed by the LWA). This is an increase of 4 percent. *The National Transuranic Waste Management Plan* reports more than 30,000 cubic meters (1,059,000 cubic feet) less of RH-TRU waste than the SEIS-II Basic Inventory. This is a decrease of 86 percent.

The SEIS-II Proposed Action (the Preferred Alternative) presents impacts adjusted to the treatment and disposal of 168,500 cubic meters (5,950,000 cubic feet) of CH-TRU waste (the maximum allowed under the Land Withdrawal Act) and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste (the maximum allowed under the C & C Agreement with the State of New Mexico). Using the *National Transuranic Waste Management Plan* in the same manner, no change would occur in the impacts for the Proposed Action except for the elimination of impacts related to storage of excess RH-TRU waste. No excess RH-TRU waste, therefore, would be left at ORNL and Hanford.

For the generator-storage sites with significant changes in waste volumes, individual site impacts could vary to a greater extent than indicated by the differences in the total volumes noted above. Under Action Alternatives 1, 2, and 3 and for the individual sites, the following changes would be expected:

- Negligible changes to the impacts would be anticipated in areas of land use and management, biological resources, cultural resources, noise, water resources and infrastructure, long-term performance, or consequences of lag storage accidents. No change would be expected in consequences from treatment accidents or WIPP disposal accidents.

- Changes in the estimated impacts for human health, life-cycle costs (except transportation costs), air quality, industrial safety, and economics would be directly related to changes in CH-TRU and RH-TRU waste volumes. Site impacts would change, as presented in the "percent difference" columns of Table J-1 for CH-TRU waste and Table J-2 for RH-TRU waste. Unlike most other impact areas, CH-TRU waste is a much higher contributor to impacts for involved workers than is RH-TRU waste; therefore, large decreases in RH-TRU waste volumes would have little impact for involved workers. However, at WIPP, large decreases in the amount of RH-TRU waste volumes would reduce the operations time needed for excavation and emplacement, reducing industrial safety and economics impacts.

- Changes in transportation impacts, including costs, are directly related to the number of shipments, which is dependent upon the type of waste treatment. Tables J-4 and J-5 present detailed CH-TRU and RH-TRU waste shipment information for all sites under all alternatives using The National Transuranic Waste Management Plan volumes. Table J-6 (and Table 5-95 presented here) summarize the differences in shipments and the percentages of the total inventories between The National Transuranic Waste Management Plan and the Basic Inventory.

Overall, impacts would be slightly lower using data from *The National Transuranic Waste Management Plan* because, although CH-TRU waste volumes are slightly higher, the RH-TRU waste volumes are markedly lower (except for the impacts to the involved workers, as noted above). The difference is quite marked for transportation impacts because of the reduction of nearly 61,000 shipments of RH-TRU waste under Action Alternative 3 (see Table 5-95).

Table 5-95
Comparison of Shipments Between Alternatives Using
***The National Transuranic Waste Management Plan* and Basic Inventory**

Alternatives	Number of Shipments to WIPP for the Total Inventory			
	NTRUWM Plan	BIR-3	Difference	Percentage of BIR-3 Shipments (NTRUWM/BIR-3)
Proposed Action				
CH-TRU Waste	27,988	29,766 [a]	-1,778	94%
RH-TRU Waste	7,626	7,957	-331	96%
Action Alternative 1				
CH-TRU Waste	41,027	41,003	24	100%
RH-TRU Waste	11,509	62,162	-50,653	19%
Action Alternative 2A				
CH-TRU Waste	43,749	42,775	974	102%
RH-TRU Waste	4,028	21,895	-17,867	18%
Action Alternative 2B				
CH-TRU Waste	43,750	42,774	976	102%
RH-TRU Waste	4,028	21,895	-17,867	18%
Action Alternative 2C				
CH-TRU Waste	43,431	41,206	2,225	105%
RH-TRU Waste	11,507	62,160	-50,653	19%
Action Alternative 3				
CH-TRU Waste	65,922	67,309	-1,387	98%
RH-TRU Waste	13,808	74,606	-60,798	19%

[a] RH-TRU waste volumes are adjusted to the limits of the C&C Agreement. CH-TRU waste volumes are adjusted to reflect the capacity allowed under the LWA taking into account the RH-TRU waste limits of the C&C Agreement.

Changes in volume-dependent impacts (for example, human health impacts) would be expected at some sites. The changes in impacts would be greatest at INEEL, a major generator, treatment, and potential consolidation site under all alternatives, where volume-dependent impacts could increase by about 124 percent. Impacts at RFETS would increase by about 50 percent and at SRS by less than 10 percent. Impacts at Hanford would decrease dramatically: approximately 50 percent from CH-TRU waste and 90 percent from RH-TRU waste. ORNL impacts, mainly from RH-TRU waste, would be about 60 percent lower. Impacts at LANL, the other key generator site, would also decrease by about 15 to 20 percent.

Additional information on how these impacts would change, as well as information on other waste volumes, is presented in Appendix J.

5.14 REFERENCES CITED IN CHAPTER 5

Buck, J., et al., 1997, *Analysis of the Long-Term Impacts of TRU Waste Remaining at Generator/Storage Sites for No Action Alternative 2 - Support Information for the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, PNNL-11251, Pacific Northwest National Laboratory, Richland, Washington.

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1991, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1990*, DOE/WIPP 91-008, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1992, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1991*, DOE/WIPP 92-007, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1993, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1992*, DOE/WIPP 93-017, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994a, *Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives*, DOE/WIPP 93-058, February, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994b, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1993*, DOE/WIPP 94-2033, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994c, *Environmental Assessment for Commercialization of the Mound Plant*, DOE/EA-1001, October, Miamisburg, Ohio.

DOE (U.S. Department of Energy), 1995a, *Emergency Planning, Response, and Recovery Roles and Responsibilities for TRU-Waste Transportation Incidents*, DOE/CAO-94-1039, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement*, DOE/EIS-0203-F, April, Washington, D.C.

DOE (U.S. Department of Energy), 1995c, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994*, DOE/WIPP 95-2094, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995d, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995e, *WIPP Radiological Control Manual, Volume 1, and WIPP Radiation Safety Procedures Manual, Volume 2*, WP-12-5, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Waste Isolation Pilot Plant Land Management Plan*, DOE/WIPP 93-004, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Transuranic Materials Transportation Guide*, DOE-CAO 96-1055, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996c, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, WIPP-DOE-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1995*, DOE/WIPP-96-2182, May, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996e, *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, September, Washington, D.C.

DOE (U.S. Department of Energy), 1996f, *The National Transuranic Waste Management Plan*, DOE/NTP-96-1204, Revision 0, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996g, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996h, *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement*, DOE/EIS-0229-F, December, Washington, D.C.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

Fischer, L.E., et al., 1987, *Shipping Container Response to Severe Highway and Railway Accident Conditions: Volumes 1 and 2*, NUREG/CR-4829, Lawrence Livermore National Laboratory, Livermore, California.

Greenfield, M.A., and T.J. Sargent, 1995, *An Analysis of the Annual Probability of Failure of the Waste Hoist Brake System at the Waste Isolation Pilot Plant (WIPP)*, EEG-59, Environmental Evaluation Group, New Mexico.

Hollen, J., 1996, Documentation of Verbal Communication, DVC-023, February 5, Battelle, Albuquerque, New Mexico.

ICRP (International Commission on Radiological Protection), 1991, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Pergamon Press, New York.

Johnson, P.E., et al., 1993, *Highway 3.1- An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual*, ORNL/TM-12124, Oak Ridge, Tennessee.

NCRP (National Council on Radiation Protection and Measurements), 1987, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, Bethesda, Maryland.

Neuhauser, K.S., and F.L. Kanipe, 1992, *RADTRAN IV- Volume 3: User Guide*. SAND89-2370, TTC-0943, January, Albuquerque, New Mexico.

NMSH&TD (New Mexico State Highway and Transportation Department), 1997, *Road Segments by Traffic (AADT) Info*, Consolidated Highway Data Base, March, Santa Fe, New Mexico.

Rao, R.K., et al., 1982, *Nonradiological Impacts of Transporting Radioactive Material*, SAND81-1703, TTC-0236, Sandia National Laboratories, Albuquerque, New Mexico.

Saricks, C., and T. Kvitek, 1994, *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight*, ANL/ESD/TM-68, March, Argonne National Laboratory, Argonne, Illinois.

Thompson, T.W., et al., 1996, *Inadvertent Intrusion Borehole Permeability*, May, Final Draft Report to Sandia National Laboratories, Albuquerque, New Mexico.

Tillman, J.B., 1988a, Letter to J. Shively (New Mexico Environmental Improvement Division), WIPP:HJD:E88-023, March 4, U.S. Department of Energy, Carlsbad, New Mexico.

Tillman, J.B., 1988b, Letter to J. Shively (New Mexico Environmental Improvement Division), July 7, U.S. Department of Energy, Carlsbad, New Mexico.

CHAPTER 6
CONSULTATIONS AND PERMITS

This chapter discusses the results of consultations with various agencies during the preparation of the *Waste Isolation Pilot Plant* (WIPP) *Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II). This chapter also lists active, pending and potentially required permits for WIPP.

The National Environmental Policy Act (NEPA) requires that federal, state, and local agencies with jurisdiction or special expertise regarding environmental impacts be consulted and involved in the NEPA process. Agencies involved include those with authority to issue permits, licenses, and other regulatory approvals. Other agencies also include those responsible for protecting significant resources, such as endangered species or wetlands. All such agencies have been sent copies of this SEIS-II document.

The following governmental agencies were consulted.

- New Mexico Forestry Division, New Mexico Energy, Minerals, and Natural Resources Department, 408 Galisteo, Villagra Building, P.O. Box 1948, Santa Fe, NM 87504 (Karen Lightfoot, 505-827-7865)

- U.S. Fish and Wildlife Service, U.S. Department of Interior, New Mexico Ecological Services State Office, 2105 Osuna Road NE, Albuquerque, NM 87113 (Jennifer Fowler-Propst, State Supervisor, 505-761-4525)

- New Mexico Game and Fish Department, P.O. Box 25112, Santa Fe, NM 87504 (Jerry Maracchini, Director, 505-827-9912)

These agencies were contacted in September 1995 in regards to federal- and state-listed endangered, threatened, proposed, and candidate plant species. The agencies responded with species lists (Sivinski and Lightfoot 1995, NMDG&F 1995, and USFWS 1995). Table 4-1 lists the species of special concern for the area surrounding the WIPP site.

Also required by NEPA is a list of permits that are active, pending, or potentially required before disposal can begin at WIPP. Table 6-1, which presents this information, begins on the next page. Other realty components that are constructed, maintained, and utilized by WIPP are referenced in the *WIPP Land Management Plan* (DOE 1996).

Table 6-2 lists DOE orders applicable to this EIS.

Table 6-1
Active, Pending, and Potentially Required Permits and Approvals for the Waste Isolation Pilot Plant Disposal Operations

Granting Agency [a]	Type of Permit or Approval	Status
U.S. Department of the Interior, BLM	Right-of-Way for Water Pipeline	Active
U.S. Department of the Interior, BLM	Right-of-Way for the North Access Road	Active
U.S. Department of the Interior, BLM	Right-of-Way for Railroad	Active
U.S. Department of the Interior, BLM	Right-of-Way for Dosimetry and Aerosol Sampling Sites	Active
U.S. Department of the Interior, BLM	Right-of-Way for Seven Subsidence Monuments	Active
U.S. Department of the Interior, BLM	Right-of-Way for Aerosol Sampling Site	Active
U.S. Department of the Interior, BLM	Right-of-Way for Ten Raptor Nesting Platforms	Active
U.S. Department of the Interior, BLM	Right-of-Way for Survey Monument Installation	Active
U.S. Department of the Interior, BLM	Free Use Permit for Caliche	Active
N.M. Environment Department	Operating Permit for two Backup Generators	Active
N.M. Environment Department	RCRA Part B Permit Application	Pending
N.M. Department of Game and Fish	Individual Banding	Active
N.M. Department of Game and Fish	Master Collecting	Active
N.M. Department of Game and Fish	Concurrence that WIPP disposal activities will have no significant impact on State-listed threatened or endangered species	Active
U.S. Department of the Interior, Fish and Wildlife Service	Master Personal Banding	Active
U.S. Department of the Interior, Fish and Wildlife Service	Concurrence that there are no Federally listed, threatened, proposed, or endangered species at WIPP	Active
U.S. Environmental Protection Agency	Notification of the presence of two Underground Storage Tanks	Active
U.S. Environment Protection Agency	N.M. NPDES Storm Water General Permit	Active
U.S. Environmental Protection Agency	Certification of Compliance with 40 CFR 194	Pending
U.S. Nuclear Regulatory Commission	Certificate of Compliance for the TRUPACT-II	Active
U.S. Nuclear Regulatory Commission	Certificate of Compliance for the RH-72B cask	Pending
N.M. Commissioner of Public Lands	Right-of-Way for High Volume Air Sampler	Active
N.M. State Engineer Office	H-19b1 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b2 well, permit to appropriate the under waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b3 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b4 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b5 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b6 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b7 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-1 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-2 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-3 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-4 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-5 well, permit to appropriate the underground waters of N.M. for monitoring ad characterization	Active
N.M. State Engineer Office	WQSP-6, well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-7 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	Appropriation: Exhaust Shaft Exploratory Borehole	Active
N.M. State Engineer Office	Exploratory: Exhaust Shaft Exploratory Borehole	Active
N.M. State Engineer Office	H-14 and H-15 Test Wells	Active

[a] U.S. = United States, BLM = Bureau of Land Management, N.M. = New Mexico

Table 6-2
Laws and Regulations Relevant to the WIPP Disposal Phase

Primary Implementing Agency	Law or Regulation	
U.S. Department of Energy Orders	Order 451.1,	National Environmental Policy Act Compliance Program
	Order 5000.3B,	Occurrence Reporting and Processing of Operations Information
	Order 5400.1,	General Environmental Protection Program
	Order 5400.2A,	Environmental Compliance Issue Coordination
	Order 5400.3,	Hazardous and Radioactive Mixed Waste Program
	Order 5400.5,	Radiation Protection of the Public and the Environment
	Order 5480.1B,	Environmental Protection, Safety and Health Protection Program for DOE Operations
	Order 5480.21,	Unreviewed Safety Questions
	Order 5480.22,	Technical Safety Requirement
	Order 5480.23,	Nuclear Safety Analysis Reports
	Order 5480.24,	Nuclear Criticality Safety
	Order 5480.3B,	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
	Order 5480.4,	Environmental Protection, Safety, and Health Protection Standards
	Order 5480.9,	Construction Safety and Health Program
	Order 5480.10,	Contract Industrial Hygiene Program
	Order 5480.11,	Radiation Protection for Occupational Workers
	Order 5481.B,	Safety Analysis and Review System
	Order 5482.1B,	Environmental, Safety and Health Appraisal Program
	Order 5483.1A,	Occupational Safety and Health Program for DOE Contractor Employees at government-Owned Contractor-Operated Facilities
	Order 5484.1,	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
	Order 5500.3A,	Planning, and Preparedness for Operational Emergencies
	Order 5700.6C,	Quality Assurance
	Order 5820.2A,	Radioactive Waste Management
	Order 6430.1A,	General Design Criteria

This page intentionally left blank.

INDEX

4

40 CFR 191, S-3, 1-9, 1-18, 2-15, 2-24, 3-10, 4-9, 4-19, 4-69, 5-44, 5-193, A-67, B-2, B-34, H-107
40 CFR 194, S-3, 1-9, 3-50, 5-44, 5-45, 6-2, H-5, H-13, H-14

A

accident, S-4, S-5, S-29, S-31, S-43, S-44, S-45, S-46, S-47, S-48, S-50, S-57, S-58, S-59, S-60, S-69, S-70, S-71, S-72, S-73, 1-10, 1-15, 1-16,3-6, 3-7, 3-8, 3-50, 3-55, 3-56, 4-48, 4-51, 4-53, 4-56, 4-58, 4-60, 4-61, 4-63, 4-65, 4-67, 5-5, 5-6, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, 5-22, 5-23, 5-24, 5-25, 5-26, 5-34, 5-35, 5-36, 5-37, 5-38, 5-40, 5-41, 5-42, 5-43, 5-50, 5-52, 5-55, 5-57, 5-61, 5-62, 5-63, 5-64, 5-65, 5-66, 5-67, 5-73, 5-74, 5-75, 5-76, 5-77, 5-80, 5-82, 5-85, 5-93, 5-94, 5-95, 5-98, 5-99, 5-106, 5-107, 5-108, 5-109, 5-110, 5-111, 5-112, 5-113, 5-114, 5-115, 5-121, 5-123, 5-127, 5-128, 5-129, 5-130, 5-137, 5-138, 5-139, 5-140, 5-141, 5-142, 5-143, 5-144, 5-145, 5-147, 5-148, 5-150, 5-154, 5-155, 5-156, 5-162, 5-164, 5-169, 5-170, 5-180, 5-181, 5-182, 5-188, 5-190, 5-193, A-3, A-61, B-7, E-2, E-4, E-12, E-14, E-19, E-23, E-26, E-27, E-30, E-31, E-32, E-34, E-40, E-41, E-42, E-43, E-44, E-45, E-46, E-47, E-48, E-49, E-50, E-51, E-52, E-55, E-56, E-57, E-58, E-59, E-60, E-63, E-64, E-66, E-67, E-68, E-69, E-70, E-71, E-72, E-73, E-76, E-77, F-8, G-1, G-2, G-3, G-4, G-5, G-6, G-7, G-8, G-9, G-10, G-11, G-12, G-13, G-14, G-15, G-16, G-17, G-18, G-19, G-20, G-22, G-23, G-24, G-25, G-26, G-27, G-28, G-29, G-30, G-31, G-32, G-33, G-34, G-35, G-36, G-37, G-38, G-39, G-40, G-41, G-42, G-43, G-44, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-54, G-55, G-56, G-57, G-58, G-59, G-60, G-61, G-62, G-63, G-64, G-65, G-66, G-67, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, G-80, H-32, H-56, J-4
Additional Inventory, S-4, S-9, S-12, S-13, S-20, S-22, S-23, S-24, 2-2, 2-6, 2-8, 3-1, 3-2, 3-12, 3-15, 3-16, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-36, 3-39, 3-40, 3-42, 3-43, 5-3, 5-52, 5-54, 5-59, 5-61, 5-62, 5-63, 5-83, 5-88, 5-89, 5-90, 5-92, 5-93, 5-94, 5-96, 5-122, 5-125, 5-126, 5-127, 5-128, 5-129, 5-149, 5-152, 5-153, 5-176, 5-183, A-2, A-9, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-23, A-26, A-27, A-61, B-4, B-7, B-8, E-19, F-6, F-15, I-36
air quality, S-27, S-29, S-31, S-73, 1-16, 4-6, 4-47, 4-49, 4-51, 5-1, 5-5, 5-6, 5-16, 5-56, 5-82, 5-84, 5-121, 5-122, 5-148, 5-150, 5-164, 5-178, 5-186, 5-188, 5-190, B-6, C-1, C-4, C-5, C-6, C-8, C-10, C-11, J-4
alpha radiation, S-1, S-12, 1-1, 2-3, 2-5, 2-18, 3-10, 4-45, 4-55, 5-180, 5-183, A-7, A-35, E-34, E-72, G-79
americium (Am), S-1, 2-3, 4-46, 4-48, 4-65, 5-37, 5-49, 5-50, 5-80, 5-117, 5-119, 5-146, 5-147, A-37, A-38, A-39, A-40, A-41, A-42, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-55, A-56, A-57, A-58, A-59, A-60, B-9, B-10, E-32, E-45, F-15, F-16, F-17, F-20, G-2, G-8, H-30, H-31, H-53, H-55, H-62, H-63, H-64, H-65, H-70, H-71, H-73, H-74, H-75, H-78, H-80, H-81, H-82, H-83, H-86, H-87, H-88, H-90, I-20, I-27, I-28, I-30, I-31
Ames Laboratory- Iowa State University, S-10, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-28, A-43, E-19, E-24
aquifer, S-29, S-31, S-32, S-33, S-34, S-35, S-36, 4-24, 4-28, 4-47, 4-49, 4-52, 4-55, 4-57, 4-59, 4-60, 4-63, 4-64, 4-66, 5-174, H-26, H-94, H-96, H-99, I-21, I-23, I-32
archeological site, S-27, S-29, S-31, 4-1, 4-35, 4-38, 4-47, 4-50, 4-53, 4-55, 4-65
ARCO Medical Products Company, 2-8, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, A-9, A-15, A-18, A-19, A-20, A-22, A-26, A-27, A-33, A-35, A-37, A-39, A-43, E-19, E-25
Argonne National Laboratory-East (ANL-E), S-10, S-29, S-38, S-43, S-67, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, 4-46, 4-47, 4-48, 5-5, 5-11, 5-34, 5-56, 5-60, 5-84, 5-122, 5-150, 5-166, 5-184, 5-187, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-28, A-34, A-35, A-36, A-37, A-39, A-43, A-45, A-47, A-64, B-2, B-4, B-5, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-7, D-14, E-2, E-9, E-33, F-16, F-17
Argonne National Laboratory-West (ANL-W), S-10, S-22, S-23, S-24, 2-6, 3-3, 3-17, 3-18, 3-21, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, 5-61, 5-92, 5-96, 5-129, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-31, A-43, D-2, D-3, D-4, D-5, D-6, D-7, E-22, E-23, E-26, E-35, E-37, E-73, I-13

B

backfill, S-19, S-27, 3-10, 3-11, 3-50, 4-6, 5-189, H-3, H-4, H-6, H-10, H-17, H-23, H-24, H-29, H-41, H-53, H-77, H-85, I-14
background radiation, 4-45, 4-48, 5-17, E-30, F-30
Baseline Inventory Report (BIR), S-5, S-10, S-12, S-16, S-73, 1-4, 1-10, 2-6, 3-3, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, 5-32, 5-55, 5-183, 5-185, 5-189, 5-191, A-2, A-3, A-4, A-8, A-9, A-10, A-12, A-13, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23,

A-24, A-25, A-35, A-36, A-43, A-61, A-62, B-3, E-12, E-31, E-44, F-6, H-31, I-3, I-12, J-1
Basic Inventory, S-9, S-10, S-12, S-13, S-18, S-19, S-20, S-22, S-23, S-24, S-41, S-50, S-73, S-82, 2-2, 2-6, 3-1, 3-2, 3-3, 3-4, 3-15, 3-16, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-36, 3-39, 3-40, 3-42, 3-43, 3-45, 5-3, 5-10, 5-54, 5-59, 5-61, 5-62, 5-63, 5-68, 5-70, 5-72, 5-83, 5-88, 5-89, 5-90, 5-92, 5-93, 5-94, 5-96, 5-100, 5-103, 5-105, 5-122, 5-125, 5-127, 5-128, 5-129, 5-131, 5-133, 5-135, 5-149, 5-152, 5-153, 5-158, 5-159, 5-160, 5-165, 5-167, 5-168, 5-169, 5-176, 5-177, 5-189, 5-190, 5-191, A-1, A-2, A-8, A-9, A-10, A-12, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-25, A-26, A-27, A-30, A-34, A-35, A-61, B-8, E-19, F-6, F-15, F-26, F-28, F-29, F-34, F-38, G-43, I-36, J-1, J-4, J-5, J-7
Battelle Columbus Laboratories (BCL), S-10, 2-6, 3-3, 3-18, 3-24, 3-27, 3-30, 3-34, 3-40, 3-43, 3-46, A-10, A-12, A-16, A-21, A-23, A-24, A-31
berm, S-19, S-37, S-38, S-39, 3-14, 3-20, 3-30, 3-37, 5-4, 5-6, 5-8, 5-84, 5-122, C-10
beryllium (Be), 2-16, 4-46, 5-25, 5-28, 5-42, 5-46, 5-50, 5-109, 5-144, A-61, A-62, E-58, E-59, E-60, G-3, G-4, G-6, G-9, G-26, G-30, G-31, G-39, G-41, G-42, G-50, G-58, G-61, G-70, G-72, G-75, G-78, H-31, H-53, H-55, H-62, H-63, H-64, H-71, H-74, H-80, H-82, H-87, H-89, I-20, I-21, I-27, I-28, I-29, I-30, I-31
beta radiation, 2-3, 2-5, 3-10, 4-45
Bettis Atomic Power Laboratory, S-10, 2-6, 3-3, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, A-2, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-31, A-43, E-19, E-24, E-25
brine, S-4, S-6, S-19, S-27, S-28, S-61, 1-11, 2-11, 2-17, 2-18, 3-10, 3-13, 4-9, 4-13, 4-21, 4-22, 4-23, 4-24, 4-28, 4-29, 4-30, 4-31, 4-33, 4-70, 5-45, 5-46, 5-48, 5-49, 5-50, 5-78, 5-80, 5-82, 5-116, 5-117, 5-119, 5-146, 5-147, 5-148, H-2, H-3, H-4, H-5, H-6, H-7, H-8, H-9, H-10, H-13, H-14, H-15, H-17, H-23, H-24, H-25, H-27, H-28, H-38, H-39, H-40, H-42, H-43, H-44, H-45, H-46, H-47, H-48, H-49, H-50, H-51, H-52, H-54, H-55, H-56, H-57, H-58, H-59, H-60, H-62, H-63, H-65, H-67, H-68, H-69, H-70, H-71, H-75, H-77, H-83, H-85, H-86, H-89, H-92, H-94, H-96, H-97, H-101, H-105, H-108

C

cadmium (Cd), 2-4, 2-5, 2-16, 5-25, 5-46, 5-50, A-4, A-28, A-29, A-30, A-31, A-33, A-37, A-38, A-39, A-40, A-45, A-47, A-50, A-51, A-53, A-56, A-61, A-62, A-63, E-58, E-60, G-3, G-4, G-6, G-9, G-39, G-41, G-42, G-50, G-58, G-61, H-31, H-53, H-55, H-62, H-63, H-64, H-71, H-74, H-80, H-82, H-87, H-89, I-20, I-21, I-27, I-28, I-29, I-30, I-31
cancer, S-29, S-46, S-49, S-51, S-52, S-53, S-54, S-55, S-56, S-61, S-67, S-68, 4-48, 4-51, 4-58, 5-16, 5-17, 5-19, 5-20, 5-24, 5-27, 5-28, 5-29, 5-30, 5-31, 5-32, 5-33, 5-34, 5-35, 5-37, 5-38, 5-40, 5-42, 5-50, 5-54, 5-61, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-75, 5-76, 5-80, 5-82, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-107, 5-109, 5-111, 5-112, 5-115, 5-119, 5-121, 5-129, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-142, 5-144, 5-147, 5-148, 5-157, 5-158, 5-159, 5-160, 5-162, 5-166, 5-167, 5-168, 5-169, 5-175, 5-176, 5-177, 5-178, 5-180, 5-186, 5-187, B-7, B-8, B-11, B-29, B-30, B-31, B-32, B-33, E-12, E-66, E-67, F-2, F-3, F-13, F-35, F-36, F-37, F-38, F-39, G-1, G-2, G-3, G-20, G-22, G-24, G-25, G-26, G-27, G-29, G-30, G-31, G-32, G-33, G-34, G-35, G-44, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-54, G-55, G-56, G-69, G-70, G-71, G-73, G-74, G-75, G-76, G-77, H-56, H-58, H-62, H-64, H-67, H-70, H-74, H-75, H-78, H-82, H-83, H-89, H-91, I-3, I-5, I-6, I-7, I-25, I-27, I-28, I-29, I-30, I-31, I-32, I-33, I-36
carcinogen, 5-24, 5-27, 5-32, 5-35, 5-36, 5-42, 5-73, 5-74, 5-75, 5-104, 5-106, 5-107, 5-109, 5-111, 5-115, 5-136, 5-137, 5-138, 5-140, 5-141, 5-144, 5-162, 5-175, 5-176, F-1, F-3, F-4, F-35, F-38, F-39, G-1, G-3, G-5, G-20, G-22, G-24, G-25, G-26, G-27, G-29, G-30, G-31, G-32, G-34, G-35, G-41, G-44, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-55, G-56, G-70, G-71, G-73, G-74, G-76, G-77, H-56, H-64, H-74, H-82, H-89, I-5, I-6, I-9, I-10, I-22, I-25, I-29, I-33, I-36
commercial rail, S-6, S-19, 3-1, 3-18, 3-27, 3-37, 3-45, 3-56, 5-58, 5-88, 5-89, 5-125
commercial waste, S-9
Compliance Certification Application (CCA), S-3, S-4, S-5, 1-9, 1-10, 2-10, 4-19, 4-22, 4-24, 4-25, 4-26, 4-27, 4-28, 4-30, 4-31, 4-68, A-2, H-2, H-3, H-4, H-5, H-6, H-9, H-11, H-13, H-14, H-15, H-16, H-17, H-23, H-24, H-25, H-26, H-28, H-29, H-32, H-37, H-39, H-40, H-41, H-42, H-43, H-44, H-45, H-46, H-47, H-48, H-49, H-50, H-52, H-53, H-54, H-55, H-57, H-75, H-83, H-90, H-91, H-92, H-93, H-94, H-95, H-96, H-97, H-100, H-101, H-102, H-104, H-105, H-106, H-107
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), S-31, S-32, S-35, S-37, 1-8, 3-3, 3-12, 4-51, 4-52, 4-55, 4-59, 4-63, 4-67, 5-52, A-12
consolidation sites, S-24, S-50, S-56, 1-15, 3-2, 3-4, 3-6, 3-38, 3-43, 3-45, 3-47, 5-2, 5-88, 5-89, 5-92, 5-125, 5-126, D-1, D-8, E-61, E-72, F-6, F-7, F-10, F-11, F-12, F-13, F-17, F-29, F-30, F-36, F-37, G-39
Consultation and Cooperation Agreement (C&C), S-9, S-12, S-13, S-20, S-82, 1-3, 3-2, 3-3, 3-20, 3-30, 3-37, 3-56, 5-10, 5-191, J-7
contact-handled (CH) TRU waste, S-5, S-6, S-7, S-12, S-13, S-16, S-17, S-18, S-19, S-22, S-23, S-24,

S-49, S-51, S-52, S-53, S-54, S-55, S-57, S-58, S-60, S-61, S-67, S-73, S-82, 1-1, 1-3, 1-4, 1-5, 1-7, 1-9, 1-11, 1-12, 2-3, 2-4, 2-5, 2-11, 2-15, 2-17, 2-18, 3-2, 3-3, 3-4, 3-6, 3-9, 3-10, 3-11, 3-16, 3-17, 3-18, 3-20, 3-21, 3-22, 3-23, 3-26, 3-27, 3-29, 3-32, 3-34, 3-37, 3-38, 3-39, 3-42, 3-43, 3-45, 3-50, 5-3, 5-10, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-21, 5-22, 5-24, 5-25, 5-27, 5-28, 5-29, 5-30, 5-31, 5-32, 5-34, 5-36, 5-37, 5-40, 5-41, 5-45, 5-50, 5-55, 5-59, 5-61, 5-62, 5-63, 5-66, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-77, 5-78, 5-80, 5-83, 5-88, 5-89, 5-90, 5-91, 5-92, 5-93, 5-94, 5-95, 5-96, 5-98, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-106, 5-107, 5-108, 5-109, 5-110, 5-111, 5-113, 5-114, 5-116, 5-117, 5-119, 5-125, 5-126, 5-127, 5-128, 5-129, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-140, 5-142, 5-143, 5-144, 5-145, 5-146, 5-147, 5-152, 5-153, 5-154, 5-155, 5-156, 5-157, 5-158, 5-159, 5-160, 5-161, 5-162, 5-163, 5-165, 5-167, 5-168, 5-169, 5-172, 5-173, 5-174, 5-175, 5-177, 5-179, 5-180, 5-183, 5-189, 5-190, 5-191, A-2, A-3, A-5, A-6, A-7, A-10, A-12, A-13, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-24, A-25, A-26, A-27, A-28, A-29, A-30, A-33, A-34, A-35, A-36, A-37, A-38, A-39, A-40, A-42, A-43, A-44, A-45, A-47, A-48, A-50, A-51, A-53, A-55, A-56, A-57, A-60, A-61, A-62, A-63, A-64, A-65, A-66, B-3, B-4, B-5, B-6, B-8, B-9, B-10, B-11, C-8, C-9, D-8, D-9, E-12, E-13, E-14, E-19, E-22, E-24, E-25, E-30, E-32, E-33, E-34, E-35, E-36, E-40, E-44, E-45, E-47, E-48, E-49, E-50, E-52, E-55, E-57, E-58, E-60, E-61, E-68, E-69, E-70, E-71, E-73, F-2, F-7, F-8, F-9, F-10, F-13, F-15, F-16, F-17, F-18, F-19, F-20, F-21, F-22, F-24, F-25, F-26, F-27, F-30, F-32, F-37, G-2, G-3, G-7, G-8, G-9, G-10, G-11, G-12, G-13, G-15, G-22, G-23, G-27, G-28, G-33, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-54, G-55, G-56, G-57, G-58, G-59, G-60, G-64, G-65, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, H-30, H-41, H-53, H-57, H-63, H-65, H-67, H-70, H-71, H-73, H-74, H-75, H-78, H-80, H-81, H-82, H-83, H-86, H-87, H-88, H-89, H-90, I-12, I-13, I-21, I-26, I-27, I-29, I-30, I-31, I-32, J-1, J-4, J-5, J-7

contaminant, S-28, S-31, S-35, S-36, S-61, S-67, 2-18, 4-9, 4-22, 4-30, 4-33, 4-49, 4-52, 4-53, 4-58, 4-60, 4-64, 5-33, 5-45, 5-50, 5-54, 5-82, 5-119, 5-148, 5-164, 5-171, 5-172, 5-174, 5-175, 5-176, 5-187, A-65, E-42, E-52, G-11, G-13, G-15, G-19, H-1, H-7, H-8, H-9, H-10, H-13, H-14, H-15, H-16, H-17, H-23, H-24, H-26, H-27, H-28, H-39, H-54, H-55, H-56, H-65, H-67, H-71, H-75, H-83, H-89, H-90, H-92, H-95, H-98, H-100, H-102, H-103, H-104, H-105, H-107, I-1, I-2, I-4, I-5, I-6, I-7, I-8, I-9, I-10, I-11, I-13, I-14, I-16, I-17, I-18, I-19, I-20, I-21, I-22, I-23, I-24, I-32, I-33, I-38

creep, 2-10, 3-9, 3-11, 3-13, 5-177, E-71, E-72, H-2, H-3, H-6, H-15, H-17, H-23, H-39, H-45, H-51, H-57, H-93, H-102

criteria pollutants, S-31, S-32, S-35, S-36, S-38, 4-6, 4-47, 4-49, 4-51, 4-54, 4-56, 4-62, 4-64, 4-66, 5-5, 5-6, 5-84, 5-150, 5-187, C-2, C-5, C-6, C-10

criticality, 2-2, 5-37, 6-3, A-8, G-9, G-10, G-38, H-57

cultural resource, S-28, S-32, S-33, S-35, S-36, S-38, S-39, S-40, S-73, 4-2, 4-35, 4-38, 4-48, 4-53, 4-55, 4-57, 4-61, 4-63, 4-65, 4-67, 5-2, 5-4, 5-7, 5-8, 5-56, 5-57, 5-58, 5-82, 5-83, 5-85, 5-121, 5-122, 5-123, 5-148, 5-149, 5-151, 5-165, 5-188, 5-190, B-6, J-4

cumulative impact, S-12, 1-15, 3-8, 5-183, 5-186, B-1, B-6, G-43

D

decommissioning, S-1, S-3, S-9, S-12, S-19, S-37, S-38, S-39, S-41, S-43, S-60, S-61, 1-1, 1-3, 1-4, 1-14, 2-1, 3-2, 3-4, 3-12, 3-14, 3-16, 3-20, 3-22, 3-27, 3-30, 3-34, 3-37, 3-40, 4-2, 4-6, 4-64, 4-69, 5-1, 5-6, 5-7, 5-8, 5-10, 5-11, 5-43, 5-44, 5-56, 5-58, 5-77, 5-84, 5-85, 5-115, 5-116, 5-122, 5-123, 5-145, 5-150, 5-151, 5-152, 5-153, 5-163, 5-164, 5-165, 5-170, 5-172, 5-188, 5-189, A-1, A-2, C-3, C-10, D-1, D-2, D-3, D-4, D-5, D-6, D-13, E-67, J-1

decontamination, S-1, S-9, S-12, S-41, 1-1, 1-3, 1-14, 2-1, 2-11, 3-10, 4-64, 4-69, 5-10, 5-178, 5-179, A-1, A-2, D-1, D-2, D-3, D-4, D-5, D-6, E-44, J-1

dedicated rail, S-6, S-22, S-23, S-24, S-40, S-41, S-44, S-69l, 3-1, 3-6, 3-18, 3-27, 3-37, 3-45, 5-55, 5-60, 5-64, 5-65, 5-83, 5-88, 5-89, 5-90, 5-92, 5-98, 5-121, 5-125, 5-129, 5-149, 5-152, 5-156, 5-182, D-9, E-61, E-64, E-65, E-66

defense waste, S-13, 2-2, 5-166, A-1

design-basis, G-32, G-43

dose, S-1, S-6, S-29, S-31, S-32, S-33, S-34, S-35, S-36, S-37, S-47, S-48, S-68, 1-1, 1-3, 1-11, 2-3, 3-20, 4-45, 4-48, 4-51, 4-53, 4-56, 4-58, 4-60, 4-61, 4-63, 4-65, 4-67, 4-70, 5-16, 5-17, 5-18, 5-20, 5-22, 5-26, 5-27, 5-28, 5-31, 5-34, 5-37, 5-42, 5-49, 5-50, 5-65, 5-67, 5-72, 5-80, 5-82, 5-99, 5-105, 5-115, 5-119, 5-131, 5-135, 5-136, 5-144, 5-147, 5-148, 5-157, 5-161, 5-169, 5-177, 5-180, 5-189, A-1, A-55, B-7, B-29, B-30, B-31, B-32, B-33, E-30, E-31, E-32, E-33, E-34, E-35, E-36, E-37, E-40, E-43, E-44, E-51, E-52, E-56, E-65, E-66, E-67, F-2, F-3, F-5, F-6, F-7, F-13, F-15, F-16, F-17, F-18, F-19, F-20, F-21, F-24, F-27, F-30, F-32, F-33, F-34, F-39, G-1, G-2, G-7, G-8, G-18, G-19, G-23, G-28, G-30, G-31, G-33, G-36, G-38, G-45, G-48, G-49, G-50, G-52, G-56, G-73, G-76, G-79, H-29, H-30, H-31, H-55, H-56, H-57, H-59, H-62, H-64, H-65, H-67, H-70, H-73, H-74, H-75, H-78, H-81, H-82, H-83, H-86, H-88, H-90, I-1, I-3, I-4, I-6, I-7, I-8, I-9, I-10, I-20, I-21, I-24, I-26, I-27, I-28, I-29, I-30, I-31, I-33

E

earthquake, S-32, S-33, S-37, S-57, S-58, S-59, S-71, S-72, 3-55, 3-56, 4-14, 4-16, 4-49, 4-52, 4-54, 4-57, 4-60, 4-62, 4-64, 4-66, 5-35, 5-36, 5-38, 5-40, 5-73, 5-74, 5-75, 5-76, 5-107, 5-108, 5-109, 5-110, 5-111, 5-112, 5-113, 5-137, 5-138, 5-139, 5-140, 5-141, 5-142, 5-162, G-6, G-10, G-12, G-14, G-15, G-16, G-17, G-18, G-19, G-22, G-23, G-24, G-25, G-26, G-27, G-28, G-29, G-30, G-32, G-33, G-34, G-37, G-38, G-43, G-44, G-45, G-46, G-47, G-50, G-51, G-53, G-54, G-64
emergency response, S-4, 3-7, 5-14, 5-15, 5-188, E-4, E-51, E-52, E-57, E-63, G-4, G-21
employment, S-28, S-31, S-37, S-40, S-43, 4-38, 4-39, 4-41, 4-50, 4-53, 4-58, 4-67, 4-71, 5-9, 5-11, 5-12, 5-59, 5-60, 5-86, 5-87, 5-90, 5-91, 5-124, 5-125, 5-126, 5-153, 5-154, D-10, D-11, D-12, D-13, D-14, D-16
endangered species, S-28, S-29, S-31, S-32, S-33, S-34, S-35, S-36, S-37, S-39, 4-34, 4-35, 4-36, 4-37, 4-47, 4-50, 4-53, 4-55, 4-57, 4-59, 4-60, 4-63, 4-65, 4-67, 4-71, 5-4, 5-6, 5-7, 5-56, 5-57, 5-83, 5-85, 5-122, 5-123, 5-149, 5-150, 6-1, 6-2
Energy Technical Engineering Center (ETEC), S-10, 2-6, 3-3, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-31, A-34, A-35, A-37, A-39, A-41, A-42, A-43, B-3, B-4
environmental justice, S-31, S-68, S-69, 1-15, 4-42, 4-50, 5-181, B-6
exposure pathway, 5-17, 5-21, 5-24, 5-34, 5-106, 5-137, B-7, E-43, E-51, F-6, F-12, G-22, G-38, G-44, G-68, H-62, H-70, H-78, H-86, I-5, I-6, I-9, I-25, I-33

F

fatalities, S-2, S-29, S-43, S-44, S-46, S-50, S-60, S-68, S-69, S-71, S-72, 1-2, 3-50, 3-55, 3-56, 4-48, 5-12, 5-14, 5-15, 5-16, 5-17, 5-20, 5-42, 5-43, 5-44, 5-52, 5-61, 5-62, 5-65, 5-66, 5-67, 5-77, 5-93, 5-98, 5-99, 5-115, 5-116, 5-127, 5-130, 5-144, 5-145, 5-154, 5-155, 5-156, 5-162, 5-163, 5-170, 5-178, 5-181, 5-182, 5-185, 5-186, 5-187, B-7, B-8, E-2, E-12, E-14, E-19, E-26, E-27, E-30, E-56, E-60, E-63, E-64, E-66, E-67, E-68, E-69, E-70, E-71, E-72, E-73, F-2, G-1, G-25, G-27, G-32, G-44, H-56, I-3, I-6, I-7, I-25, I-27, I-28, I-30, I-31, I-32
Federal Facility Compliance Act (FFCAct), S-3, 1-14, 2-9, 3-38, E-1
Final Environmental Impact Statement (FEIS), S-1, S-27, 1-4, 1-5, 1-15, 2-2, 3-47, 3-49, 4-1, 4-6, 4-9, 4-35, 4-38, 4-45, 4-46, 5-5, 5-8, 5-170, 5-171, 5-187, 5-189, A-1, C-10, E-42, I-1
fire, 2-3, 2-11, 3-8, 4-2, 4-5, 5-12, 5-35, 5-36, 5-37, 5-38, 5-41, 5-60, 5-74, 5-75, 5-76, 5-91, 5-109, 5-110, 5-113, 5-114, 5-126, 5-137, 5-138, 5-139, 5-140, 5-141, 5-142, 5-143, A-61, C-6, E-4, E-40, E-41, E-42, E-43, E-44, E-45, E-46, E-47, E-48, E-52, E-55, E-57, E-58, G-6, G-9, G-10, G-11, G-12, G-16, G-17, G-23, G-24, G-25, G-26, G-32, G-33, G-34, G-36, G-37, G-41, G-42, G-43, G-45, G-46, G-49, G-53, G-54, G-56, G-57, G-59, G-63, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-76, G-77, I-21
fugitive dust emissions, S-38, 5-5, 5-188, C-3

G

gamma radiation, 2-3, 2-5, 3-10, 4-45, E-31, E-32, E-72, G-2, G-38
generator-storage sites, S-18, S-19, S-29, S-38, S-49, S-52, S-54, S-55, S-56, S-61, S-67, S-71, S-72, S-73, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 1-15, 2-9, 2-10, 3-4, 3-6, 3-7, 3-8, 3-16, 3-20, 3-22, 3-36, 3-45, 3-47, 3-50, 3-56, 4-1, 4-46, 5-34, 5-61, 5-68, 5-70, 5-71, 5-72, 5-95, 5-101, 5-102, 5-105, 5-131, 5-132, 5-134, 5-136, 5-149, 5-151, 5-157, 5-160, 5-165, 5-166, 5-167, 5-168, 5-169, 5-170, 5-172, 5-174, 5-175, 5-176, 5-190, A-3, A-35, A-55, A-61, D-7, E-2, E-12, E-14, E-19, E-30, E-59, E-61, E-73, F-1, F-2, F-3, F-12, F-13, F-15, F-18, F-25, F-30, F-32, F-35, F-37, G-10, G-44, G-54, H-27, I-1, I-25, I-32, I-33, J-1
groundwater, S-19, S-28, S-31, S-32, S-33, S-34, S-35, S-36, S-37, 2-11, 3-49, 3-50, 4-1, 4-2, 4-5, 4-9, 4-13, 4-21, 4-24, 4-25, 4-27, 4-30, 4-45, 4-46, 4-47, 4-48, 4-49, 4-51, 4-52, 4-55, 4-57, 4-59, 4-60, 4-62, 4-64, 4-66, 4-68, 5-4, 5-50, 5-54, 5-172, 5-174, 5-175, 5-176, A-65, F-6, H-5, H-6, H-7, H-13, H-17, H-24, H-26, H-29, H-54, H-57, H-59, H-67, H-95, H-96, H-99, H-100, H-102, H-106, H-107, I-3, I-5, I-6, I-8, I-9, I-18, I-21, I-25, I-32, I-33, I-36, I-37

H

habitat, S-28, S-37, S-38, S-39, S-40 4-34, 4-35, 4-51, 4-55, 4-57, 4-59, 4-61, 4-63, 4-67, 5-4, 5-6, 5-7, 5-56, 5-57, 5-83, 5-85, 5-122, 5-123, 5-149, 5-151, 5-188
half-life, 1-1, 5-21, 5-22, 5-180, E-41, E-52, E-55, F-6, F-7, H-29, H-31, H-56
HALFPACK, 2-3, E-13
Hanford Site, S-10, S-22, S-23, S-24, S-29, S-31, S-40, S-43, S-47, S-49, S-51, S-53, S-54, S-55, S-58, S-59, S-67, S-73, S-82, 2-6, 3-2, 3-3, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 4-48, 4-49, 4-50, 4-51, 5-9, 5-10, 5-11, 5-13, 5-14, 5-21, 5-22, 5-32, 5-34, 5-36, 5-37, 5-38, 5-40, 5-54, 5-55, 5-59, 5-60, 5-61, 5-63, 5-70, 5-73, 5-75, 5-76, 5-86, 5-87, 5-88, 5-89, 5-90, 5-92, 5-96, 5-99, 5-100, 5-101, 5-102, 5-103, 5-106, 5-107, 5-108, 5-109, 5-110, 5-111, 5-124, 5-125, 5-126, 5-129, 5-130, 5-131, 5-132, 5-133, 5-134, 5-137, 5-138, 5-139, 5-140, 5-141, 5-149, 5-153, 5-156, 5-157, 5-158, 5-159, 5-161, 5-162, 5-166, 5-168, 5-172,

5-173, 5-174, 5-175, 5-176, 5-184, 5-185, 5-186, 5-190, 5-191, A-2, A-8, A-9, A-10, A-12, A-14, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-30, A-31, A-33, A-34, A-35, A-37, A-39, A-41, A-42, A-43, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-56, A-57, A-58, A-59, A-64, A-65, B-2, B-3, B-4, B-5, B-6, B-9, B-10, B-11, B-29, B-30, B-31, B-32, B-33, C-12, D-2, D-3, D-4, D-5, D-6, D-7, D-9, D-13, D-14, D-15, D-16, E-10, E-22, E-23, E-25, E-26, E-33, E-35, E-37, E-45, E-73, F-7, F-8, F-9, F-10, F-12, F-13, F-15, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-30, F-31, F-33, F-34, F-35, F-36, F-37, F-38, F-40, G-7, G-8, G-10, G-15, G-18, G-19, G-20, G-22, G-23, G-24, G-25, G-26, G-27, G-28, G-29, G-30, G-31, G-33, G-34, G-35, G-37, G-39, G-44, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-54, G-55, G-79, G-80, I-1, I-2, I-5, I-12, I-13, I-15, I-22, I-23, I-26, I-27, I-28, I-29, I-30, I-31, I-32, I-33, I-36, I-37, I-38, J-1, J-5, J-7

hazard index (HI), S-61, 5-27, 5-28, 5-29, 5-30, 5-32, 5-34, 5-54, 5-68, 5-69, 5-70, 5-71, 5-101, 5-102, 5-104, 5-132, 5-134, 5-135, 5-136, 5-157, 5-159, 5-166, 5-167, 5-168, 5-173, 5-174, 5-175, 5-176, F-3, F-4, F-32, F-35, F-36, F-37, F-38, F-39, H-56, H-82, H-89, I-3, I-5, I-8, I-24, I-25, I-29, I-32, I-36, I-37

hazardous chemical, S-46, S-48, S-49, S-51, S-52, S-53, S-54, S-55, S-56, S-67, S-68, 1-15, 1-16, 2-4, 3-6, 4-63, 5-1, 5-2, 5-21, 5-22, 5-23, 5-24, 5-25, 5-26, 5-27, 5-28, 5-29, 5-30, 5-31, 5-33, 5-34, 5-35, 5-37, 5-38, 5-40, 5-42, 5-61, 5-64, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-75, 5-76, 5-98, 5-99, 5-101, 5-102, 5-104, 5-106, 5-107, 5-109, 5-111, 5-112, 5-113, 5-115, 5-129, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-142, 5-143, 5-144, 5-155, 5-157, 5-159, 5-160, 5-163, 5-164, 5-166, 5-167, 5-168, 5-169, 5-172, 5-173, 5-174, 5-175, 5-176, 5-177, 5-178, 5-180, A-63, B-7, B-11, B-29, B-30, B-31, B-32, B-33, E-12, E-57, E-58, E-59, E-67, F-1, F-3, F-4, F-7, F-9, F-10, F-12, F-13, F-30, F-35, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-10, G-17, G-20, G-22, G-24, G-25, G-26, G-27, G-29, G-30, G-31, G-32, G-33, G-34, G-35, G-37, G-39, G-41, G-44, G-47, G-48, G-49, G-50, G-51, G-52, G-54, G-55, G-56, G-57, G-60, G-72, G-75, G-78, H-6, H-58, I-4, I-5, I-10, I-26, I-29, I-32, I-37, J-1

hazardous metals, S-61, A-61

hazardous waste, S-1, S-5, S-17, S-18, 1-8, 1-10, 1-12, 2-4, 2-9, 4-51, A-61, B-1, E-4, E-5, G-63

heavy metals, S-2, 1-2, 2-5, 2-16, 2-18, 2-19, 4-21, 5-24, 5-25, 5-35, 5-36, 5-38, 5-40, 5-42, 5-46, 5-48, 5-50, 5-54, 5-74, 5-75, 5-78, 5-80, 5-82, 5-98, 5-99, 5-107, 5-109, 5-110, 5-111, 5-113, 5-114, 5-115, 5-117, 5-119, 5-137, 5-138, 5-139, 5-140, 5-141, 5-146, 5-147, 5-148, 5-157, 5-164, 5-174, 5-188, E-58, G-1, G-3, G-7, G-8, G-9, G-20, G-22, G-26, G-27, G-32, G-36, G-37, G-39, G-43, G-44, G-49, G-50, G-57, G-58, G-60, G-61, G-63, G-64, G-65, G-69, G-70, G-73, G-75, G-76, H-1, H-8, H-10, H-11, H-13, H-17, H-27, H-28, H-29, H-31, H-32, H-55, H-58, H-62, H-63, H-65, H-67, H-70, H-75, H-78, H-83, H-89, H-90, I-29

High Efficiency Particulate Air (HEPA) filter, S-38, 2-4, 2-17, 3-6, A-4, 5-35, 5-42, 5-84, 5-107, 5-114, 5-137, 5-144, 5-150, 5-179, 5-188, G-10, G-11, G-12, G-13, G-15, G-17, G-18, G-58, G-61, G-65, G-66

hydraulic conductivity, 4-24, 4-25, 4-27, 4-33, 5-45, H-9, H-13, H-67, H-97, H-99, H-102, H-104, I-23

I

Idaho National Engineering and Environmental Laboratory (INEEL), S-10, S-17, S-22, S-23, S-24, S-31, S-32, S-38, S-40, S-43, S-50, S-52, S-56, S-58, S-59, S-67, S-82, 1-5, 1-12, 1-15, 2-6, 2-22, 3-2, 3-3, 3-17, 3-18, 3-21, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 4-51, 4-52, 4-53, 5-9, 5-11, 5-34, 5-36, 5-38, 5-52, 5-59, 5-60, 5-70, 5-73, 5-75, 5-84, 5-86, 5-87, 5-90, 5-99, 5-100, 5-103, 5-106, 5-107, 5-108, 5-109, 5-110, 5-111, 5-112, 5-124, 5-125, 5-130, 5-131, 5-133, 5-137, 5-138, 5-139, 5-140, 5-141, 5-149, 5-150, 5-153, 5-156, 5-158, 5-159, 5-161, 5-166, 5-168, 5-172, 5-173, 5-174, 5-175, 5-176, 5-183, 5-184, 5-185, 5-186, 5-191, A-7, A-9, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-30, A-31, A-33, A-35, A-37, A-39, A-41, A-42, A-43, A-45, A-46, A-47, A-49, A-50, A-51, A-53, A-56, A-57, A-58, A-59, A-64, A-65, B-2, B-3, B-4, B-5, B-7, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-4, D-5, D-6, D-7, D-13, D-14, D-15, D-16, E-10, E-22, E-24, E-26, E-27, E-33, E-35, E-36, E-73, F-7, F-9, F-10, F-12, F-13, F-15, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-30, F-31, F-33, F-34, F-35, F-36, F-37, F-38, F-39, G-7, G-8, G-19, G-20, G-22, G-23, G-24, G-26, G-28, G-29, G-31, G-33, G-34, G-35, G-39, G-45, G-46, G-48, G-49, G-50, G-51, G-53, G-54, I-1, I-2, I-13, I-15, I-21, I-23, I-26, I-27, I-28, I-29, I-30, I-31, I-33, I-36, I-37, J-1, J-5, J-7

Immediately Dangerous to Life or Health (IDLH), 5-24, 5-25, 5-35, 5-42, 5-43, 5-74, 5-107, 5-111, 5-137, 5-140, E-57, E-58, E-59, E-60, G-4, G-5, G-6, G-20, G-21, G-24, G-25, G-26, G-29, G-32, G-34, G-41, G-45, G-46, G-47, G-48, G-49, G-51, G-52, G-54, G-55, G-70, G-71, G-73, G-74, G-76, G-77, H-58

inhalation, 5-17, 5-22, 5-24, 5-33, 5-34, 5-43, 5-50, 5-67, 5-72, 5-80, 5-105, 5-106, 5-135, 5-136, 5-137, 5-147, 5-161, 5-169, 5-174, 5-175, 5-176, A-7, E-43, E-45, E-51, E-52, E-56, E-59, E-66, F-4, F-5, F-6, F-12, G-2, G-3, G-7, G-18, G-19, G-22, G-38, G-39, G-44, G-68, I-3, I-4, I-8, I-10, I-20, I-24, I-29, I-32, I-33, I-36, I-37

injuries, S-43, S-44, S-50, S-60, S-69, 5-12, 5-14, 5-15, 5-40, 5-43, 5-44, 5-52, 5-61, 5-62, 5-76, 5-77, 5-93, 5-113, 5-116, 5-127, 5-142, 5-145, 5-154, 5-155, 5-163, 5-170, 5-182, 5-185, E-2, E-12, E-14, E-19, E-26, E-27, E-30, E-72, G-44
involved worker, S-49, S-51, S-52, S-53, S-54, S-55, S-56, S-57, S-60, S-67, S-68, S-73, S-82, 5-26, 5-27, 5-28, 5-30, 5-31, 5-32, 5-33, 5-35, 5-38, 5-40, 5-42, 5-43, 5-52, 5-67, 5-71, 5-72, 5-73, 5-74, 5-76, 5-82, 5-99, 5-104, 5-105, 5-106, 5-107, 5-110, 5-111, 5-112, 5-113, 5-115, 5-121, 5-130, 5-134, 5-135, 5-136, 5-138, 5-139, 5-140, 5-141, 5-142, 5-143, 5-144, 5-149, 5-156, 5-160, 5-161, 5-166, 5-168, 5-169, 5-180, 5-188, 5-190, B-7, B-11, F-1, F-2, F-3, F-6, F-8, F-12, F-13, F-14, F-15, F-17, F-21, F-24, F-25, F-26, F-29, F-30, F-35, F-37, G-1, G-4, G-11, G-12, G-14, G-15, G-16, G-17, G-22, G-26, G-27, G-32, G-36, G-37, G-44, G-49, G-52, G-56, G-60, G-61, G-62, G-63, G-66, G-67, G-70, G-72, G-75, G-76, G-78, H-32, J-4, J-5
ionizing radiation, A-7

K

Knolls Atomic Power Laboratory, 2-8, 3-18, 3-24, 3-27, 3-30, 3-34, 3-40, 3-43, A-9, A-16, A-21, A-23, A-33, A-41, A-42, A-43, E-19, E-25

L

lag storage, S-22, S-23, S-49, S-51, S-52, S-53, S-54, S-55, S-73, 3-16, 3-24, 3-36, 5-56, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-82, 5-83, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-121, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-139, 5-149, 5-157, 5-167, 5-190, B-6, D-3, D-4, D-5, D-7, F-12, F-24, F-25, F-27, F-30, F-35, F-36, F-37, G-43, J-4
land disposal restrictions (LDR), S-3, S-5, S-16, S-22, S-24, 1-4, 1-8, 1-10, 2-9, 2-15, 2-18, 3-21, 3-22, 3-38, 5-83, 5-87, 5-94, A-14, B-4, B-5, B-6, B-7, E-1, F-7, F-12, F-19, F-20, F-36, F-38, G-1, G-12, G-43, G-49
Land Withdrawal Act (LWA), S-3, S-6, S-7, S-9, S-12, S-13, S-19, S-20, S-37, S-73, S-82, 1-1, 1-3, 1-4, 1-8, 1-9, 1-11, 1-15, 2-1, 2-4, 2-9, 2-11, 2-15, 2-18, 3-2, 3-3, 3-9, 3-14, 3-15, 3-20, 3-30, 3-37, 3-56, 4-1, 4-2, 4-5, 4-38, 5-4, 5-150, 5-177, 5-183, 5-189, 5-190, 5-191, A-1, A-12, A-35, A-42, A-44, E-67, J-4, J-7
latent cancer fatality (LCF), S-29, S-31, S-32, S-33, S-34, S-35, S-36, S-37, S-46, S-47, S-48, S-49, S-50, S-51, S-52, S-53, S-54, S-55, S-56, S-58, S-59, S-60, S-61, S-67, S-68, S-69, S-71, S-72, 4-48, 4-51, 4-53, 4-56, 4-58, 4-60, 4-61, 4-63, 4-65, 4-67, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, 5-22, 5-27, 5-28, 5-29, 5-30, 5-31, 5-34, 5-35, 5-36, 5-38, 5-40, 5-41, 5-42, 5-49, 5-50, 5-52, 5-54, 5-62, 5-63, 5-66, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-75, 5-76, 5-80, 5-82, 5-93, 5-94, 5-95, 5-96, 5-98, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-106, 5-107, 5-108, 5-109, 5-111, 5-112, 5-114, 5-115, 5-117, 5-119, 5-127, 5-128, 5-129, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-143, 5-144, 5-147, 5-148, 5-155, 5-156, 5-157, 5-158, 5-159, 5-160, 5-161, 5-162, 5-164, 5-166, 5-167, 5-168, 5-169, 5-173, 5-174, 5-175, 5-176, 5-177, 5-178, 5-180, 5-182, 5-185, 5-186, 5-187, B-7, B-8, B-11, B-29, B-30, B-31, B-32, B-33, E-12, E-14, E-19, E-26, E-27, E-31, E-34, E-40, E-43, E-56, E-60, E-66, E-67, E-68, E-69, E-70, E-71, E-72, E-73, F-2, F-3, F-27, F-33, F-34, G-1, G-2, G-18, G-22, G-23, G-25, G-26, G-27, G-28, G-30, G-31, G-32, G-33, G-35, G-44, G-45, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-54, G-55, G-56, G-69, G-70, G-73, G-75, G-76, H-56, H-62, H-63, H-64, H-65, H-67, H-70, H-73, H-74, H-75, H-78, H-81, H-82, H-83, H-86, H-88, H-89, H-90, I-3, I-4, I-25, I-26, I-27, I-28, I-29, I-30, I-31, I-32, I-33, I-36
Lawrence Berkeley Laboratory (LBL), 2-8, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, A-9, A-15, A-18, A-19, A-20, A-22, A-26, A-27, A-33, A-35, A-37, A-39, A-43, B-3, B-4
Lawrence Livermore National Laboratory (LLNL), S-10, S-32, S-38, S-43, S-67, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, 4-54, 4-55, 4-56, 5-5, 5-9, 5-11, 5-28, 5-30, 5-34, 5-56, 5-60, 5-68, 5-70, 5-84, 5-122, 5-150, 5-166, 5-167, 5-168, 5-172, 5-173, 5-174, 5-175, 5-176, 5-184, 5-185, 5-187, A-8, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-35, A-37, A-39, A-43, A-45, A-47, A-56, A-57, A-64, A-65, B-2, B-4, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-7, D-13, D-14, D-15, D-16, E-2, E-11, E-33, F-16, F-17, I-2, I-3, I-15, I-23, I-30, I-31, I-33, I-36, I-37
lead (Pb), S-1, S-34, S-38, 1-1, 2-3, 2-4, 2-5, 2-16, 3-3, 4-30, 4-46, 4-58, 4-64, 5-5, 5-25, 5-46, 5-49, 5-50, 5-55, 5-76, 5-78, 5-85, 5-109, 5-117, 5-144, 5-173, 5-176, A-4, A-12, A-28, A-29, A-30, A-31, A-33, A-37, A-38, A-39, A-40, A-41, A-42, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-56, A-57, A-58, A-60, A-61, A-62, A-63, C-1, C-12, C-13, E-58, E-60, F-18, G-3, G-4, G-5, G-6, G-7, G-9, G-14, G-15, G-25, G-26, G-30, G-31, G-32, G-35, G-37, G-39, G-41, G-42, G-49, G-58, G-61, G-66, G-70, G-72, G-75, G-78, H-8, H-9, H-27, H-30, H-31, H-53, H-55, H-62, H-63, H-64, H-65, H-71, H-73, H-74, H-75, H-80, H-81, H-82, H-83, H-86, H-87, H-88, H-89, H-90, I-20, I-21, I-27, I-28, I-29, I-30, I-31, I-32, I-36, I-37
life-cycle costs, S-41, S-73, 1-16, 5-2, 5-9, 5-10, 5-11, 5-59, 5-60, 5-83, 5-87, 5-88, 5-89, 5-90, 5-121, 5-124, 5-125, 5-149, 5-152, 5-153, 5-165, 5-190, B-6, D-1, J-4
Los Alamos National Laboratory (LANL), S-10, S-17, S-22, S-23, S-24, S-33, S-40, S-43, S-50, S-52, S-53, S-54, S-55, S-56, S-58, S-59, S-67, S-69, S-83, 1-12, 1-13, 2-6, 2-9, 3-2, 3-3, 3-17, 3-18, 3-20, 3-21, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32,

3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 4-56, 4-57, 4-58, 5-9, 5-11, 5-28, 5-30, 5-34, 5-36, 5-37, 5-52, 5-59, 5-60, 5-64, 5-68, 5-69, 5-70, 5-73, 5-75, 5-76, 5-84, 5-86, 5-90, 5-100, 5-101, 5-103, 5-106, 5-107, 5-108, 5-111, 5-124, 5-125, 5-131, 5-132, 5-133, 5-137, 5-138, 5-139, 5-140, 5-141, 5-149, 5-150, 5-153, 5-157, 5-158, 5-159, 5-161, 5-162, 5-166, 5-167, 5-168, 5-172, 5-173, 5-174, 5-175, 5-176, 5-181, 5-182, 5-184, 5-185, 5-186, 5-191, A-8, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-25, A-26, A-27, A-28, A-31, A-32, A-33, A-35, A-37, A-39, A-41, A-42, A-43, A-45, A-46, A-47, A-49, A-50, A-53, A-56, A-57, A-58, A-59, A-64, A-65, B-2, B-3, B-4, B-5, B-7, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-4, D-5, D-6, D-7, D-13, D-14, D-15, D-16, E-11, E-24, E-25, E-33, E-73, F-9, F-10, F-12, F-13, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-30, F-31, F-33, F-34, F-35, F-36, F-37, F-38, F-39, G-7, G-8, G-19, G-20, G-22, G-23, G-24, G-25, G-26, G-28, G-29, G-30, G-33, G-34, G-35, G-39, G-45, G-46, G-48, G-50, G-51, G-53, G-54, G-55, I-2, I-15, I-23, I-26, I-27, I-28, I-30, I-31, I-33, I-36, I-37, J-1, J-5, J-7

M

magnesium oxide (MgO), S-19, S-27, 3-10, 3-11, H-3, H-4, H-24, H-41, H-53
maximally exposed individual (MEI), S-29, S-31, S-32, S-33, S-34, S-35, S-36, S-37, S-47, S-48, S-49, S-51, S-52, S-53, S-54, S-55, S-56, S-58, S-59, S-60, S-61, S-67, 4-48, 4-51, 4-53, 4-56, 4-58, 4-60, 4-61, 4-63, 4-65, 4-67, 5-18, 5-19, 5-25, 5-26, 5-27, 5-28, 5-29, 5-34, 5-36, 5-37, 5-40, 5-41, 5-42, 5-67, 5-68, 5-69, 5-70, 5-75, 5-94, 5-100, 5-101, 5-103, 5-108, 5-109, 5-111, 5-112, 5-114, 5-115, 5-129, 5-130, 5-131, 5-132, 5-133, 5-138, 5-140, 5-141, 5-143, 5-144, 5-148, 5-156, 5-157, 5-158, 5-159, 5-162, 5-166, 5-167, 5-172, 5-175, 5-178, 5-179, 5-180, B-7, B-8, B-11, B-29, B-30, B-31, B-32, B-33, E-23, E-32, E-34, E-40, E-55, E-56, E-59, E-60, E-66, E-67, F-1, F-2, F-4, F-7, F-10, F-12, F-13, F-14, F-31, F-32, F-35, F-36, F-37, F-38, F-39, G-1, G-3, G-19, G-20, G-22, G-23, G-24, G-25, G-27, G-28, G-29, G-30, G-32, G-33, G-34, G-35, G-44, G-45, G-46, G-47, G-48, G-50, G-51, G-53, G-54, G-55, G-67, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, I-3, I-4, I-5, I-6, I-9, I-10, I-24, I-25, I-32, I-33, I-36
mercury (Hg), 5-25, 5-46, 5-49, 5-50, 5-76, 5-109, 5-144, 5-173, 5-175, 5-176 ,A-61, A-62, E-11, E-58, E-60, G-3, G-4, G-6, G-9, G-14, G-15, G-25, G-26, G-30, G-31, G-32, G-35, G-39, G-41, G-42, G-49, G-58, G-61, G-66, G-70, G-72, G-75, G-78, H-31, H-53, H-55, H-62, H-63, H-64, H-71, H-74, H-80, H-82, H-87, H-89, I-20, I-21, I-27, I-28, I-29, I-30, I-31, I-32, I-36, I-37
Mound Plant, S-10, S-34, S-43, S-67, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, 4-58, 4-59, 4-68, 4-69, 5-11, 5-13, 5-14, 5-21, 5-34, 5-60, 5-61, 5-63, 5-92, 5-96, 5-99, 5-130, 5-156, 5-166, 5-186, 5-192, A-9, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-30, A-34, A-35, A-39, A-43, A-64, B-3, B-4, C-11, D-2, D-3, D-7, D-13, D-14, D-15, D-16, E-2, E-9, E-22, E-27, E-36, F-16, F-17, I-2

N

National Environmental Policy Act (NEPA), S-1, S-2, S-4, S-6, S-7, S-8, S-17, S-20, S-22, S-23, S-24, 1-1, 1-2, 1-4, 1-7, 1-9, 1-11, 1-12, 1-15, 2-2, 2-8, 2-17, 2-18, 2-20, 3-1, 3-2, 3-12, 3-15, 3-22, 3-33, 3-39, 5-2, 5-4, 5-6, 5-7, 5-8, 5-35, 5-52, 5-56, 5-57, 5-58, 5-83, 5-85, 5-86, 5-105, 5-122, 5-123, 5-124, 5-135, 5-149, 5-151, 5-161, 5-183, 5-185, 5-189, 6-1, A-1, B-1, B-2, G-7, G-15, G-36, G-37
Nevada Test Site (NTS), S-10, S-34, S-35, S-43, S-67, 1-13, 1-18, 2-6, 3-3, 3-17, 3-20, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, 3-49, 4-45, 4-60, 4-61, 5-5, 5-11, 5-13, 5-14, 5-21, 5-34, 5-56, 5-60, 5-61, 5-63, 5-64, 5-84, 5-92, 5-96, 5-122, 5-150, 5-166, 5-184, 5-187, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-35, A-36, A-38, A-40, A-43, A-45, A-47, A-64, B-3, B-4, B-9, B-10, B-29, B-30, B-31, B-32, B-33, C-12, C-13, D-2, D-3, D-7, D-13, D-14, D-15, D-16, E-11, E-22, E-24, E-27, E-33, E-36, F-16, F-17, I-2
noise, S-40, S-73, 4-6, 4-9, 5-8, 5-9, 5-58, 5-82, 5-86, 5-121, 5-124, 5-148, 5-151, 5-165, 5-190, J-4
No-Migration Variance Petition, S-5, 1-10, 1-18, 2-24, 4-9, 4-69, H-31, H-53, H-93, H-94, H-107, I-21, I-37
noncarcinogenic effects, S-49, S-67, S-68, 4-53, 5-24, 5-27, 5-28, 5-29, 5-30, 5-31, 5-32, 5-35, 5-37, 5-38, 5-40, 5-50, 5-54, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-75, 5-76, 5-80, 5-82, 5-101, 5-102, 5-104, 5-106, 5-107, 5-109, 5-111, 5-112, 5-119, 5-121, 5-132, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-147, 5-148, 5-157, 5-159, 5-160, 5-166, 5-167, 5-168, 5-169, 5-174, 5-175, 5-176, 5-177, 5-178, 5-180, F-1, F-4, F-32, F-35, F-37, F-38, G-1, G-3, G-4, G-5, G-20, G-22, G-25, G-26, G-30, G-31, G-32, G-35, G-41, G-44, G-45, G-47, G-48, G-51, G-52, G-55, G-70, G-73, G-76, H-56, H-62, H-70, H-78, H-83, H-89, H-91, I-3, I-5, I-6, I-9, I-10, I-22, I-25, I-36
noninvolved worker, S-49, S-51, S-52, S-53, S-54, S-55, S-56, S-58, S-59, S-60, S-67, S-68, 5-26, 5-27, 5-29, 5-30, 5-34, 5-35, 5-38, 5-40, 5-42, 5-52, 5-67, 5-69, 5-70, 5-71, 5-72, 5-74, 5-75, 5-76, 5-82, 5-99, 5-102, 5-103, 5-104, 5-107, 5-109, 5-111, 5-112, 5-113, 5-115, 5-121, 5-130, 5-132, 5-133, 5-134, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-143, 5-144, 5-149, 5-156, 5-158, 5-159, 5-160, 5-166, 5-167, 5-168, 5-178, 5-180, 5-188, B-7, B-8, B-11, F-1, F-2, F-7, F-10, F-12, F-13, F-14, F-30, F-32, F-35, F-37, F-38, F-39, G-1, G-19, G-20, G-22, G-26, G-27, G-31, G-32, G-35, G-44, G-48,

G-52, G-55, G-58, G-67, G-68, G-70, G-72, G-75, G-76, G-78, H-31
nonradiological impacts, S-44, 5-70, 5-71, 5-82, 5-104, 5-121, 5-127, 5-133, 5-148, E-12, E-19, E-72
nuclear fission, 3-47, 3-49, E-48, G-2, G-38, H-31
Nuclear Regulatory Commission (NRC), S-18, 1-1, 1-4, 1-9, 1-18, 2-1, 2-3, 2-11, 2-16, 3-6, 3-7, 3-10, 3-49, 3-65, 5-20, 5-22, 5-37, 6-2, A-8, A-9, A-67, E-2, E-13, E-19, E-23, E-32, E-40, E-42, E-43, E-46, E-47, E-48, E-49, E-63, E-76, E-77, G-58, G-60, H-6
nuclear weapon, S-1, S-12, 1-1, 1-8, 1-13, 2-1, 4-56, 4-58, 4-62, 4-64, A-1, B-1, E-42

O

Oak Ridge National Laboratory (ORNL), S-10, S-17, S-22, S-23, S-24, S-35, S-43, S-49, S-50, S-51, S-52, S-54, S-55, S-56, S-58, S-59, S-67, S-73, S-82, 2-6, 2-9, 2-10, 3-2, 3-3, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 4-62, 5-10, 5-11, 5-28, 5-29, 5-30, 5-32, 5-34, 5-36, 5-38, 5-40, 5-54, 5-59, 5-60, 5-68, 5-70, 5-73, 5-75, 5-76, 5-89, 5-90, 5-100, 5-103, 5-106, 5-107, 5-108, 5-109, 5-110, 5-124, 5-125, 5-131, 5-133, 5-137, 5-138, 5-139, 5-149, 5-153, 5-157, 5-158, 5-159, 5-166, 5-167, 5-168, 5-172, 5-173, 5-174, 5-175, 5-176, 5-187, 5-190, 5-191, 5-193, A-9, A-10, A-12, A-14, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-26, A-27, A-29, A-32, A-33, A-34, A-35, A-36, A-38, A-40, A-41, A-42, A-43, A-45, A-46, A-47, A-49, A-52, A-54, A-56, A-57, A-58, A-59, A-64, A-65, B-3, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-4, D-5, D-6, D-7, E-2, E-9, E-23, E-24, E-25, E-33, E-73, E-76, E-77, F-7, F-8, F-9, F-10, F-12, F-13, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-31, F-33, F-34, F-35, F-36, F-37, F-38, G-7, G-8, G-19, G-20, G-22, G-23, G-25, G-27, G-28, G-32, G-33, G-35, G-37, G-39, G-44, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-53, G-54, I-2, I-5, I-15, I-23, I-26, I-27, I-28, I-30, I-31, I-32, I-33, I-36, I-37, J-5, J-7
Oak Ridge Reservation (ORR), S-35, 4-62, 4-63, 5-184, B-3, B-4, B-5, B-6, D-13, D-14, D-15, D-16, I-37
overpack, 2-3, 5-37, 5-161, A-8, A-9, E-13

P

Paducah Gaseous Diffusion Plant (PGDP), S-10, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-34, A-35, A-38, A-40, A-43, B-3, B-4
panels, S-6, S-19, S-22, S-23, 1-11, 2-15, 3-9, 3-12, 3-15, 3-20, 3-21, 3-22, 3-24, 3-27, 3-30, 3-32, 3-37, 3-38, 4-24, 4-29, 4-30, 5-41, 5-77, 5-78, 5-113, 5-116, 5-117, 5-142, 5-145, 5-146, 5-177, 5-179, 5-189, E-72, F-22, F-24, F-32, G-65, G-69, H-4, H-10, H-11, H-15, H-17, H-23, H-27, H-28, H-29, H-38, H-39, H-54, H-67, H-75, H-83
Pantex Plant, S-2, S-13, S-17, 1-2, 1-6, 1-12, 5-184, A-38
particulate matter (PM_{10}), S-31, S-32, S-38
performance assessment, S-2, S-3, S-4, S-5, S-6, S-61, S-73, 1-2, 1-5, 1-7, 1-9, 1-10, 1-11, 1-15, 2-2, 2-5, 3-1, 3-13, 4-6, 4-9, 4-13, 4-26, 4-31, 4-33, 4-71, 5-19, 5-33, 5-44, 5-45, 5-77, 5-83, 5-116, 5-121, 5-145, 5-149, 5-163, 5-170, 5-183, 5-189, 5-190, A-1, A-4, A-55, E-13, E-40, G-38, H-1, H-2, H-3, H-4, H-5, H-6, H-7, H-8, H-9, H-10, H-11, H-14, H-17, H-24, H-26, H-29, H-30, H-31, H-32, H-37, H-39, H-53, H-54, H-56, H-57, H-59, H-63, H-67, H-75, H-77, H-83, H-91, H-92, H-94, H-95, H-97, H-98, H-99, H-100, H-101, H-102, H-103, H-104, H-105, H-106, H-108, J-4
permanent marker system, 3-14
permissible exposure level (PEL), 5-28, 5-32, 5-136, 5-173, 5-174, F-3, F-4, F-5, F-35, F-37, I-27, I-28, I-29, I-30
plutonium (Pu), S-1, S-9, S-34, 1-1, 1-9, 1-13, 1-14, 2-1, 2-2, 2-5, 3-2, 3-65, 4-46, 4-48, 4-58, 4-59, 4-64, 4-65, 5-13, 5-37, 5-49, 5-80, 5-82, 5-117, 5-119, 5-146, 5-147, 5-148, 5-184, 5-185, A-1, A-5, A-7, A-8, A-37, A-38, A-39, A-40, A-41, A-42, A-44, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-56, A-57, A-58, A-59, A-60, B-9, B-10, D-8, E-14, E-42, E-45, E-55, F-6, F-16, F-17, F-20, G-2, G-8, H-30, H-31, H-53, H-55, H-62, H-63, H-64, H-65, H-67, H-70, H-71, H-73, H-74, H-75, H-78, H-80, H-81, H-82, H-83, H-86, H-87, H-88, H-90, I-20, I-27, I-28, I-30, I-31
polychlorinated biphenyls (PCB), S-1, S-6, S-9, S-10, S-13, S-16, S-20, S-22, S-23, S-24, S-57, S-71, S-72, 1-4, 2-1, 2-2, 2-6, 2-15, 2-18, 3-3, 3-15, 3-17, 3-18, 3-21, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 3-55, 5-67, 5-83, 5-99, 5-122, 5-130, 5-149, 5-156, 5-183, A-9, A-10, A-12, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-30, A-62, E-73
population dose, S-68, 5-17, 5-22, 5-67, 5-93, 5-99, 5-177, 5-180, E-34, E-52, E-56, E-66, E-67, F-6, F-21, F-24, F-27, F-30, I-33
Post-1970 waste, S-4
potential releases, S-61, 5-76, 5-188, E-48, G-13, G-14, H-58
previously disposed waste, S-9, S-12, 1-3, 1-8, 2-3, 2-8, 3-3, A-9, A-10, A-12, E-1

R

radioactive decay, S-23, S-27, 2-2, 2-3, 3-47, 3-49, 4-52, 5-31, 5-37, 5-72, 5-73, 5-105, 5-106, 5-135, 5-136, 5-161, 5-162, 5-169, 5-172, A-7, A-35, A-57, A-59, E-72, F-7, F-15, F-21, F-30, H-7, H-16, H-17, H-28, H-29, H-31, H-57, I-4, I-8, I-9, I-10, I-18

radiological impacts, S-44, S-45, S-46, S-49, S-50, S-51, S-52, S-53, S-54, S-55, S-56, S-57, S-58, S-59, S-60, S-68, S-69, 5-12, 5-16, 5-17, 5-18, 5-20, 5-26, 5-27, 5-29, 5-31, 5-32, 5-49, 5-50, 5-62, 5-63, 5-64, 5-65, 5-66, 5-68, 5-70, 5-71, 5-72, 5-73, 5-74, 5-75, 5-76, 5-80, 5-82, 5-93, 5-94, 5-95, 5-99, 5-101, 5-102, 5-104, 5-105, 5-106, 5-117, 5-119, 5-121, 5-127, 5-128, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-147, 5-148, 5-155, 5-156, 5-157, 5-159, 5-160, 5-161, 5-162, 5-166, 5-167, 5-168, 5-169, 5-173, 5-174, 5-175, 5-176, 5-180, 5-182, 5-188, B-11, E-2, E-6, E-19, E-23, E-30, E-31, E-34, E-41, E-52, E-56, E-66, F-1, F-2, F-6, F-7, F-13, F-15, F-24, F-29, F-30, G-2, G-22, G-25, G-26, G-32, H-29, H-62, H-63, H-67, H-70, H-75, H-78, H-83, H-86, H-89, H-90, I-29, I-33
radionuclide, S-1, S-2, S-5, S-12, S-28, S-29, S-31, S-32, S-33, S-34, S-35, S-36, S-37, S-38, S-46, S-47, S-51, S-61, S-62, S-63, S-64, S-65, S-66, S-71, S-72, 1-2, 1-10, 1-12, 1-15, 2-3, 2-5, 2-16, 2-18, 2-19, 2-20, 3-10, 3-27, 3-47, 3-50, 4-9, 4-21, 4-25, 4-45, 4-46, 4-48, 4-49, 4-51, 4-52, 4-53, 4-56, 4-58, 4-60, 4-61, 4-63, 4-64, 4-65, 4-67, 4-69, 4-70, 5-1, 5-2, 5-5, 5-16, 5-17, 5-20, 5-21, 5-22, 5-26, 5-31, 5-32, 5-34, 5-37, 5-38, 5-44, 5-45, 5-46, 5-47, 5-48, 5-49, 5-50, 5-51, 5-54, 5-61, 5-67, 5-73, 5-74, 5-76, 5-77, 5-78, 5-79, 5-80, 5-81, 5-82, 5-84, 5-95, 5-99, 5-106, 5-110, 5-111, 5-112, 5-116, 5-117, 5-118, 5-119, 5-120, 5-131, 5-137, 5-139, 5-140, 5-141, 5-143, 5-145, 5-146, 5-147, 5-148, 5-150, 5-157, 5-160, 5-163, 5-172, 5-180, 5-183, 5-188, 5-189, A-2, A-3, A-7, A-8, A-13, A-35, A-36, A-37, A-38, A-39, A-40, A-41, A-42, A-43, A-44, A-45, A-46, A-47, A-48, A-49, A-50, A-51, A-52, A-53, A-54, A-55, A-56, A-57, A-58, A-59, A-60, B-7, B-8, B-9, B-10, B-11, B-29, B-30, B-31, B-32, B-33, E-2, E-31, E-32, E-34, E-41, E-43, E-44, E-45, E-47, E-48, E-51, E-52, E-55, E-56, E-66, E-67, E-72, E-76, F-1, F-2, F-6, F-10, F-12, F-13, F-15, F-16, F-17, F-18, F-19, F-20, F-21, F-24, F-30, F-31, G-1, G-2, G-7, G-8, G-9, G-13, G-17, G-18, G-22, G-25, G-26, G-27, G-30, G-31, G-32, G-33, G-35, G-36, G-37, G-38, G-39, G-44, G-45, G-49, G-52, G-56, G-57, G-58, G-60, G-61, G-64, G-65, G-66, G-67, H-1, H-5, H-6, H-7, H-8, H-10, H-11, H-13, H-14, H-16, H-17, H-24, H-25, H-26, H-27, H-28, H-29, H-30, H-31, H-32, H-45, H-53, H-54, H-55, H-56, H-57, H-58, H-59, H-60, H-61, H-62, H-63, H-64, H-65, H-66, H-67, H-68, H-70, H-71, H-73, H-74, H-75, H-76, H-78, H-79, H-80, H-81, H-82, H-83, H-84, H-86, H-87, H-88, H-89, H-90, H-91, H-92, H-94, H-98, H-99, H-101, H-103, H-104, I-4, I-5, I-6, I-7, I-8, I-9, I-18, I-19, I-20, I-24, I-25, I-27, I-28, I-30, I-31, J-1
RADTRAN, 5-16, 5-18, 5-20, 5-62, 5-64, 5-66, 5-94, 5-128, 5-155, 5-193, E-23, E-30, E-31, E-32, E-42, E-44, E-50, E-56, E-64, E-77
rail transportation, S-2, S-6, S-18, S-19, S-22, S-23, S-24, S-34, S-40, S-41, S-44, S-46, S-48, S-69, 1-2, 1-8, 2-3, 3-1, 3-2, 3-6, 3-7, 3-18, 3-20, 3-27, 3-37, 3-45, 3-56, 4-45, 4-48, 4-53, 4-56, 4-65, 5-3, 5-9, 5-15, 5-22, 5-55, 5-56, 5-58, 5-59, 5-60, 5-61, 5-64, 5-65, 5-66, 5-67, 5-83, 5-86, 5-88, 5-89, 5-90, 5-92, 5-98, 5-99, 5-121, 5-124, 5-125, 5-129, 5-130, 5-149, 5-151, 5-152, 5-153, 5-156, 5-182, 5-185, 5-188, A-7, A-25, A-26, A-27, D-8, D-9, E-2, E-3, E-40, E-43, E-55, E-61, E-63, E-64, E-65, E-66, E-67, E-68, E-69, E-70, E-71
Record of Decision (ROD), S-1, S-3, S-7, S-8, S-18, S-22, 1-5, 1-6, 1-7, 1-13, 1-14, 2-5, 2-9, 2-21, 3-4, 5-1, 5-3, 5-171, 5-185, 5-187, I-1
Region of Influence (ROI), S-29, S-31, S-32, S-33, S-35, S-36, S-37, S-43, 4-1, 4-38, 4-39, 4-40, 4-41, 4-42, 4-47, 4-48, 4-50, 4-53, 4-56, 4-58, 4-61, 4-63, 4-65, 4-67, 5-11, 5-12, 5-60, 5-90, 5-91, 5-125, 5-126, 5-153, 5-154, D-10, D-11, D-12, D-13, D-14, D-15, D-16
remote-handled (RH) TRU waste, S-5, S-6, S-7, S-12, S-13, S-16, S-17, S-18, S-19, S-22, S-23, S-24, S-41, S-49, S-51, S-52, S-53, S-54, S-55, S-58, S-61, S-67, S-73, S-82, 1-1, 1-3, 1-4, 1-5, 1-8, 1-10, 1-11, 1-12, 2-3, 2-4, 2-5, 2-9, 2-11, 2-15, 3-2, 3-3, 3-4, 3-6, 3-9, 3-10, 3-11, 3-12, 3-15, 3-16, 3-18, 3-20, 3-21, 3-22, 3-24, 3-27, 3-30, 3-32, 3-33, 3-34, 3-36, 3-37, 3-38, 3-40, 3-43, 3-45, 3-50, 5-3, 5-10, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-21, 5-22, 5-24, 5-27, 5-28, 5-29, 5-30, 5-31, 5-32, 5-33, 5-34, 5-36, 5-37, 5-38, 5-40, 5-41, 5-45, 5-50, 5-54, 5-55, 5-59, 5-61, 5-62, 5-63, 5-66, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-77, 5-78, 5-80, 5-82, 5-88, 5-89, 5-90, 5-92, 5-93, 5-94, 5-95, 5-96, 5-98, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-106, 5-107, 5-108, 5-109, 5-110, 5-113, 5-114, 5-116, 5-117, 5-119, 5-125, 5-126, 5-127, 5-128, 5-129, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-138, 5-139, 5-142, 5-143, 5-145, 5-146, 5-147, 5-148, 5-152, 5-153, 5-154, 5-155, 5-156, 5-158, 5-159, 5-160, 5-161, 5-163, 5-165, 5-167, 5-168, 5-169, 5-172, 5-173, 5-174, 5-175, 5-177, 5-179, 5-180, 5-190, 5-191, A-1, A-2, A-3, A-5, A-6, A-10, A-12, A-13, A-14, A-16, A-17, A-21, A-23, A-24, A-25, A-26, A-27, A-31, A-32, A-33, A-34, A-35, A-36, A-41, A-42, A-43, A-44, A-46, A-48, A-49, A-52, A-54, A-55, A-58, A-59, A-61, A-62, A-64, A-65, B-3, B-4, B-5, B-6, B-8, B-9, B-10, B-11, C-8, C-9, C-10, D-8, D-9, E-12, E-14, E-19, E-23, E-25, E-30, E-32, E-33, E-34, E-37, E-40, E-44, E-45, E-47, E-48, E-49, E-50, E-52, E-55, E-57, E-61, E-68, E-69, E-70, E-71, E-73, F-8, F-9, F-10, F-13, F-15, F-17, F-18, F-31, F-32, F-35, F-37, G-2, G-3, G-7, G-8, G-9, G-11, G-12, G-13, G-15, G-22, G-23, G-26, G-27, G-28, G-33, G-36, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-52, G-53, G-54, G-55, G-56, G-57, G-59, G-64, G-65, G-66, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, H-30, H-41, H-53, H-57, H-63, H-65, H-67, H-70, H-71, H-73, H-74, H-75, H-78, H-80, H-81, H-82, H-83, H-86, H-87, H-88, H-89, H-90, H-93, I-12, I-13, I-21, I-26, I-28, I-29, I-30, I-31, I-32, J-1, J-4, J-5, J-7
Resource Conservation and Recovery Act (RCRA), S-1, S-3, S-4, S-5, S-16, S-19, S-20, 1-1, 1-4, 1-8,

1-10, 1-18, 2-2, 2-3, 2-4, 2-5, 2-8, 2-9, 2-15, 2-18, 2-24, 3-3, 3-6, 3-10, 3-11, 3-12, 3-15, 3-22, 3-65, 4-5, 5-23, 5-44, 5-52, 6-2, A-3, A-12, A-14, A-61, A-62, A-63, A-65, A-66, B-2, B-4, B-34, C-14, E-1, F-7, F-39, G-1, G-39, G-79, H-107
restoration, S-1, S-9, S-32, S-34, 1-1, 1-13, 1-14, 1-17, 2-1, 2-8, 2-22, 3-2, 4-53, 4-54, 4-58, 4-62, 4-69, 5-184, 5-192, A-1, A-2, B-3, B-4, B-7, I-37, J-1
retrievable storage, S-4, S-9, S-10, 1-3, 2-1, 2-2, 2-6, 2-8, 3-2, 5-3, 5-149, 5-150, 5-163, A-1, A-9, A-23, B-2, B-6, I-1, I-2
RH-72B, S-18, S-19, S-40, S-44, S-45, S-47, S-48, 2-3, 2-5, 2-11, 2-16, 3-6, 3-7, 3-9, 3-10, 3-11, 3-16, 3-22, 3-34, 5-9, 5-12, 5-14, 5-16, 5-20, 5-21, 5-22, 5-23, 5-25, 5-27, 5-37, 5-58, 5-64, 5-66, 5-67, 5-95, 5-99, 5-128, 5-129, 5-155, 5-156, 6-2, A-5, A-6, A-7, A-25, A-66, D-8, E-2, E-14, E-32, E-34, E-40, E-41, E-45, E-47, E-49, E-55, E-56, E-57, E-64, E-66, E-67
risk assessment, 5-12
Rocky Flats Environmental Technology Site (RFETS)), S-2, S-10, S-17, S-22, S-23, S-36, S-38, S-43, S-50, S-53, S-55, S-57, S-58, S-59, S-67, S-82, 1-2, 1-12, 1-14, 2-6, 2-9, 2-17, 2-22, 3-3, 3-17, 3-21, 3-23, 3-26, 3-29, 3-32, 3-33, 3-34, 3-38, 3-39, 3-42, 3-46, 4-63, 4-64, 4-65, 5-5, 5-9, 5-11, 5-13, 5-14, 5-21, 5-28, 5-29, 5-30, 5-34, 5-36, 5-37, 5-56, 5-60, 5-61, 5-63, 5-68, 5-70, 5-73, 5-75, 5-84, 5-90, 5-92, 5-96, 5-100, 5-101, 5-102, 5-103, 5-106, 5-107, 5-108, 5-110, 5-111, 5-112, 5-122, 5-125, 5-126, 5-129, 5-137, 5-138, 5-139, 5-140, 5-141, 5-149, 5-150, 5-153, 5-157, 5-158, 5-159, 5-161, 5-162, 5-164, 5-166, 5-172, 5-173, 5-174, 5-175, 5-176, 5-184, 5-185, 5-187, 5-191, A-8, A-9, A-10, A-12, A-13, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-30, A-35, A-36, A-38, A-40, A-43, A-44, A-45, A-47, A-50, A-53, A-56, A-57, A-62, A-64, A-65, B-3, B-4, B-5, B-9, B-10, B-29, B-30, B-31, B-32, B-33, C-12, C-13, D-2, D-3, D-4, D-5, D-6, D-7, D-9, D-13, D-14, D-15, D-16, E-11, E-22, E-27, E-33, E-36, E-73, F-7, F-9, F-10, F-12, F-13, F-15, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-30, F-31, F-33, F-34, F-35, F-36, F-37, F-38, F-39, G-7, G-8, G-19, G-20, G-22, G-23, G-24, G-25, G-27, G-28, G-29, G-32, G-33, G-34, G-39, G-45, G-46, G-47, G-48, G-49, G-50, G-51, G-53, G-54, I-2, I-3, I-13, I-15, I-21, I-22, I-23, I-29, I-30, I-31, I-33, I-36, I-37, J-1, J-5
roof fall, 3-9, 5-41, 5-42, 5-113, 5-115, 5-142, 5-144, G-56, G-65, G-70, G-72, G-75, G-76, G-78

S

Safety Analysis Report (SAR), S-5, 1-10, 1-17, 1-18, 3-6, 4-9, 4-69, 6-3, A-3, A-6, A-7, A-8, A-61, A-62, A-66, A-67, E-2, E-13, F-15, F-39, F-40, G-9, G-41, G-56, G-65, G-69, G-79, G-80, H-31, H-107, I-21, I-38
salt, S-19, S-27, S-38, S-39, S-60, S-67, 2-4, 2-10, 2-11, 2-17, 2-19, 3-9, 3-13, 3-14, 3-20, 3-21, 3-30, 3-32, 3-37, 3-38, 3-45, 3-47, 3-50, 4-1, 4-2, 4-6, 4-9, 4-13, 4-14, 4-17, 4-19, 4-21, 4-22, 4-23, 4-24, 4-25, 4-28, 4-30, 4-31, 4-33, 4-34, 4-71, 5-5, 5-6, 5-7, 5-8, 5-43, 5-45, 5-50, 5-57, 5-85, 5-123, 5-150, 5-177, 5-179, 5-180, 5-189, A-4, A-7, A-28, A-29, A-30, A-63, C-2, C-3, C-4, C-6, C-10, E-71, E-72, G-58, G-79, H-2, H-3, H-6, H-7, H-9, H-16, H-17, H-23, H-24, H-37, H-38, H-39, H-40, H-42, H-44, H-45, H-46, H-51, H-57, H-91, H-93, H-94, H-97, H-99, H-105
Sandia National Laboratories- Albuquerque (SNL), S-10, S-17, S-32, S-50, 1-12, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, 4-9, 4-54, 4-71, 5-184, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-33, A-36, A-43, B-3, B-4, H-6, H-7, H-11, H-17, H-26, H-29, H-53, H-91, H-92, H-95, H-97, H-100, H-101, H-102, H-103, H-104, H-105, H-108
Savannah River Site (SRS), S-10, S-17, S-22, S-23, S-24, S-36, S-37, S-43, S-47, S-50, S-53, S-54, S-55, S-59, S-67, S-69, S-82, 1-12, 2-6, 3-3, 3-17, 3-21, 3-23, 3-26, 3-29, 3-32, 3-33, 3-34, 3-38, 3-39, 3-42, 3-46, 4-65, 4-66, 4-67, 5-11, 5-22, 5-34, 5-36, 5-60, 5-73, 5-75, 5-76, 5-90, 5-100, 5-101, 5-102, 5-103, 5-106, 5-107, 5-108, 5-109, 5-110, 5-111, 5-112, 5-125, 5-133, 5-134, 5-137, 5-138, 5-139, 5-140, 5-141, 5-149, 5-153, 5-158, 5-159, 5-160, 5-161, 5-166, 5-173, 5-174, 5-175, 5-176, 5-181, 5-182, 5-184, 5-185, 5-187, 5-191, A-8, A-10, A-12, A-13, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-33, A-36, A-38, A-40, A-43, A-44, A-45, A-47, A-50, A-51, A-53, A-56, A-57, A-64, A-65, B-3, B-4, B-5, B-9, B-10, B-29, B-30, B-31, B-32, B-33, D-2, D-3, D-4, D-5, D-6, D-7, D-13, D-14, D-15, D-16, E-10, E-22, E-24, E-25, E-26, E-27, E-33, E-35, E-36, E-45, E-73, F-9, F-10, F-12, F-13, F-16, F-17, F-19, F-20, F-26, F-28, F-29, F-30, F-31, F-33, F-34, F-36, F-37, F-38, G-7, G-8, G-19, G-20, G-22, G-23, G-24, G-28, G-29, G-33, G-34, G-39, G-45, G-46, G-48, G-50, G-51, G-53, G-54, I-1, I-2, I-5, I-15, I-23, I-26, I-27, I-30, I-31, I-32, I-33, I-36, I-37, J-5
scoping, S-8, S-24, 2-20, 3-1, 3-47, 3-50, F-16, G-41
SEIS-I, S-1, S-3, S-10, S-18, S-19, S-27, S-28, S-29, 1-5, 1-6, 1-7, 1-8, 1-9, 1-10, 1-11, 1-15, 1-16, 2-2, 2-6, 2-9, 2-11, 2-15, 2-20, 2-21, 3-3, 3-7, 3-8, 3-12, 3-14, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, 4-1, 4-2, 4-6, 4-9, 4-10, 4-14, 4-19, 4-34, 4-35, 4-38, 4-39, 4-41, 4-45, 4-46, 5-1, 5-5, 5-7, 5-12, 5-14, 5-25, 5-44, 5-46, 5-85, 5-170, 5-171, 5-187, 5-188, 5-189, A-1, A-2, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-44, B-2, B-3, B-4, B-6, B-7, B-8, B-11, B-29, E-1, E-2, E-3, E-12, E-19, E-43, E-48, E-51, E-57, E-63, F-1, F-3, F-6, F-7, F-18, G-56, G-66, H-1, H-6, H-7, H-8, H-10, H-13, H-23, H-29, H-31, H-54, H-55, H-92, H-94, H-95, H-96, H-97, H-98, H-100, H-101, H-102, H-103, H-104, I-1
SEIS-II, S-1, S-2, S-3, S-5, S-6, S-7, S-8, S-9, S-10, S-12, S-13, S-16, S-17, S-18, S-20, S-22, S-23,

S-24, S-27, S-28, S-41, S-43, S-48, S-57, S-60, S-61, S-67, S-68, S-73, 1-1, 1-2, 1-3, 1-4, 1-5, 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-16, 2-1, 2-2, 2-3, 2-5, 2-6, 2-8, 2-9, 2-15, 2-17, 2-20, 3-1, 3-2, 3-3, 3-4, 3-12, 3-15, 3-17, 3-18, 3-20, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-37, 3-39, 3-40, 3-42, 3-43, 3-45, 3-46, 3-47, 3-50, 4-38, 4-42, 5-1, 5-2, 5-3, 5-4, 5-5, 5-7, 5-8, 5-10, 5-11, 5-12, 5-15, 5-18, 5-20, 5-24, 5-27, 5-33, 5-35, 5-37, 5-44, 5-45, 5-46, 5-50, 5-52, 5-55, 5-58, 5-59, 5-63, 5-64, 5-65, 5-83, 5-95, 5-128, 5-155, 5-171, 5-177, 5-181, 5-183, 5-185, 5-186, 5-187, 5-189, 5-190, 6-1, A-1, A-2, A-3, A-7, A-8, A-9, A-10, A-12, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-25, A-36, A-44, A-61, A-63, B-1, B-2, B-3, B-6, B-7, B-8, D-1, D-2, D-3, D-4, D-5, D-6, D-10, D-13, E-6, E-13, E-41, E-43, E-44, E-45, F-3, F-4, F-6, F-7, F-14, G-2, G-3, G-4, G-5, G-10, G-12, G-15, G-17, G-56, G-59, G-65, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, H-13, H-14, H-17, H-26, H-28, H-37, H-57, H-91, H-92, H-93, H-94, H-95, H-99, H-101, H-105, H-106, I-2, I-24

shred and grout, S-13, S-16, S-23, S-58, S-59, S-60, 2-2, 2-15, 2-17, 2-18, 3-32, 3-36, 3-50, 5-2, 5-55, 5-122, 5-129, 5-130, 5-137, 5-142, 5-143, 5-164, A-17, A-21, A-25, B-4, B-5, B-7, E-52, E-73, F-7, F-8, F-19, F-20, F-25, F-26, F-36, G-1, G-7, G-8, G-9, G-10, G-15, G-17, G-18, G-32, G-33, G-34, G-40, G-41, G-42, G-43, G-44, G-52, G-53, G-54, G-56, G-57, G-60, G-61, G-62, G-63, G-65, G-66, G-69, H-2, I-11

solubility, S-6, S-19, 1-11, 3-10, 5-45, H-3, H-7, H-9, H-16, H-24, H-28, H-29, H-31, H-53, H-92, I-8, I-11, I-18, I-19, I-21, I-22

spent nuclear fuel, 3-47, 4-48, 4-65, B-3

standard waste box, S-19, 1-9, 2-3, 2-5, 3-9, 3-10, 3-11, 3-43, 5-27, 5-37, 5-177, A-5, F-13, G-38, G-57, G-58, G-59, G-60, G-61, G-63, G-64, G-65, G-67

strata, 4-9, 4-33, H-99

strontium (Sr), 4-46, 4-48, 5-37, 5-50, 5-80, 5-119, 5-147, A-35, A-37, A-38, A-39, A-40, A-41, A-42, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-56, A-57, A-58, A-59, A-60, E-45, H-30, H-31, H-53, H-63, H-64, H-65, H-71, H-73, H-74, H-80, H-81, H-82, H-87, H-88, H-90, I-20, I-27, I-28, I-30, I-31

surface water, S-7, S-33, S-37, S-67, 2-11, 4-19, 4-21, 4-45, 4-46, 4-52, 4-55, 4-57, 4-59, 4-60, 4-62, 4-64, 4-66, 5-4, 5-174, 5-175, 5-176, F-6, I-5, I-6, I-8, I-9, I-24, I-25, I-32, I-33

T

thermal power, 2-2, 2-5, 2-9, 2-16, 2-17, 3-15, 3-27, 5-13, 5-113, A-3, A-5, A-7, A-13, A-14, A-17, A-25, A-35, D-8, E-1, E-14, E-45, F-18, G-38, G-65, H-93

thermal treatment, S-6, S-10, S-13, S-20, S-23, S-47, S-48, S-49, S-53, S-58, S-59, S-69, 2-6, 2-10, 2-15, 2-18, 2-19, 3-3, 3-12, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-46, 5-2, 5-52, 5-55, 5-83, 5-87, 5-88, 5-89, 5-93, 5-95, 5-98, 5-99, 5-101, 5-102, 5-104, 5-106, 5-109, 5-113, 5-114, 5-156, 5-157, 5-160, 5-162, 5-163, 5-182, A-10, A-12, A-14, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-64, A-65, E-56, E-73, F-7, F-12, F-25, F-26, F-36, F-38, G-7, G-8, G-12, G-13, G-14, G-15, G-18, G-27, G-32, G-40, G-63, H-10, H-75

total effective dose equivalent (TEDE), 5-177, E-56, E-66, E-67, F-2, F-18, F-24, F-30, G-1, G-25, G-26, G-28, G-30, G-31, G-35, G-44, G-45, G-47, G-48, G-49, G-50, G-51, G-52, G-55, G-56, I-4

Total Inventory, S-6, S-13, S-20, S-22, S-23, S-24, S-29, S-61, S-73, S-82, 1-11, 2-3, 3-1, 3-15, 3-16, 3-17, 3-18, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-38, 3-39, 3-40, 3-42, 3-43, 3-56, 5-37, 5-60, 5-67, 5-68, 5-69, 5-70, 5-72, 5-100, 5-102, 5-103, 5-105, 5-126, 5-130, 5-131, 5-132, 5-133, 5-135, 5-156, 5-158, 5-159, 5-160, 5-161, 5-164, 5-167, 5-191, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-26, A-27, A-35, B-8, B-11, E-13, E-19, F-6, F-26, F-28, F-29, F-34, G-43, J-4, J-7

TRANSCOM, 3-7, 3-8, 5-188, E-3, E-4, E-42

transuranic (TRU) waste, S-1, S-2, S-3, S-4, S-5, S-6, S-7, S-9, S-10, S-12, S-13, S-16, S-17, S-18, S-19, S-20, S-22, S-23, S-24, S-27, S-38, S-39, S-40, S-41, S-43, S-44, S-45, S-46, S-49, S-50, S-51, S-52, S-53, S-54, S-55, S-56, S-57, S-58, S-59, S-60, S-61, S-67, S-69, S-71, S-72, S-73, S-82, S-83, 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-13, 1-14, 1-15, 1-16, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-8, 2-9, 2-10, 2-11, 2-15, 2-16, 2-17, 2-18, 2-19, 2-20, 3-1, 3-2, 3-3, 3-4, 3-6, 3-7, 3-9, 3-10, 3-11, 3-12, 3-14, 3-15, 3-16, 3-17, 3-18, 3-20, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-36, 3-37, 3-38, 3-39, 3-40, 3-42, 3-43, 3-45, 3-47, 3-49, 3-50, 3-55, 3-56, 4-50, 5-1, 5-2, 5-3, 5-4, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-22, 5-23, 5-24, 5-25, 5-26, 5-27, 5-29, 5-31, 5-32, 5-33, 5-34, 5-36, 5-37, 5-38, 5-40, 5-41, 5-44, 5-45, 5-50, 5-52, 5-54, 5-55, 5-56, 5-57, 5-58, 5-59, 5-61, 5-62, 5-64, 5-65, 5-66, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-74, 5-77, 5-78, 5-80, 5-82, 5-83, 5-86, 5-88, 5-89, 5-90, 5-91, 5-92, 5-93, 5-94, 5-95, 5-99, 5-101, 5-102, 5-104, 5-105, 5-106, 5-107, 5-109, 5-110, 5-111, 5-113, 5-114, 5-116, 5-117, 5-119, 5-122, 5-123, 5-124, 5-125, 5-126, 5-129, 5-130, 5-131, 5-132, 5-134, 5-135, 5-136, 5-137, 5-139, 5-140, 5-142, 5-144, 5-145, 5-146, 5-147, 5-148, 5-150, 5-151, 5-152, 5-153, 5-154, 5-156, 5-157, 5-158, 5-160, 5-161, 5-162, 5-163, 5-164, 5-165, 5-166, 5-167, 5-169, 5-170, 5-171, 5-172, 5-173, 5-174, 5-175, 5-177, 5-178, 5-179, 5-180, 5-181, 5-182, 5-183, 5-185, 5-186, 5-187, 5-188, 5-189, 5-190, 5-191, A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8, A-9, A-10, A-12, A-13, A-14, A-15, A-16, A-17,

A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-25, A-35, A-36, A-42, A-44, A-48, A-55, A-61, A-62, A-63, A-65, B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8, B-9, B-10, B-11, C-3, C-8, C-10, D-7, D-8, D-9, D-13, D-14, E-1, E-2, E-3, E-4, E-6, E-12, E-13, E-14, E-19, E-30, E-31, E-32, E-33, E-34, E-40, E-41, E-42, E-44, E-45, E-46, E-48, E-52, E-55, E-56, E-57, E-58, E-59, E-61, E-63, E-64, E-67, E-71, E-72, E-73, F-1, F-2, F-6, F-7, F-8, F-9, F-10, F-13, F-15, F-17, F-18, F-19, F-21, F-22, F-24, F-25, F-26, F-27, F-30, F-31, F-32, F-36, F-37, F-38, G-1, G-2, G-3, G-5, G-7, G-8, G-9, G-10, G-11, G-12, G-13, G-15, G-22, G-26, G-27, G-32, G-36, G-37, G-38, G-39, G-45, G-47, G-48, G-49, G-50, G-51, G-52, G-54, G-55, G-56, G-57, G-58, G-59, G-60, G-64, G-65, G-66, G-69, G-73, G-75, G-76, G-78, H-27, H-29, H-31, H-53, H-57, H-63, H-67, H-70, H-75, H-78, H-83, H-86, H-89, H-93, I-1, I-2, I-3, I-4, I-5, I-7, I-8, I-10, I-11, I-12, I-13, I-14, I-16, I-17, I-18, I-19, I-21, I-22, I-25, I-26, I-29, I-32, J-1, J-4, J-5

treatment sites, S-3, S-5, S-23, S-24, S-39, S-41, S-43, S-46, S-49, S-51, S-52, S-53, S-54, S-55, S-57, S-68, S-69, S-71, S-72, 1-11, 2-10, 2-16, 2-17, 3-6, 3-8, 3-16, 3-18, 3-21, 3-36, 3-50, 3-55, 5-1, 5-2, 5-3, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-13, 5-14, 5-15, 5-20, 5-26, 5-29, 5-35, 5-36, 5-43, 5-56, 5-57, 5-59, 5-60, 5-61, 5-62, 5-63, 5-68, 5-69, 5-70, 5-75, 5-77, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 5-89, 5-90, 5-92, 5-99, 5-101, 5-102, 5-106, 5-108, 5-112, 5-115, 5-122, 5-123, 5-124, 5-125, 5-127, 5-128, 5-130, 5-131, 5-132, 5-133, 5-137, 5-138, 5-140, 5-145, 5-149, 5-150, 5-151, 5-152, 5-153, 5-154, 5-155, 5-157, 5-158, 5-159, 5-162, 5-163, 5-165, 5-166, 5-167, 5-168, 5-171, 5-180, 5-181, 5-182, 5-186, 5-189, A-10, A-14, A-17, A-23, A-24, A-25, A-48, A-55, B-2, B-5, B-7, C-1, D-4, D-5, D-6, D-9, D-10, D-13, D-14, E-1, E-14, E-41, E-59, E-61, G-7, G-13, G-22, G-25, G-27, G-33, G-38, I-2, I-10, I-19, I-26

tritium (H-3), S-32, S-34, 1-9, 4-26, 4-27, 4-29, 4-48, 4-55, 4-58, 4-59,4-60, 4-65, 4-67, 4-69, 5-184, H-13, H-14, H-17, H-58, H-70, H-71, H-73, H-74, H-78, H-80, H-81, H-82, H-98

TRU mixed waste, S-1, S-3, S-16, S-46, S-49, 1-1, 1-4, 1-13, 1-14, 2-4, 2-5, 2-9, 2-18, 2-19, 3-21, 5-23, 5-27, A-28, A-29, A-30, A-32, A-34, A-61, B-2, E-57

truck transportation, S-6, S-18, S-19, S-22, S-23, S-24, S-29, S-40, S-41, S-44, S-46, S-48, S-69, S-70, S-71, S-72, 1-8, 3-1, 3-6, 3-7, 3-9, 3-18, 3-27, 3-37, 3-45, 3-50, 3-55, 3-56, 4-48, 5-8, 5-10, 5-13, 5-14, 5-15, 5-16, 5-18, 5-19, 5-20, 5-21, 5-22, 5-23, 5-25, 5-55, 5-58, 5-59, 5-60, 5-61, 5-62, 5-63, 5-64, 5-65, 5-66, 5-67, 5-86, 5-88, 5-89, 5-90, 5-92, 5-93, 5-94, 5-95, 5-96, 5-98, 5-124, 5-125, 5-126, 5-127, 5-128, 5-129, 5-151, 5-152, 5-153, 5-155, 5-156, 5-182, 5-185, 5-188, A-5, A-6, A-25, A-26, A-27, A-34, A-35, C-6, C-7, C-9, D-8, D-9, E-3, E-5, E-6, E-8, E-11, E-12, E-13, E-14, E-19, E-22, E-23, E-24, E-25, E-30, E-33, E-34, E-40, E-41, E-43, E-47, E-49, E-50, E-51, E-52, E-55, E-60, E-61, E-63, E-64, E-65, E-66, E-67, F-27, F-29

TRUPACT-II, S-18, S-19, S-40, S-44, S-45, S-47, S-48, 1-9, 1-18, 2-2, 2-3, 2-5, 2-11, 2-16, 2-17, 2-24, 3-6, 3-7, 3-9, 3-10, 5-9, 5-12, 5-14, 5-16, 5-20, 5-22, 5-23, 5-25, 5-27, 5-37, 5-58, 5-64, 5-66, 5-67, 5-95, 5-99, 5-128, 5-129, 5-155, 5-156 6-2, A-5, A-6, A-7, A-8, A-13, A-24, A-25, A-34, A-35, A-66, A-67, D-8, E-2, E-12, E-13, E-14, E-30, E-32, E-34, E-40, E-41, E-42, E-43, E-45, E-46, E-47, E-49, E-52, E-55, E-56, E-57, E-58, E-60, E-63, E-64, E-66, E-67, F-18, F-27

U

U.S. Army Materiel Command (USAMC), S-10, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-35, A-37, A-39, A-43, E-19

University of Missouri Research Reactor, S-10, 2-6, 3-3, 3-17, 3-23, 3-26, 3-29, 3-33, 3-39, 3-42, 3-46, A-10, A-12, A-15, A-18, A-19, A-20, A-22, A-24, A-26, A-27, A-29, A-35, B-3, B-4

uranium (U), S-1, 1-13, 4-46, 4-55, 4-62, 4-69, 5-17, 5-37, 5-50, 5-80, 5-119, 5-147, 5-184, A-37, A-38, A-39, A-40, A-41, A-42, A-45, A-46, A-47, A-49, A-50, A-51, A-52, A-53, A-54, A-56, A-57, A-58, A-59, A-60, E-45, E-48, H-30, H-31, H-53, H-55, H-63, H-64, H-65, H-71, H-73, H-74, H-80, H-81, H-82, H-87, H-88, H-90, I-20, I-31

V

volatile organic compounds (VOC), S-27, S-32, S-34, S-36, S-61, 2-16, 4-6, 4-7, 4-55, 4-59, 4-64, 5-5, 5-23, 5-25, 5-27, 5-29, 5-30, 5-32, 5-35, 5-36, 5-38, 5-40, 5-43, 5-50, 5-64, 5-68, 5-70, 5-71, 5-73, 5-74, 5-75, 5-76, 5-80, 5-98, 5-99, 5-101, 5-102, 5-104, 5-106, 5-107, 5-109, 5-110, 5-111, 5-113, 5-119, 5-121, 5-129, 5-131, 5-134, 5-136, 5-137, 5-138, 5-139, 5-140, 5-141, 5-147, 5-156, 5-157, 5-160, 5-164, 5-189, A-61, A-62, A-63, A-65, B-4, C-1, C-10, C-12, C-13, E-57, E-58, E-59, F-1, F-3, F-4, F-5, F-6, F-7, F-8, F-9, F-10, F-12, F-13, F-14, F-32, F-35, F-36, F-37, F-38, F-39, G-1, G-3, G-4, G-5, G-7, G-8, G-9, G-11, G-12, G-14, G-15, G-16, G-17, G-20, G-22, G-24, G-26, G-27, G-29, G-32, G-34, G-36, G-37, G-39, G-40, G-41, G-42, G-43, G-44, G-45, G-46, G-49, G-53, G-56, G-57, G-58, G-60, G-61, G-62, G-63, G-64, G-65, G-66, G-69, G-70, G-71, G-72, G-73, G-75, G-76, G-77, G-78, H-1, H-8, H-10, H-27, H-28, H-29, H-31, H-56, H-75, I-29, I-37

W

Waste Acceptance Criteria (WAC), S-6, S-16, S-18, S-19, S-20, S-24, S-41, S-46, S-47, S-49, S-51, S-57, S-58, S-59, 1-9, 1-12, 1-15, 1-18, 2-2, 2-5, 2-10, 2-15, 2-16, 2-17, 2-18, 2-20, 2-24, 3-1, 3-2,

3-3, 3-4, 3-6, 3-7, 3-12, 3-15, 3-16, 3-45, 3-56, 4-1, 5-3, 5-10, 5-13, 5-20, 5-22, 5-23, 5-26, 5-30, 5-32, 5-34, 5-37, 5-52, 5-54, 5-55, 5-59, 5-64, 5-74, 5-87, 5-88, 5-89, 5-110, 5-111, 5-114, 5-124, 5-139, 5-140, 5-143, 5-152, 5-164, 5-165, 5-166, 5-169, 5-170, 5-192, A-3, A-5, A-7, A-8, A-9, A-12, A-13, A-14, A-35, A-66, B-4, B-5, B-6, B-7, E-1, E-2, E-41, E-44, E-45, E-55, E-57, E-58, E-76, F-6, F-7, F-8, F-9, F-18, F-19, F-20, F-25, F-26, F-32, F-36, F-38, F-39, G-1, G-2, G-7, G-8, G-9, G-10, G-12, G-15, G-18, G-22, G-23, G-24, G-25, G-32, G-37, G-38, G-39, G-40, G-41, G-42, G-43, G-44, G-45, G-46, G-49, G-57, G-58, G-59, G-60, G-61, G-62, G-63, G-64, G-65, G-66, G-69, G-73, G-75, G-79, H-7, H-27, H-57, H-93, H-107

waste canister, S-19, S-23, 2-3, 2-5, 3-9, 3-10, 3-11, 3-12, 3-15, 3-16, 3-20, 3-21, 3-22, 3-30, 3-32, 3-34, 3-37, 3-49, 3-50, 4-22, 5-22, 5-32, 5-38, 5-41, 5-113, 5-114, 5-142, 5-143, 5-163, 5-177, A-5, A-7, A-13, A-14, A-16, A-17, A-21, A-25, E-2, E-40, E-71, E-77, F-8, F-9, F-10, F-18, G-3, G-13, G-14, G-36, G-38, G-39, G-43, G-44, G-56, G-57, G-59, G-64, G-66, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-76, G-77

waste disposal, S-1, S-2, S-3, S-4, S-5, S-6, S-7, S-10, S-12, S-17, S-18, S-19, S-20, S-22, S-23, S-27, S-34, S-35, S-37, S-38, S-39, S-40, S-48, S-49, S-50, S-51, S-52, S-53, S-54, S-55, S-57, S-59, S-60, S-61, S-70, S-71, S-73, 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-13, 1-14, 2-1, 2-2, 2-3, 2-6, 2-8, 2-9, 2-10, 2-11, 2-15, 2-16, 2-18, 2-20, 3-1, 3-2, 3-3, 3-4, 3-6, 3-8, 3-9, 3-11, 3-12, 3-14, 3-15, 3-16, 3-17, 3-18, 3-20, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-36, 3-37, 3-45, 3-47, 3-49, 3-50, 3-55, 3-56, 4-2, 4-22, 4-24, 4-31, 4-33, 4-60, 4-63, 4-66, 4-70, 4-71, , 5-1, 5-3, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-26, 5-27, 5-28, 5-29, 5-30, 5-31, 5-34, 5-40, 5-41, 5-43, 5-50, 5-52, 5-54, 5-55, 5-56, 5-57, 5-59, 5-60, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-76, 5-80, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 5-89, 5-90, 5-91, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-106, 5-113, 5-114, 5-122, 5-124, 5-125, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-142, 5-143, 5-144, 5-147, 5-149, 5-151, 5-156, 5-162, 5-165, 5-166, 5-169, 5-175, 5-177, 5-178, 5-179, 5-180, 5-182, 5-183, 5-184, 5-185, 5-187, 5-189, 5-190, 5-191 6-1, 6-2, 6-3, A-1, A-5, A-8, A-12, A-13, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-23, A-25, A-35, A-42, A-55, A-63, B-1, B-2, B-4, B-5, B-6, B-7, B-8, B-34, C-2, C-3, C-8, C-9, D-1, D-7, D-8, D-13, E-1, E-67, F-1, F-2, F-6, F-7, F-9, F-10, F-13, F-15, F-17, F-21, F-24, F-27, F-29, F-30, F-32, G-1, G-2, G-5, G-6, G-7, G-10, G-37, G-49, G-56, G-57, G-65, G-67, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, G-79, G-80, H-1, H-2, H-3, H-5, H-6, H-7, H-8, H-10, H-11, H-14, H-15, H-17, H-23, H-24, H-25, H-27, H-28, H-29, H-31, H-32, H-37, H-38, H-39, H-40, H-44, H-45, H-46, H-54, H-56, H-57, H-58, H-75, H-91, H-93, H-96, H-97, H-102, H-105, H-106, H-107, I-2, I-3, I-4, I-32, I-37, J-1, J-4

waste drum, S-4, S-12, S-19, S-24, S-47, S-57, S-59, 1-4, 1-7, 1-9, 2-2, 2-3, 2-5, 2-10, 2-17, 2-18, 3-9, 3-10, 3-11, 3-36, 3-43, 5-23, 5-24, 5-27, 5-31, 5-32, 5-34, 5-35, 5-36, 5-37, 5-38, 5-41, 5-42, 5-43, 5-74, 5-75, 5-76, 5-107, 5-108, 5-109, 5-110, 5-111, 5-112, 5-113, 5-115, 5-129, 5-137, 5-139, 5-140, 5-141, 5-142, 5-144, 5-162, 5-163, 5-177, A-5, A-6, A-7, A-8, A-13, A-14, A-16, A-17, A-21, A-24, A-25, A-28, A-29, A-34, A-35, A-36, A-55, A-61, A-62, A-65, C-10, D-8, E-12, E-13, E-14, E-45, E-55, E-57, E-71, E-72, F-2, F-8, F-9, F-10, F-13, F-18, F-19, F-20, F-21, F-27, F-28, F-30, F-32, F-37, F-38, G-3, G-8, G-9, G-10, G-11, G-12, G-13, G-14, G-15, G-16, G-17, G-18, G-23, G-24, G-25, G-26, G-27, G-28, G-29, G-30, G-37, G-38, G-42, G-43, G-44, G-45, G-46, G-49, G-50, G-51, G-52, G-53, G-54, G-56, G-57, G-58, G-59, G-60, G-61, G-63, G-64, G-65, G-66, G-67, G-68, G-69, H-23, H-27, I-11, I-13, I-14, I-16, I-17, I-18, I-19, I-21

Waste Handling Building, S-7, S-23, 2-11, 3-6, 3-9, 5-8, 5-27, 5-31, 5-32, 5-41, 5-42, 5-73, 5-113, 5-114, 5-136, 5-142, 5-143, 5-144, F-1, F-12, G-7, G-56, G-58, G-59, G-60, G-61, G-63, G-66, G-68, G-69, G-70, G-71

waste hoist, S-71, S-72, 3-55, 5-41, 5-42, 5-113, 5-114, 5-115, 5-142, 5-144, 5-182, G-63

waste inventory, S-2, S-3, S-9, S-12, S-49, S-57, 1-2, 1-3, 1-7, 2-2, 2-6, 2-8, 3-1, 3-12, 5-12, 5-91, 5-152, 5-183, A-1, A-2, A-9, A-25, B-6, B-7, E-32, E-44, E-73, F-1, F-7, G-38, J-4

Waste Isolation Pilot Plant (WIPP), S-1, S-2, S-3, S-4, S-5, S-6, S-7, S-8, S-9, S-10, S-12, S-13, S-16, S-17, S-18, S-19, S-20, S-22, S-23, S-24, S-27, S-28, S-37, S-38, S-39, S-40, S-41, S-43, S-46, S-47, S-48, S-49, S-50, S-51, S-52, S-53, S-54, S-55, S-57, S-58, S-59, S-60, S-61, S-67, S-68, S-69, S-70, S-71, S-72, S-73, S-82, 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-9, 1-10, 1-11, 1-12, 1-13, 1-15, 1-16, 1-17, 1-18, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-9, 2-10, 2-11, 2-15, 2-16, 2-17, 2-18, 2-20, 2-22, 2-23, 2-24, 3-1, 3-2, 3-3, 3-4, 3-6, 3-7, 3-8, 3-9, 3-10, 3-12, 3-13, 3-14, 3-15, 3-16, 3-17, 3-18, 3-20, 3-21, 3-22, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-32, 3-33, 3-34, 3-36, 3-37, 3-38, 3-39, 3-40, 3-42, 3-43, 3-45, 3-46, 3-47, 3-50, 3-55, 3-56, 3-65, 4-1, 4-2, 4-3, 4-5, 4-6, 4-7, 4-9, 4-10, 4-13, 4-14, 4-16, 4-17, 4-18, 4-19, 4-20, 4-21, 4-22, 4-23, 4-24, 4-25, 4-26, 4-27, 4-28, 4-29, 4-30, 4-31, 4-32, 4-33, 4-34, 4-35, 4-36, 4-37, 4-38, 4-39, 4-41, 4-42, 4-45, 4-46, 4-67, 4-68, 4-69, 4-70, 4-71, 5-1, 5-2, 5-3, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-16, 5-18, 5-19, 5-20, 5-23, 5-26, 5-27, 5-28, 5-29, 5-30, 5-31, 5-32, 5-33, 5-34, 5-37, 5-38, 5-40, 5-41, 5-42, 5-43, 5-44, 5-45, 5-46, 5-50, 5-54, 5-55, 5-56, 5-57, 5-58, 5-59, 5-60, 5-61, 5-62, 5-63, 5-67, 5-68, 5-69, 5-70, 5-71, 5-72, 5-73, 5-76, 5-77, 5-80, 5-82, 5-83, 5-84, 5-85, 5-86, 5-87, 5-88, 5-89, 5-90, 5-91, 5-92, 5-94, 5-95, 5-98, 5-99, 5-100, 5-101, 5-102, 5-103, 5-104, 5-105, 5-106, 5-107, 5-108, 5-109, 5-110,

5-111, 5-112, 5-113, 5-114, 5-115, 5-116, 5-121, 5-122, 5-123, 5-124, 5-125, 5-126, 5-128, 5-130, 5-131, 5-132, 5-133, 5-134, 5-135, 5-136, 5-137, 5-142, 5-143, 5-144, 5-145, 5-147, 5-148, 5-149, 5-150, 5-151, 5-152, 5-153, 5-154, 5-156, 5-162, 5-163, 5-164, 5-165, 5-166, 5-169, 5-170, 5-172, 5-177, 5-178, 5-180, 5-181, 5-182, 5-183, 5-185, 5-187, 5-188, 5-189, 5-190, 5-191, 5-192, 5-193, 5-194, 6-1, 6-2, 6-3, A-1, A-2, A-3, A-4, A-5, A-7, A-8, A-9, A-10, A-12, A-13, A-14, A-16, A-17, A-20, A-23, A-24, A-25, A-26, A-27, A-35, A-42, A-44, A-48, A-55, A-61, A-66, A-67, B-2, B-4, B-5, B-6, B-7, B-10, B-33, B-34, C-1, C-2, C-4, C-6, C-10, C-14, D-1, D-5, D-7, D-8, D-9, D-10, D-11, D-12, D-13, D-14, D-16, D-17, E-1, E-2, E-3, E-4, E-5, E-6, E-9, E-10, E-11, E-12, E-13, E-14, E-19, E-22, E-23, E-24, E-25, E-26, E-27, E-30, E-31, E-33, E-34, E-35, E-36, E-37, E-41, E-42, E-57, E-59, E-61, E-63, E-67, E-71, E-72, E-73, E-76, F-1, F-2, F-3, F-6, F-7, F-8, F-9, F-10, F-11, F-12, F-13, F-14, F-15, F-17, F-18, F-19, F-20, F-21, F-24, F-25, F-26, F-27, F-28, F-29, F-30, F-31, F-32, F-33, F-35, F-36, F-37, F-39, F-40, G-1, G-2, G-5, G-6, G-7, G-8, G-9, G-10, G-13, G-18, G-19, G-20, G-22, G-27, G-28, G-29, G-30, G-31, G-37, G-38, G-39, G-41, G-50, G-51, G-52, G-56, G-57, G-58, G-63, G-64, G-65, G-67, G-68, G-69, G-70, G-71, G-72, G-73, G-74, G-75, G-76, G-77, G-78, G-79, G-80, H-1, H-2, H-3, H-4, H-5, H-6, H-7, H-8, H-9, H-10, H-13, H-17, H-23, H-25, H-26, H-27, H-28, H-29, H-31, H-32, H-49, H-52, H-54, H-55, H-56, H-57, H-58, H-59, H-63, H-67, H-75, H-91, H-92, H-94, H-95, H-96, H-97, H-99, H-100, H-101, H-103, H-104, H-105, H-106, H-107, H-108, I-2, I-38, J-1, J-4, J-7

Waste Management Programmatic Environmental Impact Statement (WM PEIS), S-16, S-17, S-18, S-22, S-50, S-68, 1-6, 1-8, 1-11, 1-12, 1-14, 1-16, 2-9, 2-10, 3-3, 3-4, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 3-46, 2-15, 5-1, 5-2, 5-3, 5-4, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-12, 5-26, 5-28, 5-30, 5-31, 5-43, 5-54, 5-58, 5-67, 5-77, 5-83, 5-85, 5-99, 5-115, 5-124, 5-130, 5-145, 5-149, 5-151, 5-156, 5-162, 5-166, 5-170, 5-181, 5-183, 5-185, 5-186, A-12, A-14, A-15, A-16, A-17, A-18, A-19, A-20, A-21, A-22, A-23, A-24, A-42, A-44, B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8, B-9, B-10, B-11, B-29, B-30, B-31, B-32, B-33, 11Cü, C-12, C-13, D-1, D-2, D-3, D-4, D-5, D-6, D-13, E-1, E-19, E-72, F-1, F-10, F-13, I-2, I-3, I-5, I-7, I-23, I-24

waste management, S-1, S-2, S-6, S-9, S-34, S-39, S-40, S-41, S-43, S-69, 1-1, 1-2, 1-3, 1-6, 1-9, 1-11, 1-13, 1-14, 1-15, 1-16, 2-1, 2-9, 3-2, 3-45, 4-48, 4-52, 4-54, 4-58, 4-62, 4-65, 5-4, 5-6, 5-7, 5-11, 5-34, 5-57, 5-88, 5-106, 5-123, 5-137, 5-165, 5-166, 5-169, 5-171, 5-181, 5-186, 5-187, A-1, B-1, B-2, B-5, B-6, B-7, D-1, D-2, D-7, D-13, D-14, G-10, G-13

waste matrix, 2-4, 2-16, 5-114, 5-142, 5-143, A-4, A-7, F-7, F-36, G-8, G-40, G-58

waste retrieval, 1-15, 2-16, D-1

waste stream, 2-4, 2-10, 2-17, 2-18, A-2, A-3, A-4, A-5, A-7, A-8, A-9, A-13, A-14, A-21, A-24, A-25, A-36, A-55, A-61, D-8, E-31, E-32, G-10, H-53, I-12

water resources, S-73, 5-2, 5-9, 5-59, 5-190, B-6, J-4

West Valley Demonstration Project (WVDP), 2-8, 3-17, 3-18, 3-23, 3-24, 3-26, 3-27, 3-29, 3-30, 3-33, 3-34, 3-39, 3-40, 3-42, 3-43, 5-184, A-9, A-15, A-16, A-18, A-19, A-20, A-21, A-22, A-23, A-26, A-27, A-33, A-41, A-42, A-43, B-3, B-4

DOE/EIS-0026-S-2

Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement

Volume II
Appendices

September 1997

Department of Energy
Carlsbad Area Office
Carlsbad, New Mexico

This Document Printed on Recycled Paper

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN, 37831; prices available from (423) 576-1301.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Copies of this document are available
(while supplies last) upon written request to:

U.S. Department of Energy
Carlsbad Area Office
P.O. Box 3090
Carlsbad, NM 88221

or by calling
1 (800) 336-9477

COVER SHEET

Lead Agency: U.S. Department of Energy

Title: Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement
Eddy County, near Carlsbad, New Mexico

Contact:

For further information about this Environmental Impact Statement, contact:

Harold Johnson, WIPP EIS
U.S. Department of Energy
101 W. Greene Street
Carlsbad, NM 88220
(505) 234-7349 phone
(505) 887-6970 fax

For general information on the Department of Energy's process for implementing the National Environmental Policy Act, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance
Office of the Assistant Secretary for Environment, Safety and Health
U.S. Department of Energy (EH-42)
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-4600 or leave a message at (800) 472-2756

Abstract:

The purpose of *the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II) is to provide information on environmental impacts regarding the Department of Energy's (DOE) proposed disposal operations at WIPP. To that end, SEIS-II has been prepared to assess the potential impacts of continuing the phased development of WIPP as a geologic repository for the safe disposal of transuranic (TRU) waste. SEIS-II evaluates a Proposed Action, three Action Alternatives based on the waste management options presented in the *Final Waste Management Programmatic Environmental Impact Statement*, and two No Action Alternatives. The Proposed Action describes the treatment and disposal of the Basic Inventory of TRU waste over a 35-year period. The Basic Inventory is that waste currently permitted in WIPP based on current laws and agreements. The Action Alternatives propose the treatment of the Basic Inventory and an Additional Inventory as well as the transportation of the treated waste to WIPP for disposal over a 150- to 190-year period. The three Action Alternatives include the treatment of TRU waste at consolidation sites to meet WIPP planning-basis Waste Acceptance Criteria, the thermal treatment of TRU waste to meet Land Disposal Restrictions, and the treatment of TRU waste by a shred and grout process. The No Action Alternatives propose the dismantling and closure of WIPP and storage of the waste. One No Action Alternative proposes treating the waste thermally before placing it in retrievable storage.

SEIS-II evaluates environmental impacts resulting from the various treatment options; the transportation of TRU waste to WIPP using truck, a combination of truck and regular rail service, and a combination of truck and dedicated rail service; and the disposal of this waste in the repository. Evaluated impacts include those to the general environment and to human health. Additional issues associated with the implementation of the alternatives are discussed to provide further understanding of the decisions to be reached and to provide the opportunity for public input on improving DOE's Environmental Management Program.

This page intentionally left blank.

TABLE OF CONTENTS — VOLUME II

APPENDIX A: WASTE INVENTORY A-1

A.1 INTRODUCTION A-1
A.1.1 Changes and New Information Since SEIS-I A-2
A.1.2 Data Sources A-3
A.2 WASTE CHARACTERIZATION A-4
A.2.1 Planning-Basis WAC A-5
A.2.1.1 Weight Limits for Packaging TRU Waste A-5
A.2.1.2 Planning-Basis WAC Thermal Power Limits A-7
A.2.1.3 PE-Ci A-7
A.2.1.4 Fissile-Gram Equivalents A-8
A.3 WASTE VOLUMES A-9
A.3.1 Basic Inventory Volumes A-9
A.3.2 Additional Inventory Volumes A-9
A.3.3 Waste Volumes for the Proposed Action A-10
A.3.4 Waste Volumes for Action Alternative 1 ..... A-14
A.3.5 Waste Volumes for Action Alternative 2 ..... A-14
A.3.6 Waste Volumes for Action Alternative 3 ..... A-17
A.3.7 Waste Volumes for No Action Alternative 1 ..... A-23
A.3.8 Waste Volumes for No Action Alternative 2 ..... A-24
A.3.9 Number of Waste Shipments A-24
A.3.10 Final Waste Form Data A-34
A.4 RADIONUCLIDE INVENTORY A-34
A.4.1 Inventory Information in 1995 ..... A-34
A.4.2 Radionuclide Estimates for the Proposed Action A-43
A.4.2.1 CH-TRU Waste A-43
A.4.2.2 RH-TRU Waste A-43
A.4.3 Radionuclide Estimates for Action Alternative 1 ..... A-43
A.4.3.1 CH-TRU Waste A-43
A.4.3.2 RH-TRU Waste A-47
A.4.4 Radionuclide Estimates for Action Alternative 2 ..... A-47
A.4.4.1 CH-TRU Waste A-47
A.4.4.2 RH-TRU Waste A-47
A.4.5 Radionuclide Estimates for Action Alternative 3 ..... A-47
A.4.5.1 CH-TRU Waste A-47
A.4.5.2 RH-TRU Waste A-47
A.4.6 Radionuclide Estimates for No Action Alternative 1 ..... A-47
A.4.7 Radionuclide Estimates for No Action Alternative 2 ..... A-54
A.4.7.1 CH-TRU Waste A-54
A.4.7.2 RH-TRU Waste A-54
A.4.8 Radionuclide Concentrations for Drilling Intrusions A-54
A.5 HAZARDOUS CONSTITUENTS INVENTORY A-60
A.5.1 Metals Inventory A-60
A.5.2 Inventory of Volatile Organic Compounds A-61
A.6 REFERENCES CITED IN APPENDIX A A-65

APPENDIX B: SUMMARY OF THE WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT AND ITS USE IN DETERMINING HUMAN HEALTH IMPACTS AT TREATMENT SITES B-1

B.1 RELATIONSHIP OF DIFFERENT LEVELS OF NEPA DOCUMENTS B-1
B.2 WASTE MANAGEMENT DECISIONS TO BE MADE BY DOE B-1
B.3 OVERVIEW OF THE WM PEIS TRU WASTE ANALYSES B-2
B.3.1 TRU Waste B-2
B.3.2 TRU Waste Generator Sites and Inventories B-2
B.3.3 Waste Treatment B-4
B.3.4 Alternatives B-5
B.3.4.1 Decentralized Alternative B-5
B.3.4.2 Regionalized Alternatives B-5
B.3.4.3 Centralized Alternative B-6
B.3.4.4 No Action Alternative B-6
B.4 INCORPORATION OF WM PEIS INTO SEIS-II ANALYSES B-6
B.5 USING HUMAN HEALTH IMPACTS AT TREATMENT SITES FROM THE WM PEIS B-7
B.6 REFERENCES CITED IN APPENDIX B B-34

APPENDIX C: AIR QUALITY C-1

C.1 MODELS C-1
C.2 RECEPTORS C-2
C.3 SOURCE TERMS AND IMPACTS C-2
C.3.1 Salt Dust Emissions C-3
C.3.2 Backup Generators C-4
C.3.3 Above-Ground Diesel Equipment C-6
C.3.4 Underground Diesel Equipment C-8
C.3.5 Decommissioning of WIPP C-10
C.3.6 Volatile Organic Compounds C-10
C.3.7 Criteria Air Pollutants at Generator-Storage and Treatment Sites C-10
C.4 REFERENCES CITED IN APPENDIX C C-14

APPENDIX D: LIFE-CYCLE COSTS AND ECONOMIC IMPACTS D-1

D.1 LIFE-CYCLE COSTS D-1
D.1.1 Waste Treatment Facility Costs D-1
D.1.2 Waste Transportation Costs D-8
D.1.3 WIPP Operations Budget D-10
D.2 ECONOMIC IMPACTS IN THE WIPP ROI D-10
D.3 ECONOMIC IMPACTS IN THE TREATMENT SITE ECONOMIC REGIONS D-13
D.4 REFERENCES CITED IN APPENDIX D D-17

APPENDIX E: TRANSPORTATION E-1

E.1 INTRODUCTION E-1
E.2 TRUCK TRANSPORTATION AND HIGHWAY ROUTES E-3
E.2.1 HIGHWAY Code E-5
E.2.2 Regulations Applicable to Highway Route Selection E-5
E.2.3 Proposed Routes E-6
E.3 NONRADIOLOGICAL IMPACTS FROM TRUCK TRANSPORTATION E-12
E.3.1 Methodology E-12
E.3.2 Results E-19
E.4 RADIOLOGICAL IMPACTS FROM TRUCK TRANSPORTATION E-19
E.4.1 Radiological Impacts Due to Accident-Free Transportation E-30
E.4.1.1 Methodology E-31
E.4.1.2 Results E-34
E.4.2 Radiological Impacts of Transportation Accidents E-34
E.4.2.1 Methodology E-42
E.4.2.2 Results E-52
E.4.3 Radiological Impacts of Bounding-Case Transportation Accidents E-52
E.4.3.1 Assumptions E-55
E.4.3.2 Results E-56
E.5 HAZARDOUS CHEMICAL IMPACTS FROM TRUCK TRANSPORTATION ACCIDENTS E-57
E.5.1 Methodology E-57
E.5.2 Results E-59
E.6 IMPACTS OF CONSOLIDATION E-59
E.7 IMPACTS FROM RAIL TRANSPORTATION E-61
E.7.1 Fatal Accident Rates E-63
E.7.2 Radiological Impacts of Accident-Free Rail Transportation E-64
E.7.2.1 Radiation Exposure to Individuals Residing Close to the Transportation Corridor E-64
E.7.2.2 Radiation Exposure to Individuals Sharing the Transportation Corridor E-64
E.7.2.3 Radiation Exposure During Stops E-65
E.7.3 Impacts from Severe Rail Accidents E-66
E.8 RETRIEVAL AND RECOVERY E-67
E.8.1 Waste Retrieval E-71
E.8.2 Waste Recovery E-72
E.9 COMPARISON OF ALTERNATIVES E-73
E.10 REFERENCES CITED IN APPENDIX E E-76

APPENDIX F: HUMAN HEALTH F-1

F.1 TECHNICAL APPROACH F-1
F.1.1 Radiological Impacts F-2

F.1.2 Hazardous Chemical Impacts F-3
F.2 ANALYSIS METHODS AND ASSUMPTIONS F-6
F.2.1 Source Terms F-6
F.2.1.1 Radionuclide Source Term F-6
F.2.1.2 VOC Source Term F-7
F.2.2 Atmospheric Transport F-10
F.2.3 Exposure Scenarios F-12
F.2.3.1 Storage Site Exposure Scenarios F-13
F.2.3.2 WIPP Disposal Exposure Scenarios F-13
F.2.3.3 External Radiation Dose of Involved Workers ... F-15
F.3 HUMAN HEALTH IMPACTS F-30
F.3.1 Radiological Impacts F-30
F.3.2 Impacts from VOCs F-32
F.3.2.1 Proposed Action F-32
F.3.2.2 Action Alternative 1 ..... F-35
F.3.2.3 Action Alternative 2 ..... F-36
F.3.2.4 Action Alternative 3 ..... F-36
F.3.2.5 No Action Alternative 1 ..... F-38
F.3.2.6 No Action Alternative 2 ..... F-38
F.4 REFERENCES CITED IN APPENDIX F F-39

APPENDIX G: FACILITY ACCIDENTS G-1

G.1 TECHNICAL APPROACH G-1
G.1.1 Radionuclide Impacts G-1
G.1.2 Hazardous Chemical Consequences G-3
G.1.2.1 Carcinogenic Consequences from Hazardous Chemicals G-3
G.1.2.2 Noncarcinogenic Consequences from Hazardous Chemicals G-4
G.1.2.3 Volatile Organic Compound Screening G-5
G.1.3 Selection of Accident Scenarios G-6
G.2 TREATMENT ACCIDENT SCENARIOS G-7
G.2.1 Inventory G-7
G.2.1.1 Radionuclide Inventory G-7
G.2.1.2 Hazardous Chemical Inventory G-8
G.2.2 Treatment Accident Analysis G-9
G.2.2.1 Accidents During Treatment to Planning-Basis WAC G-10
G.2.2.2 Accidents During Thermal Treatment G-12
G.2.2.3 Accidents During Shred and Grout Treatment ... G-15
G.2.2.4 Source Term Analysis G-17
G.2.3 Exposure Analysis G-18
G.2.4 Consequences of Treatment Accidents G-22
G.2.4.1 Treatment Accident Consequences for the Proposed Action, Action Alternative 1, and No Action Alternative 2 ..... G-22
G.2.4.2 Treatment Accident Consequences for Action Alternative 2 and No Action Alternative 1 ..... G-27

G.2.4.3 Treatment Accident Consequences for Action Alternative 3 ..... G-32
G.3 STORAGE ACCIDENT SCENARIOS G-36
G.3.1 Inventory G-37
G.3.1.1 Radionuclide Inventory G-38
G.3.1.2 Hazardous Chemical Inventory G-39
G.3.2 Storage Accident Analyses G-42
G.3.3 Consequences of Storage Accidents G-44
G.3.3.1 Storage Accident Consequences for Action Alternative 1 and No Action Alternative 2 ..... G-45
G.3.3.2 Storage Accident Consequences for Action Alternative 2 and No Action Alternative 1 ..... G-49
G.3.3.3 Storage Accident Consequences for Action Alternative 3 ..... G-52
G.4 WIPP DISPOSAL ACCIDENT SCENARIOS G-56
G.4.1 Inventory G-57
G.4.2 WIPP Disposal Accident Analysis G-57
G.4.3 Consequences of WIPP Disposal Accidents G-67
G.4.3.1 Accident Consequences for Proposed Action and Action Alternative 1 ..... G-69
G.4.3.2 Accident Consequences for the Action Alternative 2 Subalternatives G-73
G.4.3.3 Accident Consequences for Action Alternative 3 ..... G-75
G.5 REFERENCES CITED IN APPENDIX G G-79

APPENDIX H: LONG-TERM CONSEQUENCE ANALYSIS FOR PROPOSED ACTION AND ACTION ALTERNATIVES H-1

H.1 INTRODUCTION H-1
H.2 CHANGES IN PERFORMANCE ASSESSMENT ANALYSIS SINCE THE 1990 *FINAL SUPPLEMENT ENVIRONMENTAL IMPACT STATEMENT FOR THE WASTE ISOLATION PILOT PLANT* (SEIS-I) H-1
H.2.1 Pre-Disposal and Disposal Phase Experimental Programs H-1
H.2.2 Computational Tools and Codes H-6
H.3 DESCRIPTION OF APPROACH H-8
H.3.1 Data Sources and Parameter Selection H-9
H.3.2 Release Scenarios Analyzed H-9
H.3.2.1 Undisturbed Conditions H-10
H.3.2.2 Disturbed Conditions H-11
H.3.3 Source-Term Release and Transport Codes H-14
H.3.3.1 BRAGFLO H-14
H.3.3.2 NUTS H-15
H.3.3.3 CUTTINGS_S H-16
H.3.3.4 SECOFL2D and SECOTP2D H-17
H.4 CONCEPTUAL MODEL OF THE REPOSITORY DISPOSAL SYSTEM H-17
H.4.1 Repository System H-17

H.4.1.1 Salt Creep H-17
H.4.1.2 Brine Flow H-23
H.4.1.3 Gas Generation H-23
H.4.1.4 Source-Term Release Mechanisms H-23
H.4.1.5 Dilation and Fracturing of the Anhydrite Interbeds H-23
H.4.1.6 Repository Features H-24
H.4.1.7 Engineered Components H-24
H.4.2 Salado Formation H-24
H.4.3 Units Above and Below the Salado Formation H-25
H.4.3.1 Rustler Formation H-25
H.4.3.2 Dewey Lake (Redbeds) Member and Supra-Dewey Lake Units H-27
H.4.3.3 Castile Formation and Brine Reservoirs H-27
H.5 CONCEPTUAL MODEL OF THE SOURCE-TERM RELEASE H-27
H.5.1 Key Assumptions for Source-Term Release H-28
H.5.2 Source-Term Constituents H-29
H.5.2.1 Screening and Selection of Radionuclides H-29
H.5.2.2 Heavy Metals H-31
H.5.2.3 VOCs H-31
H.6 REPOSITORY DISPOSAL SYSTEM NUMERICAL MODEL H-32
H.6.1 Model Geometry H-32
H.6.2 Boundary and Initial Conditions H-37
H.6.3 Repository and Panel Parameters H-38
H.6.4 Shaft and Seal Parameters H-40
H.6.5 Salado Formation H-44
H.6.5.1 Impure Halite H-44
H.6.5.2 Anhydrite Interbeds H-44
H.6.5.3 Disturbed Rock Zone H-45
H.6.5.4 Units Above the Salado Formation H-46
H.6.6 The Castile Formation H-49
H.6.7 Intrusion Borehole Parameters H-49
H.6.8 Solubility-Controlled Release Model Parameters H-53
H.7 CULEBRA DOLOMITE MODEL H-54
H.7.1 Model Geometry, Boundaries, and Assumed Flow Conditions H-54
H.7.2 Radionuclide and Heavy Metal Transport H-55
H.8 ANALYSIS AND RESULTS OF LONG-TERM PERFORMANCE ASSESSMENT H-56
H.8.1 Exposure Scenarios H-56
H.8.1.1 Undisturbed Conditions H-56
H.8.1.2 Disturbed Conditions H-56
H.8.2 Results for the Proposed Action H-59
H.8.2.1 Impacts of Undisturbed Conditions H-60
H.8.2.2 Impacts of Disturbed Conditions H-62
H.8.3 Results for Action Alternative 1 ..... H-67
H.8.3.1 Impacts of Undisturbed Conditions H-68

H.8.3.2 Impacts of Disturbed Conditions H-70
H.8.4 Results for Action Alternative 2 ..... H-74
H.8.4.1 Impacts of Undisturbed Conditions H-77
H.8.4.2 Impacts of Disturbed Conditions H-77
H.8.5 Results for Action Alternative 3 ..... H-82
H.8.5.1 Impacts of Undisturbed Conditions H-85
H.8.5.2 Impacts of Disturbed Conditions H-85
H.9 ALTERNATIVE CONCEPTUAL MODELS AND VIEWS OF DISPOSAL PERFORMANCE H-90
H.9.1 WIPP Characteristics and Conceptual Models H-90
H.9.1.1 Repository Characteristics H-90
H.9.1.2 Salado Formation H-92
H.9.1.3 Rustler/Salado Contact H-93
H.9.1.4 Rustler Formation/Culebra Dolomite Member .. H-94
H.9.1.5 Supra-Rustler Units H-103
H.9.2 Issues Related to Human Impacts and Intrusion H-104
H.10 REFERENCES CITED IN APPENDIX H H-105

APPENDIX I: LONG-TERM CONSEQUENCE ANALYSIS FOR NO ACTION ALTERNATIVE 2 ..... I-1

I.1 INTRODUCTION I-1
I.1.1 Background I-1
I.1.2 Purpose and Scope I-2
I.2 RISK ANALYSIS METHODOLOGY I-3
I.2.1 Inadvertent Human Intrusion Impacts I-3
I.2.2 Impacts of Long-Term Environmental Releases I-5
I.3 COMPUTER CODES I-9
I.3.1 MEPAS® Code I-9
I.3.2 GENII Code I-10
I.4 WASTE CHARACTERISTICS I-10
I.4.1 Description of TRU Waste Forms and TRU Waste-Form Categories I-10
I.4.2 Quantity of Each TRU Waste-Form Category I-12
I.4.3 Contaminant Inventory Distribution of Each TRU Waste-Form Category I-13
I.5 WASTE CONFIGURATION AND CONTAMINANT RELEASE SCENARIOS I-13
I.5.1 Waste Storage Configuration I-14
I.5.1.1 Facility and Waste Degradation I-16
I.5.1.2 Distribution of TRU Waste Forms I-17
I.5.2 Contaminant Release Scenarios I-17
I.5.2.1 Soil/Debris TRU Waste Form I-18
I.5.2.2 Cemented TRU Waste Form I-18
I.5.3 Geochemical Controls on TRU Waste-Form Leaching I-19
I.6 CONTAMINANTS OF CONCERN (CoC) I-19
I.6.1 Radioactive Contaminant Screening Analysis I-20
I.6.2 Inorganic Contaminant Screening Analysis I-21
I.6.3 Organic Contaminant Screening Analysis I-21

I.6.4 Key Contaminants Evaluated in No Action Alternative 2 ..... I-22
I.6.5 Flux Factors I-22
I.7 WATERBORNE AND AIRBORNE TRANSPORT I-23
I.7.1 Waterborne Transport Parameters I-23
I.7.2 Calculated Waste Infiltration Rates I-23
I.7.3 Airborne Transport Parameters I-23
I.7.4 Calculated Soil Erosion Rates I-24
I.7.5 Air and Water Receptor Locations I-24
I.8 CALCULATION OF UNIT EXPOSURE AND UNIT IMPACT FACTORS I-24
I.8.1 Background Information and Scope of Analysis I-24
I.8.1.1 Exposure Scenario I-25
I.8.1.2 Receptor Type I-25
I.8.1.3 Exposure Media I-25
I.8.1.4 Pollutant Type I-25
I.8.2 Individual UDF and UIF Calculations I-25
I.8.3 Population UDF and UIF Calculations I-25
I.9 HUMAN HEALTH IMPACTS OF NO ACTION ALTERNATIVE 2 ..... I-25
I.9.1 Impacts from Intrusion into Wastes I-26
I.9.1.1 Intrusion into Buried Waste I-26
I.9.1.2 Intrusion into Surface-Stored Wastes I-29
I.9.2 Impacts of Long-Term Environmental Release I-32
I.9.2.1 Radiological Impacts I-33
I.9.2.2 Chemical Carcinogen Impacts I-36
I.9.2.3 Noncarcinogenic Impacts I-36
I.10 REFERENCES CITED IN APPENDIX I I-37

APPENDIX J: UPDATED ESTIMATES OF THE DEPARTMENT OF ENERGY'S TRANSURANIC WASTE VOLUMES J-1

APPENDIX K: LIST OF PREPARERS AND CONTRIBUTORS K-1

APPENDIX L: DISTRIBUTION LIST L-1
L.1 Full SEIS-II L-1
L.2 Summary L-36

INDEX IN-1

LIST OF TABLES — VOLUME II

Table A-1 Final TRU Waste Form Code Group Definitions....A-4

Table A-2 CH-TRU Waste Shipping Weights A-6

Table A-3 Basic Inventory TRU Waste Volumes A-10

Table A-4 Additional Inventory TRU Waste Volumes.... A-11

Table A-5 TRU Waste Volumes (Basic Inventory) for the Proposed Action A-12

Table A-6 CH-TRU Waste Volumes for Action Alternative 1 .... A-15

Table A-7 RH-TRU Waste Volumes for Action Alternative 1 .... A-16

Table A-8 CH-TRU Waste Volumes for Action Alternative 2A A-18

Table A-9 CH-TRU Waste Volumes for Action Alternative 2B A-19

Table A-10 CH-TRU Waste Volumes for Action Alternative 2C A-20

Table A-11 RH-TRU Waste Volumes for Action Alternatives 2A, 2B, and 2C.... A-21

Table A-12 CH-TRU Waste Volumes for Action Alternative 3 .... A-22

Table A-13 RH-TRU Waste Volumes for Action Alternative 3 .... A-23

Table A-14 TRU Waste Volumes for No Action Alternative 2.... A-24

Table A-15 Number of Truck Shipments to WIPP by Alternative A-26

Table A-16 CH-TRU Final Waste Form Data.... A-28

Table A-17 Final Waste Form Data for RFETS CH-TRU Waste Residues A-30

Table A-18 Final Waste Form Data for PCB-Commingled Waste A-30

Table A-19 Example LANL Data for Shipment Calculations A-31

Table A-20 RH-TRU Final Waste Form Data.... A-31

Table A-21 Previously Disposed TRU Final Waste Form Data A-32

Table A-22 Commercial/Nondefense TRU Final Waste Form Data A-32

Table A-23 Possible Future TRU Final Waste Form Data.... A-33

Table A-24 Radionuclide Inventories (curies) for Stored CH-TRU Waste in 1995 ..... A-36

Table A-25 Radionuclide Inventories (grams) for Stored CH-TRU Waste in 1995 ..... A-38

Table A-26 Radionuclide Inventories (curies) for Stored RH-TRU Waste in 1995 ..... A-40

Table A-27 Radionuclide Inventories (grams) for Stored RH-TRU Waste in 1995 ..... A-41

Table A-28 Volume Factors Used to Estimate Total CH-TRU Waste Radionuclide Inventories at Each Site A-42

Table A-29 Volume Factors Used to Estimate Total RH-TRU Waste Radionuclide Inventories at Each Site A-42

Table A-30 Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for the Proposed Action A-44

Table A-31 Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for the Proposed Action A-45

Table A-32 Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 1 ..... A-46

Table A-33 Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for Action Alternative 1 ..... A-48

Table A-34 Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 2A A-49

Table A-35 Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 2B A-50

Table A-36 Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for Action Alternatives 2A, 2B, and 2C A-51

Table A-37 Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 3 ..... A-52

Table A-38 Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for Action Alternative 3 ..... A-53

Table A-39 Radionuclide Inventories (curies) for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2 ..... A-55

Table A-40 Decayed Radionuclide Inventories (curies) Adjusted for Decay Through 2133 for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2..... A-56

Table A-41 Radionuclide Inventories (curies) for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2 ..... A-57

Table A-42 Decayed Radionuclide Inventories (curies) Adjusted for Decay Through 2133 for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2..... A-58

Table A-43 Radionuclide Concentrations (curies/cubic meter) for Drilling Intrusions into CH-TRU Waste..... A-59

Table A-44 Concentration of Hazardous Metals A-60

Table A-45 Inventory (kilograms) of Hazardous Metals by Alternative A-61

Table A-46 Average Concentrations (ppmv) of Volatile Organic Compounds as Reported from the RCRA Part B Permit Application A-62

Table A-47 Volume-Weighted Average Concentrations (ppmv) of Volatile Organic Compounds in CH-TRU Waste by Treatment Site for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2..... A-63

Table A-48 Volume-Weighted Average Concentrations (ppmv) of Volatile Organic Compounds in RH-TRU Waste by Treatment Site for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2..... A-63

Table A-49 Inventory (grams) of Volatile Organic Compounds in CH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2..... A-64

Table A-50 Inventory (grams) of Volatile Organic Compounds in RH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2..... A-64

Table B-1 Transuranic Waste Volumes of the WM PEIS (cubic meters) B-4

Table B-2 Key Radionuclide Concentration and Volume Adjustment Factors For CH-TRU and RH-TRU Waste B-9

Table B-3 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for the Proposed Action Total (Basic) Inventory.....B-12

Table B-4 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Total Inventory B-13

Table B-5 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Total Inventory B-14

Table B-6 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1B Total Inventory.....B-15

Table B-7 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Total Inventory B-16

Table B-8 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Total Inventory B-17

Table B-9 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2 Total (Basic/Newly Generated) Inventory.....B-18

Table B-10 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Basic Inventory B-19

Table B-11 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Basic Inventory B-20

Table B-12 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1B Basic Inventory.....B-21

Table B-13 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Basic Inventory B-22

Table B-14 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Basic Inventory B-23

Table B-15 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Additional Inventory.....B-24

Table B-16 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Additional Inventory B-25

Table B-17 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1A Additional Inventory B-26

Table B-18 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Additional Inventory.....B-27

Table B-19 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Additional Inventory.....B-28

Table B-20 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Decentralized Alternative.....B-29

Table B-21 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 1 Alternative B-30

Table B-22 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 2 Alternative B-31

Table B-23 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 3 Alternative B-32

Table B-24 Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Centralized Alternative B-33

Table C-1 Multiplying Factors to Estimate Maximum Concentration at Various Averaging Times for a Given 1-hour Maximum Concentration C-2

Table C-2 Stack Parameters for the Back-up Generator and Exhaust Shaft..... C-3

Table C-3 Source Term for Calculating Salt Dust Emission Impacts for All Alternatives Except No Action Alternatives 1 and 2..... C-4

Table C-4 Estimated Impacts on Air Quality from Salt Dust Emissions for All Alternatives Except No Action Alternatives 1 and 2..... C-4

Table C-5 Maximum Annual and Hourly Emission Rates from Two Back-up Generators C-5

Table C-6 Source Term for Calculating Back-up Diesel Generator Emission Impacts C-5

Table C-7 Criteria Pollutant Air Quality Impacts from the Emissions of Two Back-up Generators..... C-6

Table C-8 Estimated Emission Rates for Diesel Dump Truck..... C-7

Table C-9 Estimated Emission Rates for Industrial Diesel Engines..... C-7

Table C-10 Source Term for Calculating Impacts from Surface Diesel Equipment C-7

Table C-11 Criteria Pollutant Air Quality Impacts from Surface Diesel Equipment Emissions C-8

Table C-12 Diesel Equipment and Total Available Power for Underground Operations C-9

Table C-13 Source Term for Calculating Impacts from Underground Diesel Equipment Emissions C-9

Table C-14 Criteria Pollutant Air Quality Impacts from Underground Diesel Equipment Emissions C-9

Table C-15 Percent of Standard/Guidelines for Criteria Air Pollutants During Operations and Maintenance..... C-12

Table C-16 Percent of General Conformity Rule for Criteria Air Pollutants During Construction..... C-13

Table D-1 Waste Treatment Facility Costs for the Proposed Action in Millions of 1994 Dollars D-2

Table D-2 Waste Treatment Facility Costs for Action Alternative 1 in Millions of 1994 Dollars D-3

Table D-3 Waste Treatment Facility Costs for Action Alternative 2A in Millions of 1994 Dollars D-4

Table D-4 Waste Treatment Facility Costs for Action Alternative 2B in Millions of 1994 Dollars D-4

Table D-5 Waste Treatment Facility Costs for Action Alternative 2C in Millions of 1994 Dollars D-5

Table D-6 Waste Treatment Facility Costs for Action Alternative 3 in Millions of 1994 Dollars D-5

Table D-7 Waste Treatment Facility Costs for No Action Alternative 1A in Millions of 1994 Dollars D-6

Table D-8 Waste Treatment Facility Costs for No Action Alternative 1B in Millions of 1994 Dollars D-6

Table D-9 Volume Adjustment Factors by Alternative D-7

Table D-10 Present Values of Hypothetical Annual Costs Incurred Over 35 Years D-8

Table D-11 Truck and Rail Transportation Costs by Alternative in Millions of 1994 Dollars D-9

Table D-12 Annual Split of Total ROI Economic Impacts of the Proposed Action D-12

Table D-13 Determination of Treatment Site Economic Region D-15

Table D-14 Development of Economic Impact Scaling Factors for Treatment Sites D-16

Table E-1 Number of Shipments for CH-TRU Waste E-15

Table E-2 Number of Shipments for RH-TRU Waste E-17

Table E-3 Number of CH-TRU and RH-TRU Waste Shipments to Consolidation/Treatment Sites from Sites with Smaller Quantities of TRU Waste E-19

Table E-4 CH-TRU and RH-TRU Waste Shipments from Major Generator-Storage Sites to Treatment Sites E-20

Table E-5 CH-TRU Waste Transportation in Miles (kilometers) E-22

Table E-6 RH-TRU Waste Transportation in Miles (kilometers) E-23

Table E-7 Mileages (kilometers) to Treatment Sites from Sites with Small Quantities of TRU Waste E-24

Table E-8 Nonradiological Impacts per Shipment from Accidents and Pollution Related Health Effects E-26

Table E-9 Aggregate Nonradiological Impacts for CH-TRU and RH-TRU Waste Transport E-28

Table E-10 RADTRAN Input for Transportation Analyses E-30

Table E-11 Transportation Indices for TRU Waste Transported from the 10 Major Sites (millirem per hour at 1 meter [3.3 feet]) E-33

Table E-12 Population Dose per CH-TRU Waste Shipment E-35

Table E-13 Population Dose per RH-TRU Waste Shipment E-37

Table E-14 Aggregate Accident-Free Dose (person-rem) from CH-TRU and RH-TRU Waste Shipments E-38

Table E-15 Aggregate Dose (rem) and LCFs (values in parentheses) to MEIs from CH-TRU and RH-TRU Waste Shipments E-40

Table E-16 Fractional Truck Accident Occurrences by Accident Severity Category and Population Density Zone E-43

Table E-17 Bounding Case Radionuclide Inventories for CH-TRU and RH-TRU Waste Accidents E-45

Table E-18 Impact Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments E-47

Table E-19 Thermal Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments E-49

Table E-20 CH-TRU Waste Truck Transportation Release Fractions E-50

Table E-21 RH-TRU Waste Truck Transportation Release Fractions E-50

Table E-22 Aggregate Radiological Impacts from Severe Accidents (person-rem) E-53

Table E-23 Chemical Constituents Analyzed in CH-TRU Waste E-58

Table E-24 Chemical Airborne Releases for a Severity Category VIII Accident (CH-TRU Waste Truck Shipment) E-60

Table E-25 Transportation Impacts for Consolidation of Waste from Major Generator-Storage Sites E-60

Table E-26 Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Major Generator Sites to Treatment Sites E-61

Table E-27 Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Small Quantity Sites E-61

Table E-28 Small Quantity Sites Transportation Impacts Relative to Major Generator-Storage Site Transportation Risk E-62

Table E-29 Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 1 .....E-68

Table E-30 Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 2 .....E-69

Table E-31 Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 3 .....E-70

Table E-32 Rail (Regular and Dedicated) Transportation Impacts for No Action Alternative 1 .....E-71

Table E-33 Waste Retrieval Impacts E-72

Table E-34 Waste Recovery Impacts.....E-73

Table E-35 Comparison of Impacts Across Alternatives (CH-TRU and RH-TRU Waste).....E-74

Table F-1 Carcinogenic Risk Factors for VOCs F-4

Table F-2 Noncarcinogenic Health Effect Measures for VOCs F-5

Table F-3 Involved Worker Supplemental Noncarcinogenic Health Effect Measures for VOCs F-5

Table F-4 TRU Waste VOC Headspace Concentrations Used in Health Impact Analyses for WIPP F-8

Table F-5 Average Single Drum Release Rate of Headspace VOCs (grams per second) F-9

Table F-6 Number of Drum-Equivalents Assumed for the Evaluation of Routine VOC Releases F-10

Table F-7 Meteorologic Joint Frequency Data Used for WIPP Atmospheric Releases (Percent of Time) F-11

Table F-8 WIPP Stack Release Parameters F-12

Table F-9 MEI and Noninvolved Worker Locations for Lag Storage Operations.....F-12

Table F-10 1990 Population Distribution Within 80 Kilometers (50 Miles) of WIPP F-14

Table F-11 Proposed Action External Dose Screening Values for CH-TRU Waste.....F-16

Table F-12 Action Alternative 1 External Dose Screening Values for CH-TRU Waste F-16

Table F-13 Action Alternative 2A, Action Alternative 3, and No Action Alternative 1A External Dose Screening Values for CH-TRU Waste F-16

Table F-14 Action Alternative 2B and No Action Alternative 1B External Dose Screening Values for CH-TRU Waste F-17

Table F-15 No Action Alternative 2 External Dose Screening Values for CH-TRU Waste F-17

Table F-16 Specific Planning-Basis WAC Requirements Limiting Waste Container Radionuclide Contents F-18

Table F-17 Average Surface and 1-Meter (3.3-Foot) Dose Rates of CH-TRU Waste Drums (1995 activities) F-19

Table F-18 Radionuclide-Specific Dose Rates for Various Waste Densities (rem/h per Ci/drum-equivalent) F-20

Table F-19 Average Density and Activity of Site-Specific CH-TRU Wastes F-20

Table F-20 WIPP Involved Worker Annual Doses (rem/y per worker) F-22

Table F-21 Maximum Storage Site Involved Worker Population Estimates F-26

Table F-22 Site-Specific Treatment Facility Throughputs F-28

Table F-23 Shipment Rates During the Design-and-Construction Phases and the Fully Operational Treatment Phases F-29

Table F-24 Assumed Truck Transfer Schedule F-29

Table F-25 Radiation Doses from Routine Releases of Gaseous Radionuclides for the Public and Non-Involved Workers F-31

Table F-26 Aggregate Dose to WIPP Involved Worker Populations F-32

Table F-27 Aggregate Lag Storage Worker Population Impacts F-33

Table F-28 Storage Site Involved Worker Lifetime Radiological Impacts (35-year Exposures) F-34

Table F-29 Overpackaging Involved Worker Radiological Impacts for No Action Alternative 1 (35-year Exposures) F-34

Table F-30 Proposed Action Human Health Impacts from Routine Releases of VOCs at WIPP and Excess RH-TRU Waste Storage Impacts at Hanford and ORNL F-35

Table F-31 Action Alternative 1 Human Health Impacts from Routine Releases of VOCs F-36

Table F-32 Action Alternative 3 Human Health Impacts from Routine Releases of VOCs F-37

Table F-33 No Action Alternative 2 Human Health Impacts from Routine Releases of VOCs .. F-38

Table G-1 Carcinogenic Risk Factors for Heavy Metals G-3

Table G-2 IDLH Values for Facility Accident Noncarcinogenic Consequence Analysis G-4

Table G-3 ERPG Values for Facility Accident Noncarcinogenic Impact Analysis G-6

Table G-4 Radionuclide Activity per Drum for Treatment Accident Analyses G-8

Table G-5 VOC Headspace Concentrations for Treatment Accident Analyses G-9

Table G-6 Heavy Metal Concentrations in TRU Waste for Treatment Accident Analyses G-9

Table G-7 Annual Frequencies of Occurrence for Treatment Accidents G-10

Table G-8 Accident Analysis Parameters for Waste Treatment to Planning-Basis WAC for the Proposed Action, Action Alternative 1, and No Action Alternative 2 ..... G-12

Table G-9 Accident Analysis Parameters for Thermal Treatment of Waste for the Action Alternative 2 and No Action Alternative 1 Subalternatives G-15

Table G-10 Accident Analysis Parameters for Shred and Grout Treatment of Waste for Action Alternative 3 ..... G-17

Table G-11 Exposed Population Locations, Sizes, and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis G-19

Table G-12 MEI and Noninvolved Worker Locations and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis G-20

Table G-13 Radiological Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC G-23

Table G-14 Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC G-24

Table G-15 Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC G-24

Table G-16 Radiological Consequences from Treatment Accidents for Thermally Treated Waste G-28

Table G-17 Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Thermally Treated Waste G-29

Table G-18 Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Thermally Treated Waste G-29

Table G-19 Radiological Consequences from Treatment Accidents for Waste Treatment by Shred and Grout G-33

Table G-20 Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Waste Treatment by Shred and Grout G-34

Table G-21 Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Waste Treatment by Shred and Grout G-34

Table G-22 Planning-Basis WAC Requirements that Reduce Accident Risk G-38

Table G-23 Average Radionuclide Content of CH-TRU Waste (PE-Ci per drum-equivalent) at the Major Storage Sites and WIPP G-39

Table G-24 Average Radionuclide Content of RH-TRU Waste (PE-Ci per canister) at the Major Storage Sites and WIPP G-39

Table G-25 VOC Headspace Concentrations in Treated TRU Waste G-40

Table G-26 VOCs with Major Consequence Contribution for Storage Accidents G-41

Table G-27 Heavy Metal Concentrations in Treated TRU Waste G-42

Table G-28 Summary of Storage Accident Scenario Parameters G-43

Table G-29 Radiological Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)..... G-45

Table G-30 Hazardous Chemical Carcinogenic Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2) G-46

Table G-31 Hazardous Chemical Noncarcinogenic Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2) G-46

Table G-32 Radiological Consequences from Storage Accidents for Thermally Treated Waste (Action Alternative 2 and No Action Alternative 1) G-50

Table G-33 Hazardous Chemical Carcinogenic and Noncarcinogenic Consequences from Storage Accidents for Thermally Treated Waste (Action Alternative 2 and No Action Alternative 1) G-51

Table G-34 Radiological Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3) G-53

Table G-35 Hazardous Chemical Carcinogenic Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3) G-53

Table G-36 Hazardous Chemical Noncarcinogenic Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3) G-54

Table G-37 WIPP Disposal Accident Scenarios..... G-56

Table G-38 Average WIPP Radionuclide Content of CH-TRU Waste and RH-TRU Waste (PE-Ci per waste container)..... G-57

Table G-39 Accident Analysis Parameters for Waste Treated to Planning-Basis WAC for the Proposed Action and Action Alternative 1..... G-59

Table G-40 Accident Analysis Parameters for Thermally Treated and Grouted Waste for the Action Alternative 2 Subalternatives and Action Alternative 3 ..... G-59

Table G-41 Source Terms for Off-site Releases from WIPP Disposal Accidents (PE-Ci)..... G-68

Table G-42 Involved Worker Intakes from WIPP Disposal Accidents (PE-Ci)..... G-68

Table G-43 Annual Frequencies of Occurrence for WIPP Disposal Accidents G-69

Table G-44 Radiological Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1 ..... G-70

Table G-45 Hazardous Chemical Carcinogenic Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1..... G-71

Table G-46 Hazardous Chemical Noncarcinogenic Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1 ..... G-71

Table G-47 Ratios of Exposure Air Concentrations to ERPG-2 Values for WIPP Disposal Accidents for the Proposed Action and Action Alternative 1 ..... G-72

Table G-48 Radiological Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives G-73

Table G-49 Heavy Metal Carcinogenic Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives..... G-74

Table G-50 Heavy Metal Noncarcinogenic Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives..... G-74

Table G-51 Ratios of Exposure Air Concentrations to ERPG-2 Values for the Action Alternative 2 Subalternatives G-75

Table G-52 Radiological Consequences of WIPP Disposal Accidents for Action Alternative 3 ..... G-76

Table G-53 Hazardous Chemical Carcinogenic Consequences of WIPP Disposal Accidents for Action Alternative 3 ..... G-77

Table G-54 Hazardous Chemical Noncarcinogenic Consequences of WIPP Disposal Accidents for Action Alternative 3 ..... G-77

Table G-55 Ratios of Exposure Air Concentrations to ERPG-2 Values for WIPP Disposal Accidents for Action Alternative 3 ..... G-78

Table H-1 Summary of Computer Codes Used in the 1992 WIPP Performance Assessment H-7

Table H-2 Cases Considered in Long-term Performance Analysis of the Proposed Action and Action Alternatives H-10

Table H-3 Brine and Gas Migration Modeling Assumptions H-18

Table H-4 Radionuclides with Highest Inventories (curies) for Action Alternative 1 ..... H-30

Table H-5 Radionuclide Screening of Dose Contribution for Long-term Performance Assessment H-30

Table H-6 Dimensional Lengths of Rest-of-Repository Material Zone Grid Elements for the Proposed Action; Action Alternatives 1, 2, 3; and Resulting Grid Element and Material Zone H-37

Table H-7 Fluid Property Parameter Values H-39

Table H-8 Repository and Panel Seal Parameter Values H-40

Table H-9 Parameter Values for the Average Stoichiometry Gas-Generation Model H-41

Table H-10 Shaft Materials Parameter Values H-42

Table H-11 Parameter Values for Salado Formation Halite H-44

Table H-12 Parameter Values for the Salado Formation Anhydrite Interbeds A and B and Marker Beds 138 and 139 ..... H-45

Table H-13 Parameter Values for the Salado Formation Anhydrite Interbeds A and B and Marker Beds 138 and 139 Fracture H-45

Table H-14 Parameter Values for the Disturbed Rock Zone H-46

Table H-15 Parameter Values for the Culebra Member of the Rustler Formation H-47

Table H-16 Parameter Values for the Magenta Member of the Rustler Formation H-47

Table H-17 Parameter Values for the Forty-Niner, Tamarisk, and Unnamed Lower Members of the Rustler Formation H-48

Table H-18 Parameter Values for the Dewey Lake Formation H-48

Table H-19 Parameter Values for the Units Above the Dewey Lake Formation H-49

Table H-20 Parameter Values for the Castile Formation H-50

Table H-21 Parameter Values for the Brine Reservoir H-50

Table H-22 Exploratory Borehole Parameter Values Used After Intrusion H-52

Table H-23 Select Parameter Values Used in CUTTINGS_S Code H-52

Table H-24 Log Solubility Values for Elements H-53

Table H-25 Radionuclide Releases (curies) to the Ground Surface from Drilling Intrusions for the Proposed Action H-63

Table H-26 Releases (kilograms) of Heavy Metals to the Ground Surface from Drilling Intrusions for the Proposed Action H-63

Table H-27 Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for the Proposed Action H-64

Table H-28 Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals for Drilling Intrusion into the Repository for the Proposed Action H-64

Table H-29 Radiation Dose to the Well-Site Geologist from Drilling Intrusions for the Proposed Action H-65

Table H-30 Radionuclide Releases (curies) to the Ground Surface from Drilling Intrusions for Action Alternative 1 ..... H-71

Table H-31 Releases (kilograms) of Heavy Metals to the Ground Surface from Drilling Intrusions for Action Alternative 1 ..... H-71

Table H-32 Radiation Dose to a Member of the Drilling Crew for a Drilling Intrusion for Action Alternative 1 ..... H-72

Table H-33 Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals for Drilling Intrusion into the Repository for Action Alternative 1 ..... H-73

Table H-34 Radiation Dose to the Well-Site Geologist from Drilling Intrusions for Action Alternative 1 ..... H-73

Table H-35 Radionuclide Releases (curies) to the Ground Surface from Drilling Intrusions for Action Alternative 2 ..... H-79

Table H-36 Releases (kilograms) of Heavy Metals to the Ground Surface from Drilling Intrusions for Action Alternative 2 ..... H-79

Table H-37 Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for Action Alternative 2 ..... H-80

Table H-38 Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals from Drilling Intrusion into the Repository for Action Alternative 2 ..... H-81

Table H-39 Radiation Dose to the Well-Site Geologist from Drilling Intrusions for Action Alternative 2 ..... H-81

Table H-40 Radionuclide Releases (curies) to the Ground Surface from Drilling Intrusions for Action Alternative 3 ..... H-86

Table H-41 Releases (kilograms) of Heavy Metals to the Ground Surface from Drilling Intrusions for Action Alternative 3 ..... H-86

Table H-42 Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for Action Alternative 3 ..... H-87

Table H-43 Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals from Drilling Intrusions into the Repository for Action Alternative 3 ..... H-88

Table H-44 Radiation Dose to the Well-Site Geologist from Drilling Intrusions for Action Alternative 3 ..... H-89

Table I-1 Categorization of BIR-3 TRU Waste Materials into General Waste-Form Categories I-12

Table I-2 Relative Quantities and Volumes of Each TRU Waste-Form Category by Release Site I-13

Table I-3 Waste Zone Volumes, Horizontal Areas, and Configurations for Each Waste-Form Category by Release Site I-15

Table I-4 Contaminants of Concern for No Action Alternative 2 ..... I-20

Table I-5 Nonzero Contaminant Flux Factors by Site and TRU Waste-Form Category I-22

Table I-6 MEPAS©-Calculated Water Infiltration and Soil Erosion Rates for Each Site I-23

Table I-7 Radiation Dose and Hazardous Chemical Impacts from Buried CH-TRU Waste Intrusion Scenarios I-27

Table I-8 Radiation Dose and Hazardous Chemical Impacts from Buried RH-TRU Waste Intrusion Scenarios I-28

Table I-9 Radiation Dose and Hazardous Chemical Impacts from Scavenger Intrusion into Surface-Stored Wastes I-30

Table I-10 Radiation Dose and Hazardous Chemical Impacts for First Year of Farmer Intrusion into Surface-Stored Wastes..... I-31

Table I-11 Maximum Lifetime MEI and Population Impacts at Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2 ..... I-33

Table I-12 Aggregate LCFs over 10,000 Years for Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2 ..... I-36

Table I-13 Noncarcinogenic Impacts to a Maximally Exposed Individual at Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2 ..... I-37

Table J-1 Comparison of CH-TRU Waste Volumes in Basic Inventory and *The National Transuranic Waste Management Plan* J-2

Table J-2 Comparison of RH-TRU Waste Volumes in Basic Inventory and *The National Transuranic Waste Management Plan* J-3

Table J-3 Comparison of Waste Volumes Among Alternatives Using *The National Transuranic Waste Management Plan* and Basic Inventory Volumes.....J-4

Table J-4 Number of CH-TRU Waste Shipments from Each Potential Consolidation Site to WIPP by Alternative Using *The National Transuranic Waste Management Plan* Volumes.....J-6

Table J-5 Number of RH-TRU Waste Shipments from Each Potential Consolidation Site to WIPP by Alternative Using *The National Transuranic Waste Management Plan* Volumes.....J-7

Table J-6 Comparison of Shipments Between Alternatives Using *The National Transuranic Waste Management Plan* and Basic Inventory.....J-7

LIST OF FIGURES — VOLUME II

Figure E-1 Proposed TRU Waste Truck Transportation Routes on U.S. and Interstate Highways E-7

Figure E-2 Proposed TRU Waste Truck Transportation Routes in New Mexico E-8

Figure H-1 Schematic Side View of the Repository and Disposal System Associating Major Performance Assessment Codes with Principal Components H-11

Figure H-2 Illustration of Exploratory Drilling Equipment for Human-Intrusion Scenario..... H-12

Figure H-3 Release Processes for Inadvertent Drilling Intrusion at Varying Repository Pressure and Waste Permeability H-14

Figure H-4 Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Undisturbed Cases..... H-33

Figure H-5 Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Disturbed Cases..... H-34

Figure H-6 Top-Down (Plan) View of the Model Through the Disposal System..... H-35

Figure H-7 Grid Spaces Representing the Rest of the Repository Adjusted for Simulation of Action Alternatives 1, 2, and 3..... H-36

Figure H-8 Volume-Averaged Brine Pressures in a Waste Panel for the Proposed Action H-60

Figure H-9 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) for the Proposed Action..... H-61

Figure H-10 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) for the Proposed Action..... H-66

Figure H-11 Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 1 ..... H-68

Figure H-12 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) for Action Alternative 1..... H-69

Figure H-13 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 9) for Action Alternative 1..... H-75

Figure H-14 Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 2 ..... H-76

Figure H-15 Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) for Action Alternative 2 ..... H-78

Figure H-16 Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 14) for Action Alternative 2 ..... H-83

Figure H-17 Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 3 ..... H-84

Figure I-1 Buried or Soil-Covered TRU Waste Storage Zone Configuration I-14

Figure I-2 Surface TRU Waste Storage Zone Configuration I-15

Figure I-3 Schematic of Screening Process for Contaminants of Concern I-19

Figure I-4 Lifetime Doses to the MEIs at Seven Major Generator-Storage Sties over 10,000 Years Following Loss of Institutional Control Under No Action Alternative 2 ..... I-34

Figure I-5 Lifetime Population Doses for Seven Major Generator-Storage Sites over 10,000 Years Following Loss of Institutional Control Under No Action Alternative 2 ..... I-35

LIST OF TEXT BOXES — VOLUME II

Appendix A RFETS Plutonium Residues A-8

Appendix E TRANSCOM System E-4

Western Governors Association E-6

Proposed Use of HALFPACKS for Transportation E-13

Accident-Free Exposures E-32

Bounding Case Accidents E-41

Protection of the TRU Waste Shipments From Sabotage/Terrorist Activities E-42

Release Fractions for Thermally Treated Waste E-44

Appendix H Release Scenarios Considered But Not Analyzed H-57

This page intentionally left blank.

APPENDIX A
WASTE INVENTORY

This appendix provides information on the characteristics and quantities of transuranic (TRU) waste that may be disposed of at the Waste Isolation Pilot Plant (WIPP). This information is necessary for assessing the potential impacts from the transportation of TRU waste, from WIPP operations, and from the long-term performance of WIPP.

A.1 INTRODUCTION

TRU waste has been generated since the 1940s as part of the nuclear defense research and production activities of the Federal government. Several types of operations generate TRU waste: (1) nuclear weapons development and manufacturing, (2) prior plutonium recovery, (3) research and development, (4) environmental restoration, and decontamination and decommissioning activities, (5) waste management programs, and (6) testing and research at facilities under U.S. Department of Energy (DOE or the Department) contract.

Until about 1970, TRU waste, along with low-level waste, was disposed of in shallow trenches without an intent to retrieve it. In 1970, it was determined that TRU waste should be isolated and disposed of in a different manner than low-level waste. Thus, the Atomic Energy Commission, a DOE predecessor agency, adopted a policy requiring that waste containing TRU elements be placed in containers that could be retrieved from storage within 20 years.

The WIPP Land Withdrawal Act (LWA) (Public Law 102-579) limits (1) the volume of TRU waste that can be disposed of at WIPP to 175,600 cubic meters (6.2 million cubic feet); (2) the total activity of remote-handled (RH) TRU waste to 5.1 million curies (Ci); (3) the activity of RH-TRU waste averaged over the volume of a disposal container to 23 Ci per liter; and (4) the RH-TRU waste volume having a surface dose rate that exceeds 100 rem per hour to 5 percent. DOE and the State of New Mexico agreed to limit the volume of RH-TRU waste to no more than 7,080 cubic meters (250,000 cubic feet) (DOE 1981). This limit results in disposal of RH-TRU waste with total curies below the LWA limit. WIPP capacities for contact-handled (CH) TRU waste and RH-TRU waste are 168,500 cubic meters (5,950,000 cubic feet) and 7,080 cubic meters (250,000 cubic feet), respectively.

As explained in Chapter 2, TRU waste is broadly categorized to include (1) defense wastes of the type that were subject to previous WIPP-related National Environmental Policy Act (NEPA) reviews and (2) other defense and nondefense TRU wastes for which DOE retains management responsibility. TRU wastes analyzed in the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) included wastes resulting from defense activities and programs that were placed in retrievable storage pursuant to the 1970 Atomic Energy Commission policy. TRU wastes that were reasonably expected to be generated by ongoing defense activities and programs were also analyzed. For the purpose of this *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), this TRU waste inventory is referred to as the "Basic Inventory."

Defense and nondefense TRU wastes that had not previously been analyzed by FEIS and SEIS-I include (1) nondefense and commercial TRU waste, (2) defense TRU waste commingled with

polychlorinated biphenyls (PCB), and (3) defense (and perhaps some nondefense) TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. This TRU waste inventory is referred to as the "Additional Inventory."

A.1.1 Changes and New Information Since SEIS-I

The following major changes in information and assumptions regarding TRU waste differ from those used in SEIS-I (DOE 1990).

- Additional sites that have, or expect to generate, TRU waste have been identified. TRU waste volumes at these sites, however, account for only a small percent of the total TRU waste volume.
- Estimates of the future generation of TRU waste differ for some sites due to changes in those sites' missions.
- More detailed descriptions of the volume and physical characteristics of waste streams have been developed at many sites.
- More detailed descriptions of the radionuclide content of waste streams have been developed at many sites.

In SEIS-I, the volume of TRU waste was estimated at 159,000 cubic meters (5.6 million cubic feet) for CH-TRU waste and 2,690 cubic meters (95,000 cubic feet) for RH-TRU waste. These estimates were based on current volumes of stored waste and waste expected to be generated through the year 2013 (DOE 1990). The volume of TRU waste for the SEIS-II Basic Inventory is estimated at 135,000 cubic meters (4.7 million cubic feet) for CH-TRU waste and 35,000 cubic meters (1.2 million cubic feet) for RH-TRU waste. These estimates are based on current volumes of stored waste and waste expected to be generated through the year 2033. (More recent estimates of these volumes are presented in Appendix J.)

There is a high level of uncertainty and a current lack of consistent data regarding waste to be produced by future potential decontamination and decommissioning (D&D) and environmental restoration (ER) activities. DOE developed ER and D&D inventories through the 1996 *Baseline Environmental Management Report* (BEMR) (DOE 1996d). However, the BEMR data were not available in time to be included in the *WIPP Transuranic Waste Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996c) or SEIS-II. Battelle Columbus Laboratories, Bettis Atomic Power Laboratories (Bettis), and the Hanford Site (Hanford) reported D&D and ER projections that were included in BIR-3. Consistent with the *Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1996f) (CCA), SEIS-II analyses used the waste volumes reported in BIR-3 and the *Integrated Data Base Report* (DOE 1994a) (IDB).

Revision 1 of BIR reported Hanford's submittal as approximately 46,000 cubic meters (1.6 million cubic feet) of projected RH-TRU waste, of which 43,000 cubic meters (1.5 million cubic feet) were called "suspect" RH-TRU waste due to insufficient information. Reevaluation of the 46,000 cubic meters (1.6 million cubic feet) of projected RH-TRU waste by Hanford personnel has resulted in a decrease of the reported projected RH-TRU waste to approximately 21,500 cubic meters (760,000 cubic feet) (through the year 2022) for BIR-2 and BIR-3. Additional evaluations of the reported Hanford RH-TRU waste volumes are ongoing, and the results will be reported in

future revisions of BIR. Hanford now reports approximately 200 cubic meters (7,000 cubic feet) of stored RH-TRU wastes, with the rest of the waste still to be generated.

To conservatively estimate potential impacts, analyses in SEIS-II are based on the larger total volumes in the earlier BIR-3 (DOE 1996c), which incorporates the waste volumes of its second revision (BIR-2) (DOE 1995d), although analyses based on *The National Transuranic Waste Management Plan* (DOE 1996e) are also included (see Appendix J). The SEIS-II estimates, based on BIR-3, include 62,000 cubic meters (2.2 million cubic feet) of stored defense CH-TRU waste and 3,600 cubic meters (127,000 cubic feet) of stored defense RH-TRU waste. SEIS-II estimates also include 73,000 cubic meters (2.6 million cubic feet) of newly generated defense CH-TRU waste and 32,000 cubic meters (1.1 million cubic feet) of newly generated defense RH-TRU waste that will be generated through the year 2033.

A.1.2 Data Sources

Six main data sources were used to develop the TRU waste volume estimates, radionuclide inventories, and hazardous constituent inventories in SEIS-II. These six data sources are the following:

- *WIPP Transuranic Waste Baseline Inventory Report*, Revision 3 (BIR-3) (DOE 1996c), which incorporates by reference the waste volume estimates in the *WIPP Transuranic Waste Baseline Inventory Report*, Revision 2 (BIR-2) (DOE 1995d)
- *Integrated Data Base Report-1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics* (IDB) (DOE 1994a)
- *Waste Isolation Pilot Plant Safety Analysis Report* (SAR) (DOE 1995c)
- *Waste Isolation Pilot Plant Safety Analysis Report* (SAR) (DOE 1997a)
- *Comment Responses and Revisions to the Resource Conservation and Recovery Act* (RCRA) *Part B Permit Application* (DOE 1996a)
- *Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (WAC), Revision 5 (DOE 1996b)

The BIR-3 database contains detailed physical descriptions of TRU waste as well as TRU waste volumes and radionuclide inventories associated with individual waste streams at generator-storage sites. The database contains both currently stored waste volumes and waste volumes expected to be generated through the year 2022. BIR-3, both WIPP SARs, and the WIPP RCRA Part B Permit Application were used to estimate the inventory of hazardous constituents. Limits for several waste form characteristics, such as thermal power limits, were obtained from the planning-basis WAC.

Not all of the BIR-3 waste streams have associated radionuclide inventories. For example, only about 80 percent of the CH-TRU waste stream volumes and about 15 percent of the RH-TRU waste stream volumes have reported radionuclide inventories. Where possible, BIR-3 radionuclide data were used to analyze the impacts due to TRU waste handling, shipping, and accidents. To supplement missing radionuclide site information, however, an estimate of the total radionuclide inventory for a particular site as reported in the IDB was used. Because data presented in the IDB

are site-wide, not waste-stream based, the IDB data were used to estimate the total radionuclide inventory of WIPP in the performance assessment calculations of long-term performance.

A.2 WASTE CHARACTERIZATION

DOE has developed waste matrix codes which organize waste streams by their physical and chemical properties. Over 900 waste streams listed in BIR-3 have been grouped into the following 11 waste matrix code groups or final TRU waste forms: combustible, filter, graphite, heterogeneous, inorganic nonmetal, lead/cadmium metal, uncategorized metal, salt, soil, solidified inorganic, and solidified organic (DOE 1996c). A brief description of each final TRU waste form is given in Table A-1.

Table A-1
Final TRU Waste Form Code Group Definitions

Final TRU Waste Form Code Group	Definition
Combustible	Debris that is approximately 95 percent or more, by volume, combustible materials. Examples of combustible debris are materials constructed of plastic, rubber, wood, paper, and cloth.
Filter	Debris that is approximately 50 percent or more, by volume, High Efficiency Particulate Air (HEPA) filters or additional filters constructed of more than one material type (e.g., metal, inorganic nonmetal, and combustibles).
Graphite	Debris that is approximately 95 percent or more, by volume, graphite-based solid materials. Graphite debris includes crucibles, graphite components, and pure graphite.
Heterogeneous	Debris that is at least 50 percent by volume materials that do not meet criteria for assignment into other categories. For example, waste that is a mixture of metal and combustible debris, neither of which comprises 95 percent or more of the waste by volume.
Inorganic nonmetal	Debris that is approximately 95 percent or more, by volume, inorganic nonmetal material. Examples of waste in this group include glass and ceramics.
Lead/cadmium metal	Debris that is approximately 95 percent or more, by volume, metal that contains bulk lead or cadmium as part of the matrix. Examples of this waste include glovebox parts with lead clad in stainless-steel or cadmium sheets.
Uncategorized metal	Debris that is approximately 95 percent or more, by volume, metal but either lacks sufficient information to enable characterization into one of the other categories or contains both lead and cadmium as part of the bulk matrix.
Salt	Debris that is at least 50 percent by volume salts. Stable pyrochemical salt is an example of this group.
Soil	Debris that is approximately 95 percent or more, by volume, soil. This includes sand, silt, and rock/gravel where rock/gravel volumes total less than 50 percent of the matrix.
Solidified inorganic	Debris that is at least 50 percent by volume inorganic process residues. This group includes solidified sludges and small particles.
Solidified organic	Debris that is at least 50 percent by volume organic process residues. These are defined as process residues with a base structure that is primarily organic. The matrix may contain some inorganic solids content such that approximately 20 percent by weight of the waste would remain as residue ash/solids following incineration. Examples include organic resins, organic sludges and solidified organic liquids.

A.2.1 Planning-Basis WAC

TRU waste must be certified to meet planning-basis WAC before it is transported to WIPP (DOE 1989). WAC established conditions that govern the physical, radiological, chemical composition, and packaging requirements of TRU waste. With a broader scope, WAC Revision 4 (DOE 1991) consolidated all of the requirements for TRU waste storage at WIPP into one document. WAC Revision 5 (DOE 1996b) was published in April 1996, providing an update to the requirements.

In developing TRU waste transportation and disposal volumes, the following criteria consistent with planning-basis WAC were incorporated:

- A TRUPACT-II's maximum gross weight must not exceed 8,730 kilograms (19,250 pounds) and the maximum gross weight of the canister of the RH-72B cask is 3,630 kilograms (8,000 pounds).
- The total gross weight for a truck shipment is 36,300 kilograms (80,000 pounds).
- The maximum thermal power (heat-generating capacity) is 40 watts (W) for a TRUPACT-II container and 300 W for an RH-TRU waste canister.
- The maximum plutonium-239 (Pu-239) equivalent activity (PE-Ci) for untreated CH-TRU waste is 80 PE-Ci for a drum, and 130 PE-Ci for a standard waste box. Untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity if overpacked in standard waste boxes or 10-drum overpacks. Drums containing solidified or vitrified CH-TRU waste may contain up to 1,800 PE-Ci of activity per drum. RH-TRU waste canisters may not exceed 1,000 PE-Ci.

Planning-basis WAC for the TRU waste weight, thermal power, and PE-Ci are discussed in the following sections. These factors are used to determine the number of shipments required for waste streams of varying densities and thermal properties.

A.2.1.1 Weight Limits for Packaging TRU Waste

Weight limits apply to the packaging of CH-TRU waste in 55-gallon drums, TRUPACT-IIs, and RH-72B casks. A CH-TRU waste drum shall not exceed 454 kilograms (1,000 pounds). This limit includes the weight of the drum itself, approximately 27 kilograms (60 pounds). Once the CH-TRU waste drum is loaded onto the TRUPACT-II, additional weight limits apply. In addition, the RH-72B cask is limited to a total waste canister payload of 3,630 kilograms (8,000 pounds).

Below are the weight values associated with TRUPACT-IIs and the tractor and trailer, as taken from the *CH-TRU Waste Packaging Optimization Report* (DOE 1995a):

- Maximum gross vehicle weight — 36,300 kilograms (80,000 pounds)
- Maximum tractor and trailer weight — 12,700 kilograms (28,000 pounds)
- Maximum loaded individual TRUPACT-II weight — 8,730 kilograms (19,250 pounds)
- Average empty individual TRUPACT-II weight — 5,760 kilograms (12,705 pounds)

- Weight of pallet, slip sheets, and guide tubes — 120 kilograms (265 pounds) per TRUPACT-II
- Seven-pack of empty dunnage drums weight — 190 kilograms (420 pounds)

Due to the maximum gross vehicle weight restriction, a shipment consisting of three TRUPACT-IIs per trailer, the maximum number of TRUPACT-IIs for a truck shipment, would not exceed the maximum TRUPACT-II weight limit. The average weight of the contents of a drum in this case, as indicated in Table A-2, is up to 142 kilograms (312 pounds).

Table A-2
CH-TRU Waste Shipping Weights [a]

Number of TRUPACT-IIs per Trailer	Number of Drums per Shipment	Payload per Shipment (kilograms)	Average Weight of Drum Contents (kilograms)	Dunnage Weight per TRUPACT-II (kilograms)
3	42	5,950	Up to 142	0
2	28	5,710	142 to 204	0
2	14	5,330	204 to 381	190
2	12	5,272	381 to 427 [b]	218

[a] Adapted from Table A-1 of the *CH-TRU Waste Packaging Optimization Report* (DOE 1995a).
[b] The maximum drum weight is 454 kilograms.

When two TRUPACT-IIs are shipped with no dunnage, the maximum TRUPACT-II payload for the shipment is equal to two fully loaded TRUPACT-IIs, 5,710 kilograms (12,590 pounds). For shipments of higher density waste, it may be necessary to use dunnage to meet the TRUPACT-II maximum weight restriction while allowing the drums to approach their maximum weight. Table A-2 shows two cases that evaluate the average drum weight when using dunnage. The first case involves a seven-pack of empty drums, to demonstrate the average case. The second case involves eight empty drums per TRUPACT-II, which nearly maximizes the allowable weight of the drum.

RH-TRU waste truck shipments are limited to one RH-72B cask by the maximum gross vehicle weight. Assuming the RH-72B cask is loaded with three drums and spacers, the maximum payload in an RH-72B cask is 3,629 kilograms (8,000 pounds). Because only one cask can be shipped by truck per shipment, the cask can always be maximally loaded. Below is a listing of other weights associated with the RH-72B cask, as taken from the *Safety Analysis Report for the RH-72B Waste Shipping Package* (DOE 1994c):

- Gross RH-72B cask weight — 20,412 kilograms (45,000 pounds)
- RH-72B outer cask weight — 12,647 kilograms (27,883 pounds)
- Inner vessel weight — 1,825 kilograms (4,023 pounds)

- Weight of impact limiters 2,311 kilograms (5,094 pounds)
- Loaded canister weight 3,629 kilograms (8,000 pounds)

Both the TRUPACT-II and the RH-72B cask can be maximally loaded when shipped by rail. Three TRUPACT-IIs or two RH-72B casks can be loaded onto a single, standard railcar.

A.2.1.2 Planning-Basis WAC Thermal Power Limits

Some heat is generated by TRU waste due to the decay energy of the different radioactive isotopes. The amount of heat generated in a given volume depends on the radionuclide activity and the average energy of the alpha particles as they are released during decay.

In addition to heat, hydrogen gas is generated when high-energy alpha particles strike polymers such as plastic. The amount of hydrogen gas generated is a function of the amount of energy deposited by ionizing radiation in the hydrogenous material present in the TRU waste. Thermal power limits have been established by the *TRUPACT Content Codes* (TRUCON) to ensure that the concentration of flammable gas within the innermost plastic bag of the waste configuration is less than 5 percent after a 60-day period (DOE 1994b). These thermal power levels, expressed in terms of watts per waste drum, have been developed as a surrogate for direct calculation of the ionizing energy deposition. The 60-day period is assumed to be the maximum time a container would remain in an unvented, loaded TRUPACT-II. As might be expected, the more layers of plastic used in packaging materials, the more restrictive the thermal power limit. Thermal power limits were obtained from Table 6-1 of TRUCON and are included later in this appendix (see Tables A-16 through A-18 and A-20 through A-23).

A.2.1.3 PE-Ci

The PE-Ci concept was developed to eliminate the dependency of radiological analyses on the specific radionuclide composition of TRU waste streams. The inhalation hazard of radionuclides was normalized to the hazard associated with Pu-239. Because SEIS-II evaluates the radiation hazard associated with individual radionuclides, PE-Ci values were used to evaluate whether the radionuclide inventory of specific waste matrix code groups meet the PE-Ci limits specified in planning-basis WAC (DOE 1996b). Additional detail on the PE-Ci concept can be obtained from Appendix B of the WIPP SAR (DOE 1995c and 1997a). Specific calculations for a mix of radionuclides are provided in Table A-2 of the WIPP SAR (DOE 1995c and 1997a).

PE-Ci values were calculated for all final TRU waste forms. Radionuclide weighting factors, derived from the normalized inhalation hazards, were taken from the planning-basis WAC (DOE 1996b). One final waste form, CH-TRU salt waste at Idaho National Engineering and Environmental Laboratory (INEEL), slightly exceeds the PE-Ci limits under Action Alternative 2. A value of 142.6 PE-Ci per cubic meter for 8.85 cubic meters (313 cubic feet) of stored waste was calculated. Under the volume reduction assumptions for thermal processing, this yields an equivalent value of 407.5 PE-Ci per cubic meter for 3.1 cubic meters (109 cubic feet) of processed waste. This waste stream would require a volume dilution to 3.3 cubic meters (117 cubic feet) to meet the PE-Ci limit.

All TRU waste volume calculations, including the PE-Ci calculations described above, were performed on integrated data for final TRU waste forms. Each final TRU waste form is comprised

of several (8 to 10 on average) individual waste streams. In addition, residue data from Rocky Flats Environmental Technology Site (RFETS) included TRU waste volumes for nine final TRU waste forms. The radionuclide inventory, however, was only given as the radionuclide activity for the total volume. The treatment of the waste streams into final TRU waste forms provides the integrated values for the PE-Ci calculations. Because the radionuclide activity of the waste streams is averaged, however, situations may exist where the activity of a single waste stream, or the combination of particular waste streams, would be high enough to exceed the PE-Ci limits.

A.2.1.4 Fissile-Gram Equivalents

The WAC has addressed criticality concerns with the imposition of a limit on the amount of fissile-gram equivalents (FGE) of plutonium that can be loaded in an individual drum or shipped in a TRUPACT-II. Currently, the WAC plutonium limits are 200 FGE per drum and 325 FGE per TRUPACT-II. Fissile-gram equivalents of plutonium are calculated by multiplying weighting factors by the mass of plutonium isotopes and adding these products. The computational method and FGE factors are described in Table A-2 of the WIPP SAR (DOE 1995c and 1997a).

As noted in Section A.2.1.3, all TRU waste volume calculations were performed on integrated data to obtain final TRU waste forms. Each final TRU waste form is comprised of 8 to 10 individual waste streams. With the exception of the RFETS residue wastes, all integrated waste forms meet the FGE requirements of the WAC. Based on the waste stream characteristics of the RFETS data and the gas generation limits given in Table 6.1 of the TRUCON (1994b), the RFETS residue wastes would require 1,205 shipments to WIPP.

The U.S. Nuclear Regulatory Commission (NRC) has recently approved the use of pipe overpacks in the TRUPACT-II shipping container (NRC 1997). This change will allow a pipe overpack in a drum to contain 200 FGE; therefore, if the TRUPACT-II is allowed to carry 14 such drums, the TRUPACT-II limit would be 2,800 FGE. DOE now estimates (Rivera 1997) that residue cleanup activities at RFETS will generate 45,800 drums of waste, of which approximately 22,000 drums will contain pipe overpacks.

RFETS PLUTONIUM RESIDUES

DOE is currently preparing an environmental impact statement on the management of certain plutonium residues and scrub alloy stored at RFETS, as announced in a Notice of Intent (NOI) on November 19, 1996 (61 Federal Register [FR] 58866). The SEIS-II Basic Inventory includes approximately 4,200 cubic meters (148,322 cubic feet) of plutonium residues at RFETS (see Table A-17). This residual volume includes approximately 3,000 kilograms (6,614 pounds) of plutonium, which is consistent with the estimated plutonium activity at RFETS in the NOI. The NOI also states the RFETS residues have an estimated mass of 106,600 kilograms (235,013 pounds), but about 42,300 kilograms (93,255 pounds) would not meet the required safeguards for disposal. The NOI further notes the presence of plutonium scrub alloy at RFETS (approximately 700 kilograms [1,543 pounds] with 200 curies of plutonium) and an additional 18,400 kilograms (40,565 pounds) of plutonium residues stored among SRS, Hanford, LLNL, and LANL. The BIR-3, which were used as the basis for the SEIS-II inventory estimates, contain no specific information on scrub alloys or on plutonium residues at other sites. Because the information on these materials is considered uncertain, neither has been included for consideration in SEIS-II nor has their final disposition been evaluated or determined. SEIS-II assumes that plutonium residues at RFETS can be transported to WIPP using pipe overpacks. Further discussion has been provided in Section A.2.1.4.

Although the use of pipe overpacks has been approved by the NRC, it has not yet been integrated into the WAC. For the purpose of analyses in SEIS-II, it has been assumed that the pipe overpack will be incorporated into the WAC. Therefore, approximately 1,205 shipments will be required to transport the RFETS residue waste pipe overpacks to the WIPP site.

A.3 WASTE VOLUMES

BIR-3 contains detailed information on waste streams and volumes according to generator-storage site for the following: (1) TRU waste currently in retrievable storage (the stored volume) and (2) TRU waste expected to be generated in 28 years (the projected volume). In the context of SEIS-II, "TRU waste volumes" refers to the total TRU waste volume disposed of over the lifetime of WIPP. To be conservative, SEIS-II analyses were based upon an upper TRU waste generation limit taken from BIR-3.

A.3.1 Basic Inventory Volumes

Under the Proposed Action, it is assumed that WIPP operations would begin in 1998 and continue for 35 years, ending TRU waste receipt operations in 2033. Projected TRU waste volumes ($V_{projected}$) are given in BIR-3; however, these values reflect volumes estimated in the year 2022. To estimate the total TRU waste inventory volume at a generator-storage site in 2033, the following calculation was used:

$$V_{site} = V_{stored} + [38\ (R_{generate})] \qquad \text{(Equation A-1)}$$

where

V_{site} = estimated TRU waste volume through the year 2033

V_{stored} = TRU waste volume stored at the generator-storage site through 1995

38 = the number of years of waste generation (35 plus 3 years until 1998)

$R_{generate}$ = ($V_{projected}$) / 28 years; this is the TRU waste volume generation rate

The Basic Inventory TRU waste volume for each generator-storage site is given in Table 2-2, presented in this appendix as Table A-3. These are the final TRU waste form volumes based on the minimum level of treatment necessary to meet planning-basis WAC. Generator-storage site volumes for the year 2022 are provided solely for comparison with the volumes in BIR-3; they are not used in further calculations.

A.3.2 Additional Inventory Volumes

TRU waste in the Additional Inventory includes the following: (1) TRU waste commingled with PCBs at Hanford, INEEL, and Mound Plant (Mound); (2) commercial/nondefense waste at ARCO Medical Products Company (ARCO), West Valley Demonstration Project (WVDP), Oak Ridge National Laboratory (ORNL), Lawrence Berkeley Laboratory (LBL), and Knolls Atomic Power Laboratory (Knolls); and (3) previously disposed of TRU waste at a number of sites. These volumes are shown in Table 2-3, presented here as Table A-4.

Table A-3
Basic Inventory TRU Waste Volumes [a]

Site [d]	Stored (1995) (cubic meters)		Estimated Total through 2022 [b] (cubic meters)		Estimated Total through 2033 [c] (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering and Environmental Laboratory (INEEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	--- [e]	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-3 (DOE 1996c), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily for PCB-commingled waste. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2 (1995d).

[c] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033.

[d] Sites in boldface were included in SEIS-I. INEEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.

[e] Dashes indicate no waste.

BIR-3 contains estimates of the total volume of previously disposed of TRU waste by site; however, it does not divide these wastes into CH-TRU and RH-TRU waste categories. The ratio of CH-TRU to RH-TRU waste volumes from the Basic Inventory, therefore, was used to divide the previously disposed of TRU waste into CH-TRU and RH-TRU waste categories on a site-by-site basis. In addition, some site information exists for TRU waste commingled with PCBs, commercial, and nondefense TRU waste in BIR-3. The volumes of these types of waste, expected to be generated by 2033, are also given in Table A-4.

A.3.3 Waste Volumes for the Proposed Action

Under the Proposed Action, CH-TRU waste would be consolidated at 10 sites and RH-TRU waste consolidated at four sites before shipment to WIPP. Figure 3-1 identifies the treatment sites for the Proposed Action. Table 3-1, presented here as Table A-5, identifies the treatment sites and

Table A-4
Additional Inventory TRU Waste Volumes [a, b]

Site [c]	PCB (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	---	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering and Environmental Laboratory (INEEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The volume of TRU waste represents the 1995 existing and projected waste (DOE 1995d). The thermal treatment, though, is not necessarily for PCB-commingled waste.
[b] Actual totals may differ due to rounding.
[c] Sites in boldface also store post-1970 defense TRU waste, see Table 2-2. The remaining four sites currently have no post-1970 defense TRU waste.

Table A-5
TRU Waste Volumes (Basic Inventory) for the Proposed Action [a]

Site [d]	Site Volume Through 2033 (cubic meters)		Pretreatment Consolidated Volume [b] (cubic meters)		Post-Treatment Disposal Volume (cubic meters)		Disposal Volume (cubic meters) [c]
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU [e]	RH-TRU [f]	RH-TRU
Hanford Site (Hanford)	57,000	29,000	57,000	29,000	57,000	42,000	2,800
Los Alamos National Laboratory (LANL)	21,000	230	21,000	230	21,000	330	330
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	28,000	220	29,000	2,000	30,000	2,800	2,800
Argonne National Laboratory - West (ANL-W)	1,000	1,700	--- [h]	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	200	---	---
Savannah River Site (SRS)	12,000	---	12,000	---	12,000	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	17,000	---	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,800	3,700	1,900	5,300	1,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	1,200	---	---
Nevada Test Site (NTS)	630	---	630	---	630	---	---
Mound Plant (Mound)	300	---	300	---	340	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	---	---	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	---	---	---	---
Total	**135,000**	**35,000**	**135,000**	**35,000**	**143,000** [i]	**50,000**	**7,080** [j]
Disposal Volume Allowed by WIPP LWA and Agreement for Consultation and Cooperation (C & C)	**---**	**---**	**---**	**---**	**168,500** [i]	**7,080**	**---**

[a] The inventory for SEIS-II is based on BIR-3, which took into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment does not necessarily include PCB-commingled waste. Volumes have been rounded. Actual totals may differ due to rounding. The site volumes through 2033 match the final columns on Table 2-2.

[b] Volumes include consolidation of waste as indicated on Figure 3-1.

[c] All LANL and INEEL RH-TRU waste is assumed to be disposed of; RH-TRU waste disposed of for Hanford would be approximately 2,800 cubic meters; that for ORNL would be 1,100 cubic meters (after consolidation).

[d] Sites in boldface were included in SEIS-I.

[e] Post-treatment volumes have been adjusted to meet packaging and transportation requirements to meet the planning-basis WAC.

[f] Values represent WIPP emplacement volumes, except for Hanford and ORNL.

[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, are counted as one site in SEIS-II.

[h] Dashes indicate no waste.

[i] Though 143,000 cubic meters of CH-TRU waste are part of the Basic Inventory, additional CH-TRU waste may become a part of that inventory should RCRA or Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) action lead to retrieval of previously disposed of waste. Therefore, SEIS-II assesses the impact of the entire disposal volume allowed, 168,500 cubic meters.

[j] The Waste Isolation Pilot Plant Land Withdrawal Act (LWA) limits the total RH-TRU waste curie content of WIPP to 5.1 million. Under the Proposed Action, the total curie content associated with the 7,080 cubic meters is less than 1 million curies.

waste volumes for the Proposed Action. These volumes are projected for the year 2033. Table A-5 differs from Table 3-1 in that an additional column entitled "Disposal Volume" for RH-TRU waste has been added.

The volumes in BIR-3 represent WIPP disposal volumes. They do not, however, account for volume dilution required for some CH-TRU waste streams in order to meet thermal power (hydrogen gas generation) limits for transportation in the TRUPACT-II containers. The CH-TRU waste volumes in the "Post-Treatment Disposal Volumes" column in Table A-5 include volume expansion due to packaging to meet thermal power limits. These are the anticipated TRU waste volumes that would be disposed of at WIPP.

The volume expansion for CH-TRU waste is based on the thermal loading (W/cubic meter) of the final waste form and on limits to the thermal loading per container as set by TRUCON. The TRU waste radioisotopic inventory from BIR-3 was used to determine the thermal loading for each site on a final waste form basis. If the calculated thermal power exceeds the thermal power limit, then volume expansion is required. Less than 4 percent of the stored CH-TRU waste (other than the RFETS residues) requires volume expansion to meet thermal power limits, provided that plastic wrap is not used when the waste drums are filled (bagless posting). When the RFETS residue waste is considered, this total climbs to nearly 9 percent of the waste. If bagless posting is not used, disposal volumes for CH-TRU waste nearly double.

To determine the volume due to expansion ($V_{Expansion}$), the thermal output for the final TRU waste form ($W_{Calculated}$) in watts per cubic meter is divided by the watt limit per cubic meter for the final TRU waste form (W_{Limit}). $W_{Calculated}$ is calculated from the radionuclide inventory waste stream. W_{Limit} values were obtained from Table 6-1 in TRUCON and converted from watts per drum to watts per cubic meter to facilitate calculations and comparisons (DOE 1994b). If the fraction ($W_{Calculated}/W_{limit}$) is greater than 1, it is multiplied by the initial TRU waste volume ($V_{Initial}$) before packaging. Otherwise, the volume due to expansion would remain the same as the volume before packaging. The equation is as follows:

$$\text{For } \left(\frac{W_{Calculated}}{W_{Limit}}\right) > 1;\ V_{Expansion} = \left(\frac{W_{Calculated}}{W_{Limit}}\right) \times V_{Initial} \qquad \text{(Equation A-2a)}$$

$$\text{For } \left(\frac{W_{Calculated}}{W_{Limit}}\right) < 1;\ V_{Expansion} = V_{Initial} \qquad \text{(Equation A-2b)}$$

Thermal processing is assumed to destroy the materials that generate hydrogen gas, so volume expansion due to thermal power is not applied to thermally processed waste. The Savannah River Site (SRS) has indicated that it would package or treat waste as required to meet planning-basis WAC, including gas generation limitations (Williams 1996). The SRS operations are expected to include both thermal processing and transferal of some high-activity waste from the CH-TRU waste to the RH-TRU waste category. It is assumed that there is no net increase or decrease in the volume of CH-TRU waste and RH-TRU waste at the SRS as a result of this processing.

With the RH-TRU waste volume limit at WIPP of 7,080 cubic meters (250,000 cubic feet), the volume disposed of was calculated using the capacity of the waste containers rather than the

volume of the waste within the containers. An RH-TRU waste canister has a volume capacity of 0.89 cubic meter (32 cubic feet); therefore, the volume disposed of for one canister is 0.89 cubic meter (32 cubic feet). Three drums would be placed in an RH-TRU waste canister.

It was assumed that all RH-TRU waste would be contained in 55-gallon drums prior to being inserted into RH-TRU waste canisters, and would remain in place by spacers within the canister. The RH-TRU waste canister would, therefore, account for only 0.624 cubic meter (22 cubic feet) of RH-TRU waste at a site. This type of packaging would require approximately 1.43 times as much volume in WIPP as the volumes of waste stored in drums at the sites. This assumption results in an overestimated total volume disposed of relative to current storage practices. Also, for the purpose of the Proposed Action analysis, it was assumed that all sites except Hanford and ORNL are able to send all RH-TRU waste to WIPP. The waste would go to a treatment site and then to WIPP. Hanford and ORNL would only send about 6.7 percent of their RH-TRU waste to WIPP under the Proposed Action. As with CH-TRU waste, the RH-TRU waste disposal volumes are given in the "Post-Treatment Disposal Volumes" column in Table A-5.

A.3.4 Waste Volumes for Action Alternative 1

Under Action Alternative 1, CH-TRU waste would be consolidated at 10 sites and RH-TRU waste consolidated at four sites before shipment to WIPP based on the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997b) Decentralized option. The treatment sites under Action Alternative 1 are shown in Figure 3-2. The CH-TRU waste volumes for Action Alternative 1 are given in Table 3-2, presented here as Table A-6. Similarly, the RH-TRU waste volumes under Action Alternative 1 are given in Table 3-3, presented here as Table A-7. The most notable difference under this alternative, as compared to the Proposed Action, is that all of the TRU waste identified in Table A-4 would be sent to WIPP, except for the TRU waste commingled with PCBs.

Under Action Alternative 1, it is assumed that all waste is packaged to meet planning-basis WAC requirements. Table A-6 columns containing CH-TRU waste post-treatment disposal volumes account for the volume expansion that is assumed necessary to meet thermal power limits; therefore, these volumes would be disposed of at WIPP. Tables A-6 and A-7 are divided into columns which identify the amount of waste under the Basic Inventory and Additional Inventory assumed under this alternative.

A.3.5 Waste Volumes for Action Alternative 2

Three important differences impact waste volumes under Action Alternative 2 as compared to the Proposed Action. These differences are: (1) all RH-TRU waste would be disposed of at WIPP rather than being limited to 7,080 cubic meters (250,000 cubic feet), (2) all of the waste identified in Tables A-3 and A-4 would be sent to WIPP, and (3) all waste would be subjected to thermal treatment to meet RCRA Land Disposal Restrictions (LDR) for hazardous constituents. A 65-percent reduction in the TRU waste volume to be disposed of was assumed due to LDR thermal treatment of both CH-TRU and RH-TRU waste (DOE 1995b). In an operational sense, the volume change for thermal processing would depend heavily on the physical characteristics of the individual waste stream.

Table A-6
CH-TRU Waste Volumes for Action Alternative 1 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	57,000	63,000	120,000	57,000	63,000	120,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	21,000	14,000	35,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	86,000	30,000	57,000	87,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	200	---	200	200	---	200
Savannah River Site (SRS)	12,000	4,900	17,000	12,000	4,900	17,000	12,000	4,900	17,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	17,000	---	17,000
Oak Ridge National Laboratory (ORNL)	1,700	56	1,700	1,800	260	2,100	1,800	260	2,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	1,200	---	1,200	1,200	---	1,200
Nevada Test Site (NTS)	630	---	630	630	---	630	630	---	630
Mound Plant (Mound)	300	---	300	300	---	300	340	---	340
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**273,000**	**135,000**	**138,000**	**273,000**	**143,000**	**138,000**	**281,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-2.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

Table A-7
RH-TRU Waste Volumes for Action Alternative 1 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	29,000	1,000	30,000	42,000	1,500	43,000
Los Alamos National Laboratory (LANL)	230	120	350	230	120	350	330	170	490
Idaho National Engineering Laboratory (INEEL) [f]	220	440	660	2,000	440	2,400	2,800	630	3,400
Argonne National Laboratory - West (ANL-W)	1,700	--- [g]	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	2,000	5,600	5,200	2,700	8,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	80	80	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**50,000**	**5,000**	**55,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-2.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] Additional Inventory (no TRU waste commingled with PCBs is included).
[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

Using an aggregate volume reduction factor of 0.35 for all waste treated by thermal processing, the resulting disposal volume for CH-TRU waste was calculated as:

$$V_{Disposal} = (0.35)\ V_{Consolidated} \qquad \text{(Equation A-3)}$$

For RH-TRU waste, the disposal volume resulting from thermal treatment was calculated in a similar manner. A volume expansion factor of 1.43 was applied to account for the placement of three waste drums in an RH-TRU waste canister (Equation A-4).

$$V_{Disposal} = (0.35)\ V_{Consolidated} \times 1.43 \qquad \text{(Equation A-4)}$$

$V_{Consolidated}$ refers to the TRU waste volume prior to thermal treatment. $V_{Disposal}$ refers to the TRU waste volume resulting from thermal treatment that would be disposed of at WIPP.

Thermal processing produces waste in the form of a slag. A density change assumption, therefore, is made such that a 55-gallon drum containing the slag would weigh 454 kilograms (1,000 pounds). Waste density values are used in the determination of the number of shipments (Section A.3.9).

See Table A-2 for the CH-TRU waste average drum weights used to determine the number of shipments.

Three separate waste treatment site options, based on the WM PEIS Regionalized 2, Regionalized 3, and Centralized Alternatives exist under Action Alternative 2. These subalternatives are Action Alternative 2A, 2B, and 2C, respectively. Both the type of waste treatment and the waste volume remain the same for all the Action Alternative 2 subalternatives; only the locations of the waste treatment sites are different. The treatment sites for Action Alternative 2A, 2B, and 2C are indicated in Figures 3-3, 3-4, and 3-5, respectively.

CH-TRU waste volumes for treatment sites under Action Alternative 2A, based on the WM PEIS Regionalized 2 Alternative, are shown in Table 3-4 and presented here as Table A-8. CH-TRU waste volumes for treatment sites under Action Alternative 2B, based on the WM PEIS Regionalized 3 Alternative, are shown in Table 3-6 and presented here as Table A-9. CH-TRU waste volumes for treatment sites under Action Alternative 2C, based on the WM PEIS Centralized Alternative, are shown in Table 3-8 presented here as Table A-10.

RH-TRU waste treatment sites are the same for each of the three WM PEIS waste treatment scenarios. The corresponding RH-TRU waste volumes under Action Alternative 2 are given in Tables 3-5, 3-7, and 3-9. These tables are consolidated here in Table A-11. The total volume of RH-TRU waste to be disposed of at WIPP would be 19,000 cubic meters (670,000 cubic feet). Waste volumes for Action Alternative 2 are all projected to the year 2033.

Accounting both for the large volume reduction factor after waste treatment and for placing three 55-gallon drums into each RH-TRU waste canister, there would be 12,400 cubic meters (438,000 cubic feet) more RH-TRU waste disposed of under Action Alternative 2 than under the Proposed Action.

A.3.6 Waste Volumes for Action Alternative 3

Under Action Alternative 3, CH-TRU waste would be consolidated at five sites and RH-TRU waste would be consolidated at two sites before shipment to WIPP. Figure 3-6 shows the treatment sites under this alternative. CH-TRU waste volumes under Action Alternative 3 are given in Table 3-10 and presented here as Table A-12. The RH-TRU waste volumes under Action Alternative 3 are given in Table 3-11 and presented here as Table A-13. Both the Basic Inventory (Table A-3) and the Additional Inventory, with the exception of TRU waste commingled with PCBs (Table A-4), are sent to WIPP. Shred and grout would be the dominant waste treatment process.

The post-treatment disposal volumes of CH-TRU waste (Table A-12) indicate the volume expansions assumed necessary to meet thermal power limits and due to the shred and grout process. These volumes would be disposed of at WIPP. Post-treatment disposal volumes of RH-TRU waste (Table A-13) account for volume adjustments pertaining to the placement of three 55-gallon drums into the RH-TRU waste canisters and volume expansion from the shred and grout process.

Table A-8
CH-TRU Waste Volumes for Action Alternative 2A [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	20	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-3.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

Table A-9
CH-TRU Waste Volumes for Action Alternative 2B [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-4.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste.

[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

Table A-10
CH-TRU Waste Volumes for Action Alternative 2C [a]

Site [b]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume (cubic meters)			Post-Treatment Disposal Volume (cubic meters)		
	Basic Inventory	Additional Inventory [c]	Total Inventory	Basic Inventory	Additional Inventory [c]	Total Inventory	Basic Inventory	Additional Inventory [c]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	--- [d]	---	---	---	---	---
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [e]	28,000	57,000	85,000	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	---	---	---	---	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
WIPP [f]	---	---	---	135,000	139,000	274,000	47,000	60,000	107,000
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Sites in boldface were included in SEIS-I.

[c] TRU waste commingled with PCBs is included.

[d] Dashes indicate no waste.

[e] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[f] TRU waste is consolidated and treated at WIPP.

Table A-11
RH-TRU Waste Volumes for Action Alternatives 2A, 2B, and 2C [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-5.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

Using an aggregate volume expansion factor of 1.2 of all waste treated by the shred and grout process, the resulting disposal volume for CH-TRU waste is calculated as:

$$V_{Disposal} = (1.2)\ V_{Consolidated} \qquad \text{(Equation A-5)}$$

As in Equation A-4, an additional volume expansion factor of 1.43 is applied to RH-TRU waste calculations to account for the placement of three waste drums in an RH-TRU waste canister (Equation A-6).

$$V_{Disposal} = (1.2)\ V_{Consolidated} \times 1.43 \qquad \text{(Equation A-6)}$$

The waste density would increase for the shred and grout process because much of the waste drum's void space would be filled. A density increase factor of 1.263 is used for waste streams that are already solidified, and a density increase factor of 2.357 is used for all other waste streams (DOE 1995b).

Table A-12
CH-TRU Waste Volumes for Action Alternative 3 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	121,000	70,000	75,000	146,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	25,000	17,000	42,000
Idaho National Engineering and Environmental Laboratory (INEEL) [f]	28,000	57,000	85,000	30,000	57,000	86,000	37,000	68,000	105,000
Argonne National Laboratory - West (ANL-W)	1,000	--- [g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	17,000	6,200	23,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	19,000	---	19,000
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	---	300	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**138,000**	**273,000**	**135,000**	**138,000**	**273,000**	**168,000**	**166,000**	**334,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-6.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.

[f] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[g] Dashes indicate no waste.

Table A-13
RH-TRU Waste Volumes for Action Alternative 3 [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume [b] (cubic meters)			Post-Treatment Disposal Volume [c] (cubic meters)		
	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory	Basic Inventory	Additional Inventory [e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	54,000	2,700	57,000
Los Alamos National Laboratory (LANL)	230	120	350	--- [f]	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory (INEEL) [g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	6,300	3,300	10,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**60,000**	**6,000**	**66,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.
[f] Dashes indicate no waste.
[g] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

A.3.7 Waste Volumes for No Action Alternative 1

The TRU waste volumes under No Action Alternative 1A are identical to those under Action Alternative 2A (see Tables A-8 and A-11). Likewise, TRU waste volumes under No Action Alternative 1B are identical to those under Action Alternative 2B (see Tables A-9 and A-11).

Two TRU waste treatment scenarios exist under No Action Alternative 1. No Action Alternative 1A assumes the same waste treatment sites as under the WM PEIS Regionalized 2 Alternative. No Action Alternative 1B assumes the same waste treatment sites as the WM PEIS (DOE 1997b) Regionalized 3 Alternative. Waste treatment would be the same as that in Action Alternative 2; however, TRU waste would be placed in retrievable storage at the treatment sites rather than being sent to WIPP.

A.3.8 Waste Volumes for No Action Alternative 2

TRU waste volumes for No Action Alternative 2, projected to the year 2033, are given in Table 3-16 and presented here as Table A-14. As shown in this table, all RH-TRU waste in the Basic Inventory was included in the analysis. For the purpose of analysis, no consolidation of waste was assumed.

A.3.9 Number of Waste Shipments

The number of shipments required to transport waste from the treatment sites to WIPP primarily depends on the type of waste (CH-TRU or RH-TRU), the waste volume, and the waste density. Some final CH-TRU waste forms are dense enough that TRUPACT-II weight limits impact the number of waste drums that can be carried in one trip (Section A.2.1.1). Material parameter data are found in BIR-3 for most of the 900 waste streams. From the material parameter data, average waste densities were derived for the final waste form at each waste generator-storage site. The

Table A-14
TRU Waste Volumes for No Action Alternative 2 [a]

Site [b]	Site Volume Through 2033 (cubic meters)		Stored Volume (1995) (cubic meters)		Newly Generated Post-Treatment Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	57,000	29,000	12,000	200	45,000	29,000
Los Alamos National Laboratory (LANL)	21,000	230	11,000	90	10,000	130
Idaho National Engineering and Environmental Laboratory (INEEL) [c]	28,000	220	28,000	220	---	---
Argonne National Laboratory - West (ANL-W)	1,000	1,700	7	20	1,000	1,700
Argonne National Laboratory - East (ANL-E)	200	--- [d]	25	---	180	---
Savannah River Site (SRS)	12,000	---	2,900	---	9,200	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	4,900	---	6,000	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,300	2,500	350	600
Lawrence Livermore National Laboratory (LLNL)	1,200	---	230	---	960	---
Nevada Test Site (NTS)	630	---	620	---	10	---
Mound Plant (Mound)	300	---	300	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	170	9
Sandia National Laboratories - Albuquerque (SNL)	17	---	7	---	10	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	2	6	---	1
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	5,801	---	---
Total	**135,000**	**35,000**	**62,000**	**3,600**	**73,000**	**32,000**

[a] The inventory for SEIS-II is based on BIR-3, which takes into account potential thermal treatment at some sites (DOE 1996c). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Sites in boldface were included in SEIS-I.

[c] INEEL and ANL-W are considered as one site in the WM PEIS and, therefore, counted as one site in SEIS-II.

[d] Dashes indicate no waste.

average density data were used to estimate the number of truck shipments required to move waste from each site. Table A-15 provides the number of truck shipments from waste treatment sites to WIPP according to waste inventory (Basic or Additional) and alternative, where applicable. It was assumed that thermal processing would result in a dense waste stream such that a standard waste drum would weigh 1,000 pounds (454 kilograms).

The number of RH-TRU waste shipments assumes the use of one RH-TRU waste canister per shipment. For the Proposed Action, the number of CH-TRU waste shipments has been adjusted to the WIPP allowable volume of approximately 168,500 cubic meters (5.95 million cubic feet) rather than the 143,000 cubic meters (5 million cubic feet) shown in Table A-5.

When considering rail analysis, it was assumed that one railcar would carry six TRUPACT-IIs or two RH-72B casks, twice as much as a truck. A maximum of three railcars would be used per shipment; thus, 18 TRUPACT-IIs or six RH-72B casks could be transported per shipment. As identified in Table A-2, certain CH-TRU waste density configurations require that waste shipments be made using only two TRUPACT-IIs rather than three. Under the Proposed Action and Action Alternative 1, about 38 percent of the TRU waste shipments would fall into this category. All of the waste shipments for Action Alternative 2 reflect two TRUPACT-IIs per shipment. Under Action Alternative 3, about 86 percent of the waste shipments would consist of two TRUPACTS-IIs rather than three.

The number of RH-TRU waste shipments from a treatment site can be calculated from the corresponding post-treatment disposal volume. RH-TRU waste post-treatment disposal volumes have been calculated for the Proposed Action and each alternative, and are presented in a series of tables in this appendix. Assuming that an RH-TRU waste shipment consists of a single waste canister, the number of shipments is determined by dividing the RH-TRU waste post-treatment volume by 0.89 cubic meter (32 cubic feet), the volume of a single RH-TRU waste canister.

In addition to the post-treatment disposal volume, calculations for the number of CH-TRU waste shipments require the waste density of each final waste form at each treatment site. The waste density, calculated from material parameters in BIR-3, is adjusted for volume expansion to meet thermal power or PE-Ci limits, or density changes due to thermal or shred and grout treatment. The CH-TRU waste post-treatment disposal volumes presented in the tables within this appendix reflect site totals; they do not contain details on the final waste form by site. Average densities for each final waste form, before adjustments, are given in Tables A-16 through A-18 and A-20 through A-23. Waste defined as “Possible Future Wastes” in Table A-23 represents waste that would most likely be sent to WIPP. This waste was included as part of the Basic Inventory for the purpose of SEIS-II analysis.

Calculating the number of CH-TRU waste shipments from a site begins with the post-treatment disposal volume of a final waste form. From this, the number of drums is determined using the assumption that the volume of each drum is 0.208 cubic meter (7.3 cubic feet). Next, the adjusted waste density is used to determine the number of drums that can be moved in one shipment (Table A-2). The process is repeated for each final waste form at the treatment site. The result is the total number of waste shipments from the treatment site.

Example calculations for the number of shipments from a site are presented for CH-TRU waste at Los Alamos National Laboratory (LANL) under the Proposed Action in Table A-19. First, a volume multiplier is calculated using Equation A-2 to determine if the waste form must be

Table A-15
Number of Truck Shipments to WIPP by Alternative [a]

Sites	Proposed Action	Action Alternative 1			Action Alternative 2A			Action Alternative 2B		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste										
Hanford	13,666	11,562	7,167	18,729	8,230	8,813	17,043	8,230	8,813	17,043
LANL	5,009	4,238	1,590	5,828	2,952	1,947	4,899	---	---	---
INEEL	5,782	4,892	6,474	11,366	4,178	12,388	16,566	8,653	14,335	22,988
ANL-W	---	---	---	---	---	---	---	---	---	---
SRS	2,238	1,893	558	2,451	2,020	723	2,743	2,020	723	2,743
RFETS	2,485	2,102	0	2,102	1,524	0	1,524	---	---	---
ORNL	251	212	8	220	---	---	---	---	---	---
LLNL	162	137	0	137	---	---	---	---	---	---
NTS	86	73	0	73	---	---	---	---	---	---
Mound	59	50	23	73	---	---	---	---	---	---
ANL-E	28	24	0	24	---	---	---	---	---	---
Bettis	---	---	---	---	---	---	---	---	---	---
SNL	---	---	---	---	---	---	---	---	---	---
PGDP	---	---	---	---	---	---	---	---	---	---
USAMC	---	---	---	---	---	---	---	---	---	---
ETEC	---	---	---	---	---	---	---	---	---	---
U of Mo	---	---	---	---	---	---	---	---	---	---
Ames	---	---	---	---	---	---	---	---	---	---
ARCO	---	---	---	---	---	---	---	---	---	---
LBL	---	---	---	---	---	---	---	---	---	---
WVDP	---	---	---	---	---	---	---	---	---	---
Totals	29,766	25,183	15,820	41,003	18,904	23,871	42,775	18,903	23,871	42,774
RH-TRU Waste										
Hanford	3,178	47,156	1,651	48,807	17,730	1,031	18,761	17,730	1,031	18,761
LANL	367	367	190	557	---	---	---	---	---	---
INEEL	3,136	3,136	711	3,847	---	---	---	---	---	---
ORNL	1,276	5,875	3,076	8,951	2,057	1,077	3,134	2,057	1,077	3,134
Totals	7,957	56,534	5,628	62,162	19,787	2,108	21,895	19,787	2,108	21,895

[a] The transportation analysis conservatively assumes the number of rail shipments is one-half of the truck shipments.

Table A-15
Number of Truck Shipments to WIPP By Alternative — Continued [a]

Sites	Action Alternative 2C			Action Alternative 3		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste						
Hanford	11,562	7,194	18,756	24,531	8,600	33,131
LANL	4,236	1,590	5,826	7,628	1,907	9,535
INEEL	4,776	6,639	11,415	10,386	7,769	18,155
ANL-W	116	0	116	---	---	---
SRS	1,893	558	2,451	2,885	706	3,591
RFETS	2,102	0	2,102	2,897	0	2,897
ORNL	192	8	200	---	---	---
LLNL	137	0	137	---	---	---
NTS	73	0	73	---	---	---
Mound	50	3	53	---	---	---
ANL-E	22	0	22	---	---	---
Bettis	20	0	20	---	---	---
SNL-AL	2	1	3	---	---	---
PGDP	1	0	1	---	---	---
USAMC	1	0	1	---	---	---
ETEC	1	0	1	---	---	---
U of Mo	1	0	1	---	---	---
Ames	1	0	1	---	---	---
ARCO	0	1	1	---	---	---
LBL	0	1	1	---	---	---
WVDP	0	23	23	---	---	---
Totals	25,188	16,018	41,206	48,327	18,982	67,309
RH-TRU Waste						
Hanford	17,730	1,031	18,761	60,789	3,076	63,865
LANL	---	---	---	---	---	---
INEEL	---	---	---	---	---	---
ORNL	2,057	1,077	3,134	7,050	3,691	10,741
Totals	19,787	2,108	21,895	67,839	6,767	74,606

[a] The transportation analysis conservatively assumes the number of rail shipments is one-half of the truck shipments.

Table A-16
CH-TRU Final Waste Form Data [a]

Site	Final Waste Form	Type [b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit [c] Bagless (W/cubic meter)	PE Ci/cubic meter	Average Density (kg/cubic meter)
Ames	Solidified Inorganics	CH-MTRU	0.0	0.4	0.3668	13.7400	---	793.2
ANL-E	Lead/Cadmium Metal	CH-MTRU	1.1	1.3	---	1.0820	---	330.0
	Solidified Inorganics	CH-MTRU	5.2	0.0	0.0001	13.7400	---	355.4
	Solidified Organics	CH-MTRU	0.2	0.0	---	13.7400	---	697.2
	Uncategorized Metal	CH-TRU	5.0	128.5	0.1090	1.0820	---	302.9
ANL-W	Combustible	CH-MTRU	0.0	2.0	0.2609	0.5413	7.85	401.2
	Heterogeneous	CH-MTRU	1.7	0.0	0.0648	0.5413	1.77	512.3
	Combustible	CH-TRU	0.0	99.6	---	0.5413	---	401.2
	Heterogeneous	CH-TRU	4.8	345.4	---	0.5413	---	512.3
	Uncategorized Metal	CH-TRU	0.0	293.8	---	1.0820	---	423.7
Bettis	Heterogeneous	CH-TRU	0.0	123.3	0.3782	0.5413	0.04	332.7
ETEC	Heterogeneous	CH-TRU	1.7	0.0	---	0.5413	0.14	512.3
Hanford	Combustible	CH-MTRU	455.7	1,247.3	0.2288	0.5413	8.06	133.9
	Lead/Cadmium Metal	CH-MTRU	14.2	34.5	0.1391	1.0820	4.90	328.2
	Solidified Organics	CH-MTRU	7.4	9.4	0.1315	13.7400	4.63	160.7
	Uncategorized Metal	CH-MTRU	444.9	19,635.2	0.1971	1.0820	0.14	419.4
	Heterogeneous,	CH-TRU	11,190.8	6,271.3	0.3931	0.5413	8.91	865.5
	Inorganic Non-Metal	CH-TRU	34.7	69.1	0.1466	1.0820	5.28	204.7
	Soils	CH-TRU	119.5	5,961.7	1.4339	13.7400	1.08	635.7
	Solidified Inorganics	CH-TRU	12.9	7.1	0.1423	13.7400	4.90	432.5
INEEL	Filter	CH-MTRU	131.0	0.0	0.9120	0.5413	27.72	96.6
	Inorganic Non-Metal	CH-MTRU	2,066.1	0.0	0.5747	1.0820	18.05	1,827.6
	Solidified Organics	CH-MTRU	789.7	0.0	0.0620	13.7400	2.12	894.9
	Inorganic Non-Metal	CH-TRU	853.6	0.0	0.4966	1.0820	---	2,463.3
	Combustible	CH-MTRU	3,239.2	0.0	0.0936	0.5413	2.96	725.8
	Graphite	CH-MTRU	410.6	0.0	0.1647	1.0820	5.71	310.9
	Heterogeneous	CH-MTRU	6,334.2	0.0	0.0755	0.5413	1.97	415.5
	Lead/Cadmium Metal	CH-MTRU	14.4	0.0	---	1.0820	---	313.5
	Salt	CH-MTRU	8.8	0.0	4.5238	13.7400	142.63	203.6
	Solidified Inorganics	CH-MTRU	3,991.7	0.0	0.5209	13.7400	15.80	674.6
	Uncategorized Metal	CH-MTRU	5,789.8	0.0	0.2055	1.0820	5.88	306.3
	Combustible	CH-TRU	65.8	0.0	3.0165	0.5413	76.67	280.3
	Graphite	CH-TRU	87.6	0.0	0.3372	1.0820	11.61	338.8
	Heterogeneous	CH-TRU	4,274.3	0.0	0.0633	0.5413	0.40	318.1
	Salt	CH-TRU	11.7	0.0	1.3889	13.7400	37.33	318.3
	Uncategorized Metal	CH-TRU	77.1	0.0	10.7713	1.0820	88.22	403.6
LANL	Combustible	CH-MTRU	266.3	698.9	0.7201	0.5413	20.90	354.1
	Solidified Inorganics	CH-MTRU	4,883.2	1,952.3	1.2818	13.7400	17.02	1,248.3
	Uncategorized Metal	CH-MTRU	2,561.9	1,118.2	0.3720	1.0820	12.14	417.7
	Combustible	CH-TRU	1,555.2	1,677.3	1.1597	0.5413	35.73	354.1
	Heterogeneous	CH-TRU	16.0	29.1	0.0529	0.5413	7.99	346.3
	Soils	CH-TRU	110.6	29.1	0.0706	13.7400	1.98	1,200.0
	Solidified Inorganics	CH-TRU	5.0	81.5	4.0527	13.7400	111.66	1,004.8
	Solidified Organics	CH-TRU	1.5	29.1	0.1459	13.7400	4.49	1,296.0
	Uncategorized Metal	CH-TRU	1,652.5	1,735.6	1.1597	1.0820	32.38	525.0

[a] Dashed line indicates that information was not available.
[b] MTRU denotes TRU mixed waste.
[c] Values were obtained from Table 6-1 of TRUCON (DOE 1994b) and converted from watts per drum to watts per cubic meter to facilitate calculations.

Table A-16
CH-TRU Final Waste Form Data — Continued [a]

Site	Final Waste Form	Type [b]	Stored Volume (cubic meter)	Projected Volume (cubic meter)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit [c] Bagless (W/cubic meter)	PE Ci/cubic meter	Average Density (kg/cubic meter)
LLNL	Heterogeneous	CH-MTRU	8.6	0.0	0.2682	0.5413	4.45	221.3
	Solidified Organics	CH-MTRU	1.0	5.8	0.0872	13.7400	3.08	268.0
	Filter	CH-TRU	15.5	32.3	0.1801	0.5413	3.36	213.9
	Heterogeneous	CH-TRU	190.2	663.8	0.1269	0.5413	4.36	165.3
	Salt	CH-TRU	0.6	3.0	0.2268	13.7400	7.94	342.0
	Solidified Inorganics	CH-TRU	14.4	5.8	0.0939	13.7400	3.31	268.0
Mound	Combustible	CH-MTRU	1.7	0.0	3.1350	0.5413	86.97	401.2
	Solidified Inorganics	CH-MTRU	1.9	0.0	0.2405	13.7400	6.60	1,074.6
	Combustible	CH-TRU	5.4	0.0	3.0542	0.5413	83.90	401.2
	Filter	CH-TRU	0.8	0.0	0.0653	0.5413	1.55	96.0
	Heterogeneous	CH-TRU	0.6	0.0	0.9581	0.5413	27.80	512.3
	Soils	CH-TRU	177.2	0.0	0.0076	13.7400	0.22	846.8
	Solidified Inorganics	CH-TRU	4.2	0.0	0.0040	13.7400	0.11	1,143.0
	Uncategorized Metal	CH-TRU	82.5	0.0	0.1613	1.0820	3.86	423.7
NTS	Heterogeneous	CH-MTRU	613.3	9.0	0.1667	0.5413	5.29	225.2
	Solidified Inorganics	CH-TRU	5.7	0.0	0.2243	13.7400	7.78	272.0
ORNL	Heterogeneous	CH-MTRU	697.6	256.3	0.0051	0.5413	0.15	251.8
	Heterogeneous	CH-TRU	606.5	0.0	0.0633	0.5413	1.89	251.8
PGDP	Inorganic Non-Metal	CH-MTRU	0.0	1.9	0.0031	1.0820	0.08	63.6
RFETS	Combustible	CH-MTRU	151.4	736.5	0.0908	0.5413	3.00	131.2
	Filter	CH-MTRU	2.1	325.4	0.1273	0.5413	4.42	84.9
	Heterogeneous	CH-MTRU	1.2	0.0	0.0232	0.5413	0.81	362.0
	Inorganic Non-Metal	CH-MTRU	16.5	291.7	0.0499	1.0820	1.73	249.8
	Lead/Cadmium Metal	CH-MTRU	4.0	298.3	0.1349	1.0820	4.41	245.2
	Solidified Inorganics	CH-MTRU	150.2	1,193.3	0.0894	13.7400	0.56	714.9
	Solidified Organics	CH-MTRU	109.8	0.0	0.0276	13.7400	1.33	983.5
	Uncategorized Metal	CH-MTRU	1.5	0.0	0.8873	1.0820	30.47	215.5
	Combustible	CH-TRU	34.1	124.6	0.0668	0.5413	2.16	79.5
	Filter	CH-TRU	70.0	152.2	0.2361	0.5413	8.15	90.5
	Graphite	CH-TRU	13.7	47.6	0.2060	1.0820	7.17	279.1
	Heterogeneous	CH-TRU	2.6	0.0	0.0232	0.5413	0.19	370.8
	Inorganic Non-metal	CH-TRU	41.8	575.0	0.0836	1.0820	2.90	219.0
	Salt	CH-TRU	0.0	325.9	---	13.7400	---	536.4
	Solidified Inorganics	CH-TRU	15.2	64.3	1.1542	13.7400	39.53	685.4
	Solidified Organics	CH-TRU	0.0	31.1	0.0701	13.7400	2.44	349.1
	Uncategorized Metal	CH-TRU	91.9	236.1	0.0836	1.0820	2.89	321.3
SNL	Heterogeneous	CH-TRU	6.7	7.5	0.0522	0.5413	0.94	166.1
SRS	Heterogeneous	CH-MTRU	2,611.6	5,465.2	2.9701	0.5413	83.78	173.2
	Solidified Inorganics	CH-MTRU	200.2	1,169.6	1.7429	13.7400	48.26	2,185.5
	Uncategorized Metal	CH-MTRU	70.4	120.5	2.9701	1.0820	83.78	387.1
	Heterogeneous	CH-TRU	0.0	10.7	3.0504	0.5413	83.64	161.5
U of Mo	Heterogeneous	CH-MTRU	0.2	0.8	0.0513	0.5413	1.54	101.3
USAMC	Heterogeneous	CH-TRU	2.5	0.0	0.0028	0.5413	0.09	512.3

[a] Dashed line indicates that information was not available.
[b] MTRU denotes TRU mixed waste.
[c] Values were obtained from Table 6-1 of TRUCON (DOE 1994b) and converted from watts per drum to watts per cubic meter to facilitate calculations.

Table A-17
Final Waste Form Data for RFETS CH-TRU Waste Residues [a, b]

Final Waste Form	Type	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Combustible	CH-TRU	184.4	0.0	2.5205	0.5413	83.4	---
Filter	CH-TRU	592.8	0.0	2.5205	0.5413	83.4	---
Graphite	CH-TRU	47.1	0.0	2.5205	1.0820	83.4	---
Heterogeneous	CH-TRU	3.8	0.0	2.5205	0.5413	83.4	---
Inorganic Non-Metal	CH-TRU	2,509.6	0.0	2.5205	1.0820	83.4	---
Lead/Cadmium Metal	CH-TRU	7.6	0.0	2.5205	1.0820	83.4	---
Salt	CH-TRU	376.5	0.0	2.5205	13.7400	83.4	---
Solidified Inorganics	CH-TRU	404.6	0.0	2.5205	13.7400	83.4	---
Uncategorized Metal	CH-TRU	55.5	0.0	2.5205	1.0820	83.4	---

[a] RFETS residue data is part of the Basic Inventory.
[b] Dashed line indicates that information was not available.

Table A-18
Final Waste Form Data for PCB-Commingled Waste [a]

Site	Final Waste Form	Type [b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Hanford	Uncategorized Metal	CH-MTRU	66.1	113.4	---	---	---	255.7
	Lead/Cadmium Metal	CH-MTRU	3.8	0.0	---	---	---	327.9
	Solidified Organics	CH-MTRU	2.1	8.3	---	---	---	160.4
	Solidified Organics	CH-MTRU	1.2	2.5	---	---	---	153.2
	Uncategorized Metal	CH-MTRU	0.2	0.0	---	---	---	338.1
INEEL	Inorganic Non-Metal	CH-MTRU	108.6	0.0	---	---	---	2,500.0
	Solidified Organics	CH-MTRU	352.8	0.0	---	---	---	903.9
Mound	Unknown	CH-TRU	19.0	0.0	---	---	---	---
	Unknown	CH-TRU	0.2	0.0	---	---	---	---

[a] Dashed line indicates that information was not available.
[b] MTRU denotes TRU mixed waste.

Table A-19
Example LANL Data for Shipment Calculations

Final Waste Form	Watts per Cubic Meter	Watt Limit with Bagless Posting	Volume Multiplier for Watts	Average Density (kg/cubic meter)	Adjusted Average Density (kg/cubic meter)	Shipment Volume Multiplier for Density	Site Volume	Shipment Volume
Combustible	0.7201	0.5413	1	354.1	354.1	1	1,214.8	1,214.8
Lead/Cadmium Metal Waste	Missing	1.0820	1	313.5	313.5	1	1.9	1.9
Solidified Inorganics	1.2818	13.7400	1	1,248.3	1,248.3	3	7,532.7	22,598.2
Uncategorized Metal	0.3720	1.0820	1	417.7	417.7	1	4,079.5	4,079.5
Combustible	1.1597	0.5413	1	354.1	354.1	1	3,831.5	3,831.5
Heterogeneous	0.0529	0.5413	1	346.3	346.3	1	55.5	55.5
Soils	0.0706	13.7400	1	1,200.0	1,200.0	3	150.1	450.3
Solidified Inorganics	4.0527	13.7400	1	1,004.8	1,004.8	3	115.6	346.9
Solidified Organics	0.1459	13.7400	1	1,296.0	1,296.0	3	41.0	122.9
Uncategorized Metal	1.1597	1.0820	1.0718	525.0	489.8	1	4,007.9	4,295.7

Table A-20
RH-TRU Final Waste Form Data [a]

Site	Final Waste Form	Type [b]	Stored Volume (cubic meters	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
ANL-W	Inorganic Nonmetal	RH-MTRU	0.0	21.4	---	337.1	---	132.5
	Solidified Inorganics	RH-MTRU	1.8	28.5	---	337.1	---	1,074.6
	Heterogeneous	RH-TRU	0.0	1,208.6	---	337.1	---	512.3
	Lead/Cadmium Metal	RH-TRU	0.0	6.2	---	337.1	---	423.7
BCL	Heterogeneous	RH-TRU	580.5	0.0	---	337.1	0.01	2,000.0
Bettis	Heterogeneous	RH-TRU	0.0	6.7	6.3620	337.1	45.45	885.0
ETEC	Lead/Cadmium Metal	RH-MTRU	0.9	0.0	---	337.1	13.19	313.5
Hanford	Heterogeneous	RH-MTRU	0.0	2,617.5	---	337.1	---	432.4
	Lead/Cadmium Metal	RH-MTRU	2.7	60.5	0.0012	337.1	0.06	592.0
	Uncategorized Metal	RH-MTRU	0.0	0.0	0.0003	337.1	0.00	519.1
	Heterogeneous	RH-TRU	199.4	1,448.9	1.9994	337.1	0.61	460.2
	Uncategorized Metal	RH-TRU	0.0	17,400.4	0.0003	337.1	0.00	283.5
INEEL	Combustible	RH-MTRU	21.4	0.0	0.2655	337.1	9.17	294.0
	Heterogeneous	RH-MTRU	43.9	0.0	0.1421	337.1	4.82	210.3
	Inorganic Non-Metal	RH-MTRU	33.2	0.0	1.2867	337.1	39.34	1,930.6
	Lead/Cadmium Metal	RH-MTRU	3.6	0.0	---	337.1	---	313.5
	Solidified Inorganics	RH-MTRU	65.3	0.0	0.6192	337.1	18.68	466.1
	Solidified Organics	RH-MTRU	3.6	0.0	0.5015	337.1	17.04	842.1
	Uncategorized Metal	RH-MTRU	22.5	0.0	0.0672	337.1	2.34	221.4
	Heterogeneous	RH-TRU	5.9	0.0	0.0048	337.1	0.09	378.2
	Inorganic Non-Metal	RH-TRU	13.1	0.0	4.4674	337.1	39.85	2,500.0
	Uncategorized Metal	RH-TRU	8.3	0.0	22.2868	337.1	204.34	341.5
LANL	Uncategorized Metal	RH-MTRU	16.9	33.8	0.9587	337.1	9.57	557.5
	Combustible	RH-TRU	15.1	49.0	0.1466	337.1	2.92	354.1
	Heterogeneous	RH-TRU	11.6	0.0	0.1990	337.1	3.17	302.9
	Uncategorized Metal	RH-TRU	50.7	16.0	0.0002	337.1	0.00	567.4
ORNL	Heterogeneous	RH-MTRU	1,347.5	240.3	0.0005	337.1	0.01	251.8
	Solidified Inorganics	RH-MTRU	1,036.9	206.5	---	337.1	0.01	793.3
	Heterogeneous	RH-TRU	84.5	0.0	0.0107	337.1	0.09	251.8

[a] Dashed line indicates that information was not available.
[b] MTRU denotes TRU mixed waste.

Table A-21
Previously Disposed TRU Final Waste Form Data [a]

Site	Final Waste Form	Type	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Hanford	Buried	CH-TRU	62,599.1	0.0	---	---	---	---
		RH-TRU	1,029.9	0.0	---	---	---	---
INEEL	Buried	CH-TRU	56,556.5	0.0	---	---	---	---
		RH-TRU	443.5	0.0	---	---	---	---
LANL	Buried	CH-TRU	13,881.5	0.0	---	---	---	---
		RH-TRU	118.5	0.0	---	---	---	---
ORNL	Buried	CH-TRU	60.8	0.0	---	---	---	---
		RH-TRU	115.2	0.0	---	---	---	---
SNL	Buried	CH-TRU	1.3	0.0	---	---	---	---
SRS	Buried	CH-TRU	4,874.0	0.0	---	---	---	---
WVDP	Unknown, Buried Assume RH-TRU	RH-TRU	1,353.2	0.0	---	---	---	---

[a] Dashed line indicates that information was not available.

Table A-22
Commercial/Nondefense TRU Final Waste Form Data [a]

Site	Final Waste Form	Type [b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
LBL	Heterogeneous	CH-TRU	0.6	1.0	---	---	---	1,565.0
ORNL	Heterogeneous	CH-MTRU [b]	1.0	0.0	---	---	---	251.8
	Unknown	CH-TRU	4.4	0.0	---	---	---	251.8
Knolls	Heterogeneous	RH-TRU	2.5	51.0	---	---	---	252.9
	Heterogeneous	RH-MTRU	0.0	6.9	---	---	---	253.8
ARCO	Heterogeneous	CH-TRU	0.2	0.2	---	---	---	---
WVDP	Unknown	CH-MTRU	10.0	0.0	---	---	---	---
	Solidified Inorganics	CH-TRU	0.2	0.0	---	---	---	---
	Solidified Inorganics	CH-TRU	0.4	0.0	---	---	---	---
	Unknown	CH-TRU	0.2	0.0	---	---	---	---
	Solidified Inorganics	CH-MTRU	1.5	0.0	---	---	---	---
	Heterogeneous	CH-TRU	3.7	0.0	---	---	---	---
	Unknown	CH-TRU	0.6	0.0	---	---	---	---
	Inorganic Non-Metal	CH-TRU	0.2	0.0	---	---	---	---
	Unknown	CH-TRU	0.4	0.0	---	---	---	---
	Heterogeneous	CH-TRU	13.0	88.0	---	---	---	---
	Heterogeneous	CH-TRU	2.1	29.1	---	---	---	---
	Uncategorized Metal	CH-TRU	0.2	0.0	---	---	---	---
	Lead/Cadmium Metal	CH-MTRU	2.1	0.0	---	---	---	---
	Solidified Organics	CH-MTRU	0.4	0.0	---	---	---	---
	Filter	RH-TRU	3.8	0.0	---	---	---	---
	Filter	RH-TRU	49.0	46.0	---	---	---	---
	Unknown	RH-TRU	17.8	0.0	---	---	---	---
	Uncategorized Metal	RH-TRU	89.9	0.0	---	---	---	---

[a] Dashed line indicates that information was not available.
[b] MTRU denotes TRU mixed waste.

Table A-23
Possible Future TRU Final Waste Form Data [a, b]

Site	Final Waste Form	Type [c]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
ANL-E	Uncategorized - Unknown	CH-TRU	13.3	0.0	---	---	---	---
ETEC	Uncategorized - Unknown	RH-MTRU	5.4	0.8	---	---	---	---
Mound	Uncategorized - Unknown	CH-TRU	23.0	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	4.2	0.0	---	---	---	---
ORNL	Uncategorized - Unknown	CH-TRU	17.7	0.0	---	---	---	---
	Uncategorized - Unknown	RH-TRU	0.9	0.0	---	---	---	---
PGDP	Uncategorized - Unknown	CH-MTRU	0.0	1.9	---	---	---	---
	Uncategorized - Unknown	CH-MTRU	0.0	1.9	---	---	---	---
Hanford	Uncategorized - Unknown	CH-MTRU	0.4	0.0	---	---	---	---
	Uncategorized - Unknown	CH-MTRU	0.2	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	0.2	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	1.5	0.8	---	---	---	---
	Uncategorized - Unknown	CH-TRU	19.0	61.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	0.4	0.0	---	---	---	---

[a] Dashed line indicates that information was not available.
[b] This waste volume has been included as part of the Basic Inventory.
[c] MTRU denotes TRU mixed waste.

expanded (void space) to reduce the gas generation to acceptable limits for shipment in the TRUPACT-II. This multiplier is calculated for every final waste form. Next, the average density for the final waste form is divided by the volume multiplier from the watt calculations to obtain the average density of the expanded waste form. In this example, the uncategorized metal is the only waste form that requires volume expansion to meet the gas generation limits. Next, a shipment volume multiplier is determined for every final waste form by computing the weight of a drum as 0.208 x (Adjusted Average Density) and looking up the shipment volume multiplier in Table A-2. Finally, the shipment volume is determined as the product of the site volume, the density volume multiplier, and the watt multiplier. The shipment volume is simply a mathematical construct that incorporates the amount of void space needed to completely fill three TRUPACT-IIs on a truck.

The total shipment volume is the sum of the shipment volume over all waste forms. For LANL, this number is 36,997.2 cubic meters (1,306,543.8 cubic feet). Each truck can carry three TRUPACT-IIs for a total of 42 drums, with a total waste volume of 8.736 cubic meters (308.5 cubic feet). Thus, the shipment volume of 36,997.2 cubic meters (1,306,543.8 cubic feet) requires 4,235 shipments. LANL also serves as a consolidation site and receives enough additional waste for two more shipments, for a total of 4,237 shipments to WIPP. Finally, the analysis for

the Proposed Action assumes that the repository takes as much CH-TRU waste as is allowed under the LWA. This assumption requires the volume of waste to be increased by 18.2 percent. Thus, the total number of shipments from LANL to WIPP under the Proposed Action is 5,009 ($= 4{,}237 \times 1.182$).

A.3.10 Final Waste Form Data

The data from which the volume, density, and PE-Ci results were derived are presented in Table A-16. Cells with dashed lines indicate that BIR-3 data were not available to calculate the values. Where thermal power or PE-Ci data were missing, it was assumed that the waste form met planning-basis WAC requirements without volume expansion. When density data were missing, it was assumed that a CH-TRU waste shipment can handle three fully loaded TRUPACT-II's, except under Action Alternative 2 where a shipment consists of 12 drums and an RH-TRU waste shipment can handle three drums.

A.4 RADIONUCLIDE INVENTORY

The WIPP facility has been designed with the intent to use it for disposal of TRU waste. TRU wastes are defined to be wastes containing more than 100 nanocuries of alpha-emitting TRU radionuclides per gram of waste, with half-lives greater than 20 years, subject to a number of conditions (see Chapter 1). TRU waste at the generator-storage sites typically include non-TRU radionuclides commingled with the TRU waste. Data on all of the radionuclides are presented in this appendix. The four non-TRU radionuclides with the greatest activity in the waste are strontium-90 (Sr-90), yttrium-90 (Y-90), cesium-137 (Cs-137), and barium-137m (Ba-137m).

A.4.1 Inventory Information in 1995

The radionuclide activity by site was obtained from IDB (DOE 1994a), and the activity was adjusted to account for decay to December 31, 1995. Radionuclide information for CH-TRU waste was available for the following sites: Argonne National Laboratory-East (ANL-E), ARCO, U.S. Army Materiel Command (USAMC), Energy Technical Engineering Center (ETEC), Hanford, INEEL, LBL, LANL, Lawrence Livermore National Laboratory (LLNL), Mound, University of Missouri (U of Mo), Nevada Test Site (NTS), ORNL, Paducah Gaseous Diffusion Plant (PGDP), and RFETS. More than 99 percent of the CH-TRU waste volume in the Basic Inventory is located at these sites.

RH-TRU waste radionuclide information was only available from the following sites: ETEC, Hanford, INEEL, LANL, NTS, ORNL. In the Basic Inventory, approximately 98 percent of the RH-TRU waste volume is located at these sites.

The percentages of RH-TRU waste volumes at these sites in the Total Inventory for Action Alternatives 1, 2, 3, No Action Alternative 1, and No Action Alternative 2 are 93, 84, 93, 81, and 94 percent, respectively. Most of the remaining RH-TRU waste volume is accounted for at Battelle-Columbus; however, no information was available for this site.

Four sites (NTS, ANL-E, SRS, and Sandia National Laboratories (SNL)) provided RH-TRU waste radionuclide inventories in the IDB and BIR-3; however, they did not identify any waste volumes associated with RH-TRU waste. For the purpose of analyses, the assumption was made that these sites do not have any RH-TRU waste.

Due to a lack of radionuclide information for some waste streams in BIR-3, site radionuclide information for all but RFETS and ORNL were obtained from IDB. RFETS residue data were only found in BIR-3 and, therefore, were added to RFETS IDB data. ORNL's CH-TRU waste data for Cs-137 and Ba-137m radionuclide concentrations in the IDB were found to exceed the 200 millirem per hour limit to be designated as CH-TRU waste. Likewise, the data in BIR-3 for ORNL exceeded this limit. As an example, waste stream OR-W044 reported 520 cubic meters (18,360 cubic feet) of waste with a concentration of 0.489 Ci per cubic meter. ORNL staff confirmed that only 13 drums (2.704 cubic meters [95 cubic feet]) within this waste stream have the 0.489 Ci per cubic meter concentration, and yet it was applied to the entire waste stream. SEIS-II uses the Cs-137 data from BIR-3 rather than from IDB. OR-W044 waste stream data were adjusted to show Cs-137 in only 13 drums (2.704 cubic meters [95 cubic feet]). Under these assumptions, a total stored inventory of 1.328 Ci for Cs-137 and about 1.256 Ci for Ba-137m were determined. The radionuclide inventories (expressed as both activity in curies and mass in grams) for stored CH-TRU waste in 1995 according to generator-storage site are given in Tables A-24 and A-25, respectively. The radionuclide inventories (expressed as both activity in curies and mass in grams) for stored RH-TRU waste in 1995 according to generator-storage site are given in Tables A-26 and A-27, respectively.

The site radionuclide information represents the radionuclide inventory in a given volume as determined from IDB or BIR-3. The radionuclide inventory by site for an alternative was calculated using the following equation:

$$I_{Alternative} = I_{1995} + \left(\frac{I_{1995}}{V_{IDB}}\right)(V_{Estimated} - V_{Stored}) \qquad \text{(Equation A-7)}$$

where

$I_{Alternative}$ = total site radionuclide inventory (in Ci) used in the analysis for an alternative

I_{1995} = inventory in 1995 from IDB

V_{IDB} = volume associated with I_{1995}

$V_{Estimated}$ = estimated volume from Tables 2-2 and 2-3 to be generated through 2033 for an alternative

V_{Stored} = stored, post-treatment 1995 volume based on Tables 2-2 and 2-3.

Table A-24
Radionuclide Inventories (curies) for Stored CH-TRU Waste in 1995 [a]

Isotope	ANL-E	ARCO	USAMC	ETEC	Hanford	INEEL	LBL	LANL	LLNL	MOUND
Pu-238	2.11E+00	3.70E+02	---	1.11E-01	8.05E+04	5.98E+04	2.32E-04	1.15E+05	7.65E+01	4.97E+02
Pu-241	5.43E+01	---	---	6.22E+00	3.78E+04	1.50E+05	4.48E-07	1.62E+03	1.63E+03	---
Pu-239	3.28E+01	---	1.80E+01	1.79E+00	2.63E+04	4.01E+04	8.45E-06	7.91E+04	1.64E+02	6.28E+00
Am-241	5.89E+00	---	---	5.19E-01	4.73E+03	9.01E+04	9.17E-02	1.17E+04	1.44E+02	---
Pu-240	9.42E+00	---	---	6.12E-01	6.14E+03	9.84E+03	5.14E-03	1.01E+02	6.44E+01	---
Cs-137	---	---	---	---	6.83E+02	6.04E+01	---	4.81E+01	1.66E-06	---
Ba-137m	---	---	---	---	6.46E+02	5.71E+01	---	4.55E+01	1.57E-06	---
Cm-244	---	---	---	---	6.83E+01	4.93E+02	8.70E-02	1.56E+02	6.54E+01	---
Y-90	---	---	---	2.00E-01	6.92E+02	1.96E+00	---	4.44E+01	---	---
Sr-90	---	---	---	2.00E-01	6.92E+02	1.96E+00	---	4.44E+01	---	---
U-233	3.00E-02	---	---	1.20E-11	8.00E+01	8.99E+02	4.81E-03	4.46E+01	5.95E-09	---
Pu-242	1.00E-02	---	---	5.00E-05	3.80E-01	9.45E-01	1.01E-02	4.85E+02	2.02E-02	---
U-234	---	1.05E-03	---	1.93E-06	5.37E+01	6.18E+00	4.73E-09	6.06E+00	3.29E-03	2.47E-02
Pa-233	---	---	---	9.49E-07	2.72E-01	8.53E-01	6.32E-06	3.22E-02	4.71E-04	---
Np-237	---	---	---	9.49E-07	2.72E-01	8.53E-01	6.32E-06	3.22E-02	4.71E-04	---
Co-60	---	---	---	---	---	6.24E+01	---	7.91E-06	---	---
Eu-155	---	---	---	---	1.06E-03	3.83E-01	---	2.41E-01	---	---
Cf-252	---	---	---	---	3.52E+01	2.19E-03	---	---	---	---
Pb-212	---	---	---	---	5.18E-02	2.62E+01	---	6.16E-03	---	---
Ra-224	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---
Bi-212	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---
Po-216	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---
Rn-220	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---
Th-228	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---
U-232	---	---	---	---	---	2.53E+01	---	1.67E-03	---	---
Np-239	9.52E-02	---	---	---	9.01E-02	3.79E-01	3.85E-02	3.83E+00	2.45E-02	---
Am-243	9.52E-02	---	---	---	9.01E-02	3.79E-01	3.85E-02	3.83E+00	2.45E-02	---
Tc-99	---	---	---	---	9.51E-06	2.16E-03	---	1.02E-02	---	---
Po-212	---	---	---	---	3.32E-02	1.68E+01	---	8.48E-04	---	---
Cm-245	---	---	---	---	1.68E+01	9.09E-06	2.27E-06	1.60E-06	---	---
Tl-208	---	---	---	---	1.86E-02	9.42E+00	---	4.76E-04	---	---
U-237	---	---	---	1.53E-04	9.27E-01	3.67E+00	---	3.98E-02	4.00E-02	---
Ra-226	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	3.99E-08	4.47E-09
Po-218	---	---	1.40E-11	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	---	4.47E-09
Rn-222	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	---	4.47E-09
Bi-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09
Pb-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09
Po-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09
Ag-109m	---	---	---	---	---	---	---	6.56E+00	---	---
Cd-109	---	---	---	---	---	---	---	6.55E+00	---	---
Pa-234m	---	---	---	---	5.86E+00	1.16E-01	---	2.38E-02	3.03E-02	---
Th-234	---	---	---	---	5.86E+00	1.16E-01	---	2.36E-02	3.03E-02	---
U-238	---	---	---	---	5.86E+00	1.16E-01	---	2.36E-02	3.03E-02	---
Pm-147	---	---	---	---	4.78E-02	2.62E+00	---	2.00E+00	---	---
U-235	---	---	1.77E-08	1.06E-08	1.71E+00	6.18E-02	---	5.27E-01	5.93E-04	1.05E-07
Th-231	---	---	1.77E-08	1.06E-08	1.71E+00	6.18E-02	---	5.27E-01	1.76E-03	1.05E-07
Ac-225	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
Th-229	---	---	---	---	1.31E-01	1.52E+00	5.75E-06	8.06E-02	---	---
Ra-225	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
At-217	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
Bi-213	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
Fr-221	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
Pb-209	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---
Po-213	---	---	---	---	1.28E-01	1.49E+00	5.33E-06	7.89E-02	---	---
C-14	---	---	---	---	1.60E+00	1.66E-01	---	2.00E-07	---	---
Bi-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10
Po-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10
Pb-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10
Eu-152	---	---	---	---	7.34E-07	1.62E-01	---	4.18E-04	1.33E-06	---
Cm-243	---	---	---	---	1.52E-02	---	---	1.11E+00	---	---
Eu-154	---	---	---	---	6.22E-05	6.43E-01	---	2.45E-02	5.25E-07	---

[a] Dashed line indicates that the radionuclide was not present or that information was not reported.

Table A-24
Radionuclide Inventories (curies) for Stored CH-TRU Waste in 1995 — Continued [a]

Isotope	U of MO	NTS	ORNL	PGDP	Pantex	RFETS	RFETS Residues	SRS	Total
Pu-238	---	3.15E+04	3.50E+03	---	---	3.43E+02	8.14E+03	5.53E+05	8.52E+05
Pu-241	6.32E-03	2.40E+02	4.79E+04	---	---	5.23E+04	1.02E+06	1.12E+05	1.42E+06
Pu-239	2.46E-02	2.76E+03	2.72E+03	5.57E+01	5.55E-02	9.98E+03	1.74E+05	9.35E+03	3.44E+05
Am-241	3.24E-01	2.84E+02	1.61E+03	---	---	1.10E+04	1.09E+05	2.01E+03	2.30E+05
Pu-240	---	2.66E+01	9.48E+02	---	---	7.22E+03	3.98E+04	2.31E+03	6.64E+04
Cs-137	---	3.60E-01	1.33E+00	---	---	---	---	7.51E+00	8.01E+02
Ba-137m	---	3.41E-01	1.26E+00	---	---	---	---	7.11E+00	7.57E+02
Cm-244	---	2.28E+02	1.06E+03	---	---	---	---	1.17E+03	3.24E+03
Y-90	---	3.10E-01	1.48E+03	---	---	---	---	6.98E+00	2.22E+03
Sr-90	---	3.10E-01	1.48E+03	---	---	---	---	6.98E+00	2.22E+03
U-233	1.78E-09	1.81E+00	1.77E+02	1.42E-03	---	1.29E+01	---	3.75E+00	1.22E+03
Pu-242	---	8.70E-02	2.37E-01	---	---	9.63E-05	---	3.75E-01	4.87E+02
U-234	2.98E-13	1.26E-02	1.57E+01	---	---	4.81E-03	---	2.56E+01	1.07E+02
Pa-233	2.28E-04	5.78E-03	7.32E-01	5.50E+01	---	1.70E-02	---	8.59E+00	6.55E+01
Np-237	2.28E-04	5.78E-03	7.27E-01	5.50E+01	---	1.70E-02	---	8.59E+00	6.55E+01
Co-60	---	---	1.84E-06	---	---	---	---	3.56E-01	6.28E+01
Eu-155	---	3.80E-03	---	---	---	---	---	5.28E+01	5.34E+01
Cf-252	---	1.70E-02	1.60E-01	---	---	---	---	3.62E-01	3.58E+01
Pb-212	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Ra-224	---	1.71E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Bi-212	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Po-216	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Rn-220	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Th-228	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
U-232	---	1.65E-02	2.90E-01	---	---	---	---	8.94E-02	2.57E+01
Np-239	---	1.22E+00	1.49E+01	---	---	---	---	7.55E-01	2.13E+01
Am-243	---	1.22E+00	1.16E+01	---	---	---	---	7.55E-01	1.81E+01
Tc-99	---	5.99E-05	1.78E+01	---	---	---	---	4.50E-06	1.78E+01
Po-212	---	1.05E-02	1.82E-01	---	---	---	---	5.89E-03	1.70E+01
Cm-245	---	9.44E-06	3.35E-05	---	---	---	---	---	1.68E+01
Tl-208	---	5.89E-03	1.02E-01	---	---	---	---	3.31E-03	9.55E+00
U-237	1.55E-07	5.88E-03	1.18E+00	---	---	1.28E+00	---	1.52E+00	8.66E+00
Ra-226	---	2.50E-01	6.54E+00	---	---	---	---	7.30E-06	7.77E+00
Po-218	---	2.50E-01	6.49E+00	---	---	---	---	7.30E-06	7.73E+00
Rn-222	---	2.50E-01	6.49E+00	---	---	---	---	7.30E-06	7.73E+00
Bi-214	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Pb-214	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Po-214	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Ag-109m	---	---	---	---	---	---	---	---	6.56E+00
Cd-109	---	---	---	---	---	---	---	---	6.55E+00
Pa-234m	1.16E-07	3.46E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
Th-234	1.16E-07	3.18E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
U-238	1.16E-07	1.64E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
Pm-147	---	1.05E-01	1.94E-02	---	---	---	---	1.24E-05	4.80E+00
U-235	4.44E-11	1.17E-02	1.33E-02	3.29E-07	1.09E-10	4.78E-05	---	5.84E-03	2.33E+00
Th-231	3.75E-08	6.15E-05	1.45E-02	3.29E-07	1.09E-10	4.78E-05	---	5.84E-03	2.32E+00
Ac-225	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Th-229	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Ra-225	---	2.41E-03	2.07E-01	4.02E-07	4.02E-07	---	---	1.31E-05	1.94E+00
At-217	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Bi-213	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Fr-221	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Pb-209	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Po-213	---	2.36E-03	2.02E-01	3.93E-07	---	---	---	1.28E-05	1.90E+00
C-14	---	2.50E-04	---	---	---	---	---	---	1.77E+00
Bi-210	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Po-210	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Pb-210	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Eu-152	---	1.06E+00	6.18E-04	---	---	---	---	---	1.22E+00
Cm-243	---	---	---	---	---	---	---	---	1.12E+00
Eu-154	---	4.28E-01	---	---	---	---	---	2.84E-04	1.10E+00

[a] Dashed line indicates that the radionuclide was not present or that information was not reported.

Table A-25
Radionuclide Inventories (grams) for Stored CH-TRU Waste in 1995 [a]

Isotope	ANL-E	ARCO	USAMC	ETEC	Hanford	INEEL	LBL	LANL	LLNL	Mound
Pu-238	1.23E-01	2.16E+01	---	6.46E-03	4.70E+03	3.49E+03	1.35E-05	6.69E+03	4.46E+00	2.90E+01
Pu-241	5.27E-01	---	---	6.03E-02	3.66E+02	1.45E+03	4.34E-09	1.57E+01	1.58E+01	---
Pu-239	5.27E+02	---	2.90E+02	2.88E+01	4.22E+05	6.45E+05	1.36E-04	1.27E+06	2.64E+03	1.01E+02
Am-241	1.71E+00	---	---	1.51E-01	1.38E+03	2.62E+04	2.67E-02	3.40E+03	4.18E+01	---
Pu-240	4.13E+01	---	---	2.68E+00	2.69E+04	4.32E+04	2.25E-02	4.44E+02	2.82E+02	---
Cs-137	---	---	---	---	7.85E+00	6.93E-01	---	5.52E-01	1.91E-08	---
Ba-137m	---	---	---	---	1.20E-06	1.06E-07	---	8.45E-08	2.92E-15	---
Cm-244	---	---	---	---	8.43E-01	6.08E+00	1.07E-03	1.93E+00	8.07E-01	---
Y-90	---	---	---	3.68E-07	1.27E-03	3.60E-06	---	8.16E-05	---	---
Sr-90	---	---	---	1.47E-03	5.07E+00	1.44E-02	---	3.25E-01	---	---
U-233	3.11E+00	---	---	1.24E-09	8.28E+03	9.31E+04	4.98E-01	4.62E+03	6.16E-07	---
Pu-242	2.54E+00	---	---	1.27E-02	9.67E+01	2.40E+02	2.56E+00	1.23E+05	5.13E+00	---
U-234	---	1.69E-01	---	3.09E-04	8.61E+03	9.89E+02	7.58E-07	9.72E+02	5.27E-01	3.96E+00
Pa-233	---	---	---	4.57E-11	1.31E-05	4.11E-05	3.04E-10	1.55E-06	2.27E-08	---
Np-237	---	---	---	1.35E-03	3.85E+02	1.21E+03	8.95E-03	4.57E+01	6.67E-01	---
Co-60	---	---	---	---	---	6.34E-02	---	8.04E-09	---	---
Eu-155	---	---	---	---	2.27E-06	8.23E-04	---	5.18E-04	---	---
Cf-252	---	---	---	---	6.55E-02	4.06E-06	---	---	---	---
Pb-212	---	---	---	---	3.71E-08	1.88E-05	---	4.41E-09	---	---
Ra-224	---	---	---	---	3.23E-07	1.64E-04	---	8.26E-09	---	---
Bi-212	---	---	---	---	3.54E-09	1.79E-06	---	9.04E-11	---	---
Po-216	---	---	---	---	8.57E-17	4.33E-14	---	2.19E-18	---	---
Rn-220	---	---	---	---	5.62E-11	2.84E-08	---	1.43E-12	---	---
Th-228	---	---	---	---	6.31E-05	3.19E-02	---	1.61E-06	---	---
U-232	---	---	---	---	---	1.18E+00	---	7.82E-05	---	---
Np-239	4.09E-07	---	---	---	3.87E-07	1.63E-06	1.65E-07	1.64E-05	1.05E-07	---
Am-243	4.77E-01	---	---	---	4.52E-01	1.90E+00	1.93E-01	1.92E+01	1.23E-01	---
Tc-99	---	---	---	---	5.61E-04	1.27E-01	---	6.02E-01	---	---
Po-212	---	---	---	---	1.10E-16	5.54E-14	---	2.80E-18	---	---
Cm-245	---	---	---	---	9.77E+01	5.29E-05	1.32E-05	9.33E-06	---	---
Tl-208	---	---	---	---	6.38E-11	3.23E-08	---	1.63E-12	---	---
U-237	---	---	---	1.87E-09	1.13E-05	4.49E-05	---	4.87E-07	4.90E-07	---
Ra-226	---	---	---	---	3.18E-05	4.85E-02	3.40E-02	9.14E-01	4.03E-08	4.51E-09
Po-218	---	---	4.94E-20	---	1.11E-13	1.70E-10	1.19E-10	3.20E-09	---	1.58E-17
Rn-222	---	---	---	---	2.05E-10	3.11E-07	2.18E-07	5.87E-06	---	2.90E-14
Bi-214	---	---	---	---	7.10E-13	1.08E-09	7.58E-10	2.04E-08	---	1.01E-16
Pb-214	---	---	---	---	9.60E-13	1.46E-09	1.03E-09	2.76E-08	---	1.36E-16
Po-214	---	---	---	---	9.79E-20	1.49E-16	1.05E-16	2.81E-15	---	1.39E-23
Ag-109m	---	---	---	---	---	---	---	2.52E-09	---	---
Cd-109	---	---	---	---	---	---	---	2.48E-03	---	---
Pa-234m	---	---	---	---	8.52E-09	1.68E-10	---	3.46E-11	4.40E-11	---
Th-234	---	---	---	---	2.53E-04	5.00E-06	---	1.02E-06	1.31E-06	---
U-238	---	---	---	---	1.74E+07	3.44E+05	---	7.02E+04	9.00E+04	---
Pm-147	---	---	---	---	5.14E-05	2.82E-03	---	2.16E-03	---	---
U-235	---	---	8.20E-03	4.90E-03	7.90E+05	2.86E+04	---	2.44E+05	2.74E+02	4.86E-02
Th-231	---	---	3.33E-14	1.99E-14	3.21E-06	1.16E-07	---	9.89E-07	3.31E-09	1.97E-13
Ac-225	---	---	---	---	2.25E-06	2.62E-05	9.39E-11	1.39E-06	---	---
Th-229	---	---	---	---	6.14E-01	7.13E+00	2.70E-05	3.79E-01	---	---
Ra-225	---	---	---	---	3.33E-06	3.87E-05	1.39E-10	2.05E-06	---	---
At-217	---	---	---	---	8.03E-17	9.34E-16	3.35E-21	4.96E-17	---	---
Bi-213	---	---	---	---	6.80E-09	7.91E-08	2.84E-13	4.20E-09	---	---
Fr-221	---	---	---	---	7.36E-10	8.56E-09	3.07E-14	4.54E-10	---	---
Pb-209	---	---	---	---	2.83E-08	3.29E-07	1.18E-12	1.75E-08	---	---
Po-213	---	---	---	---	1.01E-17	1.18E-16	4.23E-22	6.25E-18	---	---
C-14	---	---	---	---	3.59E-01	3.73E-02	---	4.48E-08	---	---
Po-210	---	---	---	---	1.17E-09	5.98E-06	1.99E-06	6.22E-05	---	1.15E-13
Pb-210	---	---	---	---	6.93E-08	3.53E-04	1.17E-04	3.67E-03	---	6.80E-12
Eu-152	---	---	---	---	4.15E-09	9.20E-04	---	2.37E-06	7.53E-09	---
Cm-243	---	---	---	---	2.94E-04	---	---	2.14E-02	---	---
Eu-154	---	---	---	---	2.36E-07	2.44E-03	---	9.28E-05	1.99E-09	---

[a] Dashed line indicates that the radionuclide was not present or that information was not reported.

Table A-25
Radionuclide Inventories (grams) for Stored CH-TRU Waste in 1995 — Continued [a]

Isotope	U of MO	NTS	ORNL	PGDP	RFETS	RFETS Residues	SRS	Grand Total
Pu-238	---	1.84E+03	2.04E+02	---	2.00E+01	4.75E+02	3.23E+04	4.97E+04
Pu-241	6.13E-05	2.32E+00	4.65E+02	---	5.07E+02	9.85E+03	1.09E+03	1.38E+04
Pu-239	3.96E-01	4.44E+04	4.38E+04	8.95E+02	1.60E+05	2.79E+06	1.50E+05	5.53E+06
Am-241	9.42E-02	8.27E+01	4.70E+02	---	3.19E+03	3.16E+04	5.84E+02	6.69E+04
Pu-240	---	1.17E+02	4.15E+03	---	3.17E+04	1.74E+05	1.01E+04	2.91E+05
Cs-137	---	4.14E-03	1.53E-02	---	---	---	8.63E-02	9.20E+00
Ba-137m	---	6.33E-10	2.33E-09	---	---	---	1.32E-08	1.41E-06
Cm-244	---	2.82E+00	1.31E+01	---	---	---	1.44E+01	4.00E+01
Y-90	---	5.69E-07	2.71E-03	---	---	---	1.28E-05	4.08E-03
Sr-90	---	2.27E-03	1.08E+01	---	---	---	5.11E-02	1.63E+01
U-233	1.85E-07	1.88E+02	1.83E+04	1.47E-01	1.34E+03	---	3.89E+02	1.26E+05
Pu-242	---	2.21E+01	6.03E+01	---	2.45E-02	---	9.55E+01	1.24E+05
U-234	4.78E-11	2.01E+00	2.51E+03	---	7.71E-01	---	4.10E+03	1.72E+04
Pa-233	1.10E-08	2.78E-07	3.52E-05	2.65E-03	8.21E-07	---	4.14E-04	3.15E-03
Np-237	3.23E-01	8.19E+00	1.03E+03	7.79E+04	2.42E+01	---	1.22E+04	9.28E+04
Co-60	---	---	1.87E-09	---	---	---	3.61E-04	6.38E-02
Eu-155	---	8.16E-06	---	---	---	---	1.13E-01	1.15E-01
Cf-252	---	3.17E-05	2.98E-04	---	---	---	6.73E-04	6.65E-02
Pb-212	---	1.18E-08	2.03E-07	---	---	---	6.59E-09	1.90E-05
Ra-224	---	1.07E-07	1.77E-06	---	---	---	5.74E-08	1.66E-04
Bi-212	---	1.12E-09	1.93E-08	---	---	---	6.28E-10	1.81E-06
Po-216	---	2.71E-17	4.69E-16	---	---	---	1.52E-17	4.39E-14
Rn-220	---	1.78E-11	3.07E-10	---	---	---	9.97E-12	2.88E-08
Th-228	---	2.00E-05	3.45E-04	---	---	---	1.12E-05	3.24E-02
U-232	---	7.68E-04	1.35E-02	---	---	---	4.17E-03	1.20E+00
Np-239	---	5.26E-06	6.39E-05	---	---	---	3.25E-06	9.16E-05
Am-243	---	6.13E+00	5.83E+01	---	---	---	3.79E+00	9.06E+01
Tc-99	---	3.53E-03	1.05E+03	---	---	---	2.65E-04	1.05E+03
Po-212	---	3.47E-17	5.99E-16	---	---	---	1.94E-17	5.62E-14
Cm-245	---	5.49E-05	1.95E-04	---	---	---	---	9.77E+01
Tl-208	---	2.02E-11	3.49E-10	---	---	---	1.13E-11	3.27E-08
U-237	1.90E-12	7.19E-08	1.44E-05	---	1.57E-05	---	1.86E-05	1.06E-04
Ra-226	---	2.52E-01	6.61E+00	---	---	---	7.38E-06	7.86E+00
Po-218	---	8.82E-10	2.29E-08	---	---	---	2.58E-14	2.73E-08
Rn-222	---	1.62E-06	4.21E-05	---	---	---	4.74E-11	5.01E-05
Bi-214	---	5.62E-09	1.46E-07	---	---	---	1.64E-13	1.74E-07
Pb-214	---	7.60E-09	1.98E-07	---	---	---	2.22E-13	2.35E-07
Po-214	---	7.75E-16	2.02E-14	---	---	---	2.27E-20	2.40E-14
Ag-109m	---	---	---	---	---	---	---	2.52E-09
Cd-109	---	---	---	---	---	---	---	2.48E-03
Pa-234m	1.69E-16	5.04E-13	6.19E-11	---	---	---	8.30E-12	8.84E-09
Th-234	5.02E-12	1.37E-08	1.84E-06	---	---	---	2.46E-07	2.62E-04
U-238	3.46E-01	4.88E+02	1.27E+05	---	---	---	1.70E+04	1.81E+07
Pm-147	---	1.12E-04	2.08E-05	---	---	---	1.33E-08	5.17E-03
U-235	2.05E-05	5.41E+03	6.16E+03	1.52E-01	2.21E+01	---	2.70E+03	1.08E+06
Th-231	7.04E-14	1.15E-10	2.73E-08	6.18E-13	8.97E-11	---	1.10E-08	4.36E-06
Ac-225	---	4.15E-08	3.57E-06	6.91E-12	---	---	2.25E-10	3.34E-05
Th-229	---	1.13E-02	9.71E-01	1.89E-06	---	---	6.15E-05	9.11E+00
Ra-225	---	6.13E-08	5.27E-06	1.02E-11	---	---	3.33E-10	4.94E-05
At-217	---	1.48E-18	1.27E-16	2.47E-22	---	---	8.05E-21	1.19E-15
Bi-213	---	1.25E-10	1.08E-08	2.09E-14	---	---	6.81E-13	1.01E-07
Fr-221	---	1.36E-11	1.17E-09	2.26E-15	---	---	7.38E-14	1.09E-08
Pb-209	---	5.21E-10	4.48E-08	8.69E-14	---	---	2.83E-12	4.20E-07
Po-213	---	1.87E-19	1.60E-17	3.11E-23	---	---	1.01E-21	1.50E-16
C-14	---	5.60E-05	---	---	---	---	---	3.96E-01
Bi-210	---	5.39E-07	1.02E-05	---	---	---	8.93E-12	1.33E-05
Po-210	---	1.48E-05	2.80E-04	---	---	---	2.46E-10	3.65E-04
Pb-210	---	8.76E-04	1.66E-02	---	---	---	1.45E-08	2.16E-02
Eu-152	---	6.00E-03	3.50E-06	---	---	---	---	6.92E-03
Cm-243	---	---	---	---	---	---	---	2.17E-02
Eu-154	---	1.62E-03	---	---	---	---	1.08E-06	4.15E-03

[a] Dashed line indicates that the radionuclide was not present or that information was not reported

Table A-26
Radionuclide Inventories (curies) for Stored RH-TRU Waste in 1995 [a]

Isotope	ETEC	Hanford	INEEL	Knolls	LANL	ORNL	WVDP	Total
Y-90	2.62E+00	6.46E+03	1.70E+03	5.70E+01	1.24E+02	3.52E+04	1.96E+01	4.36E+04
Sr-90	2.62E+00	6.46E+03	1.70E+03	5.70E+01	1.24E+02	3.52E+04	1.96E+01	4.36E+04
Cs-137	2.62E+00	6.98E+03	1.90E+03	5.71E+01	1.35E+02	9.78E+03	5.35E+01	1.89E+04
Ba-137m	2.48E+00	6.61E+03	1.80E+03	5.40E+01	1.28E+02	9.25E+03	5.06E+01	1.79E+04
Pu-241	---	4.67E+03	4.81E+01	7.77E-01	---	3.97E-07	---	4.72E+03
Eu-152	---	---	1.14E-01	---	5.09E-04	3.66E+03	---	3.66E+03
Eu-154	---	---	7.90E-01	1.40E+00	3.50E-02	1.77E+03	---	1.78E+03
Cm-244	---	---	9.63E-02	---	---	9.44E+02	---	1.10E+03
Co-60	2.30E+00	3.36E+02	1.30E+01	2.75E-01	4.17E+00	6.14E+02	---	9.70E+02
Pu-239	4.00E-01	3.35E+02	2.98E+01	3.30E-03	9.28E+01	9.85E+01	---	5.59E+02
Am-241	5.85E-02	1.93E+02	4.68E+01	5.07E-02	---	2.42E+02	5.39E-01	4.83E+02
Eu-155	---	---	3.35E-01	1.81E-01	1.77E+00	3.51E+02	---	3.53E+02
Pu-240	---	1.67E+02	2.48E+01	3.10E-03	---	1.07E+00	---	1.93E+02
Th-231	4.73E-10	1.46E-01	6.42E-03	---	8.78E-03	1.86E+02	---	1.86E+02
U-235	4.73E-10	1.46E-01	5.38E-03	---	8.78E-03	1.86E+02	---	1.86E+02
Pu-238	---	4.67E+01	6.09E+01	9.27E-01	3.90E+00	2.81E+01	1.98E+01	1.69E+02
Cm-243	---	---	1.45E-02	---	---	1.48E+02	---	1.48E+02
Cs-134	---	---	5.38E+01	4.73E+00	2.42E-02	9.57E+00	---	6.81E+01
U-233	---	4.15E-01	3.91E-01	---	---	5.73E+01	---	5.81E+01
Pm-147	---	---	1.49E+01	4.34E+00	1.13E+01	---	---	3.34E+01
Rh-106	---	---	6.65E-02	4.98E-01	3.38E-01	3.21E+01	---	3.30E+01
Ru-106	---	---	6.65E-02	4.98E-01	3.38E-01	3.21E+01	---	3.30E+01
Pr-144	---	---	3.93E+00	1.54E+00	1.58E-02	1.51E+01	---	2.05E+01
Ce-144	---	---	3.98E+00	1.56E+00	1.60E-02	1.20E+01	---	1.75E+01
C-14	---	---	4.00E-02	---	---	6.11E+00	---	6.15E+00
Kr-85	---	---	5.95E+00	---	---	---	---	5.95E+00
Sb-125	---	---	9.81E-01	5.33E-01	2.79E+00	---	---	4.30E+00
Cf-252	---	---	---	---	---	3.86E+00	---	3.86E+00
Ni-63	---	---	3.50E+00	---	---	---	---	3.50E+00
U-238	---	1.03E-02	3.57E-03	---	2.00E-05	3.37E+00	---	3.38E+00
Pa-234m	---	1.03E-02	1.38E-03	---	2.00E-05	3.37E+00	---	3.38E+00
Th-234	---	1.03E-02	1.38E-03	---	2.00E-05	3.37E+00	---	3.38E+00
U-232	---	---	---	---	---	1.76E+00	---	1.76E+00
Po-216	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.69E+00
Bi-212	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Pb-212	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Ra-224	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Rn-220	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Th-228	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
U-234	---	1.29E+00	1.51E-01	4.98E-06	1.11E-05	2.02E-03	4.94E-04	1.45E+00
Po-212	---	9.54E-04	1.70E-05	---	---	1.07E+00	---	1.07E+00
Te-125m	---	---	2.39E-01	1.30E-01	6.88E-01	---	---	1.06E+00

[a] Dashed line indicates that the radionuclide was not present or that information was not reported.

Rearranging terms, this equation can be written as:

$$I_{Alternative} = I_{1995}\left[1 + \left(\frac{V_{Estimated} - V_{Stored}}{V_{IDB}}\right)\right] \text{ or}$$

$$I_{Alternative} = I_{1995}\, V_{factor} \qquad \text{(Equation A-8)}$$

where

V_{factor} = complex volume variable used to estimate the total site radionuclide inventory for each alternative

Table A-27
Radionuclide Inventories (grams) for Stored RH-TRU Waste in 1995 [a]

Isotope	ETEC	Hanford	INEEL	Knolls	LANL	ORNL	WVDP	Total
Y-90	4.81E-06	1.19E-02	3.11E-03	1.05E-04	2.28E-04	6.47E-02	3.60E-05	8.01E-02
Sr-90	1.92E-02	4.73E+01	1.24E+01	4.17E-01	9.08E-01	2.58E+02	1.43E-01	3.19E+02
Cs-137	3.01E-02	8.02E+01	2.18E+01	6.56E-01	1.55E+00	1.12E+02	6.15E-01	2.17E+02
Ba-137m	4.61E-09	1.23E-05	3.33E-06	1.00E-07	2.38E-07	1.72E-05	9.39E-08	3.32E-05
Pu-241	---	4.53E+01	4.67E-01	7.53E-03	---	3.86E-09	---	4.57E+01
Eu-152	---	---	6.44E-04	---	2.88E-06	2.07E+01	---	2.07E+01
Eu-154	---	---	2.99E-03	5.30E-03	1.32E-04	6.72E+00	---	6.72E+00
Cm-244	---	---	1.19E-03	---	---	1.17E+01	---	1.17E+01
Co-60	2.34E-03	3.42E-01	1.32E-02	2.80E-04	4.24E-03	6.24E-01	---	9.86E-01
Pu-239	6.44E+00	5.39E+03	4.79E+02	5.31E-02	1.49E+03	1.58E+03	---	8.95E+03
Am-241	1.70E-02	5.62E+01	1.36E+01	1.48E-02	---	7.04E+01	1.57E-01	1.40E+02
Eu-155	---	---	7.21E-04	3.89E-04	3.81E-03	7.54E-01	---	7.59E-01
Pu-240	---	7.30E+02	1.09E+02	1.36E-02	---	4.69E+00	---	8.44E+02
Th-231	8.89E-16	2.74E-07	1.21E-08	---	1.65E-08	3.49E-04	---	3.49E-04
U-235	2.19E-04	6.75E+04	2.49E+03	---	4.06E+03	8.59E+07	---	8.60E+07
Pu-238	---	2.73E+00	3.55E+00	5.41E-02	2.28E-01	1.64E+00	1.16E+00	9.36E+00
Cm-243	---	---	2.81E-04	---	---	2.87E+00	---	2.87E+00
Cs-134	---	---	1.68E-02	1.48E-03	7.56E-06	3.00E-03	---	2.13E-02
U-233	---	4.29E+01	4.05E+01	---	---	5.93E+03	---	6.02E+03
Pm-147	---	---	1.60E-02	4.68E-03	1.22E-02	---	---	3.29E-02
Rh-106	---	---	4.87E-09	3.64E-08	2.47E-08	2.35E-06	---	2.42E-06
Ru-106	---	---	1.98E-05	1.49E-04	1.01E-04	9.58E-03	---	9.85E-03
Pr-144	---	---	5.21E-08	2.04E-08	2.10E-10	1.99E-07	---	2.72E-07
Ce-144	---	---	1.25E-03	4.87E-04	5.02E-06	3.75E-03	---	5.49E-03
C-14	---	---	8.96E-03	---	---	1.37E+00	---	1.38E+00
Kr-85	---	---	1.51E-02	---	---	---	---	1.51E-02
Sb-125	---	---	9.50E-04	5.16E-04	2.70E-03	---	---	4.16E-03
Cf-252	---	---	---	---	---	7.17E-03	---	7.17E-03
Ni-63	---	---	5.92E-02	---	---	---	---	5.92E-02
U-238	---	3.05E+04	1.06E+04	---	5.95E+01	1.00E+07	---	1.01E+07
Pa-234m	---	1.49E-11	2.01E-12	---	2.91E-14	4.90E-09	---	4.92E-09
Th-234	---	4.43E-07	5.97E-08	---	8.64E-10	1.45E-04	---	1.46E-04
U-232	---	---	---	---	---	8.24E-02	---	8.24E-02
Po-216	---	2.46E-18	4.38E-20	---	---	2.77E-15	---	2.77E-15
Bi-212	---	1.02E-10	1.81E-12	---	---	1.14E-07	---	1.14E-07
Pb-212	---	1.07E-09	1.90E-11	---	---	1.20E-06	---	1.20E-06
Ra-224	---	9.29E-09	1.65E-10	---	---	1.04E-05	---	1.05E-05
Rn-220	---	1.61E-12	2.87E-14	---	---	1.81E-09	---	1.82E-09
Th-228	---	1.81E-06	3.23E-08	---	---	2.04E-03	---	2.04E-03
U-234	---	2.07E+02	2.42E+01	7.98E-04	1.78E-03	3.23E-01	7.92E-02	2.32E+02
Po-212	---	3.15E-18	5.60E-20	---	---	3.54E-15	---	3.54E-15
Te-125m	---	---	1.33E-05	7.22E-06	3.82E-05	---	---	5.86E-05

[a] Dashed line indicates that the radionuclide was not present or that information was not reported.

CH-TRU waste volume factors (V_{Factor}) are presented in Table A-28. To meet the LWA limit of 168,500 cubic meters (5.95 million cubic feet), radionuclide activity was adjusted by a factor of approximately 1.182 under the Proposed Action. Likewise, CH-TRU waste volume factors for the Proposed Action were adjusted by this factor. Because volume factors are determined according to waste treatment site, and do not depend upon which wastes are included at WIPP, or how wastes are treated prior to disposal, the volume factors among the WM PEIS (DOE 1997b) regionalized options within an alternative are the same. Those sites without radionuclide inventory estimates in IDB were not included in the table.

Table A-29 gives RH-TRU waste volume factors according to site. Here, the Proposed Action radionuclide loading was adjusted down to meet the WIPP regulatory limit of 7,080 cubic meters

Table A-28
Volume Factors Used to Estimate Total CH-TRU Waste Radionuclide Inventories at Each Site [a]

Site	Proposed Action	Action Alternatives 1 and 3	Action Alternative 2 and No Action Alternative 1	No Action Alternative 2
Ames Laboratory - Iowa State University (Ames)	N/A	N/A	N/A	N/A
ARCO Medical Products Company (ARCO)	0.000	2.500	2.500	0.000
Argonne National Laboratory- East (ANL-E)	9.587	8.111	8.111	8.111
Argonne National Laboratory- West (ANL-W)	N/A	N/A	N/A	N/A
Bettis Atomic Power Laboratory (Bettis)	N/A	N/A	N/A	N/A
Energy Technology Engineering Center (ETEC)	1.182	1.000	1.000	1.000
Hanford Site (Hanford)	5.524	9.762	9.782	4.673
Idaho National Engineering and Environmental Laboratory (INEEL)	1.182	3.009	3.026	1.000
Lawrence Berkeley Laboratory (LBL)	0.000	3.262	3.262	0.000
Lawrence Livermore National Laboratory (LLNL)	6.130	5.186	5.186	5.186
Los Alamos National Laboratory (LANL)	2.249	3.158	3.158	1.903
Mound Plant (Mound)	1.182	1.000	1.064	1.000
Nevada Test Site (NTS)	1.205	1.020	1.020	1.020
Oak Ridge National Laboratory (ORNL)	1.493	1.313	1.313	1.263
Paducah Gaseous Diffusion Plant (PGDP) [b]	1.604	1.357	1.357	1.357
Rocky Flats Environmental Technology Site (RFETS) [c]	11.185	9.462	9.462	9.462
Sandia National Laboratories (SNL)	N/A	N/A	N/A	N/A
Savannah River Site (SRS) [d]	2.362	2.528	2.528	1.998
U.S. Army Materiel Command (USAMC)	1.182	1.000	1.000	1.000
University of Missouri Research Reactor (U of MO)	7.599	6.429	6.429	6.429
West Valley Demonstration Project (WVDP)	N/A	N/A	N/A	N/A

[a] Volume factors are used in Equation A-8
[b] PDGP is assumed to be the projected BIR-3 volume
[c] RFETS residue data are not included in the volume factors
[d] IDB volume of 9,200 cubic meters used for SRS

N/A = Not Applicable

Table A-29
Volume Factors Used to Estimate Total RH-TRU Waste Radionuclide Inventories at Each Site [a]

Site	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3	No Action Alternative 1	No Action Alternative 2
ETEC	1.179	1.179	1.179	1.179	1.179	1.179
Hanford	9.779	150.708	150.708	150.708	145.610	150.708
INEEL	1.000	3.009	3.009	3.009	1.000	3.009
Knolls [b]	0.000	6.712	6.712	6.712	0.000	6.712
LANL	2.421	3.677	3.677	3.677	2.421	3.677
ORNL	0.084	1.292	1.292	1.292	1.246	1.292
WVDP	0.000	5.606	5.606	5.606	0.000	5.606

[a] Volume factors are used in Equation A-8
[b] IDB volume for Knolls assumed to be 20 percent of the BIR-3 projected volume

(250,000 cubic feet). As stated previously, volume factors among the WM PEIS regionalized options within an alternative are the same.

A.4.2 Radionuclide Estimates for the Proposed Action

The following sections discuss the radionuclide estimates used for risk analyses of the Proposed Action.

A.4.2.1 CH-TRU Waste

Assuming that the volume of CH-TRU waste disposed of at WIPP would be the maximum allowed under the LWA, the Proposed Action CH-TRU waste radionuclide inventory, summed over all radionuclides, would be approximately 5.8×10^6 Ci. The Proposed Action CH-TRU waste radionuclide inventory for each treatment site is given in Table A-30. Only radionuclides with total inventories of 1 Ci or more were included in the analyses.

When radionuclide inventory data were not available for a site, the average radionuclide concentration taken from the other sites were assigned. RFETS residue data were not included in the determination of the average radionuclide concentrations due to the unique characteristics of the residues.

Plutonium-238 (Pu-238) is a major contributor to the total radionuclide activity, accounting for 32 percent of the total activity. Approximately half of the Pu-238 is generated at SRS. These SEIS-II data are higher than that reported in SEIS-I, where Pu-238 represented only about 1 percent of the total CH-TRU waste activity.

A.4.2.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under the Proposed Action is given in Table A-31. Radionuclides with total inventories of less than 1 Ci were not included in the analysis. The total radionuclide loading for the Proposed Action is 4.3×10^5 Ci, which is less than the LWA imposed limit of 5.1×10^6 Ci.

A.4.3 Radionuclide Estimates for Action Alternative 1

The following sections describe the radionuclide estimates for the risk analyses conducted for Action Alternative 1.

A.4.3.1 CH-TRU Waste

CH-TRU waste radionuclide inventory according to treatment site for Action Alternative 1 is given in Table A-32. Radionuclides with total inventories of less than 1 Ci were not included in the analysis.

When radionuclide inventory data were not available for a site, the average radionuclide concentration taken from the other sites were assigned. As previously mentioned, RFETS residue data were excluded when computing the average concentration of CH-TRU waste. The total radionuclide loading for CH-TRU waste under Action Alternative 1 is 7.3×10^6 Ci.

Table A-30
Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for the Proposed Action [a]

Isotope	Hanford	INEEL	LANL	LLNL	MOUND	NTS	ORNL	RFETS	SRS	ANL-E	Total
Pu-238	4.45E+05	8.40E+04	2.58E+05	4.69E+02	5.88E+02	3.79E+04	7.44E+03	1.20E+04	1.31E+06	2.02E+01	2.151E+06
Pu-241	2.09E+05	1.84E+05	3.76E+03	1.00E+04	0.00E+00	2.96E+02	7.26E+04	1.60E+06	2.64E+05	5.21E+02	2.344E+06
Pu-239	1.45E+05	5.01E+04	1.78E+05	1.01E+03	7.42E+00	3.33E+03	4.63E+03	2.85E+05	2.21E+04	3.14E+02	6.897E+05
Am-241	2.61E+04	1.08E+05	2.63E+04	8.81E+02	0.00E+00	3.43E+02	2.73E+03	2.31E+05	4.74E+03	5.65E+01	4.008E+05
Pu-240	3.39E+04	1.21E+04	2.35E+02	3.95E+02	0.00E+00	3.28E+01	1.48E+03	1.21E+05	5.45E+03	9.03E+01	1.742E+05
Cs-137	3.77E+03	8.40E+01	1.08E+02	1.02E-05	0.00E+00	4.34E-01	4.09E+00	0.00E+00	1.77E+01	0.00E+00	3.988E+03
Ba-137m	3.57E+03	7.95E+01	1.03E+02	9.64E-06	0.00E+00	4.11E-01	3.87E+00	0.00E+00	1.68E+01	0.00E+00	3.772E+03
Cm-244	3.77E+02	6.33E+02	3.53E+02	4.01E+02	0.00E+00	2.75E+02	1.59E+03	0.00E+00	2.76E+03	0.00E+00	6.390E+03
Y-90	3.82E+03	3.75E+01	1.01E+02	0.00E+00	0.00E+00	6.10E-01	2.21E+03	0.00E+00	1.65E+01	0.00E+00	6.189E+03
Sr-90	3.82E+03	3.75E+01	1.01E+02	0.00E+00	0.00E+00	6.10E-01	2.21E+03	0.00E+00	1.65E+01	0.00E+00	6.187E+03
U-233	4.42E+02	1.08E+03	1.01E+02	3.65E-08	0.00E+00	2.18E+00	2.67E+02	1.45E+02	8.86E+00	2.88E-01	2.048E+03
Pu-242	2.10E+00	8.83E+00	1.09E+03	1.24E-01	0.00E+00	1.05E-01	1.64E+00	1.08E-03	8.86E-01	9.59E-02	1.105E+03
U-234	2.97E+02	9.00E+00	1.37E+01	2.02E-02	2.92E-02	1.51E-02	2.37E+01	5.38E-02	6.04E+01	0.00E+00	4.037E+02
Pa-233	1.50E+00	2.04E+00	8.97E-02	2.89E-03	0.00E+00	6.97E-03	8.95E+01	1.91E-01	2.03E+01	0.00E+00	1.136E+02
Np-237	1.50E+00	2.04E+00	8.97E-02	2.89E-03	0.00E+00	6.97E-03	8.95E+01	1.91E-01	2.03E+01	0.00E+00	1.136E+02
Co-60	0.00E+00	7.48E+01	1.65E-02	0.00E+00	0.00E+00	0.00E+00	1.65E-01	0.00E+00	8.40E-01	0.00E+00	7.580E+01
Eu-155	5.83E-03	1.30E+00	5.56E-01	0.00E+00	0.00E+00	4.58E-03	1.41E-01	0.00E+00	1.25E+02	0.00E+00	1.267E+02
Cf-252	1.95E+02	5.69E-01	9.42E-03	0.00E+00	0.00E+00	2.05E-02	3.33E-01	0.00E+00	8.55E-01	0.00E+00	1.965E+02
Pb-212	2.86E-01	3.14E+01	2.08E-02	0.00E+00	0.00E+00	1.98E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.225E+01
Ra-224	2.86E-01	3.14E+01	9.97E-03	0.00E+00	0.00E+00	2.07E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.224E+01
Bi-212	2.86E-01	3.14E+01	9.97E-03	0.00E+00	0.00E+00	1.98E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.224E+01
Po-216	2.86E-01	3.14E+01	9.97E-03	0.00E+00	0.00E+00	1.98E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.224E+01
Rn-220	2.86E-01	3.14E+01	9.97E-03	0.00E+00	0.00E+00	1.98E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.224E+01
Th-228	2.86E-01	3.14E+01	9.97E-03	0.00E+00	0.00E+00	1.98E-02	4.93E-01	0.00E+00	2.17E-02	0.00E+00	3.224E+01
U-232	0.00E+00	3.03E+01	1.05E-02	0.00E+00	0.00E+00	1.98E-02	5.01E-01	0.00E+00	2.11E-01	0.00E+00	3.108E+01
Np-239	4.98E-01	7.86E-01	8.61E+00	1.50E-01	0.00E+00	1.47E+00	2.23E+01	0.00E+00	1.78E+00	9.12E-01	3.648E+01
Am-243	4.98E-01	7.35E-01	8.61E+00	1.50E-01	0.00E+00	1.47E+00	1.74E+01	0.00E+00	1.78E+00	9.12E-01	3.158E+01
Tc-99	5.26E-05	2.85E-01	2.77E-02	0.00E+00	0.00E+00	7.22E-05	2.66E+01	0.00E+00	1.06E-05	0.00E+00	2.695E+01
Po-212	1.84E-01	2.01E+01	6.39E-03	0.00E+00	0.00E+00	1.27E-02	3.16E-01	0.00E+00	1.39E-02	0.00E+00	2.066E+01
Cm-245	9.27E+01	2.66E-01	4.42E-03	0.00E+00	0.00E+00	1.14E-05	4.42E-02	0.00E+00	0.00E+00	0.00E+00	9.301E+01
Tl-208	1.03E-01	1.13E+01	3.58E-03	0.00E+00	0.00E+00	7.10E-03	1.77E-01	0.00E+00	7.81E-03	0.00E+00	1.158E+01
U-237	5.12E+00	4.48E+00	9.18E-02	2.45E-01	0.00E+00	7.26E-03	1.78E+00	1.43E+01	3.59E+00	0.00E+00	2.965E+01
Ra-226	1.74E-04	1.80E-01	2.04E+00	2.45E-07	5.28E-09	3.01E-01	9.78E+00	0.00E+00	1.72E-05	0.00E+00	1.230E+01
Po-218	1.74E-04	1.79E-01	2.04E+00	0.00E+00	5.28E-09	3.01E-01	9.71E+00	0.00E+00	1.72E-05	0.00E+00	1.223E+01
Rn-222	1.74E-04	1.79E-01	2.04E+00	0.00E+00	5.28E-09	3.01E-01	9.71E+00	0.00E+00	1.72E-05	0.00E+00	1.223E+01
Bi-214	1.74E-04	1.79E-01	2.04E+00	0.00E+00	5.28E-09	3.01E-01	9.71E+00	0.00E+00	1.72E-05	0.00E+00	1.222E+01
Pb-214	1.74E-04	1.79E-01	2.04E+00	0.00E+00	5.28E-09	3.01E-01	9.71E+00	0.00E+00	1.72E-05	0.00E+00	1.222E+01
Po-214	1.74E-04	1.79E-01	2.04E+00	0.00E+00	5.28E-09	3.01E-01	9.71E+00	0.00E+00	1.72E-05	0.00E+00	1.222E+01
Ag-109m	0.00E+00	1.04E-01	1.47E+01	0.00E+00	0.00E+00	0.00E+00	1.72E-02	0.00E+00	0.00E+00	0.00E+00	1.487E+01
Cd-109	0.00E+00	1.04E-01	1.47E+01	0.00E+00	0.00E+00	0.00E+00	1.72E-02	0.00E+00	0.00E+00	0.00E+00	1.486E+01
Pa-234m	3.24E+01	2.33E-01	5.51E-02	1.86E-01	0.00E+00	4.17E-04	7.95E-02	0.00E+00	1.35E-02	0.00E+00	3.293E+01
Th-234	3.24E+01	2.33E-01	5.47E-02	1.86E-01	0.00E+00	3.84E-04	7.95E-02	0.00E+00	1.35E-02	0.00E+00	3.293E+01
U-238	3.24E+01	2.33E-01	5.47E-02	1.86E-01	0.00E+00	1.98E-04	7.95E-02	0.00E+00	1.35E-02	0.00E+00	3.293E+01
Pm-147	2.64E-01	3.18E+00	4.51E+00	0.00E+00	0.00E+00	1.26E-01	4.15E-02	0.00E+00	2.92E-05	0.00E+00	8.118E+00
U-235	9.44E+00	1.10E-01	1.19E+00	3.63E-03	1.24E-07	1.41E-02	2.60E-02	5.35E-04	1.38E-02	0.00E+00	1.080E+01
Th-231	9.44E+00	1.10E-01	1.19E+00	1.08E-02	1.24E-07	7.41E-05	2.78E-02	5.35E-04	1.38E-02	0.00E+00	1.079E+01
Ac-225	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.047E+00
Th-229	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
Ra-225	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
At-217	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
Bi-213	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
Fr-221	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
Pb-209	7.22E-01	1.83E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.14E-01	0.00E+00	3.09E-05	0.00E+00	3.046E+00
Po-213	7.06E-01	1.79E+00	1.78E-01	0.00E+00	0.00E+00	2.84E-03	3.07E-01	0.00E+00	3.03E-05	0.00E+00	2.980E+00
C-14	8.83E+00	2.25E-01	4.65E-04	0.00E+00	0.00E+00	3.01E-04	4.64E-03	0.00E+00	0.00E+00	0.00E+00	9.063E+00
Bi-210	2.93E-05	5.80E-02	6.31E-01	0.00E+00	6.14E-10	8.06E-02	1.89E+00	0.00E+00	2.62E-06	0.00E+00	2.662E+00
Po-210	2.93E-05	5.80E-02	6.31E-01	0.00E+00	6.14E-10	8.06E-02	1.89E+00	0.00E+00	2.62E-06	0.00E+00	2.662E+00
Pb-210	2.93E-05	5.80E-02	6.31E-01	0.00E+00	6.14E-10	8.06E-02	1.89E+00	0.00E+00	2.62E-06	0.00E+00	2.662E+00
Eu-152	4.05E-06	2.11E-01	1.26E-03	8.15E-06	0.00E+00	1.28E+00	4.14E-03	0.00E+00	0.00E+00	0.00E+00	1.493E+00
Cm-243	8.40E-02	1.78E-02	2.49E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-03	0.00E+00	0.00E+00	0.00E+00	2.594E+00
Eu-154	3.44E-04	7.78E-01	5.54E-02	3.22E-06	0.00E+00	5.16E-01	2.88E-03	0.00E+00	6.71E-04	0.00E+00	1.353E+00

[a] This table lists only radionuclides with activities of 1 curie or more. Information about radionuclides with lower activities is contained in Table 4-6 of the Compliance Certification Application (DOE 1996f).

Table A-31
Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for the Proposed Action [a]

Isotope	Hanford	INEEL	LANL	ORNL	Total
Y-90	6.32E+04	2.45E+04	3.01E+02	1.07E+04	9.88E+04
Sr-90	6.32E+04	2.45E+04	3.00E+02	1.07E+04	9.87E+04
Cs-137	6.83E+04	1.18E+04	3.27E+02	4.19E+03	8.46E+04
Ba-137m	6.46E+04	1.12E+04	3.10E+02	3.96E+03	8.00E+04
Pu-241	4.56E+04	2.52E+03	0.00E+00	8.40E+02	4.90E+04
Eu-152	0.00E+00	1.92E+03	1.23E-03	9.59E+02	2.88E+03
Eu-154	0.00E+00	9.31E+02	8.47E-02	4.64E+02	1.40E+03
Cm-244	0.00E+00	5.79E+02	0.00E+00	2.76E+02	8.55E+02
Co-60	3.29E+03	5.22E+02	1.01E+01	2.24E+02	4.05E+03
Pu-239	3.28E+03	3.23E+02	2.25E+02	1.08E+02	3.93E+03
Am-241	1.89E+03	3.00E+02	0.00E+00	1.06E+02	2.30E+03
Eu-155	0.00E+00	1.85E+02	4.29E+00	9.22E+01	2.82E+02
Pu-240	1.63E+03	1.26E+02	0.00E+00	3.44E+01	1.79E+03
Th-231	1.43E+00	9.74E+01	2.13E-02	4.86E+01	1.48E+02
U-235	1.43E+00	9.74E+01	2.13E-02	4.86E+01	1.48E+02
Pu-238	4.57E+02	1.50E+02	9.44E+00	3.25E+01	6.48E+02
Cm-243	0.00E+00	7.77E+01	0.00E+00	3.88E+01	1.17E+02
Cs-134	0.00E+00	8.95E+01	5.85E-02	1.29E+01	1.02E+02
U-233	4.06E+00	3.08E+01	0.00E+00	1.51E+01	5.00E+01
Pm-147	0.00E+00	3.24E+01	2.73E+01	5.95E+00	6.57E+01
Rh-106	0.00E+00	1.74E+01	8.18E-01	8.56E+00	2.67E+01
Ru-106	0.00E+00	1.74E+01	8.18E-01	8.56E+00	2.67E+01
Pr-144	0.00E+00	1.47E+01	3.84E-02	4.92E+00	1.97E+01
Ce-144	0.00E+00	1.32E+01	3.88E-02	4.13E+00	1.73E+01
C-14	0.00E+00	3.26E+00	0.00E+00	1.61E+00	4.87E+00
Kr-85	0.00E+00	9.07E+00	0.00E+00	1.06E+00	1.01E+01
Sb-125	0.00E+00	3.24E+00	6.75E+00	7.66E-01	1.08E+01
Cf-252	0.00E+00	2.02E+00	0.00E+00	1.01E+00	3.03E+00
Ni-63	0.00E+00	5.34E+00	0.00E+00	6.23E-01	5.96E+00
U-238	1.00E-01	1.78E+00	4.84E-05	8.84E-01	2.76E+00
Pa-234m	1.00E-01	1.77E+00	4.84E-05	8.84E-01	2.76E+00
Th-234	1.00E-01	1.77E+00	4.84E-05	8.84E-01	2.76E+00
U-232	0.00E+00	9.25E-01	0.00E+00	4.62E-01	1.39E+00
Po-216	1.46E-02	8.84E-01	0.00E+00	4.40E-01	1.34E+00
Bi-212	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Pb-212	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Ra-224	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Rn-220	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Th-228	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
U-234	1.26E+01	9.08E-01	2.69E-05	2.57E-01	1.38E+01
Po-212	9.33E-03	5.63E-01	0.00E+00	2.81E-01	8.53E-01
Te-125m	0.00E+00	7.94E-01	1.67E+00	1.88E-01	2.65E+00

[a] This table lists only radionuclides with activities of 1 curie or more. Information about radionuclides with lower activities is contained in Table 4-6 of the Compliance Certification Application (DOE 1996f).

Table A-32
Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 1

Isotope	Hanford	INEEL	LANL	LLNL	MOUND	NTS	ORNL	RFETS	SRS	ANL-E	Total
Pu-238	7.86E+05	1.93E+05	3.62E+05	3.97E+02	3.06E+03	3.21E+04	7.74E+03	1.14E+04	1.40E+06	1.71E+01	2.79E+06
Pu-241	3.69E+05	4.58E+05	5.24E+03	8.46E+03	1.22E+03	2.50E+02	6.40E+04	1.51E+06	2.83E+05	4.40E+02	2.70E+06
Pu-239	2.57E+05	1.23E+05	2.50E+05	8.52E+02	5.24E+02	2.82E+03	4.12E+03	2.68E+05	2.36E+04	2.66E+02	9.30E+05
Am-241	4.62E+04	2.73E+05	3.69E+04	7.46E+02	3.69E+02	2.90E+02	2.44E+03	2.12E+05	5.07E+03	4.78E+01	5.77E+05
Pu-240	6.00E+04	3.00E+04	3.28E+02	3.34E+02	8.09E+01	2.78E+01	1.31E+03	1.08E+05	5.84E+03	7.64E+01	2.06E+05
Cs-137	6.67E+03	1.94E+02	1.52E+02	8.62E-06	2.43E+00	3.67E-01	3.85E+00	0.00E+00	1.90E+01	0.00E+00	7.04E+03
Ba-137m	6.31E+03	1.84E+02	1.44E+02	8.16E-06	2.30E+00	3.47E-01	3.64E+00	0.00E+00	1.80E+01	0.00E+00	6.66E+03
Cm-244	6.67E+02	1.53E+03	4.95E+02	3.39E+02	9.83E+00	2.33E+02	1.40E+03	0.00E+00	2.95E+03	0.00E+00	7.63E+03
Y-90	6.76E+03	4.11E+01	1.41E+02	0.00E+00	6.74E+00	5.16E-01	1.94E+03	0.00E+00	1.77E+01	0.00E+00	8.91E+03
Sr-90	6.76E+03	4.11E+01	1.41E+02	0.00E+00	6.74E+00	5.16E-01	1.94E+03	0.00E+00	1.76E+01	0.00E+00	8.91E+03
U-233	7.81E+02	2.72E+03	1.41E+02	3.08E-08	3.70E+00	1.85E+00	2.36E+02	1.23E+02	9.49E+00	2.43E-01	4.02E+03
Pu-242	3.74E+00	1.06E+01	1.53E+03	1.05E-01	1.48E+00	8.88E-02	1.59E+00	9.11E-04	9.49E-01	8.11E-02	1.55E+03
U-234	5.25E+02	2.03E+01	1.92E+01	1.70E-02	3.50E-01	1.28E-02	2.08E+01	4.55E-02	6.47E+01	0.00E+00	6.50E+02
Pa-233	2.65E+00	3.60E+00	1.20E-01	2.44E-03	1.99E-01	5.89E-03	7.58E+01	1.61E-01	2.17E+01	0.00E+00	1.04E+02
Np-237	2.65E+00	3.60E+00	1.20E-01	2.44E-03	1.99E-01	5.89E-03	7.57E+01	1.61E-01	2.17E+01	0.00E+00	1.04E+02
Co-60	0.00E+00	1.89E+02	1.79E-02	0.00E+00	1.91E-01	0.00E+00	1.65E-01	0.00E+00	8.99E-01	0.00E+00	1.90E+02
Eu-155	1.03E-02	2.00E+00	7.76E-01	0.00E+00	1.62E-01	3.87E-03	1.41E-01	0.00E+00	1.33E+02	0.00E+00	1.37E+02
Cf-252	3.44E+02	5.73E-01	1.02E-02	0.00E+00	1.09E-01	1.74E-02	3.04E-01	0.00E+00	9.15E-01	0.00E+00	3.46E+02
Pb-212	5.06E-01	7.93E+01	2.70E-02	0.00E+00	8.07E-02	1.67E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
Ra-224	5.06E-01	7.93E+01	1.17E-02	0.00E+00	8.07E-02	1.75E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
Bi-212	5.06E-01	7.93E+01	1.17E-02	0.00E+00	8.07E-02	1.67E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
Po-216	5.06E-01	7.93E+01	1.17E-02	0.00E+00	8.07E-02	1.67E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
Rn-220	5.06E-01	7.93E+01	1.17E-02	0.00E+00	8.07E-02	1.67E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
Th-228	5.06E-01	7.93E+01	1.17E-02	0.00E+00	8.07E-02	1.67E-02	4.42E-01	0.00E+00	2.33E-02	0.00E+00	8.04E+01
U-232	0.00E+00	7.66E+01	1.26E-02	0.00E+00	7.81E-02	1.68E-02	4.49E-01	0.00E+00	2.26E-01	0.00E+00	7.74E+01
Np-239	1.01E+00	1.48E+00	1.21E+01	1.27E-01	6.47E-02	1.25E+00	1.96E+01	0.00E+00	1.91E+00	7.72E-01	3.83E+01
Am-243	1.01E+00	1.43E+00	1.21E+01	1.27E-01	5.48E-02	1.25E+00	1.53E+01	0.00E+00	1.91E+00	7.72E-01	3.40E+01
Tc-99	9.29E-05	2.89E-01	3.74E-02	0.00E+00	5.41E-02	6.11E-05	2.34E+01	0.00E+00	1.14E-05	0.00E+00	2.38E+01
Po-212	3.24E-01	5.08E+01	7.52E-03	0.00E+00	5.17E-02	1.07E-02	2.83E-01	0.00E+00	1.49E-02	0.00E+00	5.15E+01
Cm-245	1.64E+02	2.66E-01	4.77E-03	0.00E+00	5.09E-02	9.62E-06	4.42E-02	0.00E+00	0.00E+00	0.00E+00	1.64E+02
Tl-208	1.82E-01	2.85E+01	4.22E-03	0.00E+00	2.90E-02	6.01E-03	1.59E-01	0.00E+00	8.36E-03	0.00E+00	2.89E+01
U-237	9.04E+00	1.12E+01	1.28E-01	2.07E-01	2.63E-02	6.14E-03	1.57E+00	1.21E+01	3.84E+00	0.00E+00	3.81E+01
Ra-226	1.10E-01	2.68E-01	2.86E+00	2.07E-07	2.36E-02	2.54E-01	8.61E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Po-218	1.10E-01	2.67E-01	2.86E+00	0.00E+00	2.35E-02	2.54E-01	8.54E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Rn-222	1.10E-01	2.67E-01	2.86E+00	0.00E+00	2.35E-02	2.54E-01	8.54E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Bi-214	1.10E-01	2.67E-01	2.86E+00	0.00E+00	2.34E-02	2.54E-01	8.54E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Pb-214	1.10E-01	2.67E-01	2.86E+00	0.00E+00	2.34E-02	2.54E-01	8.54E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Po-214	1.10E-01	2.67E-01	2.86E+00	0.00E+00	2.34E-02	2.54E-01	8.54E+00	0.00E+00	1.84E-05	0.00E+00	1.21E+01
Ag-109m	0.00E+00	1.04E-01	2.07E+01	0.00E+00	1.99E-02	0.00E+00	1.72E-02	0.00E+00	0.00E+00	0.00E+00	2.08E+01
Cd-109	0.00E+00	1.04E-01	2.07E+01	0.00E+00	1.99E-02	0.00E+00	1.72E-02	0.00E+00	0.00E+00	0.00E+00	2.08E+01
Pa-234m	5.72E+01	4.45E-01	7.69E-02	1.57E-01	1.84E-02	3.53E-04	7.19E-02	0.00E+00	1.44E-02	0.00E+00	5.80E+01
Th-234	5.72E+01	4.45E-01	7.63E-02	1.57E-01	1.84E-02	3.24E-04	7.19E-02	0.00E+00	1.44E-02	0.00E+00	5.80E+01
U-238	5.72E+01	4.45E-01	7.63E-02	1.57E-01	1.84E-02	1.67E-04	7.19E-02	0.00E+00	1.44E-02	0.00E+00	5.80E+01
Pm-147	4.66E-01	7.97E+00	6.33E+00	0.00E+00	1.46E-02	1.07E-01	3.80E-02	0.00E+00	3.12E-05	0.00E+00	1.49E+01
U-235	1.67E+01	2.23E-01	1.66E+00	3.08E-03	7.07E-03	1.19E-02	2.36E-02	4.52E-04	1.48E-02	0.00E+00	1.86E+01
Th-231	1.67E+01	2.23E-01	1.66E+00	9.15E-03	7.04E-03	6.27E-05	2.52E-02	4.52E-04	1.48E-02	0.00E+00	1.86E+01
Ac-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Th-229	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Ra-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
At-217	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Bi-213	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Fr-221	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Pb-209	1.28E+00	4.60E+00	2.55E-01	0.00E+00	5.89E-03	2.46E-03	2.77E-01	0.00E+00	3.31E-05	0.00E+00	6.42E+00
Po-213	1.25E+00	4.50E+00	2.50E-01	0.00E+00	5.76E-03	2.40E-03	2.71E-01	0.00E+00	3.24E-05	0.00E+00	6.28E+00
C-14	1.56E+01	5.29E-01	5.02E-04	0.00E+00	5.36E-03	2.55E-04	4.64E-03	0.00E+00	0.00E+00	0.00E+00	1.61E+01
Bi-210	2.93E-02	1.07E-01	8.86E-01	0.00E+00	5.00E-03	6.82E-02	1.66E+00	0.00E+00	2.80E-06	0.00E+00	2.76E+00
Po-210	2.93E-02	1.07E-01	8.86E-01	0.00E+00	5.00E-03	6.82E-02	1.66E+00	0.00E+00	2.80E-06	0.00E+00	2.76E+00
Pb-210	2.93E-02	1.07E-01	8.86E-01	0.00E+00	5.00E-03	6.82E-02	1.66E+00	0.00E+00	2.80E-06	0.00E+00	2.76E+00
Eu-152	7.16E-06	5.08E-01	1.67E-03	6.90E-06	3.71E-03	1.08E+00	4.03E-03	0.00E+00	0.00E+00	0.00E+00	1.60E+00
Cm-243	1.48E-01	1.78E-02	3.50E+00	0.00E+00	3.41E-03	0.00E+00	2.95E-03	0.00E+00	0.00E+00	0.00E+00	3.67E+00
Eu-154	6.07E-04	1.95E+00	7.77E-02	2.72E-06	3.33E-03	4.37E-01	2.88E-03	0.00E+00	7.19E-04	0.00E+00	2.48E+00

A.4.3.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under Action Alternative 1 is given in Table A-33. Radionuclides with total inventories of less than 1 Ci were not included in the analysis. The total radionuclide loading for RH-TRU waste under Action Alternative 1 is 5.1×10^6 Ci.

A.4.4 Radionuclide Estimates for Action Alternative 2

The following sections present the radionuclide estimates for the risk analyses of Action Alternative 2.

A.4.4.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory according to treatment site under Action Alternative 2A is given in Table A-34. Treatment based on the Action Alternative 2B is given in Table A-35. Under Action Alternative 2C, all waste is treated at WIPP. The radionuclide inventory values for Action Alternative 2C, therefore, may be obtained from the "Total" column of either Table A-34 or Table A-35. The total radionuclide loading for CH-TRU waste under both Action Alternatives 2A and 2B is 7.3×10^6 Ci.

A.4.4.2 RH-TRU Waste

RH-TRU waste handling would be the same under Action Alternatives 2A, 2B, and 2C. The radionuclide inventories for all are represented in Table A-36. The total radionuclide loading for RH-TRU waste under Action Alternative 2 would be 5.1×10^6 Ci.

A.4.5 Radionuclide Estimates for Action Alternative 3

The following sections discuss radionuclide estimates for risk analyses for Action Alternative 3.

A.4.5.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory according to treatment site under Action Alternative 3 is given in Table A-37. The total radionuclide loading for CH-TRU waste under this alternative would be 7.3×10^6 Ci.

A.4.5.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under Action Alternative 3 is given in Table A-38. The total radionuclide loading for RH-TRU waste under this alternative would be 5.1×10^6 Ci.

A.4.6 Radionuclide Estimates for No Action Alternative 1

The CH-TRU waste radionuclide inventory for the treatment sites for No Action Alternative 1 would be the same as those under Action Alternatives 2A and 2B. The radionuclide information is given in Tables A-34 and A-35, respectively.

Table A-33
Radionuclide Inventories (curies) for RH-TRU Waste by Treatment Site for Action Alternative 1

Isotope	Hanford	INEEL	LANL	ORNL	Total
Y-90	9.74E + 05	2.80E + 04	4.56E + 02	5.38E + 04	1.06E + 06
Sr-90	9.74E + 05	2.80E + 04	4.56E + 02	5.38E + 04	1.06E + 06
Cs-137	1.05E + 06	1.56E + 04	4.97E + 02	1.67E + 04	1.09E + 06
Ba-137m	9.96E + 05	1.48E + 04	4.70E + 02	1.58E + 04	1.03E + 06
Pu-241	7.03E + 05	2.62E + 03	0.00E + 00	8.45E + 02	7.07E + 05
Eu-152	0.00E + 00	1.92E + 03	1.87E-03	5.39E + 03	7.31E + 03
Eu-154	0.00E + 00	9.33E + 02	1.29E-01	2.62E + 03	3.55E + 03
Cm-244	0.00E + 00	5.79E + 02	0.00E + 00	1.42E + 03	2.00E + 03
Co-60	5.07E + 04	5.48E + 02	1.53E + 01	9.69E + 02	5.22E + 04
Pu-239	5.05E + 04	3.83E + 02	3.41E + 02	2.27E + 02	5.15E + 04
Am-241	2.91E + 04	3.94E + 02	0.00E + 00	4.02E + 02	2.99E + 04
Eu-155	0.00E + 00	1.86E + 02	6.52E + 00	5.17E + 02	7.10E + 02
Pu-240	2.51E + 04	1.76E + 02	0.00E + 00	3.57E + 01	2.53E + 04
Th-231	2.20E + 01	9.75E + 01	3.23E-02	2.73E + 02	3.93E + 02
U-235	2.20E + 01	9.75E + 01	3.23E-02	2.73E + 02	3.93E + 02
Pu-238	7.04E + 03	2.72E + 02	1.43E + 01	1.84E + 02	7.51E + 03
Cm-243	0.00E + 00	7.77E + 01	0.00E + 00	2.18E + 02	2.96E + 02
Cs-134	0.00E + 00	1.98E + 02	8.89E-02	5.62E + 01	2.54E + 02
U-233	6.25E + 01	3.16E + 01	0.00E + 00	8.44E + 01	1.79E + 02
Pm-147	0.00E + 00	6.24E + 01	4.15E + 01	3.51E + 01	1.39E + 02
Rh-106	0.00E + 00	1.75E + 01	1.24E + 00	5.07E + 01	6.94E + 01
Ru-106	0.00E + 00	1.75E + 01	1.24E + 00	5.07E + 01	6.94E + 01
Pr-144	0.00E + 00	2.26E + 01	5.83E-02	3.34E + 01	5.61E + 01
Ce-144	0.00E + 00	2.12E + 01	5.90E-02	2.91E + 01	5.03E + 01
C-14	0.00E + 00	3.34E + 00	0.00E + 00	8.99E + 00	1.23E + 01
Kr-85	0.00E + 00	2.10E + 01	0.00E + 00	1.06E + 00	2.21E + 01
Sb-125	0.00E + 00	5.21E + 00	1.03E + 01	4.34E + 00	1.98E + 01
Cf-252	0.00E + 00	2.02E + 00	0.00E + 00	5.67E + 00	7.69E + 00
Ni-63	0.00E + 00	1.24E + 01	0.00E + 00	6.23E-01	1.30E + 01
U-238	1.55E + 00	1.78E + 00	7.36E-05	4.96E + 00	8.29E + 00
Pa-234m	1.55E + 00	1.78E + 00	7.36E-05	4.96E + 00	8.28E + 00
Th-234	1.55E + 00	1.78E + 00	7.36E-05	4.96E + 00	8.28E + 00
U-232	0.00E + 00	9.25E-01	0.00E + 00	2.59E + 00	3.52E + 00
Po-216	2.24E-01	8.84E-01	0.00E + 00	2.47E + 00	3.57E + 00
Bi-212	2.24E-01	8.79E-01	0.00E + 00	2.46E + 00	3.57E + 00
Pb-212	2.24E-01	8.79E-01	0.00E + 00	2.46E + 00	3.57E + 00
Ra-224	2.24E-01	8.79E-01	0.00E + 00	2.46E + 00	3.57E + 00
Rn-220	2.24E-01	8.79E-01	0.00E + 00	2.46E + 00	3.57E + 00
Th-228	2.24E-01	8.79E-01	0.00E + 00	2.46E + 00	3.57E + 00
U-234	1.95E + 02	1.21E + 00	4.08E-05	2.63E-01	1.96E + 02
Po-212	1.44E-01	5.63E-01	0.00E + 00	1.58E + 00	2.29E + 00
Te-125m	0.00E + 00	1.27E + 00	2.53E + 00	1.06E + 00	4.87E + 00

Table A-34
Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 2A

Isotope	Hanford	INEEL	LANL	RFETS	SRS	Total
Pu-238	7.88E+05	2.26E+05	3.62E+05	1.14E+04	1.41E+06	2.80E+06
Pu-241	3.78E+05	4.60E+05	5.24E+03	1.51E+06	3.49E+05	2.70E+06
Pu-239	2.58E+05	1.27E+05	2.50E+05	2.68E+05	2.85E+04	9.31E+05
Am-241	4.70E+04	2.75E+05	3.69E+04	2.12E+05	7.93E+03	5.79E+05
Pu-240	6.04E+04	3.02E+04	3.28E+02	1.08E+05	7.31E+03	2.06E+05
Cs-137	6.68E+03	1.96E+02	1.52E+02	0.00E+00	2.53E+01	7.05E+03
Ba-137m	6.32E+03	1.85E+02	1.44E+02	0.00E+00	2.39E+01	6.67E+03
Cm-244	1.01E+03	1.77E+03	4.95E+02	0.00E+00	4.36E+03	7.64E+03
Y-90	6.77E+03	4.17E+01	1.41E+02	0.00E+00	1.97E+03	8.92E+03
Sr-90	6.77E+03	4.16E+01	1.41E+02	0.00E+00	1.97E+03	8.92E+03
U-233	7.82E+02	2.74E+03	1.41E+02	1.23E+02	2.49E+02	4.04E+03
Pu-242	3.86E+00	1.07E+01	1.53E+03	9.11E-04	4.10E+00	1.55E+03
U-234	5.26E+02	2.04E+01	1.92E+01	4.55E-02	8.59E+01	6.51E+02
Pa-233	2.66E+00	3.62E+00	1.20E-01	1.61E-01	9.77E+01	1.04E+02
Np-237	2.66E+00	3.62E+00	1.20E-01	1.61E-01	9.77E+01	1.04E+02
Co-60	0.00E+00	1.90E+02	1.79E-02	0.00E+00	1.25E+00	1.91E+02
Eu-155	1.03E-02	2.01E+00	7.76E-01	0.00E+00	1.34E+02	1.37E+02
Cf-252	3.45E+02	5.91E-01	1.02E-02	0.00E+00	1.33E+00	3.47E+02
Pb-212	5.07E-01	7.98E+01	2.70E-02	0.00E+00	5.46E-01	8.09E+01
Ra-224	5.07E-01	7.98E+01	1.17E-02	0.00E+00	5.46E-01	8.08E+01
Bi-212	5.07E-01	7.98E+01	1.17E-02	0.00E+00	5.46E-01	8.08E+01
Po-216	5.07E-01	7.98E+01	1.17E-02	0.00E+00	5.46E-01	8.08E+01
Rn-220	5.07E-01	7.98E+01	1.17E-02	0.00E+00	5.46E-01	8.08E+01
Th-228	5.07E-01	7.98E+01	1.17E-02	0.00E+00	5.46E-01	8.08E+01
U-232	0.00E+00	7.70E+01	1.26E-02	0.00E+00	7.52E-01	7.78E+01
Np-239	1.13E+00	2.73E+00	1.21E+01	0.00E+00	2.23E+01	3.83E+01
Am-243	1.13E+00	2.68E+00	1.21E+01	0.00E+00	1.81E+01	3.40E+01
Tc-99	9.31E-05	2.89E-01	3.74E-02	0.00E+00	2.35E+01	2.38E+01
Po-212	3.25E-01	5.11E+01	7.52E-03	0.00E+00	3.50E-01	5.18E+01
Cm-245	1.64E+02	2.66E-01	4.77E-03	0.00E+00	9.50E-02	1.65E+02
Tl-208	1.82E-01	2.87E+01	4.22E-03	0.00E+00	1.96E-01	2.90E+01
U-237	9.27E+00	1.13E+01	1.28E-01	1.21E+01	5.44E+00	3.82E+01
Ra-226	1.10E-01	5.23E-01	2.86E+00	0.00E+00	8.63E+00	1.21E+01
Po-218	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.57E+00	1.21E+01
Rn-222	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.57E+00	1.21E+01
Bi-214	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
Pb-214	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
Po-214	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
Ag-109m	0.00E+00	1.04E-01	2.07E+01	0.00E+00	3.71E-02	2.08E+01
Cd-109	0.00E+00	1.04E-01	2.07E+01	0.00E+00	3.71E-02	2.08E+01
Pa-234m	5.75E+01	4.47E-01	7.69E-02	0.00E+00	1.05E-01	5.81E+01
Th-234	5.75E+01	4.47E-01	7.63E-02	0.00E+00	1.05E-01	5.81E+01
U-238	5.75E+01	4.47E-01	7.63E-02	0.00E+00	1.05E-01	5.81E+01
Pm-147	4.67E-01	8.12E+00	6.33E+00	0.00E+00	5.26E-02	1.50E+01
U-235	1.67E+01	2.36E-01	1.66E+00	4.52E-04	4.54E-02	1.87E+01
Th-231	1.67E+01	2.24E-01	1.66E+00	4.52E-04	4.70E-02	1.87E+01
Ac-225	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Th-229	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Ra-225	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
At-217	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Bi-213	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Fr-221	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Pb-209	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.83E-01	6.44E+00
Po-213	1.25E+00	4.53E+00	2.50E-01	0.00E+00	2.76E-01	6.30E+00
C-14	1.56E+01	5.32E-01	5.02E-04	0.00E+00	9.99E-03	1.62E+01
Bi-210	2.93E-02	1.76E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Po-210	2.93E-02	1.76E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Pb-210	2.93E-02	1.76E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Eu-152	1.41E-05	1.59E+00	1.67E-03	0.00E+00	7.73E-03	1.60E+00
Cm-243	1.49E-01	1.78E-02	3.50E+00	0.00E+00	6.35E-03	3.67E+00
Eu-154	6.11E-04	2.40E+00	7.77E-02	0.00E+00	6.92E-03	2.49E+00

Table A-35
Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 2B

Isotope	Hanford	INEEL	SRS	Total
Pu-238	7.88E+05	6.00E+05	1.41E+06	2.80E+06
Pu-241	3.78E+05	1.98E+06	3.49E+05	2.70E+06
Pu-239	2.58E+05	6.45E+05	2.85E+04	9.31E+05
Am-241	4.70E+04	5.24E+05	7.93E+03	5.79E+05
Pu-240	6.04E+04	1.39E+05	7.31E+03	2.06E+05
Cs-137	6.68E+03	3.48E+02	2.53E+01	7.05E+03
Ba-137m	6.32E+03	3.29E+02	2.39E+01	6.67E+03
Cm-244	1.01E+03	2.27E+03	4.36E+03	7.64E+03
Y-90	6.77E+03	1.83E+02	1.97E+03	8.92E+03
Sr-90	6.77E+03	1.83E+02	1.97E+03	8.92E+03
U-233	7.82E+02	3.01E+03	2.49E+02	4.04E+03
Pu-242	3.86E+00	1.54E+03	4.10E+00	1.55E+03
U-234	5.26E+02	3.96E+01	8.59E+01	6.51E+02
Pa-233	2.66E+00	3.91E+00	9.77E+01	1.04E+02
Np-237	2.66E+00	3.91E+00	9.77E+01	1.04E+02
Co-60	0.00E+00	1.90E+02	1.25E+00	1.91E+02
Eu-155	1.03E-02	2.79E+00	1.34E+02	1.37E+02
Cf-252	3.45E+02	6.01E-01	1.33E+00	3.47E+02
Pb-212	5.07E-01	7.98E+01	5.46E-01	8.09E+01
Ra-224	5.07E-01	7.98E+01	5.46E-01	8.08E+01
Bi-212	5.07E-01	7.98E+01	5.46E-01	8.08E+01
Po-216	5.07E-01	7.98E+01	5.46E-01	8.08E+01
Rn-220	5.07E-01	7.98E+01	5.46E-01	8.08E+01
Th-228	5.07E-01	7.98E+01	5.46E-01	8.08E+01
U-232	0.00E+00	7.71E+01	7.52E-01	7.78E+01
Np-239	1.13E+00	1.48E+01	2.23E+01	3.83E+01
Am-243	1.13E+00	1.48E+01	1.81E+01	3.40E+01
Tc-99	9.31E-05	3.26E-01	2.35E+01	2.38E+01
Po-212	3.25E-01	5.11E+01	3.50E-01	5.18E+01
Cm-245	1.64E+02	2.71E-01	9.50E-02	1.65E+02
Tl-208	1.82E-01	2.87E+01	1.96E-01	2.90E+01
U-237	9.27E+00	2.35E+01	5.44E+00	3.82E+01
Ra-226	1.10E-01	3.38E+00	8.63E+00	1.21E+01
Po-218	1.10E-01	3.38E+00	8.57E+00	1.21E+01
Rn-222	1.10E-01	3.38E+00	8.57E+00	1.21E+01
Bi-214	1.10E-01	3.38E+00	8.56E+00	1.21E+01
Pb-214	1.10E-01	3.38E+00	8.56E+00	1.21E+01
Po-214	1.10E-01	3.38E+00	8.56E+00	1.21E+01
Ag-109m	0.00E+00	2.08E+01	3.71E-02	2.08E+01
Cd-109	0.00E+00	2.08E+01	3.71E-02	2.08E+01
Pa-234m	5.75E+01	5.24E-01	1.05E-01	5.81E+01
Th-234	5.75E+01	5.23E-01	1.05E-01	5.81E+01
U-238	5.75E+01	5.23E-01	1.05E-01	5.81E+01
Pm-147	4.67E-01	1.45E+01	5.26E-02	1.50E+01
U-235	1.67E+01	1.90E+00	4.54E-02	1.87E+01
Th-231	1.67E+01	1.89E+00	4.70E-02	1.87E+01
Ac-225	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Th-229	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Ra-225	1.28E+00	4.88E+00	2.83E-01	6.44E+00
At-217	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Bi-213	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Fr-221	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Pb-209	1.28E+00	4.88E+00	2.83E-01	6.44E+00
Po-213	1.25E+00	4.78E+00	2.76E-01	6.30E+00
C-14	1.56E+01	5.32E-01	9.99E-03	1.62E+01
Bi-210	2.93E-02	1.06E+00	1.67E+00	2.76E+00
Po-210	2.93E-02	1.06E+00	1.67E+00	2.76E+00
Pb-210	2.93E-02	1.06E+00	1.67E+00	2.76E+00
Eu-152	1.41E-05	1.59E+00	7.73E-03	1.60E+00
Cm-243	1.49E-01	3.51E+00	6.35E-03	3.67E+00
Eu-154	6.11E-04	2.48E+00	6.92E-03	2.49E+00

Table A-36
Radionuclide Inventories (curies) for RH-TRU Waste
by Treatment Site for Action Alternatives 2A, 2B, and 2C

Isotope	Hanford	ORNL	Total
Y-90	1.00E+06	5.38E+04	1.06E+06
Sr-90	1.00E+06	5.38E+04	1.06E+06
Cs-137	1.07E+06	1.67E+04	1.09E+06
Ba-137m	1.01E+06	1.58E+04	1.03E+06
Pu-241	7.06E+05	8.45E+02	7.07E+05
Eu-152	1.92E+03	5.39E+03	7.31E+03
Eu-154	9.33E+02	2.62E+03	3.55E+03
Cm-244	5.79E+02	1.42E+03	2.00E+03
Co-60	5.13E+04	9.69E+02	5.22E+04
Pu-239	5.12E+04	2.27E+02	5.15E+04
Am-241	2.95E+04	4.02E+02	2.99E+04
Eu-155	1.93E+02	5.17E+02	7.10E+02
Pu-240	2.53E+04	3.57E+01	2.53E+04
Th-231	1.19E+02	2.73E+02	3.93E+02
U-235	1.19E+02	2.73E+02	3.93E+02
Pu-238	7.33E+03	1.84E+02	7.51E+03
Cm-243	7.77E+01	2.18E+02	2.96E+02
Cs-134	1.98E+02	5.62E+01	2.54E+02
U-233	9.41E+01	8.44E+01	1.79E+02
Pm-147	1.04E+02	3.51E+01	1.39E+02
Rh-106	1.87E+01	5.07E+01	6.94E+01
Ru-106	1.87E+01	5.07E+01	6.94E+01
Pr-144	2.27E+01	3.34E+01	5.61E+01
Ce-144	2.12E+01	2.91E+01	5.03E+01
C-14	3.34E+00	8.99E+00	1.23E+01
Kr-85	2.10E+01	1.06E+00	2.21E+01
Sb-125	1.55E+01	4.34E+00	1.98E+01
Cf-252	2.02E+00	5.67E+00	7.69E+00
Ni-63	1.24E+01	6.23E-01	1.30E+01
U-238	3.33E+00	4.96E+00	8.29E+00
Pa-234m	3.32E+00	4.96E+00	8.28E+00
Th-234	3.32E+00	4.96E+00	8.28E+00
U-232	9.25E-01	2.59E+00	3.52E+00
Po-216	1.11E+00	2.47E+00	3.57E+00
Bi-212	1.10E+00	2.46E+00	3.57E+00
Pb-212	1.10E+00	2.46E+00	3.57E+00
Ra-224	1.10E+00	2.46E+00	3.57E+00
Rn-220	1.10E+00	2.46E+00	3.57E+00
Th-228	1.10E+00	2.46E+00	3.57E+00
U-234	1.96E+02	2.63E-01	1.96E+02
Po-212	7.07E-01	1.58E+00	2.29E+00
Te-125m	3.80E+00	1.06E+00	4.87E+00

Table A-37
Radionuclide Inventories (curies) for CH-TRU Waste by Treatment Site for Action Alternative 3

Isotope	Hanford	INEEL	LANL	RFETS	SRS	Total
Pu-238	7.86E+05	2.25E+05	3.62E+05	1.14E+04	1.41E+06	2.79E+06
Pu-241	3.77E+05	4.58E+05	5.24E+03	1.51E+06	3.49E+05	2.70E+06
Pu-239	2.57E+05	1.26E+05	2.50E+05	2.68E+05	2.85E+04	9.30E+05
Am-241	4.69E+04	2.73E+05	3.69E+04	2.12E+05	7.93E+03	5.77E+05
Pu-240	6.03E+04	3.01E+04	3.28E+02	1.08E+05	7.31E+03	2.06E+05
Cs-137	6.67E+03	1.95E+02	1.52E+02	0.00E+00	2.53E+01	7.04E+03
Ba-137m	6.31E+03	1.84E+02	1.44E+02	0.00E+00	2.39E+01	6.66E+03
Cm-244	1.01E+03	1.77E+03	4.95E+02	0.00E+00	4.36E+03	7.63E+03
Y-90	6.76E+03	4.16E+01	1.41E+02	0.00E+00	1.97E+03	8.91E+03
Sr-90	6.76E+03	4.16E+01	1.41E+02	0.00E+00	1.97E+03	8.91E+03
U-233	7.81E+02	2.73E+03	1.41E+02	1.23E+02	2.49E+02	4.02E+03
Pu-242	3.85E+00	1.07E+01	1.53E+03	9.11E-04	4.10E+00	1.55E+03
U-234	5.25E+02	2.03E+01	1.92E+01	4.55E-02	8.59E+01	6.50E+02
Pa-233	2.66E+00	3.61E+00	1.20E-01	1.61E-01	9.77E+01	1.04E+02
Np-237	2.66E+00	3.61E+00	1.20E-01	1.61E-01	9.77E+01	1.04E+02
Co-60	0.00E+00	1.89E+02	1.79E-02	0.00E+00	1.25E+00	1.90E+02
Eu-155	1.03E-02	2.00E+00	7.76E-01	0.00E+00	1.34E+02	1.37E+02
Cf-252	3.44E+02	5.91E-01	1.02E-02	0.00E+00	1.33E+00	3.46E+02
Pb-212	5.06E-01	7.93E+01	2.70E-02	0.00E+00	5.46E-01	8.04E+01
Ra-224	5.06E-01	7.93E+01	1.17E-02	0.00E+00	5.46E-01	8.04E+01
Bi-212	5.06E-01	7.93E+01	1.17E-02	0.00E+00	5.46E-01	8.04E+01
Po-216	5.06E-01	7.93E+01	1.17E-02	0.00E+00	5.46E-01	8.04E+01
Rn-220	5.06E-01	7.93E+01	1.17E-02	0.00E+00	5.46E-01	8.04E+01
Th-228	5.06E-01	7.93E+01	1.17E-02	0.00E+00	5.46E-01	8.04E+01
U-232	0.00E+00	7.66E+01	1.26E-02	0.00E+00	7.52E-01	7.74E+01
Np-239	1.13E+00	2.73E+00	1.21E+01	0.00E+00	2.23E+01	3.83E+01
Am-243	1.13E+00	2.68E+00	1.21E+01	0.00E+00	1.81E+01	3.40E+01
Tc-99	9.29E-05	2.89E-01	3.74E-02	0.00E+00	2.35E+01	2.38E+01
Po-212	3.24E-01	5.08E+01	7.52E-03	0.00E+00	3.50E-01	5.15E+01
Cm-245	1.64E+02	2.66E-01	4.77E-03	0.00E+00	9.50E-02	1.64E+02
Tl-208	1.82E-01	2.85E+01	4.22E-03	0.00E+00	1.96E-01	2.89E+01
U-237	9.25E+00	1.12E+01	1.28E-01	1.21E+01	5.44E+00	3.81E+01
Ra-226	1.10E-01	5.22E-01	2.86E+00	0.00E+00	8.63E+00	1.21E+01
Po-218	1.10E-01	5.21E-01	2.86E+00	0.00E+00	8.57E+00	1.21E+01
Rn-222	1.10E-01	5.21E-01	2.86E+00	0.00E+00	8.57E+00	1.21E+01
Bi-214	1.10E-01	5.21E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
TPb-214	1.10E-01	5.21E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
Po-214	1.10E-01	5.21E-01	2.86E+00	0.00E+00	8.56E+00	1.21E+01
Ag-109m	0.00E+00	1.04E-01	2.07E+01	0.00E+00	3.71E-02	2.08E+01
Cd-109	0.00E+00	1.04E-01	2.07E+01	0.00E+00	3.71E-02	2.08E+01
Pa-234m	5.73E+01	4.45E-01	7.69E-02	0.00E+00	1.05E-01	5.80E+01
Th-234	5.73E+01	4.45E-01	7.63E-02	0.00E+00	1.05E-01	5.80E+01
U-238	5.73E+01	4.45E-01	7.63E-02	0.00E+00	1.05E-01	5.80E+01
Pm-147	4.66E-01	8.08E+00	6.33E+00	0.00E+00	5.26E-02	1.49E+01
U-235	1.67E+01	2.35E-01	1.66E+00	4.52E-04	4.54E-02	1.86E+01
Th-231	1.67E+01	2.23E-01	1.66E+00	4.52E-04	4.70E-02	1.86E+01
Ac-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Th-229	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Ra-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
At-217	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Bi-213	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Fr-221	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Pb-209	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.83E-01	6.42E+00
Po-213	1.25E+00	4.50E+00	2.50E-01	0.00E+00	2.76E-01	6.28E+00
C-14	1.56E+01	5.29E-01	5.02E-04	0.00E+00	9.99E-03	1.61E+01
Bi-210	2.93E-02	1.75E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Po-210	2.93E-02	1.75E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Pb-210	2.93E-02	1.75E-01	8.86E-01	0.00E+00	1.67E+00	2.76E+00
Eu-152	1.41E-05	1.59E+00	1.67E-03	0.00E+00	7.73E-03	1.60E+00
Cm-243	1.48E-01	1.78E-02	3.50E+00	0.00E+00	6.35E-03	3.67E+00
Eu-154	6.10E-04	2.39E+00	7.77E-02	0.00E+00	6.92E-03	2.48E+00

Table A-38
Radionuclide Inventories (curies) for RH-TRU Waste
by Treatment Site for Action Alternative 3

Isotope	Hanford	ORNL	Total
Y-90	1.00E+06	5.38E+04	1.06E+06
Sr-90	1.00E+06	5.38E+04	1.06E+06
Cs-137	1.07E+06	1.67E+04	1.09E+06
Ba-137m	1.01E+06	1.58E+04	1.03E+06
Pu-241	7.06E+05	8.45E+02	7.07E+05
Eu-152	1.92E+03	5.39E+03	7.31E+03
Eu-154	9.33E+02	2.62E+03	3.55E+03
Cm-244	5.79E+02	1.42E+03	2.00E+03
Co-60	5.13E+04	9.69E+02	5.22E+04
Pu-239	5.12E+04	2.27E+02	5.15E+04
Am-241	2.95E+04	4.02E+02	2.99E+04
Eu-155	1.93E+02	5.17E+02	7.10E+02
Pu-240	2.53E+04	3.57E+01	2.53E+04
Th-231	1.19E+02	2.73E+02	3.93E+02
U-235	1.19E+02	2.73E+02	3.93E+02
Pu-238	7.33E+03	1.84E+02	7.51E+03
Cm-243	7.77E+01	2.18E+02	2.96E+02
Cs-134	1.98E+02	5.62E+01	2.54E+02
U-233	9.41E+01	8.44E+01	1.79E+02
Pm-147	1.04E+02	3.51E+01	1.39E+02
Rh-106	1.87E+01	5.07E+01	6.94E+01
Ru-106	1.87E+01	5.07E+01	6.94E+01
Pr-144	2.27E+01	3.34E+01	5.61E+01
Ce-144	2.12E+01	2.91E+01	5.03E+01
C-14	3.34E+00	8.99E+00	1.23E+01
Kr-85	2.10E+01	1.06E+00	2.21E+01
Sb-125	1.55E+01	4.34E+00	1.98E+01
Cf-252	2.02E+00	5.67E+00	7.69E+00
Ni-63	1.24E+01	6.23E-01	1.30E+01
U-238	3.33E+00	4.96E+00	8.29E+00
Pa-234m	3.32E+00	4.96E+00	8.28E+00
Th-234	3.32E+00	4.96E+00	8.28E+00
U-232	9.25E-01	2.59E+00	3.52E+00
Po-216	1.11E+00	2.47E+00	3.57E+00
Bi-212	1.10E+00	2.46E+00	3.57E+00
Pb-212	1.10E+00	2.46E+00	3.57E+00
Ra-224	1.10E+00	2.46E+00	3.57E+00
Rn-220	1.10E+00	2.46E+00	3.57E+00
Th-228	1.10E+00	2.46E+00	3.57E+00
U-234	1.96E+02	2.63E-01	1.96E+02
Po-212	7.07E-01	1.58E+00	2.29E+00
Te-125m	3.80E+00	1.06E+00	4.87E+00

The RH-TRU waste radionuclide inventory for the treatment sites under this alternative would be the same as those under Action Alternatives 2A and 2B. This radionuclide information is given in Table A-36.

A.4.7 Radionuclide Estimates for No Action Alternative 2

The following sections discuss radionuclide estimates used for the No Action Alternative 2 analyses.

A.4.7.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory for the seven largest generator-storage sites under No Action Alternative 2 is given in Table A-39.

No Action Alternative 2 long-term performance calculations are initiated at the assumed time of loss of institutional control at the generator-storage sites. A decayed radionuclide inventory was required for long-term performance assessment calculations. The CH-TRU waste radionuclide inventory at treatment sites decayed to the year 2133 is given in Table A-40. Only those radionuclides with activities greater than 1 Ci and half-lives greater than approximately 10 minutes have been retained.

A.4.7.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory at each treatment site for No Action Alternative 2 is given in Table A-41. Again, No Action Alternative 2 long-term performance calculations require the use of a decayed radionuclide inventory to account for the 100 years after WIPP would have ceased operation. These values are given in Table A-42. Only those radionuclides with activities greater than 1 Ci and half-lives greater than approximately 10 minutes have been retained.

A.4.8 Radionuclide Concentrations for Drilling Intrusions

The long-term performance assessment analyses presented in Chapter 5 include examination of the effects of drilling into waste disposal rooms. Estimates of the median and 75th percentile concentrations of individual nuclides for drilling intrusions into CH-TRU waste are provided in Table A-43. These values are representative of uncompacted waste, are decayed through the end of 1995, and are based on 457 waste streams. The concentration estimates were based on 1,000 replicates of random sampling of waste streams where the probability of selection of a particular waste stream was proportional to the volume of the waste stream. Each replicate was formed by integrating data from three separate waste streams because the CH-TRU waste drums would be stacked three high in the disposal rooms. The samples were then ordered on the basis of the concentration of Am-241 because more than 85 percent of the dose to the drilling crew came from Am-241.

Only a limited amount of information was available for the RH-TRU waste streams, and the random sampling scheme did not yield representative results. Therefore, the RH-TRU waste concentrations used for all drilling analyses were average results, with no differentiation between median and 75th percentile values.

Table A-39
Radionuclide Inventories (curies) for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEEL	LANL	LLNL	ORNL	RFETS	SRS
Pu-238	3.76E+05	7.31E+04	2.18E+05	3.97E+02	6.64E+03	1.14E+04	1.10E+06
Pu-241	1.76E+05	1.56E+05	3.20E+03	8.46E+03	6.16E+04	1.51E+06	2.24E+05
Pu-239	1.23E+05	4.28E+04	1.51E+05	8.52E+02	3.98E+03	2.68E+05	1.87E+04
Am-241	2.21E+04	9.20E+04	2.22E+04	7.46E+02	2.36E+03	2.12E+05	4.01E+03
Pu-240	2.87E+04	1.03E+04	2.00E+02	3.34E+02	1.27E+03	1.08E+05	4.61E+03
Cs-137	3.19E+03	7.30E+01	9.17E+01	8.62E-06	3.78E+00	0.00E+00	1.50E+01
Ba-137m	3.02E+03	6.91E+01	8.68E+01	8.16E-06	3.58E+00	0.00E+00	1.42E+01
Cm-244	3.19E+02	5.44E+02	2.98E+02	3.39E+02	1.35E+03	0.00E+00	2.33E+03
Y-90	3.24E+03	3.71E+01	8.51E+01	0.00E+00	1.87E+03	0.00E+00	1.40E+01
Sr-90	3.23E+03	3.71E+01	8.51E+01	0.00E+00	1.87E+03	0.00E+00	1.39E+01
U-233	3.74E+02	9.18E+02	8.52E+01	3.08E-08	2.27E+02	1.23E+02	7.50E+00
Pu-242	1.78E+00	8.66E+00	9.23E+02	1.05E-01	1.58E+00	9.11E-04	7.50E-01
U-234	2.51E+02	7.87E+00	1.16E+01	1.70E-02	2.01E+01	4.55E-02	5.11E+01
Pa-233	1.27E+00	1.89E+00	7.85E-02	2.44E-03	7.57E+01	1.61E-01	1.72E+01
Np-237	1.27E+00	1.89E+00	7.85E-02	2.44E-03	7.57E+01	1.61E-01	1.72E+01
Co-60	0.00E+00	6.34E+01	1.65E-02	0.00E+00	1.65E-01	0.00E+00	7.11E-01
Eu-155	4.93E-03	1.23E+00	4.73E-01	0.00E+00	1.41E-01	0.00E+00	1.06E+02
Cf-252	1.65E+02	5.69E-01	9.42E-03	0.00E+00	2.96E-01	0.00E+00	7.23E-01
Pb-212	2.42E-01	2.66E+01	1.87E-02	0.00E+00	4.28E-01	0.00E+00	1.84E-02
Ra-224	2.42E-01	2.66E+01	9.52E-03	0.00E+00	4.28E-01	0.00E+00	1.84E-02
Bi-212	2.42E-01	2.66E+01	9.52E-03	0.00E+00	4.28E-01	0.00E+00	1.84E-02
Po-216	2.42E-01	2.66E+01	9.52E-03	0.00E+00	4.28E-01	0.00E+00	1.84E-02
Rn-220	2.42E-01	2.66E+01	9.52E-03	0.00E+00	4.28E-01	0.00E+00	1.84E-02
Th-228	2.42E-01	2.66E+01	9.52E-03	0.00E+00	4.28E-01	0.00E+00	1.84E-02
U-232	0.00E+00	2.57E+01	9.96E-03	0.00E+00	4.34E-01	0.00E+00	1.79E-01
Np-239	4.21E-01	7.17E-01	7.29E+00	1.27E-01	1.88E+01	0.00E+00	1.51E+00
Am-243	4.21E-01	6.65E-01	7.29E+00	1.27E-01	1.47E+01	0.00E+00	1.51E+00
Tc-99	4.45E-05	2.84E-01	2.41E-02	0.00E+00	2.25E+01	0.00E+00	8.99E-06
Po-212	1.55E-01	1.71E+01	6.10E-03	0.00E+00	2.74E-01	0.00E+00	1.18E-02
Cm-245	7.84E+01	2.66E-01	4.42E-03	0.00E+00	4.42E-02	0.00E+00	0.00E+00
Tl-208	8.71E-02	9.57E+00	3.42E-03	0.00E+00	1.54E-01	0.00E+00	6.60E-03
U-237	4.33E+00	3.81E+00	7.80E-02	2.07E-01	1.51E+00	1.21E+01	3.04E+00
Ra-226	1.47E-04	1.71E-01	1.72E+00	2.07E-07	8.28E+00	0.00E+00	1.46E-05
Po-218	1.47E-04	1.70E-01	1.72E+00	0.00E+00	8.22E+00	0.00E+00	1.46E-05
Rn-222	1.47E-04	1.70E-01	1.72E+00	0.00E+00	8.22E+00	0.00E+00	1.46E-05
Bi-214	1.47E-04	1.70E-01	1.72E+00	0.00E+00	8.22E+00	0.00E+00	1.46E-05
Pb-214	1.47E-04	1.70E-01	1.72E+00	0.00E+00	8.22E+00	0.00E+00	1.46E-05
Po-214	1.47E-04	1.70E-01	1.72E+00	0.00E+00	8.21E+00	0.00E+00	1.46E-05
Ag-109m	0.00E+00	1.04E-01	1.25E+01	0.00E+00	1.72E-02	0.00E+00	0.00E+00
Cd-109	0.00E+00	1.04E-01	1.25E+01	0.00E+00	1.72E-02	0.00E+00	0.00E+00
Pa-234m	2.74E+01	2.12E-01	4.69E-02	1.57E-01	6.97E-02	0.00E+00	1.14E-02
Th-234	2.74E+01	2.12E-01	4.65E-02	1.57E-01	6.97E-02	0.00E+00	1.14E-02
U-238	2.74E+01	2.12E-01	4.65E-02	1.57E-01	6.97E-02	0.00E+00	1.14E-02
Pm-147	2.23E-01	2.70E+00	3.82E+00	0.00E+00	3.71E-02	0.00E+00	2.47E-05
U-235	7.99E+00	9.87E-02	1.00E+00	3.08E-03	2.30E-02	4.52E-04	1.17E-02
Th-231	7.99E+00	9.85E-02	1.00E+00	9.15E-03	2.45E-02	4.52E-04	1.17E-02
Ac-225	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.67E-01	0.00E+00	2.61E-05
Th-229	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
Ra-225	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
At-217	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
Bi-213	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
Fr-221	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
Pb-209	6.10E-01	1.55E+00	1.54E-01	0.00E+00	2.66E-01	0.00E+00	2.61E-05
Po-213	5.97E-01	1.52E+00	1.51E-01	0.00E+00	2.61E-01	0.00E+00	2.56E-05
C-14	7.47E+00	1.94E-01	4.65E-04	0.00E+00	4.64E-03	0.00E+00	0.00E+00
Bi-210	2.48E-05	5.31E-02	5.34E-01	0.00E+00	1.60E+00	0.00E+00	2.22E-06
Po-210	2.48E-05	5.31E-02	5.34E-01	0.00E+00	1.60E+00	0.00E+00	2.22E-06
Pb-210	2.48E-05	5.30E-02	5.34E-01	0.00E+00	1.60E+00	0.00E+00	2.22E-06
Eu-152	3.43E-06	1.82E-01	1.12E-03	6.90E-06	4.00E-03	0.00E+00	0.00E+00
Cm-243	7.11E-02	1.78E-02	2.11E+00	0.00E+00	2.95E-03	0.00E+00	0.00E+00
Eu-154	2.91E-04	6.61E-01	4.69E-02	2.72E-06	2.88E-03	0.00E+00	5.68E-04

Table A-40
Decayed Radionuclide Inventories (curies) Adjusted for Decay Through 2133 for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotopes	Hanford	INEEL	LANL	LLNL	ORNL	RFETS	SRS
Pu-238	1.71E+05	3.26E+04	9.88E+04	1.80E+02	2.94E+03	5.17E+03	4.61E+05
Pu-239	1.23E+05	4.25E+04	1.51E+05	8.50E+02	3.90E+03	2.67E+05	1.86E+04
Am-241	2.41E+04	8.27E+04	1.90E+04	8.81E+02	3.82E+03	2.25E+05	9.79E+03
Pu-240	2.85E+04	1.01E+04	1.98E+02	3.31E+02	1.27E+03	1.07E+05	4.56E+03
Pu-241	1.52E+03	1.27E+03	2.58E+01	6.87E+01	5.06E+02	1.23E+04	1.12E+03
Pu-242	3.74E+02	9.16E+02	8.52E+01	1.10E-06	2.29E+02	1.23E+02	7.51E+00
U-233	1.78E+00	7.91E+00	9.23E+02	1.05E-01	1.46E+00	9.11E-04	7.50E-01
U-234	3.26E+02	2.18E+01	5.43E+01	9.48E-02	2.16E+01	2.28E+00	2.80E+02
Cs-137	3.20E+02	1.05E+01	9.23E+00	8.63E-07	2.98E+02	0.00E+00	1.19E+00
Y-90	2.97E+02	3.09E+00	7.81E+00	0.00E+00	1.74E+02	0.00E+00	1.01E+00
Sr-90	2.97E+02	3.09E+00	7.81E+00	0.00E+00	1.74E+02	0.00E+00	1.01E+00
Cm-245	6.95E+00	1.17E+01	6.47E+00	7.36E+00	2.97E+01	0.00E+00	3.45E+01
Cm-244	7.80E+01	2.38E-01	3.96E-03	0.00E+00	3.96E-02	0.00E+00	0.00E+00
Th-234	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
U-238	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
Tc-99	4.18E-01	6.31E-01	7.21E+00	1.26E-01	1.48E+01	0.00E+00	1.50E+00
Pa-233	4.18E-01	6.31E-01	7.21E+00	1.26E-01	1.48E+01	0.00E+00	1.50E+00
Np-237	4.45E-05	2.57E-01	2.37E-02	0.00E+00	2.28E+01	0.00E+00	8.99E-06
Np-239	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Am-243	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Th-229	4.12E+00	1.02E+01	9.53E-01	5.31E-09	2.42E+00	1.16E+00	7.76E-02
Ra-225	4.12E+00	1.01E+01	9.53E-01	5.31E-09	2.42E+00	1.16E+00	7.75E-02
Ac-225	4.12E+00	1.01E+01	9.53E-01	5.30E-09	2.42E+00	1.16E+00	7.75E-02
Pb-212	4.55E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	6.38E-02
Ra-224	4.55E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	6.38E-02
Th-228	4.53E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	6.38E-02
U-232	5.56E-03	1.53E-01	1.65E+00	1.13E-06	8.03E+00	1.81E-05	3.38E-03
Ra-226	1.42E-04	1.52E-01	1.65E+00	1.99E-07	8.03E+00	0.00E+00	1.39E-05
Rn-222	0.00E+00	9.81E+00	3.55E-03	0.00E+00	1.65E-01	0.00E+00	6.21E-02
U-235	1.38E-04	1.50E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.37E-05
Th-231	1.38E-04	1.50E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.37E-05
Pb-210	1.38E-04	1.49E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.37E-05
Bi-210	8.00E+00	9.51E-02	1.00E+00	3.08E-03	2.26E-02	4.52E-04	1.17E-02
Po-210	8.00E+00	9.51E-02	1.00E+00	3.08E-03	2.26E-02	4.52E-04	1.17E-02
C-14	7.40E+00	1.90E-01	4.15E-04	0.00E+00	4.14E-03	0.00E+00	0.00E+00

Table A-41
Radionuclide Inventories (curies) for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEEL	LANL	ORNL	Total
Y-90	9.41E+05	2.45E+04	3.01E+02	5.16E+04	1.02E+06
Sr-90	9.41E+05	2.45E+04	3.00E+02	5.16E+04	1.02E+06
Cs-137	1.02E+06	1.18E+04	3.27E+02	1.55E+04	1.04E+06
Ba-137M	9.62E+05	1.12E+04	3.10E+02	1.47E+04	9.88E+05
Pu-241	6.79E+05	2.52E+03	0.00E+00	8.39E+02	6.83E+05
Eu-152	0.00E+00	1.92E+03	1.23E-03	5.22E+03	7.13E+03
Eu-154	0.00E+00	9.31E+02	8.47E-02	2.52E+03	3.46E+03
Cm-244	0.00E+00	5.79E+02	0.00E+00	1.37E+03	1.95E+03
Co-60	4.90E+04	5.21E+02	1.01E+01	9.38E+02	5.04E+04
Pu-239	4.88E+04	3.23E+02	2.25E+02	2.22E+02	4.96E+04
Am-241	2.81E+04	3.00E+02	0.00E+00	3.87E+02	2.88E+04
Eu-155	0.00E+00	1.85E+02	4.29E+00	5.00E+02	6.89E+02
Pu-240	2.43E+04	1.26E+02	0.00E+00	3.56E+01	2.44E+04
Th-231	2.13E+01	9.74E+01	2.13E-02	2.64E+02	3.83E+02
U-235	2.13E+01	9.74E+01	2.13E-02	2.64E+02	3.83E+02
Pu-238	6.80E+03	1.50E+02	9.44E+00	6.51E+01	7.03E+03
Cm-243	0.00E+00	7.77E+01	0.00E+00	2.11E+02	2.89E+02
Cs-134	0.00E+00	8.95E+01	5.85E-02	2.40E+01	1.14E+02
U-233	6.04E+01	3.08E+01	0.00E+00	8.17E+01	1.73E+02
Pm-147	0.00E+00	3.24E+01	2.73E+01	5.95E+00	6.57E+01
Rh-106	0.00E+00	1.74E+01	8.18E-01	4.59E+01	6.40E+01
Ru-106	0.00E+00	1.74E+01	8.18E-01	4.59E+01	6.40E+01
Pr-144	0.00E+00	1.47E+01	3.84E-02	2.24E+01	3.71E+01
Ce-144	0.00E+00	1.32E+01	3.88E-02	1.81E+01	3.13E+01
C-14	0.00E+00	3.26E+00	0.00E+00	8.70E+00	1.20E+01
Kr-85	0.00E+00	9.07E+00	0.00E+00	1.06E+00	1.01E+01
Sb-125	0.00E+00	3.24E+00	6.75E+00	7.66E-01	1.08E+01
Cf-252	0.00E+00	2.02E+00	0.00E+00	5.49E+00	7.51E+00
Ni-63	0.00E+00	5.34E+00	0.00E+00	6.23E-01	5.96E+00
U-238	1.49E+00	1.78E+00	4.84E-05	4.80E+00	8.07E+00
Pa-234m	1.49E+00	1.77E+00	4.84E-05	4.80E+00	8.06E+00
Th-234	1.49E+00	1.77E+00	4.84E-05	4.80E+00	8.06E+00
U-232	0.00E+00	9.24E-01	0.00E+00	2.51E+00	3.44E+00
Po-216	2.17E-01	8.84E-01	0.00E+00	2.39E+00	3.49E+00
Bi-212	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Pb-212	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Ra-224	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Rn-220	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Th-228	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
U-234	1.88E+02	9.08E-01	2.69E-05	2.60E-01	1.89E+02
Po-212	1.39E-01	5.63E-01	0.00E+00	1.53E+00	2.23E+00
Te-125m	0.00E+00	7.93E-01	1.67E+00	1.88E-01	2.65E+00

Table A-42
Decayed Radionuclide Inventories (curies) Adjusted for Decay Through 2133 for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEEL	LANL	ORNL
Cs-137	1.02E + 05	1.18E + 03	3.27E + 01	1.55E + 03
Y-90	8.64E + 04	2.25E + 03	2.75E + 01	4.75E + 03
Sr-90	8.64E + 04	2.25E + 03	2.75E + 01	4.75E + 03
Pu-239	4.87E + 04	3.22E + 02	2.24E + 02	2.22E + 02
Am-241	4.37E + 04	3.29E + 02	0.00E + 00	3.54E + 02
Pu-240	2.40E + 04	1.26E + 02	0.00E + 00	3.89E + 01
Pu-241	5.52E + 03	2.05E + 01	0.00E + 00	6.82E + 00
Pu-238	3.08E + 03	6.80E + 01	4.28E + 00	2.96E + 01
Th-231	2.13E + 01	9.74E + 01	2.13E-02	2.65E + 02
U-235	2.13E + 01	9.74E + 01	2.13E-02	2.65E + 02
U-234	1.89E + 02	9.38E-01	1.88E-03	2.74E-01
U-233	6.04E + 01	3.08E + 01	0.00E + 00	8.17E + 01
Cm-244	0.00E + 00	1.26E + 01	0.00E + 00	2.97E + 01
Eu-152	0.00E + 00	1.06E + 01	6.80E-06	2.88E + 01
Cm-243	0.00E + 00	6.81E + 00	0.00E + 00	1.85E + 01
C-14	0.00E + 00	3.22E + 00	0.00E + 00	8.61E + 00
U-238	1.49E + 00	1.78E + 00	4.84E-05	4.80E + 00
Th-234	1.49E + 00	1.78E + 00	4.84E-05	4.80E + 00
Ni-63	0.00E + 00	2.60E + 00	0.00E + 00	3.03E-01

Table A-43
Radionuclide Concentrations (curies/cubic meter)
for Drilling Intrusions into CH-TRU Waste

CH-TRU Radionuclide	Proposed Action		Action Alternative 1		Action Alternative 2		Action Alternative 3	
	50% Level	75% Level	50% Level	75% Level	50% Level	75% Level	50% Level	75% Level
Am-241	1.89E+00	2.83E+00	1.58E+00	2.37E+00	4.16E+00	6.24E+00	1.33E+00	1.99E+00
Am-243	8.79E-06	1.32E-05	7.35E-06	1.10E-05	1.94E-05	2.91E-05	6.17E-06	9.26E-06
Ba-137m	4.74E-03	3.43E-03	3.96E-03	2.87E-03	1.05E-02	7.57E-03	3.33E-03	2.41E-03
Bi-214	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
C-14	9.79E-10	1.47E-09	8.19E-10	1.23E-09	2.16E-09	3.24E-09	6.88E-10	1.03E-09
Cm-243	4.05E-07	6.07E-07	3.39E-07	5.08E-07	8.93E-07	1.34E-06	2.84E-07	4.26E-07
Cm-244	2.66E-02	3.99E-02	2.23E-02	3.34E-02	5.87E-02	8.80E-02	1.87E-02	2.80E-02
Co-60	5.53E-03	8.30E-03	4.63E-03	6.94E-03	1.22E-02	1.83E-02	3.88E-03	5.83E-03
Cs-137	5.76E-02	8.24E-02	4.82E-02	6.89E-02	1.27E-01	1.82E-01	4.05E-02	5.79E-02
Eu-152	4.11E-06	6.17E-06	3.44E-06	5.16E-06	9.06E-06	1.36E-05	2.89E-06	4.33E-06
Eu-154	4.04E-05	6.06E-05	3.38E-05	5.07E-05	8.91E-05	1.34E-04	2.84E-05	4.26E-05
Eu-155	2.71E-05	4.06E-05	2.26E-05	3.40E-05	5.97E-05	8.95E-05	1.90E-05	2.85E-05
Np-237	8.25E-06	1.24E-05	6.90E-06	1.04E-05	1.82E-05	2.73E-05	5.79E-06	8.69E-06
Np-239	1.10E-13	1.65E-13	9.22E-14	1.38E-13	2.43E-13	3.65E-13	7.74E-14	1.16E-13
Pa-233	5.72E-08	8.58E-08	4.78E-08	7.18E-08	1.26E-07	1.89E-07	4.02E-08	6.03E-08
Pb-210	4.94E-07	7.40E-07	4.13E-07	6.19E-07	1.09E-06	1.63E-06	3.47E-07	5.20E-07
Pb-212	8.33E-12	1.25E-11	6.96E-12	1.05E-11	1.84E-11	2.75E-11	5.85E-12	8.77E-12
Pb-214	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
Pm-147	1.36E-02	2.04E-02	1.14E-02	1.70E-02	2.99E-02	4.49E-02	9.54E-03	1.43E-02
Po-214	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
Po-218	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
Pu-238	7.98E+00	2.37E+00	6.67E+00	1.98E+00	1.76E+01	5.23E+00	5.60E+00	1.66E+00
Pu-239	1.91E+00	1.34E+00	1.60E+00	1.12E+00	4.22E+00	2.94E+00	1.34E+00	9.38E-01
Pu-240	4.47E-01	3.29E-01	3.74E-01	2.75E-01	9.86E-01	7.25E-01	3.14E-01	2.31E-01
Pu-241	1.24E+01	9.44E+00	1.04E+01	7.89E+00	2.74E+01	2.08E+01	8.72E+00	6.63E+00
Pu-242	3.51E-05	3.20E-05	2.94E-05	2.68E-05	7.74E-05	7.06E-05	2.47E-05	2.25E-05
Ra-225	1.28E-17	1.92E-17	1.07E-17	1.61E-17	2.82E-17	4.23E-17	8.99E-18	1.35E-17
Ra-226	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
Rn-222	1.13E-06	1.69E-06	9.41E-07	1.41E-06	2.48E-06	3.72E-06	7.91E-07	1.19E-06
Sr-90	5.29E-02	7.56E-02	4.42E-02	6.32E-02	1.17E-01	1.67E-01	3.72E-02	5.31E-02
Tc-99	1.74E-07	2.60E-07	1.45E-07	2.18E-07	3.83E-07	5.74E-07	1.22E-07	1.83E-07
Th-228	8.33E-12	1.25E-11	6.96E-12	1.05E-11	1.84E-11	2.75E-11	5.85E-12	8.77E-12
Th-234	2.18E-09	3.27E-09	1.83E-09	2.74E-09	4.81E-09	7.22E-09	1.53E-09	2.30E-09
U-232	7.06E-04	1.06E-03	5.90E-04	8.85E-04	1.56E-03	2.33E-03	4.96E-04	7.43E-04
U-233	2.11E-02	3.17E-02	1.77E-02	2.65E-02	4.66E-02	6.98E-02	1.48E-02	2.22E-02
U-234	1.32E-04	1.19E-04	1.10E-04	9.91E-05	2.91E-04	2.61E-04	9.26E-05	8.32E-05
U-235	2.60E-06	2.12E-06	2.17E-06	1.77E-06	5.72E-06	4.67E-06	1.82E-06	1.49E-06
U-238	2.47E-05	4.11E-06	2.07E-05	3.43E-06	5.45E-05	9.05E-06	1.74E-05	2.88E-06
Y-90	4.89E-03	3.59E-03	4.09E-03	3.00E-03	1.08E-02	7.92E-03	3.44E-03	2.52E-03

A.5 HAZARDOUS CONSTITUENTS INVENTORY

TRU mixed waste is defined as any TRU waste that is commingled with a hazardous waste regulated by RCRA (40 Code of Federal Regulations 261, Subparts C and D). There are two classes of RCRA-regulated constituents of concern relative to WIPP, metals and volatile organic compounds (VOC). For the purposes of conducting analyses that bound adverse impacts, all TRU wastes to be emplaced in WIPP were assumed to be TRU mixed waste. As compared with the approximate 60 percent of the volume of stored waste classified as TRU mixed wastes (see Table A-16). No attempt was made to forecast future operational procedures at generator-storage sites that would treat TRU and TRU mixed waste streams differently.

A.5.1 Metals Inventory

BIR-3 does not contain detailed information on hazardous constituents. An inventory of hazardous metals, however, was developed for fire and explosion accident scenarios in the SAR (DOE 1995c, Table 5.1-2). These inventory values, which correspond to a 110-kilogram (243-pound) drum, are: 0.023 kilograms (0.051 pounds) for beryllium; 3.3×10^{-4} kilograms (7.3×10^{-4} pounds) for cadmium; 0.91 kilograms (2 pounds) for lead; and 0.39 kilograms (0.86 pounds) for mercury.

Using the average material parameter data in BIR-3, a drum of CH-TRU waste is expected to contain approximately 120 kilograms (265 pounds) of waste. Similarly, a drum of RH-TRU waste is expected to contain 105 kilograms (230 pounds) of waste. CH-TRU waste metal concentrations were adjusted from the 110-kilogram drum in SAR to the 120-kilogram drum for SEIS-II. Similarly, the RH-TRU waste metal concentrations were adjusted down to the 105-kilogram drum for SEIS-II. The BIR-3 lead inventory value of 464 kilograms per cubic meter (29 pounds per cubic feet), which includes lead for shielding, was used for the RH-TRU waste concentration. Concentrations of metals used in SEIS-II analyses for both CH-TRU and RH-TRU waste are listed in Table A-44.

Total inventory values for hazardous metals analyzed in SEIS-II are given in Table A-45. These values are based on the metal concentration in Table A-44 as well as the Basic Inventory and Additional Inventory.

Table A-44
Concentration of Hazardous Metals

Metal	CH-TRU Waste Inventory (kg/cubic meter)	RH-TRU Waste Inventory (kg/cubic meter)
Beryllium	1.21E-01	1.21E-01
Cadmium	1.73E-03	1.74E-03
Lead	4.79E + 00	4.64E + 02
Mercury	2.05E + 00	2.05E + 00

Table A-45
Inventory (kilograms) of Hazardous Metals by Alternative

Alternatives	CH-TRU Waste	RH-TRU Waste	Total
Lead Inventory			
Proposed Action	8.08E+05	3.29E+06	4.09E+06
Action Alternative 1	1.31E+06	1.80E+07	1.93E+07
Action Alternative 2	1.31E+06	1.80E+07	1.93E+07
Action Alternative 3	1.31E+06	1.80E+07	1.93E+07
No Action Alternative 1	1.31E+06	1.80E+07	1.93E+07
No Action Alternative 2	6.46E+05	1.64E+07	1.70E+07
Beryllium Inventory			
Proposed Action	2.04E+04	8.58E+02	2.13E+04
Action Alternative 1	3.31E+04	4.70E+03	3.78E+04
Action Alternative 2	3.32E+04	4.70E+03	3.79E+04
Action Alternative 3	3.31E+04	4.70E+03	3.78E+04
No Action Alternative 1	3.32E+04	4.70E+03	3.79E+04
No Action Alternative 2	1.63E+04	4.27E+03	2.06E+04
Cadmium Inventory			
Proposed Action	2.93E+02	1.23E+01	3.05E+02
Action Alternative 1	4.75E+02	6.74E+01	5.42E+02
Action Alternative 2	4.76E+02	6.74E+01	5.43E+02
Action Alternative 3	4.75E+02	6.74E+01	5.42E+02
No Action Alternative 1	4.76E+02	6.74E+01	5.43E+02
No Action Alternative 2	2.34E+02	6.13E+01	2.96E+02
Mercury Inventory			
Proposed Action	3.46E+05	1.45E+04	3.61E+05
Action Alternative 1	5.61E+05	7.97E+04	6.40E+05
Action Alternative 2	5.62E+05	7.97E+04	6.42E+05
Action Alternative 3	5.61E+05	7.97E+04	6.40E+05
No Action Alternative 1	5.62E+05	7.97E+04	6.42E+05
No Action Alternative 2	2.77E+05	7.25E+04	3.49E+05

A.5.2 Inventory of Volatile Organic Compounds

Other than to indicate the presence of a relatively small volume of PCB-commingled waste, the BIR-3 database does not contain information on organic compounds. PCB-commingled waste is only considered under Action Alternative 2 and No Action Alternative 1. Further, PCB waste would be thermally treated, which would completely destroy the PCBs. Risk analyses, therefore, were not performed for PCB-commingled TRU waste.

The *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, published after SAR, provided more recent headspace sampling data and was used to estimate concentrations of VOCs (DOE 1996a, Table C2-4). The permit application summarizes the results of a headspace sampling and analysis study conducted on RFETS CH-TRU waste. Approximately 930 drums of varying waste types were sampled. Average concentrations of the VOCs that present the greatest potential risk to human health are expressed as parts per million per volume in Table A-46. Where compounds were not detected in the sampling process,

Table A-46
Average Concentrations (ppmv) of Volatile Organic Compounds as Reported from the RCRA Part B Permit Application

Final TRU Waste Form	Carbon Tetrachloride	Chlorobenzene	Chloroform	Methyl Ethyl Ketone	Methylene Chloride
Combustible	566.52	1.54	41.09	7.60	12.29
Filter	1.44	0.18	0.19	5.11	0.48
Graphite	0.10	0.03	0.06	8.09	0.91
Heterogeneous	91.07	9.46	18.99	62.05	143.13
Inorganic Non-Metal	3.27	0.16	1.03	7.29	2.56
Lead/Cadmium Metal	255.28	4.94	6.86	42.56	8.61
Salt	4.32	0.18	0.23	5.50	0.56
Soils	0	0	0	0	0
Solidified Inorganics	316.51	1.29	1.15	6.83	8.05
Solidified Organics	8,319.32	94.30	135.98	717.96	214.47
Uncategorized Metal	9.58	13.40	7.94	39.34	1,941.71
Final TRU Waste Form	**1,1,2,2-Tetrachloroethane**	**Toluene**	**1,1-Dichloroethene**	**1,2-Dichloroethane**	**1,1,1-Trichloroethane**
Combustible	96.25	1.75	1.98	1.57	7.38
Filter	16.08	0.14	0.32	0.26	11.63
Graphite	8.06	0.03	0.04	0.03	0.63
Heterogeneous	711.98	7.64	14.42	7.62	24.11
Inorganic Non-Metal	29.33	0.17	1.01	0.16	4.31
Lead/Cadmium Metal	510.47	4.89	11.62	5.23	8.97
Salt	4.86	0.04	0.17	0.04	5.04
Soils	0	0	0	0	0
Solidified Inorganics	125.09	1.26	2.45	1.06	6.26
Solidified Organics	4,543.96	81.87	88.25	81.40	204.59
Uncategorized Metal	126.88	7.06	7.52	7.02	29.03

one-half of the detection limit was used for calculating average concentrations. The best available data was used to calculate concentrations of VOCs, but DOE recognizes that the data may not reflect actual usage of hazardous chemicals at all sites. Conservative assumptions, such as the assumption that all waste is mixed waste, were used to ensure the impacts stated in this document reflect a reasonable upper limit of likely impacts.

The average concentrations for the VOCs were computed for the various final TRU waste forms. SEIS-II volume data was divided into final TRU waste forms in order to compute a volume-weighted average concentration for the VOCs, according to site. The weighted average concentrations for CH-TRU waste under No Action Alternative 2 are given in Table A-47.

Concentrations of VOCs were directly used in the analyses and are given in Tables A-47 and A-48 for No Action Alternative 2. Both No Action Alternative 2 and the Proposed Action address disposal of the same waste; therefore, the same concentrations were appropriate for both. The same concentration was assumed to apply to all of the waste under Action Alternatives 1 and 3. Finally, the thermal processing assumed under Action Alternative 2 and No Action Alternative 1, removes any VOCs.

Table A-47
Volume-Weighted Average Concentrations (ppmv)
of Volatile Organic Compounds in CH-TRU Waste by Treatment Site
for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Volatile Organic Compound	Hanford	LANL	INEEL	SRS	RFETS	ORNL	LLNL	NTS	Mound	ANL-E
Carbon Tetrachloride	60.20	271.20	372.68	122.89	274.93	90.19	152.06	93.09	22.44	28.93
Chlorobenzene	9.65	6.20	9.41	8.33	2.67	9.37	9.45	9.39	3.75	12.16
Chloroform	11.84	13.65	17.73	16.13	8.98	18.81	18.53	18.83	3.20	7.35
Methyl Ethyl Ketone	40.40	21.00	54.23	53.43	19.57	61.45	62.88	61.55	11.22	36.64
Methylene Chloride	964.63	753.36	480.29	157.99	91.73	141.75	133.50	141.92	532.07	1,734.17
1,1,2,2-Tetrachloroethane	309.63	128.16	452.87	613.68	141.52	705.13	692.38	706.71	41.00	128.39
Toluene	6.05	3.78	7.04	6.69	2.23	7.57	7.68	7.59	2.02	6.49
1,1-Dichloroethene	8.60	4.47	10.16	12.51	3.21	14.28	13.99	14.31	2.18	7.03
1,2-Dichloroethane	6.01	3.64	6.96	6.64	2.18	7.55	7.66	7.56	2.00	6.45
1,1,1-Trichloroethane	22.31	15.67	23.18	21.56	10.12	23.88	24.44	23.95	8.32	26.42

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

Table A-48
Volume-Weighted Average Concentrations (ppmv)
of Volatile Organic Compounds in RH-TRU Waste by Treatment Site
for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Volatile Organic Compound	Hanford	LANL	INEEL	ORNL
Carbon Tetrachloride	26.13	212.58	119.03	172.05
Chlorobenzene	12.61	8.97	8.80	6.53
Chloroform	10.08	20.34	17.44	12.58
Methyl Ethyl Ketone	43.76	29.16	56.88	42.19
Methylene Chloride	1,586.14	1,161.64	172.75	94.56
1,1,2,2-Tetrachloroethane	241.67	145.58	638.56	500.94
Toluene	7.17	5.20	7.05	5.35
1,1-Dichloroethene	8.87	5.89	13.07	10.12
1,2-Dichloroethane	7.13	5.11	7.02	5.26
1,1,1-Trichloroethane	28.01	21.05	22.56	17.69

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

The RCRA Part B Permit Application sampling data were taken from drums containing CH-TRU waste. In the absence of further information, the same concentrations were assumed to apply to RH-TRU waste. The weighted average concentrations by site for RH-TRU waste for No Action Alternative 2 are given in Table A-48.

For analyses that require a total inventory, such as the groundwater analysis of No Action Alternative 2, headspace data were used to calculate a total inventory of organic contaminants. Rault's Law and the assumption that the maximum average quantity of organic liquid in TRU waste is 1-weight percent were used. The concentrations of volatile organic material in thermally treated waste forms were assumed to be zero, because these contaminants are removed during high-temperature processing. The calculated VOC inventories for both CH-TRU and RH-TRU waste according to site are shown in Tables A-49 and A-50.

Table A-49
Inventory (grams) of Volatile Organic Compounds in CH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Compound	Hanford	INEEL	LANL	ORNL	RFETS	SRS	LLNL
Carbon Tetrachloride	139,660	438,499	230,351	6,730	120,509	59,830	7,333
Chloroform	20,560	15,608	8,674	1,050	2,946	5,878	669
1,1-Dichloroethylene	3,759	2,253	715	201	265	1,147	127
Methylene Chloride	698,580	176,405	199,743	3,302	12,551	24,010	2,010
1,1,2,2-Tetrachloroethane	16,234,213	12,042,561	2,460,196	1,189,188	1,401,930	6,752,290	754,557
Chlorobenzene	216,336	106,937	50,878	6,756	11,324	39,169	4,401
Methyl Ethyl Ketone	136,670	93,043	26,013	6,686	12,509	37,925	4,421
Toluene	56,419	33,311	12,894	2,272	3,939	13,090	1,489
1,2-Dichloroethane	24,633	14,463	5,461	994	1,691	5,705	652
1,1,1-Trichloroethane	47,554	25,053	12,230	1,637	4,074	9,645	1,083

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

Table A-50
Inventory (grams) of Volatile Organic Compounds in RH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Compound	Hanford	INEEL	LANL	ORNL
Carbon Tetrachloride	31,024	9,397	1,959	25,450
Chloroform	8,958	1,031	140	1,392
1,1-Dichloroethylene	1,983	194	10	282
Methylene Chloride	587,915	4,257	3,342	4,366
1,1,2,2-Tetrachloroethane	6,485,477	1,139,327	30,327	1,674,680
Chlorobenzene	144,586	6,712	798	9,323
Methyl Ethyl Ketone	75,757	6,547	392	9,100
Toluene	34,223	2,238	193	3,181
1,2-Dichloroethane	14,949	978	83	1,374
1,1,1-Trichloroethane	30,552	1,636	178	2,405

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

A.6 REFERENCES CITED IN APPENDIX A

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy) and the State of New Mexico, 1981, "Agreement for Consultation and Cooperation" on the WIPP (Modified November 30, 1984, August 4, 1987, and March 22, 1988).

DOE (U.S. Department of Energy), 1989, *Safety Analysis Report for the TRUPACT-II Shipping Package (*March 3, 1989). Supplements dated May 26, June 27, June 30, August 3, and August 8, 1989; April 18, July 10, July 25, August 24, and December 20, 1990; April 11, April 29, and June 17, 1991; and September 24, 1992.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environment Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1991, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 4, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994a, *Integrated Data Base Report-1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Revision 11, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DOE (U.S. Department of Energy), 1994b, *TRUPACT-II Content Codes (TRUCON)*, DOE/WIPP 89-004, Revision 8, WIPP Project Office, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1994c, *Safety Analysis Report for the RH-72B Waste Shipping Package*, Revision 0, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *CH-TRU Waste Packaging Optimization Report*, Revision 0, September, Carlsbad, New Mexico.

DOE (U. S. Department of Energy), 1995b, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995c, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 0, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995d, *WIPP Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 2, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP 91-005, Revision 5.2, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996c, *WIPP Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *The 1996 Baseline Environmental Management Report*, DOE/EM-0290, June, Washington, D.C.

DOE (U.S. Department of Energy), 1996e, *The National Transuranic Waste Management Plan*, DOE/NTP-96-1204, Revision 0, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996f, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997a, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997b, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1997, *Certificate of Compliance No. 9218 for the Model No. TRUPACT-II Package*, Revision 8, Docket Number 71-9218, Washington, D.C.

Rivera, M., 1997, Documentation of Verbal Communication, DVC-40, May 6, 1997, Battelle, Albuquerque, New Mexico.

Williams, L., 1996, Documentation of Verbal Communication, DVC-18, December 12, 1995 and January 4, 1996, Battelle, Albuquerque, New Mexico.

APPENDIX B
SUMMARY OF THE WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT AND ITS USE IN DETERMINING HUMAN HEALTH IMPACTS AT TREATMENT SITES

The *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997) is a nationwide study examining the environmental impacts of managing five types of radioactive and hazardous wastes that result primarily from nuclear defense activities – the development, production, and testing of nuclear weapons at a variety of sites located around the United States. The five waste types are the following: low-level mixed waste, low-level waste, transuranic (TRU) waste, high-level waste, and hazardous waste.

For each waste-type system, facilities are needed to treat, store, and/or dispose of the waste. In the WM PEIS, the Department of Energy (DOE or the Department) has not only examined, in an integrated fashion, the impacts of complex-wide waste management for each waste type but also the specific cumulative impacts for all the waste facilities at a given site. The WM PEIS provides information on the impacts of various siting alternatives, which DOE will use in deciding where to locate additional treatment, storage, and/or disposal capacity for each waste type. However, the location of a facility at a selected site will not be decided until completion of a subsequent sitewide or project-specific National Environmental Policy Act (NEPA) review.

B.1 RELATIONSHIP OF DIFFERENT LEVELS OF NEPA DOCUMENTS

In accordance with DOE NEPA regulations, three types of NEPA documentation may be prepared: programmatic, sitewide, and project-level. Programmatic documents, such as the WM PEIS, provide environmental input into decisions on broad agency actions, such as the adoption of new plans, programs, and policies to guide future actions. Sitewide NEPA documents, such as this document (SEIS-II), provide the opportunity for considering changes in the overall operating mode of a DOE site, including mission change, and provide a current environmental baseline at the site. Project-level NEPA documents evaluate the impacts of a specific project at a specific location on a site and are intended to provide environmental input into the manner in which the facility should be constructed and operated. Sitewide NEPA documents, which evaluate projects that could be implemented in the near-term at a site, may also serve as project-level NEPA documents for specified projects.

B.2 WASTE MANAGEMENT DECISIONS TO BE MADE BY DOE

The WM PEIS is intended to provide environmental information to assist DOE in determining where to consolidate waste and where it should modify existing waste management facilities or construct new facilities. The TRU waste management facilities proposed in the WM PEIS are treatment and storage facilities. DOE needs to identify sites for waste management facilities in order to protect public health and safety, comply with federal law, and minimize adverse effects to the environment. If sites are selected for TRU waste treatment and storage facilities, DOE intends

to select the sites using the WM PEIS analysis but will not select the level of treatment needed. Treatment level decisions will be made using SEIS-II analyses. Specific locations for the waste management facilities within a site will be selected on the basis of subsequent sitewide or project-level NEPA documents.

B.3 OVERVIEW OF THE WM PEIS TRU WASTE ANALYSES

SEIS-II refers to relevant information, primarily concerning treatment sites, from several documents, including the *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1996b), the *Resource Conservation and Recovery Act (RCRA) Part B Application* (DOE 1996a) and the WM PEIS (DOE 1997); SEIS-II updates and scales information with more recent information from these other documents. The following sections present an overview of information in the WM PEIS that is relevant to SEIS-II.

B.3.1 TRU Waste

TRU waste analyzed in the WM PEIS considers both contact-handled (CH) TRU and remote-handled (RH) TRU waste placed in retrievable storage across the DOE complex since 1970 and projected to be generated for 20 years. For the purposes of WM PEIS analyses, DOE included the small amount of nondefense TRU waste.

In addition, approximately 60 percent of the TRU waste also contains hazardous constituents as defined by the Resource Conservation and Recovery Act (RCRA); this waste is called TRU mixed waste. For purposes of the WM PEIS analyses, DOE assumed that the entire inventory of TRU waste was TRU mixed waste.

Management activities associated with TRU waste that are discussed in the WM PEIS include (1) retrieving TRU waste from storage and transporting it to a treatment facility; (2) sorting and treating the TRU waste as appropriate, packaging the waste, and certifying the waste for shipment to the Waste Isolation Pilot Plant (WIPP) for disposal; (3) storing certified waste; and (4) transporting the TRU waste to WIPP for disposal. For all of its alternatives except its no action alternative, the WM PEIS assumed that TRU waste would be disposed of at WIPP.

B.3.2 TRU Waste Generator Sites and Inventories

Sixteen sites are identified in the WM PEIS that have or are expected to generate or manage TRU waste.

Major sites identified in the WM PEIS include the following:

- Argonne National Laboratory-East (ANL-E) near Chicago, Illinois
- Hanford Site (Hanford) at Richland, Washington
- Idaho National Engineering and Environmental Laboratory (INEEL) near Idaho Falls, Idaho
- Lawrence Livermore National Laboratory (LLNL) near San Francisco, California
- Los Alamos National Laboratory (LANL) at Los Alamos, New Mexico

- Mound Plant (Mound) at Miamisburg, Ohio
- Nevada Test Site (NTS) near Las Vegas, Nevada
- Oak Ridge Reservation (ORR) at Oak Ridge, Tennessee (identified as Oak Ridge National Laboratory [ORNL] in SEIS-II)
- Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado
- Savannah River Site (SRS) at Aiken, South Carolina.

Identified as smaller generators are the following:

- Energy Technology Engineering Center (ETEC) at Canoga Park, California
- Lawrence Berkeley Laboratory (LBL) at Berkeley, California
- Paducah Gaseous Diffusion Plant (PGDP) at Paducah, Kentucky
- Sandia National Laboratories (SNL) at Albuquerque, New Mexico
- University of Missouri at Columbia (U of Mo), Missouri
- West Valley Demonstration Project (WVDP) at West Valley, New York. The small amount of waste from this site originated from commercial reprocessing of spent nuclear fuel and so is not defense related.

The WM PEIS analyzes the potential environmental impacts for managing approximately 67,000 cubic meters (2.4 million cubic feet) of retrievably stored CH-TRU waste and about 1,700 cubic meters (60,000 cubic feet) of retrievably stored RH-TRU waste. Approximately 95 percent of the existing CH-TRU waste and RH-TRU waste is stored at Hanford, INEEL, LANL, ORR, RFETS, and SRS.

An additional 47,000 cubic meters (1.7 million cubic feet) of CH-TRU waste and 17,000 cubic meters (600,000 cubic feet) of RH-TRU waste was assumed to be generated over the next 20 years (excluding TRU waste that would result from environmental restoration activities), for a total of about 132,000 cubic meters (4.7 million cubic feet) of retrievably stored TRU waste. The inventory and annual generator rates for the WM PEIS were obtained from the *Interim Mixed Waste Inventory Report* (DOE 1993) and the *Integrated Data Base for 1992* (DOE 1992). Updated information on waste volumes was used for Hanford and SRS. Updated data for TRU waste were taken from two sources: the *Mixed Waste Inventory Summary Report* (MWIR 95) (DOE 1995a) and the *Transuranic Waste Baseline Inventory Report, Revision 2* (BIR-2) (DOE 1995b), with most of the new information taken from MWIR 95. Table B-1 presents the waste volumes as used in WM PEIS risk calculations; this table is the same as WM PEIS Table 8.1-1. SEIS-II analyses differ slightly from the WM PEIS regarding TRU waste volumes, years of generation, and the number of sites producing waste as discussed in Appendix A. These

changes presented in SEIS-II were necessary to evaluate the most recent information and Departmental planning assumptions that were available for analysis. For example, SEIS-II waste volumes include environmental restoration wastes in the Additional Inventory; SEIS-II also assumes a 35-year operations period; and the number of TRU waste sites was expanded to include smaller sites captured in the updated inventory.

Table B-1
Transuranic Waste Volumes of the WM PEIS (cubic meters)

	CH-TRU Waste			RH-TRU Waste			
Site [a]	**Inventory**	**20-Year Projected Generation**	**Estimated Inventory + 20 Year Generation**	**Inventory**	**20-Year Projected Generation**	**Estimated Inventory + 20 Year Generation**	**Total**
ANL-E	15	940	960	---	340	340	1,300
ETEC	0.02	---	0.02	---	---	---	0.02
Hanford	12,000	24,000	36,000	200	15,400	16,000	52,000
INEEL	38,000	280	38,000	110	500	610	39,000
LANL	8,200	2,500	11,000	79	10	89	11,000
LBL	0.8	0.2	1	---	---	---	1
LLNL	200	1,500	1,700	---	---	---	1,700
Mound	274	1,200	1,500	---	---	---	1,500
NTS	610	---	610	---	---	---	610
ORR	670	360	1,000	1,300	360	1,700	2,700
PGDP	14	---	14	---	---	---	14
RFETS	1,500	4,800	6,200	---	---	---	6,200
SNL	1	---	1	---	---	---	1
SRS	5,100	11,500	16,600	---	---	---	16,600
U of Mo	---	2	2	---	---	---	2
WVDP	0.5	---	0.5	---	---	---	0.5
Total	**67,000**	**47,000**	**114,000**	**1,700**	**17,000**	**18,000**	**132,000**

[a] WIPP, the seventeenth site, does not currently have any TRU waste.

Note: Volume data are rounded from field estimates and columns and rows do not add. Waste volume projections contained in this and other WM PEIS tables were based on 1993 or earlier data and may vary from the latest site estimates at the time of publication.

Source: WM PEIS, Table 8.1-1

B.3.3 Waste Treatment

There are three alternative waste treatments considered in the WM PEIS: treatment to the Waste Acceptance Criteria (WAC); shredding and using grout; and treatment to the RCRA Land Disposal Restrictions (LDR). Compliance with WAC is the minimum level of treatment required. The shred and grout treatment would be used to further stabilize the waste and reduce the rate of potential gas generation. Treatment to meet LDRs would further stabilize and consolidate waste and destroy volatile organic compounds (VOCs) in the waste. For more information on these treatment technologies, see Chapter 2.

B.3.4 Alternatives

As stated above, the WM PEIS was prepared to support decisions on where to treat and store TRU waste. To assist DOE in making decisions regarding the sites at which it should locate waste management facilities, the WM PEIS considers four categories of alternatives for each waste type: the no action alternative, decentralized alternatives that would minimize the transportation of waste between sites, regionalized alternatives that would locate waste management facilities at several sites throughout the nation, and a centralized alternative that would locate large waste management facilities at only one site for CH-TRU waste and two sites for RH-TRU waste. For TRU waste, DOE considers more than one regionalized alternative in order to vary the number of sites having waste management facilities and the sites at which the facilities could be located. This variation among alternatives allows flexibility when considering the future configuration of waste management facilities. These TRU waste alternatives are summarized in the following subsections. All WM PEIS action alternatives discussed below assume that the waste would be shipped to WIPP for disposal.

B.3.4.1 Decentralized Alternative

Under the WM PEIS Decentralized Alternative, DOE would, as needed, treat and package TRU waste to meet WAC. The treatment and packaging would occur at all sites. After treatment, CH-TRU waste would be shipped to the nearest one of the 10 sites with the larger amount of TRU waste for storage prior to disposal in WIPP.

B.3.4.2 Regionalized Alternatives

The WM PEIS regionalized alternatives would consolidate TRU waste for treatment and storage prior to disposal. Three TRU waste regionalized alternatives are analyzed, with varying degrees of treatment at six and four sites, and storage at those sites prior to disposal in WIPP.

Regionalized 1

Under the WM PEIS Regionalized 1 Alternative, CH-TRU waste would be shipped from the 10 smallest generators to the four sites with the largest volumes of TRU waste (Hanford, INEEL, LANL, and SRS). In addition, RFETS would continue to treat its own waste, but would not receive waste from off site. RH-TRU waste would be shipped from ANL-E, INEEL, and LANL to Hanford or ORR for treatment. At all six treatment sites, TRU waste would be treated using a shred and grout process (referred to in the WM PEIS as the “reduce gas generation potential”). The six treatment sites proposed under this alternative have 95 percent of current and anticipated TRU waste inventories.

Regionalized 2

Under the WM PEIS Regionalized 2 Alternative, DOE would use the same waste consolidation configuration as in Regionalized 1, except that the TRU waste would be treated to meet the LDRs.

Regionalized 3

Under the WM PEIS Regionalized 3 Alternative, the consolidation of waste for treatment at four sites (Hanford, INEEL, ORR, and SRS) where approximately 80 percent of TRU waste is already located or is expected to be generated is considered. CH-TRU waste would be treated at

Hanford, INEEL, and SRS; RH-TRU waste would be treated at Hanford and ORR. Under this alternative, TRU waste would be treated to meet the LDRs.

B.3.4.3 Centralized Alternative

Under the WM PEIS Centralized Alternative, DOE would ship all CH-TRU waste to WIPP for treatment to meet the LDRs and for disposal. RH-TRU waste would be shipped to Hanford and ORR for treatment to meet the LDRs and eventually disposed of in WIPP.

B.3.4.4 No Action Alternative

Under the WM PEIS No Action Alternative, DOE would continue to characterize, process, and package newly generated TRU waste based on the current WAC for storage at sites where existing or planned facilities are available. DOE would continue to store TRU waste in existing storage facilities for the duration of this analysis (20 years) and would not ship TRU waste for off-site storage; there would be no disposal. All sites are assumed to have adequate capabilities to package and store TRU waste generated in the future. Eleven sites have projected future TRU waste generation, including five sites generating both CH-TRU and RH-TRU waste. The WM PEIS No Action Alternative does not assess the health risks, environmental impacts, or costs of removing TRU waste from retrievable storage and packaging it.

B.4 INCORPORATION OF WM PEIS INTO SEIS-II ANALYSES

WM PEIS analyses form the basis of the SEIS-II analysis of generator site impacts. These impacts, adjusted for different inventories and other analysis assumptions and combined with the SEIS-II analyses of impacts from waste disposal at WIPP and lag storage at the generator sites, present a comprehensive picture of the potential human health impacts complex-wide from management, treatment, and disposal of TRU waste.

The WM PEIS examines potential impacts of management and treatment of the various waste types. Impact areas evaluated in the WM PEIS for all of the waste types include human health risks, air quality, water resources, ecological resources, socioeconomics, land use, environmental justice, infrastructure, cultural resources, and cost.

The relevant portions of the WM PEIS have been summarized and incorporated in SEIS-II. Where appropriate, the WM PEIS impacts have been adjusted to reflect recent information such as revised estimates of future waste generation, cumulative impacts, and potential future activities at the sites. Life-cycle costs and transportation analyses have been reexamined and revised with the results presented in Chapter 5 and methods presented in Appendices D and E, respectively. Human health impacts from the WM PEIS have also been adjusted to reflect waste inventory differences and other factors considered under the SEIS-II alternatives.

For routine operations involving treatment, health impacts in the WM PEIS are evaluated for the off-site population, the on-site worker population not involved in treatment, and waste management workers directly involved in treatment activities. Impacts are quantified using two approaches: analysis of population health risk impacts and analysis of individual health risk impacts. Population impacts focus on the total number of people in each population who may experience adverse health impacts if a particular alternative were implemented.

B.5 USING HUMAN HEALTH IMPACTS AT TREATMENT SITES FROM THE WM PEIS

SEIS-II focuses on impacts from disposal of TRU waste. However, human health impacts from management and treatment of TRU waste at the generator sites, addressed in the WM PEIS, may be a major contributor to the overall risk of disposing of TRU waste and preparing it for disposal.

Overall, in the WM PEIS the numerically largest health risks result from alternatives where TRU waste is treated to meet the LDRs (the WM PEIS Regionalized 2, Regionalized 3, and Centralized alternatives). These alternatives assume the use of thermal destruction of organic waste to meet the LDRs. This treatment method results in emissions of radionuclides that result in additional off-site cancer risks; the maximally exposed individuals (MEI) are at LANL, INEEL, and WIPP. Although postulated waste management worker fatalities primarily result from physical hazards, fatalities are lower when TRU waste is treated to planning-basis WAC or by a shred and grout process than when TRU waste is treated to meet the LDRs.

Because of differences between the WM PEIS and SEIS-II, it was necessary to adjust the impacts from the WM PEIS before they could be used in SEIS-II. SEIS-II analyses use different TRU waste volumes and radionuclide inventories than those in the WM PEIS, and include environmental restoration wastes in the Additional Inventory. SEIS-II alternatives also differ from the WM PEIS by having more years of waste generation and site operation, more sites producing waste, and, in some cases, the waste inventory and the manner of waste consolidation. Human health impacts adjusted from the WM PEIS are those occurring as a result of routine waste treatment and management operations and do not include accidents involving workers or members of the public. Therefore, only those impacts resulting from routine releases and exposure to radioactive material and hazardous chemicals, resulting in potential latent fatal cancers (LCFs) or cancer incidence, respectively, were adjusted.

Radiation-related human health impacts for members of the public and noninvolved workers at the treatment/generator sites were adjusted based on differences in (1) waste volumes treated at the major treatment sites and (2) site-specific concentrations of key radionuclides. These adjustments resulted in a volume ratio (VR) and a concentration ratio (CR), respectively. Radiation-related human health impacts for involved workers and all estimates of cancer incidence from exposure to hazardous chemicals were adjusted only on differences in the waste volumes handled and treated. Key radionuclide and exposure pathway information for involved workers and quantitative hazardous chemical information were not available in the WM PEIS.

Equation B-1 was used to calculate the adjusted radiation dose and LCFs from waste treatment to the off-site population, the MEI, the noninvolved worker population, and the maximally exposed noninvolved worker for the SEIS-II.

$$\text{SEIS-II treatment impact} = \text{VR} \times \text{CR} \times (\text{WM PEIS treatment impact}) \quad \text{(Equation B-1)}$$

Equation B-2 was used to calculate the adjusted radiation dose and LCFs for the involved worker population and the hazardous chemical cancer incidence for all populations and individuals.

$$\text{SEIS-II treatment impact} = \text{VR} \times (\text{WM PEIS treatment impact}) \quad \text{(Equation B-2)}$$

where

VR = SEIS-II/WM PEIS waste volume ratio

and CR = SEIS-II/WM PEIS key radionuclide concentration ratio

with both VR and CR varied for each treatment site, alternative, inventory type (Total, Additional, or Basic) and waste type (CH-TRU or RH-TRU). Table B-2 presents the VR and key radionuclide CR for each treatment site, alternative, inventory type (Total, Basic, and Additional) and waste type (CH-TRU and RH-TRU).

Waste volume information for SEIS-II was taken from the "Pre-Treatment Consolidated Volume" columns of Tables A-5 through A-14 of Appendix A. The WM PEIS TRU waste volumes used were those presented in Table B-1 and in Table 8.1-1 of the WM PEIS. The volume ratio calculations were done for each of three SEIS-II inventories: the Basic Inventory, the Additional Inventory, and the Total Inventory except for the Proposed Action and No Action Alternative 2 for which the Basic and Total Inventory are the same (for more information on these inventories, see Chapters 2 and 3 and Appendix A).

Key radionuclides are those defined in Appendix D of the WM PEIS as the single radionuclide contributing the highest risk of latent cancer fatality at each site under each alternative. Key radionuclides contributing the highest risk to off-site populations are listed in WM PEIS Table D.3.4-18 for CH-TRU waste and in WM PEIS Table D.3.4-34 for RH-TRU waste. These key radionuclide concentrations were also used to adjust impacts to the MEI, noninvolved worker population and the maximally exposed noninvolved worker.

Once these key radionuclides were identified, radionuclide concentrations for the SEIS-II alternatives were calculated using the radionuclide inventory and volume data shown in Appendix A. Concentrations were determined by dividing the total activity per year of a particular radionuclide by the total annual volume in cubic meters per year.

The concentrations of the WM PEIS key radionuclides at the various sites were taken from the tables in Appendix B of *Transuranic Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement* (ANL 1995). The tables used for WM PEIS CH-TRU waste radionuclide concentrations were as follows (for an explanation of the SEIS-II alternatives, see Chapter 3 of this document):

Table B-2 was used for the Proposed Action, Action Alternative 1, and No Action Alternative 2

- Table B-3 was used for Action Alternative 3
- Table B-4 was used for Action Alternative 2A and No Action Alternative 1A
- Table B-5 was used for Action Alternative 2B and No Action Alternative 1B
- Table B-6 was used for Action Alternative 2C

Table B-2
Key Radionuclide Concentration and Volume Adjustment Factors for CH-TRU and RH-TRU Waste

Site	Key Radionuclide [a]	SEIS/WM PEIS			
		Concentration Ratio	Volume Ratio		
			Total	Basic	Additional
Proposed Action (Decentralized) [b]					
CH-TRU Waste					
ANL-E	Plutonium-239	0.47	0.21	Same as Total	N/A
Hanford	Plutonium-238	0.26	1.60		N/A
INEEL	Americium-241	1.86	0.77		N/A
LANL	Americium-241	0.07	1.91		N/A
LLNL	Plutonium-239	0.49	0.70		N/A
NTS	Plutonium-239	40.67	1.04		N/A
RFETS	Americium-241	6.72	1.75		N/A
SRS	Plutonium-238	0.25	0.73		N/A
RH-TRU Waste					
Hanford	Plutonium-239	0.14	1.89	Same as Total	N/A
INEEL	Plutonium-241	0.04	3.21		N/A
LANL	Plutonium-239	0.56	2.57		N/A
ORNL	Curium-244	0.42	2.16		N/A
Action Alternative 1 (Decentralized) [b]					
CH-TRU Waste					
ANL-E	Plutonium-239	0.40	0.21	0.21	-- [c]
Hanford	Plutonium-238	0.22	3.34	1.60	1.74
INEEL	Americium-241	1.59	2.26	0.77	1.49
LANL	Americium-241	0.06	3.18	1.91	1.26
LLNL	Plutonium-239	0.42	0.70	0.70	-- [c]
NTS	Plutonium-239	34.41	1.04	1.04	-- [c]
RFETS	Americium-241	6.17	1.75	1.75	-- [c]
SRS	Plutonium-238	0.19	1.02	0.73	0.29
RH-TRU Waste					
Hanford	Plutonium-239	0.22	1.95	1.89	0.07
INEEL	Plutonium-241	0.04	3.93	3.21	0.73
LANL	Plutonium-239	0.56	3.90	2.57	1.33
ORNL	Curium-244	0.42	3.29	2.16	1.13
Action Alternative 2A and No Action Alternative 1A (Regionalized 2) [b]					
CH-TRU Waste					
Hanford	Plutonium-238	0.24	3.22	1.56	1.67
INEEL	Americium-241	1.62	2.25	0.77	1.48
LANL	Americium-241	0.06	3.18	1.91	1.26
RFETS	Americium-241	10.67	1.75	1.75	-- [c]
SRS	Plutonium-238	3.85	0.98	0.72	0.26
RH-TRU Waste					
Hanford	Plutonium-239	1.54	2.04	1.94	0.10
ORNL	Curium-244	0.16	2.71	1.78	0.93

[a] WM PEIS key radionuclides are found in Table D.3.4-18 for CH-TRU waste and in Table D.3.4-34 for RH-TRU waste.
[b] The WM PEIS alternative is shown in parenthesis.
[c] No waste in this inventory.

N/A = Not Applicable

Table B-2
Key Radionuclide Concentration and Volume
Adjustment Factors for CH-TRU and RH-TRU Waste — Continued

Site	Key Radionuclide [a]	SEIS/WM PEIS			
		Concentration Ratio	Volume Ratio		
Action Alternative 2B and No Action Alternative 1B (Regionalized 3) [b]					
CH-TRU Waste					
Hanford	Plutonium-238	4.14	**Total**	**Basic**	**Additional**
INEEL	Americium-241	1.29	2.38	1.11	1.27
SRS	Plutonium-238	3.85	0.98	0.72	0.26
RH-TRU Waste					
Hanford	Plutonium-239	1.54	2.04	1.94	0.10
ORNL	Curium-244	0.16	2.71	1.78	0.93
Action Alternative 2C (Centralized) [b]					
CH-TRU Waste					
WIPP	Plutonium-238	1.43	2.41	1.19	1.22
RH-TRU Waste					
Hanford	Plutonium-239	1.54	2.04	1.94	0.10
ORNL	Curium-244	0.16	2.71	1.78	0.93
Action Alternative 3 (Regionalized 1) [b]					
CH-TRU Waste					
Hanford	Plutonium-238	4.14	3.22	1.56	1.66
INEEL	Americium-241	6.16	2.24	0.77	1.46
LANL	Americium-241	16.35	3.18	1.91	1.26
RFETS	Americium-241	0.09	1.75	1.75	
SRS	Plutonium-238	3.85	0.97	0.72	0.26
RH-TRU Waste					
Hanford	Plutonium-239	0.22	2.04	1.94	0.10
ORNL	Curium-244	0.16	2.71	1.78	0.93
No Action Alternative 2 (Decentralized) [b]					
CH-TRU Waste					
ANL-E	Plutonium-239	2.50	0.19	Same as Total	N/A
Hanford	Plutonium-238	4.47	1.26		N/A
INEEL	Americium-241	0.63	0.03		N/A
LANL	Americium-241	16.35	0.91		N/A
LLNL	Plutonium-239	2.39	0.56		N/A
NTS	Plutonium-239	0.03	0.02		N/A
RFETS	Americium-241	0.16	0.96		N/A
SRS	Plutonium-238	4.66	0.55		N/A
RH-TRU Waste					
Hanford	Plutonium-239	0.22	1.89	Same as Total	N/A
INEEL	Plutonium-241	0.01	2.57		N/A
LANL	Plutonium-239	0.89	3.21		N/A
ORNL	Curium-244	0.19	2.16		N/A

[a] WM PEIS key radionuclides are found in Table D.3.4-18 for CH-TRU waste and in Table D.3.4-34 for RH-TRU waste.
[b] The WM PEIS alternative is shown in parenthesis.
[c] No waste in this inventory.

N/A = Not Applicable

The tables used for WM PEIS RH-TRU waste radionuclide concentrations were as follows:

- Table B-8 was used for the Proposed Action, Action Alternative 1, and No Action Alternative 2
- Table B-9 was used for Action Alternative 3
- Table B-10 was used for Action Alternatives 2A, 2B, and 2C and No Action Alternatives 1A and 1B.

The WM PEIS presents only the total site-specific impacts (Volume II; impacts not broken out by CH-TRU or RH-TRU waste) and the total programmatic impact from CH-TRU and RH-TRU waste (Appendix D of the WM PEIS). For most sites, this does not present a problem because most are principally either a CH-TRU or a RH-TRU waste site. For these sites, the impact from CH-TRU and RH-TRU waste was apportioned by the relative volumes of CH-TRU and RH-TRU waste treated at the site. At Hanford, impacts to the offsite population, the MEI, the noninvolved worker population, and the maximally exposed noninvolved worker were apportioned by the differences between the Regionalized 2 and Regionalized 3 alternatives (which have identical human health impacts at Hanford, where both CH-TRU and RH-TRU waste are treated) and the Centralized alternative, where only RH-TRU waste is treated at Hanford. However, under the SEIS-II alternatives, the CH-TRU and RH-TRU waste volumes at Hanford are very similar, and impacts to the involved worker population would be expected to be significantly higher from handling CH-TRU waste than from handling the same volume of RH-TRU waste. Therefore, impacts to the Hanford involved worker population from CH-TRU and RH-TRU waste were apportioned using the ratio of CH-TRU and RH-TRU waste programmatic impacts for each WM PEIS alternative, shown in Appendix D of the WM PEIS (Tables D.3.4-3 and D.3.4-23). Calculated impacts from hazardous chemicals are generally higher from RH-TRU waste than from CH-TRU waste, while radiological impacts are higher from CH-TRU waste than from RH-TRU waste.

No impacts are expected to any of the analyzed groups from exposure to hazardous chemicals; and there is no expectation of LCFs in the MEI, noninvolved worker population, or the noninvolved worker MEI. For RH-TRU waste treatment, there is no expectation of cancer incidence or LCF from exposure to hazardous chemicals or radionuclides. SEIS-II estimates of waste treatment impacts adjusted from WM PEIS human health impacts are principally noted for the off-site populations and for waste treatment worker populations. The adjusted human health impacts from DOE site treatment of CH-TRU and RH-TRU waste are presented by site for each of the SEIS-II alternatives, Total, Basic, and Additional inventories, in Tables B-3 through B-19. Radiation-related LCFs may be expected in the population under Action Alternatives 2A, 2B, and 2C and No Action Alternatives 1A and 1B. There is a calculated expectation of up to 2.4 LCFs for the Total Inventory under Action Alternative 2A and No Action Alternative 1A. Up to 2.3 LCFs may be expected under Action Alternative 2B and No Action Alternative 1B, and about 1 LCF (0.9) may be expected under Action Alternative 2C.

Table B-3
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for the Proposed Action Total (Basic) Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	1.9E-02	4.1E-07	9.7E-04	1.6E-06	4.9E+02	4.7E-05	9.9E-10	2.4E-06	4.0E-09	9.0E-01	1.9E-02	4.1E-07	9.7E-04	1.6E-06	5.0E+02
LANL	1.5E-02	1.5E-06	1.3E-03	1.0E-06	6.8E+02	1.3E-03	1.3E-07	1.1E-04	8.5E-08	7.4E+00	1.6E-02	1.6E-06	1.5E-03	1.1E-06	6.9E+02
INEEL	3.2E-03	3.9E-07	9.5E-04	8.1E-07	4.8E+02	4.3E-06	5.2E-10	1.3E-06	1.1E-09	3.2E+01	3.2E-03	3.9E-07	9.6E-04	8.2E-07	5.1E+02
SRS	2.8E-02	2.6E-07	2.9E-03	2.6E-06	1.2E+02	0	0	0	0	0	2.8E-02	2.6E-07	2.9E-03	2.6E-06	1.2E+02
RFETS	2.2E-01	2.9E-06	1.1E-02	6.7E-06	3.3E+01	0	0	0	0	0	2.2E-01	2.9E-06	1.1E-02	6.7E-06	3.3E+01
ORNL	0	0	0	0	0	1.4E-03	4.4E-08	4.8E-05	4.4E-08	1.5E+01	1.4E-03	4.4E-08	4.8E-05	4.4E-08	1.5E+01
LLNL	2.4E-03	3.8E-08	1.2E-04	4.2E-08	9.8E-01	0	0	0	0	0	2.4E-03	3.8E-08	1.2E-04	4.2E-08	9.8E-01
NTS	9.7E-06	2.5E-09	2.7E-05	1.2E-07	5.4E-01	0	0	0	0	0	9.7E-06	2.5E-09	2.7E-05	1.2E-07	5.4E-01
ANL-E	4.0E-04	2.2E-09	2.1E-06	2.1E-09	4.6E+00	0	0	0	0	0	4.0E-04	2.2E-09	2.1E-06	2.1E-09	4.6E+00
Total	2.9E-01		1.7E-02		1.8E+03	2.7E-03		1.6E-04		5.5E+01	2.9E-01		1.8E-02		1.9E+03
Radiation-Related LCFs															
Hanford	9.7E-06	2.0E-10	3.9E-07	6.6E-10	2.0E-01	2.4E-08	5.0E-13	9.4E-10	1.6E-12	3.6E-04	9.7E-06	2.0E-10	3.9E-07	6.6E-10	2.0E-01
LANL	7.5E-06	7.5E-10	5.4E-07	4.1E-10	2.7E-01	6.3E-07	6.3E-11	4.5E-08	3.4E-11	3.0E-03	8.2E-06	8.2E-10	5.8E-07	4.4E-10	2.8E-01
INEEL	1.6E-06	2.0E-10	3.8E-07	3.3E-10	1.9E-01	2.1E-09	2.6E-13	5.1E-10	4.3E-13	1.3E-02	1.6E-06	2.0E-10	3.8E-07	3.3E-10	2.0E-01
SRS	1.4E-05	1.3E-10	1.2E-06	1.0E-09	4.9E-02	0	0	0	0	0	1.4E-05	1.3E-10	1.2E-06	1.0E-09	4.9E-02
RFETS	1.1E-04	1.5E-09	4.4E-06	2.7E-09	1.3E-02	0	0	0	0	0	1.1E-04	1.5E-09	4.4E-06	2.7E-09	1.3E-02
ORNL	0	0	0	0	0	7.2E-07	2.2E-11	1.9E-08	1.8E-11	5.9E-03	7.2E-07	2.2E-11	1.9E-08	1.8E-11	5.9E-03
LLNL	1.2E-06	1.9E-11	4.7E-08	1.7E-11	3.9E-04	0	0	0	0	0	1.2E-06	1.9E-11	4.7E-08	1.7E-11	3.9E-04
NTS	4.9E-09	1.2E-12	1.1E-08	4.9E-11	2.2E-04	0	0	0	0	0	4.9E-09	1.2E-12	1.1E-08	4.9E-11	2.2E-04
ANL-E	2.0E-07	1.1E-12	8.3E-10	8.3E-13	1.8E-03	0	0	0	0	0	2.0E-07	1.1E-12	8.3E-10	8.3E-13	1.8E-03
Total	1.5E-04		7.0E-06		7.3E-01	1.4E-06		6.6E-08		2.2E-02	1.5E-04		7.0E-06		7.5E-01
Chemicals - Cancer Incidence															
Hanford	1.3E-10	0	8.0E-11	1.6E-13	3.5E-08	6.3E-13	0	3.8E-13	7.4E-16	6.4E-11	1.3E-10	0	8.0E-11	1.6E-13	3.5E-08
LANL	1.3E-09	1.6E-13	6.5E-10	4.0E-13	6.6E-08	1.4E-11	1.7E-15	7.0E-12	4.3E-15	7.2E-10	1.3E-09	1.6E-13	6.5E-10	4.0E-13	6.7E-08
INEEL	1.7E-09	2.4E-13	2.3E-09	1.9E-12	6.9E-06	1.2E-10	1.6E-14	1.5E-10	1.3E-13	4.7E-07	1.9E-09	2.6E-13	2.4E-09	2.0E-12	7.4E-06
SRS	1.4E-11	0	6.9E-12	8.0E-15	3.1E-09	0	0	0	0	0	1.4E-11	0	6.9E-12	8.0E-15	3.1E-09
RFETS	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08	0	0	0	0	0	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08
ORNL	0	0	0	0	0	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06
LLNL	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07	0	0	0	0	0	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07
NTS	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10	0	0	0	0	0	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10
ANL-E	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10	0	0	0	0	0	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10
Total	9.6E-08		2.4E-08		7.7E-06	3.5E-07		1.1E-07		6.9E-06	4.4E-07		1.4E-07		1.5E-05

Table B-4
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Total Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	3.4E-02	7.2E-07	1.7E-03	2.9E-06	1.0E+03	7.8E-05	1.6E-09	3.9E-06	6.6E-09	9.4E-01	3.4E-02	7.2E-07	1.7E-03	2.9E-06	1.0E+03
LANL	2.1E-02	2.1E-06	1.9E-03	1.4E-06	1.1E+03	1.9E-03	1.9E-07	1.7E-04	1.3E-07	1.1E+01	2.3E-02	2.3E-06	2.1E-03	1.6E-06	1.1E+03
INEEL	8.1E-03	9.9E-07	2.4E-03	2.1E-06	1.4E+03	5.3E-06	6.4E-10	1.6E-06	1.3E-09	3.9E+01	8.1E-03	9.9E-07	2.4E-03	2.1E-06	1.4E+03
SRS	3.0E-02	2.8E-07	3.2E-03	2.8E-06	1.7E+02	0	0	0	0	0	3.0E-02	2.8E-07	3.2E-03	2.8E-06	1.7E+02
RFETS	2.1E-01	2.7E-06	1.0E-02	6.2E-06	3.3E+01	0	0	0	0	0	2.1E-01	2.7E-06	1.0E-02	6.2E-06	3.3E+01
ORNL	0	0	0	0	0	2.2E-03	6.7E-08	7.4E-05	6.7E-08	2.2E+01	2.2E-03	6.7E-08	7.4E-05	6.7E-08	2.2E+01
LLNL	2.0E-03	3.2E-08	1.0E-04	3.5E-08	9.8E-01	0	0	0	0	0	2.0E-03	3.2E-08	1.0E-04	3.5E-08	9.8E-01
NTS	8.2E-06	2.1E-09	2.3E-05	1.0E-07	5.4E-01	0	0	0	0	0	8.2E-06	2.1E-09	2.3E-05	1.0E-07	5.4E-01
ANL-E	3.3E-04	1.8E-09	1.8E-06	1.8E-09	4.6E+00	0	0	0	0	0	3.3E-04	1.8E-09	1.8E-06	1.8E-09	4.6E+00
Total	3.0E-01		1.9E-02		3.8E+03	4.2E-03		2.5E-04		7.4E+01	3.1E-01		2.0E-02		3.9E+03
Radiation-Related LCFs															
Hanford	1.7E-05	3.6E-10	6.8E-07	1.2E-09	4.1E-01	3.9E-08	8.2E-13	1.6E-09	2.7E-12	3.7E-04	1.7E-05	3.6E-10	6.9E-07	1.2E-09	4.1E-01
LANL	1.1E-05	1.1E-09	7.6E-07	5.7E-10	4.5E-01	9.6E-07	9.6E-11	6.8E-08	5.1E-11	4.5E-03	1.2E-05	1.2E-09	8.2E-07	6.2E-10	4.6E-01
INEEL	4.1E-06	4.9E-10	9.6E-07	8.2E-10	5.6E-01	2.6E-09	3.2E-13	6.2E-10	5.3E-13	1.6E-02	4.1E-06	5.0E-10	9.6E-07	8.2E-10	5.8E-01
SRS	1.5E-05	1.4E-10	1.3E-06	1.1E-09	6.9E-02	0	0	0	0	0	1.5E-05	1.4E-10	1.3E-06	1.1E-09	6.9E-02
RFETS	1.0E-04	1.4E-09	4.1E-06	2.5E-09	1.3E-02	0	0	0	0	0	1.0E-04	1.4E-09	4.1E-06	2.5E-09	1.3E-02
ORNL	0	0	0	0	0	1.1E-06	3.3E-11	2.9E-08	2.7E-11	8.9E-03	1.1E-06	3.3E-11	2.9E-08	2.7E-11	8.9E-03
LLNL	1.0E-06	1.6E-11	4.0E-08	1.4E-11	3.9E-04	0	0	0	0	0	1.0E-06	1.6E-11	4.0E-08	1.4E-11	3.9E-04
NTS	4.1E-09	1.1E-12	9.1E-09	4.1E-11	2.2E-04	0	0	0	0	0	4.1E-09	1.1E-12	9.1E-09	4.1E-11	2.2E-04
ANL-E	1.7E-07	9.2E-13	7.0E-10	7.0E-13	1.8E-03	0	0	0	0	0	1.7E-07	9.2E-13	7.0E-10	7.0E-13	1.8E-03
Total	1.5E-04		7.8E-06		1.5E+00	2.1E-06		1.0E-07		2.9E-02	1.5E-04		7.9E-06		1.5E+00
Chemicals - Cancer Incidence															
Hanford	2.8E-10	0	1.7E-10	3.3E-13	7.3E-08	6.6E-13	0	3.9E-13	7.7E-16	6.6E-11	2.8E-10	0	1.7E-10	3.3E-13	7.3E-08
LANL	2.1E-09	2.6E-13	1.1E-09	6.6E-13	1.1E-07	2.1E-11	2.6E-15	1.1E-11	6.6E-15	1.1E-09	2.2E-09	2.6E-13	1.1E-09	6.7E-13	1.1E-07
INEEL	5.1E-09	7.1E-13	6.7E-09	5.5E-12	2.0E-05	1.4E-10	2.0E-14	1.9E-10	1.6E-13	5.7E-07	5.2E-09	7.3E-13	6.8E-09	5.7E-12	2.1E-05
SRS	1.9E-11	0	9.7E-12	1.1E-14	4.3E-09	0	0	0	0	0	1.9E-11	0	9.7E-12	1.1E-14	4.3E-09
RFETS	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08	0	0	0	0	0	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08
ORNL	0	0	0	0	0	5.3E-07	2.7E-11	1.7E-07	1.6E-10	9.9E-06	5.3E-07	2.7E-11	1.7E-07	1.6E-10	9.9E-06
LLNL	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07	0	0	0	0	0	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07
NTS	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10	0	0	0	0	0	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10
ANL-E	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10	0	0	0	0	0	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10
Total	1.0E-07		2.9E-08		2.1E-05	5.3E-07		1.7E-07		1.0E-05	6.3E-07		2.0E-07		3.2E-05

Table B-5
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Total Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	2.6E+02	5.3E-03	1.2E+01	2.2E-02	1.0E+03	4.1E+00	8.5E-05	2.0E-01	3.5E-04	2.0E+01	2.6E+02	5.4E-03	1.3E+01	2.2E-02	1.0E+03
LANL	2.5E+02	2.5E-02	2.3E+01	1.7E-02	1.1E+03	0	0	0	0	0	2.5E+02	2.5E-02	2.3E+01	1.7E-02	1.1E+03
INEEL	5.4E+01	6.5E-03	1.6E+01	1.3E-02	1.3E+03	0	0	0	0	0	5.4E+01	6.5E-03	1.6E+01	1.3E-02	1.3E+03
SRS	1.7E+01	1.6E-04	1.8E+00	1.6E-03	1.9E+02	0	0	0	0	0	1.7E+01	1.6E-04	1.8E+00	1.6E-03	1.9E+02
RFETS	4.1E+03	5.6E-02	2.1E+02	1.3E-01	3.2E+01	0	0	0	0	0	4.1E+03	5.6E-02	2.1E+02	1.3E-01	3.2E+01
ORNL	0	0	0	0	0	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02
Total	4.7E+03		2.6E+02		3.6E+03	4.4E+01		1.6E+00		6.4E+02	4.7E+03		2.6E+02		4.2E+03
Radiation-Related LCFs															
Hanford	1.3E-01	2.6E-06	5.0E-03	8.7E-06	4.0E-01	2.1E-03	4.3E-08	8.0E-05	1.4E-07	8.1E-03	1.3E-01	2.7E-06	5.0E-03	8.8E-06	4.1E-01
LANL	1.3E-01	1.3E-05	9.2E-03	6.7E-06	4.3E-01	0	0	0	0	0	1.3E-01	1.3E-05	9.2E-03	6.7E-06	4.3E-01
INEEL	2.7E-02	3.2E-06	6.3E-03	5.3E-06	5.2E-01	0	0	0	0	0	2.7E-02	3.2E-06	6.3E-03	5.3E-06	5.2E-01
SRS	8.5E-03	7.9E-08	7.2E-04	6.3E-07	7.4E-02	0	0	0	0	0	8.5E-03	7.9E-08	7.2E-04	6.3E-07	7.4E-02
RFETS	2.1E+00	2.8E-05	8.2E-02	5.0E-05	1.3E-02	0	0	0	0	0	2.1E+00	2.8E-05	8.2E-02	5.0E-05	1.3E-02
ORNL	0	0	0	0	0	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01
Total	2.3E+00		1.0E-01		1.4E+00	2.2E-02		6.2E-04		2.6E-01	2.4E+00		1.0E-01		1.7E+00
Chemicals - Cancer Incidence															
Hanford	4.2E-10	0	2.4E-10	4.8E-13	5.9E-07	1.1E-12	0	6.1E-13	1.2E-15	1.2E-08	4.2E-10	0	2.4E-10	4.8E-13	6.1E-07
LANL	3.5E-09	4.1E-13	1.7E-09	1.0E-12	1.2E-06	0	0	0	0	0	3.5E-09	4.1E-13	1.7E-09	1.0E-12	1.2E-06
INEEL	3.8E-09	5.1E-13	4.9E-09	4.2E-12	4.9E-05	0	0	0	0	0	3.8E-09	5.1E-13	4.9E-09	4.2E-12	4.9E-05
SRS	2.8E-11	0	1.5E-11	1.7E-14	3.6E-08	0	0	0	0	0	2.8E-11	0	1.5E-11	1.7E-14	3.6E-08
RFETS	1.5E-09	0	3.0E-10	1.5E-13	1.1E-07	0	0	0	0	0	1.5E-09	0	3.0E-10	1.5E-13	1.1E-07
ORNL	0	0	0	0	0	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05
Total	9.1E-09		7.1E-09		5.1E-05	3.0E-07		1.0E-07		1.4E-05	3.1E-07		1.1E-07		6.4E-05

Table B-6
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1B Total Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	4.4E+03	9.0E-02	2.1E+02	3.7E-01	1.0E+03	4.1E+00	8.5E-05	2.0E-01	3.5E-04	2.0E+01	4.4E+03	9.1E-02	2.1E+02	3.7E-01	1.0E+03
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	2.5E+02	3.0E-02	7.5E+01	6.3E-02	1.4E+03	0	0	0	0	0	2.5E+02	3.0E-02	7.5E+01	6.3E-02	1.4E+03
SRS	1.7E+01	1.6E-04	1.8E+00	1.6E-03	1.9E+02	0	0	0	0	0	1.7E+01	1.6E-04	1.8E+00	1.6E-03	1.9E+02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02
Total	4.7E+03		2.9E+02		2.6E+03	4.4E+01		1.6E+00		6.4E+02	4.7E+03		2.9E+02		3.3E+03
Radiation-Related LCFs															
Hanford	2.2E+00	4.5E-05	8.5E-02	1.5E-04	4.0E-01	2.1E-03	4.3E-08	8.0E-05	1.4E-07	8.1E-03	2.2E+00	4.5E-05	8.5E-02	1.5E-04	4.1E-01
INEEL	1.2E-01	1.5E-05	3.0E-02	2.5E-05	5.8E-01	0	0	0	0	0	1.2E-01	1.5E-05	3.0E-02	2.5E-05	5.8E-01
SRS	8.5E-03	7.9E-08	7.2E-04	6.3E-07	7.4E-02	0	0	0	0	0	8.5E-03	7.9E-08	7.2E-04	6.3E-07	7.4E-02
ORNL	0	0	0	0	0	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01
Total	2.3E+00		1.2E-01		1.1E+00	2.2E-02		6.2E-04		2.6E-01	2.3E+00		1.2E-01		1.3E+00
Chemicals - Cancer Incidence															
Hanford	4.2E-10	0	2.4E-10	4.8E-13	5.9E-07	1.1E-12	0	6.1E-13	1.2E-15	1.2E-08	4.2E-10	0	2.4E-10	4.8E-13	6.1E-07
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	4.0E-09	5.6E-13	5.4E-09	4.4E-12	7.7E-05	0	0	0	0	0	4.0E-09	5.6E-13	5.4E-09	4.4E-12	7.7E-05
SRS	2.8E-11	0	1.5E-11	1.7E-14	3.6E-08	0	0	0	0	0	2.8E-11	0	1.5E-11	1.7E-14	3.6E-08
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05
Total	4.4E-09		5.6E-09		7.8E-05	3.0E-07		1.0E-07		1.4E-05	3.0E-07		1.1E-07		9.2E-05

Table B-7
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Total Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	0	0	0	0	0	4.1E+00	8.4E-05	1.9E-01	3.4E-04	2.0E+01	4.1E+00	8.4E-05	1.9E-01	3.4E-04	2.0E+01
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02	4.0E+01	1.2E-03	1.4E+00	1.2E-03	6.2E+02
WIPP	1.8E+03	4.8E-01	1.4E+02	5.5E-01	9.9E+01	0	0	0	0	0	1.8E+03	4.8E-01	1.4E+02	5.5E-01	7.3E+02
Total	1.8E+03		1.4E+02		9.9E+01	4.4E+01		1.5E+00		6.4E+02	1.8E+03		1.5E+02		1.4E+03
Radiation-Related LCFs															
Hanford	0	0	0	0	0	2.0E-03	4.2E-08	7.8E-05	1.4E-07	8.1E-03	2.0E-03	4.2E-08	7.8E-05	1.4E-07	8.1E-03
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01	2.0E-02	6.1E-07	5.4E-04	4.9E-07	2.5E-01
WIPP	9.0E-01	2.4E-04	5.8E-02	2.2E-04	4.0E-02	0	0	0	0	0	1	0	0	0	2.9E-01
Total	9.0E-01		5.8E-02		4.0E-02	2.2E-02		6.2E-04		2.6E-01	9.2E-01		5.9E-02		5.5E-01
Chemicals - Cancer Incidence															
Hanford	0	0	0	0	0	1.6E-10	0	9.5E-11	1.9E-13	3.5E-09	1.6E-10	0	9.5E-11	1.9E-13	3.5E-09
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05	3.0E-07	1.5E-11	1.0E-07	9.5E-11	1.4E-05
WIPP	1.3E-09	5.1E-13	6.7E-10	3.1E-12	6.4E-05	0	0	0	0	0	1.3E-09	5.1E-13	6.7E-10	3.1E-12	6.4E-05
Total	1.3E-09		6.7E-10		6.4E-05	3.0E-07		1.0E-07		1.4E-05	3.0E-07		1.0E-07		7.8E-05

Table B-8
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Total Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	1.1E+00	2.3E-05	5.3E-02	9.2E-05	1.0E+03	1.5E-04	3.0E-09	7.2E-06	1.2E-08	1.1E+01	1.1E+00	2.3E-05	5.3E-02	9.2E-05	1.1E+03
LANL	6.7E+00	7.2E-04	6.2E-01	4.6E-04	1.1E+03	0	0	0	0	0	6.7E+00	7.2E-04	6.2E-01	4.6E-04	1.1E+03
INEEL	3.9E-02	4.9E-06	1.2E-02	1.0E-05	1.4E+03	0	0	0	0	0	3.9E-02	4.9E-06	1.2E-02	1.0E-05	1.4E+03
SRS	1.0E+00	9.4E-06	1.1E+00	9.4E-05	1.9E+02	0	0	0	0	0	1.0E+00	9.4E-06	1.1E+00	9.4E-05	1.9E+02
RFETS	4.9E-03	6.6E-08	2.5E-04	1.5E-07	3.3E+01	0	0	0	0	0	4.9E-03	6.6E-08	2.5E-04	1.5E-07	3.3E+01
ORNL	0	0	0	0	0	7.4E-04	2.2E-08	2.5E-05	2.3E-08	1.9E+01	7.4E-04	2.2E-08	2.5E-05	2.3E-08	1.9E+01
Total	8.8E+00		1.8E+00		3.8E+03	8.9E-04		3.2E-05		3.0E+01	8.8E+00		1.8E+00		3.8E+03
Radiation-Related LCFs															
Hanford	5.4E-04	1.1E-08	2.1E-05	3.7E-08	4.2E-01	7.3E-08	1.5E-12	2.9E-09	4.9E-12	4.5E-03	5.4E-04	1.1E-08	2.1E-05	3.7E-08	4.2E-01
LANL	3.3E-03	3.6E-07	2.5E-04	1.9E-07	4.5E-01	0	0	0	0	0	0	0	0	0	4.5E-01
INEEL	2.0E-05	2.4E-09	4.7E-06	4.0E-09	5.5E-01	0	0	0	0	0	0	0	0	0	5.5E-01
SRS	5.1E-04	4.7E-09	4.3E-04	3.7E-08	7.4E-02	0	0	0	0	0	0	0	0	0	7.4E-02
RFETS	2.5E-06	3.3E-11	9.9E-08	6.0E-11	1.3E-02	0	0	0	0	0	0	0	0	0	1.3E-02
ORNL	0	0	0	0	0	3.7E-07	1.1E-11	9.9E-09	9.1E-12	7.5E-03	3.7E-07	1.1E-11	9.9E-09	9.1E-12	7.5E-03
Total	4.4E-03		7.1E-04		1.5E+00	4.4E-07		1.3E-08		1.2E-02	4.4E-03		7.1E-04		1.5E+01
Chemicals - Cancer Incidence															
Hanford	4.2E-10	0	2.5E-10	5.1E-13	3.5E-07	1.1E-12	0	6.4E-13	1.3E-15	3.7E-09	4.2E-10	0	2.5E-10	5.1E-13	3.5E-07
LANL	3.0E-09	6.6E-13	1.5E-09	9.5E-13	4.7E-07	0	0	0	0	0	3.0E-09	6.6E-13	1.5E-09	9.5E-13	4.7E-07
INEEL	5.1E-09	7.0E-13	6.8E-09	5.7E-12	3.3E-05	0	0	0	0	0	5.1E-09	7.0E-13	6.8E-09	5.7E-12	3.3E-05
SRS	3.0E-11	0	1.5E-11	1.8E-14	2.1E-08	0	0	0	0	0	3.0E-11	0	1.5E-11	1.8E-14	2.1E-08
RFETS	1.1E-09	0	2.3E-10	1.1E-13	3.7E-08	0	0	0	0	0	1.1E-09	0	2.3E-10	1.1E-13	3.7E-08
ORNL	0	0	0	0	0	4.3E-07	2.2E-11	1.4E-07	1.4E-10	9.2E-06	4.3E-07	2.2E-11	1.4E-07	1.4E-10	9.2E-06
Total	9.6E-09		8.8E-09		3.4E-05	4.3E-07		1.4E-07		9.2E-06	4.4E-07		1.5E-07		4.3E-05

Table B-9
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2 Total (Basic/Newly Generated) Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	2.6E-01	5.4E-06	1.3E-02	2.2E-05	3.9E+02	7.6E-05	1.6E-09	3.8E-06	6.4E-09	9.0E-01	2.6E-01	5.4E-06	1.3E-02	2.2E-05	3.9E+02
LANL	1.6E+00	1.6E-04	1.4E-01	1.1E-04	3.2E+02	2.0E-03	2.0E-07	1.8E-04	1.4E-07	7.4E+00	1.6E+00	1.6E-04	1.4E-01	1.1E-04	3.3E+02
INEEL	4.3E-05	5.2E-09	1.3E-05	1.1E-08	1.9E+01	7.8E-07	9.5E-11	2.3E-07	2.0E-10	3.2E+01	4.4E-05	5.3E-09	1.3E-05	1.1E-08	5.1E+01
SRS	3.8E-01	3.6E-06	4.1E-02	3.6E-05	9.4E+01	0	0	0	0	0	3.8E-01	3.6E-06	4.1E-02	3.6E-05	9.4E+01
RFETS	3.0E-03	3.9E-08	1.5E-04	8.9E-08	1.8E+01	0	0	0	0	0	3.0E-03	3.9E-08	1.5E-04	8.9E-08	1.8E+01
ORNL	0	0	0	0	0	6.5E-04	2.0E-08	2.2E-05	2.0E-08	1.5E+01	6.5E-04	2.0E-08	2.2E-05	2.0E-08	1.5E+01
LLNL	9.2E-03	1.5E-07	4.6E-04	1.6E-07	7.8E-01	0	0	0	0	0	9.2E-03	1.5E-07	4.6E-04	1.6E-07	7.8E-01
NTS	1.3E-10	3.4E-14	3.7E-10	1.7E-12	1.0E-02	0	0	0	0	0	1.3E-10	3.4E-14	3.7E-10	1.7E-12	1.0E-02
ANL-E	1.9E-03	1.0E-08	1.0E-05	1.0E-08	4.2E+00	0	0	0	0	0	1.9E-03	1.0E-08	1.0E-05	1.0E-08	4.2E+00
Total	2.3E+00		2.0E-01		8.5E+02	2.7E-03		2.1E-04		5.5E+01	2.3E+00		2.0E-01		9.1E+02
Radiation-Related LCFs															
Hanford	1.3E-04	2.7E-09	5.2E-06	8.7E-09	0.2	3.8E-08	8.0E-13	1.5E-09	2.6E-12	3.6E-04	1.3E-04	2.7E-09	5.2E-06	8.8E-09	0.2
LANL	8.1E-04	8.1E-08	5.8E-05	4.4E-08	0.1	1.0E-06	1.0E-10	7.2E-08	5.4E-11	3.0E-03	8.1E-04	8.1E-08	5.8E-05	4.4E-08	0.1
INEEL	2.2E-08	2.6E-12	5.1E-09	4.3E-12	7.4E-03	3.9E-10	4.7E-14	9.2E-11	7.8E-14	1.3E-02	2.2E-08	2.7E-12	5.2E-09	4.4E-12	2.0E-02
SRS	1.9E-04	1.8E-09	1.6E-05	1.4E-08	3.7E-02	0	0	0	0	0	1.9E-04	1.8E-09	1.6E-05	1.4E-08	3.7E-02
RFETS	1.5E-06	1.9E-11	5.8E-08	3.5E-11	7.3E-03	0	0	0	0	0	1.5E-06	1.9E-11	5.8E-08	3.5E-11	7.3E-03
ORNL	0	0	0	0	0	3.2E-07	9.9E-12	8.7E-09	7.9E-12	5.9E-03	3.2E-07	9.9E-12	8.7E-09	7.9E-12	5.9E-03
LLNL	4.6E-06	7.4E-11	1.8E-07	6.4E-11	3.1E-04	0	0	0	0	0	4.6E-06	7.4E-11	1.8E-07	6.4E-11	3.1E-04
NTS	6.7E-14	1.7E-17	1.5E-13	6.7E-16	4.2E-06	0	0	0	0	0	6.7E-14	1.7E-17	1.5E-13	6.7E-16	4.2E-06
ANL-E	9.5E-07	5.2E-12	4.0E-09	4.0E-12	1.7E-03	0	0	0	0	0	9.5E-07	5.2E-12	4.0E-09	4.0E-12	1.7E-03
Total	1.1E-03		8.0E-05		0.3	1.4E-06		8.2E-08		2.2E-02	1.1E-03		8.0E-05		0.4
Chemicals - Cancer Incidence															
Hanford	1.1E-10	0	6.3E-11	1.2E-13	2.8E-08	6.3E-13	0	3.8E-13	7.4E-16	6.4E-11	1.1E-10	0	6.3E-11	1.2E-13	2.8E-08
LANL	6.1E-10	7.5E-14	3.1E-10	1.9E-13	3.2E-08	1.4E-11	1.7E-15	7.0E-12	4.3E-15	7.2E-10	6.3E-10	7.7E-14	3.1E-10	1.9E-13	3.2E-08
INEEL	6.8E-11	9.4E-15	8.9E-11	7.4E-14	2.7E-07	1.2E-10	1.6E-14	1.5E-10	1.3E-13	4.7E-07	1.8E-10	2.6E-14	2.4E-10	2.0E-13	7.4E-07
SRS	1.0E-11	0	5.2E-12	6.1E-15	2.3E-09	0	0	0	0	0	1.0E-11	0	5.2E-12	6.1E-15	2.3E-09
RFETS	4.6E-10	0	9.2E-11	4.7E-14	6.5E-09	0	0	0	0	0	4.6E-10	0	9.2E-11	4.7E-14	6.5E-09
ORNL	0	0	0	0	0	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06
LLNL	7.3E-08	1.6E-12	1.7E-08	5.0E-12	4.9E-07	0	0	0	0	0	7.3E-08	1.6E-12	1.7E-08	5.0E-12	4.9E-07
NTS	7.6E-15	0	1.0E-13	4.2E-16	1.8E-11	0	0	0	0	0	7.6E-15	0	1.0E-13	4.2E-16	1.8E-11
ANL-E	2.9E-10	0	5.9E-12	5.3E-15	3.6E-10	0	0	0	0	0	2.9E-10	0	5.9E-12	5.3E-15	3.6E-10
Total	7.4E-08		1.7E-08		8.3E-07	3.5E-07		1.1E-07		6.9E-06	4.2E-07		1.3E-07		7.8E-06

Table B-10
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Basic Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker		Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker		Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker		Worker Population
			Population	Individual				Population	Individual				Population	Individual	
Radiation Dose (in rem or person-rem)															
Hanford	1.6E-02	3.5E-07	8.2E-04	1.4E-06	4.9E+02	7.6E-05	1.6E-09	3.8E-06	6.4E-09	9.0E-01	1.6E-02	3.5E-07	8.2E-04	1.4E-06	5.0E+02
LANL	1.3E-02	1.3E-06	1.1E-03	8.6E-07	6.8E+02	1.3E-03	1.3E-07	1.1E-04	8.5E-08	7.4E+00	1.4E-02	1.4E-06	1.2E-03	9.4E-07	6.9E+02
INEEL	2.8E-03	3.4E-07	8.2E-04	7.0E-07	4.8E+02	4.3E-06	5.2E-10	1.3E-06	1.1E-09	3.2E+01	2.8E-03	3.4E-07	8.2E-04	7.0E-07	5.1E+02
SRS	2.1E-02	2.0E-07	2.2E-03	2.0E-06	1.2E+02	0	0	0	0	0	2.1E-02	2.0E-07	2.2E-03	2.0E-06	1.2E+02
RFETS	2.1E-01	2.7E-06	1.0E-02	6.2E-06	3.3E+01	0	0	0	0	0	2.1E-01	2.7E-06	1.0E-02	6.2E-06	3.3E+01
ORNL	0	0	0	0	0	1.4E-03	4.4E-08	4.8E-05	4.4E-08	1.5E+01	1.4E-03	4.4E-08	4.8E-05	4.4E-08	1.5E+01
LLNL	2.0E-03	3.2E-08	1.0E-04	3.5E-08	9.8E-01	0	0	0	0	0	2.0E-03	3.2E-08	1.0E-04	3.5E-08	9.8E-01
NTS	8.2E-06	2.1E-09	2.3E-05	1.0E-07	5.4E-01	0	0	0	0	0	8.2E-06	2.1E-09	2.3E-05	1.0E-07	5.4E-01
ANL-E	3.3E-04	1.8E-09	1.8E-06	1.8E-09	4.6E+00	0	0	0	0	0	3.3E-04	1.8E-09	1.8E-06	1.8E-09	4.6E+00
Total	2.6E-01		1.5E-02		1.8E+03	2.8E-03		1.7E-04		5.5E+01	2.6E-01		1.5E-02		1.9E+03
Radiation-Related LCFs															
Hanford	8.2E-06	1.7E-10	3.3E-07	5.6E-10	2.0E-01	3.8E-08	8.0E-13	1.5E-09	2.6E-12	3.6E-04	8.2E-06	1.7E-10	3.3E-07	5.6E-10	2.0E-01
LANL	6.4E-06	6.4E-10	4.5E-07	3.4E-10	2.7E-01	6.3E-07	6.3E-11	4.5E-08	3.4E-11	3.0E-03	7.0E-06	7.0E-10	5.0E-07	3.8E-10	2.8E-01
INEEL	1.4E-06	1.7E-10	3.3E-07	2.8E-10	1.9E-01	2.1E-09	2.6E-13	5.1E-10	4.3E-13	1.3E-02	1.4E-06	1.7E-10	3.3E-07	2.8E-10	2.0E-01
SRS	1.1E-05	9.8E-11	9.0E-07	7.9E-10	4.9E-02	0	0	0	0	0	1.1E-05	9.8E-11	9.0E-07	7.9E-10	4.9E-02
RFETS	1.0E-04	1.4E-09	4.1E-06	2.5E-09	1.3E-02	0	0	0	0	0	1.0E-04	1.4E-09	4.1E-06	2.5E-09	1.3E-02
ORNL	0	0	0	0	0	7.2E-07	2.2E-11	1.9E-08	1.8E-11	5.9E-03	7.2E-07	2.2E-11	1.9E-08	1.8E-11	5.9E-03
LLNL	1.0E-06	1.6E-11	4.0E-08	1.4E-11	3.9E-04	0	0	0	0	0	1.0E-06	1.6E-11	4.0E-08	1.4E-11	3.9E-04
NTS	4.1E-09	1.1E-12	9.1E-09	4.1E-11	2.2E-04	0	0	0	0	0	4.1E-09	1.1E-12	9.1E-09	4.1E-11	2.2E-04
ANL-E	1.7E-07	9.2E-13	7.0E-10	7.0E-13	1.8E-03	0	0	0	0	0	1.7E-07	9.2E-13	7.0E-10	7.0E-13	1.8E-03
Total	1.3E-04		6.1E-06		7.3E-01	1.4E-06		6.6E-08		2.2E-02	1.3E-04		6.2E-06		7.5E-01
Chemicals - Cancer Incidence															
Hanford	1.3E-10	0	8.0E-11	1.6E-13	3.5E-08	6.3E-13	0	3.8E-13	7.4E-16	6.4E-11	1.3E-10	0	8.0E-11	1.6E-13	3.5E-08
LANL	1.3E-09	1.6E-13	6.5E-10	4.0E-13	6.6E-08	1.4E-11	1.7E-15	7.0E-12	4.3E-15	7.2E-10	1.3E-09	1.6E-13	6.5E-10	4.0E-13	6.7E-08
INEEL	1.7E-09	2.4E-13	2.3E-09	1.9E-12	6.9E-06	1.2E-10	1.6E-14	1.5E-10	1.3E-13	4.7E-07	1.9E-09	2.6E-13	2.4E-09	2.0E-12	7.4E-06
SRS	1.4E-11	0	6.9E-12	8.0E-15	3.1E-09	0	0	0	0	0	1.4E-11	0	6.9E-12	8.0E-15	3.1E-09
RFETS	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08	0	0	0	0	0	8.4E-10	0	1.7E-10	8.6E-14	1.2E-08
ORNL	0	0	0	0	0	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06	3.5E-07	1.7E-11	1.1E-07	1.1E-10	6.5E-06
LLNL	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07	0	0	0	0	0	9.1E-08	2.0E-12	2.1E-08	6.3E-12	6.2E-07
NTS	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10	0	0	0	0	0	3.9E-13	0	5.3E-12	2.2E-14	9.1E-10
ANL-E	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10	0	0	0	0	0	3.1E-10	0	6.5E-12	5.9E-15	4.0E-10
Total	9.6E-08		2.4E-08		7.7E-06	3.5E-07		1.1E-07		6.9E-06	4.4E-07		1.4E-07		1.5E-05

Table B-11
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Basic Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	1.2E+02	2.5E-03	6.0E+00	1.0E-02	4.8E+02	3.9E+00	8.1E-05	1.9E-01	3.4E-04	1.9E+01	1.3E+02	2.6E-03	6.2E+00	1.1E-02	5.0E+02
LANL	1.5E+02	1.5E-02	1.4E+01	1.0E-02	6.5E+02	0	0	0	0	0	1.5E+02	1.5E-02	1.4E+01	1.0E-02	6.5E+02
INEEL	1.9E+01	2.2E-03	5.4E+00	4.6E-03	4.5E+02	0	0	0	0	0	1.9E+01	2.2E-03	5.4E+00	4.6E-03	4.5E+02
SRS	1.2E+01	1.2E-04	1.3E+00	1.2E-03	1.4E+02	0	0	0	0	0	1.2E+01	1.2E-04	1.3E+00	1.2E-03	1.4E+02
RFETS	4.1E+03	5.6E-02	2.1E+02	1.3E-01	3.2E+01	0	0	0	0	0	4.1E+03	5.6E-02	2.1E+02	1.3E-01	3.2E+01
ORNL	0	0	0	0	0	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02
Total	4.4E+03		2.3E+02		1.7E+03	3.0E+01		1.1E+00		4.3E+02	4.4E+03		2.3E+02		2.2E+03
Radiation-Related LCFs															
Hanford	6.2E-02	1.3E-06	2.4E-03	4.2E-06	1.9E-01	2.0E-03	4.1E-08	7.7E-05	1.3E-07	7.7E-03	6.4E-02	1.3E-06	2.5E-03	4.3E-06	2.0E-01
LANL	7.5E-02	7.5E-06	5.6E-03	4.0E-06	2.6E-01	0	0	0	0	0	7.5E-02	7.5E-06	5.6E-03	4.0E-06	2.6E-01
INEEL	9.3E-03	1.1E-06	2.2E-03	1.8E-06	1.8E-01	0	0	0	0	0	9.3E-03	1.1E-06	2.2E-03	1.8E-06	1.8E-01
SRS	6.2E-03	5.8E-08	5.3E-04	4.6E-07	5.5E-02	0	0	0	0	0	6.2E-03	5.8E-08	5.3E-04	4.6E-07	5.5E-02
RFETS	2.1E+00	2.8E-05	8.2E-02	5.0E-05	1.3E-02	0	0	0	0	0	2.1E+00	2.8E-05	8.2E-02	5.0E-05	1.3E-02
ORNL	0	0	0	0	0	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01
Total	2.2E+00		9.3E-02		7.0E-01	1.5E-02		4.3E-04		1.7E-01	2.2E+00		9.3E-02		8.7E-01
Chemicals - Cancer Incidence															
Hanford	2.0E-10	0	1.2E-10	2.3E-13	2.9E-07	1.0E-12	0	5.8E-13	1.2E-15	1.1E-08	2.0E-10	0	1.2E-10	2.3E-13	3.0E-07
LANL	2.1E-09	2.5E-13	1.0E-09	6.3E-13	7.0E-07	0	0	0	0	0	2.1E-09	2.5E-13	1.0E-09	6.3E-13	7.0E-07
INEEL	1.3E-09	1.7E-13	1.7E-09	1.4E-12	1.7E-05	0	0	0	0	0	1.3E-09	1.7E-13	1.7E-09	1.4E-12	1.7E-05
SRS	2.1E-11	0	1.1E-11	1.2E-14	2.7E-08	0	0	0	0	0	2.1E-11	0	1.1E-11	1.2E-14	2.7E-08
RFETS	1.5E-09	0	3.0E-10	1.5E-13	1.1E-07	0	0	0	0	0	1.5E-09	0	3.0E-10	1.5E-13	1.1E-07
ORNL	0	0	0	0	0	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06
Total	5.1E-09		3.1E-09		1.8E-05	2.0E-07		6.6E-08		9.1E-06	2.0E-07		6.9E-08		2.7E-05

Table B-12
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1B Basic Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	2.1E+03	4.4E-02	1.0E+02	1.8E-01	4.8E+02	3.9E+00	8.1E-05	1.9E-01	3.4E-04	1.9E+01	2.1E+03	4.4E-02	1.0E+02	1.8E-01	5.0E+02
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	1.1E+02	1.4E-02	3.5E+01	2.9E-02	6.7E+02	0	0	0	0	0	1.1E+02	1.4E-02	3.5E+01	2.9E-02	6.7E+02
SRS	1.2E+01	1.2E-04	1.3E+00	1.2E-03	1.4E+02	0	0	0	0	0	1.2E+01	1.2E-04	1.3E+00	1.2E-03	1.4E+02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02
Total	2.2E+03		1.4E+02		1.3E+03	3.0E+01		1.1E+00		4.3E+02	2.3E+03		1.4E+02		1.7E+03
Radiation-Related LCFs															
Hanford	1.1E+00	2.2E-05	4.1E-02	7.2E-05	1.9E-01	2.0E-03	4.1E-08	7.7E-05	1.3E-07	7.7E-03	1.1E+00	2.2E-05	4.1E-02	7.2E-05	2.0E-01
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	5.7E-02	7.0E-06	1.4E-02	1.2E-05	2.7E-01	0	0	0	0	0	5.7E-02	7.0E-06	1.4E-02	1.2E-05	2.7E-01
SRS	6.2E-03	5.8E-08	5.3E-04	4.6E-07	5.5E-02	0	0	0	0	0	6.2E-03	5.8E-08	5.3E-04	4.6E-07	5.5E-02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01
Total	1.1E+00		5.6E-02		5.2E-01	1.5E-02		4.3E-04		1.7E-01	1.1E+00		5.6E-02		6.9E-01
Chemicals - Cancer Incidence															
Hanford	2.0E-10	0	1.2E-10	2.3E-13	2.9E-07	1.0E-12	0	5.8E-13	1.2E-15	1.1E-08	2.0E-10	0	1.2E-10	2.3E-13	3.0E-07
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	1.8E-09	2.6E-13	2.5E-09	2.1E-12	3.6E-05	0	0	0	0	0	1.8E-09	2.6E-13	2.5E-09	2.1E-12	3.6E-05
SRS	2.1E-11	0	1.1E-11	1.2E-14	2.7E-08	0	0	0	0	0	2.1E-11	0	1.1E-11	1.2E-14	2.7E-08
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06
Total	2.1E-09		2.6E-09		3.6E-05	2.0E-07		6.6E-08		9.1E-06	2.0E-07		6.8E-08		4.5E-05

Table B-13
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Basic Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	0	0	0	0	0	3.9E+00	8.0E-05	1.8E-01	3.3E-04	1.9E+01	3.9E+00	8.0E-05	1.8E-01	3.3E-04	1.9E+01
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02	2.6E+01	8.0E-04	8.9E-01	8.0E-04	4.1E+02
WIPP	8.8E+02	2.4E-01	7.1E+01	2.7E-01	3.6E+02	0	0	0	0	0	8.8E+02	2.4E-01	7.1E+01	2.7E-01	3.6E+02
Total	8.8E+02		7.1E+01		3.6E+02	3.0E+01		1.1E+00		4.3E+02	9.1E+02		7.2E+01		7.9E+02
Radiation-Related LCFs															
Hanford	0	0	0	0	0	1.9E-03	4.0E-08	7.4E-05	1.3E-07	7.7E-03	1.9E-03	4.0E-08	7.4E-05	1.3E-07	7.7E-03
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01	1.3E-02	4.0E-07	3.5E-04	3.2E-07	1.6E-01
WIPP	4.4E-01	1.2E-04	2.9E-02	1.1E-04	1.4E-01	0	0	0	0	0	0	0	0	0	1.4E-01
Total	4.4E-01		2.9E-02		1.4E-01	1.5E-02		4.3E-04		1.7E-01	4.6E-01		2.9E-02		3.2E-01
Chemicals - Cancer Incidence															
Hanford	0	0	0	0	0	1.5E-10	0	9.1E-11	1.8E-13	3.3E-09	1.5E-10	0	9.1E-11	1.8E-13	3.3E-09
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06	2.0E-07	1.0E-11	6.6E-08	6.2E-11	9.1E-06
WIPP	6.5E-10	2.5E-13	3.3E-10	1.5E-12	3.2E-05	0	0	0	0	0	6.5E-10	2.5E-13	3.3E-10	1.5E-12	3.2E-05
Total	6.5E-10		3.3E-10		3.2E-05	2.0E-07		6.6E-08		9.1E-06	2.0E-07		6.6E-08		4.1E-05

Table B-14
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Basic Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	5.3E-01	1.1E-05	2.6E-02	4.4E-05	5.1E+02	1.4E-04	2.9E-09	6.8E-06	1.2E-08	1.1E+01	5.3E-01	1.1E-05	2.6E-02	4.4E-05	5.2E+02
LANL	4.0E+00	4.3E-04	3.7E-01	2.8E-04	6.8E+02	0	0	0	0	0	4.0E+00	4.3E-04	3.7E-01	2.8E-04	6.8E+02
INEEL	1.4E-02	1.7E-06	4.0E-03	3.5E-06	4.8E+02	0	0	0	0	0	1.4E-02	1.7E-06	4.0E-03	3.5E-06	4.8E+02
SRS	7.5E-01	6.9E-06	8.0E-01	6.9E-05	1.4E+02	0	0	0	0	0	7.5E-01	6.9E-06	8.0E-01	6.9E-05	1.4E+02
RFETS	4.9E-03	6.6E-08	2.5E-04	1.5E-07	3.3E+01	0	0	0	0	0	4.9E-03	6.6E-08	2.5E-04	1.5E-07	3.3E+01
ORNL	0	0	0	0	0	4.9E-04	1.5E-08	1.6E-05	1.5E-08	1.2E+01	4.9E-04	1.5E-08	1.6E-05	1.5E-08	1.2E+01
Total	5.3E+00		1.2E+00		1.8E+03	6.3E-04		2.3E-05		2.3E+01	5.3E+00		1.2E+00		1.9E+03
Radiation-Related LCFs															
Hanford	2.6E-04	5.5E-09	1.0E-05	1.8E-08	2.0E-01	7.0E-08	1.5E-12	2.7E-09	4.7E-12	4.3E-03	2.6E-04	5.5E-09	1.0E-05	1.8E-08	0.2
LANL	2.0E-03	2.2E-07	1.5E-04	1.1E-07	2.7E-01	0	0	0	0	0	2.0E-03	2.2E-07	1.5E-04	1.1E-07	0.3
INEEL	6.8E-06	8.4E-10	1.6E-06	1.4E-09	1.9E-01	0	0	0	0	0	6.8E-06	8.4E-10	1.6E-06	1.4E-09	0.2
SRS	3.7E-04	3.5E-09	3.2E-04	2.8E-08	5.5E-02	0	0	0	0	0	3.7E-04	3.5E-09	3.2E-04	2.8E-08	5.5E-02
RFETS	2.5E-06	3.3E-11	9.9E-08	6.0E-11	1.3E-02	0	0	0	0	0	2.5E-06	3.3E-11	9.9E-08	6.0E-11	1.3E-02
ORNL	0	0	0	0	0	2.4E-07	7.3E-12	6.5E-09	5.9E-12	4.9E-03	2.4E-07	7.3E-12	6.5E-09	5.9E-12	4.9E-03
Total	2.7E-03		4.8E-04		7.3E-01	3.1E-07		9.2E-09		9.2E-03	2.7E-03		4.8E-04		7.4E-01
Chemicals - Cancer Incidence															
Hanford	2.0E-10	0	1.2E-10	2.5E-13	1.7E-07	1.0E-12	0	6.1E-13	1.2E-15	3.6E-09	2.0E-10	0	1.2E-10	2.5E-13	1.7E-07
LANL	1.8E-09	4.0E-13	8.9E-10	5.7E-13	2.8E-07	0	0	0	0	0	1.8E-09	4.0E-13	8.9E-10	5.7E-13	2.8E-07
INEEL	1.7E-09	2.4E-13	2.4E-09	2.0E-12	1.1E-05	0	0	0	0	0	1.7E-09	2.4E-13	2.4E-09	2.0E-12	1.1E-05
SRS	2.2E-11	0	1.1E-11	1.3E-14	1.6E-08	0	0	0	0	0	2.2E-11	0	1.1E-11	1.3E-14	1.6E-08
RFETS	0	0	0	0	0	0	0	0	0	0	1.1E-09	0	2.3E-10	1.1E-13	3.7E-08
ORNL	0	0	0	0	0	2.8E-07	1.4E-11	9.2E-08	8.9E-11	6.0E-06	2.8E-07	1.4E-11	9.2E-08	8.9E-11	6.0E-06
Total	4.9E-09		3.6E-09		1.2E-05	2.8E-07		9.2E-08		6.1E-06	2.9E-07		9.6E-08		1.8E-05

Table B-15
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 1 Additional Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	1.8E-02	3.8E-07	8.9E-04	1.5E-06	5.4E+02	2.6E-06	5.6E-11	1.3E-07	2.2E-10	3.2E-02	1.8E-02	3.8E-07	8.9E-04	1.5E-06	5.4E+02
LANL	8.4E-03	8.4E-07	7.5E-04	5.7E-07	4.5E+02	6.5E-04	6.5E-08	5.8E-05	4.4E-08	3.8E+00	9.1E-03	9.1E-07	8.1E-04	6.1E-07	4.5E+02
INEEL	5.4E-03	6.5E-07	1.6E-03	1.4E-06	9.2E+02	9.7E-07	1.2E-10	2.9E-07	2.5E-10	7.2E+00	5.4E-03	6.5E-07	1.6E-03	1.4E-06	9.3E+02
SRS	8.5E-03	7.9E-08	9.1E-04	7.9E-07	5.0E+01	0	0	0	0	0	8.5E-03	7.9E-08	9.1E-04	7.9E-07	5.0E+01
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	7.5E-04	2.3E-08	2.5E-05	2.3E-08	7.7E+00	7.5E-04	2.3E-08	2.5E-05	2.3E-08	7.7E+00
Total	4.0E-02		4.1E-03		2.0E+03	1.4E-03		8.4E-05		1.9E+01	4.2E-02		4.2E-03		2.0E+03
Radiation-Related LCFs															
Hanford	8.9E-06	1.9E-10	3.6E-07	6.0E-10	2.2E-01	1.3E-09	2.8E-14	5.3E-11	9.0E-14	1.3E-05	8.9E-06	1.9E-10	3.6E-07	6.0E-10	2.2E-01
LANL	4.2E-06	4.2E-10	3.0E-07	2.3E-10	1.8E-01	3.3E-07	3.3E-11	2.3E-08	1.8E-11	1.5E-03	4.5E-06	4.5E-10	3.2E-07	2.4E-10	1.8E-01
INEEL	2.7E-06	3.3E-10	6.3E-07	5.4E-10	3.7E-01	4.9E-10	5.9E-14	1.2E-10	9.8E-14	2.9E-03	2.7E-06	3.3E-10	6.3E-07	5.4E-10	3.7E-01
SRS	4.3E-06	4.0E-11	3.6E-07	3.2E-10	2.0E-02	0	0	0	0	0	4.3E-06	4.0E-11	3.6E-07	3.2E-10	2.0E-02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	3.7E-07	1.1E-11	1.0E-08	9.2E-12	3.1E-03	3.7E-07	1.1E-11	1.0E-08	9.2E-12	3.1E-03
Total	2.0E-05		1.7E-06		7.8E-01	7.0E-07		3.4E-08		7.5E-03	2.1E-05		1.7E-06		7.9E-01
Chemicals - Cancer Incidence															
Hanford	1.5E-10	0	8.7E-11	1.7E-13	3.8E-08	2.2E-14	0	1.3E-14	2.6E-17	2.2E-12	1.5E-10	0	8.7E-11	1.7E-13	3.8E-08
LANL	8.5E-10	1.0E-13	4.3E-10	2.6E-13	4.4E-08	7.3E-12	8.9E-16	3.6E-12	2.2E-15	3.7E-10	8.6E-10	1.0E-13	4.3E-10	2.7E-13	4.4E-08
INEEL	3.4E-09	4.7E-13	4.4E-09	3.7E-12	1.3E-05	2.6E-11	3.7E-15	3.4E-11	2.9E-14	1.1E-07	3.4E-09	4.7E-13	4.4E-09	3.7E-12	1.4E-05
SRS	5.6E-12	0	2.8E-12	3.2E-15	1.2E-09	0	0	0	0	0	5.6E-12	0	2.8E-12	3.2E-15	1.2E-09
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.8E-07	0	5.9E-08	5.6E-11	3.4E-06	1.8E-07	9.1E-12	5.9E-08	5.6E-11	3.4E-06
Total	4.4E-09		4.9E-09		1.4E-05	1.8E-07		5.9E-08		3.5E-06	1.9E-07		6.4E-08		1.7E-05

Table B-16
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2A and No Action Alternative 1A Additional Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	1.3E+02	2.7E-03	6.4E+00	1.1E-02	5.2E+02	2.0E-01	4.1E-06	9.6E-03	1.7E-05	9.7E-01	1.3E+02	2.7E-03	6.4E+00	1.1E-02	5.2E+02
LANL	1.0E+02	1.0E-02	9.2E+00	6.7E-03	4.3E+02	0	0	0	0	0	1.0E+02	1.0E-02	9.2E+00	6.7E-03	4.3E+02
INEEL	3.5E+01	4.2E-03	1.0E+01	8.7E-03	8.6E+02	0	0	0	0	0	3.5E+01	4.2E-03	1.0E+01	8.7E-03	8.6E+02
SRS	4.5E+00	4.2E-05	4.7E-01	4.2E-04	4.9E+01	0	0	0	0	0	4.5E+00	4.2E-05	4.7E-01	4.2E-04	4.9E+01
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02
Total	2.7E+02		2.6E+01		1.8E+03	1.4E+01		4.7E-01		2.2E+02	2.9E+02		2.7E+01		2.1E+03
Radiation-Related LCFs															
Hanford	6.6E-02	1.4E-06	2.6E-03	4.5E-06	2.1E-01	9.9E-05	2.0E-09	3.9E-06	6.7E-09	3.9E-04	6.6E-02	1.4E-06	2.6E-03	4.5E-06	2.1E-01
LANL	5.0E-02	5.0E-06	3.7E-03	2.7E-06	1.7E-01	0	0	0	0	0	5.0E-02	5.0E-06	3.7E-03	2.7E-06	1.7E-01
INEEL	1.8E-02	2.1E-06	4.2E-03	3.5E-06	3.4E-01	0	0	0	0	0	1.8E-02	2.1E-06	4.2E-03	3.5E-06	3.4E-01
SRS	2.2E-03	2.1E-08	1.9E-04	1.7E-07	2.0E-02	0	0	0	0	0	2.2E-03	2.1E-08	1.9E-04	1.7E-07	2.0E-02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	6.9E-03	2.1E-07	1.9E-04	1.7E-07	8.6E-02	6.9E-03	2.1E-07	1.9E-04	1.7E-07	8.6E-02
Total	1.4E-01		1.1E-02		7.4E-01	7.0E-03		1.9E-04		8.6E-02	1.4E-01		1.1E-02		8.3E-01
Chemicals - Cancer Incidence															
Hanford	2.2E-10	0	1.2E-10	2.5E-13	3.1E-07	5.1E-14	0	2.9E-14	5.9E-17	5.8E-10	2.2E-10	0	1.2E-10	2.5E-13	3.1E-07
LANL	1.4E-09	1.6E-13	6.8E-10	4.1E-13	4.6E-07	0	0	0	0	0	1.4E-09	1.6E-13	6.8E-10	4.1E-13	4.6E-07
INEEL	2.5E-09	3.3E-13	3.2E-09	2.8E-12	3.2E-05	0	0	0	0	0	2.5E-09	3.3E-13	3.2E-09	2.8E-12	3.2E-05
SRS	7.5E-12	0	3.9E-12	4.4E-15	9.5E-09	0	0	0	0	0	7.5E-12	0	3.9E-12	4.4E-15	9.5E-09
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06
Total	4.1E-09		4.0E-09		3.3E-05	1.0E-07		3.4E-08		4.7E-06	2.4E-07		6.8E-08		3.8E-05

Table B-17
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2B and No Action Alternative 1A Additional Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	2.3E+03	4.7E-02	1.1E+02	1.9E-01	5.2E+02	2.0E-01	4.1E-06	9.6E-03	1.7E-05	9.7E-01	2.3E+03	4.7E-02	1.1E+02	1.9E-01	5.2E+02
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	1.3E+02	1.6E-02	4.0E+01	3.4E-02	7.8E+02	0	0	0	0	0	1.3E+02	1.6E-02	4.0E+01	3.4E-02	7.8E+02
SRS	4.5E+00	4.2E-05	4.7E-01	4.2E-04	4.9E+01	0	0	0	0	0	4.5E+00	4.2E-05	4.7E-01	4.2E-04	4.9E+01
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02
Total	2.4E+03		1.5E+02		1.3E+03	1.4E+01		4.7E-01		2.2E+02	2.4E+03		1.5E+02		1.6E+03
Radiation-Related LCFs															
Hanford	1.1E+00	2.3E-05	4.4E-02	7.7E-05	2.1E-01	9.9E-05	2.0E-09	3.9E-06	6.7E-09	3.9E-04	1.1E+00	2.3E-05	4.4E-02	7.7E-05	2.1E-01
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	6.6E-02	8.1E-06	1.6E-02	1.4E-05	3.1E-01	0	0	0	0	0	6.6E-02	8.1E-06	1.6E-02	1.4E-05	3.1E-01
SRS	2.2E-03	2.1E-08	1.9E-04	1.7E-07	2.0E-02	0	0	0	0	0	2.2E-03	2.1E-08	1.9E-04	1.7E-07	2.0E-02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	6.9E-03	2.1E-07	1.9E-04	1.7E-07	8.6E-02	6.9E-03	2.1E-07	1.9E-04	1.7E-07	8.6E-02
Total	1.2E+00		6.0E-02		5.4E-01	7.0E-03		1.9E-04		8.6E-02	1.2E+00		6.1E-02		6.2E-01
Chemicals - Cancer Incidence															
Hanford	2.2E-10	0	1.2E-10	2.5E-13	3.1E-07	5.1E-14	0	2.9E-14	5.9E-17	5.8E-10	2.2E-10	0	1.2E-10	2.5E-13	3.1E-07
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	2.1E-09	3.0E-13	2.9E-09	2.4E-12	4.1E-05	0	0	0	0	0	2.1E-09	3.0E-13	2.9E-09	2.4E-12	4.1E-05
SRS	7.5E-12	0	3.9E-12	4.4E-15	9.5E-09	0	0	0	0	0	7.5E-12	0	3.9E-12	4.4E-15	9.5E-09
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06
Total	2.3E-09		3.0E-09		4.2E-05	1.0E-07		3.4E-08		4.7E-06	1.0E-07		3.7E-08		4.6E-05

Table B-18
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 2C Additional Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	0	0	0	0	0	2.0E-01	4.1E-06	9.3E-03	1.7E-05	9.7E-01	2.0E-01	4.1E-06	9.3E-03	1.7E-05	9.7E-01
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02	1.4E+01	4.2E-04	4.6E-01	4.2E-04	2.1E+02
WIPP	9.1E+02	2.5E-01	7.4E+01	2.8E-01	3.7E+02	0	0	0	0	0	9.1E+02	2.5E-01	7.4E+01	2.8E-01	3.7E+02
Total	9.1E+02		7.4E+01		3.7E+02	1.4E+01		4.7E-01		2.2E+02	9.2E+02		7.4E+01		5.9E+02
Radiation-Related LCFs															
Hanford	0	0	0	0	0	9.8E-05	2.0E-09	3.7E-06	6.6E-09	3.9E-04	9.8E-05	2.0E-09	3.7E-06	6.6E-09	3.9E-04
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	6.9E-03	2.1E-07	1.9E-04	1.7E-07	8.6E-02	6.9E-03	2.1E-07	1.9E-04	1,7E-07	8.6E-02
WIPP	4.6E-01	1.2E-04	2.9E-02	1.1E-04	1.5E-01	0	0	0	0	0	0	0	0	0	1.5E-01
Total	4.6E-01		2.9E-02		1.5E-01	7.0E-03		1.9E-04		8.6E-02	4.6E-01		3.0E-02		2.3E-01
Chemicals - Cancer Incidence															
Hanford	0	0	0	0	0	7.7E-12	0	4.6E-12	8.9E-15	1.7E-10	7.7E-12	0	4.6E-12	8.9E-15	1.7E-10
LANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INEEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06	1.0E-07	5.3E-12	3.4E-08	3.3E-11	4.7E-06
WIPP	6.7E-10	2.6E-13	3.4E-10	1.6E-12	3.3E-05	0	0	0	0	0	6.7E-10	2.6E-13	3.4E-10	1.6E-12	3.3E-05
Total	6.7E-10		3.4E-10		3.3E-05	1.0E-07		3.4E-08		4.7E-06	1.0E-07		3.5E-08		3.7E-05

Table B-19
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals of Action Alternative 3 Additional Inventory

Site	Contact-Handled (CH-TRU) Waste					Remote-Handled (RH-TRU) Waste					CH-TRU Waste + RH-TRU Waste				
	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population	Population	Maximally Exposed Individual	Noninvolved Worker Population	Noninvolved Worker Individual	Worker Population
Radiation Dose (in rem or person-rem)															
Hanford	5.6E-01	1.2E-05	2.7E-02	4.7E-05	5.4E+02	7.0E-06	1.5E-10	3.4E-07	5.9E-10	5.4E-01	5.6E-01	1.2E-05	2.7E-02	4.7E-05	5.4E+02
LANL	2.7E+00	2.9E-04	2.5E-01	1.8E-04	4.5E+02	0	0	0	0	0	2.7E+00	2.9E-04	2.5E-01	1.8E-04	4.5E+02
INEEL	2.6E-02	3.2E-06	7.6E-03	6.6E-06	9.1E+02	0	0	0	0	0	2.6E-02	3.2E-06	7.6E-03	6.6E-06	9.1E+02
SRS	2.7E-01	2.5E-06	2.9E-01	2.5E-05	4.9E+01	0	0	0	0	0	2.7E-01	2.5E-06	2.9E-01	2.5E-05	4.9E+01
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	2.5E-04	7.6E-09	8.5E-06	7.8E-09	6.4E+00	2.5E-04	7.6E-09	8.5E-06	7.8E-09	6.4E+00
Total	3.5E+00		5.7E-01		1.9E+03	2.6E-04		8.9E-06		7.0E+00	3.5E+00		5.7E-01		2.0E+03
Radiation-Related LCFs															
Hanford	2.8E-04	5.8E-09	1.1E-05	1.9E-08	2.2E-01	3.5E-09	7.3E-14	1.4E-10	2.4E-13	2.1E-04	2.8E-04	5.8E-09	1.1E-05	1.9E-08	0.2
LANL	1.3E-03	1.4E-07	9.8E-05	7.4E-08	1.8E-01	0	0	0	0	0	0	0	0	0	0.2
INEEL	1.3E-05	1.6E-09	3.1E-06	2.6E-09	3.6E-01	0	0	0	0	0	0	0	0	0	0.4
SRS	1.3E-04	1.2E-09	1.1E-04	9.8E-09	1.9E-02	0	0	0	0	0	0	0	0	0	1.9E-02
RFETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNL	0	0	0	0	0	1.3E-07	3.8E-12	3.4E-09	3.1E-12	2.6E-03	1.3E-07	3.8E-12	3.4E-09	3.1E-12	2.6E-03
Total	1.8E-03		2.3E-04		7.8E-01	1.3E-07		3.5E-09		2.8E-03	1.8E-03		2.3E-04		7.8E-01
Chemicals - Cancer Incidence															
Hanford	2.2E-10	0	1.3E-10	2.6E-13	1.8E-07	5.1E-14	0	3.1E-14	6.3E-17	1.8E-10	2.2E-10	0	1.3E-10	2.6E-13	1.8E-07
LANL	1.2E-09	2.6E-13	5.9E-10	3.8E-13	1.9E-07	0	0	0	0	0	1.2E-09	2.6E-13	5.9E-10	3.8E-13	1.9E-07
INEEL	3.3E-09	4.6E-13	4.5E-09	3.7E-12	2.2E-05	0	0	0	0	0	3.3E-09	4.6E-13	4.5E-09	3.7E-12	2.2E-05
SRS	7.9E-12	0	3.8E-12	4.6E-15	5.6E-09	0	0	0	0	0	7.9E-12	0	3.8E-12	4.6E-15	5.6E-09
RFETS	0	0	0	0	0	0	0	0	0	0	0.0E+00	0	0.0E+00	0.0E+00	0.0E+00
ORNL	0	0	0	0	0	1.5E-07	0	4.8E-08	4.7E-11	3.2E-06	1.5E-07	7.5E-12	4.8E-08	4.7E-11	3.2E-06
Total	4.7E-09		5.2E-09		2.2E-05	1.5E-07		4.8E-08		3.2E-06	1.5E-07		5.4E-08		2.5E-05

LCFs may also be expected in waste treatment workers under all alternatives and options except No Action Alternative 2. There is a calculated expectation of 1.7 radiation-related LCFs under Action Alternative 2A and No Action Alternative 1A, 1.5 LCFs under Action Alternatives 1 and 3, and 1.3 LCFs under Action Alternative 2B and No Action Alternative 1B. About 1 LCF (0.8 and 0.6, respectively) may be expected under the Proposed Action and Action Alternative 2C, while only 0.4 LCF would be expected under No Action Alternative 2.

Human health impacts taken from the WM PEIS, on which the SEIS-II estimates are based, are presented in Tables B-20 through B-24.

Table B-20
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Decentralized Alternative

Site	Population	MEI	Non-Involved Worker Population	Non-Involved Worker Individual	Worker Population
Radiation Dose (rem or person-rem) [a]					
Hanford	4.6E-02	9.7E-07	2.30E-03	3.9E-06	3.10E + 02
LANL	1.1E-01	1.1E-05	9.80E-03	7.4E-06	3.60E + 02
INEEL	2.3E-03	2.8E-07	6.80E-04	5.8E-07	6.30E + 02
SRS	1.5E-01	1.4E-06	1.60E-02	1.4E-05	1.70E + 02
RFETS	1.9E-02	2.5E-07	9.40E-04	5.7E-07	1.90E + 01
ORNL	1.6E-03	4.9E-08	5.40E-05	4.9E-08	6.80E + 00
LLNL	6.9E-03	1.1E-07	3.40E-04	1.2E-07	1.40E + 00
NTS	2.3E-07	5.9E-11	6.40E-07	2.9E-09	5.20E-01
ANL-E	4.0E-03	2.2E-08	2.10E-05	2.1E-08	2.20E + 01
Totals	3.4E-01		3.0E-02		1.5E + 03
Radiation-Related LCFs [a, b]					
Hanford	2.3E-05	4.9E-10	9.2E-07	1.6E-09	1.2E-01
LANL	5.5E-05	5.5E-09	3.9E-06	3.0E-09	1.4E-01
INEEL	1.2E-06	1.4E-10	2.7E-07	2.3E-10	2.5E-01
SRS	7.5E-05	7.0E-10	6.4E-06	5.6E-09	6.8E-02
RFETS	9.5E-06	1.3E-10	3.8E-07	2.3E-10	7.6E-03
ORNL	8.0E-07	2.5E-11	2.2E-08	2.0E-11	2.7E-03
LLNL	3.5E-06	5.5E-11	1.4E-07	4.8E-11	5.6E-04
NTS	1.2E-10	3.0E-14	2.6E-10	1.2E-12	2.1E-04
ANL-E	2.0E-06	1.1E-11	8.4E-09	8.4E-12	8.8E-03
Totals	1.7E-04		1.2E-05		6.1E-01
Hazardous Chemical Cancer Incidence [a]					
Hanford	8.4E-11	0	5.0E-11	9.8E-14	2.2E-08
LANL	6.8E-10	8.3E-14	3.4E-10	2.1E-13	3.5E-08
INEEL	2.3E-09	3.2E-13	3.0E-09	2.5E-12	9.2E-06
SRS	1.9E-11	0	9.5E-12	1.1E-14	4.2E-09
RFETS	4.8E-10	0	9.6E-11	4.9E-14	6.8E-09
ORNL	1.6E-07	8.1E-12	5.2E-08	5.0E-11	3.0E-06
LLNL	1.3E-07	2.8E-12	3.0E-08	8.9E-12	8.8E-07
NTS	3.8E-13	0	5.1E-12	2.1E-14	8.8E-10
ANL-E	1.5E-09	0	3.1E-11	2.8E-14	1.9E-09
Totals	3.0E-07		8.6E-08		1.3E-05

[a] Radiation doses and hazardous chemical cancer incidences are taken from the following tables in Volume II of the WM PEIS: Hanford II-5.3-2, II-5.3-4; LANL II-7.3-2, II-7.3-4; INEEL II-6.3-2, II-6.3-4; SRS II-16.3-2, II-16.3-4; RFETS II-14.3-2, II-14.3-4; ORNL II-10.3-2, II-10.3-4; LLNL II-8.3-2, II-8.3-4; NTS II-9.3-2, II-9.3-4; ANL-E II-2.3-2, II-2.3-4.

[b] Calculated from the radiation dose, using 5 E-4 per rem for population and MEI, and 4 E-4 per rem for NIW population, NIW individual, and worker population.

Table B-21
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 1 Alternative

Site	Population	MEI	Non-Involved Worker		Worker Population
			Population	Individual	
Radiation Dose (rem or person-rem) [a]					
Hanford	8.2E-02	1.7E-06	4.0E-03	6.9E-06	3.3E+02
LANL	1.3E-01	1.4E-05	1.2E-02	9.0E-06	3.6E+02
INEEL	2.9E-03	3.6E-07	8.6E-04	7.4E-07	6.3E+02
SRS	2.7E-01	2.5E-06	2.9E-01	2.5E-05	1.9E+02
RFETS	3.0E-02	4.0E-07	1.5E-03	9.1E-07	1.9E+01
ORNL	1.7E-03	5.1E-08	5.7E-05	5.2E-08	6.9E+00
LLNL	7.3E-03	1.2E-07	3.6E-04	1.2E-07	1.4E+00
NTS	3.0E-07	7.8E-11	8.4E-07	3.9E-09	5.0E-01
ANL-E	3.5E-03	1.9E-08	1.8E-05	1.8E-08	2.2E+01
Totals	5.3E-01		3.1E-01		1.6E+03
Radiation-Related LCFs [b]					
Hanford	4.1E-05	8.5E-10	1.6E-06	2.8E-09	1.3E-01
LANL	6.5E-05	7.0E-09	4.8E-06	3.6E-09	1.4E-01
INEEL	1.5E-06	1.8E-10	3.4E-07	3.0E-10	2.5E-01
SRS	1.4E-04	1.3E-09	1.2E-04	1.0E-08	7.6E-02
RFETS	1.5E-05	2.0E-10	6.0E-07	3.6E-10	7.6E-03
ORNL	8.5E-07	2.6E-11	2.3E-08	2.1E-11	2.8E-03
LLNL	3.7E-06	6.0E-11	1.4E-07	4.8E-11	5.6E-04
NTS	1.5E-10	3.9E-14	3.4E-10	1.6E-12	2.0E-04
ANL-E	1.8E-06	9.5E-12	7.2E-09	7.2E-12	8.8E-03
Totals	2.6E-04		1.2E-04		6.2E-01
Hazardous Chemical Cancer Incidence [a]					
Hanford	1.3E-10	0	7.9E-11	1.6E-13	1.1E-07
LANL	9.5E-10	2.1E-13	4.7E-10	3.0E-13	1.5E-07
INEEL	2.3E-09	3.2E-13	3.1E-09	2.6E-12	1.5E-05
SRS	3.1E-11	0	1.5E-11	1.8E-14	2.2E-08
RFETS	6.3E-10	0	1.3E-10	6.5E-14	2.1E-08
ORNL	1.6E-07	8.1E-12	5.2E-08	5.0E-11	3.4E-06
LLNL	2.2E-07	4.8E-12	5.2E-08	1.5E-11	1.9E-06
NTS	1.1E-12	0	1.5E-11	6.2E-14	4.4E-09
ANL-E	2.9E-09	1.3E-14	6.0E-11	5.4E-14	2.8E-09
Totals	3.9E-07		1.1E-07		2.1E-05

[a] Radiation doses and hazardous chemical cancer incidences are taken from the following tables in Volume II of the WM PEIS: Hanford II-5.3-2, II-5.3-4; LANL II-7.3-2, II-7.3-4; INEEL II-6.3-2, II-6.3-4; SRS II-16.3-2, II-16.3-4; RFETS II-14.3-2, II-14.3-4; ORNL II-10.3-2, II-10.3-4; LLNL II-8.3-2, II-8.3-4; NTS II-9.3-2, II-9.3-4; ANL-E II-2.3-2, II-2.3-4.

[b] Calculated from the radiation dose, using 5 E-4 per rem for population and MEI, and 4 E-4 per rem for NIW population, NIW individual, and worker population.

Table B-22
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 2 Alternative

Site	Population	MEI	Non-Involved Worker Population	Non-Involved Worker Individual	Worker Population
Radiation Dose (rem or person-rem) [a]					
Hanford	3.3E+02	6.8E-03	1.6E+01	2.8E-02	3.2E+02
LANL	1.3E+03	1.3E-01	1.2E+02	8.7E-02	3.4E+02
INEEL	1.5E+01	1.8E-03	4.4E+00	3.7E-03	5.9E+02
SRS	4.5E+00	4.2E-05	4.8E-01	4.2E-04	1.9E+02
RFETS	2.2E+02	3.0E-03	1.1E+01	6.7E-03	1.8E+01
ORNL	9.2E+01	2.8E-03	3.1E+00	2.8E-03	2.3E+02
LLNL	7.3E-03	1.2E-07	3.6E-04	1.2E-07	1.4E+00
NTS	3.0E-07	7.8E-11	8.4E-07	3.9E-09	5.0E-01
ANL-E	3.5E-03	1.9E-08	1.8E-05	1.8E-08	2.2E+01
Totals	2.0E+03		1.5E+02		1.7E+03
Radiation-Related LCFs [b]					
Hanford	1.7E-01	3.4E-06	6.4E-03	1.1E-05	1.3E-01
LANL	6.5E-01	6.5E-05	4.8E-02	3.5E-05	1.4E-01
INEEL	7.5E-03	9.0E-07	1.8E-03	1.5E-06	2.4E-01
SRS	2.3E-03	2.1E-08	1.9E-04	1.7E-07	7.6E-02
RFETS	1.1E-01	1.5E-06	4.4E-03	2.7E-06	7.2E-03
ORNL	4.6E-02	1.4E-06	1.2E-03	1.1E-06	9.2E-02
LLNL	3.7E-06	6.0E-11	1.4E-07	4.8E-11	5.6E-04
NTS	1.5E-10	3.9E-14	3.4E-10	1.6E-12	2.0E-04
ANL-E	1.8E-06	9.5E-12	7.2E-09	7.2E-12	8.8E-03
Totals	9.8E-01		6.2E-02		6.8E-01
Hazardous Chemical Cancer Incidence [a]					
Hanford	1.3E-10	0	7.5E-11	1.5E-13	1.9E-07
LANL	1.1E-09	1.3E-13	5.4E-10	3.3E-13	3.7E-07
INEEL	1.7E-09	2.3E-13	2.2E-09	1.9E-12	2.2E-05
SRS	2.9E-11	0	1.5E-11	1.7E-14	3.7E-08
RFETS	8.4E-10	0	1.7E-10	8.5E-14	6.2E-08
ORNL	1.1E-07	5.7E-12	3.7E-08	3.5E-11	5.1E-06
LLNL	2.2E-07	4.8E-12	5.2E-08	1.5E-11	1.9E-06
NTS	1.1E-12	0	1.5E-11	6.2E-14	4.4E-09
ANL-E	2.9E-09	1.3E-14	6.0E-11	5.4E-14	2.8E-09
Totals	3.4E-07		9.2E-08		3.0E-05

[a] Radiation doses and hazardous chemical cancer incidences are taken from the following tables in Volume II of the WM PEIS: Hanford II-5.3-2, II-5.3-4; LANL II-7.3-2, II-7.3-4; INEEL II-6.3-2, II-6.3-4; SRS II-16.3-2, II-16.3-4; RFETS II-14.3-2, II-14.3-4; ORNL II-10.3-2, II-10.3-4; LLNL II-8.3-2, II-8.3-4; NTS II-9.3-2, II-9.3-4; ANL-E II-2.3-2, II-2.3-4.

[b] Calculated from the radiation dose, using 5 E-4 per rem for population and MEI, and 4 E-4 per rem for NIW population, NIW individual, and worker population.

Table B-23
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Regionalized 3 Alternative

Site	Population	MEI	Non-Involved Worker		Worker Population
			Population	Individual	
Radiation Dose (rem or person-rem) [a]					
Hanford	3.3E+02	6.8E-03	1.6E+01	2.8E-02	3.2E+02
LANL	1.4E-01	1.5E-05	1.3E-02	9.7E-06	3.6E+02
INEEL	8.2E+01	1.0E-02	2.5E+01	2.1E-02	6.2E+02
SRS	4.5E+00	4.2E-05	4.8E-01	4.2E-04	1.9E+02
RFETS	2.4E-02	3.3E-07	2.1E-03	7.4E-07	7.4E+01
ORNL	9.2E+01	2.8E-03	3.1E+00	2.8E-03	2.3E+02
LLNL	7.3E-03	1.2E-07	3.6E-04	1.2E-07	1.4E+00
NTS	3.0E-07	7.8E-11	8.4E-07	3.9E-09	5.0E-01
ANL-E	3.5E-03	1.9E-08	1.8E-05	1.8E-08	2.2E+01
Totals	5.1E+02		4.5E+01		1.8E+03
Radiation-Related LCFs [b]					
Hanford	1.7E-01	3.4E-06	6.4E-03	1.1E-05	1.3E-01
LANL	7.0E-05	7.5E-09	5.2E-06	3.9E-09	1.4E-01
INEEL	4.1E-02	5.0E-06	1.0E-02	8.4E-06	2.5E-01
SRS	2.3E-03	2.1E-08	1.9E-04	1.7E-07	7.6E-02
RFETS	1.2E-05	1.7E-10	8.4E-07	3.0E-10	3.0E-02
ORNL	4.6E-02	1.4E-06	1.2E-03	1.1E-06	9.2E-02
LLNL	3.7E-06	6.0E-11	1.4E-07	4.8E-11	5.6E-04
NTS	1.5E-10	3.9E-14	3.4E-10	1.6E-12	2.0E-04
ANL-E	1.8E-06	9.5E-12	7.2E-09	7.2E-12	8.8E-03
Totals	2.5E-01		1.8E-02		7.3E-01
Hazardous Chemical Cancer Incidence [a]					
Hanford	1.3E-10	0	7.5E-11	1.5E-13	1.9E-07
LANL	1.9E-09	2.3E-13	9.4E-10	5.7E-13	1.7E-07
INEEL	1.7E-09	2.4E-13	2.3E-09	1.9E-12	3.3E-05
SRS	2.9E-11	0	1.5E-11	1.7E-14	3.7E-08
RFETS	1.9E-09	9.0E-15	2.3E-10	1.2E-13	2.6E-08
ORNL	1.1E-07	5.7E-12	3.7E-08	3.5E-11	5.1E-06
LLNL	2.2E-07	4.8E-12	5.2E-08	1.5E-11	1.9E-06
NTS	1.1E-12	0	1.5E-11	6.2E-14	4.4E-09
ANL-E	2.9E-09	1.3E-14	6.0E-11	5.4E-14	2.8E-09
Totals	3.4E-07		9.3E-08		4.0E-05

[a] Radiation doses and hazardous chemical cancer incidences are taken from the following tables in Volume II of the WM PEIS: Hanford II-5.3-2, II-5.3-4; LANL II-7.3-2, II-7.3-4; INEEL II-6.3-2, II-6.3-4; SRS II-16.3-2, II-16.3-4; RFETS II-14.3-2, II-14.3-4; ORNL II-10.3-2, II-10.3-4; LLNL II-8.3-2, II-8.3-4; NTS II-9.3-2, II-9.3-4; ANL-E II-2.3-2, II-2.3-4.

[b] Calculated from the radiation dose, using 5 E-4 per rem for population and MEI, and 4 E-4 per rem for NIW population, NIW individual, and worker population.

Table B-24
Human Health Impacts Associated with TRU Waste Treatment from Radionuclides and Chemicals for WM PEIS Centralized Alternative

Site	Population	MEI	Non-Involved Worker Population	Non-Involved Worker Individual	Worker Population
Radiation Dose (rem or person-rem) [a]					
Hanford	1.3E+00	2.7E-05	6.2E-02	1.1E-04	4.1E+02
LANL	1.4E-01	1.5E-05	1.3E-02	9.7E-06	3.6E+02
INEEL	3.2E-03	3.9E-07	9.4E-04	8.1E-07	6.1E+02
SRS	6.8E-02	6.4E-07	7.3E-03	6.4E-06	2.6E+02
RFETS	2.4E-02	3.3E-07	1.2E-03	7.4E-07	7.4E+01
ORNL	9.2E+01	2.8E-03	3.1E+00	2.8E-03	2.3E+02
LLNL	7.3E-03	1.2E-07	3.6E-04	1.2E-07	1.4E+00
NTS	3.0E-07	7.8E-11	8.4E-07	3.9E-09	5.0E-01
ANL-E	3.5E-03	1.9E-08	1.8E-05	1.8E-08	2.2E+01
WIPP	5.2E+02	1.4E-01	4.2E+01	1.6E-01	4.1E+01
Totals	6.1E+02		4.5E+01		2.0E+03
Radiation-Related LCFs [b]					
Hanford	6.5E-04	1.4E-08	2.5E-05	4.4E-08	1.6E-01
LANL	7.0E-05	7.5E-09	5.2E-06	3.9E-09	1.4E-01
INEEL	1.6E-06	2.0E-10	3.8E-07	3.2E-10	2.4E-01
SRS	3.4E-05	3.2E-10	2.9E-06	2.6E-09	1.0E-01
RFETS	1.2E-05	1.7E-10	4.8E-07	3.0E-10	3.0E-02
ORNL	4.6E-02	1.4E-06	1.2E-03	1.1E-06	9.2E-02
LLNL	3.7E-06	6.0E-11	1.4E-07	4.8E-11	5.6E-04
NTS	1.5E-10	3.9E-14	3.4E-10	1.6E-12	2.0E-04
ANL-E	1.8E-06	9.5E-12	7.2E-09	7.2E-12	8.8E-03
WIPP	2.6E-01	7.0E-05	1.7E-02	6.4E-05	1.6E-02
Totals	3.1E-01		1.8E-02		8.0E-01
Hazardous Chemical Cancer Incidence [a]					
Hanford	7.9E-11	0	4.7E-11	9.2E-14	7.1E-08
LANL	1.9E-09	2.3E-13	9.4E-10	5.7E-13	1.7E-07
INEEL	6.6E-09	9.1E-13	8.7E-09	7.3E-12	4.4E-05
SRS	1.4E-11	0	6.8E-12	8.0E-15	4.0E-09
RFETS	1.1E-09	9.0E-15	2.3E-10	1.2E-13	2.6E-08
ORNL	1.1E-07	5.7E-12	3.7E-08	3.5E-11	5.1E-06
LLNL	2.2E-07	4.8E-12	5.2E-08	1.5E-11	1.9E-06
NTS	1.1E-12	0	1.5E-11	6.2E-14	4.4E-09
ANL-E	2.9E-09	1.3E-14	6.0E-11	5.4E-14	2.8E-09
WIPP	5.5E-10	2.1E-13	2.8E-10	1.3E-12	4.6E-06
Totals	3.4E-07		9.9E-08		5.6E-05

[a] Radiation doses and hazardous chemical cancer incidences are taken from the following tables in Volume II of the WM PEIS: Hanford II-5.3-2, II-5.3-4; LANL II-7.3-2, II-7.3-4; INEEL II-6.3-2, II-6.3-4; SRS II-16.3-2, II-16.3-4; RFETS II-14.3-2, II-14.3-4; ORNL II-10.3-2, II-10.3-4; LLNL II-8.3-2, II-8.3-4; NTS II-9.3-2, II-9.3-4; ANL-E II-2.3-2, II-2.3-4; WIPP II-17.3-2, II-17.3-4.

[b] Calculated from the radiation dose, using 5 E-4 per rem for population and MEI, and 4 E-4 per rem for NIW population, NIW individual, and worker population.

B.6 REFERENCES CITED IN APPENDIX B

ANL (Argonne National Laboratory), 1995, *Transuranic Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement*, ANL/EAD/TM-22 (Draft), April, Argonne, Illinois.

DOE (U.S. Department of Energy), 1992, *Integrated Data Base for 1992: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Revision 8, October, Washington, D.C.

DOE (U.S. Department of Energy), 1993, *Interim Mixed Waste Inventory Report: Waste Streams, Treatment Capacities, and Technologies, Volumes 1-6*, DOE/NBM-1100, April, Washington, D.C.

DOE (U.S. Department of Energy), 1995a, *Mixed Waste Inventory Summary Report*, DOE/M96-GT-029, Washington, D.C.

DOE (U.S. Department of Energy), 1995b, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 2, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP-91-005, Revision 6, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

APPENDIX C
AIR QUALITY

This appendix describes the methods used for analyzing potential impacts to air quality at the Waste Isolation Pilot Plant (WIPP) and the major treatment sites from routine emissions of nonradological air pollutants during normal operations of the facility. Pollutants addressed in this appendix include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), carbon monoxide (CO), lead (Pb) and volatile organic compounds (VOC) as ozone precursors. Lead and ozone would not be expected to be released in amounts of concern at WIPP. In formulating inputs for air quality modeling, a series of simplifying conservative assumptions have been used and are identified.

C.1 MODELS

The Industrial Source Complex (ISC3) computer code is used to estimate the annual air quality impacts. The ISC3 code consists of a short-term model (ISCST3) and a long-term model (ISCLT3). The long-term model was used to estimate annual air quality impacts. The short-term model was not used because the hourly meteorological data required by the model were not available at the time of the analysis. The model uses steady-state Gaussian plume algorithms to estimate pollutant concentrations from a wide variety of sources associated with industrial complexes (EPA 1995c). The model is appropriate for either flat or rolling terrain, modeling domains with a radius of 50 kilometers (31 miles) or less from the point of release, and either urban or rural environments. The ISC3 code is approved by the U.S. Environmental Protection Agency (EPA) for specific regulatory applications and is designed for use on personal computers. Input requirements for the ISC3 code include source configuration and pollutant emission parameters. The user may define point, line, area, or volume sources. The ISCLT3 code uses a joint frequency distribution of wind direction, wind speed, and atmospheric stability to compute pollutant transport and dispersion. Plume rise, stack tip downwash, and building wake can be computed, and plume depletion by deposition taken into account.

To calculate the short-term (24 hours or less) criteria pollutant impacts, the SCREEN3 model is used. SCREEN3 is a screening model used to estimate short-term air pollutant concentrations, including estimates of maximum ground-level concentrations from a single source (EPA 1995b). The model uses a steady-state Gaussian plume algorithm to calculate the concentration from a single point, area, or volume source of simple geometry. The model can be applied to both simple and complex terrain for modeling domains out to 100 kilometers (62 miles). Input requirements for SCREEN3 include source configuration information and pollutant emission parameters. Plume rise, building wake downwash, and plume impaction on complex terrain can be computed. While specific meteorological values of wind speed and stability can be entered to calculate pollutant transport and diffusion, the model can also calculate worst-case maximum concentrations, examining a range of stability classes and wind speeds to identify the most conservative meteorological conditions. Output of the SCREEN3 model is 1-hour maximum concentration at specified distances. Adjustment factors can be applied to estimate concentrations for averaging periods up to 24 hours. Averaging times and their corresponding adjustment or multiplying factors are shown in Table C-1 (EPA 1992). The SCREEN3 model is approved by EPA for specific screening procedures and is designed to run on personal computers.

Table C-1
Multiplying Factors to Estimate Maximum Concentration at Various Averaging Times for a Given 1-hour Maximum Concentration

Averaging Time	Multiplying Factor
3 hours	0.9
8 hours	0.7
24 hours	0.4

C.2 RECEPTORS

Maximum ground-level pollutant concentrations for regulation-specific time periods are reported at the maximally impacted receptor location. To determine maximum short-term impacts for exposure periods from 1 to 24 hours, pollutant concentrations for receptors along the "Off Limits Area" boundary are reported. Receptors along the "Off Limits Area" boundary are used because points along this boundary are the closest unrestricted access points to a member of the public. For long-term impacts, pollutant concentrations for receptors along the Land Withdrawal Boundary are reported. Points within the Land Withdrawal Boundary were not considered because of the limited time any member of the public would spend at an on-site location over the course of a year.

ISCLT3 model runs were done using a Cartesian grid of receptors spaced at 300-meter (984-foot) intervals along the Land Withdrawal Boundary. The model runs indicated that the maximum long-term concentrations would occur at a point approximately 3,000 meters (9,840 feet) north of the source. The maximum short-term concentrations for a ground level source would be at the closest point on the "Off Limits Area" boundary to the source, approximately 1,200 meters (3,940 feet) for the excavation exhaust stack.

C.3 SOURCE TERMS AND IMPACTS

The increase in airborne concentration of criteria pollutants is assumed to result from the routine operation of WIPP. Principal emission sources of particulates would be from fugitive salt dust, the excavation and disposal of salt, and fuel combustion from backup diesel-powered electrical generators and excavation and support equipment. Emissions of particulates are conservatively assumed to be emitted entirely as PM_{10}. Principal sources of NO_2, SO_2, and CO are from fuel combustion.

In all but one case, pollutants are assumed to be released from a point source. The exception to this is that wind erosion of the salt pile is assumed to come from an area source with a center located 360 meters (1,180 feet) north of the exhaust stack (see Figure 2-3). Plume rise is calculated for emissions from two back-up diesel generators and emissions out of the exhaust stack using stack parameters. Stack parameters for the generator (WEC 1993) and the exhaust shaft (DOE 1996) are given in Table C-2. Building wake downwash is not used in the model runs; however, there should be little difference between the concentration with and without building wake effects due to the large distances to receptors.

Table C-2
Stack Parameters for the Back-up Generator and Exhaust Shaft

Parameter	Generator	Excavation Exhaust
Stack Height	4.57 meters	8.2 meters
Stack Diameter	0.305 meter	4.4 meters
Stack Temperature	619.3 Kelvin	288 Kelvin
Velocity of Gas	10.18 meters per second	4.66 meters per second

To calculate the annual and 24-hour impacts under the Proposed Action, the following operating schedule was used: (1) excavation operations performed in two 8-hour shifts per day, 5 days per week, 52 weeks per year; (2) contact-handled (CH) transuranic (TRU) waste disposal operations performed in two 8-hour shifts per day, 4 days per week, 52 weeks per year; (3) remote-handled (RH) TRU waste disposal operations performed in two 8-hour shifts per day, 4 days per week, 52 weeks per year; and (4) maintenance performed in one 8-hour shift per week, 52 weeks per year. This same schedule is assumed for Action Alternatives 1, 2, and 3. To calculate annual pollutant concentrations using the ISCLT3 model, a joint frequency distribution of wind speed, wind direction, and atmospheric stability data from Carlsbad, New Mexico, for the years 1990 through 1994 was used. A description of the meteorological data is found in Appendix F, Human Health.

No meteorological input is required for estimating the short-term averaged concentrations using the SCREEN3 model. SCREEN3 estimates the maximum concentration by examining a range of wind speed and stability classes.

C.3.1 Salt Dust Emissions

Salt dust emissions would result from wind erosion of the salt piles, emissions of salt through the ventilation system exhaust, and dust released from transferring the salt from the repository to the salt storage pile. Salt dust emissions were estimated using a ground-level release, a 1-meter-(3.3 feet)-per-second wind, and an atmospheric stability class of F (stable).

Fugitive dust emissions from the salt pile have been conservatively estimated to be 6.44 kilograms per hectare (5.75 pounds per acre) per day of particulates (Tillman 1988b). The total area of the active salt pile for all alternatives except No Action Alternatives 1 and 2, because the salt piles would be disposed of during decommissioning, is assumed to be 12 hectares (30 acres) (DOE 1980). To estimate the annual emission, it is assumed that daily emission of fugitive dust is the same for each day of the year. The estimated daily emission rate is conservative because it does not take into account crusting, which would greatly reduce salt emission, and it assumes that the entire pile contains loose salt available for resuspension, when actually only a small portion of the pile would contain loose salt. The annual emission rate is also conservative. It is assumed that fugitive dust emissions occur each day when, in reality, fugitive dust emissions would only occur during high wind events.

The emission of particulates through the ventilation system is assumed to be 1.45 kilograms (3.20 pounds) per hour (Tillman 1988a). Emission of salt through the ventilation system is assumed to be continuous during an entire 8-hour shift.

The dust released from transferring the salt from the repository to the storage pile is assumed to be 10 grams (0.36 ounces) per ton of salt moved to the pile (DOE 1980). On average, the amount of salt brought to the surface in all of the alternatives except No Action Alternatives 1 and 2 is assumed to be 5.4×10^5 kilograms (600 tons) per day and 1.4×10^8 kilograms (1.6×10^5 tons) per year (Ashford 1996).

Table C-3 summarizes the source term for PM_{10} emissions of salt dust for all alternatives except No Action Alternatives 1 and 2. Estimated impacts on air quality from salt dust emissions are shown in Table C-4.

Table C-3
Source Term for Calculating Salt Dust Emission Impacts for All Alternatives Except No Action Alternatives 1 and 2

Source	Averaging Time	Mass of Pollutant	Emission Rate
Wind Erosion	Annual	29,000 kilograms per year	7.5E-6 grams per square meter per second
	24 hour	78 kilograms per day	7.5E-6 grams per square meter per second
Emission from Ventilation	Annual	6,000 kilograms per year	0.19 grams per second
	24 hour	23 kilograms per day	0.27 grams per second
Emission during Transfer	Annual	1,600 kilograms per year	0.049 grams per second
	24 hour	6 kilograms per day	0.069 grams per second

Table C-4
Estimated Impacts on Air Quality from Salt Dust Emissions for All Alternatives Except No Action Alternatives 1 and 2

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
PM_{10}	Annual	0.65	50 [a]	1.3
	24 hour	78	150 [a]	52

[a] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.2 Backup Generators

Four ambient air pollutants, NO_2, SO_2, CO, and PM_{10}, were assumed to be emitted by two 1,500-horsepower back-up diesel generators. A permit has been obtained by WIPP for the operation of these two back-up diesel generators (NMED 1993). Permit conditions have remained unchanged since 1993, with limits on the emissions of NO_2, SO_2, CO, and particulates. The generators are allowed to run, at most, 480 hours per year. Table C-5 summarizes the annual and hourly emission rate limits for the back-up diesel generators.

Table C-5
Maximum Annual and Hourly Emission Rates from Two Back-up Generators

Pollutant	Averaging Time	Maximum Emission Rate
NO_2	Annual	10,000 kilograms per year
	Hourly	21 kilograms per hour
SO_2	Annual	730 kilograms per year
	Hourly	1.4 kilograms per hour
CO	Annual	2,220 kilograms per year
	Hourly	4.6 kilograms per hour
PM_{10}	Annual	730 kilograms per year
	Hourly	1.5 kilograms per hour

The source term for long-term impacts is assumed to be the maximum allowable annual emission rate of each pollutant as defined in the permit and the maximum allowable hourly emission rate as defined by the permit for short-term impacts. In addition, the backup generators were assumed to run for 6 hours per day for the short-term impacts. The maximum normal operating schedule is 6 hours per month, with 2 hours per month dedicated to ensure proper operation and the remaining 4 hours per month dedicated to periodic operational maintenance on the generators (WEC 1993).

Table C-6 summarizes the source terms for the emission of the four criteria pollutants for all alternatives except No Action Alternatives 1 and 2. The two no action alternatives are not included because they do not assume the use of the generators. Estimated potential air quality impacts are presented in Table C-7.

Table C-6
Source Term for Calculating Back-up Diesel Generator Emission Impacts

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	10,000	0.32
	24 hour	130	1.5
SO_2	Annual	730	0.023
	24 hour	8.4	0.098
	3 hour	1.4	0.39
CO	8 hour	27	0.95
	1 hour	4.6	1.3
PM_{10}	Annual	730	0.023
	24 hour	9.0	0.10

Table C-7
Criteria Pollutant Air Quality Impacts from the Emissions of Two Back-up Generators

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
NO_2	Annual	0.12	84 [a]	0.15
	24 hour	54	168 [a]	32
SO_2	Annual	0.0088	47 [a]	0.019
	24 hour	3.6	234 [a]	1.5
	3 hour	32	1,170 [b]	2.8
CO	8 hour	62	8,900 [a]	0.71
	1 hour	120	13,400 [a]	0.87
PM_{10}	Annual	0.0088	50 [c]	0.018
	24 hour	3.8	150 [c]	2.6

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.3 Above-Ground Diesel Equipment

In addition to the two back-up generators, the diesel equipment used on the surface during WIPP operations includes: one diesel dump truck used to haul the salt from the repository to the storage pile, a fire water pump, and an emergency hoist (Hollen 1996). All other equipment on the surface is electric.

To estimate the emissions from the diesel dump truck, emission rates for the criteria pollutants for heavy-duty construction equipment found in EPA's *Supplement A to Compilation of Air Pollution Emission Factors, Volume 2: Mobile Sources* (EPA 1991, Table 2-7.1) were used. These emission rates are summarized in Table C-8. Pollutant emissions are estimated using the emission rate for diesel industrial engines found in EPA's *Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, 5th Edition* (EPA 1995a, Table 3.3-2) for the fire water pump and emergency hoist. These emission rates are summarized in Table C-9.

Truck operation is assumed to be 40 percent of an 8-hour shift, to account for start up and shutdown of the excavation operation during a shift, operator break and lunch periods, and the time when salt is being loaded in the truck. For the other diesel equipment used during routine operations, it is assumed that the fire water pump (188 horsepower) is in operation for 30 minutes per week and the emergency hoist (115 horsepower) is in operation for 30 minutes per month (Hollen 1996).

Table C-10 summarizes the source term for emissions of the above-ground diesel equipment for all alternatives except No Action Alternatives 1 and 2, which do not assume operation of any of the above-ground diesel equipment. The potential air quality impacts are shown in Table C-11.

Table C-8
Estimated Emission Rates for Diesel Dump Truck

Pollutant	Estimated Emission Rate (grams per hour of operation)
NO_2	1,900
SO_2	210
CO	820
PM_{10}	120

Table C-9
Estimated Emission Rates for Industrial Diesel Engines

Pollutant	Estimated Emission Rate (pounds per horsepower-hour)
NO_2	0.031
SO_2	0.00205
CO	0.00668
PM_{10}	0.00220

Table C-10
Source Term for Calculating Impacts from Surface Diesel Equipment

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	3,200	0.10
	24 hour	14	0.16
SO_2	Annual	350	0.011
	24 hour	1.5	0.017
	3 hour	0.76	0.070
CO	8 hour	3.1	0.11
	1 hour	1.3	0.35
PM_{10}	Annual	200	0.0063
	24 hour	0.89	0.010

Table C-11
Criteria Pollutant Air Quality Impacts from Surface Diesel Equipment Emissions

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
NO_2	Annual	0.050	84 [a]	0.060
	24 hour	33	168 [a]	20
SO_2	Annual	0.0057	47 [a]	0.012
	24 hour	3.4	234 [a]	1.5
	3 hour	32	1,170 [b]	2.7
CO	8 hour	38	8,900 [a]	0.43
	1 hour	180	13,400 [a]	1.3
PM_{10}	Annual	0.0031	50 [c]	0.0062
	24 hour	2.1	150 [c]	1.4

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.4 Underground Diesel Equipment

A variety of diesel equipment is used in underground excavation, disposal, and maintenance operations, although only a few pieces of equipment are in operation at any one time (WEC 1995). To estimate the impacts from underground equipment, the pollutant emissions are estimated using the emission rates for diesel industrial engines found in EPA's *Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, 5th Edition* (EPA 1995a, Table 3.3-2). These emission rates are summarized in Table C-9 above.

The pollution emission for the underground diesel equipment depends upon the usage, the rated power available, and the load factor (the power actually used divided by the power available for each engine). Underground diesel equipment usage is assumed to be 40 percent of an 8-hour shift, to account for start up and shutdown of the excavation operation during a shift, operator break and lunch periods, and the time in which the equipment is not in use. To estimate the power available, a typical number and type of equipment are assumed for the excavation operation, CH-TRU waste handling, RH-TRU waste handling, and maintenance. Table C-12 shows the estimated equipment used in normal excavation, disposal, and maintenance operations (Roland 1996) along with the total available power for equipment used during a particular operation (WEC 1995). With the exception of impacts of less than three hours, a load factor of 40 percent is assumed because the equipment will normally not be running at full power. For impacts of less than three hours, the equipment is assumed to be running at full power and a load factor of 100 percent is used.

Table C-13 summarizes the source term for pollutant emissions from underground equipment. The potential air quality impacts resulting from underground equipment use are shown in Table C-14. The short-term impacts are highly conservative because they assume that the emissions are directly from the stack and do not enter into the repository where they would be diluted.

Table C-12
Diesel Equipment and Total Available Power for Underground Operations

Operation	Equipment Used	Total Available Power (horsepower)
Excavation	4 Trucks, 2 Load Haul Dumps	709
CH-TRU Waste Disposal	2 CH-TRU Waste Transports and 1 6-ton Forklift	298
RH-TRU Waste Disposal	1 40-ton Forklift and 1 20-ton Forklift	416
Maintenance	Scissor Lift, Arc Welder, 2 Tractors, Lube Truck	255

Table C-13
Source Term for Calculating Impacts from Underground Diesel Equipment Emissions

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	12,000	0.39
	24 hour	51	0.59
SO_2	Annual	810	0.026
	24 hour	3.4	0.039
	3 hour	1.59	0.15
CO	8 hour	5.5	0.19
	1 hour	4.3	1.2
PM_{10}	Annual	870	0.0275
	24 hour	3.6	0.042

Table C-14
Criteria Pollutant Air Quality Impacts from Underground Diesel Equipment Emissions

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
NO_2	Annual	0.11	84 [a]	0.13
	24 hour	23	168 [a]	14
SO_2	Annual	0.0073	47 [a]	0.015
	24 hour	1.5	234 [a]	0.63
	3 hour	13	1,170 [b]	1.1
CO	8 hour	13	8,900 [a]	0.14
	1 hour	110	13,400 [a]	0.85
PM_{10}	Annual	0.0078	50 [c]	0.016
	24 hour	1.6	150 [c]	1.1

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.5 Decommissioning of WIPP

The plans for decommissioning WIPP are described in Section 3.1.3.5. The potential air quality impacts would mainly come from construction of the berm and permanent markers, dismantling the above-ground structures (approximately 8 hectares [20 acres] of buildings outside the surface marker area), and reclamation of the salt stored on the surface. The impacts would be from fugitive dust due to construction operations and emissions from heavy-duty construction equipment.

Impacts from the dismantling of the above-ground building and construction of the berm and permanent markers would be similar to the impacts described in the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS), which describes the construction impacts for building the WIPP site. The same type of construction equipment would be used. Although the area of the berm varies between the Proposed Action and each of the action alternatives, the yearly usage of equipment and the number of acres of land disturbed by construction in a year is assumed to be similar. No Action Alternatives 1 and 2 would not require the building of the berm or setting up the permanent markers and would have smaller air quality impacts than those for the other alternatives.

Air quality impacts would also be due to reclaiming the stored salt on the surface. Stored salt could be used to close the shafts of the repository or act as a base for the berm. Emissions of criteria pollutants and the resulting air quality impacts from the shaft closure operations would be similar to those described in the FEIS. These include emissions from a mined-salt drier, loading the salt into a crusher, transporting the salt into the repository, and salt emitted out of the ventilation system. Impacts for using the reclaimed salt as the base to the berm would be similar to those for using the reclaimed salt to close the shafts since drying, crushing, and transport of the salt would be required for both. As the existing salt pile is smaller than the 12-hectare (30-acre) storage pile assumed under the Proposed Action and the action alternatives, emission and impacts from reclaiming the salt pile in No Action Alternatives 1 and 2 would be less than for the other alternatives.

C.3.6 Volatile Organic Compounds

VOC emissions were estimated using drum headspace volatile emission data (detailed in Appendix F). Emission rates for all of the individual VOCs listed were summed, and the one panel-equivalent of CH-TRU waste and RH-TRU waste (about 85,000 drum-equivalents for all alternatives) was assumed to be continuously releasing volatiles. The estimated total VOC emissions were 540 kilograms (1,200 pounds) per year. Because VOCs are ozone precursors, they were compared to the ozone release limit of 40 tons (80,000 pounds) per year in the New Mexico Prevention of Significant Deterioration (PSD) regulations (Air Quality Control Regulation [AQCR]). These emissions did not vary greatly among the Proposed Action, Action Alternative 1, and Action Alternative 3. No VOCs would be present in the thermally treated waste under Action Alternative 2 and No Action Alternative 1.

C.3.7 Criteria Air Pollutants at Generator-Storage and Treatment Sites

U.S. Department of Energy (DOE or the Department) evaluated air quality impacts at each proposed waste management site based on estimated increases in emissions of the six criteria air pollutants. Pollutant emission estimates were made for the construction and operation and maintenance activities of the waste management facilities.

In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations.

Criteria air pollutants can be emitted from construction equipment and from vehicles used to drive to the construction site; both are considered to be mobile sources. Criteria air pollutants are also emitted during operation and maintenance of waste management facilities (stationary sources) and by vehicles that are driven to the facility or used to transport waste (mobile sources). DOE evaluated air quality impacts for these pollutants at each site by comparing the estimated increases in tons per year to the allowable emission limits under either the General Conformity Rules in nonattainment areas or the PSD regulations in attainment areas.

Table C-15 shows the percent of standard/guidelines for emissions of criteria air pollutants during operation and maintenance at nine of the ten major generator-storage sites. Data are taken from the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997). Data for the Mound Plant were not included in the WM PEIS.

Table C-16 shows the percent of the General Conformity Rule for emissions of criteria air pollutants during construction at four of the ten major generator-storage sites, where data are available. Data are taken from the WM PEIS (DOE 1997).

Table C-15
Percent of Standard/Guidelines for Criteria Air Pollutants During Operations and Maintenance

Pollutant	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Argonne National Laboratory-East									
CO	0	0	0	0	0	0	0	0	0
NO_2	9	9	8	8	8	5	8	8	9
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	5	5	5	5	5	5	5	5	5
Hanford Site									
CO	0	0	0	0	0	0	0	0	0
NO_2	2	2	2	2	1	2	2	2	2
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	1	1	2	2	1	1	2	2	1
SO_2	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
Idaho National Engineering and Environmental Laboratory									
CO	0	0	0	1	0	0	0	1	0
NO_2	1	1	2	4	0	2	2	4	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	1	1	10	17	0	1	10	17	1
SO_2	0	0	4	8	0	0	4	8	0
VOC	0	0	0	0	0	0	0	0	0
Lawrence Livermore National Laboratory									
CO	8	8	9	9	9	6	9	9	8
NO_2	2	2	2	2	2	1	2	2	2
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	2	2	2	2	2	1	2	2	2
Los Alamos National Laboratory									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	2	0	0	1	2	0	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	5	0	0	0	5	0	0
SO_2	0	0	2	0	0	0	2	0	0
VOC	0	0	0	0	0	0	0	0	0
Nevada Test Site									
CO	3	3	0	0	0	0	0	0	3
NO_2	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
Oak Ridge National Laboratory									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	1	1	1	0	1	1	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	2	2	2	0	2	2	0
SO_2	0	0	1	1	1	0	1	1	0
VOC	0	0	0	0	0	0	0	0	0
Rocky Flats Environmental Technology Site									
CO	17	17	24	5	5	20	24	5	17
NO_2	3	3	5	1	1	4	5	1	3
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	1	0	0	0	1	0	0
VOC	4	4	6	1	1	5	6	1	4
Savannah River Site									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	2	2	0	1	2	2	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	9	9	0	1	9	9	0
SO_2	0	0	4	4	0	0	4	4	0
VOC	0	0	0	0	0	0	0	0	0

Source: WM PEIS (DOE 1997)

Table C-16
Percent of General Conformity Rule for Criteria Air Pollutants During Construction [a]

Pollutant	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Argonne National Laboratory-East									
CO	-	-	-	-	-	-	-	-	-
NO_2	49	49	34	34	34	40	34	34	49
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	1	1	1	1	1	0	1	1	1
SO_2	-	-	-	-	-	-	-	-	-
VOC	17	17	8	8	8	16	8	8	17
Lawrence Livermore National Laboratory									
CO	13	13	20	20	20	9	20	20	13
NO_2	7	7	10	10	10	3	10	10	7
Pb	0	0	0	0	0	0	0	0	-
PM_{10}	0	0	0	0	0	0	0	0	-
SO_2	0	0	0	0	0	0	0	0	-
VOC	4	4	5	5	5	2	5	5	4
Nevada Test Site									
CO	5	5	0	0	0	0	0	0	5
NO_2	-	-	-	-	-	-	-	-	-
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	-	-	-	-	-	-	-	-	-
VOC	-	-	-	-	-	-	-	-	-
Rocky Flats Environmental Technology Site									
CO	19	19	29	7	7	20	29	7	19
NO_2	11	11	15	4	4	11	15	4	11
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	1	1	1	0	0	1	1	0	1
SO_2	-	-	-	-	-	-	-	-	-
VOC	6	6	8	2	2	6	8	2	6

[a] Dashed line indicates that emissions of this criteria pollutant are assumed to be negligible.

Source: WM PEIS (DOE 1997)

C.4 REFERENCES CITED IN APPENDIX C

Ashford, F., 1996, Documentation of Verbal Communication, DVC-033, February 26, Battelle, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1996, *Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP 91-005, Revision 6, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1991, *Supplement A to Compilation of Air Pollution Emission Factors, Volume 2: Mobile Sources*, AP-42, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency), 1992, *Screening Procedures for Estimating the Air Quality Impacts of Stationary Sources, Revised*, EPA-454/R-92-019, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency), 1995a, *Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, 5th Edition*, AP-42, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency), 1995b, *SCREEN3 Model User's Guide*, EPA-454/B-95-004, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency), 1995c, *User's Guide for Industrial Source Complex (ISC3) Dispersion Models Volume I - User Instructions*, EPA-454/B-95-003a, Research Triangle Park, North Carolina.

Hollen, J., 1996, Documentation of Verbal Communication, DVC-023, February 5, Battelle, Albuquerque, New Mexico.

NMED (New Mexico Environmental Department), 1993, "Air Quality Permit No. 310-M-2 U.S. Department of Energy - WIPP site," Santa Fe, New Mexico.

Roland, B., 1996, Documentation of Verbal Communication, DVC-022, January 25, Battelle, Albuquerque, New Mexico.

Tillman, J.B., 1988a, Letter to J. Shively (New Mexico Environmental Improvement Division), WIPP:HJD:E88-023, March 4, U.S. Department of Energy, Carlsbad, New Mexico.

Tillman, J.B., 1988b, Letter to J. Shively (New Mexico Environmental Improvement Division), July 7, U.S. Department of Energy, Carlsbad, New Mexico.

WEC (Westinghouse Electric Company), 1993, *New Mexico Environmental Department Dispersion Modeling Report. Backup Power Supply System Generators U.S. Department of Energy Waste Isolation Plant*, September, Carlsbad, New Mexico.

WEC (Westinghouse Electric Corporation), 1995, *Waste Isolation Pilot Plant Mine Ventilation Plan*, July, Carlsbad, New Mexico.

This page intentionally left blank.

APPENDIX D
LIFE-CYCLE COSTS AND ECONOMIC IMPACTS

This appendix discusses the technical approach and sources of information used in the estimation of life-cycle costs and economic impacts of *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (SEIS-II) alternatives.

D.1 LIFE-CYCLE COSTS

Life-cycle costs were determined in three areas: waste management facility costs at the large waste consolidation sites, waste transportation costs to the Waste Isolation Pilot Plant (WIPP) site, and WIPP operations costs.

Appendix J compares the estimates of the SEIS-II transuranic (TRU) waste volumes with those from the *The National Transuranic Waste Management Plan* (DOE 1996). These estimates are lower than those used in the SEIS-II analysis. Since costs depend in large part on waste volume, the costs could be lower.

D.1.1 Waste Treatment Facility Costs

The *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) cost estimates for waste management facilities include the following major cost elements (DOE 1997):

- Preoperations costs - These include the costs of technology site adaptation, including bench tests and demonstrations; statutory and regulatory permitting; plant setup costs; and related generic design, project management, and contingencies.

- Facility construction costs - These include the costs of buildings, equipment, and related design; construction and project management; and contingencies.

- Operations and maintenance costs - These include the costs of annual operations, maintenance, utilities, contractor supervision and overhead, and related project management and contingencies.

- Decontamination and decommissioning costs - These include the costs of demolition of facilities, environmental closure, post closure and monitoring activities.

The WM PEIS also provided an equivalent accounting or breakdown of waste management facility costs on the basis of waste management functions performed at sites, including the following:

- Waste retrieval and characterization - These include the costs to retrieve and characterize the constituents prior to and following treatment.

- Waste treatment costs - These include the costs to build, operate and maintain waste treatment facilities.

- Waste storage costs - These include the costs to build, operate, and maintain storage capacity at the large waste consolidation sites.

The cost information provided in data tables in the WM PEIS provided a benchmark for estimating waste management facility costs for the SEIS-II alternatives. Tables D-1 through D-8 present these estimates. Costs were calculated by adjusting the site costs provided in the WM PEIS (Tables II-2.3-12 through II-17.3-12) by the ratio of SEIS-II waste volumes relative to the WM PEIS waste volumes.

As an example, consider the case of the Proposed Action reported in Table D-1. In the WM PEIS, the Hanford Site (Hanford) would process a total of 25,300 cubic meters (895,000 cubic feet) of waste, whereas in SEIS-II, it would process a total of 86,900 cubic meters (3,070,000 cubic feet), or 3.43 times the reported WM PEIS volume. Accordingly, the adjusted waste management facility costs at Hanford under the Proposed Action are approximately $6.2 billion -- the product of the original WM PEIS cost estimate of $1.81 billion and the volume adjustment factor -- that is, $1.81 x 3.43 = $6.2 billion (in 1994 dollars). The volume adjustment factors corresponding to the various SEIS-II Alternatives are shown in Table D-9.

This adjustment process was applied to each site for the various SEIS-II alternatives. Because WM PEIS does not contain cost information for the Mound Plant (Mound), its benchmark cost estimate reflects the average costs of other sites having relatively small waste volumes.

Table D-1
Waste Treatment Facility Costs for the Proposed Action in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [b]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Decentralized Alternative Site Costs								
INEEL/ANL-W	83	419	725	461	930	705	54	1,688
Hanford	110	403	960	338	584	1,188	39	1,810
SRS	30	134	251	90	15	457	33	505
LANL	50	237	397	234	454	438	27	919
RFETS	21	95	227	34	46	311	20	377
ORNL	33	151	286	81	109	415	28	551
Mound	12	37	62	12	12	99	12	124
LLNL	17	63	132	21	0	221	14	233
NTS	6	27	46	17	0	84	12	96
ANL-E	25	89	183	33	0	308	22	330
Total	---	---	---	---	---	---	---	6,633
SEIS-II Proposed Action Alternative Site Costs								
INEEL/ANL-W	67	338	584	371	749	568	44	1,361
Hanford	378	1,384	3,298	1,161	2,006	4,081	134	6,221
SRS	21	95	178	64	11	324	23	358
LANL	96	455	762	449	871	840	52	1,763
RFETS	37	166	398	60	81	545	35	661
ORNL	67	308	584	165	223	848	57	1,128
Mound	1	7	13	4	5	19	1	25
LLNL	12	44	93	15	0	155	10	165
NTS	6	28	48	18	0	87	12	99
ANL-E	4	13	28	5	0	48	3	51
Total	689	2,838	5,986	2,312	3,946	7,515	371	11,832
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,560

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

N/A = Not Applicable

Table D-2
Waste Treatment Facility Costs for Action Alternative 1 in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [c]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Decentralized Alternative Site Costs								
INEEL/ANL-W	83	419	725	461	930	705	54	1,688
Hanford	110	403	960	338	584	1,188	39	1,811
SRS	30	134	251	90	15	457	33	505
LANL	50	237	397	234	454	438	27	918
RFETS	21	95	227	34	46	311	20	377
ORNL	33	151	286	81	109	415	28	551
Mound	12	37	62	12	12	99	12	124
LLNL	17	63	132	21	0	221	14	234
NTS	6	27	46	17	0	84	12	96
ANL-E	25	89	183	33	0	308	22	330
Total	---	---	---	---	---	---	---	6,634
SEIS-II Action Alternative 1 Site Costs								
INEEL/ANL-W [b]	189	956	1,876	1,052	2,122	1,609	347	4,078
Hanford [b]	655	2,398	6,132	2,011	3,475	7,069	652	11,196
SRS	30	134	250	90	15	455	33	503
LANL	159	754	1,263	744	1,444	1,393	86	2,923
RFETS	37	166	398	60	81	545	35	661
ORNL [b]	94	430	867	231	311	1,183	132	1,626
Mound	1	6	13	4	5	19	1	25
LLNL	2	7	16	2	0	26	2	28
NTS	12	53	90	33	0	165	24	189
ANL-E	12	43	89	16	0	150	11	161
Total	1,191	4,947	10,994	4,243	7,453	12,614	1,323	21,390
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11,862

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($420 million), INEEL ($223 million), and ORNL ($52 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

N/A = Not Applicable

The adjustment process described above is appropriate provided that linear relationships exist between costs and waste volumes and that treatment rates considered for the SEIS-II alternatives fall within the range of operations considered in the WM PEIS. To verify that these cost conditions are satisfied, guidance provided in Feizollahi and Shropshire (1994, Table 1-1) was considered. Specifically, cost relationships involving treatment processing rates (in kilograms per hour), storage input/throughput rates (in cubic meters per hour), and storage total volumetric requirements (in cubic meters) were considered.

The operation rates implied by a 35-year period do not exceed the maximum rate (or scale) of operations referenced in Feizollahi and Shropshire (1994) at any of the sites for any of the SEIS-II alternatives. However, the operations rates implied by a 35-year period did fall below the minimum boundary identified in Feizollahi and Shropshire (1994) at several sites having relatively small consolidated waste volumes. Consequently, the rate of operations at these sites was increased by reducing the period of operations to less than 35 years. As a result, operation rates at Mound, Lawrence Livermore National Laboratory (LLNL), Argonne National Laboratory - East (ANL-E) and the Nevada Test Site (NTS) were increased by shortening the period of operations to less than 35 years.

Table D-3
Waste Treatment Facility Costs for Action Alternative 2A in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [c]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Regionalized 2 Alternative Site Costs								
INEEL/ANL-W	125	549	875	493	930	1,023	90	2,042
Hanford	187	679	1,241	384	584	1,813	95	2,491
SRS	87	327	509	100	15	982	28	1,024
LANL	56	250	480	245	454	539	37	1,031
RFETS	34	145	303	49	46	457	29	531
ORNL	64	207	335	72	109	554	14	678
Total	---	---	---	---	---	---	---	7,797
SEIS-II Action Alternative 2 A Site Costs								
INEEL/ANL-W	281	1,234	1,967	1,108	2,091	2,300	202	4,593
Hanford [b]	1,144	4,153	7,983	2,348	3,572	11,096	969	15,637
SRS	100	376	586	115	17	1,130	32	1,179
LANL	176	788	1,512	772	1,430	1,698	117	3,245
RFETS	60	254	531	86	81	801	51	933
ORNL	132	428	693	149	225	1,146	29	1,400
Other sites [d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	703
Total	1,893	7,233	13,272	4,578	7,416	18,171	1,400	27,690
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15,356

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[d] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-4
Waste Treatment Facility Costs for Action Alternative 2B in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [c]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Regionalized 3 Alternative Site Costs								
INEEL/ANL-W	157	680	1,140	508	930	1,456	100	2,485
Hanford	187	679	1,241	384	584	1,813	95	2,491
SRS	87	327	509	100	15	982	28	1,023
ORNL	64	207	335	72	109	554	14	678
Total	---	---	---	---	---	---	---	6,677
SEIS-II Action Alternative 2B Site Costs								
INEEL/ANL-W	539	2,335	3,915	1,745	3,194	5,001	343	8,527
Hanford [b]	1,144	4,541	7,590	2,348	3,572	11,088	969	15,629
SRS	100	376	586	115	17	1,130	32	1,179
ORNL	132	428	693	149	225	1,146	29	1,400
Other sites [d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,805
Total	1,915	7,680	12,784	4,357	7,008	18,365	1,373	30,551
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16,942

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[d] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-5
Waste Treatment Facility Costs for Action Alternative 2C in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [c]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Centralized Alternative Site Costs								
Hanford	128	445	917	323	584	1,180	49	1,813
ORNL	64	207	335	72	109	554	14	678
WIPP	185	832	1,243	86	0	2,346	0	2,346
Total								4,837
SEIS-II Action Alternative 2C Site Costs								
Hanford [b]	167	580	1,585	421	759	1,539	452	2,750
ORNL	133	429	695	149	226	1,149	29	1,404
WIPP	478	2,148	3,209	222	0	6,057	0	6,057
Other sites [d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18,490
Totals	778	3,157	5,489	792	985	8,745	481	28,701
Total Discounted at 4.1 percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15,909

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[d] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-6
Waste Treatment Facility Costs for Action Alternative 3 in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [c]
	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval	Treatment	Storage	
WM PEIS Regionalized 1 Alternative Site Costs								
INEEL/ANL-W	105	450	777	489	930	801	91	1,821
Hanford	156	480	1,116	371	584	1,446	93	2,123
SRS	68	246	421	120	15	780	61	855
LANL	56	260	405	240	454	468	39	961
RFETS	22	98	257	45	46	346	30	422
ORNL	45	120	247	68	109	353	19	480
Total								6,662
SEIS-II Action Alternative 3 Site Costs								
INEEL/ANL-W [b]	235	1,006	2,004	1,094	2,080	1,791	469	4,340
Hanford [b]	953	2,931	7,315	2,265	3,566	8,830	1,068	13,464
SRS	78	283	484	138	17	897	70	984
LANL	176	819	1,276	756	1,430	1,474	123	3,027
RFETS	39	172	450	79	81	606	53	740
ORNL [b]	93	248	663	141	225	730	191	1,146
Other sites [d]	N/A	N/A	N/A	N/A	N/A	A	N/A	641
Total	1,574	5,459	12,192	4,473	7,399	14,328	1,974	24,342
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13,498

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($500 million), INEEL ($266 million), and ORNL ($152 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[d] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-7
Waste Treatment Facility Costs for No Action Alternative 1A in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [b]
	Preoperations	Construction	Operations and Maintenance	Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Regionalized 2 Alternative Site Costs								
INEEL/ANL-W	125	549	875	493	930	1,023	90	2,042
Hanford	187	679	1,241	384	584	1,813	95	2,491
SRS	87	327	509	100	15	982	28	1,023
LANL	56	250	480	245	454	539	37	1,031
RFETS	34	145	303	49	46	457	29	531
ORNL	64	207	335	72	109	554	14	678
Total	---	---	---	---	---	---	---	7,796
SEIS-II No Action Alternative 1A Site Costs								
INEEL/ANL-W	281	1,321	2,219	1,108	2,091	2,300	541	4,932
Hanford	1,144	4,242	8,236	2,348	3,572	11,096	1,311	15,979
SRS	100	415	795	115	17	1,130	280	1,427
LANL	176	835	1,727	772	1,430	1,698	379	3,507
RFETS	60	289	736	86	81	801	291	1,173
ORNL	132	460	895	149	225	1,146	263	1,634
Other sites [c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	703
Total	1,893	7,562	14,608	4,578	7,416	18,171	3,065	29,355
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16,282

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[c] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-8
Waste Treatment Facility Costs for No Action Alternative 1B in Millions of 1994 Dollars [a]

Cost Components	Life-Cycle Component				Functional Area			Costs [b]
	Preoperations	Construction	Operations and Maintenance	Decommissioning	Retrieval and Characterization	Treatment	Storage	
WM PEIS Regionalized 3 Alternative Site Costs								
INEEL/ANL-W	157	680	1,140	508	930	1,456	100	2,485
Hanford	187	679	1,241	384	584	1,813	95	2,491
SRS	87	327	509	100	15	982	28	1,024
ORNL	64	207	335	72	109	554	14	678
Total	---	---	---	---	---	---	---	6,678
SEIS-II No Action Alternative 1B Site Costs								
INEEL/ANL-W	539	2,444	4,187	1,745	3,194	5,001	724	8,919
Hanford	1,144	4,242	8,231	2,348	3,572	11,088	1,311	15,971
SRS	100	415	795	115	17	1,130	280	1,427
ORNL	132	460	895	149	225	1,146	263	1,634
Other sites [c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,805
Total	1,915	7,561	14,108	4,357	7,008	18,365	2,578	31,756
Total Discounted at 4.1 Percent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17,610

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decommissioning and are also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.
[c] Total cost of preparing waste for shipment to consolidation and treatment sites.

N/A = Not Applicable

Table D-9
Volume Adjustment Factors by Alternative

Consolidated Site	Proposed Action	Action Alternative 1	Action Alternatives 2A, 3, and No Action 1A	Action Alternative 2B and No Action 1B	Action Alternative 2C
INEEL/ANL-W	0.81	2.28	2.25	3.43	N/A
Hanford	3.43	5.95	6.12	6.12	1.30
SRS	0.71	1.00	1.15	1.15	N/A
LANL	1.92	3.18	3.15	N/A	N/A
RFETS	1.75	1.75	1.75	N/A	N/A
ORNL	2.04	2.85	2.07	2.07	2.07
Mound	0.20	0.20	N/A	N/A	N/A
LLNL	0.70	0.12	N/A	N/A	N/A
NTS	1.04	1.96	N/A	N/A	N/A
ANL-E	0.15	0.49	N/A	N/A	N/A
WIPP	N/A	N/A	N/A	N/A	2.58

N/A = Not Applicable

In the cases of Action Alternatives 1, 2, and 3, the site storage costs at Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), and Oak Ridge National Laboratory (ORNL) extend beyond the 35-year waste processing period. These storage-cost adjustments are made to account for extended storage periods ranging from 100 to 155 years due to WIPP emplacement limitations for remote-handled (RH) TRU waste. Thus, the storage costs at these sites reflect periodic expenditures made every 35 years over the waste work-off period and are calculated on the basis of the remaining site inventories at the end of each period. In this way, storage costs decrease on a periodic basis over the life of the alternative as waste inventories are shipped to WIPP for disposal. Care was taken to reduce the number of sites requiring extended storage by adjusting treatment-shipment rates among the various sites, provided it did not interfere with waste handling limitations or compromise WIPP emplacement capacity. This resulted in fewer lag storage sites than the number considered in Appendix F.

The waste management facility costs, waste transportation costs, and WIPP operations costs presented in this appendix and in Chapter 5 are presented in discounted present value form. The approach for discounting the value of these costs is straightforward. In present value terms, annual costs incurred t-years from the present are discounted by multiplying them by the discount factor $(1/1+r)^t$, where "r" reflects an inflation-adjusted discount rate. A discount rate of 4.1 percent was used in the analysis of life-cycle costs presented in Chapter 5. Over the project life-cycle ($T = 35$ years), the discounted annual costs are represented by $C\ (1 + x^1 + x^2 + x^3 + \ldots + x^{35})$, where $x = (1/1+r)$ and $T = 35$ is the end year of the project.

Table D-10 provides a sample of present value calculations for a 35-year period using hypothetical annual costs of $50 million, $100 million, $500 million, and $1,000 million and inflation-adjusted discount rates of 0 percent, 3 percent, and 5 percent. The present value of the cost estimates reported in this appendix, Chapter 5 and in the summary reflect the case of a 4.1 percent discount rate; thus, they are relatively higher than if they were discounted at 5 percent and relatively lower than if they were discounted at 3 percent.

Table D-10
Present Values of Hypothetical Annual Costs Incurred Over 35 Years

Inflation-Adjusted Discount Rate	Present Value of Annual Expenditures: $50 million for 35 years	Present Value of Annual Expenditures: $100 million for 35 years	Present Value of Annual Expenditures: $500 million for 35 years	Present Value of Annual Expenditures: $1,000 million per year for 35 years
r = 0 percent	$1,750 million	$3,500 million	$17,500 million	$35,000 million
r = 3 percent	$1,074 million	$2,149 million	$10,744 million	$21,487 million
r = 5 percent	$819 million	$1,637 million	$8,187 million	$16,374 million

D.1.2 Waste Transportation Costs

The waste transportation costs for contact-handled (CH) TRU and RH-TRU waste vary by alternative, depending on the mode of transportation and the total mileage and number of shipments required for disposal of the waste volumes. Two sources of information for the estimation of waste transportation costs were used: (1) the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995) for information concerning mileage between sites and the fixed and variable costs per truck shipment between sites; and (2) the *Comparative Study of the Waste Isolation Pilot Plant (WIPP) Transportation Alternatives* (DOE 1994) for information concerning the shipment costs of CH-TRU waste and RH-TRU waste via regular-class rail service and dedicated-class rail service.

The number of shipments reflects potential weight, thermal power, or plutonium-239 equivalent curies (PE-Ci) limitations. These relationships are described in Appendix A of this document. Truck shipments are limited to a maximum of three TRUPACT-IIs or one RH-72B per shipment. Rail shipments (either regular-class or dedicated-class) are limited to a maximum of six TRUPACT-IIs or two RH-72Bs per rail car. CH-TRU waste shipments may include as many as 42 drums of low-density waste (three TRUPACT-IIs) or as few as 12 drums of high-density waste (two TRUPACT-IIs). For RH-TRU waste, no limitations were assumed in meeting container and shipping specifications.

Approximately 38 percent of the waste shipments for the Proposed Action and Action Alternative 1 reflect two TRUPACT-IIs per shipment (the remainder involves three TRUPACT-IIs per shipment). All of the waste shipments for Action Alternative 2 reflect two TRUPACT-IIs per shipment. Approximately 86 percent of the shipments for Action Alternative 3 involve two TRUPACT-IIs per shipment. These percentages are based on stored waste stream data and are extrapolated to the other wastes for Action Alternatives 1 and 3.

Total shipments cover the number of shipments made from the small sites to consolidation sites for treatment and storage, and the number of shipments of treated waste volumes to WIPP. Total mileage depends on the number of shipments required to transport the treated waste volumes from each site to WIPP and the round-trip mileage between each site and WIPP. Total cost covers fixed and variable costs of transporting waste volumes between sites under the various options. Various cost parameters were used in the estimation of waste transportation costs, including the following:

- Fixed costs by truck - the number of truck shipments required in the transportation of treated waste volumes multiplied by an average fixed cost per shipment of $9,260

- Variable costs by truck - the number of round trip miles between waste origin and destination multiplied by an average variable cost of $0.12 per mile

- Total cost by rail (regular or dedicated rail service) - the number of rail cars shipped multiplied by a round-trip carload charge that varies from site to site. The round-trip carload charge ranges from $13,880 for Rocky Flats Environmental Technology Site (RFETS) under regular rail service up to $247,314 for Hanford under dedicated rail service.

The total waste transportation costs for truck and rail transportation are presented in Table D-11. Note that the transportation cost impacts for combined CH-TRU waste and RH-TRU waste shipments range from a minimum of $33 million under No Action Alternative 1A using regular rail, to a maximum of $15.69 billion under Action Alternative 3, using dedicated rail.

Table D-11
Truck and Rail Transportation Costs
by Alternative in Millions of 1994 Dollars

Action Alternative	Total Shipments [a]	Total Mileage	Total Cost
Proposed Action	38,290	105,856,389	1,588
Action Alternative 1 (Truck)	107,179	334,124,688	4,909
Action Alternative 1 (Regular Rail)	58,827	--	1,642
Action Alternative 1 (Dedicated Rail)	58,827	--	11,315
Action Alternative 2A (Truck)	67,488	203,120,649	2,990
Action Alternative 2A (Regular Rail)	37,603	--	1,007
Action Alternative 2A (Dedicated Rail)	37,603	--	6,863
Action Alternative 2B (Truck)	72,371	225,452,149	3,301
Action Alternative 2B (Regular Rail)	40,037	--	1,144
Action Alternative 2B (Dedicated Rail)	40,037	--	7,484
Action Alternative 2C (Truck)	66,132	197,247,516	2,913
Action Alternative 2C (Regular Rail)	37,561	--	909
Action Alternative 2C (Dedicated Rail)	37,561	--	6,544
Action Alternative 3 (Truck)	149,671	467,115,976	6,837
Action Alternative 3 (Regular Rail)	83,483	--	2,344
Action Alternative 3 (Dedicated Rail)	83,483	--	15,693
No Action Alternative 1A (Truck)	2,818	335,592,652	74
No Action Alternative 1A (Regular Rail)	1,409	--	33
No Action Alternative 1A (Dedicated Rail)	1,409	--	251
No Action Alternative 1B (Truck)	7,702	14,031,655	235
No Action Alternative 1B (Regular Rail)	3,851	--	157
No Action Alternative 1B (Dedicated Rail)	3,851	--	1,184
No Action Alternative 2	0	0	0

[a] Shipment numbers include shipments to consolidate waste at treatment sites or sites consolidating waste for shipment to WIPP.

D.1.3 WIPP Operations Budget

The life-cycle cost of WIPP operations will depend on the period of emplacement operations, which varies across the different SEIS-II alternatives. The analysis relied on budgetary information provided by Krznarich (1996). This budgetary information projects an average annual WIPP operations budget of $150 million over the period of emplacement operations and an average annual WIPP project budget of $180 million. Life-cycle cost impacts were based on the WIPP operations budget, while economic impacts in the region of influence (ROI) were based on the larger WIPP project budget. Other budgetary items, such as federal transfer payments made to state and local government agencies involving WIPP operations, have not been considered in the analyses of Chapter 5.

D.2 ECONOMIC IMPACTS IN THE WIPP ROI

This section discusses the methods and assumptions used in the analysis of the economic impacts which the Proposed Action and other SEIS-II alternatives may have in the ROI. Lansford et al. (1996) provides the most recent account of WIPP's economic effects on the New Mexico economy.

This work provides information about the distribution of WIPP fiscal year (FY) 1995 expenditures across industrial sectors in the ROI. This information was combined with projected WIPP operating budgets to construct a regional input-output model of the ROI for the analysis of SEIS-II economic impacts. This technical approach identifies the direct and indirect economic effects that the Proposed Action and the SEIS-II alternatives would have on regional employment, income, and output of goods and services.

Readers should note that the economic effects reported in this document both for WIPP and the treatment sites do not necessarily reflect the "creation" of new impacts. The reported impacts are estimates of what effects would be "supported" by specific levels of ROI expenditures, which may include substantial portions of existing, recurring expenditures, in addition to some new expenditures for new program facets presented in the alternatives.

The regional input-output model was developed using the IMpact analysis for PLANning (IMPLAN) regional economic modeling framework. A detailed discussion of the IMPLAN regional modeling methods can be found in the *IMPLAN Professional: User's Guide, Analysis Guide, Data Guide* (MIG 1997). A summary of the assumptions and limitations of the IMPLAN model is provided below.

- IMPLAN is a non-survey, input-output model that uses an adaptation of the 538-sector national input-output transactions table, otherwise known as the "national table." The most recent national table was issued by the Bureau of Economic Analysis (BEA 1994) and represents the industrial technologies in-place in 1987.

- IMPLAN provides the flexibility to update the 1987-level technology of any industry, as represented in the national table, to an improved representation of the technology currently being employed.

- IMPLAN reflects technology relationships that tend to be relatively stable over 10- to 15-year spans for most industries. Rapidly changing industries, such as the computer industry, are exceptions and should be evaluated in cases where they are affected by the economic impact scenario.

- IMPLAN, like other static input-output models, assumes that all resources required to satisfy an economic expansion are either immediately available within the study region or can be immediately imported.

To analyze economic impacts of a particular policy option using IMPLAN, one must have knowledge of the *net* change in "final demand" purchases made within the regional economy. Lansford et al. (1994, 1995, and 1996) provided FY 1993 through FY 1995 WIPP expenditure data for the State of New Mexico. The three years vary greatly in the pattern of their expenditures across the industries of the New Mexico economy, indicating that several "one-time" or "periodic" purchases are made in a given year. The economic impact model used a composite expenditure pattern based on the average pattern across FY 1993 through FY 1995 to catch some of the year-to-year variation in expenditure patterns at WIPP. The projected WIPP budget estimates were provided by Krznarich (1996). Based on this regional information, the IMPLAN model was used to generate a set of economic multipliers for the Proposed Action which were applied to WIPP-related expenditures in the ROI to determine the economic impact for each alternative. The economic activity multiplier for the ROI is estimated to be 2.80, meaning that for each dollar of WIPP-related budget expenditure in the ROI, an additional $1.80 is generated in the ROI economy. The ROI employment multiplier for direct WIPP employment is estimated to be 3.23, meaning that for each direct WIPP job, an additional 2.23 ROI jobs are supported (these may be full- or part-time jobs). The ROI labor income (employment compensation) multiplier is estimated to be 2.45, meaning that for each dollar of WIPP-related income generated in the ROI, another $1.45 of additional income is generated in the ROI.

As frequently noted, the Carlsbad area of the ROI receives the majority of the WIPP-related economic impact. Most of the WIPP personnel live and shop in the Carlsbad area. Many support services are located in Carlsbad, and WIPP-related spin-off businesses have located in Carlsbad. Typically, public economic data are not resolved to any finer detail than the county level, which presents the problem of how to resolve economic impacts that are focussed on a locality within the ROI.

Adjustments to the county-level economic data can be employed to estimate the economic impact in a given locality within a county. Such an adjustment was made to the ROI economic impact estimates to separate the impact on the Carlsbad area from the total ROI economic impact. In lieu of developing a comprehensive survey of all businesses in the ROI, the approach involved using publicly available phone book data (PhoneDisc 1997) to generate establishment counts by Standard Industrial Classification (SIC) code. Business phone listings for all businesses in Eddy and Lea counties were extracted and compiled based on locality and SIC code. This effectively created a census of all businesses (that list a phone number) in the ROI from which a location quotient was developed. Use of location quotients attempts to estimate the amount of local production that gets consumed locally. Schaffer and Chu (1969) are typically credited with pioneering this approach to a difficult question.

The question at issue for this analysis is, given that economic impact models estimate only county- or multi-county-level economic impacts, what portion of the two-county ROI impact occurs in the Carlsbad area of the ROI? The establishment counts by industry sector were used to develop the following location quotient for a given industry, *i*:

$$LQ_{i,Carlsbad} = (E_{i,Carlsbad} / E_{Carlsbad}) / (E_{i,ROI} / E_{ROI}),$$

where *E* is the number of establishments – gleaned from the 1997 phone book data. Based on this formulation, ROI industry-level economic impact estimates for the Proposed Action were multiplied by the Carlsbad industry-specific location quotients to estimate the proportion of ROI impact that could be expected to occur in the Carlsbad area. Under this approach, 84.6 percent of the ROI output impacts, 89.7 percent of the ROI employment impacts, and 89.8 percent of the ROI labor income impacts are estimated to occur in the Carlsbad area of the ROI, with the balance being distributed throughout all other localities. Table D-12 provides estimates of these economic impacts based on the location quotient method.

Table D-12
Annual Split of Total ROI Economic Impacts of the Proposed Action

Industry	Carlsbad Output (millions of 1994 dollars)	Carlsbad Employment (jobs, full- and part-time)	Carlsbad Income (millions of 1994 dollars)	Other ROI Output (millions of 1994 dollars)	Other ROI Employment (jobs, full- and part-time)	Other ROI Income (millions of 1994 dollars)
Ag & Mining	2.063	21	0.445	2.169	11	0.291
Construction	6.824	109	2.998	0.363	6	0.159
Manufacturing	14.304	152	3.217	12.899	75	1.736
Trans. Comm. Utilities	16.950	168	3.741	6.350	43	1.494
Trade	28.352	493	11.471	4.355	58	1.566
FIRE	25.308	154	2.766	1.350	8	0.148
Services	63.313	874	30.428	3.288	45	1.572
Government	14.886	215	11.825	0.790	11	0.627
WIPP Direct Effect	**95.501**	**979**	**46.255**	**17.536**	**116**	**5.246**
WIPP Total Effect	**267.499**	**3,164**	**113.146**	**49.102**	**374**	**12.839**
Multipliers	**2.80**	**3.23**	**2.45**	**2.80**	**3.23**	**2.45**

The location quotient method is simplistic because these estimations are usually made with income and employment data, but such data were not available at the level of industry and geographic detail needed for a sub-county analysis. Caution should be used when applying these estimates because by ignoring some local importing and exporting behavior among localities and the rest of the country and the effect of establishment size, the estimates are conservative and would tend to overstate the Carlsbad impact, rather than understate it, forming the likely upper bound on potential impacts. The limits of this approach required that ROI economic multipliers be applied uniformly to Carlsbad and the entire ROI, but since Carlsbad is a subset of the ROI, its economic multipliers can be reasoned to be lower. However, these location quotient estimates were used to develop the information presented in Chapter 5 and the Summary.

The continued operation of WIPP at the anticipated funding levels would continue to have a stabilizing effect in the ROI economy, which has historically varied according to price trends in the oil and gas industry. Using these estimates, the Proposed Action would account for as much as 7.9 percent of all employment in the ROI. This proportion would be higher when just considering the local economy of the Carlsbad portion of the ROI. It is important to note, however, that some SEIS-II alternatives call for project life spans that reach as far as the year 2310, including the institutional control period. The models used to develop economic impact information are valid for application over perhaps a 10- to 15-year period. Long-term economic forecasting models may be applicable for a 20-50 year period. No economic impact model exists that can be reliably applied to extremely long-term planning horizons (50 to 300+ years). The only claim that can be made with these impact estimates is that they are estimated with documented methods that are consistent across the alternatives, thus allowing a relative comparison.

The potential closure of WIPP presents the most noticeable economic impact in the ROI. This event is reflected in No Action Alternatives 1 and 2. These alternatives specify that, beginning in 1998, the WIPP will begin a 10-year period of decommissioning. By the year 2008, the site will be fully dismantled and returned to near-original condition with no TRU waste disposal activities having taken place. This implies that federal budget support of WIPP will be ramping down from current levels to near zero by the year 2008. This budgetary impact on the ROI can be considered in one of two ways. Under one scenario, the WIPP site can be assumed to undergo a "straight-line" decommissioning period, meaning that budgets would be cut by equal increments over the period until the site is permanently closed in the year 2008. Alternatively, WIPP closure could involve a "front-loaded" decommissioning period where more than half of the WIPP work force would be released in the first three years and thereafter decline at a much slower rate over the remaining years. The workforce would be declining rapidly and at the same time convert from an operations workforce to a decommissioning workforce until permanent closure in the year 2008.

The economic impacts reported in Chapter 5 are based on the straight-line decommissioning assumption. Corresponding to this case, the flow of federal dollars for WIPP salaries and expenditures in the ROI would decline steadily for 10 years prior to permanent closure of the facility. The decline in direct WIPP-related business would translate into additional declines in employment and salaries in the ROI workforce and industries that supply WIPP-related goods and services. Less of the support services currently provided in the ROI would remain viable over the course of WIPP closure. Similarly, the ROI service sector would decline as individuals leave the region in search of employment opportunities. At the same time, local and state government agencies would be affected by reductions in sales tax revenue and the region's tax base. Finally, the reduction in federal payments to government agencies in the ROI for WIPP-related services would have an effect on road and highway improvements, emergency preparedness, and other public services currently provided in the ROI. These impacts are not explicitly included in the analyses of Chapter 5.

D.3 ECONOMIC IMPACTS IN THE TREATMENT SITE ECONOMIC REGIONS

This section discusses the methods and assumptions used in the analysis of the impacts which the Proposed Action and the SEIS-II alternatives would have on regional employment, income, and output of goods and services at ANL-E, Hanford, INEEL, LANL, LLNL, Mound, NTS, Oak Ridge Reservation (ORR), RFETS, and SRS. The WM PEIS (DOE 1997) provides the most recent economic assessment of waste management activities at these treatment sites. That

assessment provides information about economic impacts of the TRU waste management program for the DOE complex. The intent here is to provide further documentation for estimates found in Chapter 5.

First, economic regions were developed for the treatment sites based on the county location of the site and the associated total labor market for that county. Journey-to-work data (BEA 1996) were used to identify counties contributing to the base county's labor market, and counties were included as part of the ROI to the point that at least 95 percent of the labor market had been identified (see Table D-13). Next, the IMPLAN modeling tool was used with county data already available from this and other studies to create models for three sites. Impact models for the Hanford, LANL, and WIPP sites had been developed for previous studies and were adapted for this analysis. Each model provides estimates of output per unit of cost, employment per unit of cost, and income per unit of cost for the three ROIs mentioned. Next, FY 1996 workforce estimates for each site were divided by the 1995 ROI population for each site to estimate a consistent proportion of site employment to total ROI population. This measure was used to group the treatment sites according to similar site employment-to-population proportions. This resulted in separate groupings that linked LANL and INEEL; Hanford, ORR, and SRS; and WIPP, ANL-E, LLNL, Mound, NTS and RFETS. Based on these groupings, the impact factors from the LANL model were applied to INEEL, the impact factors from the Hanford model were applied to ORR and SRS, and WIPP impact factors were applied to ANL-E, LLNL, Mound, NTS, and RFETS (see Table D-14).

Table D-13
Determination of Treatment Site Economic Region

Treatment Site	County Location of Site	Counties Included in Economic ROI	Cumulative Percentage of Labor Market
ANL-E	Cook, IL	Cook, IL	83.7
		Du Page, IL	89.8
		Lake, IL	93.0
		Will, IL	95.2
Hanford	Benton, WA	Benton, WA	84.0
		Franklin, WA	92.9
		Yakima, WA	97.2
INEEL	Bingham, ID	Bingham, ID	83.7
		Bonneville, ID	92.5
		Bannock, ID	97.5
LANL	Los Alamos, NM	Los Alamos, NM	58.9
		Santa Fe, NM	78.3
		Rio Arriba, NM	95.6
LLNL	Alameda, CA	Alameda, CA	70.9
		Contra Costa, CA	84.2
		Santa Clara, CA	88.1
		San Francisco, CA	91.1
		San Mateo, CA	93.2
		San Joaquin, CA	95.1
Mound	Montgomery, OH	Montgomery, OH	76.1
		Greene, OH	84.8
		Warren, OH	88.1
		Miami, OH	91.4
		Clark, OH	94.2
		Butler, OH	95.6
NTS	Nye, NV	Nye, NV	58.9
		Clark, NV	95.4
ORR	Anderson, TN	Anderson, TN	51.3
		Knox, TN	76.0
		Roane, TN	87.3
		Campbell, TN	90.7
		Morgan, TN	93.5
		Loudon, TN	95.9
RFETS	Adams, CO	Adams, CO	51.8
		Jefferson, CO	66.7
		Arapahoe, CO	78.4
		Denver, CO	89.2
		Boulder, CO	94.4
		Weld, CO	97.3
SRS	Barnwell, SC	Barnwell, SC	70.9
		Bamberg, SC	79.3
		Aiken, SC	86.2
		Allendale, SC	91.7
		Orangeburg, SC	94.4
		Richmond, GA	97.0

Table D-14
Development of Economic Impact Scaling Factors for Treatment Sites

Treatment Site	FY 1996 Site Workforce	1995 Economic ROI Population	Site Employment as a Percentage of ROI Population	Economic Impact Model Used for Scaling	ROI Industrial Output per Unit of Cost	ROI Employment per Unit of Cost	ROI Labor Income per Unit of Cost
ANL-E	4,500	6,763,664	0.07	WIPP	2.80	19.7	0.70
Hanford	10,587	389,564	2.72	Hanford	1.70	32.0	1.62
INEEL	9,000	146,383	6.15	LANL	1.81	48.5	1.20
LANL	7,000	171,977	4.07	LANL	1.81	48.5	1.20
LLNL	7,300	5,696,565	0.13	WIPP	2.80	19.7	0.70
Mound	1,180	1,403,308	0.08	WIPP	2.80	19.7	0.70
NTS	5,700	1,017,156	0.56	WIPP	2.80	19.7	0.70
ORR	17,114	572,917	2.99	Hanford	1.70	32.0	1.62
RFETS	3,418	2,133,595	0.16	WIPP	2.80	19.7	0.70
SRS	16,000	466,042	3.43	Hanford	1.70	32.0	1.62

D.4 REFERENCES CITED IN APPENDIX D

BEA (Bureau of Economic Analysis), 1994, *Benchmark Input-Output Accounts of the United States, 1987*, U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, November, Washington, D.C.

BEA (Bureau of Economic Analysis), 1996, *REIS: Regional Economic Information System*, Detailed economic data on CD-ROM, Bureau of Economic Analysis, June, Washington, D.C.

DOE (U.S. Department of Energy), 1994, *Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives*, DOE/WIPP 93-058, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996, *The National Transuranic Waste Management Plan*, DOE/NTP-96-1204, Revision 0, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

Feizollahi F. and D. Shropshire, 1994, *Interim Report: Waste Management Facilities Cost Information for Transuranic Waste*, EGG-WM-11274, June, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Krznarich, T., 1996, "BEMR Budget Information for WIPP," WID Memorandum, January 12, Westinghouse Waste Isolation Division, Carlsbad, New Mexico.

Lansford, R., et al., 1994, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1993*, U.S. Department of Energy, Albuquerque, New Mexico.

Lansford, R., et al., 1995, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1994*, U.S. Department of Energy, Albuquerque, New Mexico.

Lansford, R., et al., 1996, *The Economic Impact of the Department of Energy on the State of New Mexico: Fiscal Year 1995*, U.S. Department of Energy, Albuquerque, New Mexico.

MIG (Minnesota IMPLAN Group), 1997, *IMPLAN Professional: User's Guide, Analysis Guide, Data Guide*, Minnesota IMPLAN Group, Stillwater, Minnesota.

PhoneDisc, 1997, *Business Pro*, Compact Disc listing of all U.S. businesses, Digital Directory Assistance, Bethesda, Maryland.

Schaffer, W., and K. Chu, 1969, "Nonsurvey Techniques for Construction Regional Interindustry Models," Papers of the Regional Science Association, 23:83-101.

This page intentionally left blank.

APPENDIX E
TRANSPORTATION

This appendix supports results of transportation analyses presented in Chapter 5 of this document. Plans for transporting transuranic (TRU) waste to the Waste Isolation Pilot Plant (WIPP) and the impacts associated with that transportation are discussed.

E.1 INTRODUCTION

Since the Department of Energy (DOE or the Department) prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) in 1990, new information has become available concerning the Department's TRU waste and its management. This new information falls into several categories, namely:

- ***Waste characterization:*** Due to improved site waste characterization, the volume and characteristics of waste to be transported are better understood than was the case for SEIS-I. The improved data permits more thorough analyses of the impacts associated with transporting TRU waste. Additionally, site-specific waste characterization data have been examined thoroughly to ensure that each site would meet all of the required shipping limits; including weight, volume, curie, and thermal power limits.

- ***The addition of small quantity sites under the Proposed Action and the alternatives:*** Additional sites with small quantities of TRU waste and sites with additional sources of TRU waste (previously disposed of, polychlorinated biphenyl (PCB)-commingled, commercial, and nondefense) have been added to the analyses, and the impacts of transporting waste from these sites have now been considered. Currently, DOE intends for these smaller sites to ship their TRU waste to one of the larger quantity sites for processing. Decisions on the locations of consolidation/treatment sites for TRU waste, if any, will be based upon the analysis in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997).

- ***Waste treatment agreements:*** To date, DOE has submitted Federal Facility Compliance Act (FFCAct) site treatment plans for its treatment sites, and orders or settlements have been reached with affected states and the U.S. Environmental Protection Agency (EPA). In most cases, TRU waste would be retrieved, characterized, treated, certified to meet the WIPP Waste Acceptance Criteria (WAC), and then stored pending disposal. Some of the smaller sites would ship TRU waste to another DOE site for characterization, treatment, certification to meet WAC, and then storage. As a possible exception, DOE has reached a negotiated settlement with the State of Idaho that would allow DOE to procure, construct, and operate a mixed waste treatment facility. It is currently planned that this mixed waste treatment facility would use a thermal process that would result in a waste form that would meet Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR). Treated waste would also meet WAC. Additional information regarding the management of TRU waste in the DOE complex may be found in the WM PEIS.

- ***Route changes:*** There have been changes on the routes to WIPP coming from Argonne National Laboratory - East (ANL-E), the Mound Plant (Mound), Lawrence Livermore National Laboratory (LLNL), and Oak Ridge National Laboratory (ORNL). These routes, with the exception of the LLNL route, which was modified to bypass Los Angeles, California, now feed into Interstate-20 and enter New Mexico from the south. No waste, therefore, would travel on Interstate-40 from the east into New Mexico. Additionally, minor changes in some of the routes surrounding the major generator-storage sites have been decided upon and potential bypass routes around Santa Fe, New Mexico; Roswell, New Mexico; and Carlsbad, New Mexico are under consideration.

- ***HIGHWAY and INTERLINE codes updated with 1990 census data:*** The HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) computer codes allow for flexibility in calculating highway/rail mileage and population statistics, respectively. Each code provides mileage and population densities for designated highway and rail routes and have been updated with the most current (1990) census data.

- ***RH-72B shipping cask:*** The RH-72B shipping cask was referred to as the NUPAC in SEIS-I. Testing on the NUPAC was done on a 5/8 scale model, identified as the NUPAC 125B. Shipping canisters would be placed within the cask for added shielding and stabilization. The Safety Analysis Report for Packaging application for the RH-72B shipping cask was submitted to the Nuclear Regulatory Commission (NRC) for evaluation in December of 1996.

Four types of impacts were assessed in this second supplemental environmental impact statement (SEIS-II) regarding the transportation of TRU waste to WIPP. The first was the number of traffic accidents, fatalities, and injuries likely to occur as a result of transporting TRUPACT-IIs and RH-72B casks round trip between WIPP and the generator-storage sites. The second type, accident-free radiological impacts, would be associated with the external radiation present around a TRU waste package as it is being shipped. This radiation exposes the general public and transportation workers to very low levels of radiation both during transportation and while a shipment is stopped. The third type of impact, pollution health effects, would be the result of vehicle emissions (diesel exhaust) while traveling through urban areas. The final impact would be associated with accidents that are severe enough to breach the TRU waste packages, releasing some of the radioactive and hazardous material being shipped. For these accidents, two sets of radionuclide inventories were developed for both contact-handled (CH) TRU and remote-handled (RH) TRU waste shipments. The first inventory was based upon limits presented in planning-basis WAC (DOE 1996a) and the second inventory was based upon site-average radionuclide inventories.

Each type of impact presented in this appendix depends upon the route characteristics, the number of shipments via each route; and, for accidents, the accident environment associated with a particular mode of transportation and the behavior of the waste form and packaging in that environment. Thus, this section will summarize important route characteristics, TRU waste shipments using each route, and the impacts of potential transportation accidents.

Table 3-17 of Chapter 3 presents the features of the Proposed Action and the alternatives that are critical to transportation impact analyses, including the consolidation and treatment of TRU waste and TRU waste emplacement time frames. For a comprehensive description of the TRU waste

transportation system, the reader is referred to Appendix A of this document and Appendices C, L, and M of SEIS-I (DOE 1990). Appendix L describes the design, testing, and certification of the shipping containers and casks used for TRU waste; Appendix C describes emergency-response training and capabilities; and Appendix M describes the management plan of the carrier.

E.2 TRUCK TRANSPORTATION AND HIGHWAY ROUTES

Although WIPP has facilities designed to receive TRU waste shipments either by truck or by rail, the Proposed Action considers shipment only by truck. Under the action alternatives, TRU waste transportation by truck is analyzed, and those results are used to assess the transportation impacts associated with shipments by rail.

To ensure that transportation operations proceed safely and efficiently, DOE has developed operating plans and provided communications facilities, including a dual satellite-based vehicle tracking system. DOE has awarded a contract to Colorado Allstate Trucking (CAST) Transportation, herein referred to as the "carrier." This contract, which runs for one year with options for four 1-year extensions, contains provisions for the safe and efficient transport of TRU waste and for responses to transportation emergencies. One of the contract provisions requires that the carrier prepare a management plan. The carrier's plan has been prepared and is similar to the plan discussed in Appendix M of SEIS-I (DOE 1990). Key provisions of the contract include the following:

- The carrier will provide tractors and drivers which are dedicated to contract requirements. Drivers are to be technically qualified and experienced and must complete training in twenty-eight training categories, including hazardous and radioactive materials transportation. Tractors are to be domiciled and maintained within 80 kilometers (50 miles) of WIPP. Tractors will be dispatched with a DOE-owned trailer and empty shipping containers.

- DOE will operate a transportation operations control center, the Central Monitoring Room (CMR), 24 hours per day, 7 days per week. This center will maintain day-to-day contact with the carrier and drivers. As required by DOE Order 460.2, the Transportation Tracking and Communications System (TRANSCOM) Control Center located in Oak Ridge, Tennessee, has the ability to track and communicate with shipment vehicles using the DOE TRANSCOM system. Tracking information can be disseminated to DOE users and other stakeholders, as necessary.

- The carrier will be required to meet federal regulatory requirements for the transportation of radioactive and hazardous materials, including: driver training in accordance with Title 49 of the Code of Federal Regulations (CFR), Part 172 (49 CFR 172), Subpart G entitled "Emergency Response Information"; 49 CFR Part 177.825 entitled "Routing and Training Requirements for Class 7 (Radioactive) Materials; 49 CFR Part 391 entitled "Qualifications of Drivers"; 49 CFR 397, Subpart D entitled "Routing of Class 7 (Radioactive) Materials"; the Commercial Motor Vehicle Safety Act of 1986 and subsequent amendments; and manifesting requirements for mixed waste specified in 40 CFR.

- The carrier is required to comply with emergency response guidelines for hazardous material and hazardous waste transporters outlined in the *Emergency Planning, Response, and Recovery Roles and Responsibilities for TRU Waste Transportation Accidents* (DOE 1995a).

In the event of an accident, carrier drivers would notify emergency first-responders via cellular phone and the CMR at WIPP via TRANSCOM. A senior DOE official and/or the DOE Carlsbad Area Office (CAO) Incident/Accident Team Leader would assist the state-provided on-scene commander. DOE resources would be made available to local authorities, as appropriate, to support the mitigation of the accident; including, but not limited to, package recovery and site cleanup. In the event of an accident such as a fire, breach, release, or suspected radioactive contamination, the carrier would follow established procedures for obtaining any needed federal, state, or local assistance and technical advice.

Drivers would carry instructions regarding the appropriate actions to be taken in the event of an accident and would be trained in packaging recovery procedures. In addition, the TRANSCOM system provides an electronic version of the U.S. Department of Transportation (DOT) Emergency Response Guidebook information, which is specific to each shipment material, to all TRANSCOM users. According to 49 CFR Part 390.15(b), the carrier shall maintain a register containing information on the accident for a period of one year after the accident occurs. Any carrier accident, no matter how minor, would be reported to the CAO Transportation Manager, the WIPP Traffic Manager, the CMR operator, and DOE Headquarters (HQ) Emergency Operations Center (EOC) via the DOE Albuquerque Operations Office. If not already notified by the carrier, the CMR operator would notify the shipper.

The carrier's management plan provides procedures to be followed regarding adverse weather conditions, delays, and parking during TRU waste shipments. Weather conditions would be constantly monitored, and drivers would be alerted to possible severe weather conditions. Delays may occur as the result of problems at the sites, weather conditions, or maintenance checks. Schedule delays of two or more hours from the shipping, receiving, and transit time would be immediately reported to the CMR, which would then notify the

TRANSCOM SYSTEM

DOE has developed a transportation tracking and communications system that is used to track truck and rail shipments. This satellite-based system, the TRANSCOM System, has been in operation since 1989. Since its inception, the TRANSCOM System has tracked over 500 shipments for DOE. The use of TRANSCOM is mandated by DOE Order 460.2, *Departmental Materials Transportation and Packaging Management*.

The mission of the TRANSCOM System is to provide tracking and communications for shipments of radioactive materials, hazardous materials, and other high-visibility shipping campaigns, as specified by DOE. The TRANSCOM System is managed and operated at the TRANSCOM Control Center (TCC) in Oak Ridge, Tennessee, for DOE.

The TRANSCOM System provides the TCC staff, shippers, carriers, receivers, and state, Tribal, and federal users with the ability to view information about shipments and communicate with each other during shipment tracking. Information about shipment contents, points of contact, routes, status, locations, and emergency response information is available to local emergency response teams and each user. The information is displayed in tabular and graphical form using a series of national, state, and county maps. The vehicle location can be determined to within a few meters, with position updates as frequently as every 60 seconds. Drivers are alerted to adverse weather or road conditions.

shipper or receiver, as appropriate. There would be no "deadlines" for a shipment to be received at WIPP. If a shipment were delayed, a new scheduled time of arrival would be arranged.

The carrier's management plan follows instructions provided by the Western Governor's Association (WGA) and DOE regarding the selection of suitable site parking areas. In the event of a shipping layover, carriers would use designated DOE or Department of Defense parking sites or an area designated by the affected state as a safe parking area. If a designated site were not available, the driver would select an appropriate site based on criteria such as nearby population, access, and security. The driver would also notify the nearest state police district office to confirm the appropriateness of the location. Motor vehicles transporting hazardous waste material other than Class A or Class B explosives are required not to be parked on or within 1.5 meters (5 feet) of the traveled portion of a public street or road, except for brief periods when the necessities of operation make it impracticable to park in any other place.

E.2.1 HIGHWAY Code

The HIGHWAY computer code (Johnson et al. 1993a) was used to determine the various truck routes used for these analyses. HIGHWAY is a computerized road atlas that details more than 386,000 kilometers (240,000 miles) of interstate and other highways. The user can specify the routing criteria to constrain the route selection. HIGHWAY calculates the total route length and the distances traveled through rural, suburban, and urban population zones. The HIGHWAY model contains an HM-164 and a WIPP default routing option. The HM-164 option, when activated, specifies a route that would comply with DOT regulations for highway route-controlled quantities (HRCQ) of radioactive material. The WIPP default routing option provides the New Mexico-specified routes to WIPP and uses routes defined by the HM-164 option for routes outside of New Mexico. When determining the route selection for the transportation analyses, the default settings were used in most cases, and the WIPP routing code option was activated. In this way, the most direct route that complies with DOT regulations would be selected by HIGHWAY. Population densities along each route were derived from 1990 census data. Rural, suburban, and urban areas are characterized according to the following breakdown:

- Rural mean population density of 6 persons per square kilometer (16 per square mile)
- Suburban mean population density of 719 persons per square kilometer (1,863 per square mile)
- Urban mean population density of 3,861 persons per square kilometer (10,003 per square mile)

E.2.2 Regulations Applicable to Highway Route Selection

On behalf of the carrier, DOE has coordinated shipping routes with the affected states. As a matter of policy, DOE has determined that all shipments, whether or not the definition of HRCQ has been met, will use the preferred routes in 49 CFR Part 397 Subpart D. Preferred routes consist of interstate-system highways, interstate bypasses or beltways around cities, and state-designated routes. This routing rule permits states and Indian tribes to designate routes in accordance with DOT guidelines or equivalent routing analysis. Interstate highways must be used in the absence of routes designated by states or tribes, unless a deviation is necessary.

WESTERN GOVERNORS ASSOCIATION

The Western Governors Association (WGA) WIPP Transport Advisory Group has cooperated with DOE to develop a safe transport program for waste shipments to WIPP. A memorandum of agreement between the western states and DOE *(Regional Protocol for the Safe Transport of Transuranic Waste to the WIPP)* has been signed. Also, under a contract with the WGA, the Western Interstate Energy Board prepared, *Safe Parking Areas for WIPP Shipments* in 1990, which will be strictly adhered to by the drivers. DOE sites have been designated for use as safe parking areas, and DOE has reached an agreement with the Department of Defense for the use of its facilities along the WIPP route for emergency parking. If no DOE, Department of Defense, or state-designated parking areas can be reached safely, the driver will be directed to select a safe parking area while avoiding highly populated areas, areas with difficult access or poor lighting, and crowded parking areas. The driver will then notify the State Police and the central dispatcher of the truck's location.

State-designated routes are preferred routes, selected in accordance with DOT guidelines (49 CFR Part 397.101[b] and [c]) or an equivalent routing analysis which adequately considers the overall impact to the public. The designation of routes must be preceded by substantive consultation with affected local jurisdictions and with any other states along such routes to ensure the consideration of impacts and the continuity of designated routes.

A state routing agency is an entity that is authorized to use a state legal process pursuant to 49 CFR 397, Subpart D to impose routing requirements, enforceable by state agencies, on carriers of radioactive material without regard to intrastate jurisdictional boundaries. This would include a common agency of more than one state such as one established by interstate compact. This term also includes Indian tribal authorities with police power to regulate and enforce highway routing requirements within their lands.

DOT regulations in 49 CFR 397, Subpart D provide routing and training requirements for carriers of radioactive material to ensure that the vehicles used for such transportation operate on routes that would minimize potential radiological impacts. Deviations from the state-designated route are allowed for necessary rest, fuel, and vehicle repair stops; to pick up, deliver, or transfer radioactive materials; and for emergency conditions that would make continued use of the preferred route unsafe. As required by 49 CFR Part 397.101(g), the carrier must prepare a route plan and supply a copy of the plan to the Federal Highway Administration, Traffic Control Division, the driver, and the shipper. Any deviation from the preferred route, and the reason for it, must be reported in an amendment to the route plan within thirty days following the shipment.

E.2.3 Proposed Routes

The proposed routes for transporting TRU waste by truck, as determined using HIGHWAY, are shown in Figure E-1. Figure E-2 details the routes through New Mexico. For the purposes of SEIS-II analyses, routes were selected based on the preferred routes defined in 49 CFR Part 173.403(l) and to be consistent with existing routing practices and applicable routing regulations and guidelines. These routes may not be the actual routes that would be used to transport TRU waste in the future. Details on the routes through New Mexico and from the 10 sites with the greatest number of shipments of waste to WIPP are presented below.

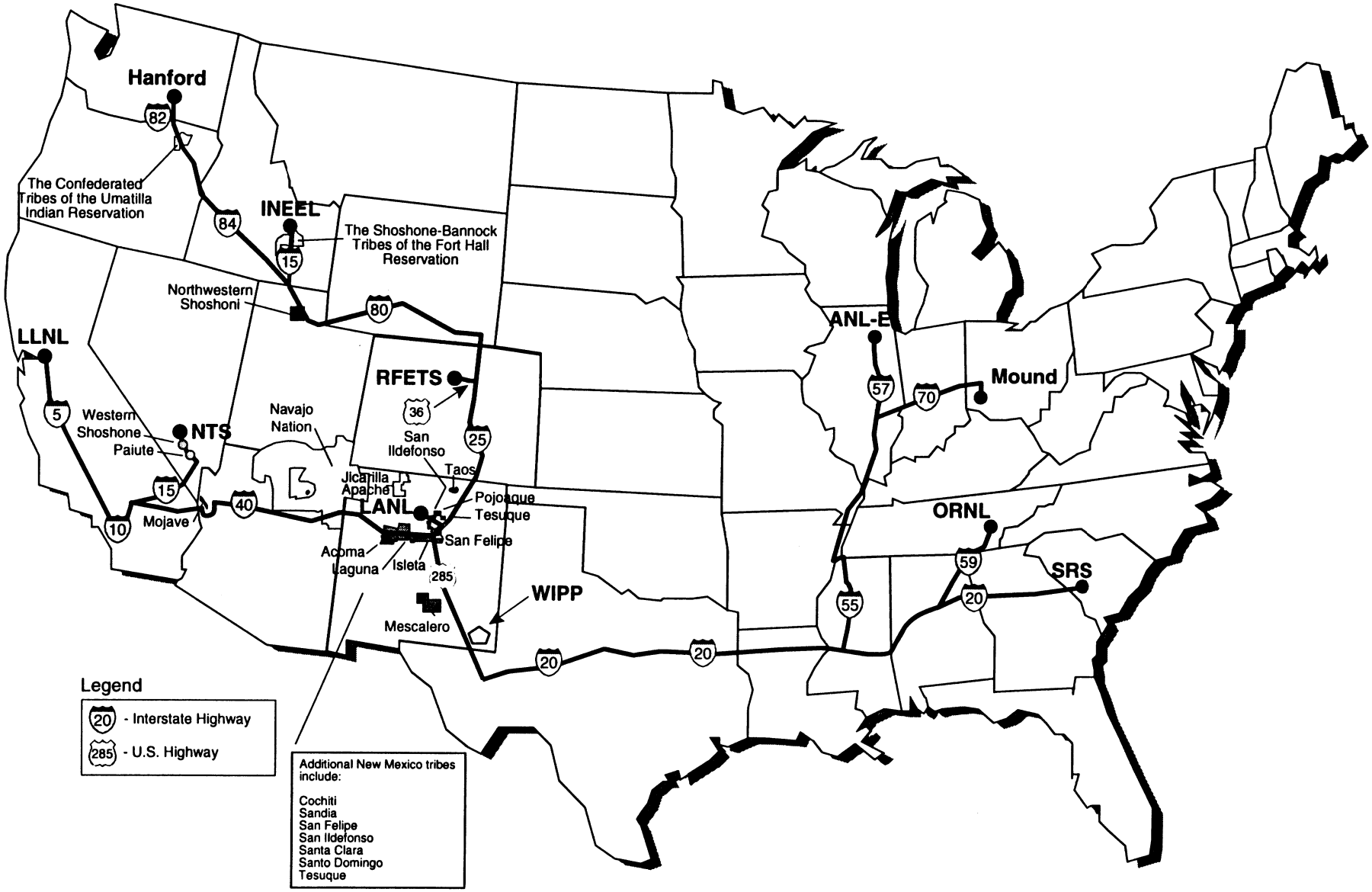


Figure E-1
Proposed TRU Waste Truck Transportation Routes on U.S. and Interstate Highways

Figure E-2
Proposed TRU Waste Truck Transportation Routes in New Mexico

Routes through the State of New Mexico. As shown in Figure E-1, all transportation routes converge in New Mexico. Transportation and routing have been identified in several agreements with the State of New Mexico. The agreements recognize that movements between interstate highways and WIPP would involve local highways, and because New Mexico is the host state, these highways would have a relatively concentrated service. Therefore, DOE agreed to support the state in efforts to obtain congressional funds necessary to repair and upgrade designated highway segments.

Route from Mound, Ohio. The proposed route is as follows:

Local Road to State 725, in Miamisburg, OH, 1.6 kilometers (1 mile)
State 725 to I-75, near Miamisburg, OH, 5 kilometers (3 miles)
I-75 to I-70, near Vandalia, OH, 29 kilometers (18 miles)
I-70 to I-465, southeast of Indianapolis, IN, 172 kilometers (107 miles)
I-465 to I-70, southwest of Indianapolis, IN, 32 kilometers (20 miles)
I-70 to I 57, near Teutopolis, IL, 211 kilometers (131 miles)
I-57 to I-55, near Sikeston, MO, 290 kilometers (180 miles)
I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from ANL-E, Illinois. The proposed route is as follows:

Cass Avenue to I-55, north of ANL-E, 1.6 kilometers (1 mile)
I-55 to I-294, southwest of Chicago, IL, 8 kilometers (5 miles)
I-294 to I-80, south of Chicago, IL, 29 kilometers (18 miles)
I-80 to I-57, near Tinley Park, 8 kilometers (5 miles)
I-57 to I-55, near Sikeston, MO, 592 kilometers (368 miles)
I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from ORNL, Tennessee. The proposed route is as follows:

Bethel Valley Road to State 95, west of ORNL, 3 kilometers (2 miles)
State 95 to I-40, south of Oak Ridge, TN, 5 kilometers (3 miles)
I-40 to I-75, southwest of Knoxville, TN, 6 kilometers (4 miles)
I-75 to I-24, east of Chattanooga, TN, 133 kilometers (83 miles)
I-24 to I-59, southwest of Chattanooga, TN, 31 kilometers (19 miles)
I-59 to I-459, northeast of Birmingham, AL, 195 kilometers (121 miles)

I-459 to I-20, southwest of Birmingham, AL, 53 kilometers (33 miles)
I-20 to I-220, east of Shreveport, LA, 684 kilometers (425 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US-180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Savannah River Site (SRS), South Carolina. The proposed route is as follows:

SRS access road to State 19, north of SRS, 14 kilometers (9 miles)
State 19 to I-20, north of Aiken, SC, 29 kilometers (18 miles)
I-20 to I-285, east of Atlanta, GA, 249 kilometers (155 miles)
I-285 to I-20, around the south side of metro Atlanta, 45 kilometers (28 miles)
I-20 to I-459, northeast of Birmingham, AL, 204 kilometers (127 miles)
I-459 to I-20, southwest of Birmingham, AL, 47 kilometers (29 miles)
I-20 to I-220, east of Shreveport, LA, 684 kilometers (425 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US-180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Hanford Site (Hanford), Washington. The proposed route is as follows:

Route 4S to State 240, in Hanford Reservation, 6 kilometers (4 miles)
State 240 to I-182, in Richland, WA, 11 kilometers (7 miles)
I-182 to I-82, southwest of Richland, WA, 8 kilometers (5 miles)
I-82 to I-84, near Hermiston, OR, 66 kilometers (41 miles)
I-84 to I-80, near Echo, UT, 949 kilometers (590 miles)
I-80 to I-25, at Cheyenne, WY, 626 kilometers (389 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Idaho National Engineering and Environmental Laboratory (INEEL), Idaho. The proposed route is as follows:

Plant Road to US-26, on INEEL Reservation, 1.6 kilometers (1 mile)
US-26 to I-15, near Blackfoot, ID, 64 kilometers (40 miles)
I-15 to I-84, southwest of Ogden, UT, 243 kilometers (151 miles)
I-84 to I-80, near Echo, UT, 63 kilometers (39 miles)
I-80 to I-25, at Cheyenne, WY, 626 kilometers (389 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Rocky Flats Environmental Technology Site (RFETS), Colorado. The proposed route is as follows:

Rocky Flats Access Road to State 93, west of RFETS, 3 kilometers (2 miles)
State 93 to State 128, south of Boulder, CO, 5 kilometers (3 miles)
State 128 to US-36, near Broomfield, CO, 13 kilometers (8 miles)
US-36 to I-25, north of Denver, CO, 14 kilometers (9 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Los Alamos National Laboratory (LANL), New Mexico. The proposed route is as follows:

Los Alamos Truck Route to State 4, east of Los Alamos, 10 kilometers (6 miles)
State 4 to State 502, east of Los Alamos, NM, 1.6 kilometers (1 mile)
State 502 to US-84, at Pojoaque, NM, 19 kilometers (12 miles)
US-84 to I-25, south of Santa Fe, NM, 32 kilometers (20 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 13 kilometers (8 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from LLNL, California. The proposed route is as follows:

Local Road to I-580, northeast of Livermore, CA, 5 kilometers (3 miles)
I-580 to I-5, near Vernalis, CA, 39 kilometers (24 miles)
I-5 to I-210, north of Los Angeles, CA, 468 kilometers (291 miles)
I-210 to I-10, near Pomona, CA, 77 kilometers (48 miles)
I-10 to I-15, in Ontario, CA, 27 kilometers (17 miles)
I-15 to I-40, in Barstow, CA, 119 kilometers (74 miles)
I-40 to US-285, near Clines Corner, NM, 1,191 kilometers (740 miles)
US-285 to US-180/62, at Carlsbad, NM, 349 kilometers (217 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Nevada Test Site (NTS), Nevada. The proposed route, which is currently being renegotiated with the state, is as follows:

Local Road to US-95, south of Mercury, NV, 10 kilometers (6 miles)
US-95 to State Road 373, near Amargon Valley, NV, 39 kilometers (24 miles)
State Road 373 to State Road 127, near Shosone, CA, 81 kilometers (50 miles)
State Road 127 to I-15, near Baker, CA, 90 kilometers (56 miles)
I-15 to I-40, in Barstow, CA, 101 kilometers (63 miles)
I-40 to US-285, near Clines Corner, NM, 1,191 kilometers (740 miles)
US-285 to US-180/62, at Carlsbad, NM, 349 kilometers (217 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

E.3 NONRADIOLOGICAL IMPACTS FROM TRUCK TRANSPORTATION

This section addresses the impacts of traffic accidents and vehicle emissions associated with transporting TRU waste to WIPP. These impacts are not related to the radioactive material or hazardous chemicals being transported and would be the same as the impacts resulting from the transportation of nonhazardous material. Accident impacts were calculated as the number of injuries and fatalities that would be expected due to additional truck traffic along the proposed routes, and were calculated on a per-shipment basis, then totaled for all shipments over the transportation period. Calculations were based on data presented in *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight* (Saricks and Kvitek 1994). These data, route mileages, and the number of shipments along each route were used to determine the aggregate impacts from transporting TRU waste. Impacts from vehicle emissions (pollution-related health effects) were calculated as the number of excess latent cancer fatalities (LCF) in the exposed population due to truck exhaust emissions.

All of the analyses were based on the impact-per-shipment from the major generator-storage sites to WIPP. Results were adjusted to account for small quantity site shipments to the major generator-storage sites (see Section E.6).

E.3.1 Methodology

Whenever material is shipped, the possibility of a traffic accident which could result in vehicular damage, injury, or death exists. Even when drivers are trained in defensive driving and take great care, there is a risk of a traffic accident. To date, shipments of empty TRUPACT-IIs have logged more than 1,529,000 kilometers (950,000 miles) without accident. However, for the SEIS-II analyses, truck accident statistics that were compiled for each state by highway type were used (Saricks and Kvitek 1994). No assumption was made that carrier drivers would be better trained or would be more careful than other truck drivers on the nation's roads.

It is important to note that the accident rates used in this assessment were computed using all interstate shipments, regardless of the cargo. Saricks and Kvitek (1994) point out that shippers and carriers of radioactive material generally have a higher-than-average awareness of transportation impacts and prepare for such shipments accordingly. Still, these effects were not considered. Separate accident rates for travel in rural, suburban, and urban population density zones in each state were used. The total accident impact for a case, therefore, depends on the total distance traveled in the various population zones within each state and does not rely on national-average accident statistics.

As discussed in Appendix A, the volumes of waste that are currently in storage and projected to be generated through the year 2033 were estimated from information provided in the *Transuranic Waste Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996b). Using the methods discussed in Appendix A, the volumes of CH-TRU and RH-TRU waste transported under the Proposed Action and each alternative were calculated. Also, the number of shipments needed to transport this waste were calculated on a site-by-site basis.

For truck shipments, it was assumed that CH-TRU waste would be packaged in Type A 55-gallon drums and transported in TRUPACT-IIs. Each TRUPACT-II would carry a maximum of two 7-packs of drums, and each shipment could carry two or three TRUPACT-II containers, a

PROPOSED USE OF HALFPACKS FOR TRANSPORTATION

A new CH-TRU waste packaging, the HALFPACK, is being developed by DOE to transport heavier-than-average drums of CH-TRU waste to WIPP. The role of the HALFPACK is to supplement the existing TRUPACT-II packaging by efficiently transporting heavy drums weighing up to 454 kilograms (1,000 pounds). The TRUPACT-II was specifically developed to transport 14 drums, each weighing an average of 227 kilograms (500 pounds).

The ability of the HALFPACK to efficiently transport heavy drums was achieved by reducing the height of the existing TRUPACT-II design by 70 centimeters (30 inches). This reduction in weight by approximately 771 kilograms (1,700 pounds) brings the empty weight of a HALFPACK to 4,581 kilograms (10,100 pounds). Although the capacity of the HALFPACK would be reduced to seven 55-gallon drums, the drums could weigh 454 kilograms (1,000 pounds) each, for a total payload capacity of 3,295 kilograms (7,265 pounds) including the pallet assembly. In accordance with the weight distribution restrictions placed on legal-weight transport truck and trailer vehicles by the U.S. Department of Transportation, the weight reduction will allow three HALFPACKs to carry 21 heavy drums per shipment instead of 14 heavy drums per shipment with TRUPACT-IIs, thereby reducing the total number of shipments overall. The table below shows the reduction in the total number of shipments under each alternative in SEIS-II if the HALFPACK were used from the onset of the transportation activities. The estimated reduction would range from more than 40 percent under Action Alternatives 2A and 2B to approximately 10 percent under Action Alternatives 1 and 2C.

Reduction in Shipments for Each Alternative by Using HALFPACK

	Number of Shipments to WIPP for the Total Inventory			
Alternatives	**With HALFPACK**	**TRUPACT-II Only**	**Difference (m3)**	**Percent Difference**
Proposed Action CH-TRU Waste	24,962	29,766	(4,804)	84%
Action Alternative 1 CH-TRU Waste	36,938	41,003	(4,065)	90%
Action Alternative 2A CH-TRU Waste	24,444	42,775	(18,331)	57%
Action Alternative 2B CH-TRU Waste	24,444	42,774	(18,331)	57%
Action Alternative 2C CH-TRU Waste	37,082	41,206	(4,124)	90%
Action Alternative 3 CH-TRU Waste	52,484	67,309	(14,825)	78%

Another benefit of the HALFPACK is its ability to transport overpack drums. An overpack drum consists of a 55-gallon drum of questionable integrity placed inside a new 85-gallon drum. The internal cavity of the HALFPACK can accommodate four of the taller overpack drums and therefore avoids the costs of repackaging and re-certification of the waste into new 55-gallon drums.

The HALFPACK will be developed in accordance with the criteria for Type B packaging by the Nuclear Regulatory Commission (NRC) as set forth in 10 CFR Part 71. Once the performance and certification criteria have been demonstrated, a Safety Analysis Report will be presented to the NRC for approval (currently scheduled for July 1998). Upon NRC approval of the HALFPACK, a Certificate of Compliance would be issued to DOE that would grant the authority to use and operate the HALFPACK.

maximum of 42 drums per shipment. The number of drums per TRUPACT-II would vary depending on waste restrictions. These restrictions include limits on weight, volume, thermal power, plutonium-239 equivalent curies (PE-Ci), and fissile-gram equivalents. It was assumed that RH-TRU waste would be transported in RH-72B casks, with only one cask per shipment. The number of CH-TRU and RH-TRU waste shipments to WIPP under the Proposed Action and the action alternatives are shown in Tables E-1 and E-2, respectively. Shipments under No Action Alternative 1 reflect the number of shipments needed to consolidate TRU waste at treatment sites. TRU waste is not shipped to WIPP under this alternative.

Under the Proposed Action and the action alternatives, there would be shipments from the small quantity sites to some of the 10 major generator-storage sites to consolidate waste prior to shipment to WIPP. These small quantity sites and the number of shipments are presented in Table E-3. Since none of the sites presented in Table E-3 would treat their waste before shipment, the number of shipments would be the same under the Proposed Action and the action alternatives. Under Action Alternatives 2 and 3, and No Action Alternative 1, some of the ten major generator-storage sites would ship their waste to one of the other major sites prior to shipment to WIPP for consolidation or treatment. These shipment numbers are presented in Table E-4.

The HIGHWAY code was used to estimate the mileages from the various sites to WIPP and to estimate the corresponding population density fractions. Additionally, mileages from the small quantity sites to the major generator sites were determined using HIGHWAY. The TRU waste origin and destination sites, total route miles, and the miles within each population zone for the 10 major generator-storage sites shipping CH-TRU waste are presented in Table E-5. This table also indicates the alternative under which the route would apply. Similar information is presented in Table E-6 for RH-TRU waste shipments. In Table E-7, the destination sites and mileages through each population zone for the small quantity sites are given.

The rural, suburban, and urban population route mileages along a given route were multiplied by state-specific rural, suburban, and urban accident, injury, or fatality rates to obtain route-specific impacts. The impacts were then summed over the route and divided by the total route mileage. For all but the State of New Mexico, the accident rate data for federally-aided interstate highways were used. For New Mexico, much of the waste travels on US-285; therefore, the rate data for federally-aided primary highways were used.

Route-specific per shipment accident, injury, and fatality rates (see Table E-8) were multiplied by the appropriate number of route shipments (Tables E-1 and E-2) to obtain the aggregate number of accidents, injuries, and fatalities. These impacts are shown in Table E-9. Because this analysis is not dependent on whether a truck is transporting full or empty TRU waste containers, twice the one-way mileage was used.

The distance traveled in an urban population zone and the impact factor for particulate and sulfur dioxide truck emissions (Rao et al. 1982) were used to estimate additional urban-area pollution health effects due to TRU waste shipments. The impact factor, 9.9×10^{-8} LCFs per kilometer (1.6×10^{-7} LCFs per mile), estimates the number of LCFs per urban mile traveled. The volume of particulates and sulfur dioxide emitted in an urban area by a single truck shipment would be quite small. A million or more simultaneous pollutant-generating shipments would be needed to achieve the minimum pollutant volume of particulates and sulfur dioxide required to cause one LCF. The LCFs attributed to diesel exhaust exposure in an urban area are very small relative to the impact of accidents, fatalities, or injuries.

Table E-1
Number of Shipments for CH-TRU Waste

Waste Origin Site	Proposed Action Scaled to WIPP Max.	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory -East	28	24	---	24	---	---	---	---	---	---	22	---	22
Hanford Site	13,666	11,562	7,167	18,729	8,230	8,813	17,043	8,230	8,813	17,043	11,562	7,194	18,756
Idaho National Engineering and Environmental Laboratory/Argonne National Laboratory-West	5,782	4,892	6,474	11,366	4,178	12,388	16,566	8,653	14,335	22,988	4,892	6,639	11,531
Lawrence Livermore National Laboratory	162	137	---	137	---	---	---	---	---	---	137	---	137
Los Alamos National Laboratory	5,009	4,238	1,590	5,828	2,952	1,947	4,899	---	---	---	4,236	1,590	5,826
Mound Plant	59	50	23	73	---	---	---	---	---	---	50	3	53
Nevada Test Site	86	73	---	73	---	---	---	---	---	---	73	---	73
Oak Ridge National Laboratory	251	212	8	220	---	---	---	---	---	---	192	8	200
Rocky Flats Environmental Technology Site	2,485	2,102	---	2,102	1,524	---	1,524	---	---	---	2,102	---	2,102
Savannah River Site	2,238	1,893	558	2,451	2,020	723	2,743	2,020	723	2,743	1,893	558	2,451
Total	**29,766**	**25,183**	**15,820**	**41,003**	**18,904**	**23,871**	**42,775`**	**18,903**	**23,871**	**42,774**	**25,159**	**15,992**	**41,151**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-1
Number of Shipments for CH-TRU Waste — Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory - East	---	---	---	22	---	22	22	---	22
Hanford Site	24,531	8,600	33,131	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory / Argonne National Laboratory-West	10,386	7,769	18,155	---	---	---	---	---	---
Lawrence Livermore National Laboratory	---	---	---	137	---	137	137	---	137
Los Alamos National Laboratory	7,628	1,907	9,535	---	---	---	4,236	1,590	5,826
Mound Plant	---	---	---	50	3	53	50	3	53
Nevada Test Site	---	---	---	73	---	73	73	---	73
Oak Ridge National Laboratory	---	---	---	192	8	200	192	8	200
Rocky Flats Environmental Technology Site	2,897	---	2,897	---	---	---	2,102	---	2,102
Savannah River Site	2,885	706	3,591	---	---	---	---	---	---
Total	**48,327**	**18,982**	**67,309**	**474**	**11**	**485**	**6,812**	**1601**	**8,413**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-2
Number of Shipments for RH-TRU Waste

Waste Origin Site	Proposed Action	Alternative 1			Alternative 2A			Alternative 2B			Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	3,178	47,156	1,651	48,807	17,730	1,031	18,761	17,730	1,031	18,761	17,730	1,031	18,761
Idaho National Engineering and Environmental Laboratory / Argonne National Laboratory-West	3,136	3,136	711	3,847	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	367	367	190	557	---	---	---	---	---	---	---	---	---
Oak Ridge National Laboratory	1,276	5,875	3,076	8,951	2,057	1,077	3,134	2,057	1,077	3,134	2,057	1,077	3,134
Total	**7,957**	**56,534**	**5,628**	**62,162**	**19,787**	**2,108**	**21,895**	**19,787**	**2,108**	**21,895**	**19,787**	**2,108**	**21,895**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-2
Number of Shipments for RH-TRU Waste — Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	60,789	3,076	63,865	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory / Argonne National Laboratory-West	---	---	---	3,136	711	3,847	3,136	711	3,847
Los Alamos National Laboratory	---	---	---	367	190	557	367	190	557
Oak Ridge National Laboratory	7,050	3,691	10,741	---	---	---	---	---	---
Total	**67,839**	**6,767**	**74,606**	**3,503**	**901**	**4,404**	**3,503**	**901**	**4,404**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-3
Number of CH-TRU and RH-TRU Waste Shipments to Consolidation/Treatment Sites from Sites with Smaller Quantities of TRU Waste

Origin Site with Smaller Quantities of Waste	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste			
Ames Laboratory	1	0	1
ARCO	0	1	1
Bettis Atomic Power Laboratory	20	0	20
Energy Technology Engineering Center	1	0	1
Lawrence Berkeley Laboratory	0	1	1
Paducah Gaseous Diffusion Plant	1	0	1
Sandia National Laboratories	2	1	3
University of Missouri	1	0	1
USAMC	1	0	1
West Valley Demonstration Project	0	23	23
Total	27	26	53
RH-TRU Waste			
Battelle Columbus Laboratory	931	0	931
Bettis Atomic Power Laboratory	15	0	15
Energy Technology Engineering Center	12	0	12
Knolls	0	130	130
West Valley Demonstration Project	0	2,762	2,762
Total	958	2,892	3,850

E.3.2 Results

Table E-9 summarizes the aggregate nonradiological impacts (accidents, injuries, fatalities, and pollution-related LCFs) associated with the transportation of TRU waste from the 10 major generator-storage sites by truck to WIPP. Impacts would be dependent on the number of shipments, which in turn, would be dependent on waste inventories and the differences in consolidation schemes and treatment options.

E.4 RADIOLOGICAL IMPACTS FROM TRUCK TRANSPORTATION

In this section, the impact analyses of the transportation of radioactive material are discussed. The impacts fall into two general categories, radiological impacts under normal transportation conditions and radiological impacts in the event of an accident.

These analyses were conducted in a manner consistent with WIPP-specific transportation analyses in SEIS-I (DOE 1990), the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995b), the WM PEIS (DOE 1997), and the *Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives* (DOE 1994). The methods used were established by the NRC in the late 1970s.

Table E-4
CH-TRU and RH-TRU Waste Shipments from Major Generator-Storage Sites to Treatment Sites

Waste Origin Site	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory - East	22	---	22	22	---	22	---	---	---
Idaho National Engineering and Environmental Laboratory / Argonne National Laboratory-West	---	---	---	---	---	---	---	---	---
Lawrence Livermore National Laboratory	137	---	137	137	---	137	---	---	---
Los Alamos National Laboratory	---	---	---	4,236	1,590	5,826	---	---	---
Mound Plant	50	3	53	50	3	53	---	---	---
Nevada Test Site	73	---	73	73	---	73	---	---	---
Oak Ridge National Laboratory	192	8	200	192	8	200			
Rocky Flats Environmental Technology Site	---	---	---	2,102	---	2,102	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**474**	**11**	**485**	**6,812**	**1,601**	**8,413**	---	---	---
RH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory / Argonne National Laboratory-West	3,136	711	3,847	3,136	711	3,847	3,136	711	3,847
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	367	190	557	367	190	557	367	190	557
Mound Plant	---	---	---	---	---	---	---	---	---
Nevada Test Site	---	---	---	---	---	---	---	---	---
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**3,503**	**901**	**4,404**	**3,503**	**901**	**4,404**	**3,503**	**901**	**4,404**

Table E-4
CH-TRU and RH-TRU Waste Shipments From Major Generator-Storage Sites to Treatment Sites — Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory - East	22	---	22	22	---	22	22	---	22
Idaho National Engineering Laboratory Argonne National Laboratory-West	---	---	---	---	---	---	---	---	---
Lawrence Livermore National Laboratory	137	---	137	137	---	137	137	---	137
Los Alamos National Laboratory	---	---	---	---	---	---	4,236	1,590	5,826
Mound Plant	50	---	50	50	3	53	50	3	53
Nevada Test Site	73	---	73	73	---	73	73	---	73
Oak Ridge National Laboratory	192	8	200	192	8	200	192	8	200
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	2,102	---	2,102
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**474**	**8**	**482**	**474**	**11**	**485**	**6,812**	**1,601**	**8,413**
RH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	---	---	---
Idaho National Engineering Laboratory Argonne National Laboratory-West	3,136	711	3,847	3,136	711	3,847	3,136	711	3,847
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	367	190	557	367	190	557	367	190	557
Mound Plant	---	---	---	---	---	---	---	---	---
Nevada Test Site	---	---	---	---	---	---	---	---	---
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**3,503**	**901**	**4,404**	**3,503**	**901**	**4,404**	**3,503**	**901**	**4,404**

Table E-5
CH-TRU Waste Transportation in Miles (kilometers)

Originating Site	Destination Site	Total One-way Truck Mileage [a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
Argonne National Laboratory-East	WIPP	1,696 (2,729)	1,412 (2,272)	259 (417)	25 (40)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	877 (1,411)	587 (945)	266 (428)	24 (38)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Hanford Site	WIPP	1,807 (2,908)	1,645 (2,647)	144 (232)	18 (29)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Idaho National Engineering and Environmental Laboratory/ANL-W	WIPP	1,392 (2,241)	1,263 (2,033)	114 (184)	15 (24)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Lawrence Livermore National Laboratory	WIPP	1,452 (2,337)	1,304 (2,099)	100 (161)	48 (77)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	Hanford	890 (1,432)	675 (1,086)	184 (296)	31 (50)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Los Alamos National Laboratory	WIPP	341 (549)	318 (512)	21 (34)	2 (3)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2C, and Action Alternative 3
	INEEL	1,145 (1,843)	1,025 (1,650)	104 (167)	16 (26)	Action Alternative 2B, and No Action Alternative 1B
Mound Plant	WIPP	1,764 (2,838)	1,359 (2,187)	382 (614)	23 (37)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	639 (1,028)	424 (682)	205 (330)	10 (16)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Nevada Test Site	WIPP	1,214 (1,954)	1,137 (1,830)	64 (103)	13 (21)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	INEEL	712 (1,146)	600 (966)	92 (148)	20 (32)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Oak Ridge National Laboratory	WIPP	1,439 (2,316)	1,160 (1,867)	265 (426)	14 (23)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	357 (575)	245 (394)	109 (175)	3 (5)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Rocky Flats Environmental Technology Site	WIPP	704 (1,133)	619 (996)	71 (114)	14 (23)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2C, and Action Alternative 3
	INEEL	732 (1,178)	669 (1,077)	54 (87)	9 (14)	Action Alternative 2B, and No Action Alternative 1B
Savannah River Site	WIPP	1,535 (2,470)	1,203 (1,936)	315 (507)	17 (27)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-6
RH-TRU Waste Transportation in Miles (kilometers)

Originating Site	Destination Site	Total One-way Truck Mileage [a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
Hanford (Richland) Site	WIPP	1,807 (2,908)	1,645 (2,647)	144 (232)	18 (29)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Idaho National Engineering and Environmental Laboratory/ANL-W	WIPP	1,392 (2,240)	1,263 (2,033)	114 (183)	15 (24)	Proposed Action, and Action Alternative 1
	Hanford	600 (966)	550 (885)	47 (76)	3 (5)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Los Alamos National Laboratory	WIPP	342 (550)	318 (512)	22 (35)	2 (3)	Proposed Action, and Action Alternative 1
	Hanford	1,560 (2,511)	1,407 (2,264)	135 (217)	18 (29)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Oak Ridge National Laboratory	WIPP	1,438 (2,314)	1,160 (1,867)	265 (426)	13 (21)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Savannah River Site	ORNL	357 (575)	245 (394)	109 (175)	3 (5)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B, No Action Alternative 2

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

The computer codes used for these analyses have been extensively documented elsewhere (Johnson et al. 1993a and 1993b, NRC 1977, and Neuhauser and Kanipe 1992). MICROSHIELD 4.21 was used to calculate the transportation index (TI) (radiation exposure rate at 1 meter [3.3 feet]) and RADTRAN was used to calculate radiological impacts (Neuhauser and Kanipe 1992). RADTRAN is the product of almost 15 years of development and is a flexible analytical tool for calculating the population impacts under both normal transportation and transportation accidents. The major RADTRAN input parameters for truck transportation are summarized in Table E-10. The RISKIND computer code (ANL 1995) was used to determine the maximally exposed individual (MEI) in an accident.

To evaluate the radiological impacts of accidents, it was necessary to consider the probability of an accident occurring and the potential consequences of that accident. This analysis included the following steps:

- Identifying the physical, chemical, and radiological characteristics of the waste
- Identifying the system that would be used for shipping (types of shipping containers, number of containers per shipment, etc.)
- Identifying potential accident scenarios in which radioactive material may be released

Table E-7
Mileages (kilometers) to Treatment Sites from Sites with Small Quantities of TRU Waste

Originating Site	Destination Site	Total One-way Truck Mileage [a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
CH-TRU Waste						
Ames Laboratory	ORNL	893 (1,438)	669 (1,077)	209 (337)	15 (24)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEEL	1,293 (2,081)	1,199 (1,930)	85 (137)	9 (15)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,255 (2,020)	1,121 (1,804)	118 (190)	16 (26)	Action Alternative 2C
Bettis Atomic Power Laboratory	ORNL	606 (975)	415 (668)	178 (286)	13 (21)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	686 (1,104)	485 (781)	188 (303)	12 (19)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,803 (2,902)	1,453 (2,338)	318 (512)	31 (50)	Action Alternative 2C
U.S. Army Materiel Command	ORNL	701 (1,128)	497 (800)	191 (307)	13 (21)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEEL	1,429 (2,300)	1,323 (2,129)	98 (158)	8 (13)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,391 (2,239)	1,245 (2,004)	131 (211)	14 (23)	Action Alternative 2C
Paducah Gaseous Diffusion Plant	ORNL	316 (509)	252 (406)	60 (97)	4 (6)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	587 (945)	393 (632)	178 (286)	17 (27)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,360 (2,189)	1,174 (1,889)	171 (275)	14 (23)	Action Alternative 2C
Energy Technology Engineering Center	NTS	375 (603)	269 (433)	61 (98)	45 (72)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEEL	958 (1,542)	755 (1,216)	142 (229)	62 (100)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,151 (1,853)	997 (1,605)	101 (163)	53 (85)	Action Alternative 2C
Sandia National Laboratories	LANL	104 (167)	82 (132)	17 (27)	5 (8)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 3, and No Action Alternative 2
	INEEL	1,170 (1,884)	1,041 (1,676)	110 (177)	18 (29)	Action Alternative 2B and No Action Alternative 1B
	WIPP	311 (501)	288 (464)	19 (31)	4 (6)	Action Alternative 2C

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-7
Mileages (kilometers) to Treatment Sites from Sites with Small Quantities of TRU Waste — Continued

Originating Site	Destination Site	Total One-way Truck Mileage [a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
CH-TRU Waste						
University of Missouri	ORNL	610 (982)	476 (766)	120 (193)	14 (23)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	881 (1,418)	617 (993)	238 (383)	26 (42)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,145 (1,843)	1,018 (1,638)	110 (177)	18 (29)	Action Alternative 2C
ARCO Medical Products Company	ORNL	658 (1,059)	411 (662)	241 (388)	6 (10)	Action Alternative 1
	SRS	724 (1,165)	463 (745)	253 (407)	8 (13)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	2,056 (3,310)	1,608 (2,589)	420 (676)	27 (43)	Action Alternative 2C
Lawrence Berkeley Laboratory	Hanford	870 (1,400)	668 (1,075)	167 (269)	35 (56)	Action Alternative 1, Action Alternative 2B, Action Alternative 3, and No Action Alternative 1B
	WIPP	1,522 (2,450)	1,320 (2,125)	131 (211)	71 (114)	Action Alternative 2C
West Valley Demonstration Project	ORNL	749 (1,206)	467 (752)	265 (427)	17 (27)	Action Alternative 1
	SRS	902 (1,452)	635 (1,022)	259 (417)	9 (15)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
RH-TRU Waste						
Battelle Columbus Laboratory	ORNL	395 (636)	269 (433)	117 (188)	9 (15)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1B, and No Action Alternative 2
Bettis Atomic Power Laboratory	ORNL	606 (976)	415 (668)	178 (287)	13 (21)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1B, and No Action Alternative 2
Knolls	ORNL	883 (1,422)	589 (948)	284 (457)	10 (16)	Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Energy Technology Engineering Center	Hanford	1,203 (1,937)	982 (1,581)	179 (288)	41 (66)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1B, and No Action Alternative 2
Sandia National Laboratories	LANL	104 (167)	82 (132)	17 (27)	5 (8)	Proposed Action, Action Alternative 1, No Action Alternative 1B, and No Action Alternative 2
	Hanford	1,586 (2,553)	1,424 (2,293)	141 (227)	21 (34)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, and No Action Alternative 1B
West Valley Demonstration Project	ORNL	749 (1,206)	467 (752)	265 (427)	17 (27)	Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, and No Action Alternative 1B

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-8
Nonradiological Impacts per Shipment
from Accidents and Pollution Related Health Effects

Originating Site	Destination Site	Impact Category	Population Zone			Total [a]
			Rural	Suburban	Urban	
Argonne National Laboratory - East	WIPP	Accidents	7.7E-4	3.6E-4	5.0E-5	1.2E-3
		Injuries	7.1E-4	1.8E-4	2.1E-5	9.1E-4
		Fatalities	9.1E-5	3.0E-5	3.4E-6	1.2E-4
		Vehicle Pollution (LCFs) [b]	---	---	8.0E-6	8.0E-6
	SRS	Accidents	3.3E-4	4.5E-4	4.6E-5	8.3E-4
		Injuries	3.3E-4	4.4E-4	4.4E-5	8.2E-4
		Fatalities	3.4E-5	3.3E-5	3.1E-6	7.0E-5
		Vehicle Pollution (LCFs) [b]	---	---	7.6E-6	7.6E-6
Hanford Site	WIPP	Accidents	1.6E-3	2.3E-4	3.2E-5	1.9E-3
		Injuries	1.0E-3	1.8E-4	2.6E-5	1.3E-3
		Fatalities	1.5E-4	1.3E-5	1.7E-6	1.7E-4
		Vehicle Pollution (LCFs) [b]	---	---	5.8E-6	5.8E-6
Idaho National Engineering and Environmental Laboratory/ ANL-W	WIPP	Accidents	1.4E-3	2.1E-4	3.0E-5	1.6E-3
		Injuries	8.2E-4	1.6E-4	2.4E-5	1.0E-3
		Fatalities	1.3E-4	1.2E-5	1.7E-6	1.5E-4
		Vehicle Pollution (LCFs) [b]	---	---	4.9E-6	4.9E-6
	Hanford	Accidents	4.0E-4	3.3E-5	2.1E-6	4.4E-4
		Injuries	3.5E-4	2.7E-5	1.7E-6	3.8E-4
		Fatalities	3.0E-5	9.8E-7	6.0E-8	3.1E-5
		Vehicle Pollution (LCFs) [b]	---	---	1.1E-6	1.1E-6
Lawrence Livermore National Laboratory	WIPP	Accidents	9.6E-4	1.4E-4	5.2E-5	1.2E-3
		Injuries	9.5E-4	1.3E-4	4.9E-5	1.1E-3
		Fatalities	1.4E-4	1.3E-5	4.4E-6	1.5E-4
		Vehicle Pollution (LCFs) [b]	---	---	1.5E-5	1.5E-5
	Hanford	Accidents	4.3E-4	1.8E-4	2.9E-5	6.4E-4
		Injuries	3.7E-4	1.7E-4	2.8E-5	5.7E-4
		Fatalities	3.7E-5	1.2E-5	1.9E-6	5.0E-5
		Vehicle Pollution (LCFs) [b]	---	---	9.9E-6	9.9E-6
Los Alamos National Laboratory	WIPP	Accidents	4.9E-4	3.3E-5	3.2E-6	5.2E-4
		Injuries	4.7E-4	3.2E-5	3.1E-6	5.1E-4
		Fatalities	7.1E-5	4.8E-6	4.7E-7	7.6E-5
		Vehicle Pollution (LCFs) [b]	---	---	6.7E-7	6.7E-7
	Hanford	Accidents	1.2E-3	2.0E-4	3.2E-5	1.5E-3
		Injuries	1.1E-3	1.6E-4	2.7E-5	1.3E-3
		Fatalities	9.3E-5	1.1E-5	1.8E-6	1.1E-4
		Vehicle Pollution (LCFs) [b]	---	---	5.9E-6	5.9E-6
	INEEL	Accidents	9.4E-4	1.7E-4	3.0E-5	1.1E-3
		Injuries	8.5E-4	1.4E-4	2.6E-5	1.0E-3
		Fatalities	7.5E-5	9.6E-6	1.8E-6	8.6E-5
		Vehicle Pollution (LCFs) [b]	---	---	5.0E-6	5.0E-6

[a] Totals may differ from the sum due to rounding.
[b] Dashed lines indicate that vehicle pollution impacts apply only to urban population zones.

Table E-8
Nonradiological Impacts per Shipment
from Accidents and Pollution Related Health Effects — Continued

Originating Site	Destination Site	Impact Category	Population Zone			Total [a]
			Rural	Suburban	Urban	
Mound Plant	WIPP	Accidents	8.0E-4	3.4E-4	3.3E-5	1.2E-3
		Injuries	7.4E-4	3.3E-4	3.2E-5	1.1E-3
		Fatalities	9.2E-5	2.9E-5	2.3E-6	1.2E-4
		Vehicle Pollution (LCFs) [b]	---	---	7.5E-6	7.5E-6
	SRS	Accidents	2.3E-4	3.2E-4	1.5E-5	5.7E-4
		Injuries	2.4E-4	3.1E-4	1.6E-5	5.7E-4
		Fatalities	2.8E-5	2.3E-5	9.8E-7	5.1E-5
		Vehicle Pollution (LCFs) [b]	---	---	3.3E-6	3.3E-6
Nevada Test Site	WIPP	Accidents	8.7E-4	1.4E-4	3.2E-5	1.0E-3
		Injuries	8.6E-4	1.3E-4	2.9E-5	1.0E-3
		Fatalities	1.2E-4	1.4E-5	3.3E-6	1.4E-4
		Vehicle Pollution (LCFs) [b]	---	---	4.3E-6	4.3E-6
	INEEL	Accidents	4.3E-4	6.8E-5	1.6E-5	5.1E-4
		Injuries	3.9E-4	6.0E-5	1.4E-5	4.6E-4
		Fatalities	3.0E-5	5.4E-6	1.4E-6	3.7E-5
		Vehicle Pollution (LCFs) [b]	---	---	6.5E-6	6.5E-6
Oak Ridge National Laboratory	WIPP	Accidents	5.6E-4	2.3E-4	1.1E-5	8.1E-4
		Injuries	5.7E-4	3.4E-4	1.4E-5	9.2E-4
		Fatalities	8.1E-5	2.8E-5	1.2E-6	1.1E-4
		Vehicle Pollution (LCFs) [b]	---	---	4.4E-6	4.4E-6
	SRS	Accidents	1.5E-4	1.8E-4	5.3E-6	3.3E-4
		Injuries	1.6E-4	1.8E-4	4.9E-6	3.4E-4
		Fatalities	1.9E-5	1.5E-5	4.1E-7	3.4E-5
		Vehicle Pollution (LCFs) [b]	---	---	9.6E-7	9.6E-7
Rocky Flats Environmental Technology Site	WIPP	Accidents	7.0E-4	1.7E-4	3.05E-5	9.0E-4
		Injuries	6.9E-4	1.5E-4	2.7E-5	8.7E-4
		Fatalities	9.0E-5	1.2E-5	1.8E-6	1.0E-4
		Vehicle Pollution (LCFs) [b]	---	---	4.5E-6	4.5E-6
	INEEL	Accidents	6.4E-4	5.9E-5	1.4E-5	7.1E-4
		Injuries	5.6E-4	3.6E-5	1.2E-5	6.0E-4
		Fatalities	4.4E-5	1.9E-6	7.2E-7	4.6E-5
		Vehicle Pollution (LCFs) [b]	---	---	2.9E-6	2.9E-6
Savannah River Site	WIPP	Accidents	6.3E-4	3.7E-4	1.9E-5	1.0E-3
		Injuries	6.1E-4	3.6E-4	1.8E-5	9.9E-4
		Fatalities	8.5E-5	2.8E-5	1.3E-6	1.1E-4
		Vehicle Pollution (LCFs) [b]	---	---	5.5E-6	5.5E-6

[a] Totals may differ from the sum due to rounding.
[b] Dashed lines indicate that vehicle pollution impacts apply only to urban population zones.

Table E-9
Aggregate Nonradiological Impacts for CH-TRU and RH-TRU Waste Transport [a]

Nonradiological Aggregate Impacts	Proposed Action Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Accidents	43	36	25	62	28	38	66	38	42	80	36	26	62
Injuries	30	26	17	43	20	25	45	27	28	55	26	17	43
Fatalities	4	4	2	6	3	3	6	3	4	7	4	3	7
Vehicle Pollution (LCF)	0.1	0.1	0.08	0.2	0.09	0.1	0.2	0.1	0.1	0.3	0.1	0.08	0.2
RH-TRU Waste													
Accidents	13	100	9	109	38	6	43	38	6	43	38	6	43
Injuries	9	68	8	76	26	5	31	26	5	31	25	5	31
Fatalities	1	9	1	10	3	1	4	3	1	4	3	1	4
Vehicle Pollution (LCF)	0.04	0.3	0.04	0.3	0.1	0.03	0.2	0.1	0.03	0.2	0.1	0.03	0.2
Total CH-TRU and RH-TRU Waste													
Accidents	56	136	34	171	66	44	109	76	48	123	74	32	105
Injuries	39	94	25	119	46	30	76	53	33	86	51	22	74
Fatalities	5	13	3	16	6	4	10	6	5	11	7	4	11
Vehicle Pollution (LCF)	0.1	0.4	0.1	0.5	0.2	0.1	0.4	0.2	0.1	0.5	0.2	0.1	0.4

[a] Total Inventory numbers may differ due to rounding.

Note: LCF = Latent Cancer Fatalities

Table E-9
Aggregate Nonradiological Impacts for CH-TRU and RH-TRU Waste Transport — Continued [a]

Nonradiological Aggregate Impacts	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Accidents	73	31	104	0.3	0.03	0.3	7	2	8
Injuries	51	20	71	0.2	0.03	0.3	6	2	8
Fatalities	7	3	10	0.02	2.1E-3	0.02	0.5	0.1	0.6
Vehicle Pollution (LCF)	0.2	0.09	0.3	2.5E-3	9.6E-5	2.6E-3	0.03	8.0E-3	0.04
RH-TRU Waste									
Accidents	124	12	135	2	3	5	2	3	5
Injuries	85	10	94	2	2	4	2	2	4
Fatalities	11	1	12	0.2	0.2	0.3	0.2	0.2	0.3
Vehicle Pollution (LCF)	0.4	0.05	0.4	6.5E-3	0.02	0.03	6.5E-03	0.02	0.03
Total CH-TRU and RH-TRU Waste									
Accidents	197	43	239	2	3	5	9	5	13
Injuries	136	30	165	2	2	4	8	4	12
Fatalities	18	4	22	0.2	0.2	0.3	0.7	0.3	1
Vehicle Pollution (LCF)	0.6	0.1	0.7	9.0E-03	0.02	0.03	0.04	0.03	0.07

[a] Total Inventory numbers may differ due to rounding.

Note 1: LCF = Latent Cancer Fatalities
Note 2: Impacts for No Action Alternatives 1A and 1B reflect the number of shipments to consolidate TRU waste from generator-storage sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-10
RADTRAN Input for Transportation Analyses

Parameter	CH-TRU Waste	RH-TRU Waste
Configuration Data		
Mode of Transportation	Truck	Truck
Package type	TRUPACT-II	72B cask
Packages/Shipment	3	1
Package characteristic dimension, meter	7.4	3.6
Movement Data		
Shipment distance	Site/alternative specific (See Table E-5 and E-6)	
Population density	Route/alternative specific per Highway or Interline Routing Models	
Shipment Speed (kilometer/hour)		
Urban	24.2	24.2
Suburban	40.3	40.3
Rural	88.6	88.6
Stop time (hour) per kilometer	0.01	0.01
Other Normal Input	RADTRAN 4 default values	RADTRAN 4 default values
Normal Exposure Data		
Transportation Index, TI (mrem/hour)	Site/alternative specific	Site/alternative specific
Number of crew members	2	2
Effective distance from source to crew	10	10
Number of people per public vehicle	2	2
Number of people exposed per stop	50	50
Exposure distance while stopped, meters	20	20
Accident Exposure Data		
Number of accident severity categories	8	8
Accident severity category frequency	(NUREG-0170 values)	(NUREG-0170 values)
Radioactive contents/parameters	See Table E-17	See Table E-17
Release fractions	See Table E-20	See Table E-21
Other accident inputs	RADTRAN 4 default values	RADTRAN 4 default values

Note: Accident, injury, and fatality rates were determined for each route using state-specific data (Saricks and Kvitek 1994)

- Assigning a probability to each release scenario
- Estimating the amount and type of material likely to be released in each scenario (the release fraction)
- Evaluating the consequences of such a release, most often in terms of radiation dose to workers and the public

These analyses were performed to estimate the radiological impacts due to the shipment of TRU waste from the major generator-storage sites to WIPP.

E.4.1 Radiological Impacts Due to Accident-Free Transportation

Accident-free radiological impacts would occur during the routine transportation of radioactive material and are the result of public and worker exposures to external radiation (at levels allowed by transportation regulations). The dose rates would be low and would typically be less than that of natural background radiation.

E.4.1.1 Methodology

To determine the radiological impacts of accident-free transportation, the TRU waste volumes, the number of shipments that would be required to transport the waste, the number of miles traveled, and a breakdown of the miles traveled according to urban, suburban, and rural population zones were used. To estimate the accident-free exposures, the speeds of the vehicle were assumed to be 15, 25, and 55 miles per hour in an urban, suburban, and rural population zone, respectively. The use of these speeds resulted in an overestimation of the accident-free exposures. They were not representative of the actual speeds the vehicles would travel in each population zone. The actual speeds are dependent on the posted speed limit or the maximum speed of the vehicle (65 miles per hour). However, the speeds used to estimate accident-free exposures would account for the potential for increased traffic in an urban population zone where an average speed could be as low as 15 miles per hour due to rush-hour traffic.The accident-free radiological impacts, expressed in person-rem, were converted to LCFs using a conversion factor of 1 person-rem = 5×10^{-4} LCFs for nonoccupational doses and 1 person-rem = 4×10^{-4} LCFs for occupational doses (ICRP 1991).

Among the more important RADTRAN input parameters are: the TI, the frequency of stops, the number of people exposed and their distances from the package surface, and the speed of the vehicle used for transportation. The following categories of accident-free occupational and nonoccupational exposures were assessed using RADTRAN (the nomenclature provided in the output are identified in parentheses):

- ***Along Route*** *(Off Link Exposure):* Exposure to individuals adjacent to routes of travel
- ***Sharing Route*** *(On Link Exposure):* Exposure to individuals sharing the right-of-way
- ***Stops*** *(Stops):* Exposure to individuals while shipments are at rest stops
- ***Occupational*** *(Occupational Exposure):* Exposure to vehicle crews

Radiation doses from the first three were summed to obtain the total nonoccupational radiation dose. Additional analyses, discussed later in this section, were conducted to identify the potential impact to the individual likely to receive the greatest radiation dose, such as the state shipment inspector or an individual living along the route.

The TI represents the radiation dose rate at 1 meter (3.3 feet) from the surface of the shipping package and is dependent on the waste density, distribution of radionuclides, quantity of radionuclides per shipment, mix of waste types, self-shielding provided by the waste, and shielding provided by the package. The TI is, therefore, very sensitive to small quantities of gamma-emitting radionuclides such as cobalt-60 (Co-60) and cesium-137 (Cs-137).

Typically, the radionuclide composition of the waste is different for each generator site, and the radionuclide composition of the waste is different from one waste stream to another. BIR-3 considers 11 different waste groups, ranging from paper to vitrified waste. For shipments to WIPP, an average radionuclide composition was developed for each site using the BIR-3 database information and information provided in the Integrated Data Base (IDB) (see Appendix A for additional details).

The shielding dimensions of the TRUPACT-II and RH-72B were used in MICROSHIELD (Worku and Negin 1995) to estimate the external dose rates from unit concentrations of the gamma-emitting radionuclides expected to make the greatest exposure impact. The dose rates were then multiplied by the activity of each radionuclide in the TRU waste inventory for each site to determine an external-dose screening value. These values indicate the comparative impact from external radiation for each radionuclide in the TRU waste inventory at each site. The radionuclides of greatest concern throughout the DOE complex would be americium-241 (Am-241), Cs-137, barium-137m (Ba-137m), and Co-60.

Dose rates were tabulated in a spreadsheet for each radionuclide in the TRU waste inventory to determine the TI. In most cases, the calculated TI was much less than 1; however, because the radionuclide inventory information may be highly variable, a TI of 4 was assumed for all CH-TRU waste shipments, and a TI of 10 was assumed for all RH-TRU waste shipments. No calculated TI exceeded these assumed values. Table E-11 presents the TIs calculated for each site for the Proposed Action and each action alternative.

ACCIDENT-FREE EXPOSURES

Conservative assumptions were made to provide a bounding estimate of potential incident-free exposures to individuals along the shipping routes. First, a bounding transportation index (the exposure from the shipping container at two meters) was chosen for CH-TRU waste and RH-TRU waste. This was done because only about 80 percent of the CH-TRU waste stream volumes and about 15 percent of the RH-TRU waste stream volumes have reported radionuclide inventories. Therefore, basing the transportation index on incomplete data may overestimate the accident-free exposures. Any adjustments made due to improved site waste characterization data would not affect the results significantly.

Conservative assumptions were also used for the accident-free MEI scenarios. The scenarios were conservatively chosen to maximize any potential impacts. For example, for the exposure to the individual living along the route it was assumed that this individual lived at a location where every shipment would pass the person's home. It was also assumed that this individual was exposed to every shipment. Results indicate that even with these conservative assumptions, the impacts to MEI would be low, and potential impacts would be considerably lower.

RADTRAN classified those living along the shipment routes as urban, suburban, and rural fractions with respective mean population densities of 3,861, 719, and 6 persons per square kilometer (10,003, 1,863, and 16 per square mile). This classification is based upon the *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977) and the population densities are quite typical of urban, suburban, and rural environments. For example, statistics from the Denver Regional Council of Governments show that, along I-25 through Denver, only a small area around downtown Denver has a population density that exceeds the urban figure used in RADTRAN (3,997 persons per square kilometer [10,354 persons per square mile] for Denver versus the 3,861 persons per square kilometer [10,003 persons per square mile] assumed by RADTRAN). Other segments through Denver have much lower population densities than the RADTRAN urban value. Fifteen miles south of downtown Denver, population densities along I-25 approach the rural value of 6 persons per square kilometer (16 persons per square mile).

Table E-11
Transportation Indices for TRU Waste Transported from the 10 Major Sites (millirem per hour at 1 meter [3.3 feet]) [a]

Sites	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3
CH-TRU Waste						
ANL-E	4.9E-3	4.1E-3	---	---	4.1E-3	---
Hanford	2.2	3.3	2.8	2.8	3.3	2.7
INEEL	0.6	0.7	1.5	1.3	0.7	0.6
LANL	0.3	0.3	0.8	---	1.3	0.2
LLNL	1.1E-3	9.7E-4	---	---	9.7E-4	---
MOUND	3.2E-5	2.7E-5	---	---	3.0E-5	---
NTS	0.05	0.04	---	---	0.04	---
ORNL	0.2	0.2	---	---	0.2	---
RFETS	0.02	0.02	0.09	---	0.05	0.02
SRS	0.07	0.06	0.2	0.2	0.06	0.06
RH-TRU Waste						
Hanford	1.2	1.2	3.2	3.2	3.2	9.2
INEEL	0.6	0.6	---	---	---	---
LANL	0.1	0.1	---	---	---	---
ORNL	0.6	0.4	1.1	1.1	1.1	1.0

[a] Dashes indicate that no TRU waste would be shipped to WIPP.

Note: The actual TI used for CH-TRU waste was 4, and the actual TI used for RH-TRU waste was 10.

Exposure scenarios were determined to assess the potential impacts from occupational and nonoccupational radiation doses. Some individuals would be exposed to only a single shipment while others would be exposed to multiple shipments. Transportation crew members would be monitored with radiation dosimeters to limit exposures. Radiation dose assessments included the following scenarios:

- A person in a traffic jam next to a truck transporting TRU waste. For this assessment, the exposure distance was assumed to be 1 meter (3.3 feet) and the exposure time assumed to be 30 minutes. The person was assumed to be exposed only once.

- An inspector of trucks ready for departure from a site. For this assessment, it was assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for 30 minutes, the inspector would work at the same job for 10 years, and there would be two shifts working the same job. The number of shipments inspected by and individual would depend on the total number of shipments from a site and the rate at which they were shipped.

- A state safety inspector. For this assessment, it was assumed that the inspector would be involved in 20 percent of the inspections over a 10-year period with an average exposure distance of approximately 1 meter (3.3 feet). Inspections may occur at the origin facility, upon arrival at WIPP, or in the corridor states at ports of entry for trucks. To allow for queues, a truck inspection time of 1 hour was used. To bound the state inspector dose, the route on which the majority of the waste (77 percent) enters New Mexico was chosen.

- A person residing along a shipment route. For this assessment, it was assumed that the individual would be exposed to every waste shipment for 70 years, at a distance of approximately 30 meters (98 feet).

- A rest stop employee. For this assessment, a stop duration of 2 hours and an exposure distance of 20 meters (66 feet) were assumed. It was also assumed that the individual would be exposed to approximately 20 percent of all CH-TRU and RH-TRU waste shipments sent to WIPP over a 10-year period. This assumption was made on the basis that all trucks stopped at the same location, an individual worked for 10 years at the truck stop, and 3 shifts worked at the truck stop.

- A driver of a truck hauling TRU waste. For this assessment, doses were assessed both when the truck was moving and when it was stopped. An exposure distance of 4 meters (13 feet) was assumed. Doses received while the trucks were stopped were assumed to be due to inspections every 100 miles, refueling, and food stops. A truck driver, rather than a service attendant, was assumed to refuel the truck. Depending upon the number of shipments from a facility and the travel time to WIPP, a truck driver may transport all or only a fraction of the shipments from a particular site. It should be noted that no matter what the estimated impacts are, current regulations state that any monitored crew member who receives a radiation dose that approaches 2 rem (the administrative limit for occupational doses) in any given year is to be reassigned to other duties involving no further dose for the remainder of the year.

Table 3-17 in Chapter 3 presents the amount of time required to emplace CH-TRU and RH-TRU waste under the Proposed Action and the action alternatives based upon a throughput rate of 50 TRUPACT-IIs and 8 RH-72Bs per week. This information was used to estimate the maximum number of shipments that the MEI would be exposed to. All doses were determined during a time fewer shipments would be traveling along the routes.

E.4.1.2 Results

Accident-free radiological impacts (per shipment) for CH-TRU and RH-TRU waste shipments from the 10 major generator sites to WIPP are presented in Tables E-12 and E-13. Results are presented as the population dose (person-rem) for occupational and nonoccupational groups for each site. These population doses were used to calculate the aggregate accident-free doses from CH-TRU and RH-TRU waste transportation. Table E-14 summarizes these doses according to alternative and provides the mathematically expected LCFs.

Aggregate MEI doses are presented in Table E-15, as are the corresponding LCFs from CH-TRU and RH-TRU waste transportation.

E.4.2 Radiological Impacts of Transportation Accidents

Radiological impacts due to transportation accidents could be incurred if any radioactive material were released into the environment. The greatest potential impact from such releases would occur when alpha-emitting radionuclides are either inhaled or ingested.

Table E-12
Population Dose per CH-TRU Waste Shipment

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Argonne National Laboratory - East	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.2	
		Sharing Route	9.7E-3	
		Along Route	5.3E-3	
		Total [a]	0.2	
	SRS	Occupational	0.02	Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.08	
		Sharing Route	5.7E-3	
		Along Route	5.2E-3	
		Total [a]	0.1	
Hanford Site	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, Action Alternatives 2A, 2B, and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	9.7E-3	
		Along Route	3.3E-3	
		Total [a]	0.2	
Idaho National Engineering and Environmental Laboratory/ANL-W	WIPP	Occupational	0.02	Proposed Action, Action Alternative 1, Action Alternatives 2A, 2B, and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.1	
		Sharing Route	7.5E-3	
		Along Route	2.7E-3	
		Total [a]	0.1	
Lawrence Livermore National Laboratory	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.5E-3	
		Along Route	4.8E-3	
		Total [a]	0.2	
	Hanford	Occupational	0.02	Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.09	
		Sharing Route	5.7E-3	
		Along Route	4.6E-3	
		Total [a]	0.1	
Los Alamos National Laboratory	WIPP	Occupational	6.0E-3	Proposed Action, Action Alternative 1, Action Alternatives 2A and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.03	
		Sharing Route	1.8E-3	
		Along Route	4.6E-4	
		Total [a]	0.04	
	INEEL	Occupational	0.02	Action Alternative 2B, and No Action Alternative 1A
		Nonoccupational		
		Stops	0.1	
		Sharing Route	6.3E-3	
		Along Route	2.5E-3	
		Total [a]	0.1	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-12
Population Dose per CH-TRU Waste Shipment — Continued

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Mound Plant	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	6.7E-3	
		Total [a]	0.2	
	SRS	Occupational	0.01	Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.06	
		Sharing Route	4.0E-3	
		Along Route	3.4E-3	
		Total [a]	0.07	
Nevada Test Site	WIPP	Occupational	0.02	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	6.4E-3	
		Along Route	1.9E-3	
		Total [a]	0.1	
	INEEL	Occupational	0.01	Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.07	
		Sharing Route	4.3E-3	
		Along Route	2.7E-3	
		Total [a]	0.08	
Oak Ridge National Laboratory	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.2E-3	
		Along Route	4.5E-3	
		Total [a]	0.2	
	SRS	Occupational	6.2E-3	Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.03	
		Sharing Route	2.2E-3	
		Along Route	1.6E-3	
		Total [a]	0.04	
Rocky Flats Environmental Technology Site	WIPP	Occupational	0.01	Proposed Action; Action Alternative 1, Action Alternatives 2A and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.07	
		Sharing Route	4.0E-3	
		Along Route	2.0E-3	
		Total [a]	0.07	
	INEEL	Occupational	0.01	Action Alternative 2B and No Action Alternative 1B
		Nonoccupational		
		Stops	0.07	
		Sharing Route	4.0E-3	
		Along Route	1.4E-3	
		Total [a]	0.08	
Savannah River Site	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, Action Alternatives 2A, 2B, and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.9E-3	
		Along Route	5.4E-3	
		Total [a]	0.2	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-13
Population Dose per RH-TRU Waste Shipment

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Hanford (Richland) Site	WIPP	Occupational	0.01	Proposed Action, Action Alternative 1, Action Alternatives 2A, 2B, and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	4.4E-3	
		Total [a]	0.2	
Idaho National Engineering and Environmental Laboratory / ANL-W	WIPP	Occupational	9.0E-3	Proposed Action and Action Alternative 1
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	3.6E-3	
		Total [a]	0.2	
	Hanford	Occupational	3.9E-3	Action Alternatives 2A, 2B, and 2C, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.08	
		Sharing Route	4.2E-3	
		Along Route	1.2E-3	
		Total [a]	0.08	
Los Alamos National Laboratory	WIPP	Occupational	2.2E-3	Proposed Action and Action Alternative 1
		Nonoccupational		
		Stops	0.04	
		Sharing Route	2.4E-3	
		Along Route	6.1E-4	
		Total [a]	0.05	
	Hanford	Occupational	0.01	Action Alternatives 2A, 2B, and 2C, Action Alternative 3, and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	4.2E-3	
		Total [a]	0.2	
Oak Ridge National Laboratory	WIPP	Occupational	9.3E-3	Proposed Action, Action Alternative 1, Action Alternatives 2A, 2B, and 2C, and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	6.0E-3	
		Total [a]	0.2	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-14
Aggregate Accident-Free Dose (person-rem) from CH-TRU and RH-TRU Waste Shipments [a, b]

Exposure Category	Proposed Action Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Occupational	705 (0.3)	600 (0.2)	410 (0.2)	1.0E+3 (0.4)	455 (0.2)	610 (0.2)	1.0E+3 (0.4)	640 (0.3)	680 (0.3)	1.3E+3 (0.6)	600 (0.2)	415 (0.2)	1.0E+3 (0.4)
Nonoccupational													
Stops	3.9E+3 (2.0)	3.3E+3 (1.7)	2.2E+3 (1.1)	5.5E+3 (2.8)	2.5E+3 (1.3)	3.4E+3 (1.7)	5.9E+3 (3.0)	3.5E+3 (1.8)	3.7E+3 (1.9)	7.2E+3 (3.7)	3.3E+3 (1.6)	2.3E+3 (1.1)	5.6E+3 (2.7)
Sharing Route	220 (0.1)	185 (0.09)	125 (0.06)	310 (0.2)	140 (0.07)	190 (0.09)	330 (0.2)	200 (0.1)	210 (0.1)	410 (0.2)	185 (0.09)	130 (0.06)	315 (0.2)
Along Route	85 (0.04)	70 (0.04)	45 (0.02)	115 (0.06)	55 (0.03)	65 (0.03)	120 (0.06)	75 (0.04)	75 (0.04)	150 (0.08)	70 (0.04)	45 (0.02)	115 (0.06)
Nonoccupational Total [c]	4.2E+3 (2.1)	3.5E+3 (1.8)	2.4E+3 (1.2)	5.9E+3 (3.0)	2.7E+3 (1.4)	3.6E+3 (1.8)	6.3E+3 (3.2)	3.8E+3 (1.9)	4.0E+3 (2.0)	7.8E+3 (3.9)	3.5E+3 (1.8)	2.5E+3 (1.2)	6.0E+3 (3.0)
RH-TRU Waste													
Occupational	80 (0.03)	635 (0.3)	70 (0.03)	705 (0.3)	245 (0.1)	40 (0.02)	285 (0.1)	245 (0.1)	40 (0.02)	285 (0.1)	245 (0.1)	40 (0.02)	285 (0.1)
Nonoccupational													
Stops	1.6E+3 (0.8)	1.3E+4 (6.3)	1.4E+3 (0.7)	1.4E+4 (7.0)	4.8E+3 (2.4)	805 (0.4)	5.6E+3 (2.8)	4.8E+3 (2.4)	805 (0.4)	5.6E+3 (2.8)	4.8E+3 (2.4)	805 (0.4)	5.6E+3 (2.8)
Sharing Route	90 (0.05)	710 (0.4)	80 (0.04)	790 (0.4)	270 (0.1)	50 (0.03)	320 (0.1)	270 (0.1)	50 (0.03)	320 (0.1)	270 (0.1)	50 (0.03)	320 (0.1)
Along Route	35 (0.02)	255 (0.1)	45 (0.02)	300 (0.1)	100 (0.05)	30 (0.02)	130 (0.07)	100 (0.05)	30 (0.02)	130 (0.07)	100 (0.05)	30 (0.02)	130 (0.07)
Nonoccupational Total [c]	1.7E+3 (0.9)	1.4E+4 (6.8)	1.5E+3 (0.7)	1.6E+4 (7.5)	5.2E+3 (2.6)	885 (0.5)	6.1E+3 (3.0)	5.2E+3 (2.6)	885 (0.5)	6.1E+3 (3.0)	5.2E+3 (2.6)	885 (0.5)	6.1E+3 (3.0)
Total CH-TRU and RH-TRU Waste													
Occupational	790 (0.3)	1.2E+3 (0.5)	480 (0.2)	1.7E+3 (0.7)	700 (0.3)	650 (0.2)	1.3E+3 (0.5)	885 (0.4)	720 (0.3)	1.6E+3 (0.7)	845 (0.3)	455 (0.2)	1.3E+3 (0.5)
Nonoccupational													
Stops	5.5E+3 (2.8)	1.6E+4 (8.0)	3.6E+3 (1.8)	2.0E+4 (9.8)	7.3E+3 (3.7)	4.2E+3 (2.1)	1.2E+4 (5.8)	8.3E+3 (4.2)	4.5E+3 (2.3)	1.3E+4 (6.5)	8.1E+3 (4.0)	3.1E+3 (1.5)	1.1E+4 (5.5)
Sharing Route	310 (0.2)	895 (0.5)	205 (0.1)	1.1E+3 (0.6)	410 (0.2)	240 (0.1)	650 (0.3)	470 (0.2)	260 (0.1)	730 (0.3)	455 (0.2)	180 (0.09)	635 (0.3)
Along Route	115 (0.06)	325 (0.1)	90 (0.04)	415 (0.2)	155 (0.08)	95 (0.05)	250 (0.1)	175 (0.09)	105 (0.06)	280 (0.2)	170 (0.09)	75 (0.04)	245 (0.1)
Nonoccupational Total [c]	5.9E+3 (3.0)	1.8E+4 (8.6)	3.9E+3 (1.9)	2.2E+4 (10.5)	7.9E+3 (4.0)	4.5E+3 (2.3)	1.2E+4 (6.2)	9.0E+3 (4.5)	4.9E+3 (2.5)	1.4E+4 (6.9)	8.7E+3 (4.4)	3.4E+3 (1.7)	1.2E+4 (6.0)

[a] Number in parentheses equals LCFs.
[b] Total Inventory numbers may differ due to rounding.
[c] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route.

Table E-14
Aggregate Accident-Free Dose (person-rem) from CH-TRU and RH-TRU Waste Shipments — Continued [a, b]

Exposure Category	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Occupational	1.2E+3 (0.5)	490 (0.2)	1.7E+3 (0.7)	5 (2.2E-3)	0.5 (1.9E-4)	6 (2.4E-3)	115 (0.05)	30 (0.01)	150 (0.06)
Nonoccupational									
Stops	6.5E+3 (3.3)	2.7E+3 (1.4)	9.3E+3 (4.7)	30 (0.02)	3 (1.3E-3)	33 (0.02)	645 (0.3)	175 (0.09)	820 (0.4)
Sharing Route	370 (0.2)	150 (0.08)	520 (0.3)	2 (9.7E-4)	0.2 (8.2E-5)	2 (1.1E-3)	40 (0.02)	10 (5.0E-3)	50 (0.03)
Along Route	135 (0.07)	55 (0.03)	190 (0.1)	2 (7.6E-4)	0.1 (6.2E-5)	2 (8.2E-4)	15 (7.6E-3)	4 (2.0E-3)	19 (9.6E-3)
Nonoccupational Total [c]	7.1E+3 (3.6)	2.9E+3 (1.5)	1.0E+4 (5.1)	35 (0.02)	3 (1.5E-3)	38 (0.02)	695 (0.4)	190 (0.1)	885 (0.5)
RH-TRU Waste									
Occupational	790 (0.3)	90 (0.04)	880 (0.4)	20 (7.3E-3)	20 (7.5E-3)	40 (0.01)	20 (7.3E-3)	20 (7.5E-3)	40 (0.01)
Nonoccupational									
Stops	1.6E+4 (7.8)	1.8E+3 (0.9)	1.7E+4 (8.7)	365 (0.2)	370 (0.2)	735 (0.4)	365 (0.2)	370 (0.2)	735 (0.4)
Sharing Route	880 (0.4)	105 (0.05)	985 (0.5)	20 (0.01)	25 (0.01)	45 (0.02)	20 (0.01)	25 (0.01)	45 (0.02)
Along Route	320 (0.2)	55 (0.03)	375 (0.2)	10 (4.1E-3)	20 (0.01)	30 (0.01)	10 (4.1E-3)	20 (0.01)	30 (0.01)
Nonoccupational Total [c]	1.7E+4 (8.4)	1.9E+3 (1.0)	1.9E+4 (9.4)	390 (0.2)	415 (0.2)	805 (0.4)	390 (0.2)	415 (0.2)	805 (0.4)
Total CH-TRU and RH-TRU Waste									
Occupational	2.0E+3 (0.8)	580 (0.2)	2.6E+3 (1.1)	25 (9.5E-3)	21 (7.7E-3)	46 (0.02)	135 (0.06)	50 (0.02)	190 (0.07)
Nonoccupational									
Stops	2.3E+4 (11.1)	4.5E+3 (2.3)	2.6E+4 (13.4)	395 (0.2)	373 (0.2)	768 (0.4)	1.0E+3 (0.5)	545 (0.3)	1.6E+3 (0.8)
Sharing Route	1.3E+3 (0.6)	255 (0.1)	1.5E+3 (0.8)	22 (0.01)	25 (0.01)	47 (0.02)	60 (0.03)	35 (0.02)	95 (0.05)
Along Route	455 (0.3)	110 (0.06)	565 (0.3)	12 (4.9E-3)	20 (0.01)	32 (0.01)	25 (0.01)	24 (0.01)	49 (0.02)
Nonoccupational Total [c]	2.4E+4 (12.0)	4.8E+3 (2.5)	2.9E+4 (14.5)	425 (0.2)	418 (0.2)	843 (0.4)	1.1E+3 (0.6)	605 (0.3)	1.7E+3 (0.9)

[a] Number in parentheses equals LCFs.
[b] Total Inventory numbers may differ due to rounding.
[c] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route.

Table E-15
Aggregate Dose (rem) and LCFs (values in parentheses)
to MEIs from CH-TRU and RH-TRU Waste Shipments

MEI	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3
CH-TRU Waste						
Person in traffic jam next to shipment	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)
Departure Inspectors	5.9 (2.4E-3)	1.1 (4.4E-4)	1.7 (6.8E-4)	1.7 (6.8E-4)	1.9 (7.6E-4)	2.6 (1.0E-3)
State Inspector	11.6 (4.6E-3)	3.7 (1.5E-3)	4.3 (1.7E-3)	4.9 (2.0E-3)	3.9 (1.6E-3)	5.2 (2.1E-3)
Individual residing adjacent to access route	0.5 (2.5E-4)	0.3 (1.5E-4)	0.3 (1.5E-4)	0.3 (1.5E-4)	0.3 (1.5E-4)	0.4 (2.0E-4)
Rest stop employee	0.3 (1.5E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)
RH-TRU Waste						
Person in traffic jam next to shipment	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)
Departure Inspector	4.0 (1.6E-3)	13.7 (5.5E-3)	5.6 (2.2E-3)	5.6 (2.2E-3)	5.6 (2.2E-3)	15.1 (6.0E-3)
State Inspectors	9.7 (3.9E-3)	17.7 (7.1E-3)	7.3 (2.9E-3)	7.3 (2.9E-3)	7.3 (2.9E-3)	19.4 (7.8E-3)
Individual residing adjacent to access route	0.3 (1.5E-4)	1.2 (6.0E-4)	0.4 (2.0E-4)	0.4 (2.0E-4)	0.4 (2.0E-4)	1.2 (6.0E-4)
Rest stop employee	0.7 (3.5E-4)	0.6 (3.0E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)	0.2 (1.0E-4)	0.6 (3.0E-4)

As previously discussed, NRC-certified Type B packages (TRUPACT-II and RH-72B cask) used to ship CH-TRU and RH-TRU waste must undergo a series of performance tests which simulate accident conditions. These tests include drops, punctures, exposure to fire, and water immersion. The packages are passed if no radioactive material is released as a result of the tests.

A 1987 NRC study (Fischer et al. 1987) estimated that only 0.6 percent of truck and rail accidents involving Type B containers or casks could cause a radiation hazard to the public. The highest number of potential accidents (nonradiological), as calculated in Section E.3, would be expected under Action Alternative 3 and would be about 331. Only half of these accidents would be expected to occur when the canister or cask is loaded; the other half would occur when the trucks were transporting empty canisters or casks back to sites. Therefore, of the 166 potential accidents occurring from transportation of TRU waste under Action Alternative 3, only one accident would be expected to result in damage to the package.

An earlier NRC study (NRC 1977) conservatively estimated that 91 percent of truck and 80 percent of rail accidents are category I and II accidents (packaging must survive without a release). Therefore, 9 percent of truck and 20 percent of rail accidents involving Type B containers or casks could result in radioactive material releases and could be more severe than the test conditions. Therefore, approximately 15 truck-related accidents could occur in which the loaded Type B container is subjected to conditions beyond those associated with severity categories I or II. Some of the low-probability events could result in a release from a Type B package. In order to assure conservative (bounding) impact estimates, the more conservative statistics from the older 1977 NRC study were used in these analyses.

BOUNDING CASE ACCIDENTS

The following assumptions were made to conservatively estimate the potential impacts of a low-probability/high-consequence event:

- Accidents occurred in the urban portion of a nonspecific, large metropolitan area (population greater than one million) with a mean population density of 3,861 persons per square kilometer. This is conservative, since typically 80 to 95 percent of travel occurs in rural or suburban population zone. Including the probability of the accident occurring in an urban population zone would reduce the frequency of occurrence.
- Thermal release fractions (Table E-19) represent the range of thermal exposures to which a TRUPACT-II or RH-72B may be subjected. As stated in SEIS-II, most thermal events result in no release of radioactive material. However, the intent of the accident analysis in SEIS-II was to estimate potential impacts from highly unlikely events.
- Accidents occurred during very stable meteorological conditions, limiting dispersion of the radioactive material plume and maximizing radiation doses. It is difficult to incorporate actual meteorological data for the bounding case accident, since it could occur anywhere along the transportation route. Therefore, given the uncertainty, meteorological conditions were chosen to limit dispersion. Other meteorological conditions that could result in higher doses are unlikely to be encountered along the transportation route.
- In the accident scenarios involving truck transportation, one TRUPACT-II or RH-72B was breached and was subsequently engulfed in fire for two hours. It is unlikely that a breach of the shipping cask would occur in combination with an all-engulfing fire.
- Doses were calculated using a resuspension particle half-life of 365 days. DOE must decrease contamination to levels below which unrestricted public access would be allowable. Continued exposure to residual radioactive contamination on or near a highway would cease following cleanup of the accident site and removal of residual contamination. Therefore, doses from resuspension would be much lower.
- The TRUPACT-II or RH-72B inventory was increased to the maximum allowed under the WIPP WAC to bound the inventory modeled in an accident. No waste shipments would have the radionuclide concentrations modeled, so any impacts from a transportation accident would be much less. In fact, average site inventories indicate that the bounding inventory represents an increase in concentration by a factor 4 to 10 for some radionuclides.

Two analyses were conducted for radiological impacts due to transportation accidents. The first analysis assessed the radiological impact due to transportation accidents occurring from each of the 10 major treatment sites to WIPP. For this analysis, a conservative radiological inventory, which assumed that every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowed by the planning-basis WAC. The total accident impact for each of the 10 sites was obtained by summing the calculated risks of each severity class.

The second analysis assessed four bounding accidents. Two accidents were assumed to involve the breach of a TRUPACT-II, and two accidents involved the breach of an RH-72B. The accidents were assumed to occur under conditions which maximized, within reasonable bounds, the impacts to exposed populations. The probability that such an accident would occur is less than 7.5×10^{-7} for a truck shipment of severity category VIII.

E.4.2.1 Methodology

This section discusses the processes used to calculate the radiological impact due to transportation accidents. Among the elements which are important to such calculations are the severity calculations, release fractions, and the dispersal of released material.

Severity Categories

Most transportation accidents are unlikely to cause any radioactive material release, but very severe accidents may. Thus, the distribution of accidents according to severity must be determined in addition to the overall accident rate.

Accident severity categories define the seriousness of an accident in terms of mechanical and thermal loads. Relevant mechanical parameters include impact speed, force, location and orientation, surface hardness, and puncture characteristics. Thermal characteristics include flame temperature, fire duration, fire source size and orientation with respect to the container, and heat transfer properties (such as flame emissivity and convection coefficients).

NRC defined eight accident severity categories for each mode of transportation in a study assessing the adequacy of regulations for radioactive material transportation (NRC 1977). Severity category I and II accidents are equivalent to the regulatory accident tests required for Type A and Type B packages. By definition, category I and II accidents do not result in any environmental releases because the shipping containers or casks are designed to withstand the accidents. RADTRAN severity categories III through VIII represent accidents that are more severe than the regulatory accident tests.

PROTECTION OF THE TRU WASTE SHIPMENTS FROM SABOTAGE/TERRORIST ACTIVITIES

The Department considers the probability of sabotage or terrorist activities to be very small because TRU waste contains only small, hard-to-recover amounts of plutonium and other materials used to manufacture nuclear weapons. In addition, any act of terrorism or sabotage in which a TRUPACT-II containing the maximum inventory permitted would be breached in an urban area would be unlikely to cause greater impacts than those presented for the accident scenarios in this appendix.

The mass and integrity of the TRUPACT-II and proposed RH-72B packages makes TRU waste shipments unattractive targets for terrorism. The packaging would withstand all but the most extreme efforts to release contaminants. The 1980 FEIS discusses the difficulty of scattering enough material to create a major health hazard. The analysis concluded that more damage would be done by the explosives used to breach the waste packages than by any radioactive materials released.

Although escorts might reduce the already small threat of terrorism, DOE does not believe such escorts are warranted. All nuclear materials are afforded some level of protection, but the level of security provided to a shipment of TRU waste, which contains small amounts of hard-to-recover plutonium, would be considerably less than the level of protection provided to a shipment of material from which nuclear weapons can be made. In the case of TRU waste shipments, current safeguards include the following: the TRANSCOM satellite tracking system would continuously monitor the position and status of shipments en route to WIPP; each vehicle would be equipped with mobile phone communications; the drivers would be required to maintain visual contact with the shipment at all times, even during rest stops; and the drivers would receive specialized training on how to respond to sabotage and terrorism.

Releases from crush impacts were not expected below accident severity category V. Releases from the TRUPACT-II were assumed to be possible during accidents involving fires in category III or above. The large majority of truck (99.90 percent) and rail (99.83 percent) accidents that involve fires last less than 30 minutes (Wolff 1984). The release fractions were combined with the accident rates (probability of fire or impact) for each severity category, the travel distance per shipment, and the fraction of travel through each population density zone to determine an aggregate, probability-weighted consequence for each shipment in terms of radiation dose and LCFs. The probability that an accident will occur diminishes as the accident severity increases. SEIS-II retains the severity classification scheme used by the NRC (1977). The fractional occurrence of truck accidents in each of the eight severity categories is presented in Table E-16.

Table E-16
Fractional Truck Accident Occurrences
by Accident Severity Category and Population Density Zone

Accident Severity Category	Fractional Occurrences	Rural	Suburban	Urban
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5E-5	0.8	0.1	0.1
VIII	1.5E-5	0.9	0.05	0.05

Release Fractions

Radionuclide release fractions were assumed to be the same from one alternative to another, which would be a conservative assumption because the inhalation of dispersed radionuclides would be the principal exposure pathway, and the fractions of respirable particles would be greatly reduced for waste treated thermally (Action Alternative 2). More realistic release fractions for thermally treated waste would have resulted in estimated accident impacts that were 1,000 times lower. Radionuclide release fraction analysis in SEIS-I determined how much radioactive material could be released as respirable particulates after a very severe accident that affected the containment capabilities of the shipping containers or casks. Because inhalation is the primary exposure pathway for TRU radionuclides, a mean aerodynamic diameter of less than 10 microns was used in the analysis. Larger particles would be trapped in mucus membranes, filtered, and expelled from the body before they could reach the lungs. This approach was consistent with existing NRC impact assessments (NRC 1977, and Fischer et al. 1987).

The following steps were used to calculate radionuclide release fractions for very severe accidents:

- Characterize the radioactive material being transported

- Identify and quantify breach of the shipping containers or casks due to accident conditions
- Identify and quantify the mechanisms by which radioactive material was released to the environment

SEIS-II analysis used representative parameter values where published data and test results are applicable and reasonable and conservative estimates where uncertainties exist.

To characterize the radioactive material being transported, the radionuclides, quantities, and concentrations used in the analyses were based on waste inventory data and projections presented in Appendix A. DOE has established criteria and procedures that govern the physical, radiological, and chemical composition of TRU waste (DOE 1996a). Physical restrictions require that the waste not be in a free-liquid form. To estimate the impacts for radiological releases in a transportation accident, two radionuclide inventories were determined for both CH-TRU and RH-TRU waste shipments. One inventory was based on maximizing the radionuclide concentrations to the limit allowed in planning-basis WAC, the other was based on average radionuclide concentrations.

For the radiological inventory based on the planning-basis WAC, the PE-Ci activity was maximized using radionuclide-specific weighting factors. To obtain this correlation, the 50-year committed effective dose equivalent (CEDE) or dose conversion factor (DCF) for a unit intake of each radionuclide was used. DCFs were determined by the methodology described in International Commission on Radiological Protection (ICRP) Publications 26 and 30 (ICRP 1977 and ICRP 1978). The radionuclide inventory was obtained by searching through BIR-3 site radionuclide inventories to find the limiting set of radionuclides for CH-TRU and RH-TRU waste.

RELEASE FRACTIONS FOR THERMALLY TREATED WASTE

The products of plasma processing are vitrified glasses and solid metals, which are predicted to withstand severe temperatures. Respirable impact-related release fractions were determined using impact test data for vitrified materials (PNL 1975). The amount of material fractured at an impact velocity of 20 meters per second (66 feet per second) ranged from 0.013 to 0.15 percent. The upper value for this range represented the amount of material released for accident severity category VIII. RADTRAN default values for an immobile material for the aerosol fraction and the respirable fraction were applied to the estimated material released to quantify the respirable impact-related release. Under thermal accident conditions, vitrified materials would be expected to behave like a refractory brick. The primary release mechanism is expected to be the aerosolization of material from contaminated surfaces, and any such releases are expected to occur only at the more severe accident categories involving a prolonged fire (category IV through VIII). The *Nuclear Fuel Cycle Facility Accident Analysis Handbook* (Ayer et al. 1988) recommends a thermal suspension factor of 2.5×10^{-5} per second. This analysis assumed that there would be an effective thermal suspension duration of one hour and that 10 percent of the material fractured would be available for release under accident severity category VIII conditions. Additionally, a decontamination factor of 5×10^{-2} was used for releases from the package cavity to the environment. This would be consistent with values used in Transportation Accident Scenarios for Commercial Spent Nuclear Fuel (Wilmot 1981) and takes credit for mitigation processes that would reduce radioactive material releases such as particulate settlement, plateout, and filtration effects along the leak path. The resulting respirable thermal release fraction was conservatively applied to accident severity categories IV through VIII. The total respirable release fraction was determined by summing the impact and thermal release components.

To determine which site would have average radionuclide inventory, the individual radionuclide concentrations for each site were multiplied by 2.8 cubic meters (100 cubic feet) to obtain the radionuclide inventory per TRUPACT-II. This value was then multiplied by the radionuclide-specific inhalation DCF, expressed in rem per curie (Ci). The resulting doses were summed to get a measure of the relative inhalation hazard associated with each radionuclide inventory. The average radionuclide inventories were found to be at SRS (for CH-TRU waste) and Hanford (for RH-TRU waste).

The bounding (maximized) radionuclide inventory was determined by increasing the average inventories until one of the planning-basis WAC limits (DOE 1996a) was reached. The goal was to increase the radionuclide activity up to the planning-basis WAC PE-Ci limit of 80 PE-Ci grams per drum while not exceeding the fissile-gram limit of 200 grams per drum and 325 grams per TRUPACT-II or the thermal power limit of 40 watts per TRUPACT-II for untreated waste. For treated waste, the PE-Ci limit is 1,800 grams per drum, and the fissile-gram and thermal power limits are the same as for untreated waste. The average inventories for SRS and Hanford were increased by approximately a factor of four. The bounding radionuclide inventories for CH-TRU and RH-TRU waste are shown in Table E-17. When estimating a bounding case inventory for treated waste (Action Alternatives 2 and 3), however, increasing the PE-Ci amount beyond 80 grams per drum would violate planning-basis WAC thermal power or fissile-gram equivalent limits. Therefore, the bounding radionuclide inventory for treated waste was not analyzed.

Table E-17
Bounding Case Radionuclide Inventories for CH-TRU and RH-TRU Waste Accidents [a]

Radionuclide	Adjusted Inventory CH-TRU Waste (Curies per TRUPACT-II)	Adjusted Inventory RH-TRU Waste (Curies per RH-72B)
Co-60	6.4E-4	2.5
Sr-90	0.01	49
Cs-137	0.01	49
U-233	---	0.03
U-235	---	1.0E-3
U-238	---	7.1E-5
Pu-238	990	1,000
Pu-239	16	20
Pu-240	4.2	10
Am-241	3.6	12
Pu-241	200	10
Pu-242	6.8E-4	---

[a] Dashes indicate radionuclides not found in the inventory.

For SEIS-II accident analysis, it was assumed that only one of the TRUPACT-IIs in the shipment would fail in an accident. This assumption was based on Fischer et al. (1987), which found that impact with a hard target, such as a bridge abutment, could potentially breach one TRUPACT-II container per shipment. While a fire of long duration engulfing three TRUPACT-IIs could result in the failure of one or more TRUPACT-IIs, the release fraction from three failed TRUPACT-IIs

in such a fire is less than the release fraction from a single package from impact; therefore, the single failure from impact was assumed to be bounding.

Although catastrophic failures would be extremely unlikely, the accident analyses are consistent with the NRC's position (Fischer et al. 1987) and did not take credit for any processes that would reduce radioactive material releases (e.g., particle settlement, vapor plate-out on interior or exterior surfaces, filtration effects along leak path). The immediate release of radioactive material from impact events and the delayed release of radioactive material from fire were assumed; however, TRU waste containers were not assumed to fail from impact until an accident of severity category V was reached. A failure threshold corresponding to severity category III (an accident with conditions slightly exceeding the NRC's test requirements) was conservatively assumed for a fire.

Normally, any release of radioactive material due to a transportation accident would progress in two stages; release inside the shipping containers or casks followed by release to the environment. It was assumed, without regard to waste form or type, that all failed waste containers release an average amount of material for each accident severity category.

In assessing releases from impact events, the following steps were used:

- Identification of the fraction of failed waste containers inside the shipping container or cask
- Determination of the fraction of radioactive material released from failed waste containers
- Calculation of the fraction of radioactive material released from failed waste containers that would aerosolize in a respirable form by the mechanical stress of impact
- Calculation of the fraction of radioactive material released from failed waste containers that becomes aerodynamically entrained in a respirable form after the loss of containment and any subsequent depressurization (e.g., TRUPACT-II design pressure of 50 pounds per square inch gauge [psig])

The algorithm used to calculate the release fraction of respirable radioactive material from impact stresses is presented as Equation E-1:

$$\mathrm{IRF} = (\mathrm{FFC})(\mathrm{FMRC})(\mathrm{FMRPI})(\mathrm{FMAI} + \mathrm{FMEI}) \qquad \text{(Equation E-1)}$$

where

IRF	=	Impact release fraction
FFC	=	Fraction of failed waste containers
FMRC	=	Fraction of material released from failed containers into the package cavity
FMAI	=	Fraction of material aerosolized from impact
FMEI	=	Fraction of material entrained to environment during an impact event
FMRPI	=	Fraction of material released from package cavity during an impact event

Values for specific algorithm parameters are presented in Table E-18.

Fischer et al. (1987) estimated that 1.7 percent of truck accidents would involve fires. For fire, the following method was used for each accident severity category:

- Identification of the fraction of radioactive material subject to thermal release mechanisms
- Calculation of the fraction of radioactive material released in a respirable form by combustion
- Calculation of the fraction of radioactive material released in a respirable form by gases and the heating of contaminated surfaces
- Determination of the fraction of radioactive material released in a respirable form by volatilization of radionuclides

In the absence of detailed knowledge about the responses of shipping and waste containers to fires that are more severe than those specified in Type B packaging requirements, it was conservatively assumed that all radioactive material was available for release, for all accidents exceeding severity category II, as limited by the specific release mechanisms.

For combustion related releases, it was assumed that combustible materials could be ignited in all accident severity categories exceeding category II. The amount of oxygen present to support combustion was calculated by assuming a loaded shipping container has an 85 percent void volume

Table E-18
Impact Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments

Parameters	Value	Basis/Reference
FFC	0.2728 lnF -2.814	(DOE 1990) where F is NRC (1977) accident severity breach force (Newtons)
FMRC	From columns below	(DOE 1990) and NRC (1977) used as guidance
FMAI	From columns below	(DOE 1990) resuspension factor of 2.00×10^{-2} m^{-1} used (mechanical stress of vigorous sweeping)
FMEI	1.50×10^{-4}	(DOE 1990) average entrainment value for 4 surfaces used with airflow of 2.5 mph for 30 minutes
FMRPI	Accident severity 1-4: 0.0 Accident severity 5-8: 1.0	Type B package design and NRC (1977) used as guidance

Severity Category	FMRC	FMAI	FMEI	FMRPI	TRUPACT-II		RH-72B Cask	
					FFC	IRF	FFC	IRF
I	0	0	0	0	0	0	0	0
II	0	0	0	0	0	0	0	0
III	0.1	8×10^{-5}	0	0	0.3	0	0.3	0
IV	0.3	8×10^{-5}	0	0	0.5	0	0.7	0
V	0.5	8×10^{-5}	1.5×10^{-4}	1	0.7	8×10^{-5}	1	1×10^{-4}
VI	0.7	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	1×10^{-4}
VII	1	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	2×10^{-4}
VIII	1	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	2×10^{-4}

and that there would be no external sources of air or oxygen (no major breach of container). The results of experiments conducted by Mishima and Schwendiman (DOE 1990) were used to assess the fraction of radioactive material released in a respirable form by the burning of combustible material.

Under accident severity categories IV through VIII, the fire may last longer than 1.5 hours. It was assumed, therefore, that more radioactive material could be converted to an aerosol because of the release of gases from the waste at elevated temperatures. Vaporization was considered as another potential release mechanism during a fire. Alexander et al. (DOE 1990) reports that volatile releases of TRU radionuclides are not of any significance until temperatures of 1,727 Celsius (°C) (3,140°Fahrenheit [°F]) are reached. It was concluded that potential accidents involving CH-TRU waste shipments cannot result in radioactive material releases in a vapor form.

The volatilization of uranium oxide becomes measurable at approximately 1,627°C (2,960°F). Flame temperatures pursuant to the open burning of hydrocarbon fuels (e.g., JP-4, gasoline, diesel) range from 760°C to 1,316°C (1,400°F to 2,400°F), with a median temperature of approximately 982°C (1,800°F). Consequently, a volatile release of material containing TRU radionuclides or uranium oxide would not be reasonably foreseeable for a transportation accident.

RH-TRU waste contains activation/fission products that may volatilize at elevated temperatures. Because the proportion of these products is uncertain, it was assumed that their release would be based on the values estimated for respirable particulate releases. The algorithm for estimating the respirable release fraction of radioactive material from thermal accident events is presented as follows:

$$\mathrm{TRF} = (\mathrm{FAT})(\mathrm{FMRPT})[(\mathrm{FMC})(\mathrm{FMAC}) + (\mathrm{FMAT})] \qquad \text{(Equation E-2)}$$

where

TRF	=	Thermal release fraction
FAT	=	Fraction of accidents involving a thermal event
FMC	=	Fraction of material consumed by combustion
FMAC	=	Fraction of material aerosolized by combustion
FMAT	=	Fraction of material aerosolized by thermal event
FMRPT	=	Fraction of material released from the package cavity during a thermal event

Values for specific algorithm parameters are summarized in Table E-19.

The calculated release fractions from impact (Table E-18) and fires (Table E-19) were added to determine the total respirable release fractions due to very severe transportation accidents and are summarized in Tables E-20 and E-21 for CH-TRU and RH-TRU waste, respectively. A maximum release fraction of 2×10^{-4} was estimated for accidents involving both CH-TRU and RH-TRU waste shipments. This is consistent with or bounds previous transportation impact studies such as SEIS-I (DOE 1990) and the NRC modal study (Fischer et al. 1987), which estimated particulate releases of 2×10^{-6} and vapor (C_s) releases of 2×10^{-4} due to spent fuel shipments.

Table E-19
Thermal Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments

Parameter	Value	Basis/Reference
FAT	1.7×10^{-2} (Truck)	Fischer et al. (1987)
FMC	Accident severity I and II: 0	No internal combustion
	Accident severity III and IV: 9×10^{-4} (TRUPACT-II) 7×10^{-4} (RH-72B Cask)	Type B package design Limited internal oxygen source: 3.95 lb O_2 (TRUPACT-II) 0.73 lb O_2 (RH-72B)
FMAC	Accident severity I and II: 0 Accident severity III - VIII: 5×10^{-4}	Type B package design Mishima and Schwendiman (DOE 1990)
FMAT	Accident severity I and II: 0	Type B package design
	Accident severity III: 2×10^{-8}	Only combustion assumed to occur, with attendant off-gas (combustion) products
	Accident severity IV - VIII: 1×10^{-5} (TRUPACT-II) 9×10^{-6} (RH-72B Cask)	Off-gassing assuming steam/graphite reaction and resuspension factor of 5.0×10^{-6} meter^{-1} corresponding to a surface stress from walking (DOE 1990)
FMRPT	Accident severity I and II: 0 Accident severity III - VIII: 1	Type B package design NRC (1977) used as guidance

Severity Category	FMC	FMAC	FMAT	FMRPT	FAT	TRF
TRUPACT-II						
I	0	0	0	0	0.02	0
II	0	0	0	0	0.02	0
III	9×10^{-4}	5×10^{-4}	2×10^{-8}	1	0.02	8×10^{-9}
IV	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
V	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VI	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VII	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VIII	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
RH-72B Cask						
I	0	0	0	0	0.02	0
II	0	0	0	0	0.02	0
III	7×10^{-4}	5×10^{-4}	2×10^{-8}	1	0.02	6×10^{-9}
IV	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
V	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VI	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VII	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VIII	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}

Table E-20
CH-TRU Waste Truck Transportation Release Fractions

Total Respirable Release Fraction (TRRF) = Impact Release Fraction (IRF) + Thermal Release Fraction (TRF)			
Accident Severity Category	**IRF [a]**	**TRF [b]**	**TRRF**
I	---	---	---
II	---	---	---
III	---	8×10^{-9}	8×10^{-9}
IV	---	2×10^{-7}	2×10^{-7}
V	8×10^{-5}	2×10^{-7}	8×10^{-5}
VI	2×10^{-4}	2×10^{-7}	2×10^{-4}
VII	2×10^{-4}	2×10^{-7}	2×10^{-4}
VIII	2×10^{-4}	2×10^{-7}	2×10^{-4}

[a] From Table E-18
[b] From Table E-19

Table E-21
RH-TRU Waste Truck Transportation Release Fractions

Total Respirable Release Fraction (TRRF) = Impact Release Fraction (IRF) + Thermal Release Fraction (TRF)			
Accident Severity Category	**IRF [a]**	**TRF [b]**	**TRRF**
I	---	---	---
II	---	---	---
III	---	6×10^{-9}	6×10^{-9}
IV	---	2×10^{-7}	2×10^{-7}
V	1×10^{-4}	2×10^{-7}	1×10^{-4}
VI	1×10^{-4}	2×10^{-7}	1×10^{-4}
VII	2×10^{-4}	2×10^{-7}	2×10^{-4}
VIII	2×10^{-4}	2×10^{-7}	2×10^{-4}

[a] From Table E-18
[b] From Table E-19

Atmospheric Dispersion and Exposure Pathways

The dispersion of airborne radioactive material during an accident is dependent on meteorologic conditions at the time of the accident. Airborne radioactive material moves downwind from the scene of the accident; its dispersal and transport are affected by the degree of atmospheric turbulence. Large areas may be affected. The degree of dispersion is influenced by factors, such as the season (which influences atmospheric turbulence), time of day, degree of cloud cover, wind speed, land surface features and characteristics, and other meteorologic parameters.

RADTRAN or similar analytical tools can be used to evaluate the impacts of radioactive material released under transportation-accident conditions. Exposure pathways must be identified and the size of exposed populations must be estimated for input to RADTRAN. Transportation accidents

may be divided into two categories: those accidents in which the shipping containers maintain their integrity (no release of radioactive material) and those accidents in which the integrity of the shipping containers is compromised. The exposure pathways and the exposed population subgroups are discussed below.

In an accident in which shipping containment is not breached, the only exposure pathway would be direct, external radiation from the intact package. The radiation dose to any member of an exposed population would be evaluated in the same manner as the exposure from normal (accident-free) transportation; adjustments would be made for the duration of exposure and the distance between the shipment and the exposed individuals. Potentially exposed populations include the truck crew, the occupants of the other vehicle(s) involved in the accident, bystanders/pedestrians, the occupants of nearby buildings, and emergency response crews.

In an accident that results in a failure of the shipping containers and the possible release of radioactive material, radiation exposures may result from both nondispersible and dispersible material. The exposure pathway from accidents involving shipping containers with nondispersible material would be direct, external radiation. Certain radioactive material forms are not dispersible because of their chemical or physical form (e.g., irradiated steel hardware); these materials may nevertheless expose individuals to penetrating radiation. The radiation doses received by exposed individuals would be evaluated in the same manner as other direct exposures. Adjustments would be made for the increased dose rates that result from a loss of shielding, as well as exposure time and distances. The exposed populations would be the same as those identified above.

According to SEIS-I (DOE 1990), there are four potential exposure pathways from accidents that could cause a release of dispersible radioactive materials:

- Cloudshine would be the pathway of direct *external* dose from the passing cloud of dispersed radioactive material. Dispersion depends on the meteorologic conditions at the accident scene, the fraction of failed shipping containers, and the fraction of released material that becomes airborne.

- Groundshine would be the pathway of direct *external* dose from material that has deposited on the ground after being dispersed from the accident site.

- Inhalation would be the pathway of intake of respirable radioactive material that may result in internal radiation doses. Doses from inhalation depend on the fraction of failed shipping containers, the fraction of airborne material, the aerosol fraction of respirable size, the dilution factor for radioactive material in the surrounding air, the breathing rate of the exposed individual, and the radiation dose per curie of radionuclide inhaled.

- Resuspension would be a secondary inhalation pathway that exists when radioactive material that was dispersed and deposited is disturbed, becomes airborne, and is inhaled. Radiation dose assessment of this pathway would require combining the mechanisms of dispersion, deposition, and inhalation, as well as estimating the fraction of deposited material that is resuspended. Resuspension may result from changes in wind speed or direction or from disturbing deposited material by other means, such as traffic through a deposition area.

The estimated population doses were calculated using a resuspension particle half-life of 365 days. The resuspension half-life is the time required for half of the initially deposited material to be unavailable for resuspension. A resuspension half-life of 365 days would be extremely conservative given the washing (rain) and weathering (wind) processes that would serve to remove contaminants from the accessible environment. Because inhalation of resuspended particles would be a primary contributor to the estimated population dose, this conservative value was chosen. The assumed population density would also affect the total calculated dose and estimated health effects.

Exposure by ingestion was not included in evaluation of the radiological impacts of accidents. It was assumed that emergency response and governmental authorities would intervene to impound contaminated foodstuffs, provide an alternative water supply, and clean up contaminated land. The bounding accident was assumed to occur in an urban area to maximize the exposed population, which eliminates the ingestion pathway.

The population subgroups that would be exposed by an accident that results in the dispersion of radioactive material include the individuals directly exposed at the scene of the accident and individuals present in the areas over which dispersion would occur.

E.4.2.2 Results

The radiological consequences of truck transportation accidents were apportioned among the eight severity categories, each of which is associated with a release fraction and a likelihood of occurrence and calculated for truck transportation. No release was assumed for accidents assigned to severity category I or II.

No releases from crush impacts were assumed for accidents below severity category VI. Releases from the TRUPACT-II were assumed to be possible during accidents involving fires in category III or above. Release fractions for each severity category were combined with the accident rates for each category, the probability of a fire or impact, the travel distance per shipment, the total number of shipments, and the travel fraction through each population density zone to determine an aggregate, probability-weighted consequence.

The results of the analyses of aggregate radiological impacts due to severe transportation accidents are presented by origination site in Table E-22. The sum of the consequences was multiplied by the likelihood of occurrence for the eight accident severity categories to estimate the impacts. Site-specific information and the bounding case radionuclide inventory for untreated waste were used. Although there are different release fractions for untreated, thermally treated, and shred and grout treated waste, the untreated release fractions were used to determine population doses in order to bound the impacts.

E.4.3 Radiological Impacts of Bounding-Case Transportation Accidents

Bounding-case transportation accident scenarios were used to calculate the impact of very severe accidents (category VIII) in higher population areas (urban) along designated transportation routes. Accidents were postulated and analyzed for both CH-TRU and RH-TRU waste shipments. Both the average and the bounding radionuclide inventories were used in these analyses.

Table E-22
Aggregate Radiological Impacts from Severe Accidents (person-rem) [a, b, c]

Impacts from Accidents	Proposed Action-Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Argonne National Laboratory-East	1 (5.0E-4)	0.8 (4.0E-4)	---	0.8 (4.0E-4)	---	---	---	---	---	---	0.7 (3.5E-4)	---	0.7 (3.5E-4)
Hanford Site	590 (0.3)	500 (0.3)	310 (0.2)	810 (0.5)	355 (0.2)	380 (0.2)	735 (0.4)	355 (0.2)	380 (0.2)	735 (0.4)	500 (0.3)	310 (0.2)	810 (0.5)
Idaho National Engineering and Environmental Laboratory/ANL-W	155 (0.08)	130 (0.07)	175 (0.09)	305 (0.2)	110 (0.06)	330 (0.2)	440 (0.3)	230 (0.1)	385 (0.2)	615 (0.3)	130 (0.07)	180 (0.09)	310 (0.2)
Lawrence Livermore National Laboratory	3 (1.5E-3)	3 (1.5E-3)	---	3 (1.5E-3)	---	---	---	---	---	---	3 (1.5E-3)	---	3 (1.5E-3)
Los Alamos National Laboratory	7 (3.5E-3)	6 (3.0E-3)	2 (1.0E-3)	8 (4.0E-3)	4 (2.0E-3)	3 (1.5E-3)	7 (3.5E-3)	---	---	---	6 (3.0E-3)	2 (1.0E-3)	8 (4.0E-3)
Mound Plant	2 (1.0E-3)	2 (1.0E-3)	---	2 (1.0E-3)	---	---	---	---	---	---	2 (1.0E-3)	0.1 (5.0E-5)	2 (1.0E-3)
Nevada Test Site	1 (5.0E-4)	1 (5.0E-4)	---	1 (5.0E-4)	---	---	---	---	---	---	1 (5.0E-4)	---	1 (5.0E-4)
Oak Ridge National Laboratory	6 (3.0E-3)	5 (2.5E-3)	1.0 (5.0E-4)	6 (3.0E-3)	---	---	---	---	---	---	5 (2.5E-3)	0.2 (1.0E-4)	5 (2.5E-3)
Rocky Flats Environmental Technology Site	16 (8.0E-3)	14 (7.0E-3)	---	14 (7.0E-3)	10 (5.0E-3)	---	10 (5.0E-3)	---	---	---	14 (7.0E-3)	---	14 (7.0E-3)
Savannah River Site	48 (0.02)	41 (0.02)	12 (6.0E-3)	53 (0.03)	44 (0.02)	16 (8.0E-3)	60 (0.03)	44 (0.02)	16 (8.0E-3)	60 (0.03)	41 (0.02)	12 (6.0E-3)	53 (0.03)
RH-TRU Waste													
Hanford Site	8 (4.0E-3)	125 (0.06)	4 (2.0E-3)	130 (0.07)	47 (0.02)	3 (1.5E-3)	50 (0.03)	47 (0.02)	3 (1.5E-3)	50 (0.03)	47 (0.02)	3 (1.5E-3)	50 (0.03)
Idaho National Engineering Laboratory/ANL-W	5 (2.6E-3)	5 (2.5E-3)	1 (5.0E-4)	6 (3.0E-3)	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	0.03 (1.5E-5)	0.03 (1.5E-5)	0.01 (5.0E-6)	0.04 (2.0E-5)	---	---	---	---	---	---	---	---	---
Oak Ridge National Laboratory	2 (1.0E-3)	9 (4.5E-3)	5 (2.5E-3)	14 (7.0E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)
Total CH-TRU and RH-TRU Waste	850	840	510	1.4E+3	570	735	1.3E+3	680	785	1.5E+3	760	510	1.3E+3
Total LCFs	0.4	0.5	0.3	0.8	0.3	0.4	0.7	0.3	0.4	0.7	0.4	0.3	0.7

[a] Mathematically expected LCFs are in parentheses.
[b] Total values may differ due to rounding.
[c] Dashes indicate that there would be no shipments to WIPP.

Table E-22
Aggregate Radiological Impacts from Severe Accidents (person-rem) —Continued [a, b, c]

Impacts from Accidents	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory-East	---	---	---	0.7 (3.5E-4)	---	0.7 (3.5E-4)	0.7 (3.5E-4)	---	0.7 (3.5E-4)
Hanford Site	1.1E+3 (0.6)	370 (0.2)	1.5E+3 (0.8)	---	---	---	---	---	---
Idaho National Engineering and Environmental Laboratory/ANL-W	280 (0.1)	210 (0.1)	490 (0.2)	---	---	---	---	---	---
Lawrence Livermore National Laboratory	---	---	---	2.7 (1.3E-3)	---	2.7 (1.3E-3)	2.7 (1.3E-3)	---	2.7 (1.3E-3)
Los Alamos National Laboratory	10 (5.0E-3)	3 (1.5E-3)	13 (6.5E-3)	---	---	---	5.7 (2.9E-3)	2.1 (1.1E-3)	7.8 (4.0E-3)
Mound Plant	---	---	---	1.8 (9.0E-4)	0.1 (5.4E-5)	1.9 (9.5E-4)	1.8 (9.0E-4)	0.1 (5.4E-5)	1.9 (9.5E-4)
Nevada Test Site	---	---	---	1 (5.0E-4)		1 (5.0E-4)	1 (5.0E-4)	---	1 (5.0E-4)
Oak Ridge National Laboratory	---	---	---	4.7 (2.4E-3)	0.2 (1.0E-4)	4.9 (2.5E-3)	4.7 (2.4E-3)	0.2 (1.0E-4)	4.9 (2.5E-3)
Rocky Flats Environmental Technology Site	19 (0.01)	---	19 (0.01)	---	---	---	13.6 (6.8E-3)	---	13.6 (6.8E-3)
Savannah River Site	62 (0.03)	15 (7.5E-3)	77 (0.04)	---	---	---	---	---	---
RH-TRU Waste									
Hanford Site	160 (0.08)	8 (4.0E-3)	170 (0.09)	---	---	---	---	---	---
Idaho National Engineering Laboratory/ANL-W	6 (3.0E-3)	1 (5.0E-4)	7 (3.5E-3)	1.8 (9.0E-4)	0.6 (3.0E-4)	2.4 (1.2E-3)	1.8 (9.0E-4)	0.6 (3.0E-4)	2.4 (1.2E-3)
Los Alamos National Laboratory	0.04 (2.0E-5)	0.02 (1.0E-5)	0.06 (3.0E-5)	0.01 (5.0E-6)	5.4E-3 (2.7E-6)	0.02 (7.7E-6)	0.01 (5.0E-6)	5.4E-3 (2.7E-6)	0.02 (7.7E-6)
Oak Ridge National Laboratory	10 (5.0E-3)	6 (3.0E-3)	16 (8.0E-3)	---	---	---	---	---	---
Total CH-TRU and RH-TRU Waste	1.7E+3	610	2.3E+3	12.7	0.9	13.6	32	3	35
Total LCFs	0.9	0.3	1.2	6.3E-3	4.5E-4	6.8E-3	0.02	1.5E-3	0.02

[a] Mathematically expected LCFs are in parentheses.
[b] Total values may differ due to rounding.
[c] Dashes indicate that there would be no shipments to WIPP.

Note: Shipments for No Action Alternative 1A and 1B are the number of shipments to consolidate TRU waste. No TRU waste would be shipped to WIPP.

E.4.3.1 Assumptions

The assumptions made regarding the bounding-case transportation accident scenarios are as follows:

- Impacts were analyzed without regard to the likelihood of the accident actually occurring.
- The waste shipment would be three fully-loaded TRUPACT-IIs on a combination tractor-trailer truck. Two types of inventories were considered for the bounding case accident. One was based on the average concentrations of radionuclides. The second was chosen to maximally bound the impacts by loading the TRUPACT-II up to the planning-basis WAC limit.
- Accidents were severity category VIII.
- All waste was packaged in Type A drums.
- A minor breach occurred, limiting external oxygen sources.
- A 0.02 percent fraction of the radioactive waste material was released to the environment in a respirable form (less than 10 microns in diameter).
- Radioactive material was evenly distributed throughout the waste volume.
- Accidents occurred in the urban portion of a nonspecific, large metropolitan area (population greater than one million) with a mean population density of 3,861 persons per square kilometer (10,003 persons per square mile).
- Accidents occurred during very stable meteorologic conditions, limiting dispersion of the radioactive material plume and maximizing radiation doses.
- In the accident scenarios involving truck transportation, one TRUPACT-II or RH-72B was breached and subsequently engulfed in fire for two hours.
- In the accident scenarios involving rail transportation, two TRUPACT-IIs or RH-72Bs were breached and subsequently engulfed in fire for two hours.
- Doses were calculated using a resuspension particle half-life of 365 days.

For the CH-TRU waste bounding accident, the radionuclide content (curies per TRUPACT-II) was increased to reach the planning-basis WAC limit for both PE-Ci and fissile-gram equivalents. This increased the amount of Pu-238 in a TRUPACT-II by approximately an order of magnitude. Due to the low likelihood of encountering very stable atmospheric conditions, a bounding radionuclide inventory, and the large population densities, radiological doses are likely to be considerably lower than the calculated values.

For the RH-TRU waste bounding accident, the amount of Pu-238 and Pu-239 was increased by factors of 1,000 and 10, respectively. This was done to maximize the consequences of an accident to both the population and the MEI. Based on reported radionuclide inventories from each site, actual doses from an accident would be expected to be an order of magnitude lower.

E.4.3.2 Results

Because it was assumed that the accidents occurred in an urban area, impacts from the ingestion of contaminated agricultural products were not applicable. Population and MEI doses were calculated by RADTRAN.

No early fatalities or morbidities were estimated. Inhalation (initial or resuspension) was the dominant contributor to radiation doses. The impacts associated with the bounding-case accidents would be as follows:

- For the bounding inventory in a breached TRUPACT-II, the total population dose was estimated to be 31,800 person-rem, resulting in 16 LCFs in the exposed population. The estimated dose to the MEI would be 123 rem total effective dose equivalent (TEDE), resulting in a 0.06 probability of an LCF.

- For the bounding inventory in a breached RH-72B, the total population dose was estimated to be 32,500 person-rem, resulting in 16 LCFs in the exposure population. The MEI dose would be 125 rem (TEDE), resulting in a 0.06 probability of an LCF.

- For the average radionuclide inventory in a breached TRUPACT-II, a total population dose of 6,370 person-rem was estimated. This would result in approximately 3 LCFs in the exposed population. The estimated MEI dose would be 80 rem (TEDE), resulting in a 0.04 probability of an LCF.

- For the average radionuclide inventory in a breached RH-72B, the total population dose would be 72 person-rem, resulting in an expectation of 0.04 LCF in the population. The estimated MEI dose would be 1.4 rem (TEDE), resulting in a 7×10^{-4} probability of an LCF.

The same bounding case accidents were analyzed for thermally treated TRU waste. The release fraction would be reduced by a factor of 1,000, however, thermal treatment increases the concentration of radionuclides by approximately a factor of 2.8. The combination of these two factors reduces the overall radiological impacts from bounding case accidents for thermally treated waste. The impacts would be as follows:

- For the bounding radionuclide inventory in a breached TRUPACT-II, the total population dose resulted in 0.09 LCFs in the exposed population. The estimated MEI dose resulted in a 3×10^{-4} probability of an LCF.

- For the bounding radionuclide inventory in a breached RH-72B, the total population dose resulted in 0.09 LCFs in the exposure population. The estimated MEI dose resulted in a 3×10^{-4} probability of an LCF.

- For the average radionuclide inventory in a breached TRUPACT-II, approximately 0.02 LCFs in the exposed population would be expected. The estimated MEI dose resulted in a 2×10^{-4} probability of an LCF.

- For the average radionuclide inventory in a breached RH-72B, the total population dose resulted in an expectation of 2×10^{-4} LCFs in the population. The estimated MEI dose resulted in a 4×10^{-6} probability of an LCF.

E.5 HAZARDOUS CHEMICAL IMPACTS FROM TRUCK TRANSPORTATION ACCIDENTS

This section evaluates the impacts associated with exposures to hazardous chemicals during the transportation of TRU waste to WIPP. Hazardous chemicals in TRU mixed waste occur as volatile organic compounds (VOC) and metals. Accidents involving hazardous chemicals and metals are evaluated as acute-release events with respect to potential exposures and associated impacts.

During accident-free transportation, exposure to hazardous chemicals and metals would be unlikely because the hazardous chemical components in the waste are completely contained in the transportation container/cask. Thus, no impacts to human health are posed by the hazardous chemical components under accident-free transportation.

The analyses used to assess impacts from hazardous chemicals exposures during transportation accidents was based on those in SEIS-I (DOE 1990).

E.5.1 Methodology

Hazardous material inventories were developed as described in Appendix A. For those VOCs where maximum levels are stipulated in the planning-basis WAC, those levels were assumed to be in the containers/casks being transported during an accident. Where no maximum level was specified in planning-basis WAC, the highest level found during waste drum sampling was selected to ensure that the typical concentration would be bounded. Details can be found in Appendix A.

Because a TRUPACT-II is likely to hold nearly three times the waste volume with hazardous chemicals than an RH-72B would hold, it was assumed that CH-TRU waste hazardous chemical accident scenarios would bound RH-TRU waste accidents. Therefore, no hazardous chemical accidents were analyzed for RH-TRU waste shipments. For the purposes of analyses, it was assumed that the RH-TRU hazardous chemical inventory would be the same as the CH-TRU hazardous chemical inventory.

Although the likelihood that a TRUPACT-II would be breached is low, such an accident would be foreseeable and constitute a source of potential hazardous chemical exposures. The hazardous chemical assessment was conservatively based on a very severe transportation accident. It was assumed that an accident would result in the breach of one of three TRUPACT-IIs and in a fire engulfing all three. This bounding-case accident scenario was also based on the assumption that the entire releasable fraction of each chemical considered was used. The assumptions used in the radiological accident assessment provide the basis for the impacts of accidents involving the chemical components of the waste. The hazardous chemical impact was compared to the maximum airborne chemical concentrations for a member of the public and the immediately dangerous to life or health (IDLH) values. Ratios smaller than one were considered to have no impact.

Based on a 30-minute exposure period and an individual who inhales 10 cubic meters (353 cubic feet) of contaminated air, the IDLHs were originally developed by the National Institute of Occupational Safety and Health (NIOSH) for emergency response purposes. The IDLH-equivalent intake level is the quantity of material inhaled during 30 minutes of exposure. The hazardous constituents analyzed for these accident scenarios and the IDLH values and IDLH-equivalent intake values are shown in Table E-23.

Table E-23
Chemical Constituents Analyzed in CH-TRU Waste

Chemical Name	IDLH (parts per million)	IDLH (milligrams per cubic meter)
Carbon Tetrachloride	200	1,278
Chloroform	500	2,480
Methylene Chloride	2,300	8,119
1,1,2,2-Tetrachloroethane	100	700
Chlorobenzene	1,000	4,680
Methyl Ethyl Ketone	3,000	9,000
Toluene	500	1,915
1,2 Dichloroethane	50	206
Beryllium	N/A	4
Cadmium	N/A	9
Lead	N/A	100
Mercury	N/A	10

N/A = Not Applicable

The following assumptions were used to maximize the hazardous chemical concentrations within the breached TRUPACT-II:

- Nonflammable VOCs with planning-basis WAC-prescribed limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be at those limits.
- Flammable VOCs were assumed to have a maximum concentration of 500 parts per million because they are limited to that in planning-basis WAC.
- VOCs without planning-basis WAC limits were assumed to be present at the maximum concentrations identified to date during sampling of CH-TRU waste.
- Heavy metals (lead, mercury, beryllium, and cadmium) were assumed to be uniformly mixed in the waste container and found in the containers in average amounts (see Appendix A). Metals would be released as particulates; therefore, the calculations used to determine the radioactive material particulate releases were applied to these as well.

Carbon tetrachloride, trichloroethylene, and methylene chloride are considered potential carcinogens by the EPA, and 1,1,1-trichloroethane may produce adverse somatic effects. Lead is the most abundant metal found in the waste by both weight and volume (DOE 1996a).

Despite the fact that a fire would destroy virtually all waste VOCs, it was conservatively assumed that VOCs were released from the breached TRUPACT-II in their entirety. The air concentrations of each hazardous chemical for the maximally exposed member of the public at the scene of the accident were determined using the Gaussian dispersion plume equation of Pasquill, as modified (DOE 1995b). Ground-level concentrations were calculated at the centerline of the plume.

Plume depletion effects from particulate settlement (by gravitational or chemical effects) were not considered. Therefore, air concentrations and the resulting intakes by inhalation were overestimated for particulate metals but not for VOCs. Additionally, each accident was postulated to occur during a period of very stable meteorologic conditions (Pasquill Stability Class F, wind speed of 1 meter per second) to introduce additional conservatism into the analyses.

The effective height of the plume from the accident was estimated to be approximately 21 meters (69 feet), which would account for the buoyancy rise associated with the thermal effects from the accident. The maximum airborne chemical concentration inhaled by a member of the public was calculated as the following:

$$Ar = \left(\frac{E}{Q}\right) R \qquad \text{(Equation E-3)}$$

where

Ar = Air concentration at the location of the least plume dispersion (maximum impact)

E/Q = Dispersion estimate, 1.13×10^{-4} seconds per cubic meter (3.2×10^{-6} seconds per cubic foot)

R = Hazardous chemical release rate over the assumed 7,200-second release period in milligrams per second

E.5.2 Results

Hazardous chemical impacts were evaluated for a bounding, severity category VIII accident (likelihood of occurrence of 1×10^{-6}). The MEI (receptor) was assumed to be located 1,000 meters (3,300 feet) downwind from the accident, exposed at the centerline of the plume for two hours under very stable meteorologic conditions and low wind speed. The hazardous chemicals analyzed and the impacts to the MEI as a fraction of the chemical-specific IDLH value are presented in Table E-24. For all chemicals analyzed, the concentration to which the MEI would be exposed would be no more than approximately 1.4×10^{-3} (for beryllium) of the chemical's IDLH value. Therefore, no human health effects would be expected from acute exposure to hazardous chemicals released from a severe transportation accident.

E.6 IMPACTS OF CONSOLIDATION

The preceding sections address the impacts of transporting TRU waste from the consolidation or treatment sites to WIPP. These impacts were used to estimate the impacts of shipping TRU waste from a small quantity site to one of the consolidation or treatment sites based on the total miles traveled. Also included in this section are the impacts of transporting waste from the 10 major generator-storage sites under Action Alternative 2 and Action Alternative 3, and No Action Alternatives 1A and 1B (Table E-25) which do not treat their waste. Table E-26 presents the total one-way miles for the Proposed Action and alternatives for shipment of TRU waste from large quantity sites. The waste is consolidated and treated at one of the sites from the list of the 10 major generator-storage sites and then the treated waste is shipped to WIPP.

Table E-24
Chemical Airborne Releases for a Severity Category VIII Accident
(CH-TRU Waste Truck Shipment)

Chemical	Quantity (milligrams per cubic meter)	Quantity (milligrams)	Release Rate (milligrams per second) [a]	Maximum Receptor Air Concentration (milligrams per cubic meter) [b, c]	Concentration per IDLH Value
Carbon Tetrachloride	1.2E+04	3.4E+04	2.4	5.4E-04	4.2E-07
Chloroform	6.8E+02	2.0E+03	1.4E-01	3.1E-05	1.3E-08
Methylene Chloride	2.3E+04	6.8E+04	4.7	1.1E-03	1.3E-07
1,1,2,2-Tetrachloroethane	3.1E+04	8.9E+04	6.2	1.4E-03	2.0E-06
Chlorobenzene	4.5E+03	1.3E+04	9.0E-01	2.0E-04	4.4E-08
Methyl Ethyl Ketone	8.8E+03	2.6E+04	1.8	4.0E-04	4.5E-08
Toluene	2.9E+03	8.5E+03	5.9E-01	1.3E-04	7.0E-08
1,2 Dichloroethane	2.3E+03	6.7E+03	4.7E-01	1.1E-04	5.1E-07
Beryllium	1.2E+05	3.5E+05	9.7E-03	5.5E-03	1.4E-03
Cadmium	1.9E+03	5.6E+03	1.6E-04	8.8E-05	9.8E-06
Lead	4.8E+06	1.4E+07	3.9E-01	2.2E-01	2.2E-03
Mercury	2.1E+06	6.0E+06	1.7E-01	9.4E-02	9.4E-03

[a] Release rate = Release fraction x quantity of hazardous constituent present in a single TRUPACT-II x 1/7200 seconds x Quantity Released
[b] The receptor is the public MEI
[c] Receptor Concentration = E/Q' (max individual) x release rate (milligrams per second); = 1.13 x 10^{-4} (seconds/cubic meter) x Release Quantity (milligrams) / 7200 seconds; assumes a two hour release.

Table E-25
Transportation Impacts for Consolidation of Waste from Major Generator-Storage Sites

Impact Category	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B
Nonradiological Impacts						
Emission-related LCFs	9.7E-3	0.04	7.3E-3	9.8E-3	9.7E-3	0.04
Vehicle Related Fatalities	0.2	0.8	0.2	0.2	0.2	0.8
Accident-free Radiological Impacts						
Occupational (person-rem)	26	170	20	26	26	170
Nonoccupational (person-rem)	465	1.3E+3	435	465	465	1.3E+3
Occupational (LCFs)	0.01	0.07	8.2E-3	0.01	0.01	0.07
Nonoccupational (LCFs)	0.2	0.7	0.2	0.2	0.2	0.7

Table E-27 presents the total one-way miles under the Proposed Action and the alternatives for the shipment of TRU waste from the small quantity sites to the consolidation sites. Chapter 3 provides the details of the consolidation. The mileage in this table along with the total miles for shipments to WIPP were used to adjust the impact results estimated for the consolidation/treatment sites. As shown in Table E-28, the impacts from the small quantity sites is a small fraction of the impacts of transportation to WIPP.

E.7 IMPACTS FROM RAIL TRANSPORTATION

This section presents a summary of transportation impacts for both regular rail and dedicated rail. Transportation by rail could be conducted from eight of the 10 major generator-storage sites. Truck shipments would be used from the sites with only small amounts of waste and from those sites without rail spurs.

Table E-26
Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Major Generator Sites to Treatment Sites

Alternatives	CH-TRU Waste	RH-TRU Waste
	Total One-way Mileage	Total One-way Mileage
Proposed Action	---	---
Action Alternative 1	---	---
Action Alternative 2A	250,000	1,800,000
Action Alternative 2B	8,500,000	1,800,000
Action Alternative 2C	---	---
Action Alternative 3	300,000	3,200,000
No Action Alternative 1A	250,000	1,800,000
No Action Alternative 1B	8,500,000	1,800,000

Table E-27
Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Small Quantity Sites

Alternatives	CH-TRU Waste	RH-TRU Waste
	Total One-way Mileage	Total One-way Mileage
Proposed Action	17,000	380,000
Action Alternative 1	34,000	2,600,000
Action Alternative 2A	42,000	3,100,000
Action Alternative 2B	45,000	3,100,000
Action Alternative 2C	103,000	3,100,000
Action Alternative 3	42,000	2,570,000
No Action Alternative 1A	42,000	3,100,000
No Action Alternative 1B	45,000	3,100,000

Table E-28
Small Quantity Sites Transportation Impacts Relative to Major Generator-Storage Site Transportation Risk

Impact Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Nonradiological Risk									
Emisson-related LCFs	3.0E-3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	3.0E-3
Vehicle-related Fatalities	0.03	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.03
Incident-free Radiological Risk									
Occupational	2.8	17	17	17	17	17	17	17	2.8
Nonoccupational	58	375	376	376	371	454	376	376	58
Occupational (LCFs)	1.1E-3	6.9E-3	6.9E-3	6.9E-3	6.7E-3	6.9E-3	6.9E-3	6.9E-3	1.1E-3
Nonoccupational (LCFs)	0.03	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.03

The impacts presented in this section were determined by adjusting the transportation impacts from truck shipments. This approach was feasible because many previous studies have performed detailed truck and detailed rail analyses (DOE 1994). These studies provided a firm basis for adjusting the rail impacts.

DOE would need to address several issues in conjunction with a decision to use rail transportation. These issues would include the following:

- The DOE trucking contractor has hired and trained drivers and would be responsible for procuring and maintaining vehicles and packagings for transporting the TRU waste. Over the last several years, all communities on highway transportation routes specified in SEIS-I were offered emergency response training. Similar development or planning has not been accomplished for rail.

- Regular rail is traditionally slower than highway; therefore, the NRC may need to allow a longer total shipping period than the 60-day truck limit. This could result in a reduction of the allowable TRUPACT-II loading to meet gas generation limits. Discussions between DOE, the NRC, and railroad industry personnel have not taken place.

- Discussions with railroad personnel regarding the use of regular train service or the safety requirements on dedicated trains have not been finalized. Thus, there is greater uncertainty surrounding rail transportation of TRU waste.

- Although projections of rail costs can be made, they are not based on a negotiated contract.

- Currently, there are no agreements in place for the tariffs for transporting TRU waste by rail from the major generator sites. This will require the coordination of a number of rail lines, depending upon the route traveled, and the coordination of the states and cities through which TRU waste would travel.

- In the event of an accident involving a derailment, a rail line could be disabled during the accident investigation with the possibility of no alternative routing for both WIPP and non-WIPP related rail shipments. It is recognized that highways are not immune to traffic delays, but the potential for a detour around an accident on a highway incident would be expected to be higher than that for rail. However, in the event of an unlikely accident resulting in a release of radioactive material, an exclusion area of typically 46 meters (150 feet) would need to be established for both truck or train transportation.

- The emergency response preparedness and training would need to be addressed in those areas possibly affected by rail transportation.

E.7.1 Fatal Accident Rates

Rail accident statistics typically include the number of rail car miles and the number of accidents and fatalities but not information concerning the number of accidents or fatalities per rail car. This omission makes apportioning accidents or fatalities to additional railcars containing TRU waste difficult. As with truck transportation, the probability of a rail car being involved in an accident is independent of the cargo being hauled. The average number of rail cars for a commercial train is 70; therefore, when a train of 70 cars is in an accident that results in one death, that fatality would

be represented as 1/70th of a fatality for each rail car. If that train included three rail cars of TRU waste, the fatality would result in 3/70ths of a fatality for rail cars carrying TRU waste.

There are no statistics for the average number of cars in dedicated trains. It was assumed, therefore, that each dedicated train would have only three rail cars, one locomotive, and one caboose, and each rail car would be carrying TRU waste. Should a dedicated train be involved in an accident that results in a fatality, that fatality would be statistically apportioned as one-fifth a fatality for each car in the train. This number could be changed a great deal, though, by increasing the number of rail cars per train.

Differences in the impacts between regular and dedicated rail service would be primarily due to the differences in apportioning fatalities to rail cars. For SEIS-II, it was estimated that the fatality rate for dedicated rail would be fourteen times greater than that for regular rail. In actuality, if only three rail cars of TRU waste would be included in both cases, the same number of trains would be needed, and the same number of accidents and fatalities would be expected to occur.

E.7.2 Radiological Impacts of Accident-Free Rail Transportation

As under truck accident-free radiological impact analyses, the impacts to three groups of individuals were assessed: those exposed because they would live along a route, those exposed because they share the transportation corridor, and those exposed during rail stops (inspectors and those at rail stops). The impact to the exposed population would be proportional to the number of TRUPACT-IIs and RH-72Bs being shipped and the individual package TIs. Because the number of packages to be shipped and the TIs are the same for both truck and rail, these terms were considered to be constants in the impact analyses.

E.7.2.1 Radiation Exposure to Individuals Residing Close to the Transportation Corridor

Using RADTRAN, the overall exposure would be proportional to the TI, the number of packages shipped, the population density, and would be inversely proportional to the speed of the truck or train. The faster the TRU waste passes by a given location, the lower the exposure. The population density can be somewhat different for rail and truck transportation; however, it would be a second order effect, speed being the most important parameter.

For truck transportation analyses, an average highway speed of 55 miles per hour was assumed for rural population areas. For rail, a speed of 40 miles per hour through rural zones was assumed. As with truck transportation, 25 miles per hour through suburban zones and 15 miles per hour through urban zones was used. Assuming that the total miles would be approximately 25 percent greater for rail transportation and the fractions through rural, suburban, and urban zones would be 89, 10, and 1 percent respectively, a 1.5 increase in the impacts would occur under rail transportation. A more accurate estimate may be obtained by using the ratios of the total miles in each population zone, multiplied by the inverse ratio of the speeds, and adding these to get the impact increase for rail. The result, in most cases, would be close to 1.5.

E.7.2.2 Radiation Exposure to Individuals Sharing the Transportation Corridor

Trains do not typically encounter other traffic of the number and vicinity of that encountered on our nation's highways. Therefore, it was conservatively assumed that the number of individuals

sharing the rail transportation route corridor is at least two orders of magnitude less than for truck transportation.

E.7.2.3 Radiation Exposure During Stops

The biggest difference in impacts between truck and rail transportation would be due to exposures during stops. The model for rail analyses assumes that the people in the vicinity of the stopped train are uniformly distributed with a population density equivalent to the suburban density, 719 individuals per square kilometer (1,863 individuals per square mile). In addition, it was assumed that the other freight cars would effectively shield most of the individuals such that the effective exposure would be 1/10th of the exposure without shielding. The effective exposure distance was assumed to range from 10 to 400 meters (33 to 1,312 feet).

The stop duration was calculated for rail using two components, stops en route and stops at classification yards. For regular rail, the stop time en route is equal to 0.033d where "d" is the distance traveled. The time spent in classification yards was assumed to be 32N where "N" is the number of classification yards that must be used to interchange with other railroads. It was assumed that the average time in such a yard would be 32 hours. For dedicated rail, the stop time en route was assumed to equal 0.004d, and the time associated with interchange was 4N. Dedicated rail would, therefore, have exposures approximately eight times smaller than those from regular rail.

The exposure at stops for regular rail would be 1/8 of those for truck transportation. For dedicated rail, exposures would be 1/64 of those for truck.

The basic equation used to model the impact from rail stops is the following:

$$D = TI \times M \times 2\pi \times \ln\left(\frac{400}{10}\right) \times S \times Pop \times T \times \left[1 + N\left(\frac{970}{M}\right)\right] \times 10^{-6} \times 10^{-3} \qquad \text{(Equation E-4)}$$

where

D = Radiation dose in person-rem

TI = Transportation index in mrem per hour

M = Distance traveled in kilometers

S = Radiation shielding factor based on the congestion of rail cars in a rail yard, 0.1

T = Stop time (hours) per kilometer, 0.033

Pop = Population density, 719 persons per square kilometer (1,863 individuals per square mile)

N = Number of rail shipment transfers, a minimum of 2 (beginning and end of route)

10^{-6} = Conversion of kilometers to meters

10^{-3} = Conversion of rem to millirem

ln = natural log

Therefore, the dose would be:

$$\text{Dose (mrem)} = 1.7\text{E-4 (TI) (M)} \qquad \text{(Equation E-5)}$$

For dedicated rail shipments, the assumed stop duration was 0.004 hours per kilometer (0.006 per mile), a factor of 8.25 lower than for regular rail shipments. The time at interchanges was a factor of 8 lower for dedicated rail. Thus, dedicated rail service would have a stop time exposure about 8 times lower than for regular rail, and the estimated dose from rail stops would be 64 times lower than the estimated dose from the truck stops.

E.7.3 Impacts from Severe Rail Accidents

The aggregate radiological consequences of rail transportation accidents were estimated from the aggregate radiological impacts of truck transportation accidents. Since the frequency of rail accidents would be less than that for truck, the aggregate radiological impacts for rail transportation were conservatively assumed to be the same as those reported for truck in Table E-22.

Assuming that there would be three rail cars, with six TRUPACT-IIs per rail car (regular or dedicated), it was estimated that two TRUPACT-IIs could be breached in an impact accident. This bounding-case accident was assumed to be a derailment where two rail cars impact bridge abutments on either side of the tracks. Although other TRUPACT-IIs may experience impact forces, it would not be expected that the forces would be sufficient to breach the container. For the scenarios analyzed, no early fatalities or morbidities were estimated. The estimated population doses were dominated by the inhalation pathway (initial or resuspension). Based upon the failure of two TRUPACT-IIs or RH-72Bs, the impacts from the rail bounding-case accident scenarios for Action Alternatives 1 and 3 would be as follows:

- For the bounding radionuclide inventory in two breached TRUPACT-II's, the total population dose was estimated to be 63,600 person-rem, resulting in 32 LCFs in the exposed population. The estimated MEI dose would be 246 rem (TEDE), resulting in a 12 percent chance of a cancer fatality.
- For the bounding radionuclide inventory in two breached RH-72B's, the total population dose was estimated to be 65,000 person-rem, resulting in 32 LCFs in the exposure population. The estimated MEI dose would be 250 rem (TEDE), resulting in a 12 percent chance of a cancer fatality.
- For the average radionuclide inventory in two breached TRUPACT-II's, a total population dose of 12,740 person-rem was estimated. This would result in approximately 6 LCFs in the exposed population. The estimated MEI dose would be 160 rem (TEDE), resulting in a 8 percent chance of a cancer fatality.
- For the average radionuclide inventory in two breached RH-72B's, the total population dose would be 144 person-rem, resulting in an expectation of 0.08 LCF in the population. The estimated MEI dose would be 2.8 rem (TEDE), resulting in a 0.14 percent chance of a cancer fatality.

The impacts due to rail accidents under Action Alternative 2 would be the following:

- For the bounding radionuclide inventory in two breached TRUPACT-II's, the total population dose was estimated to be 178 person-rem, resulting in 0.09 LCFs in the exposed population. The estimated MEI dose would be 0.7 rem (TEDE), resulting in a 0.03 percent chance of a cancer fatality.

- For the bounding radionuclide inventory in two breached RH-72B's, the total population dose was estimated to be 182 person-rem, resulting in 0.09 LCFs in the exposure population. The estimated MEI dose would be 0.7 rem (TEDE), resulting in a 0.03 percent chance of a cancer fatality.

- For the average radionuclide inventory in two breached TRUPACT-II's, a total population dose of 35.6 person-rem was estimated. This would result in approximately 0.02 LCFs in the exposed population. The estimated MEI dose would be 0.5 rem (TEDE), resulting in a 0.02 percent chance of a cancer fatality.

- For the average radionuclide inventory in two breached RH-72B's, the total population dose would be 0.4 person-rem, resulting in an expectation of 2×10^{-4} LCFs in the population. The estimated MEI dose would be 0.008 rem (TEDE), resulting in a 4×10^{-4} percent chance of a cancer fatality.

There would be negligible impacts from hazardous chemical releases in a rail transportation severe accident for all alternatives. Because there would be half as many shipments under rail transportation, the aggregate occupational exposure to the train crew would be a factor of two lower. More importantly, the crew of the train would typically be hundreds of feet from the waste. Any exposures would be minimal, and therefore, were not considered. The only radiation exposures occur during train inspections. Very conservatively, the exposure from such activities would be less than 10 percent of the exposure to the crew doing a similar inspection for truck. The train crew would spend its time equally on 70 cars, whereas the truck crew would spend their entire time in close proximity to a radioactive shipping cask. Thus, it can be conservatively estimated that the exposure to the crew of the train would be 0.05 times the occupational exposure to the truck crew.

The impacts from rail (regular and dedicated) transportation are presented in Tables E-29 through E-32. Only the fatal accident projections would be notably different between truck and rail transportation.

E.8 RETRIEVAL AND RECOVERY

The WIPP Land Withdrawal Act states that if the EPA makes a determination of noncompliance during the disposal or decommissioning phase of WIPP, DOE may be required to retrieve (or recover), to the extent practicable, any TRU waste and contaminated material from the WIPP underground disposal facility.

Table E-29
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 1

Aggregate Traffic Related Fatalities	
Regular Rail	8
Dedicated Rail	112
Aggregate Radiological Accident Impacts (LCFs)	
CH-TRU Waste	0.7
RH-TRU Waste	0.08
Total CH-TRU and RH-TRU Waste	0.8
Aggregate Accident-Free Radiological Impacts (person-rem) [a]	
CH-TRU Waste	
Occupational	50 (0.02)
Nonoccupational	
Stops	665 (0.3)
Sharing Route	3 (1.6E-3)
Along Route	170 (0.09)
Nonoccupational Total [b]	840 (0.4)
RH-TRU Waste	
Occupational	35 (0.01)
Nonoccupational	
Stops	1.7E + 3 (0.8)
Sharing Route	8 (3.9E-3)
Along Route	455 (0.2)
Nonoccupational Total [b]	2.1E + 3 (1.1)
Total CH-TRU and RH-TRU Waste	
Occupational	85 (0.03)
Nonoccupational	
Stops	2.3E + 3 (1.2)
Sharing Route	11 (5.5E-3)
Along Route	625 (0.3)
Nonoccupational Total [b]	3.0E + 3 (1.5)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational doses include exposure to people at stops, sharing the route, and along the route. Totals may differ from the sums due to rounding.

Table E-30
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 2

	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C
Aggregate Traffic Related Fatalities			
Regular Rail	5	6	6
Dedicated Rail	70	84	84
Aggregate Radiological Accident Impacts (LCFs)			
CH-TRU Waste	0.7	0.7	0.7
RH-TRU Waste	0.03	0.03	0.03
Total CH-TRU and RH-TRU Waste	0.7	0.7	0.7
Aggregate Accident-Free Radiological Impacts (person-rem) [a]			
CH-TRU Waste			
Occupational	55 (0.02)	65 (0.03)	50 (0.02)
Nonoccupational			
Stops	705 (0.4)	870 (0.4)	670 (0.3)
Sharing Route	3 (1.7E-3)	4 (2.0E-3)	3 (1.6E-3)
Along Route	185 (0.09)	230 (0.1)	175 (0.09)
Nonoccupational Total [b]	890 (0.5)	1.1E+3 (0.6)	845 (0.4)
RH-TRU Waste			
Occupational	15 (5.7E-3)	15 (5.7E-3)	15 (5.7E-3)
Nonoccupational			
Stops	675 (0.3)	675 (0.3)	675 (0.3)
Sharing Route	3 (1.6E-3)	3 (1.6E-3)	3 (1.6E-3)
Along Route	195 (0.1)	195 (0.1)	195 (0.1)
Nonoccupational Total [b]	875 (0.4)	875 (0.4)	875 (0.4)
Total CH-TRU and RH-TRU Waste			
Occupational	70 (0.03)	80 (0.03)	65 (0.03)
Nonoccupational			
Stops	1.4E+3 (0.7)	1.6E+3 (0.8)	1.3E+3 (0.7)
Sharing Route	7 (3.3E-3)	7 (3.7E-3)	6 (3.2E-3)
Along Route	380 (0.2)	425 (0.2)	370 (0.2)
Nonoccupational Total [b]	1.8E+3 (0.9)	2.0E+3 (1.0)	1.7E+3 (0.9)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

Table E-31
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 3

Aggregate Traffic Related Fatalities	
Commercial Rail	11
Dedicated Rail	154
Aggregate Radiological Accident Impacts (LCFs)	
CH-TRU Waste	1.1
RH-TRU Waste	0.1
Total CH-TRU and RH-TRU Waste	1.2
Aggregate Accident-Free Radiological Impacts (person—rem) [a]	
CH-TRU Waste	
Occupational	85 (0.03)
Nonoccupational	
Stops	1.1E+3 (0.6)
Sharing Route	5 (2.6E-3)
Along Route	285 (0.1)
Nonoccupational Total [b]	1.4E+3 (0.7)
RH-TRU Waste	
Occupational	45 (0.02)
Nonoccupational	
Stops	2.1E+3 (1.1)
Sharing Route	10 (4.9E-3)
Along Route	560 (0.3)
Nonoccupational Total [b]	2.7E+3 (1.3)
Total CH-TRU and RH-TRU Waste	
Occupational	130 (0.05)
Nonoccupational	
Stops	3.2E+3 (1.6)
Sharing Route	15 (7.5E-3)
Along Route	845 (0.4)
Nonoccupational Total	4.1E+3 (2.0)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

Table E-32
Rail (Regular and Dedicated) Transportation Impacts for No Action Alternative 1

	No Action Alternative 1A	No Action Alternative 1B
Aggregate Traffic Related Fatalities		
Regular Rail	0.2	0.5
Dedicated Rail	2.8	7.0
Aggregate Radiological Accident Impacts (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02
Aggregate Accident-Free Radiological Impacts (person—rem) [a]		
Total CH-TRU and RH-TRU Waste		
Occupational	2 (8.6E-4)	9 (3.7E-3)
Nonoccupational		
Stops	90 (0.05)	190 (0.09)
Sharing Route	0.5 (2.3E-4)	0.9 (4.6E-4)
Along Route	45 (0.02)	70 (0.04)
Nonoccupational Total [b]	140 (0.07)	260 (0.1)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

E.8.1 Waste Retrieval

Retrieval consists of the removal of TRU waste from WIPP prior to the time at which the salt creep would begin to crush the waste drums and canisters. The retrieval volumes were assumed to be the same as the emplacement volume of one panel (17,560 cubic meters [620,125 cubic feet]). The waste would be shipped back to the originating generator-storage site. Transportation impacts were based on the number of shipments required to transport a designated volume of TRU waste to WIPP. With no additional waste to transport, the number of shipments required to transport the waste back would be the same as the number required to ship the waste to WIPP. Transportation impacts for retrieval would be identical to the transportation impacts associated with TRU waste emplacement. The impacts for transporting the TRU waste retrieved from one panel at WIPP are presented in Table E-33.

Table E-33
Waste Retrieval Impacts

Nonradiological Impacts	
Vehicle Emission-related Fatalities	0.02
Vehicle Related Fatalities	0.5
Accident-Free Radiological Impacts	
Occupational (person-rem)	79
Nonoccupational (person-rem)	590
Occupational (LCFs)	0.03
Nonoccupational (LCFs)	0.3

E.8.2 Waste Recovery

Recovery is defined as the removal of TRU waste, waste containers, and any material contaminated by such waste after the time at which the salt creep has crushed some of the containers. As a result, waste would escape into the panels resulting in an additional contamination volume. For the purposes of analyses, it was assumed that recovery would occur following the closure of WIPP and the active institutional control (100-year) period, at which time all containers were assumed to be breached. Analyses were based on the waste volumes of Action Alternative 3 because this alternative has the greatest volume of waste. The total volume of waste would include the amount of contaminated salt from the breached waste drums. This volume was assumed to be 3.4×10^6 cubic meters (1.2×10^8 cubic feet).

It was assumed that, upon removal from WIPP, the waste would be transported to the consolidation sites proposed in the WM PEIS Regionalized 1 Alternative. Each site would receive more waste than its original volume because of the additional volume of contaminated salt. This additional volume of waste would be divided among the sites, commensurate with their original volume. Impacts were based on adjusting the results of the Action Alternative 3 analysis to the waste volume estimates.

Due to the increase in volume, the number of shipments would increase by a factor of approximately 8.5. Due to the decay of the radionuclides with high gamma activity, the accident-free exposures will be lower than the exposures estimated for shipments to WIPP. Therefore, it was conservatively assumed that accident-free exposures for TRU waste recovery would be the same as for shipments to WIPP. Also, given that the half-lives of the radionuclides which contribute most to internal doses (alpha emitters) are relatively long compared to the recovery time frame, it was conservatively assumed that the maximum bounding accident exposures would be the same. Because the mode of transportation would be the same and the accident statistics would remain relatively constant, the number of accidents, injuries, fatalities, and LCFs from pollution effects would also increase by a factor of approximately 8.5. As in the original shipment of the waste, the transportation impact will be dominated by nonradiological impacts. Table E-34 presents a summary of the estimated transportation impacts associated with transporting TRU waste recovered from WIPP.

Table E-34
Waste Recovery Impacts

Nonradiological Impacts	
Vehicle Emission-related Fatalities	7
Vehicle Related Fatalities	185
Accident-Free Radiological Impacts	
Occupational (person-rem)	2.6E+3
Nonoccupational (person-rem)	2.9E+4
Occupational (LCFs)	1
Nonoccupational (LCFs)	15

E.9 COMPARISON OF ALTERNATIVES

This section presents a comparison of the impacts across the alternatives. As shown in Table E-35, the impacts from transportation are directly related to the number of shipments and the miles traveled.

The increase in transportation impacts under the Proposed Action as compared to the other alternatives is primarily based upon an increase in the waste inventory shipped to WIPP. The difference in impacts between the action alternatives is based upon the treatment process and the consolidation of TRU waste. All of the action alternatives begin with the same volume of waste to be emplaced at WIPP, except for the relatively small volume of PCB-commingled waste considered under Action Alternative 2. Action Alternative 1 considers the same TRU waste treatment as the Proposed Action, but would emplace nearly twice the volume. Action Alternative 2 considers thermal treatment of the TRU waste, which would result in an approximate volume reduction of sixty-five percent and thereby reduce the shipment numbers and impacts under Action Alternative 2A and 2B (as compared to Action Alternative 1). Action Alternative 2C has essentially the same transportation impacts as Action Alternative 1 because all of the waste (less the PCB-commingled waste) would be shipped to WIPP before thermal treatment occurs. The largest relative impacts occur under Action Alternative 3. This alternative starts with the same TRU waste volume as Action Alternative 1, but the waste would be treated using a shred and grout process which would result in an increase in waste volume of approximately 20 percent. However, due to the consolidation scheme used under Action Alternative 3, the difference in impacts between Action Alternative 1 and 3 is greater than twenty percent. Under Action Alternative 1, all of the waste is shipped directly to WIPP from the 10 major generator-storage sites. Under Action Alternative 3, the TRU waste is consolidated (CH-TRU waste at Hanford, LANL, RFETS, SRS, and INEEL/ANL-W; RH-TRU waste at Hanford and ORNL) and treated before it is shipped to WIPP.

The impacts under no Action Alternatives 1A and 1B would be the same as those under Action Alternatives 2A and 2B except for those impacts resulting from the shipments to WIPP. No Action Alternatives 1A and 1B use the same consolidation and treatment processes as Action Alternatives 2A and 2B. No Action 1A would have fewer impacts than 1B since there would be less waste consolidation and more shipments under No Action Alternative 1B. Under No Action Alternative 2, TRU waste would be left where it was generated; therefore, transportation was not analyzed.

Table E-35
Comparison of Impacts Across Alternatives (CH-TRU and RH-TRU Waste) [a]

Impacts	Proposed Action Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Nonradiological Impacts													
Accidents	55	136	32	168	63	41	104	67	43	110	72	29	100
Injuries	39	94	23	116	43	28	71	45	29	74	50	19	69
Fatalities	5	13	3	16	6	4	10	6	4	10	7	3	10
Vehicle Pollution (LCF)	0.2	0.4	0.08	0.5	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.09	0.3
Radiological Impacts													
Accident-free Impacts													
Occupational (person-rem)	785 (0.3)	1.2E+3 (0.5)	465 (0.2)	1.7E+3 (0.7)	675 (0.3)	630 (0.3)	1.3E+3 (0.5)	750 (0.3)	670 (0.3)	1.4E+3 (0.6)	825 (0.3)	435 (0.2)	1.3E+3 (0.5)
Non-occupational (person-rem)	5.8E+3 (2.9)	1.7E+4 (8.5)	3.6E+3 (1.8)	2.1E+4 (10.3)	7.5E+3 (3.7)	4.1E+3 (2.0)	1.2E+4 (5.8)	7.9E+3 (4.0)	4.3E+3 (2.1)	1.2E+4 (6.1)	8.3E+3 (4.2)	2.9E+3 (1.5)	1.1E+4 (5.6)
Aggregate Accident Impacts													
Total (person-rem)	850 (0.4)	840 (0.4)	510 (0.3)	1.4E+3 (0.7)	570 (0.3)	220 (0.1)	790 (0.4)	670 (0.3)	230 (0.1)	900 (0.4)	760 (0.4)	510 (0.3)	1.3E+3 (0.7)
Number of Shipments	37,723	81,717	21,448	103,165	38,691	25,979	64,670	38,690	25,979	64,669	44,946	18,100	63,046
Total Number of Miles	1.05E+8	2.65E+8	6.38E+7	3.29E+8	1.22E+8	7.67E+7	1.99E+8	1.30E+8	8.08E+7	2.11E+8	1.39E+8	5.42E+7	1.93E+8

[a] Total Inventory numbers may differ due to rounding.

Note 1: Number in parenthesis equals LCFs (Latent Cancer Fatalities)
Note 2: Impacts for No Action Alternatives 1A and 1B reflect the number of shipments to consolidate TRU waste from generator-storage sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-35
Comparison of Impacts Across Alternatives (CH-TRU and RH-TRU Waste) — Continued [a]

Impacts	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Nonradiological Impacts									
Accidents	194	39	234	2	3	5	9	5	13
Injuries	133	28	160	2	2	4	8	4	12
Fatalities	18	4	22	0.2	0.2	0.3	0.7	0.3	1
Vehicle Pollution (LCF)	0.6	0.1	0.7	9.0E-3	0.02	0.03	0.04	0.03	0.07
Radiological Impacts									
Accident-free Impacts									
Occupational (person-rem)	2.0E+3 (0.8)	560 (0.2)	2.5E+3 (1.0)	25 (9.5E-3)	21 (7.7E-3)	46 (0.02)	135 (0.06)	50 (0.02)	190 (0.07)
Non-occupational (person-rem)	2.4E+4 (11.8)	4.4E+3 (2.2)	2.8E+4 (13.9)	425 (0.2)	418 (0.2)	843 (0.4)	1.1E+3 (0.6)	605 (0.3)	1.7E+3 (0.9)
Aggregate Accident Impacts									
Total (person-rem)	1.7E+3 (0.9)	610 (0.3)	2.3E+3 (1.2)	13 (6.3E-3)	1 (4.5E-4)	14 (6.8E-3)	32 (0.02)	3 (1.5E-3)	35 (0.02)
Number of Shipments	116,166	25,749	141,915	3,977	912	4,889	10,315	2,502	12,817
Total Number of Miles	3.76E+8	7.79E+7	4.54E+8	2.31E+6	6.84E+5	2.99E+6	8.17E+6	1.77E+6	9.94E+6

[a] Total Inventory numbers may differ due to rounding.

Note 1: Number in parenthesis equals LCFs (Latent Cancer Fatalities)
Note 2: Impacts for No Action Alternatives 1A and 1B reflect the number of shipments to consolidate TRU waste from generator-storage sites to treatment sites. No TRU waste would be shipped to WIPP.

E.10 REFERENCES CITED IN APPENDIX E

ANL (Argonne National Laboratory), 1995, *RISKIND--A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel*, ANL/EAD-1, November, Argonne, Illinois.

Ayer, J.E., et al., 1988, *The Nuclear Fuel Cycle Facility Accident Analysis Handbook*, NUREG-1320, May, U.S. Nuclear Regulatory Commission, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1994, *Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives*, DOE/WIPP 93-058, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *Emergency Planning, Response, and Recovery Roles and Responsibilities for TRU Waste Transportation Accidents*, DOE/CAO-94-1039, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Engineered Alternatives Cost/Benefit Study Final Report*, WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP 94-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

Fischer, L.E., et al., 1987, *Shipping Container Response to Severe Highway and Railway Accident Conditions: Volumes 1 and 2*, NUREG/CR-4829, Lawrence Livermore National Laboratory, Livermore, California.

ICRP (International Commission on Radiological Protection), 1977, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 26, Pergamon Press, New York.

ICRP (International Commission on Radiological Protection), 1978, *Limits for Intakes of Radionuclides by Workers*, ICRP Publication 30, Pergamon Press, New York.

ICRP (International Commission on Radiological Protection), 1991, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Pergamon Press, New York.

Johnson, P.E., et al., 1993a, *Highway 3.1- An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual*, ORNL/TM-12124, Oak Ridge, Tennessee.

Johnson, P.E., et al., 1993b, *INTERLINE 5.0 - An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual*, ORNL/TM-12090, Oak Ridge, Tennessee.

Neuhauser, K.S., and F.L. Kanipe, 1992, *RADTRAN IV- Volume 3: User Guide*. SAND89-2370, TTC-0943, January, Albuquerque, New Mexico.

NRC (U.S. Nuclear Regulatory Commission), 1977, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170, Washington, D.C.

PNL (Pacific Northwest Laboratories), 1975, *Impact Testing of Vitreous Simulated High Level Waste in Canisters*, BNWL-1903, Richland, Washington.

Rao, et al., 1982, *Nonradiological Impacts of Transporting Radioactive Material*, SAND81-1703, TTC-0236, Sandia National Laboratories, Albuquerque, New Mexico.

Saricks, C., and T. Kvitek, 1994, *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight*, ANL/ESD/TM-68, March, Argonne National Laboratory, Argonne, Illinois.

Wilmot, E. L., 1981, *Transportation—Accident Scenarios for Commercial Spent Fuel*, SAND80-2124, Sandia National Laboratories, Albuquerque, New Mexico.

Wolff, T. A., 1984, *The Transportation of Nuclear Materials*, SAND84-0062, TTC-0471, Sandia National Laboratories, Albuquerque, New Mexico.

Worku, G., and C.A. Negin, 1995, *Microshield Version 4.2: User's Manual*, Grove Engineering Inc., Rockville, Maryland.

This page intentionally left blank.

APPENDIX F
HUMAN HEALTH

This appendix describes the methods used to estimate human health impacts that may result from exposure to radioactive material and hazardous chemicals during routine storage operations at waste storage sites and during routine disposal operations at the Waste Isolation Pilot Plant (WIPP). During routine operations, members of the public and workers may be exposed to small quantities of hazardous volatile organic compounds (VOC) and radioactive gases released from vented waste containers. Routine releases of particulates are not expected because container vents have filters to prevent such a release. VOCs and gaseous radionuclides may be released to the environment from exhaust ventilation system emissions at the WIPP Waste Handling Building (WHB) and the underground area. At waste storage sites, there may be releases to the environment from the ventilation exhaust of the facilities; therefore, environmental releases would be the source of potential impacts for the population within 80 kilometers (50 miles) of the facilities, the maximally exposed individual (MEI), the noninvolved worker population (employees not directly involved in waste handling), and the maximally exposed noninvolved worker. Involved workers, those directly involved with waste storage and disposal operations, could also be exposed to direct radiation from radioactive material in the containers as well as the waste container emissions. Human health impacts were calculated for all of these potential receptors from storage and waste disposal activities. Waste treatment impacts from routine operations were based upon information presented in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997b). Information on the adjustment of the WM PEIS results is presented in Appendix B.

Based on new information and revised assumptions, these analyses update the impacts reported in the 1990 *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). The total transuranic (TRU) waste inventory, individual waste container inventories, and different types of treatment for the waste are among the more notable updates.

F.1 TECHNICAL APPROACH

To estimate human health impacts from exposure to radioactive material and VOCs, spreadsheet calculations and three computer codes were used. Spreadsheets were used to estimate the radiological impacts from routine releases of radioactive gases. The GENII computer code was used to calculate the atmospheric dispersion factors for radioactive gas emissions at waste storage sites and WIPP for input into the spreadsheets (Napier et al. 1988). Version 1.95 of the ISO-PC computer code was used to estimate external radiation doses to involved workers (Rittman 1995). The MEPAS® code was used to estimate hazardous chemical carcinogenic and noncarcinogenic (toxicological) impacts to the public and noninvolved workers from releases of VOCs (Droppo et al. 1989; Strenge and Peterson 1989; Buck et al. 1995; Strenge and Chamberlain 1995; Droppo and Buck 1996). None of these three computer codes could be used to estimate the near-field impacts to involved workers from routine releases of radioactive gases and hazardous chemicals from TRU waste containers. Therefore, for impacts to involved workers from routine operations, computer spreadsheets were used.

F.1.1 Radiological Impacts

Computer spreadsheets were used to estimate the radiological impacts to the population, MEI, noninvolved workers, and involved workers from routine releases of radioactive gases. The radionuclide inventories detailed in Appendix A include the radioactive gases radon-222, radon-220, and carbon-14. These gases may slowly escape through the composite carbon filter, which is on each waste container. No routine release of particulate radioactive material would occur at storage sites or at WIPP during routine operations because of the filters. GENII was used to calculate the average annual atmospheric dispersion factors that were used to estimate far-field radiation doses to the population, MEI, and noninvolved workers from the release of radioactive gases. Atmospheric dispersion was calculated by GENII using a straight-line Gaussian-plume model with site-specific meteorologic data. Because the GENII atmospheric dispersion model is not valid for the near-field scenario, computer spreadsheets were used to estimate the near-field radiological impacts to involved workers from releases of radioactive gases from waste containers.

The major contributor to potential radiological impacts for involved workers is external radiation emitted from the radionuclides present in TRU waste. The ISO-PC code was used to estimate the average surface and 1-meter (3.3-foot) dose rates of the TRU waste drums. The surface and 1-meter (3.3-foot) dose rates of the contact-handled (CH) TRU waste drums were used to estimate the radiological impacts to involved workers from waste handling, storage, disposal, and management activities.

The ISO-PC code, which is based on the ISOSHLD-II code, calculates dose rates from radioactive sources using user-defined geometries. Container dose rates vary with radionuclide concentration and waste density. For a given radionuclide concentration, a more dense waste would have more self-shielding and, thereby, would have a lower external dose rate. Scattering properties also differ for different materials. The density of waste is closely tied to the level of waste treatment.

Average dose rates were calculated using the geometry and wall-thickness of the TRU waste containers, the alternative- and consolidation-site-specific average TRU waste density, and the site-specific average TRU waste radionuclide concentrations. The CH-TRU waste drum was modeled as being 82 centimeters (32 inches) high and 56 centimeters (22 inches) in diameter with an iron wall 0.16 centimeters (0.06 inches) thick. It was assumed, for all alternatives, that the radionuclides and waste were uniformly dispersed within the drum. The radionuclide inventories in Appendix A were used.

Radiological impacts were calculated as the total effective dose equivalent (TEDE), which is the sum of the external effective dose equivalent and the 50-year committed effective dose equivalent from radionuclides taken into the body. The TEDE was converted into the risk of a latent cancer fatality (LCF) using dose-to-risk factors published in *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60 (ICRP 60) (ICRP 1991), which presents risk estimates based on data from populations that received relatively high radiation doses at high dose rates. When the dose to an individual is below 20 rads per year, as is typically the case with doses resulting from radioactive gas releases, a reduction factor of two is used. The dose-to-risk conversion factors used for estimating cancer deaths from radiation exposures less than 20 rads per year are: (1) 500 LCFs per million person-rem effective dose equivalent or 5.0×10^{-4} LCFs per person-rem for the general population; and (2) 400 LCFs per million person-rem or 4.0×10^{-4} LCFs per person-rem for workers. The difference between the two conversion factors is attributable to an increased sensitivity to radiation among the very young and

very old within the general population. Potential radiological impacts to populations (public, noninvolved worker, and involved worker) are reported as the expected number of LCFs that may occur. Radiological impacts to the MEI and the maximally exposed noninvolved worker are reported as the probability of an LCF occurring. No estimate of the impact to the maximally exposed involved worker was made because of the high degree of variability.

The ICRP 60 risk factors used in SEIS-II are approximately twice those values in SEIS-I, which used *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980* (BEIR-III) risk factors that were current at the time (BEIR 1980). ICRP 60 risk factors are higher due to an improved reconstruction of the exposures on which the dose-to-risk factors were based and information obtained during an extended population follow-up time. By including the incidence of nonfatal cancers and severe hereditary effects from radiation exposure, a total detriment 1.4 to 1.5 times greater than the LCF risk estimate would result (ICRP 1991). These were not included in SEIS-II.

F.1.2 Hazardous Chemical Impacts

Hazardous chemical impacts may result from the routine release of VOCs from waste containers at waste storage sites and at WIPP. No routine releases of particulate hazardous chemicals (metals) would occur at storage sites or at WIPP because the waste containers are filtered. Atmospheric dispersion was estimated by MEPAS® using a straight-line Gaussian-plume model and site-specific meteorological data. MEPAS® cannot be used for the near-field exposure scenarios of involved workers, so computer spreadsheets were used to estimate potential hazardous chemical impacts.

Impacts from exposure to carcinogenic VOCs are presented as the risk of cancer incidence. The U.S. Environmental Protection Agency (EPA) has published slope factors that are based on chronic exposures to specific hazardous chemicals (EPA 1996). Slope factors are used to estimate the mathematical expectation that an individual will contract cancer in his/her lifetime from chronic exposure to a specific hazardous chemical. Estimates of carcinogenic risk to a population indicate the number of cancers expected within a population as a result of a chronic hazardous chemical exposure. Slope factors for the VOCs evaluated in SEIS-II are found in Table F-1.

Noncarcinogenic health effects from chronic exposure to routine releases of VOCs are presented as a Hazard Index (HI). Noncarcinogenic health effects are nonprobabilistic and have an occurrence threshold. The HI is equal to the individual's estimated exposure divided by the EPA chemical-specific "reference dose" (EPA 1996). The EPA reference dose is ideally based on the exposure level at which a deleterious effect is noted following chronic exposure over a year. Table F-2 presents the reference doses used in SEIS-II analyses and the effect upon which each is based.

Toxicological effects are not expected if the estimated HI is less than one. In some cases, initial conservative screening estimates of involved worker exposures resulted in HI values greater than one. In these cases, the estimated air concentrations to which the worker was exposed were compared to the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for that VOC (NIOSH 1996) (see Table F-3). Unless otherwise noted, PELs are time-weighted averages that must not be exceeded during any 8-hour shift of a 40-hour workweek. Methylene chloride and chloroform have PEL ceiling values that must not be exceeded over any

Table F-1
Carcinogenic Risk Factors for VOCs

VOC	Slope Factor [risk per (milligram per kilogram per day)] [a]	Comment
Carbon tetrachloride	Inhalation = 0.053 Ingestion = 0.13	Probable human carcinogen.
Chlorobenzene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to poor database of carcinogenic effects upon which to base a determination.
Chloroform	Inhalation = 0.081 Ingestion = 6.1E-3	Probable human carcinogen.
Methyl Ethyl Ketone	Inhalation = 0.0 Ingestion = 0.0	Not carcinogenic.
Methylene Chloride	Inhalation = 1.6E-3 Ingestion = 7.5E-3	Probable human carcinogen.
1,1,2,2-Tetrachloroethane	Inhalation = 0.2 Ingestion = 0.2	Possible human carcinogen.
Toluene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to the poor database of carcinogenic effects upon which to base such a determination.
1,1-Dichloroethylene	Inhalation = 0.18 Ingestion = 0.6	Possible human carcinogen.
1,2-Dichloroethane	Inhalation = 0.091 Ingestion = 0.091	Probable human carcinogen.
Benzene	Inhalation = 0.029 Ingestion = 0.029	Human carcinogen (leukemia).
Xylene	Inhalation = 0 Ingestion = 0	Carcinogenicity is under review.
Tetrachloroethene	Inhalation = not available Ingestion = not available	Carcinogenicity is under review. SEIS-II assumes an inhalation slope factor of 1.8E-3 and an ingestion slope factor of 0.051, as cited in Strenge and Peterson (1989).
Ethyl Benzene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to the poor database of carcinogenic effects upon which to base such a determination.

[a] The inhalation slope factor from Integrated Risk Information System (IRIS) was converted to risk per milligram per kilogram per day by assuming an inhalation rate of 20 cubic meters (706 cubic feet) per day and an individual body mass of 70 kilograms (154 pounds) (EPA 1996).

period of time. Because a PEL does not exist for 1,1-dichloroethylene, air concentrations for this VOC were compared to the American Conference of Governmental Industrial Hygienists (ACGIH) short-term exposure limit (STEL) (NIOSH 1996). Overall, the general public is more sensitive to hazardous chemicals than are workers; therefore, an HI of greater than one for a worker signifies the need for further evaluation and perhaps mitigation rather than the expectation of the noncarcinogenic impact.

Because the noncarcinogenic health impacts are nonprobabilistic, the results of calculations for the MEI represent the bounding indicator of noncarcinogenic risks to the 80-kilometer (50-mile) population.

Table F-2
Noncarcinogenic Health Effect Measures for VOCs

VOC	Reference Dose (RfD) (milligrams per kilogram per day) [a]	Comment/Assumption
Carbon tetrachloride	Inhalation, not available Ingestion = 7E-4	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on liver lesions.
Chlorobenzene	Inhalation, under review Ingestion = 0.02	Medium confidence level for ingestion RfD, based on histopathologic changes in the liver. Assumption: Inhalation RfD = 5.7E-3, from EPA HEAST values (Strenge and Petersen 1989).
Chloroform	Inhalation, under review Ingestion = 0.01	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on fatty cyst formation in the liver.
Methyl ethyl ketone	Inhalation = 0.29 Ingestion = 0.61	Low confidence level for both inhalation and ingestion RfDs, based on decreased fetal birth weight.
Methylene chloride	Inhalation, under review Ingestion = 0.06	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on liver toxicity.
1,1,2,2-tetrachloroethane	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Toluene	Inhalation = 0.11 Ingestion = 0.2	Medium confidence level for inhalation and ingestion RfDs. Inhalation RfD based on neurological effects. Ingestion RfD based on changes in liver and kidney weight.
1,1-dichloroethylene	Inhalation, under review Ingestion = 9E-3	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, is based on the growth of hepatic lesions.
1,2-dichloroethane	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Benzene	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Xylene	Inhalation, under review Ingestion = 2.0	Assumption: Inhalation RfD = 0.086 based on previous EPA data (Strenge and Peterson 1989). Medium confidence level for ingestion RfD, based on hyperactivity, decreased body weight, and increased mortality (males only).
Tetrachloroethene	Inhalation, not available Ingestion = 0.01	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on hepatotoxicity and weight gain.
Ethyl benzene	Inhalation = 0.29 Ingestion = 0.1	Low confidence levels for inhalation and ingestion RfDs. Inhalation RfD based on developmental toxicity. Ingestion RfD based on liver and kidney toxicity.

[a] Inhalation reference concentrations listed in IRIS are converted to RfDs by assuming an inhalation rate of 20 cubic meters per day and an individual body mass of 70 kilograms (EPA 1996).

Table F-3
Involved Worker Supplemental Noncarcinogenic Health Effect Measures for VOCs

VOC	Permissible Exposure Level (PEL) [a]
Carbon Tetrachloride	2 parts per million
Chlorobenzene	75 parts per million
Chloroform	Not to exceed 2 parts per million
1,1-Dichloroethylene	None [b]
1,2-Dichloroethane	50 parts per million
Methyl Ethyl Ketone	200 parts per million
Methylene Chloride	500 parts per million [c]
1,1,2,2-Tetrachloroethane	5 parts per million
Toluene	100 parts per million [d]

[a] Time-weighted concentration over an 8-hour exposure period unless otherwise noted.
[b] ACGIH recommends a 5 ppm over an 8-hour limit, with a short-term exposure limit (STEL) of 20 ppm.
[c] Maximum 5-minute concentration of 2000 ppm, not to be exceeded.
[d] Maximum 15-minute concentration of 150 ppm for any 2-hour period.

F.2 ANALYSIS METHODS AND ASSUMPTIONS

This section describes the background data used in the routine exposure impact analyses. This information is separated into three general categories: radionuclide and VOC source terms, atmospheric transport, and exposure scenarios. Radionuclides and VOCs would be routinely released only to the atmosphere. There is no surface water or groundwater near WIPP, no water is used in the disposal process, and no mechanisms exist for direct soil contamination. Atmospheric transport modeling was used to determine the locations where maximum exposures could occur. Individuals were assumed to be present at these locations, providing a bounding exposure estimate for any individual in the region. Exposure scenarios include assumptions for both individuals and populations for the primary exposure pathways of inhalation, dermal absorption, and external exposure and for the secondary exposure pathways of contaminated food and incidental soil ingestion. Radionuclide inventories detailed in Appendix A were used. Likewise, VOC source terms were developed as described in Appendix A. To conservatively estimate the impacts to the WHB worker, VOC inventories based on the WIPP planning-basis Waste Acceptance Criteria (WAC) (DOE 1996b) limits or headspace sampling data were used.

F.2.1 Source Terms

Impacts from routine releases of gaseous radionuclides and VOCs were estimated for the Total Inventory of TRU waste. The impacts were then assigned to either the Basic Inventory or the Additional Inventory based on the fractional volume of each. The radionuclide and VOC content of the Additional Inventory is unknown; therefore, the radionuclide and VOC headspace concentrations of the Basic Inventory were used for the Additional and Total Inventories.

F.2.1.1 Radionuclide Source Term

The impact estimates from routine operations evaluated in SEIS-I have been refined in SEIS-II. Detailed radionuclide inventory information (Appendix A) was taken from the *Transuranic Baseline Inventory Report* (BIR-3) (DOE 1996d), whereas SEIS-I inventories were limited to those pertaining to plutonium-239 equivalent curies (PE-Ci). Routine radiological impacts would result from the release of gaseous radionuclides through the composite filters of the waste containers and, for involved workers only, external radiation doses from waste handling operations. Releases of gaseous radionuclides are discussed below; additional information on radionuclides contributing to involved worker external dose is presented in Section F.2.3.3.

Radiological impacts from releases of gaseous radionuclides were estimated for the major consolidation sites. Radionuclides included in the analyses were radon-222 and carbon-14. While radon-220 is listed in some of the site radionuclide inventories, it has a half-life of only 56 seconds. Very little of the gas, if any, would escape the waste container before it radioactively decays to polonium-216, a radionuclide that would be trapped as a particulate within the waste or the container filter. Small quantities of other gaseous radionuclides may also be present in TRU waste, but they would be negligible contributors to either worker or population doses.

For carbon-14, the entire WIPP or consolidation site radionuclide inventory was assumed to be released as an organic carbon (e.g., methane). Organic carbon-14 forms have a dose factor two and three orders of magnitude greater than the dose factors of carbon-14 in the form of carbon dioxide or carbon monoxide, respectively (DOE 1988b). Therefore, by assuming this chemical form, the radiological impact estimate was maximized.

Radon-222 is continuously generated in the waste from the decay of radium-226, which has a half-life of 1,600 years. For every curie (Ci) of radium-226 in the waste inventory, 2.1×10^{-6} Ci of radon-222 are produced each second. Only radon-222 is released from the waste containers, however, because particulate radon progeny are trapped by the composite filters on each container. Therefore, the ICRP 65 dose factor (ICRP 1993) for radon-222 alone, 273.8 rem-cubic meter per Ci-hour, was used to determine the radiological impacts. For waste treated to meet WAC, all of the radon-222 that would be generated over a lifetime exposure period (70 years for the MEI, 35 years for workers and populations) in the waste inventory at WIPP or the consolidation sites was assumed to escape the waste container. For waste treated to meet the WIPP Land Disposal Restrictions (LDR), only a small fraction of the radon would be able to escape the monolithic mass before it decays. It was assumed, therefore, that 25 percent of the radon generated over the lifetime exposure period was released from the container. Waste treated by shred and grout would be more porous than LDR waste and less porous than WAC waste. In this case, 50 percent of the radon-222 generated over the lifetime exposure period was assumed to escape the waste container. The estimated release fractions account for the amount of gas captured within the waste and not readily escaping the container. This same methodology was applied to determine the radiological impacts to the public and maximally exposed noninvolved workers at Hanford Site (Hanford) and Oak Ridge National Laboratory (ORNL) for the excess remote-handled (RH) TRU waste remaining at the sites under the Proposed Action.

F.2.1.2 VOC Source Term

VOCs may be released routinely from the TRU waste containers through the composite filters because the purpose of the filter is to prevent gas build-up within the container. However, no hazardous metal particulates would be released through the filter. The release rate of the VOCs would be linearly related to the headspace concentration in the waste container. Routine exposures were assessed using average waste headspace concentrations because exposures may vary over short-term periods but will average out over the long-term periods evaluated in SEIS-II.

No quantitative information on the hazardous chemical inventory of TRU waste is available. Headspace sampling data on 31 VOCs in 900 CH-TRU waste containers are provided in the Resource Conservation and Recovery Act (RCRA) Part B Permit Application (DOE 1996a, Table C8-2). This list of VOCs incorporates sampling data from TRU waste containers at Idaho National Engineering and Environmental Laboratory (INEEL) and Rocky Flats Environmental Technology Site (RFETS), whereas only RFETS data was available for SEIS-I. Information on both the average and the maximum waste container inventories is available for a number of VOCs present in TRU waste.

Headspace concentrations of each VOC vary according to the waste matrix. No VOCs would be present in waste after treatment under Action Alternative 2 or No Action Alternative 1 because the thermal treatment destroys VOCs in the waste. Waste treated to meet WAC under the Proposed Action, Action Alternative 1, and the No Action Alternative 2 would contain a variety of waste matrices. A weighted average headspace concentration for waste at WIPP and each of the major waste consolidation sites was calculated for each alternative (see Appendix A). The matrix composition varies by consolidation site, so weighted average headspace concentrations for each consolidation site under Action Alternative 1 and No Action Alternative 2 were determined. The matrix composition under Action Alternative 3 would be a uniform solidified inorganic matrix, so the headspace concentrations of all Action Alternative 3 consolidation sites were assumed to be the

same. Headspace concentrations of waste disposed of at WIPP are shown in Table F-4. The average and weighted average concentrations were used for routine release evaluations except for impacts to WIPP involved workers in the WHB, where higher concentrations were used.

Container VOC release rates were based on the diffusion rate of the VOC through the composite filter (DOE 1996c). Release rates are VOC-specific and are proportional to the headspace concentration. Filter diffusion rates and VOC release rates for a single CH-TRU drum are shown in Table F-5. Impacts for routine releases were determined using this information. The calculation of VOC impacts from excess RH-TRU waste remaining at Hanford and ORNL under the Proposed Action used the same methodology. The CH-TRU waste drum release rate of three drums were assumed to be equivalent to the release from an RH-TRU canister.

Table F-4
TRU Waste VOC Headspace Concentrations Used in Health Impact Analyses for WIPP

VOC (milligrams per cubic meter per ppmv)	Planning-Basis WAC Headspace Limit (ppmv) [a]	Treated to Meet Planning-Basis WAC (ppmv)		Treated by Shred and Grout (ppmv)	
		Weighted Average	Maximum [b]	Weighted Average	Maximum [c]
Carbon tetrachloride (6.39)	7,510	184.5	---	316.5	---
Chloroform (4.96)	6,325	13.7	---	1.2	---
1,1-dichloroethylene (4.03)	500 [d]	8.4	---	2.5	---
1,2-dichloroethane (4.11)	9,100	5.6	---	1.1	---
Methylene chloride (3.53)	368,500	662.1	---	8.1	---
Chlorobenzene (4.68)	No Limit	8.4	956.4 4,368	1.3	260
Methyl ethyl ketone (3.0)	No Limit	40.4	2,946 39,311	6.8	130
1,1,2,2-tetrachloroethane (7.0)	No Limit	335.7	537.6 4,368	125.1	270
Toluene (3.83)	No Limit	5.7	764.8 6,992	1.3	320
Benzene (3.25)	500 [d]	7.6	---	22.4	---
Ethyl benzene (4.41)	500 [d]	8.5	---	31.6	---
Tetrachloroethene (6.89)	No Limit	7.1	229.7 2184	21.6	600
Xylene (4.41)	500 [d]	25.6	---	113.9	---

[a] DOE 1996b.
[b] Used for those VOCs without a maximum planning-basis WAC limit. Top values are weighted maximums determined by the maximum headspace concentration of each matrix and were used in routine WHB worker bounding scenarios. Bottom values are maximum concentrations found in any solidified organic sample and were used for the bounding accident scenarios.
[c] Maximum concentration found in any solidified inorganic matrix for those VOCs without a planning-basis WAC limit.
[d] Flammable VOC limit.

Table F-5
Average Single Drum Release Rate of Headspace VOCs (grams per second)

VOC	Filter Diffusion Rates (mol/s/molfrac) [a]	Action Alternative 3	Proposed Action, Action Alternative 1, and No Action Alternative 2						
		All sites	Hanford	INEEL	LANL	RFETS	ORNL	SRS	WIPP Under-ground
Carbon tetrachloride	1.21E-6	5.9E-8	1.1E-8	6.9E-8	5.1E-8	5.1E-8	1.7E-8	2.3E-8	3.4E-8
Chlorobenzene	1.16E-6	1.7E-10	1.3E-9	1.2E-9	8.1E-10	3.5E-10	1.2E-9	1.1E-9	1.1E-9
Chloroform	1.34E-6	1.8E-10	1.9E-9	2.8E-9	2.2E-9	1.4E-9	3.0E-9	2.6E-9	2.2E-9
Methyl ethyl ketone	1.30E-6	6.4E-10	3.8E-9	5.1E-9	2.0E-9	1.8E-9	5.8E-9	5.0E-9	3.8E-9
Methylene chloride	1.48E-6	1.0E-9	1.2E-7	6.0E-8	9.5E-8	1.2E-8	1.8E-8	2.0E-8	8.3E-8
1,1,2,2- tetrachloroethane	1.21E-6	2.5E-8	6.3E-8	9.2E-8	2.6E-8	2.9E-8	1.4E-7	1.3E-7	6.8E-8
Toluene	1.20E-6	1.4E-10	6.7E-10	7.8E-10	4.2E-10	2.5E-10	8.4E-10	7.4E-10	6.3E-10
1,1-dichloroethene	1.40E-6	3.3E-10	1.2E-9	1.4E-9	6.1E-10	4.4E-10	1.9E-9	1.7E-9	1.1E-9
1,2-dichloroethane	1.40E-6	1.5E-10	8.3E-10	9.6E-10	5.0E-10	3.0E-10	1.1E-9	9.2E-10	7.8E-10
Benzene	1.32E-6	2.3E-9	6.0E-10	8.7E-10	1.3E-9	8.5E-10	3.0E-10	6.2E-10	7.9E-10
Ethyl benzene	1.10E-6	3.7E-9	6.8E-10	1.1E-9	1.9E-9	1.1E-9	1.9E-10	7.3E-10	9.9E-10
Tetrachloroethene	1.13E-6	4.1E-9	1.0E-9	1.5E-9	2.3E-9	1.5E-9	3.9E-10	9.6E-10	1.3E-9
Xylene (mixed)	1.11E-6	1.3E-8	1.7E-9	3.6E-9	6.3E-9	3.7E-9	4.0E-10	2.4E-9	3.0E-9

[a] Filter diffusion rates for most constituents are from Table D9-3 (DOE 1996a). For methyl ethyl ketone, benzene, ethyl benzene, tetrachloroethene, and xylene, the values were calculated from Equation D9-1 and D9-2 (DOE 1996a) assuming the respective $P_{c,\ VOC}$: 41.52, 48.34, 35.53, 44.57, 36.81; respective $T_{c,\ VOC}$: 536.8, 562.2, 617.2, 620.2, 616.2; and respective molecular weights: 72.1, 78.1, 106.2, 165.8, 106.2.

Routine hazardous chemical impacts at WIPP would be dependent on the release of VOCs from TRU waste containers in the WHB and the underground area for the Proposed Action, Action Alternative 1, and Action Alternative 3. Containers in the WHB were assumed to have VOC headspace concentrations at the planning-basis WAC limit. For VOCs without planning-basis WAC concentration limits, the weighted maximum headspace concentration was used. These concentrations were determined by weighting the *maximum* matrix-specific headspace concentrations rather than the *average* matrix-specific headspace concentrations (see Appendix A).

The resulting impact estimates bound any impacts for workers in the WHB. Containers in the underground area were assumed to have the average weighted VOC headspace concentrations shown in Table F-4. No RH-TRU waste VOC headspace concentration data are available, so concentrations were assumed to be identical to those in CH-TRU waste.

A limited number of CH-TRU drums (42) and RH-TRU containers (3) can be present in the WHB at any one time. In contrast, the WIPP underground disposal area would have a much larger number of containers at any one time. A maximum of approximately 80,000 CH-TRU drum-equivalents and approximately 1,200 RH-TRU canisters could be placed in a panel. The number of CH-TRU and RH-TRU drum-equivalents are shown in Table F-6. Total VOC releases from the underground area were calculated using the average single drum release rates in Table F-5 and multiplying them by the number of VOC releasing drum-equivalents in Table F-6.

The number of drum-equivalents of CH-TRU waste in the underground area were calculated by dividing the total volume of waste to be emplaced by 0.208 cubic meters (7 cubic feet), which is the volume of a single drum. The number of drum-equivalents of RH-TRU waste in the underground area were calculated by dividing the total RH-TRU waste volume by the waste volume of an RH-TRU canister, 0.89 cubic meters (31 cubic feet) and then multiplying by three, the number of individual drums in an RH-TRU canister. Releases from RH-TRU canisters were modeled as from the three drums contained in a canister.

Table F-6
Number of Drum-Equivalents Assumed for the Evaluation of Routine VOC Releases

Site	Proposed Action		Action Alternative 1		Action Alternative 3		No Action Alternative 2	
	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
WIPP [a]	80,814	3,620	80,815	3,621	81,170	4,345	N/A	N/A
Hanford-East [b]	N/A	N/A	288,683	73,208	699,731	191,548	138,199	49,593
Hanford-West [b]	N/A	N/A	288,603	73,208	699,731	191,548	138,199	49,593
INEEL	N/A	N/A	417,280	11,538	503,101	0	135,314	744
LANL	N/A	N/A	169,320	1,668	201,524	0	101,109	770
RFETS	N/A	N/A	82,695	0	89,869	0	52,221	0
ORNL	N/A	N/A	10,143	26,852	0	32,220	8,027	1,036
SRS	N/A	N/A	81,433	0	112,929	0	58,003	0

[a] Drum-equivalents in a single panel.
[b] Hanford's waste volume was equally distributed between the Hanford-East and Hanford-West locations.

N/A = Not Applicable

A full panel of drum-equivalent containers was assumed to continuously emit VOCs, which would be released by the underground ventilation system throughout each year of operations. Approximately 80,000 drum-equivalents were assumed for the CH-TRU source term. More likely, assuming that approximately two years would be required to fill a typical panel, there would be an average of 20,000 CH-TRU drums emitting VOCs over the first year and an average of 60,000 drums emitting VOCs over the second year. Release from RH-TRU waste does not consider any reduction from the canister containment or from use of the RH-TRU shielding plug.

Conservative VOC release estimates were also made for the waste consolidation sites. The VOCs were assumed to be released at the same rate over a lifetime exposure period, which does not consider the off-site transport of the waste from any site to WIPP for disposal.

F.2.2 Atmospheric Transport

The GENII and MEPAS® codes were used to estimate the atmospheric dispersion and transport of radionuclides and hazardous chemicals, respectively. Atmospheric transport was modeled using site-specific meteorologic data. Routine release impact analyses used annual average meteorologic data for the MEI, the maximally exposed noninvolved worker, and the noninvolved worker population and sector-averaged air concentrations (i.e., averaged across sixteen 22.5-degree sectors) for the population within 80 kilometers (50 miles) of WIPP or the storage facility.

The meteorologic data used in MEPAS® and GENII are joint frequencies of wind speed, wind direction, and atmospheric stability class. Average, multi-year data are most appropriate to use when modeling future releases because the site-specific probability of occurrence of dispersion values for any particular location in the region is recognized. Meteorologic data sets used for the major consolidation sites were the same as those used in the WM PEIS (DOE 1997b). The meteorologic joint frequency data file used for WIPP is shown in Table F-7. Meteorologic data have been recorded at the WIPP site for several years, but the data recording system has captured the data only about half of the time. These data do not adequately characterize the site-specific conditions; therefore, more complete data from the airport in Carlsbad, New Mexico, were used (NOAA 1995).

Table F-7
Meteorologic Joint Frequency Data Used for WIPP Atmospheric Releases (Percent of Time)

Average Wind Speed (m/s)	Atmospheric Stability Class	Direction (Wind Toward)															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
1.49	A	0.03	0.03	0.03	0.04	0.04	0.03	0.05	0.03	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01
	B	0.12	0.09	0.09	0.12	0.15	0.10	0.13	0.16	0.14	0.04	0.02	0.03	0.05	0.03	0.03	0.05
	C	0.07	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05	0.02	0.02	0.02	0.04	0.05	0.05	0.03
	D	0.07	0.04	0.04	0.05	0.08	0.05	0.06	0.08	0.07	0.02	0.04	0.03	0.03	0.04	0.04	0.04
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0.35	0.20	0.14	0.14	0.23	0.17	0.28	0.49	0.53	0.32	0.23	0.33	0.47	0.44	0.33	0.24
2.63	A	0.07	0.07	0.07	0.06	0.12	0.09	0.09	0.10	0.07	0.03	0.03	0.02	0.02	0.02	0.02	0.03
	B	0.25	0.25	0.24	0.30	0.44	0.37	0.55	0.57	0.40	0.06	0.08	0.07	0.06	0.04	0.08	0.13
	C	0.34	0.28	0.26	0.27	0.33	0.30	0.41	0.45	0.40	0.09	0.06	0.06	0.12	0.09	0.11	0.18
	D	0.55	0.33	0.31	0.27	0.42	0.36	0.51	0.54	0.55	0.17	0.13	0.15	0.22	0.25	0.26	0.31
	E	0.39	0.19	0.17	0.17	0.28	0.38	0.55	0.76	0.93	0.40	0.35	0.42	0.55	0.47	0.39	0.25
	F	0.94	0.46	0.26	0.23	0.46	0.50	0.79	1.56	2.03	0.97	0.69	1.01	1.51	1.39	0.95	0.69
4.27	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0.20	0.11	0.11	0.10	0.19	0.25	0.39	0.41	0.35	0.06	0.02	0.03	0.05	0.02	0.03	0.08
	C	0.72	0.31	0.17	0.17	0.42	0.49	1.08	1.25	0.98	0.12	0.11	0.14	0.20	0.11	0.17	0.31
	D	1.17	0.42	0.39	0.39	0.57	0.74	1.46	1.88	1.68	0.43	0.39	0.53	0.64	0.41	0.48	0.79
	E	0.55	0.16	0.12	0.15	0.21	0.33	0.87	1.37	2.22	0.98	0.63	1.07	1.52	1.14	0.56	0.42
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.64	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.15	0.05	0.02	0.02	0.09	0.17	0.40	0.31	0.29	0.04	0.04	0.10	0.20	0.05	0.05	0.10
	D	1.48	0.43	0.30	0.26	0.48	0.64	1.98	1.76	1.30	0.39	0.40	1.32	2.32	0.77	0.61	1.29
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.53	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.02	0	0	0	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.04	0.15	0.01	0	0.02
	D	0.29	0.07	0.02	0.02	0.04	0.07	0.23	0.11	0.09	0.10	0.12	0.51	1.29	0.23	0.14	0.35
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.88	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.01	0	0
	D	0.07	0.01	0.01	0	0	0.01	0.03	0.02	0.02	0.02	0.02	0.21	0.67	0.08	0.03	0.05
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: NOAA 1995. Carlsbad, New Mexico, airport meteorological data (1990-1994)

Meteorologic data were used with effluent release information to determine the dispersion characteristics of WIPP releases. Releases from WIPP to the environment could occur from the stacks at either the WHB or the Exhaust Filter Building, the latter handling the underground ventilation. For each stack release, a stack height and diameter, release velocity, and effluent temperature (Table F-8) was characterized in MEPAS® and GENII. The dispersion estimates used for individual and population impacts were slightly more conservative (i.e., less dispersion of the release) using the Exhaust Filter Building release parameters. Therefore, the Exhaust Filter Building release parameters were used to conservatively model both the WHB and the underground releases at WIPP. Effluent stack releases were assumed to have a 10-meter (33-foot) effective release height at all treatment/consolidation sites.

Routine releases of hazardous chemicals would occur at the consolidation sites during the lag storage period. Therefore, impacts were estimated for the major consolidation sites under all action alternatives. The locations of the MEI and noninvolved worker were determined based on dispersion estimates. Lag storage facilities under the action alternatives were assumed to be at the same locations as the No Action Alternative 2 storage facilities. The locations of the MEI and the maximally exposed noninvolved worker at the major consolidation sites are shown in Table F-9.

Table F-8
WIPP Stack Release Parameters

Parameter [a]	Waste Handling Building	Exhaust Filter Building
Stack height (meters)	14.9	8.2
Stack diameter (meters)	2.4	4.4
Release velocity (cubic meters per second)	170	200
Effluent temperature (degrees Fahrenheit) (DOE 1995b)	61	61
Number of stacks	1	2

[a] DOE 1990, unless otherwise indicated.

Table F-9
MEI and Noninvolved Worker Locations for Lag Storage Operations

Site	Noninvolved Worker Location	MEI Location
Hanford 200-East	100 meters south	16,000 meters east
Hanford 200-West	100 meters south	24,000 meters east
INEEL	100 meters south	12,000 meters south-southeast
LANL	100 meters west	2,400 meters east-southeast
RFETS	300 meters north	5,000 meters north
ORNL	100 meters southwest	4,000 meters southwest
SRS	100 meters west-southwest	12,000 meters west-southwest

F.2.3 Exposure Scenarios

Exposure scenarios define a set of conditions and assumptions under which populations and/or individuals may be impacted by radioactive material or hazardous chemicals. Exposures scenarios that may result from the routine release of radionuclides and VOCs at the storage sites and at WIPP are described below.

Human health impacts from routine, chronic exposures to VOCs and gaseous radionuclides were evaluated for the public, noninvolved workers, and involved workers. Inhalation would be the primary exposure pathway for such releases; however, impacts to involved workers from external radiation during waste handling were also evaluated. Thermal treatment of waste to meet LDRs under Action Alternative 2 and No Action Alternative 1 would destroy the VOCs in the waste, so releases of hazardous chemicals would not occur during routine operations for these alternatives. It was assumed that members of the public were exposed continuously (8,766 hours per year) while noninvolved workers were exposed for 2,000 hours per year.

Human health impacts were evaluated over a lifetime of exposure for members of the public, workers, and the MEI. The MEI was assumed to be exposed at the same location for the full 35-year operational period of the Proposed Action and No Action Alternative 2 and for a 70-year lifetime for Action Alternatives 1, 2, and 3. The average exposure period for the population was assumed to be 35 years for all alternatives to account for population turnover. Maximum working lifetimes for involved and noninvolved workers were assumed to be 35 years for all alternatives.

F.2.3.1 Storage Site Exposure Scenarios

Storage site impact estimates were based on impacts at the six major storage sites: Hanford, INEEL, Los Alamos National Laboratory (LANL), ORNL, RFETS, and Savannah River Site (SRS), where at least 98 percent of the waste would be stored under all alternatives. To estimate human health impacts to the population, MEI, noninvolved worker population, and the maximally exposed noninvolved worker from gaseous radionuclide and VOC emissions from storage facilities at consolidation sites, it was conservatively assumed that all drum-equivalents of treated waste were in storage beginning the first year of operations. It was assumed that the total number of drum-equivalents would emit VOCs over the lifetime of the exposed receptors. The population data for the consolidation sites were the same as those used for the WM PEIS (DOE 1997b), which used data from the 1990 U.S. Census to estimate the population in 80-kilometer (50-mile) areas around the major storage sites. It was assumed that the populations surrounding all sites would remain at the 1990 levels. The noninvolved worker population numbers for the storage sites were the same as those presented in the WM PEIS (DOE 1997b).

Radiological impacts to the involved worker would primarily result from external radiation; exposure to gaseous radionuclides would be a negligible contributor. Specific information on estimating involved worker external dose impacts is presented in Section F.2.3.3 below.

An estimate of the impacts to the involved worker from VOC exposure during routine operations was made by assuming that each VOC would be present at its highest allowable concentration. This concentration was based on the EPA limits of 1×10^{-6} annual probability of cancer incidence for a Class B hazardous chemicals and 1×10^{-5} annual probability of cancer incidence for a Class C hazardous chemicals. Workers at each site were assumed to be exposed for a 35-year occupational lifetime.

F.2.3.2 WIPP Disposal Exposure Scenarios

Impacts to the public and noninvolved workers were evaluated for routine releases of gaseous radionuclides and VOCs from TRU waste at WIPP. For the exposure scenarios, it was assumed that all waste was contained in drums, using “drum-equivalents” to recognize that some waste may be in standard waste boxes (SWB). The releases from the underground area were estimated on a panel basis. Only one panel would be fully ventilated and unsealed at a time. It was assumed to require 2.5 years to fill a single panel with a total of approximately 81,000 drum-equivalents of CH-TRU waste and approximately 4,000 drum-equivalents of RH-TRU waste (DOE 1997a). Impacts were conservatively estimated by assuming that a full panel would continuously emit gaseous radionuclides and VOCs each year of operations. This assumption approximately doubles the actual emission estimate of VOCs from CH-TRU waste drums. A maximum number of drums (42 CH-TRU and 3 RH-TRU drum-equivalents) were assumed to be in the WHB at all times. As noted above, there would be no release of VOCs under Action Alternative 2 or No Action Alternative 1.

1990 U.S. Census data were used to determine the population inhabiting the 80-kilometer (50-mile) region surrounding WIPP. Approximately one-third of this population is located at Carlsbad, 42 kilometers (26 miles) west of WIPP, and one-third of the population is located at Hobbs, 72 kilometers (45 miles) east-northeast of WIPP (Table F-10). Population distributions would change unpredictably over the operations time frames evaluated in SEIS-II. For the purposes of impact analyses, it was assumed that the population surrounding WIPP would remain at 1990 levels.

Table F-10
1990 Population Distribution Within 80 Kilometers (50 Miles) of WIPP

	Distance (miles)										
Direction	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**	**Total**
S	0	0	0	0	0	0	3	2	46	20	**71**
SSW	9	0	0	0	0	0	0	2	43	8	**62**
SW	0	0	0	0	0	0	37	57	0	5	**99**
WSW	0	0	0	0	0	0	1,622	191	57	62	**1,932**
W	0	0	0	0	0	0	138	25,291	197	3	**25,629**
WNW	0	0	0	0	0	0	38	5,765	242	63	**6,108**
NW	0	0	0	0	0	0	6	7	14	12,401	**12,428**
NNW	0	0	0	0	0	9	4	66	104	56	**239**
N	0	0	0	0	0	0	3	0	63	12	**78**
NNE	0	0	0	0	0	0	4	3	122	7,353	**7,482**
NE	0	0	0	0	0	0	0	11	37	9,115	**9,163**
ENE	0	0	0	0	0	0	0	10	282	30,877	**31,169**
E	0	0	0	0	0	0	6	5	2,982	19	**3,012**
ESE	0	0	0	0	0	0	0	16	2,173	97	**2,286**
SE	0	0	0	0	0	0	0	0	15	20	**35**
SSE	0	0	0	0	0	1	3	14	5	73	**96**
Total	**9**	**0**	**0**	**0**	**0**	**10**	**1,864**	**31,440**	**6,382**	**60,184**	**99,889**

Source: DOE 1995b

The location of the MEI was set at the point on the WIPP site boundary where an individual could establish a residence, with the least amount of atmospheric dispersion. This location was determined to be 3,000 meters (9,840 feet) north of the Exhaust Filter Building.

Similarly, the location of the maximally exposed noninvolved worker at WIPP was determined by identifying the on-site location (i.e., within the Exclusive Use Area) with the minimum amount of atmospheric dispersion. This location was 200 meters (660 feet) east of the Exhaust Filter Building, outside of the property protection zone and north of the railroad spur. It is unlikely that an individual would be located at this site, but the impacts here would bound any on-site noninvolved worker impacts. For impacts to the noninvolved worker population at WIPP, it was conservatively assumed that all 1,095 WIPP workers would be exposed at the same level as the maximally exposed noninvolved worker.

Involved workers at WIPP were evaluated according to two different waste-handling groups, those in the WHB and those in the underground area. This approach was necessary to estimate VOC impacts because of the considerable differences in the number of containers emitting VOCs to the ventilation air.

CH-TRU waste is handled in the WHB in a large, open area. The WHB exhaust operates at 43 cubic meters (1,505 cubic feet) per second (DOE 1990). WHB air exchange rates range from 1.5 to 12 per hour. Assuming that an air exchange rate of 12 per hour applies to the 43-cubic-meters (1,505-cubic-feet)-per-second flow rate, an air exchange rate of 1.5 would correlate to a flow rate of 5.4 cubic meters (190 cubic feet) per hour. The minimum flow rate, 5.4 cubic meters (190 cubic feet) per second, was conservatively used to estimate impacts to the WHB worker. The underground flow rate was assumed to be 100 cubic meters (3,500 cubic feet) per second, which is the flow rate of only one of the two exhaust fans that drive the underground ventilation. The external radiation dose received by involved workers is considerably greater than the internal radiation dose from gaseous releases of radionuclides. Therefore, only the external doses were calculated.

F.2.3.3 External Radiation Dose of Involved Workers

The primary source of radiological impacts to involved workers at storage sites and at WIPP would be from external radiation exposures. During routine operations, only involved workers would be exposed to external radiation emitted from the waste. The results presented in the *Waste Isolation Pilot Plant Safety Analysis Report* (DOE 1995b) indicate that the expected annual external dose to RH-TRU waste workers would be approximately 20 percent of that to CH-TRU waste workers during the time when both CH-TRU and RH-TRU waste is being disposed of. Based on this analysis, only the dose to CH-TRU workers was evaluated in detail. To determine the comparative radiological impact to workers for each alternative, screening calculations were performed to determine which radionuclides would be the primary contributors to external radiation dose. Alternative-specific variables included the volume of the Basic Inventory and Additional Inventory considered for storage or disposal and the waste density. WIPP worker radiological impact calculations were performed by using the radionuclide inventories of Appendix A. Dose rate reduction over time due to radioactive decay was not considered in screening.

To identify the primary radionuclides contributing to external dose, the radionuclide-specific air immersion dose-rate factor (DOE 1988a) was multiplied by the radionuclide inventory for each site to determine an *external dose screening value*. These values do not have meaning as an expression of absolute impact, but do indicate the comparative impact from external dose for each radionuclide in the TRU waste. For example, if radionuclide A has a higher screening value than radionuclide B, an individual would receive a greater external dose from radionuclide A, all exposure conditions being equal.

External dose screening values were calculated for the entire CH-TRU waste radionuclide inventory to be sent to WIPP and for each consolidation site. The radionuclides that contributed at least 90 percent of the site's total screening value for the Proposed Action and each alternative are tabulated in Tables F-11 through F-15. The percentage of the site's total screening values contributed by the listed radionuclides, the Department of Energy (DOE or the Department) (1988a) radionuclide-specific external dose factor, and the total screening value of all the radionuclides in each site's consolidated waste are shown in the tables.

Eight radionuclides were found to contribute the majority of the worker external dose for the sites evaluated. Americium-241 and barium-137m (the short-lived progeny of cesium-137) were found to be the largest individual contributors. Under most of the alternatives, waste consolidated at INEEL and RFETS contains the majority of the americium-241, and waste consolidated at Hanford contains the majority of the barium-137m.

Table F-11
Proposed Action External Dose Screening Values for CH-TRU Waste [a, b]

Radionuclide	Ext DF [c]	Hanford	INEEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	9.7E+5	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	1.1E+7	---	3.2E+5	---	---	---	---	---	---	3.4E+4	1.2E+7
Europium-152	5.9E+3	---	---	---	---	---	7.5E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	3.4E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.4E+3	8.0E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.9E+4	1.7E+3	---	---	---
Plutonium-238	0.44	---	---	---	---	280	1.7E+4	---	---	---	3.8E+5	---
Americium-241	95	2.5E+6	1.0E+7	2.5E+6	8.4E+4	---	3.3E+4	2.6E+5	1.2E+4	2.2E+7	3.0E+5	3.8E+7
Total		1.4E+7	1.2E+7	3.0E+6	8.5E+4	290	6.8E+4	4.0E+5	1.4E+4	2.2E+7	7.6E+5	5.2E+7
Percent Total Site Value		98	94	93	98	99	93	90	94	99	92	95

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-12
Action Alternative 1 External Dose Screening Values for CH-TRU Waste [a, b]

Radionuclide	Ext DF [c]	Hanford	INEEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	2.5E+6	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	1.9E+7	---	4.4E+5	---	---	---	1.7E+4	---	---	4.0E+4	2.0E+7
Europium-152	5.9E+3	---	---	---	---	---	6.4E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	2.8E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.1E+3	7.0E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.7E+4	870	---	---	---
Plutonium-238	0.44	---	---	---	---	240	1.4E+4	---	---	---	4.5E+5	---
Americium-241	95	4.4E+6	2.6E+7	3.5E+6	7.1E+4	---	2.8E+4	2.6E+5	6.3E+3	2.0E+7	3.5E+5	5.5E+7
Total		2.4E+7	3.0E+7	4.3E+6	7.2E+4	240	5.7E+4	4.0E+5	1.2E+4	2.0E+7	9.1E+5	8.0E+7
Percent Total Site Value		98	95	93	98	99	93	91	94	99	92	94

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Scoping values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-13
Action Alternative 2A, Action Alternative 3, and No Action Alternative 1A External Dose Screening Values for CH-TRU Waste [a, b, c]

Radionuclide	Ext DF [d]	Hanford	INEEL	LANL	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	2.5E+6	---	---	---	---
Barium-137m	3.1E+3	1.9E+7	---	4.4E+5	---	5.7E+4	2.0E+7
Bismuth-214	8.1E+3	---	---	---	---	7.0E+4	---
Plutonium-238	0.44	---	---	---	---	4.5E+5	---
Americium-241	95	4.5E+6	2.6E+7	3.5E+6	2.0E+7	6.2E+5	5.5E+7
Total		2.4E+7	3.0E+7	4.3E+6	2.0E+7	1.3E+6	8.0E+7
Percent Total Site Value		98	95	93	99	91	94

[a] Dashed lines indicate a negligible contributor to the external dose from a sites average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] Action Alternative 2C screening values are equivalent to the "All Sites" values.
[d] External dose conversion factor.

Table F-14
Action Alternative 2B and No Action Alternative 1B External Dose Screening Values for CH-TRU Waste [a, b]

Radionuclide	Ext DF [c]	Hanford	INEEL	SRS	All Sites
Bismuth-214	8.1E+3	---	---	7.0E+4	---
Barium-137m	3.1E+3	1.9E+7	---	5.7E+4	2.0E+7
Americium-241	95	4.5E+6	5.0E+7	6.2E+5	5.5E+7
Plutonium-238	0.44	---	---	4.5E+5	---
Total		2.4E+7	5.5E+7	1.3E+6	8.0E+7
Percent Total Site Value		98	91	91	94

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-15
No Action Alternative 2 External Dose Screening Values for CH-TRU Waste [a, b]

Radionuclide	Ext DF [c]	Hanford	INEEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	8.2E+5	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	9.3E+6	---	2.7E+5	---	---	---	1.0E+4	---	---	4.3E+4	9.8E+6
Europium-152	5.9E+3	---	---	---	---	---	6.4E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	2.8E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.1E+3	6.8E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.6E+4	1.4E+3	---	---	---
Plutonium-238	0.44	---	---	---	---	---	1.4E+4	---	---	---	4.9E+5	---
Americium-241	95	2.1E+6	8.7E+6	2.1E+6	7.1E+4	240	2.8E+4	2.2E+5	9.8E+3	2.0E+7	3.8E+5	3.4E+7
Total		1.2E+7	1.0E+7	2.6E+6	7.2E+4	240	5.7E+4	3.5E+5	1.2E+4	2.0E+7	9.8E+5	4.6E+7
Percent Total Site Value		98	94	93	98	99	93	92	94	99	92	95

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

External dose estimates were made for involved workers using the radionuclides indicated by the screening calculations. Although americium-241 and barium-137m would be responsible for the majority of the potential external dose, cobalt-60 would be an important potential contributor for INEEL-consolidated waste; bismuth-214 and neptunium-239 would be important for ORNL-consolidated waste; and plutonium-238 and bismuth-214 would be notable for SRS-consolidated waste. Therefore, external dose impacts were calculated by including americium-241, barium-137m, cobalt-60, bismuth-214, neptunium-239, and plutonium-238.

Involved workers may receive radiation doses either during WIPP disposal operations or during storage operations at consolidation sites. During the years of maximum impact (for the action alternatives), when both CH-TRU and RH-TRU waste would be disposed of, a greater impact would be expected for CH-TRU waste handling than for RH-TRU waste handling because RH-TRU waste would be managed remotely, and the exposure conditions would be limited by distance, shielding, and additional administrative controls contained in the *WIPP Radiological Control Manual* (DOE 1995a). Although the RH-TRU waste container external dose rates would be higher than those for CH-TRU waste, worker exposures from the routine disposal of RH-TRU

waste would be expected to be less because of remote handling operations and the smaller volume of waste. Even so, there are no differences in the maximum annual dose limit for CH-TRU and RH-TRU workers.

The external radiation dose received from handling CH-TRU waste containers would be a function of the radionuclides present, the quantity of each radionuclide, and the waste density. The quantity of radionuclides in a container may be reduced as a result of packaging in order to meet WAC or TRUPACT-II acceptance criteria prior to being sent to WIPP. The packaging of individual waste containers would be done to meet dose-rate, weight, thermal power, or PE-Ci limitations (see Table F-16). These limits result from the design criteria for WIPP operations and TRUPACT-II acceptance (DOE 1996b). Thermal power and weight limits were taken into account when estimates of shipment volumes and emplacement volumes were determined.

Table F-16
Specific Planning-Basis WAC Requirements Limiting Waste Container Radionuclide Contents

Administrative Control	Limit	Comment
Container external dose rate	CH-TRU waste surface: 200 mrem/hour RH-TRU waste surface: no more than 5 percent of the RH-TRU waste canisters are allowed dose rates of greater than 100 rem/hour	Dose rate 2 meters from the TRUPACT-II must be less than 10 mrem/hour
Container PE-Ci content	80 PE-Ci for CH-TRU waste drum 130 PE-Ci for CH-TRU waste Standard Waste Box 1,800 PE-Ci for solidified or vitrified waste or overpacked drum 1,000 PE-Ci for RH-TRU waste canister	TRUPACT-II transport container limits restrict the fissile gram equivalents (FGEs) to 325 FGEs per TRUPACT-II, with a maximum of 200 FGEs/drum. These restrictions further limit the PE-Ci content of the container.
Container thermal power limit	Thermal power limit for the contents of a TRUPACT-II is 40 watts.	- - -

The external radiation dose to a worker can also be reduced through radiation protection practices such as radiation shielding within the drum or placing the highest external-dose-rate container in a seven-drum bundle in the interior bundle location. Waste manifests require record of the maximum package dose rate, so external doses can be knowledgeably limited by administrative controls. When practiced, these procedures would lead to small annual reductions in external exposures that could accumulate to substantial reductions over time. For the purposes of SEIS-II impact analyses, however, these practices were not considered when estimating worker doses.

The WIPP annual occupational dose limit is currently 1.0 rem per year TEDE (DOE 1995a). Doses to extremities (i.e., hands) are limited to 50 rem per year. In addition, the *WIPP Radiological Control Manual* (DOE 1995a) contains the WIPP as low as reasonably achievable (ALARA) radiation protection policy, which is an administrative check of worker exposures.

Surface and 1-meter (3.3-foot) dose rates for average CH-TRU waste drums are presented in Table F-17 for the major storage sites and for WIPP. The 1995 activity of the waste was used for dose rate estimates, and drum surface dose rates were calculated according to the following equation:

Table F-17
Average Surface and 1-Meter (3.3-Foot) Dose Rates of CH-TRU Waste Drums (1995 activities)

Alternative	Waste Treatment	Site	Waste Package Density (grams/cubic meter)	Average Surface Dose Rate (mrem/hour)	Average 1-meter Dose Rate (mrem/hour)
Proposed Action	WAC	WIPP	0.582	40	2.9
Action Alternative 1	WAC	Lag-Hanford	0.592	34	2
		Lag-INEEL	0.598	31	3
		Lag-LANL	0.720	9	0.7
		Lag-RFETS	0.153	153	13
		Lag-ORNL	0.259	33	3
		Lag-SRS	0.476	4	0.3
		WIPP	0.582	32	2.3
Action Alternative 2A & No Action Alternative 1A	LDR	Lag-Hanford	1.966	42	2
		Lag-INEEL	1.966	13	1
		Lag-LANL	1.966	6	0.5
		Lag-RFETS	1.966	57	5
		Lag-SRS	1.966	3	0.3
		WIPP	1.966	25	1.6
Action Alternative 2B & No Action Alternative 1B	LDR	Lag-Hanford	1.966	42	2
		Lag-INEEL	1.966	15	1
		Lag-SRS	1.966	3	0.3
		WIPP	1.966	25	1.6
Action Alternative 2C	LDR	WIPP	1.966	25	1.6
Action Alternative 3	Shred and grout	Lag-Hanford	1.375	17	0.9
		Lag-INEEL	1.281	8	0.6
		Lag-LANL	1.224	3	0.2
		Lag-RFETS	0.631	36	3
		Lag-SRS	1.058	2	0.1
		WIPP	1.256	12	0.7
No Action Alternative 2	WAC	Hanford	0.592	34	2
		INEEL	0.621	30	3
		LANL	0.730	9	0.8
		RFETS	0.369	200 [a]	21
		ORNL	0.259	33	2
		SRS	0.476	6	0.4

[a] Calculated surface dose rate was 242 mrem per hour for RFETS. Individual waste containers exceeding limits would be repackaged or internally shielded to meet the planning-basis WAC limit of 200 mrem per hour surface dose rate for CH-TRU waste. This packaging would subsequently reduce the 1-meter (3.3-foot) dose rate.

$$S_{icd} = D_{id} \times C_{ic} \qquad \text{(Equation F-1)}$$

where

S_{icd} = surface dose rate from a drum with radionuclide "i" for waste at consolidation site "c" with a waste density "d" in units of rem per hour

D_{id} = surface dose rate of a drum with 1 Ci of radionuclide "i" and a waste density "d" in units of rem per hour per Ci per drum (see Table F-18)

C_{ic} = activity of radionuclide "i" in Ci for an average drum at consolidation site "c" (see Table F-19)

The total surface dose rate of consolidation site waste was calculated by summing the S_{icd} values for the radionuclides of concern. The 1-meter (3.3-foot) dose rates were calculated in a similar manner, using the 1-meter (3.3-foot) dose rate value (see Table F-18) for the D_{id} variable.

Table F-18
Radionuclide-Specific Dose Rates for Various Waste Densities (rem/h per Ci/drum-equivalent)

Density [a]	Am-241		Ba-137m		Co-60		Pu-238		Bi-214		Np-239	
(g/cm^3)	surface	1-meter	surface	1-meter	surface	1-meter	surface	1-meter	surface	1-meter	surface	1-meter
0.260-W	7.90E-2	6.56E-3	3.994	2.03E-1	12.48	6.33E-1	1.35E-4	8.5E-6	7.832	0.4	1.17	6.22E-2
0.370-W	5.97E-2	5.09E-3	3.566	1.85E-11	11.35	5.85E-1	1.1E-4	7.0E-6	N/A	N/A	N/A	N/A
0.480-W	4.75E-2	4.12E-3	3.154	1.66E-1	10.25	5.35E-1	9.08E-5	5.86E-6	N/A	N/A	N/A	N/A
0.580-W	3.98E-2	3.5E-3	2.822	1.5E-1	9.337	4.92E-1	7.79E-5	5.06E-6	N/A	N/A	N/A	N/A
0.595-W	3.89E-2	3.42E-3	2.776	1.48E-1	9.208	4.86E-1	7.62E-5	4.96E-6	N/A	N/A	N/A	N/A
0.625-W	3.71E-2	3.27E-3	2.687	1.44E-1	8.956	4.74E-1	7.31E-5	4.76E-6	N/A	N/A	N/A	N/A
0.625-G	1.53E-2	1.39E-3	2.992	1.57E-1	10.61	5.50E-1	6.58E-5	3.90E-6				
0.725-W	3.21E-2	2.86E-3	2.42	1.31E-1	8.179	4.36E-1	6.41E-5	4.20E-6	N/A	N/A	N/A	N/A
1.060-G	9.11E-3	8.36E-4	2.193	1.19E-1	8.211	4.37E-1	4.26E-5	2.59E-6	3.891	0.211	N/A	N/A
1.250-G	7.73E-3	7.11E-4	1.938	1.06E-1	7.38	3.96E-1	3.667E-5	2.24E-6	N/A	N/A	N/A	N/A
1.370-G	7.05E-3	6.49E-4	1.801	9.86E-2	6.918	3.72E-1	3.36E-5	2.06E-6	N/A	N/A	N/A	N/A
1.966-L	4.9E-3	4.5E-4	1.32	7.31E-2	5.195	2.84E-1	2.38E-5	1.47E-6	2.260	0.125	N/A	N/A

[a] W = WAC waste, G = grouted waste, L = waste treated to meet LDRs.

N/A = Not Applicable

Table F-19
Average Density and Activity of Site-Specific CH-TRU Wastes

Waste form / site	Density	Radionuclide concentration (average Ci/drum-equivalent)											
		Am-241		Ba137m		Co-60		Pu-238		Bi-214		Np-239	
WAC	(g/cm^3)	AA1	NA2	AA1	NA2	AA1	NA2	AA1	NA2	AA1	NA2	AA1	NA2
Hanford	0.592	8.02E-2	8.00E-2	1.09E-2	1.09E-2	0	0	1.36E+0	1.36E+0	N/A	N/A	N/A	N/A
INEEL	0.598	6.54E-1	6.66E-1	5.13E-4	4.22E-4	4.53E-4	4.61E-4	4.60E-1	4.42E-1	N/A	N/A	N/A	N/A
LANL	0.720	2.18E-1	2.20E-1	8.50E-4	8.56E-4	9.51E-8	1.49E-10	2.14E+0	2.16E+0	N/A	N/A	N/A	N/A
RFETS	0.369	2.56E+0	4.07E+0	0	0	0	0	1.38E-1	2.18E-1	N/A	N/A	N/A	N/A
ORNL	0.259	2.73E-1	2.54E-1	5.46E-4	1.98E-4	3.15E-5	2.89E-10	9.75E-1	5.50E-1	9.57E-4	1.02E-3	2.20E-3	2.34E-3
SRS	0.476	4.92E-2	6.91E-2	1.74E-4	2.45E-4	8.73E-6	1.23E-5	1.35E+1	1.90E+1	N/A	N/A	N/A	N/A
WIPP	0.582	4.27E-1	N/A	4.93E-3	N/A	1.41E-4	N/A	1.79E+0	N/A	N/A	N/A	N/A	N/A
LDR		**AA2A**	**AA2B**	**AA2A**	**AA2B**	**AA2A**	**AA2B**	**AA2A**	**AA2B**	**AA2A**	**AA2B**	**AA2A**	**AA2B**
Hanford	1.966	2.30E-1	2.30E-1	3.10E-2	3.10E-2	0	0	3.86E+0	3.86E+0	N/A	N/A	N/A	N/A
INEEL	1.966	1.38E+0	1.90E+0	1.08E-3	1.31E-3	9.56E-4	6.89E-4	1.13E+0	2.17E+0	N/A	N/A	N/A	N/A
LANL	1.966	6.28E-1	N/A	2.45E-3	N/A	2.74E-7	N/A	6.16E+0	N/A	N/A	2.60E-4	N/A	N/A
RFETS	1.966	1.16E+1	N/A	0	N/A	0	N/A	6.24E-1	N/A	N/A	2.60E-4	N/A	N/A
SRS	1.966	2.41E-1	2.41E-1	7.26E-4	7.26E-4	3.80E-5	3.80E-5	4.28E+1	4.28E+1	N/A	N/A	N/A	N/A
WIPP	1.966	1.13E+0	1.13E+0	1.30E-2	1.30E-2	3.72E-4	3.72E-4	4.71E+0	4.71E+0	N/A	N/A	N/A	N/A
Grout		**AA3**		**AA3**		**AA3**		**AA3**		**AA3**		**AA3**	
Hanford	1.375	6.72E-2		9.03E-3		0		1.13E+0		N/A		N/A	
INEEL	1.281	5.43E-1		4.25E-4		3.76E-4		4.45E-1		N/A		N/A	
LANL	1.224	1.83E-1		7.15E-4		7.99E-8		1.80E+0		N/A		N/A	
RFETS	0.631	2.36E+0		0		0		1.27E-1		N/A		N/A	
SRS	1.058	7.02E-2		2.12E-4		1.11E-5		1.25E+1		7.58E-5		N/A	
WIPP	1.256	3.58E-1		4.15E-3		1.18E-4		1.50E+0		N/A		N/A	

N/A = Not Applicable

WIPP Involved Workers

Individual exposures to WIPP involved workers were calculated for each alternative based on an annual 400-hour exposure time at 1 meter (3.3 feet) from the CH-TRU waste. A total of 36 involved workers would be involved in waste handling operations annually. Aggregate worker population doses were calculated to account for the total CH-TRU operations period required to dispose of all CH-TRU waste under each alternative.

Annual Exposures

Each involved worker could be exposed to waste for a maximum of 400 hours annually (2 hours per day, 4 days per week, 50 weeks per year), unless this exposure time would result in an annual dose of more than the occupational dose limit of 1 rem per year. The annual doses to involved workers based on a 400-hour annual exposure time are indicated in Table F-20 for each action alternative. Annual doses are decay-corrected each year. The values are conservative because the calculated CH-TRU dose rates were not decay-corrected when the 1995 radionuclide inventories were used to determine the indicated doses for 1998.

Annual doses for WIPP involved workers exposed for 400 hours were calculated using Equation F-2.

$$D_A = (\Sigma\, d_{A,r}) \times 400/1{,}000 \qquad \text{(Equation F-2)}$$

where

D_A = worker annual occupational external dose from CH-TRU operations for alternative “A”, in rem

$d_{A,r}$ = decay-corrected average 1-meter (3.3-foot) dose rate from CH-TRU waste for radionuclide “r” under alternative “A”, in millirem per hour summed over all radionuclides

400 = exposure time at 1 meter (3.3 feet) from the CH-TRU waste drums, in hours per year

1,000 = millirem per rem

The individual worker doses under the Proposed Action in Table F-20 are the calculated doses based on a 400-hour annual exposure time. For the first 20 years of disposal operations, the doses are expected to be greater than 1 rem per year, which is above the administrative limit and would not be permitted. All Proposed Action workers would not be permitted to work the maximum exposure time of 400 hours annually; they would be permitted to work until exposures were the maximum 1 rem per year. WIPP involved worker exposure times under the Proposed Action would start out at 340 hours annually for the first year of disposal operations, then would increase over the first 20 years of disposal operations as radiological decay reduced the average 1-meter (3.3-foot) dose rate. In other words, individuals would work 356 hours per year through the fifth year of disposal operations, 368 hours per year through the tenth year, 384 hours per year through the fifteenth year, and 396 hours per year through the twentieth year of disposal operations. Given the expectation that 2.5 years would be required to fill a single panel with CH-TRU waste at a disposal efficiency of 75 percent (DOE 1997a) and that 10 panels and 35 years of disposal

Table F-20
WIPP Involved Worker Annual Doses (rem/y per worker)

Calendar Year	Years of Disposal Operations	WIPP Worker Annual Dose (rem/year per worker)				Aggregate h/y per worker [b]	Aggregate WIPP Involved Worker Population Dose (person-rem/y)				
		Proposed Action [a]	Action Alternative 1	Action Alternative 2	Action Alternative 3		Proposed Action [c]	Action Alternative 1	Action Alternative 2	Action Alternative 3	Dose Limit (1rem/y per worker)
1998	1	**1.17**	0.92	0.63	0.30	400	**36**	33	23	11	36
1999	2	**1.16**	0.91	0.61	0.29	800	**72**	66	45	21	72
2000	3	**1.15**	0.90	0.60	0.29	1200	**108**	99	66	31	108
2001	4	**1.14**	0.89	0.59	0.28	1600	**144**	131	87	42	144
2002	5	**1.13**	0.88	0.58	0.27	2000	**180**	163	108	51	180
2003	6	**1.12**	0.87	0.56	0.27	2400	**216**	194	129	61	216
2004	7	**1.11**	0.87	0.55	0.26	2800	**252**	225	149	71	252
2005	8	**1.10**	0.86	0.54	0.26	3200	**288**	256	168	80	288
2006	9	**1.09**	0.85	0.53	0.25	3600	**324**	287	187	89	324
2007	10	**1.08**	0.84	0.52	0.25	4000	**360**	317	206	98	360
2008	11	**1.08**	0.83	0.52	0.25	4400	**396**	347	225	107	396
2009	12	**1.07**	0.83	0.51	0.24	4800	**432**	377	243	116	432
2010	13	**1.06**	0.82	0.50	0.24	5200	**468**	406	261	124	468
2011	14	**1.05**	0.81	0.49	0.23	5600	**504**	436	279	133	504
2012	15	**1.04**	0.81	0.48	0.23	6000	**540**	465	296	141	540
2013	16	**1.04**	0.80	0.48	0.23	6400	**576**	493	313	149	576
2014	17	**1.03**	0.79	0.47	0.22	6800	**612**	522	330	157	612
2015	18	**1.02**	0.79	0.46	0.22	7200	**648**	550	347	165	648
2016	19	**1.02**	0.78	0.45	0.22	7600	**684**	579	363	173	684
2017	20	**1.01**	0.78	0.45	0.22	8000	**720**	606	379	181	720
2018	21	1.00	0.77	0.44	0.21	8400	756	634	395	189	756
2019	22	1.00	0.77	0.44	0.21	8800	792	662	411	196	792
2020	23	0.99	0.76	0.43	0.21	9200	828	689	426	204	828
2021	24	0.99	0.75	0.42	0.20	9600	863	716	441	211	864
2022	25	0.98	0.75	0.42	0.20	10000	898	743	457	218	900
2023	26	0.97	0.74	0.41	0.20	10400	934	770	471	225	936
2024	27	0.97	0.74	0.41	0.20	10800	968	797	486	232	972
2025	28	0.96	0.74	0.40	0.19	11200	1003	823	501	239	1008
2026	29	0.96	0.73	0.40	0.19	11600	1038	849	515	246	1044
2027	30	0.95	0.73	0.39	0.19	12000	1072	876	529	253	1080
2028	31	0.95	0.72	0.39	0.19	12400	1106	902	543	260	1116
2029	32	0.94	0.72	0.38	0.18	12800	1140	927	557	266	1152
2030	33	0.94	0.71	0.38	0.18	13200	1174	953	570	273	1188
2031	34	0.93	0.71	0.37	0.18	13600	1207	979	584	279	1224

[a] Bolded doses indicated are those calculated. Exposure during actual operations would be limited to 1 rem/y.

[b] Aggregate hrs per year assuming 400 h/y per worker for all alternatives except the Proposed Action. See text for Proposed Action Annual exposure times.

[c] Bolded values reflect an administratively limited 1 rem/y dose per worker.

Table F-20
WIPP Involved Worker Annual Doses (rem/y per worker) - Continued

Calendar Year	Years of Disposal Operations	WIPP Worker Annual Dose (rem/year per worker)				Aggregate h/y per worker [b]	Aggregate for WIPP Involved Worker Population Dose (person-rem/y)				
		Proposed Action [a]	Action Alternative 1	Action Alternative 2	Action Alternative 3		Proposed Action [c]	Action Alternative 1	Action Alternative 2	Action Alternative 3	Dose Limit (1rem/y per worker)
2032	35	0.93	0.70	0.37	0.18	14000	1240	1004	597	286	1260
2033	36	0.92	0.70	0.36	0.18	14400		1029	610	292	1296
2034	37	0.92	0.70	0.36	0.17	14800		1054	623	298	1332
2035	38	0.91	0.69	0.36	0.17	15200		1079	636	305	1368
2036	39	0.91	0.69	0.35	0.17	15600		1104	648	311	1404
2037	40	0.90	0.68	0.35	0.17	16000		1129	661	317	1440
2038	41	0.90	0.68	0.34	0.17	16400		1153	673	323	1476
2039	42	0.90	0.68	0.34	0.17	16800		1177	686	329	1512
2040	43	0.89	0.67	0.34	0.16	17200		1202	698	335	1548
2041	44	0.89	0.67	0.33	0.16	17600		1226	710	340	1584
2042	45	0.88	0.67	0.33	0.16	18000		1250	722	346	1620
2043	46	0.88	0.66	0.33	0.16	18400		1274	733	352	1656
2044	47	0.88	0.66	0.32	0.16	18800		1298	745	358	1692
2045	48	0.87	0.66	0.32	0.16	19200		1321	756	363	1728
2046	49	0.87	0.65	0.32	0.15	19600		1345	768	369	1764
2047	50	0.86	0.65	0.31	0.15	20000		1368	779	374	1800
2048	51	0.86	0.65	0.31	0.15	20400		1391	790	380	1836
2049	52	0.86	0.64	0.31	0.15	20800		1415	801	385	1872
2050	53	0.85	0.64	0.30	0.15	21200		1438	812	390	1908
2051	54	0.85	0.64	0.30	0.15	21600		1461	823	396	1944
2052	55	0.85	0.64	0.30	0.15	22000		1484	834	401	1980
2053	56	0.84	0.63	0.29	0.14	22400		1506	844	406	2016
2054	57	0.84	0.63	0.29	0.14	22800		1529	855	411	2052
2055	58	0.84	0.63	0.29	0.14	23200		1552	865	416	2088
2056	59	0.83	0.62	0.29	0.14	23600		1574	875	421	2124
2057	60	0.83	0.62	0.28	0.14	24000		1597	886	426	2160
2058	61	0.83	0.62	0.28	0.14	24400		1619	896	431	2196
2059	62	0.82	0.62	0.28	0.14	24800		1641	906	436	2232
2060	63	0.82	0.61	0.28	0.14	25200		1663	916	441	2268
2061	64	0.82	0.61	0.27	0.13	25600		1685	926	446	2304
2062	65	0.81	0.61	0.27	0.13	26000		1707	936	451	2340
2063	66	0.81	0.61	0.27	0.13	26400		1729	945	455	2376
2064	67	0.81	0.60	0.27	0.13	26800		1751	955	460	2412
2065	68	0.81	0.60	0.27	0.13	27200		1772	964	465	2448
2066	69	0.80	0.60	0.26	0.13	27600		1794	974	469	2484
2067	70	0.80	0.60	0.26	0.13	28000		1816	983	474	2520

[a] Bolded doses indicated are those calculated. Exposure during actual operations would be limited to 1 rem/y.
[b] Aggregate hrs per year assuming 400 h/y per worker for all alternatives except the Proposed Action. See text for Proposed Action Annual exposure times.
[c] Bolded values reflect an administratively limited 1 rem/y dose per worker.

operations are assumed under the Proposed Action, the loss of a small portion of worker hours during the first 20 years of operations would not reduce the overall volume of CH-TRU waste disposed of under the Proposed Action.

Aggregate Dose

To calculate the aggregate dose for the WIPP involved worker population over the entire time period of each alternative, the annual population dose to 36 workers was summed over the years of CH-TRU disposal operations. The time required to completely fill a CH-TRU panel is estimated to be 2.5 years at a 75 percent disposal efficiency rate (DOE 1997a). Under Action Alternative 2, each panel is filled with half the CH-TRU volume of the other alternatives; therefore, 1.25 years of worker exposure time are assumed. Using these operational time periods and the number of CH-TRU panels required for disposal, the expected population doses of each alternative was calculated. Table F-20 indicates the aggregate WIPP involved worker population doses under each alternative. Doses are calculated out to 70 years, indicative of the upper-bound impacts to two generations of involved workers. For comparison purposes, the far right column of Table F-20 indicates the aggregate dose to 36 workers exposed annually to the administrative limit of 1 rem.

Storage Site Involved Workers - Routine Handling and Monitoring

Radiological impacts to involved workers at CH-TRU waste storage facilities would result from the handling and monitoring of CH-TRU waste. Under No Action Alternative 1, however, radiological impacts would result mainly from routine overpacking of CH-TRU waste and were evaluated separately. The radiological impacts to individual workers were assumed to be bounded by site-specific occupational dose limits. The TEDE received by an individual worker cannot exceed 5 rem per year (Title 10 of the Code of Federal Regulations [CFR] Part 835) and may be more restrictive at any of the DOE sites.

The amount of CH-TRU waste in storage will vary over time as a result of the rate of waste characterization and treatment and the rate that waste is shipped from the lag storage site. The number of workers required to handle and monitor the waste varies according to the volume of waste in storage. Other factors that can affect the dose received by storage workers are the design of the storage facilities, the amount of waste handling automation, monitoring activities, and waste handling procedures.

Maximum Annual Storage Worker Populations

To develop radiological impact estimates for storage facility workers, uniform assumptions were applied across all CH-TRU waste storage operations. Individual worker impacts were determined by assuming that exposures occurred at 1 meter (3.3 feet) from CH-TRU waste for 2 hours per day, 5 days per week, 50 weeks per year over the entire 35-year career of the worker. The radionuclides identified as the primary contributors to external doses in the CH-TRU inventory were used to determine the 1-meter (3.3-foot) dose rates (see Tables F-17 and F-18). These radionuclides were decayed over the 35-year exposure period.

To determine maximum storage site worker population doses, the entire site storage worker population was assumed to be exposed in the same manner as the individual worker. Worker populations were estimated by assuming that 20 percent of the total waste volume would be in the storage facility each year and that each worker could manage 1,000 cubic meters (35,300 cubic

feet) of waste per year (see Equation F-3). Table F-21 presents involved worker population estimates at storage sites under Action Alternatives 1, 2, and 3 and No Action Alternative 2. The results are extremely conservative because the total waste volume of any site is not expected to be in the storage facility for any extended length of time (see discussion of aggregate storage worker impacts for further discussion of expected waste volumes in storage).

$$W_s = \frac{0.2 \times V_{CH,s}}{T} \qquad \text{(Equation F-3)}$$

where

W_s = worker population at site "s"

$V_{CH,s}$ = site-specific (site "s") post-treatment CH-TRU waste volume from Chapter 3 or Appendix A

T = a constant of 1,000 cubic meters (35,000 cubic feet) of stored waste handled per worker per year

0.2 = fraction of total waste at site "s" handled per year

The number of years of operation for the lag storage sites was assumed to be the maximum occupation exposure period of 35 years. Under the action alternatives, this creates very conservative impact estimates but includes none of the highly uncertain assumptions regarding when each storage site will send waste to WIPP. The results provide an upper-bound case for storage impacts to involved workers. In the following section, the calculation of the aggregate impacts to storage site workers reasonably estimates the amount of waste in storage according to assumed site-specific treatment and shipment rates.

Aggregate Impacts to Storage Site Workers

The volume of waste and length of time that waste is located at a lag storage facility is directly related to the impacts received by storage workers at each site. Assumptions regarding waste treatment and shipment rate are required to determine estimates of the volume and length of time waste is located in lag storage. These assumptions were also made in order to present more realistic estimates of expected impacts to storage workers that can be used for comparison across alternatives and that can be used to estimate aggregate storage worker impacts.

Waste Treatment Facility Throughput

Estimates were made of the CH-TRU waste treatment throughput rates to determine the extent of lag storage under the action alternatives (no lag storage would be required under the Proposed Action). Waste was assumed to be treated at a constant annual rate over the 35-year waste treatment period under each alternative. All sites were assumed to be able to characterize waste to meet the planning-basis WAC in 1998. Design and construction of waste treatment facilities to thermally treat waste and to shred and grout waste was assumed to last 12 years before treatment operations could begin (see Chapter 3).

It was assumed that a small amount of waste could meet the thermal or grouted waste treatment criteria and would be sent to WIPP during the design and construction period. For thermal treatment (Action Alternative 2), it was assumed that enough waste could be shipped to WIPP to

Table F-21
Maximum Storage Site Involved Worker Population Estimates

Site	Alternative	Total Worker Population	
		Basic Inventory	Total Inventory
Total	Action Alternative 1	28	28
	Action Alternative 2A	10	21
	Action Alternative 2B	9	21
	Action Alternative 3	33	67
	No Action Alternative 2	27	N/A
Hanford	Action Alternative 1	12	12
	Action Alternative 2A	4	9
	Action Alternative 2B	4	9
	Action Alternative 3	14	29
	No Action Alternative 2	12	N/A
INEEL	Action Alternative 1	6	6
	Action Alternative 2A	2	8
	Action Alternative 2B	4	11
	Action Alternative 3	7	21
	No Action Alternative 2	6	N/A
LANL	Action Alternative 1	4	4
	Action Alternative 2A	1	2
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	5	8
	No Action Alternative 2	4	N/A
RFETS	Action Alternative 1	4	4
	Action Alternative 2A	1 [a]	1 [a]
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	4	4
	No Action Alternative 2	5	N/A
ORNL	Action Alternative 1	1 [a]	1 [a]
	Action Alternative 2A	N/A	N/A
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	N/A	N/A
	No Action Alternative 2	1 [a]	N/A
SRS	Action Alternative 1	2	2
	Action Alternative 2A	1	1
	Action Alternative 2B	1	1
	Action Alternative 3	3	5
	No Action Alternative 2	2	N/A

[a] Involved workers were assumed to not be involved in waste handling full-time.

N/A = Not Applicable

operate the waste receiving and emplacement operations at 25 percent throughput. For shred and grout treatment (Action Alternative 3), it was assumed that enough waste could be shipped to WIPP to operate the waste receiving and emplacement operations at 40 percent throughput capacity. A result of this assumption is that no site would require the full 35-year treatment period to treat the waste volume under Action Alternative 2 or Action Alternative 3.

To estimate site-specific waste treatment throughput, a “standard facility” was determined for each treatment type (i.e., WAC, thermal treatment, or shred and grout) and for treatment of the Basic Inventory or Total Inventory. The standard facility was sized to be able to treat one-half of the waste at the site with the largest volume of CH-TRU waste within the 35-year waste treatment period for each action alternative. The site with the largest CH-TRU waste volume would have standard-sized treatment facilities, while sites with less waste volume would have correspondingly smaller waste treatment facilities. For Action Alternative 2C, where CH-TRU waste is treated only at WIPP, a single standard facility was sized to process the entire volume of waste over

35 years. The number of standard-sized treatment facilities at each site under each action alternative is presented in Table F-22. Standard facility throughput rates are presented in the footnote of Table F-22.

Waste Shipment Rates

The WIPP CH-TRU waste receiving docks can handle a maximum of 50 TRUPACT-IIs per week. This rate is considered a WIPP shipment receiving efficiency of 100 percent. For this aggregate storage worker impact analysis, it is assumed that the receipt of WIPP waste can occur at a maximum efficiency of 80 percent (13 to 14 trucks per week) when waste treatment facilities are operational. Prior to treatment facility operations under Action Alternatives 2 and 3, the number of trucks received at WIPP would be consistent with operating efficiencies of 25 percent (4 trucks per week) and 42 percent (7 trucks per week), respectively.

Under Action Alternatives 1 and 3, waste trucks sent from a site to WIPP are assumed to bear three TRUPACT-IIs, each carrying 14 drum-equivalents of waste, for a total volume per truck of 8.74 cubic meters (308.65 cubic feet). Transportation impact assumptions for Action Alternative 3 indicate that about 86 percent of the trucks would consist of two TRUPACT-IIs instead of three (see Section A.3.9). This lack of consistency was investigated and found to not result in a significant difference in the time required to send all waste to WIPP. For the dense waste of Action Alternative 2, each of the three TRUPACT-IIs on a truck were assumed to contain seven drums of waste and seven drums of dunnage. This Action Alternative 2 assumption is consistent with transportation impact assumptions which indicate that, under Action Alternative 2, shipments would consist of two full TRUPACT-IIs per truck (see Section A.3.9).

The number of trucks transporting waste from each specific lag storage site are indicated in Table F-23. The number of trucks sending waste to WIPP from each lag storage site was determined according to the relative total waste volumes at each site destined for WIPP and the treatment throughput rates. Sites with smaller waste volumes destined for WIPP will complete shipping before the larger sites. When trucks finish shipping waste to WIPP from the smaller sites, they would be sent to the larger sites to maintain the 80 percent shipment receiving operation efficiency at WIPP. Table F-24 indicates how and when available trucks would be distributed to the larger sites.

Storage Worker Impacts

The annual amount of waste in lag storage is calculated by assuming alternative- and site-specific treatment and shipment rates. The amount of waste in storage can be used with site-specific dose rates at 1 meter (3.3 feet) and the number of workers who routinely monitor the waste to estimate worker population impacts over the entire period of lag storage. The data is then used to determine the expected maximum fraction of the total waste volume that can be found in lag storage, the number of years each site ships waste to WIPP, the total number of worker-years required to monitor waste in lag storage, and the aggregate worker population consequences of the lag storage (i.e., aggregate population dose and LCF estimates) over the entire disposal operations period under each alternative. Section F.3.1 includes the results of this analysis.

Table F-22
Site-Specific Treatment Facility Throughputs

Alternative	Lag Storage Site	Inventory (m^3)	Treatment Facility size (*n* x standard plant size) [a]	Period of Waste Treatment (in years)
Action Alternative 1	**Hanford**	Basic 57,000	2 x B	35
		Total 120,000	2 x T	35
	INEEL	Basic 30,000	1.25 x B	30
		Total 87,000	1.5 x T	34
	LANL	Basic 21,000	1 x B	26
		Total 35,000	0.75 x T	28
	RFETS	Basic 17,000	1 x B	21
		Total 17,000	0.5 x T	20
	SRS	Basic 12,000	0.75 x B	20
		Total 17,000	0.5 x T	20
	ORNL	Basic 1,800	0.25 x B	9
		Total 2,100	0.25 x T	5
Action Alternative 2A	**Hanford**	Basic 21,000	2 x B	29
		Total 43,000	2 x T	32
	INEEL	Basic 10,000	1 x B	25
		Total 41,000	2 x T	32
	LANL	Basic 7,400	1 x B	21
		Total 12,000	0.75 x T	24
	RFETS	Basic 3,800	0.5 x B	17
		Total 3,800	0.5 x T	9
	SRS	Basic 5,000	0.5 x B	25
		Total 6,800	0.5 x T	19
Action Alternative 2B	**Hanford**	Basic 21,000	2 x B	29
		Total 43,000	2 x T	24
	INEEL	Basic 22,000	2 x B	29
		Total 57,000	2 x T	32
	SRS	Basic 5,000	1 x B	13
		Total 6,900	1 x T	7
Action Alternative 2C	**WIPP**	Basic 47,000	1 x B	28
		Total 107,000	1 x T	32
Action Alternative 3	**Hanford**	Basic 70,000	2 x B	29
		Total 146,000	2 x T	32
	INEEL	Basic 37,000	1.5 x B	20
		Total 105,000	2 x T	24
	LANL	Basic 25,000	1 x B	20
		Total 42,000	1 x T	18
	RFETS	Basic 19,000	1 x B	14
		Total 19,000	0.5 x T	14
	SRS	Basic 17,000	1 x B	12
		Total 23,000	0.5 x T	18

[a] Standard Plant sizes for Basic Inventory (B) and Total Inventory (T) in drum-equivalents per day (dr-eq/d) are:

AA1: B = 21 dr-eq/d, T = 44 dr-eq/d.
AA2A: B = 9.5 dr-eq/d, T = 19.5 dr-eq/d.
AA2B: B = 9.5 dr-eq/d, T = 26.5 dr-eq/d.
AA2C: B = 43 dr-eq/d, T = 98 dr-eq/d.
AA3: B = 38.5 dr-eq/d, T = 80 dr-eq/d.

Table F-23
Shipment Rates During the Design-and-Construction Phases and the Fully Operational Treatment Phases

Sites	AA1 All years	AA2A Disposal years 1-12	AA2A Disposal years 13+	AA2B Disposal years 1-12	AA2B Disposal years 13+	AA2C Disposal years 1-12	AA2C Disposal years 13+	AA3 Disposal years 1-12	AA3 Disposal years 13+
Hanford	5	1.5	5	1.5	5.5	N/A	N/A	2.5	4
INEEL	3.5	1	4.5	2	6	N/A	N/A	1.5	3
LANL	2	0.5	2	N/A	N/A	N/A	N/A	1	2
RFETS	1.5	0.5	1.5	N/A	N/A	N/A	N/A	1	2
SRS	1.5	0.5	1	0.5	2	N/A	N/A	1	2
ORNL	0.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WIPP	N/A	N/A	N/A	N/A	N/A	4	13	N/A	N/A

N/A = Not Applicable

Table F-24
Assumed Truck Transfer Schedule

	Basic Inventory				Total Inventory			
	Disposal Year	*n* Trucks Added per Week	To Site	From Site	Disposal Year	*n* Trucks Added per Week	To Site	From Site
Action Alternative 1	10	0.5	RFETS	ORNL	11	0.5	Hanford	ORNL
					27	1	LANL	RFETS
					27	1	Hanford	0.5
					27	1	INEEL	RFETS + 0.5
					37	2	INEEL	SRS
					37	1	Hanford	
Action Alternative 2A		No Changes [a]			22	1	INEEL	RFETS
					22	0.5	Hanford	RFETS
					38	2	INEEL	LANL
					39	1	Hanford	SRS
Action Alternative 2B		No Changes [a]			26	1	Hanford	SRS
					26	1	INEEL	SRS + 0.5 new
Action Alternative 2C		No Changes				No Changes		
Action Alternative 3	17	0.5	Hanford	RFETS	17	1	Hanford	RFETS
	17	0.5	INEEL	RFETS	17	1	INEEL	RFETS
					34	1	LANL	SRS
					34	1	Hanford	SRS
					49	2	INEEL	LANL
					49	1	Hanford	LANL

[a] The WIPP waste receipt efficiency cannot reach 80 percent because waste volume resulting from treatment limits the amount annually available for shipment. If waste treatment rates were increased, the efficiency of the WIPP waste receiving operations could reach 80 percent.

Overpacking Operations for No Action Alternative 1

Despite the variation in operations at each packaging facility, the impacts from overpackaging were calculated to provide a rough idea of how radiological impacts to the involved worker would compare across the consolidation sites under No Action Alternative 1. Overpacking impact estimates were determined by assuming identical waste handling at all consolidation sites. For impacts to the worker population, it was assumed that the average worker would be 1 meter (3.3 feet) from the waste for 2 hours per day, 5 days per week, 50 weeks per year, and all individuals in the worker population would be involved in these operations over 35 years. The maximally exposed involved worker was assumed to be exposed for twice as long (4 hours per day). The average 1-meter (3.3-foot) dose rates were adjusted annually for radioactive decay; the

greatest external dose rates would occur early in the operations period. Therefore, the maximum impacts to workers were estimated from year 20 to year 55 for storage operations because CH-TRU waste containers have a design life of 20 years. The annual occupational dose limit (TEDE) as regulated by 10 CFR Part 835 is 5 rem and was assumed to apply to all packaging workers at the various sites.

The involved worker populations under No Action Alternative 1 were determined by assuming that 4.2 workers would be required to overpackage 12 drums a day. This level of overpackaging maximizes the worker population because worker personnel protection (e.g., workers have self-contained breathing apparatus and are fully suited-up) is maximized. The involved worker population required at each site for overpackaging operations, based on site-specific volumes of waste, are as follows for No Action Alternative 1A: 35 total workers with 14 at Hanford, 14 at INEEL, 4 at LANL, 1 at RFETS, and 2 at SRS; and for No Action Alternative 1B: 35 total workers with 14 at Hanford, 19 at INEEL, and 2 at SRS.

F.3 HUMAN HEALTH IMPACTS

The radiological and hazardous chemical impacts from TRU waste storage at the major consolidation sites and from WIPP disposal operations are presented in this section.

F.3.1 Radiological Impacts

Radiological impacts to the public and noninvolved workers at the storage sites and WIPP may result from the releases of gaseous radionuclides present in TRU waste containers. Radionuclides contributing to these impacts are carbon-14 and radon-222. The radiation doses resulting from gaseous releases are presented in Table F-25 and are well below background radiation levels. The radiological impacts of these doses, presented in Chapter 5, were estimated using ICRP 60 dose-to-risk factors.

Radiological impacts to involved workers at WIPP and at storage sites are presented in Tables F-26 and F-27. Table F-26 indicates the WIPP involved worker dose estimates under each alternative, the individual involved worker and population dose for a 35-year occupational exposure period, the individual involved worker dose for the time required to dispose of the CH-TRU waste under each alternative (bounded at 35 years), and the aggregate involved worker population dose for the time required to dispose of CH-TRU waste in the 2.5-year timeframe required to fill a panel. For comparison, the WIPP administrative limit (1 rem per year per person) for a 35-year exposure period is also indicated in Table F-26.

Radiological presents to the involved workers at lag storage sites are presented in Table F-28. These are upper-bound occupational exposures, assuming routine handling and monitoring of a site's total waste volume for 35 years. No Action Alternative 1 requires periodic repackaging operations, and Table F-29 indicates the radiological impacts of these repackaging operations.

Table F-27 presents the results of the more realistic assessment of storage worker impacts, where site-specific shipment and treatment rates were considered in the analysis. These impacts may better reflect the comparative radiological impacts to the population of involved workers across the alternatives. The maximum fraction of a site's total expected waste volume in storage is indicated in the table.

Table F-25
Radiation Doses from Routine Releases of Gaseous Radionuclides for the Public and Non-Involved Workers [a, b]

Alternative	Hanford C-14	INEEL Rn-222	LANL Rn-222	RFETS	ORNL Rn-222	SRS Rn-222	WIPP Rn-222
Proposed Action [c]							
MEI (rem per 35 years)	0E+0	N/A	N/A	N/A	2E-6	N/A	5E-4
Population (person-rem per 35 years)	0E+0				4E-2		0.6
Noninvolved Worker (rem per 35 years)	0E+0				2E-5		1E-3
Action Alternative 1							
MEI (rem per 70 years)	2E-5	3E-6	1E-3	No known inventory for Rn-222 or C-14	3E-3	2E-10	9E-4
Population (person-rem per 35 years)	2E-1	1E-2	4E+0		2E+1	8E-6	6E-1
Noninvolved Worker (rem per 35 years)	3E-4	1E-4	2E-3		2E-2	2E-8	1E-3
Action Alternative 2A							
MEI (rem per 70 years)	7E-6	1E-6	3E-4	No known inventory for Rn-222 or C-14	N/A	2E-5	2E-4
Population (person-rem per 35 years)	1E-1	5E-3	1E+0			1E+0	1E-1
Noninvolved Worker (rem per 35 years)	2E-4	6E-5	6E-4			3E-3	4E-4
Action Alternative 2B							
MEI (rem per 70 years)	7E-6	9E-6	N/A	N/A	N/A	2E-5	2E-4
Population (person-rem per 35 years)	1E-1	3E-2				1E+0	1E-1
Noninvolved Worker (rem per 35 years)	2E-4	4E-4				3E-3	4E-4
Action Alternative 2C							
MEI (rem per 70 years)	N/A	N/A	N/A	N/A	N/A	N/A	2E-4
Population (person-rem per 35 years)							1E-1
Noninvolved Worker (rem per 35 years)							4E-4
Action Alternative 3							
MEI (rem per 70 years)	1E-5	3E-6	6E-4	No known inventory of Rn-222 or C-14	N/A	5E-5	5E-4
Population (person-rem per 35 years)	1E-1	1E-2	2E+0			2E+0	3E-1
Noninvolved Worker (rem per 35 years)	2E-4	1E-4	1E-3			5E-3	7E-4
No Action Alternative 2							
MEI (rem per 70 years)	2E-6	5E-7	7E-4	No known inventory of Rn-222 or C-14	3E-3	2E-10	N/A
Population (person-rem per 35 years)	3E-2	2E-3	3E+0		2E+0	7E-6	
Noninvolved Worker (rem per 35 years)	5E-5	2E-5	1E-3		2E-2	2E-8	

[a] The predominant gaseous radionuclide is carbon-14 (C-14) or radon-222 (Rn-222), as indicated below site heading.
[b] N/A indicates the site is not a consolidation site under the alternative.
[c] The Hanford and ORNL doses are from the excess RH-TRU waste remaining at these sites under the Proposed Action.

Table F-26
Aggregate Dose to WIPP Involved Worker Populations

Alternative	Maximum Involved Worker Dose (total rem over 35 years)	Maximum Involved Worker Population Dose (person-rem over 35 years)	Inventory	Number of Panels	Years of CH-TRU Waste Disposal Operations	Involved Worker (rem) [a]	Aggregate Worker Population Dose (person-rem) [b]
Proposed Action	35	1240	Basic Basic	10 10	25 (min.) 35 (max.)	25 35	898 1240
Action Alternative 1	28	1010	Basic Total	8.5 16.7	22 43	18 28	662 1202
Action Alternative 2	17	612	Basic Total	5.7 12.8	7 15	4 8	149 296
Action Alternative 3	8	288	Basic Total	10.0 19.8	25 50	6 8	218 374
Administrative Limit	35	1260	N/A N/A	N/A N/A	35 70	35 N/A	N/A N/A

[a] Exposure period is equal to the lesser of the years of CH-TRU waste operations or 35 years.
[b] Exposure period is equal to the years of CH-TRU waste disposal operations.

N/A = Not Applicable

F.3.2 Impacts from VOCs

The impacts of routine releases of VOCs from TRU waste containers at the major storage sites and WIPP were evaluated for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2. Waste would not be stored at sites under the Proposed Action, and no VOCs would be emitted under Action Alternative 2 and No Action Alternative 1 because of the thermal waste treatment.

F.3.2.1 Proposed Action

Forty-two CH-TRU and three RH-TRU waste drum-equivalents were assumed to be constantly present in the WHB. All 45 drums were assumed to contain VOCs at the planning-basis WAC concentration limit or, where no specific limit was established, the weighted maximum VOC concentration. From the underground, a full single panel containing approximately 84,000 drum-equivalents of TRU waste (alternative-specific values indicated in Table F-6) was assumed to be continuously releasing VOCs every year. All drums in the underground area were assumed to contain the weighted average concentrations of VOCs. Panels would be sealed upon filling; therefore, no more than one panel would be open at any one time. All VOCs were assumed to be released to the atmosphere from the underground exhaust ventilation stack of the Exhaust Filter Building. WHB workers and the underground workers would be exposed to VOCs in the ventilation air; low ventilation rates were assumed to bound potential exposures.

The impacts, dominated by the releases from the underground area rather than from the WHB, are presented in Table F-30. The maximum HI resulting from the stack releases would be 6×10^{-4} (noninvolved worker) and 7×10^{-5} (MEI) from the carbon tetrachloride releases. An HI of one or greater to a member of the public would predict a noncarcinogenic health effect. WHB and underground area workers would have HIs greater than one for carbon tetrachloride (see Table F-30). The HI for methylene chloride is 0.9 for the WHB workers.

Table F-27
Aggregate Lag Storage Worker Population Impacts

Alternative	Storage Sites and Inventories [a]	Maximum Fraction	Time to Ship (in years)	Worker-years	Aggregate Population Dose (person-rem)	LCFs
Action Alternative 1	Basic					
	Hanford	0.00	35	0	0	0
	INEEL	0.00	30	0	0	0
	LANL	0.00	26	0	0	0
	RFETS	0.09	22	25	160	6.4E-2
	SRS	0.00	20	0	0	0
	ORNL	0.00	9	0	0	0
	Total			25	160	6.4E-2
	Total					
	Hanford	0.28	46	193	117	4.7E-2
	INEEL	0.36	46	179	199	7.9E-2
	LANL	0.31	36	57	20	7.8E-3
	RFETS	0.23	26	25	160	6.4E-2
	SRS	0.23	26	25	3.4	1.4E-3
	ORNL	0.48	10	9	11	4.2E-3
	Total			488	509	2.0E-1
Action Alternative 2A	Basic					
	Hanford	0.00	41	0	0	0
	INEEL	0.00	37	0	0	0
	LANL	0.00	33	0	0	0
	RFETS	0.00	29	0	0	0
	SRS	0.00	37	0	0	0
	Total			0	0	0
	Total					
	Hanford	0.03	49	27	21	8.5E-3
	INEEL	0.10	52	32	10	4.2E-3
	LANL	0.04	37	0	0	0
	RFETS	0.00	21	0	0	0
	SRS	0.23	38	25	1.9	7.5E-3
	Total			84	34	1.3E-2
Action Alternative 2B	Basic					
	Hanford	0	41	0	0	0
	INEEL	0	41	0	0	0
	SRS	0	25	0	0	0
	Total			0	0	0
	Total					
	Hanford	0.19	43	43	29	1.1E-2
	INEEL	0.12	49	50	22	8.7E-3
	SRS	0.37	25	12	0.9	3.7E-4
	Total			105	51	2.1E-2
Action Alternative 2C	Basic					
	WIPP	0	40	0	0	0
	Total					
	WIPP	0	44	0	0	0
Action Alternative 3	Basic					
	Hanford	0.03	42	29	8	3.1E-3
	INEEL	0.02	32	19	4	1.6E-3
	LANL	0.10	35	22	1.9	7.7E-4
	RFETS	0.09	16	15	24	9.5E-3
	SRS	0.08	26	13	0.5	2.1E4
	Total			98	38	1.5E-2
	Total					
	Hanford	0.41	65	359	76	3.0E-2
	INEEL	0.55	62	336	65	2.6E-2
	LANL	0.50	48	95	8	3.2E-3
	RFETS	0.12	16	15	24	9.5E-3
	SRS	0.13	33	20	0.8	3.2E4
	Total			825	174	6.9E-2

Table F-28
Storage Site Involved Worker Lifetime Radiological Impacts (35-year Exposures)

Site	Alternative	Individual		Population			
				Dose (person-rem)		Number of LCFs	
		Dose (rem)	Probability of an LCF	Basic Inventory	Total Inventory	Basic Inventory	Total Inventory
Hanford	Action Alternative 1	24	0.01	279	279	0.1	0.1
	Action Alternative 2A	29	0.01	119	247	0.05	0.1
	Action Alternative 2B	29	0.01	119	247	0.05	0.1
	Action Alternative 3	11	4E-03	162	334	0.06	0.1
	No Action Alternative 2	24	0.01	279	N/A	0.1	N/A
INEEL	Action Alternative 1	40	0.02	241	241	0.1	0.1
	Action Alternative 2A	13	5E-03	26	104	0.01	0.04
	Action Alternative 2B	16	6E-03	71	189	0.03	0.08
	Action Alternative 3	8	3E-03	57	161	0.02	0.06
	No Action Alternative 2	39	0.02	225	N/A	0.09	N/A
LANL	Action Alternative 1	12	5E-03	52	52	0.02	0.02
	Action Alternative 2A	7	3E-03	10	17	4E-03	7E-03
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	3	1E-03	16	27	6E-03	0.01
	No Action Alternative 2	12	5E-03	51	N/A	0.02	N/A
RFETS	Action Alternative 1	191	0.08	764	764	0.3	0.3
	Action Alternative 2A	89	0.04	68	68	0.03	0.03
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	56	0.02	209	209	0.08	0.08
	No Action Alternative 2	153	0.06	764	N/A	0.3	N/A
ORNL	Action Alternative 1	32	0.01	12	12	5E-03	5E-03
	Action Alternative 2A	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	N/A	N/A	N/A	N/A	N/A	N/A
	No Action Alternative 2	7	3E-03	3	N/A	1E-03	N/A
SRS	Action Alternative 1	5	2E-03	11	11	4E-03	4E-03
	Action Alternative 2A	3	1E-03	3	4	1E-03	2E-03
	Action Alternative 2B	3	1E-03	3	4	1E-03	2E-03
	Action Alternative 3	1	4E-04	5	7	2E-03	3E-03
	No Action Alternative 2	2	8E-04	4	N/A	2E-03	N/A

N/A = Not Applicable

Table F-29
Overpackaging Involved Worker Radiological Impacts for No Action Alternative 1 (35-year Exposures)

Site	No Action Alternative 1A				No Action Alternative 1B			
	Maximally Exposed Worker		Worker Population		Maximally Exposed Worker		Worker Population	
	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs
Hanford	38	0.02	266	0.1	38	0.02	266	0.1
INEEL	22	9E-3	154	0.06	30	0.01	285	0.1
LANL	12	5E-3	24	0.01	N/A	N/A	N/A	N/A
RFETS	172	0.07	86	0.03	N/A	N/A	N/A	N/A
SRS	5	2E-3	5	2E-3	5	2E-3	5	2E-3

N/A = Not Applicable

Table F-30
Proposed Action Human Health Impacts from Routine Releases of VOCs at WIPP and Excess RH-TRU Waste Storage Impacts at Hanford and ORNL

Individual/Population	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (86)	6E-4	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (96)	7E-5	Carbon tetrachloride
50-mile Population	2E-5	1,1,2,2-tetrachloroethane (89)	N/A	N/A
WHB Worker	2E-4	1,2-dichloroethane (30)	2	Carbon tetrachloride
Underground Worker	9E-4	1,1,2,2-tetrachloroethane (86)	6	Carbon tetrachloride
Sites	**Excess RH-TRU Waste Storage Impacts**			
Noninvolved Worker –				
Hanford	4E-8	1,1,2,2 – tetrachloroethane (91)	1E-4	Carbon tetrachloride
ORNL	9E-9	1,1,2,2 – tetrachloroethane (97)	1E-5	Carbon tetrachloride
70-year MEI –				
Hanford	2E-8	1,1,2,2 – tetrachloroethane (72)	8E-6	Carbon tetrachloride
ORNL	4E-8	1,1,2,2 – tetrachloroethane (98)	1E-5	Carbon tetrachloride
50-mile Population –				
Hanford	1E-4	1,1,2,2 – tetrachloroethane (92)	N/A	N/A
ORNL	2E-4	1,1,2,2 – tetrachloroethane (95)	N/A	N/A

N/A = Not Applicable

For these VOCs, the air concentration was compared to the OSHA PEL (see Table F-3). The air concentration for the workers would be at least three orders of magnitude less than the PELs; therefore, no involved worker noncarcinogenic health effects would be expected at WIPP from routine releases under the Proposed Action. A lifetime probability of cancer incidence of 1 x 10^{-7} (noninvolved worker) and 3 x 10^{-8} (MEI) may result from the routine releases of VOCs over the 35-year operating period. Annual risk would be 1/35th of the total values. No cancers would occur in the 80-kilometer (50-mile) population (2 x 10^{-5} cancers).

F.3.2.2 Action Alternative 1

The same assumptions used for the Proposed Action to analyze the impacts at WIPP were used for Action Alternative 1 impact analyses.

The impacts to the noninvolved worker, MEI, and populations at WIPP and the lag storage sites under Action Alternative 1 are presented in Table F-31. The maximum annual HI from stack releases of carbon tetrachloride would be 4 x 10^{-3} (noninvolved worker at INEEL) and 6 x 10^{-4} (MEI at LANL or Hanford). No noncarcinogenic effects would be expected from the routine VOC releases under Action Alternative 1. Impacts to the involved workers in the WHB and the underground area would be the same under Action Alternative 1 as under the Proposed Action. The highest individual probabilities of cancer incidence estimated for the routine releases of hazardous chemicals were 5 x 10^{-7} (noninvolved worker at INEEL) and 1 x 10^{-7} (MEI at Hanford, LANL, or ORNL). This would be the lifetime carcinogenic risk for the 35 years (noninvolved worker) and 70 years (MEI) to which the individual was conservatively assumed to be exposed. The maximum annual impact would be equivalent to 1/35th or 1/70th of the total noninvolved worker or MEI value, respectively. No cancers would be expected in the 80-kilometer (50-mile) population (maximum expected cancers over each 35-year period would be 1 x 10^{-3} for RFETS).

Table F-31
Action Alternative 1 Human Health Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
WIPP				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (86)	6E-4	Carbon tetrachloride
70-year MEI	5E-8	1,1,2,2-tetrachloroethane (94)	7E-5	Carbon tetrachloride
50-mile Population	2E-5	1,1,2,2-tetrachloroethane (89)	N/A	N/A
WHB Worker	2E-4	1,2-dichloroethane (30)	2	Carbon tetrachloride
Underground Worker	9E-4	1,1,2,2-tetrachloroethane (86)	6	Carbon tetrachloride
Lag storage - Hanford East & West				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (92)	5E-4	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (95)	6E-4	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (91)	N/A	N/A
Lag storage - INEEL				
Noninvolved Worker	5E-7	1,1,2,2-tetrachloroethane (84)	4E-3	Carbon tetrachloride
70-year MEI	4E-8	1,1,2,2-tetrachloroethane (90)	3E-5	Carbon tetrachloride
50-mile Population	1E-4	1,1,2,2-tetrachloroethane (80)	N/A	N/A
Lag storage - LANL				
Noninvolved Worker	4E-8	1,1,2,2-tetrachloroethane (64)	7E-4	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (79)	6E-4	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (66)	N/A	N/A
Lag storage - RFETS				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (72)	2E-4	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (88)	6E-5	Carbon tetrachloride
50-mile Population	1E-3	1,1,2,2-tetrachloroethane (65)	N/A	N/A
Lag storage - ORNL				
Noninvolved Worker	3E-8	1,1,2,2-tetrachloroethane (96)	3E-5	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (99+)	3E-5	Carbon tetrachloride
50-mile Population	6E-4	1,1,2,2-tetrachloroethane (95)	N/A	N/A
Lag storage - SRS				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (92)	2E-4	Carbon tetrachloride
70-year MEI	3E-8	1,1,2,2-tetrachloroethane (96)	2E-5	Carbon tetrachloride
50-mile Population	5E-4	1,1,2,2-tetrachloroethane (93)	N/A	N/A

N/A = Not Applicable

F.3.2.3 Action Alternative 2

No routine releases of VOCs would occur because VOCs in the waste would be destroyed during thermal treatment to meet the LDRs.

F.3.2.4 Action Alternative 3

Action Alternative 3 considers the treatment of the Basic and Additional Inventories of TRU waste by shred and grout. The VOC headspace concentrations are driven by the waste matrix, and the matrix of all Action Alternative 3 waste is a uniform solidified inorganic. As a result, all headspace concentrations for the waste at all consolidation sites were assumed to be identical.

The increased waste volume (as compared to WAC-packaged waste) resulting from the shred and grout process would require that more time be given to dispose of the waste. There is lag storage

of waste at consolidation sites. Impacts at WIPP would be greatest in the early years of operations, when both the CH-TRU waste and RH-TRU waste are being disposed of. The maximum annual impacts were estimated using methods similar to those described for Action Alternative 1. It was conservatively assumed that the total number of drum-equivalents that a consolidation site would eventually send to WIPP would release VOCs into the atmosphere at the lag storage sites at the beginning of the operations period. It was also assumed that the MEI would be exposed to this release over a 70-year period, and the noninvolved worker and noninvolved worker population would be exposed over a 35-year period.

The impacts to the noninvolved worker, MEI, and populations at WIPP and the lag storage sites are presented in Table F-32. The maximum HIs for the noninvolved worker and the MEI would be 7×10^{-3} (noninvolved worker at Hanford) and 9×10^{-4} (MEI at LANL) for carbon tetrachloride. Therefore, no noncarcinogenic effects would be expected from routine stack releases under Action Alternative 3. The Action Alternative 3 WHB worker and underground worker have HIs greater than one for carbon tetrachloride (2 [WHB] and 10 [underground]). Air concentrations for involved workers would be at least two orders of magnitude below the PEL. Individual

Table F-32
Action Alternative 3 Human Health Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
WIPP				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (62)	1E-3	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (77)	1E-4	Carbon tetrachloride
50-mile Population	1E-5	1,1,2,2-tetrachloroethane (60)	N/A	N/A
WHB Worker	6E-5	Carbon tetrachloride (72)	2	Carbon tetrachloride
Underground Worker	5E-4	1,1,2,2-tetrachloroethane (60)	10	Carbon tetrachloride
Lag storage - Hanford East & West				
Noninvolved Worker	4E-7	1,1,2,2-tetrachloroethane (63)	7E-3	Carbon tetrachloride
70-year MEI	2E-7	1,1,2,2-tetrachloroethane (76)	7E-4	Carbon tetrachloride
50-mile Population	6E-4	1,1,2,2-tetrachloroethane (58)	N/A	N/A
Lag storage - INEEL				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (67)	4E-3	Carbon tetrachloride
70-year MEI	3E-8	1,1,2,2-tetrachloroethane (83)	9E-5	Carbon tetrachloride
50-mile Population	6E-5	1,1,2,2-tetrachloroethane (59)	N/A	N/A
Lag storage - LANL				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (63)	9E-4	Carbon tetrachloride
70-year MEI	2E-7	1,1,2,2-tetrachloroethane (81)	9E-4	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (60)	N/A	N/A
Lag storage - RFETS				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (63)	2E-4	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (81)	7E-5	Carbon tetrachloride
50-mile Population	1E-3	1,1,2,2-tetrachloroethane (62)	N/A	N/A
Lag storage - ORNL				
Noninvolved Worker	5E-9	1,1,2,2-tetrachloroethane (70)	8E-5	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (81)	1E-4	Carbon tetrachloride
50-mile Population	1E-4	1,1,2,2-tetrachloroethane (59)	N/A	N/A
Lag storage - SRS				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (76)	6E-4	Carbon tetrachloride
70-year MEI	1E-8	1,1,2,2-tetrachloroethane (76)	6E-5	Carbon tetrachloride
50-mile Population	2E-4	1,1,2,2-tetrachloroethane (58)	N/A	N/A

N/A = Not Applicable

probabilities of cancer incidence of 4 x 10^{-7} (noninvolved worker at Hanford) and 2 x 10^{-7} (MEI at LANL) were estimated from exposure to routine releases of VOCs. This would be the lifetime carcinogenic risk for the 35 years (noninvolved worker) and 70 years (MEI) that the individual was conservatively assumed to be exposed. No cancers would occur in the 80-kilometer (50-mile) population (maximum expected number of cancers over each 35-year period would be 1 x 10^{-3} for RFETS).

F.3.2.5 No Action Alternative 1

No routine releases of VOCs would occur because VOCs in the waste would be destroyed during thermal treatment to meet the LDRs.

F.3.2.6 No Action Alternative 2

No Action Alternative 2 considers treating newly generated, Basic Inventory TRU waste to meet WAC. To estimate impacts due to chronic exposure to VOCs, it was assumed that the total number of drum-equivalents of waste for each major storage site would be present in the facility at the beginning of the operations period. All exposed individuals were assumed to be exposed for the entire 35-year operating period.

Impacts to the noninvolved worker, MEI, and populations are presented in Table F-33. The maximum HI would be 1 x 10^{-3} (noninvolved worker at INEEL) and 4 x 10^{-4} (MEI at LANL), for carbon tetrachloride. No noncarcinogenic effects would be expected for routine releases for No

Table F-33
No Action Alternative 2 Human Health Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
Hanford East & West				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (92)	3E-4	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (83)	3E-5	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (94)	N/A	N/A
INEEL				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (81)	1E-3	Carbon tetrachloride
35-year MEI	5E-9	1,1,2,2-tetrachloroethane (64)	1E-5	Carbon tetrachloride
50-mile Population	5E-5	1,1,2,2-tetrachloroethane (83)	N/A	N/A
LANL				
Noninvolved Worker	2E-8	1,1,2,2-tetrachloroethane (64)	4E-4	Carbon tetrachloride
35-year MEI	4E-8	1,1,2,2-tetrachloroethane (80)	4E-4	Carbon tetrachloride
50-mile Population	2E-4	1,1,2,2-tetrachloroethane (65)	N/A	N/A
RFETS				
Noninvolved Worker	7E-9	1,1,2,2-tetrachloroethane (70)	1E-4	Carbon tetrachloride
35-year MEI	5E-9	1,1,2,2-tetrachloroethane (85)	4E-5	Carbon tetrachloride
50-mile Population	7E-4	1,1,2,2-tetrachloroethane (65)	N/A	N/A
ORNL				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (92)	1E-5	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (97+)	2E-5	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (93)	N/A	N/A
SRS				
Noninvolved Worker	9E-8	1,1,2,2-tetrachloroethane (97)	1E-4	Carbon tetrachloride
35-year MEI	1E-8	1,1,2,2-tetrachloroethane (92)	1E-5	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (92)	N/A	N/A

N/A = Not Applicable

Action Alternative 2. An individual probability of cancer incidence of 2 x 10^{-7} (noninvolved worker at INEEL) and 4 x 10^{-8} (MEI at LANL) would result from the routine releases of VOCs. The annual risk would be equivalent to 1/35th of the total value. No cancers are expected in the 80-kilometer (50-mile) population (maximum number of cancers would be 7 x 10^{-4} for RFETS).

VOCs would presumably be emitted from the storage area stack after the waste disposition operations end. Impacts to the population and noninvolved worker would be no greater than that estimated during the operations period. Conservatively assuming constant emission rates, the maximum impact to an MEI exposed for 70 years would be twice that of the 35-year carcinogenic impact to the MEI (see Table F-33) for the operations period. The HI for the 70-year MEI would not be any greater than that of the 35-year MEI exposed during the operations period, because HIs are determined on an annual basis.

F.4 REFERENCES CITED IN APPENDIX F

BEIR (Biological Effects of Ionizing Radiation), 1980, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980*, Report III, National Academy Press, Washington, D.C.

Buck, J.W., et al., 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS®) Application Guidance: Guidance for Evaluating MEPAS® Input Parameters for Version 3.1*, PNL-10395, Pacific Northwest Laboratory, Richland, Washington.

DOE (U.S. Department of Energy), 1988a, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0070, DOE, Washington, D.C.

DOE (U.S. Department of Energy), 1988b, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, DOE, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, Vols. 1 and 2, DOE, Washington, D.C.

DOE (U.S. Department of Energy), 1995a, *WIPP Radiological Control Manual*, Vol. 1 and *WIPP Radiation Safety Procedures Manual*, Volume 2, WP-12-5, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 0, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, Revision 5.2, DOE/WIPP 91-005, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996c, *Final No Migration Variance Petition*, DOE/CAO-96-2160, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997a, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997b, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

Droppo, J.G., Jr., et al., 1989, *Supplemental Mathematical Formulations: The Multimedia Environmental Pollutant Assessment System (MEPAS®)*, PNL-7201, Pacific Northwest Laboratory, Richland, Washington.

Droppo, J.G., and Buck, J.W., 1996, *The Multimedia Environmental Pollutant Assessment System (MEPAS®): Atmospheric Pathway Formulations*, PNNL-11080, Pacific Northwest National Laboratory, Richland, Washington.

EPA (U.S. Environmental Protection Agency), 1996, *IRIS - Integrated Risk Information System*, in TOMES®- Toxicology, Occupational Medicine, and Environmental Series (CD-ROM). Database used: IRIS.

ICRP (International Commission on Radiological Protection), 1991, *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Pergamon Press, New York.

ICRP (International Commission on Radiological Protection), 1993, *Protection Against Radon-222 at Home and at Work*, ICRP Publication 65, Pergamon Press, New York.

Napier, B.A., et al, 1988, *GENII - The Hanford Environmental Radiation Dosimetry Software System*, Vols. 1 and 2, Pacific Northwest Laboratory, Richland, Washington.

NIOSH (National Institute for Occupational Safety and Health), 1996, *NIOSH Pocket Guide to Chemical Hazards*, in TOMES®-Toxicological, Occupational Medicine, and Environmental Series (CD-ROM), Database used: NIOSH Pocket Guide.

National Oceanic and Atmospheric Administration (NOAA), 1995, *Carlsbad Airport STAR formatted data for 1990-1994*, National Climatic Data Center, Asheville, N.C.

Rittmann, P.D, 1995, *ISO-PC Version 1.98 User's Guide*, WHC-SD-WM-UM-030, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Strenge, D.L., and S.R. Peterson, 1989, *Chemical Databases for the Multimedia Environmental Pollutant Assessment System (MEPAS®): Version 1*, PNL-7145, Pacific Northwest Laboratory, Richland, Washington.

Strenge, D.L. and Chamberlain, P.J., 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS®): Exposure Pathway and Human Health Impact Assessment Models.*, PNL-10523, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX G
FACILITY ACCIDENTS

This appendix describes the methods used to estimate the health consequences that may result from exposure to radioactive materials and hazardous chemicals from postulated facility accident scenarios during (1) treatment at various U.S. Department of Energy (DOE or the Department) facilities, (2) storage of treated waste at these facilities, and (3) disposal of treated waste at the Waste Isolation Pilot Plant (WIPP). The health consequences analyzed include the carcinogenic and noncarcinogenic effects that may result from the release of radionuclides, volatile organic compounds (VOC), and heavy metals.

The potential consequences of an accident depend on both the type of treatment and the treated waste form, which vary by alternative. Waste could be minimally treated to meet the requirements of the planning-basis Waste Acceptance Criteria (WAC) (as under the Proposed Action, Action Alternative 1, and No Action Alternative 2), thermally treated to meet the Resource Conservation and Recovery Act (RCRA) land disposal restrictions (LDR) (as under all of the Action Alternative 2 subalternatives and No Action Alternative 1 subalternatives), or treated by a shred and grout process (as under Action Alternative 3). Descriptions of the waste treatment methods are included in Chapter 2. Generalized characteristics of the final waste forms from each treatment method are as follows:

- *Waste treated to planning-basis WAC* contains a variety of combustible and noncombustible transuranic (TRU) waste materials in various unconsolidated and consolidated forms.
- *Waste treated thermally* is immobilized in a glass-like, noncombustible, uniformly mixed mass and contains no VOCs, which are removed during the treatment process.
- *Waste treated by a shred and grout process* solidifies liquid waste and small pieces of solid TRU waste into a uniform, concrete-like matrix. For the purposes of analysis, it was assumed that this waste would contain the same headspace volume and concentration of VOCs as waste treated to planning-basis WAC.

G.1 TECHNICAL APPROACH

The following sections describe the technical approach used to calculate potential consequences to human health from exposure to radionuclides and hazardous chemicals.

G.1.1 Radionuclide Impacts

The health consequences from acute exposures to radionuclides from accidental releases were calculated. Total effective dose equivalents (TEDE) were calculated and converted to estimates of latent cancer fatalities (LCF) using dose conversion factors recommended by the International Commission on Radiological Protection (ICRP) and endorsed by the National Council on Radiation Protection and Measurements (NCRP) and federal regulatory bodies. For populations, the number of estimated LCFs is reported. For individuals, the estimated probability of an LCF occurring is reported for the maximally exposed individual (MEI), the maximally exposed noninvolved worker (worker who would not directly handle waste), and the maximally exposed involved worker (worker who would directly handle waste).

The nominal values of lifetime cancer risk for low dose or low-dose rate exposure used in this supplemental environmental impact statement (SEIS-II) are 5×10^{-4} per person-rem for a population of all ages and 4×10^{-4} per person-rem for a working population. These values are based on recommendations of the ICRP (1991) and endorsed by the NCRP (1993). The ICRP concluded that it would be appropriate to use a nominal value of 1×10^{-3} per person-rem effective dose for the lifetime risk of fatal cancer for a population of all ages and a nominal value of 8×10^{-4} per person-rem for a working population for high dose or high-dose rate exposure (ICRP 1991). The ICRP also recommended a Dose and Dose-Rate Effectiveness Factor (DDREF) of two to convert risk estimates after high dose and high-dose rate exposure to those expected after low dose or low-dose rate exposure. For the purposes of estimating radiological consequences from acute exposures due to accidental releases, analyses in SEIS-II do not include the DDREF if the annual effective dose equivalent in any year is greater than 20 rem. This assumption is applied to dose equivalents from low and high linear energy transfer (LET) radiation and may result in overestimating the number of LCFs from a given radiation dose by a factor of two.

Exposure Pathway, Radionuclide, and Waste-Type Screening

Consequences of accidents involving TRU waste are caused mainly by inhalation intakes during the period of plume passage. Consequences from the external dose pathway were also considered, but were determined to be five or more orders of magnitude less than inhalation impacts; therefore, they are not included in the consequences reported here. The ingestion pathway was not considered in the accident analyses because, in the event of an accident, it was assumed that DOE would take action to mitigate potential consequences from ingestion of crops and animal products raised within the area potentially affected by accident releases. Were they to be considered, radiological consequences from the ingestion pathway would only account for 10 percent of the contact-handled (CH) TRU waste consequences from inhalation and about 15 to 30 percent of the remote-handled (RH) TRU waste consequences from inhalation.

The radionuclides most likely to pose the greatest overall risk in the event of a treatment accident were identified by screening. Screening calculations for the inhalation pathway were determined in a manner similar to that of the external dose pathway in Appendix F. Radionuclide-specific inhalation dose factors (DF) were multiplied by the waste volumes and the radionuclide and hazardous chemical inventories (1995 activity) at each treatment waste consolidation site to create an inhalation screening value. Inhalation DFs were obtained from DOE (1988). Five TRU radionuclides – plutonium-238 (Pu-238), plutonium-239 (Pu-239), plutonium-240 (Pu-240), plutonium-241 (Pu-241), and americium-241 (Am-241) – were found to be the largest dose contributors via the inhalation pathway. The plutonium-239 equivalent curies (PE-Ci) limits in the planning-basis WAC were used as a bounding waste radionuclide inventory for evaluating radiological impacts from waste storage and WIPP disposal operations and accidents.

The number of accident scenarios that potentially involve RH-TRU waste container breaches is limited. The main difference between the RH-TRU waste and CH-TRU waste is the presence of larger amounts of fission and activation products (e.g., cesium-137 [Cs-137]/barium-137m [Ba-137m] and cobalt-60 [Co-60]) in RH-TRU waste. These fission and activation products emit penetrating X- and gamma radiation and are more likely to enter human food chains. However, RH-TRU waste containers are constructed to prevent breaching in the event of a severe

consequence accident and, therefore, would be expected to release only small amounts of particulates. Also, RH-TRU waste packages were assumed to be doubly contained in drums and waste canisters.

The average PE-Ci levels of RH-TRU waste are typically less than those of CH-TRU waste. As a result, the radiological consequences of CH-TRU waste accidents will be greater than (and, therefore, will bound) RH-TRU waste accidents.

G.1.2 Hazardous Chemical Consequences

The following sections describe how carcinogenic and noncarcinogenic consequences from VOCs and heavy metals were calculated.

G.1.2.1 Carcinogenic Consequences from Hazardous Chemicals

Carcinogenic consequences from hazardous chemicals are presented as the number of cancers that may occur in an exposed population and as the probability of a cancer occurring in a MEI. Slope factors have been developed by the U.S. Environmental Protection Agency (EPA) to assist in estimating the potential for cancer incidence from a lifetime (estimated to be 70 years) of exposure to a specific hazardous chemical (EPA 1996). Table G-1 presents the slope factors for heavy metals included in SEIS-II. Only cadmium and beryllium were included in SEIS-II analyses for carcinogenic consequences, because slope factors are not available for lead and mercury. Slope factors for VOCs analyzed in SEIS-II are found in Appendix F.

No standard method exists to calculate the carcinogenic risk from an acute (one-time or short-term) intake. SEIS-II analyses used the chronic-exposure slope factors and assumed the total acute intake was averaged over the 70-year lifetime. In practice, then, slope factors were used but specified as the risk per total acute intake.

Table G-1
Carcinogenic Risk Factors for Heavy Metals

Hazardous Chemical	Inhalation Slope Factor [risk per milligram per kilogram per day] [a]	Comment
Cadmium	6.3	Probable human carcinogen. SEIS-II assumes the ingestion slope factor equals the inhalation slope factor.
Beryllium	8.4	Probable human carcinogen.
Lead	Not Available	Probable human carcinogen. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. As a result, development of carcinogenic risk factors using standard methods was not believed to be appropriate.
Mercury	Not Available	Classification as a carcinogen is not possible due to poor database of carcinogenic effects upon which to base a determination.

[a] Inhalation slope factor from Integrated Risk Information System converted risk per microgram per cubic meter to risk per milligram per kilogram per day by assuming a 20 cubic meter per day inhalation rate and an individual body mass of 70 kilograms (EPA 1996).

G.1.2.2 Noncarcinogenic Consequences from Hazardous Chemicals

Two methods were used to estimate the noncarcinogenic consequences from postulated hazardous chemical releases. The first method was to compare the intake estimate to the "equivalent intakes" of the National Institute for Occupational Safety and Health (NIOSH) immediately dangerous to life or health (IDLH) values (NIOSH 1996). The IDLH values, originally developed by NIOSH for emergency response purposes, are air concentrations based on a 30-minute exposure period in which an individual is assumed to inhale 10 cubic meters (353 cubic feet) of contaminated air. The IDLH-equivalent intake level is the quantity of material inhaled during the 30 minutes of exposure at the IDLH concentration. The exposure time of the individuals in the SEIS-II accident scenarios is much shorter than 30 minutes, given the assumptions that involved workers would immediately exit the accident site and that the air concentration is the result of a 1-second release. As a result of the short exposure time, the IDLH-equivalent intake was used as the impact measure reference value rather than the IDLH concentration. IDLH and IDLH-equivalent intake values are presented in Table G-2.

The second method of evaluating noncarcinogenic accident consequences was to calculate and compare the air concentrations to which workers would be exposed to Emergency Response Planning Guidelines (ERPG) developed by the American Industrial Hygiene Association (AIHA). The ERPGs are air concentrations that may be tolerated by an individual for a 60-minute period, defined for three levels of health impacts:

Table G-2
IDLH Values for Facility Accident Noncarcinogenic Consequence Analysis

Hazardous Chemical [a]	IDLH Values [b]	IDLH-Equivalent Intake Values (milligrams)
Benzene (3.25)	500 ppm	16,250
Carbon Tetrachloride (6.39)	200 ppm	12,780
Chlorobenzene (4.68)	1,000 ppm	46,800
Chloroform (4.96)	500 ppm	24,800
1,1-Dichloroethylene (4.03)	Not Determined	----
1,2-Dichloroethane (4.11)	50 ppm	2,060
Ethyl Benzene (4.41)	800 ppm	35,280
Methyl Ethyl Ketone (3.0)	3,000 ppm	90,000
Methylene Chloride (3.53)	2,300 ppm	81,190
1,1,2,2-Tetrachloroethane (7.0)	100 ppm	7,000
Tetrachloroethene (6.89)	150 ppm	10,335
Toluene (3.83)	500 ppm	19,150
Xylene (4.41)	900 ppm	39,690
Beryllium	4 milligrams/cubic meter	40
Cadmium	9 milligrams/cubic meter	90
Lead	100 milligrams/cubic meter	1,000
Mercury	10 milligrams/cubic meter	100

[a] Values in parentheses for VOCs are milligrams per cubic meter per ppm conversion factors for the calculation of the IDLH-equivalent intake.

[b] NIOSH 1996.

- The ERPG-1 air concentration is the "low" health impact level and is defined as the maximum air concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing anything other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor.

- ERPG-2 air concentrations are slightly more hazardous. The ERPG-2 level is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

- ERPG-3 air concentrations indicate a high impact from the exposure. The ERPG-3 level is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening effects. Above ERPG-3 values, an individual may experience or develop a life-threatening effect as a result of a 1-hour exposure.

Analyses using ERPGs are useful in determining if individuals could encounter levels of VOCs that could potentially lead to transient or serious health effects.

The difficulty with using the ERPG approach to evaluate potential consequences from accidental releases is that values have not been defined for all of the hazardous chemicals evaluated in SEIS-II. When no AIHA ERPG value was available, a substitute value was used (Craig et al. 1994). These substitute methods use resources such as time-weighted average (TWA) concentrations and short-term exposure limits (STEL) from the American Conference of Governmental Industrial Hygienists (ACGIH) and IDLHs from NIOSH. Table G-3 presents the ERPG values used in SEIS-II; where no AIHA value was available, the substitute method used is indicated.

The ERPG values were compared to the air concentrations to which an individual would be acutely exposed for the accident scenarios evaluated under treatment, storage, or disposal operations. If the ratio of the air concentration to the ERPG was greater than one, an adverse impact would be expected.

G.1.2.3 Volatile Organic Compound Screening

The 13 VOCs that may be found in TRU waste (see Tables F-1 or F-2 in Appendix F) were screened to determine which were major contributors to carcinogenic and noncarcinogenic impacts. To develop a VOC screening value, VOC impact measures were compared to the VOC container headspace concentration. For example, screening values for carcinogenic impact were determined by multiplying the VOC slope factor by the headspace concentration, while two noncarcinogenic impact screening values were determined by dividing the headspace concentration by the IDLH-equivalent intake and the ERPG-2 values. Those VOCs with the greatest individual impact contribution were included for more detailed accident consequence analyses, with an estimated summed impact of at least 90 percent of the overall VOC impact. The VOCs included in the SEIS-II accident analyses are presented in Sections G.2 (Treatment Accident Scenarios) and G.3 (Storage Accident Scenarios). All 13 VOCs were evaluated for the WIPP disposal accident scenarios (Section G.4).

Table G-3
ERPG Values for Facility Accident Noncarcinogenic Impact Analysis

Chemical Name	ERPG-1 (milligrams/ cubic meter)	ERPG-2 (milligrams/ cubic meter)	ERPG-3 (milligrams/ cubic meter)	Reference
Carbon tetrachloride	130	640	4800	HEHF 1995
Chloroform	500	5000	25,000	HEHF 1995
1,1-dichloroethylene	60 [a]	100 [c]	---	ACGIH 1995
1,2-dichloroethane	120 [a]	200 [c]	200 [d]	ACGIH/NIOSH 1995
Methylene chloride	---	1400	3500	HEHF 1995
Chlorobenzene	140 [a]	230 [c]	4700 [d]	ACGIH/NIOSH 1995
Methyl ethyl ketone	885 [b]	3000 [c]	9000 [d]	ACGIH/NIOSH 1995
1,1,2,2-tetrachloroethane	21 [a]	35 [c]	700 [d]	ACGIH/NIOSH 1995
Toluene	580	770	7700	Craig et al. 1994
Benzene	80	800	3300	HEHF 1995
Ethyl benzene	543 [b]	2200 [c]	3500 [d]	ACGIH/NIOSH 1995
Tetrachloroethene	690	1380	3500	Craig et al. 1994
Xylene	660	880	4400	Craig et al. 1994
Beryllium	0.006 [a]	0.025	0.1	HEHF 1995
Cadmium	0.2	1	10	HEHF 1995
Lead	0.15 [a]	0.25 [c]	100 [d]	ACGIH/NIOSH 1995
Mercury	0.075	0.1	28	Craig et al. 1994

Footnotes indicate the method of calculation of a substitute value: [a] TWA x 3; [b] STEL; [c] TWA x 5; [d] IDLH

G.1.3 Selection of Accident Scenarios

Three scenarios were selected for analysis of treatment and storage accidents: one high-frequency/low-consequence accident, one low-frequency/high-consequence accident, and one natural disaster. These scenarios were selected to offer a wide span of possible accidents, while allowing comparability between alternatives. Though the scenarios change among alternatives, each includes a waste spill, a waste fire or explosion, and an earthquake that would collapse the storage or treatment building. An earthquake was selected as the beyond-design-basis accident for analysis (rather than a plane crash or tornado, for instance), but the risk would be comparable to other beyond-design-basis accidents. The estimated accident frequencies among alternatives and sites were assumed to be identical except for some storage and WIPP disposal accidents involving thermally treated waste, which were lower because of the final waste form. Seismic design guidelines for DOE facilities are based on facility usage categories. For each category, an earthquake hazard level is specified using site-specific seismic hazard data. This process ensures that facilities are designed on a uniform basis for the effects of seismic events, regardless of their locations. A beyond-design-basis earthquake, regardless of accident frequency, must be assumed to defeat all building confinement functions. Buildings are typically constructed to withstand earthquakes. Therefore, the frequency of the beyond-design-basis earthquake scenario was leveled across the country by the assumption that the building would collapse.

Only three scenarios are presented for treatment and storage accidents because no actual facility design or specific facility location has been selected or would be selected as a result of this

supplemental environmental impact statement. Additional site-specific National Environmental Policy Act (NEPA) reviews and safety analyses would be conducted before operations of such facilities would be begun.

At WIPP, no future NEPA reviews are planned before a decision is made on whether to begin disposal operations. For that reason, eight accident scenarios were assessed for WIPP disposal accidents. These accidents include both CH-TRU and RH-TRU waste accidents in the Waste Handling Building and underground.

G.2 TREATMENT ACCIDENT SCENARIOS

This section presents the evaluation of the potential consequences of treatment facility accidents for each of three types of treatment: treatment to planning-basis WAC (under the Proposed Action, Action Alternative 1, and No Action Alternative 2); thermal treatment (under the Action Alternative 2 subalternatives and No Action Alternative 1 subalternatives); and treatment by a shred and grout process (under Action Alternative 3). Accident scenarios were evaluated for each of the treatment alternatives at the major CH-TRU waste treatment sites – Hanford Site (Hanford), Idaho National Engineering and Environmental Laboratory (INEEL), Los Alamos National Laboratories (LANL), Rocky Flats Environmental Technology Site (RFETS), Savannah River Site (SRS), and, for Action Alternative 2C only, WIPP. Ninety-five percent of the existing CH-TRU waste would be treated at the first five sites over a longer period of time than other sites under analysis; thus, these five sites would have the greater risk of accidents across all alternatives. Accident scenarios were also evaluated for the RH-TRU waste treatment sites, Oak Ridge National Laboratory (ORNL) and Hanford under all alternatives and INEEL and LANL under the Proposed Action and Action Alternative 1.

Because no VOC sampling has been conducted for RH-TRU waste, CH-TRU waste and RH-TRU waste VOC headspace concentrations were assumed to be the same. Estimated heavy metal concentrations presented in Appendix A are also the same for all metals except lead, where RH-TRU waste quantities were estimated to be about 100 times those of CH-TRU waste quantities. Heavy metal impacts, however, were estimated to be quite low in all cases, even under conservative accident assumptions. (RH-TRU waste heavy metal impacts could be higher than CH-TRU waste heavy metal impacts as a result of the lead content of RH-TRU waste. It is likely, though, that they would be less than the factor of 100 difference in lead content.)

G.2.1 Inventory

The inventory of materials to be treated that could potentially cause human health impacts includes both radionuclides and hazardous chemicals. Hazardous chemicals that may be present in TRU waste include VOCs and heavy metals. Appendix A presents the description of the radionuclide and hazardous chemical inventories in greater detail.

G.2.1.1 Radionuclide Inventory

Screening calculations were performed to determine which radionuclides were significant contributors to dose at each site. The total inventory of each radionuclide (see Appendix A) was multiplied by the radionuclide dose conversion factor for inhalation. These screening values were then summed over all radionuclides and ranked according to their contribution to the total value. Those radionuclides that cumulatively contributed to more than 90 percent of the total screening

value were selected for further evaluation in the consequence analyses. Nine radionuclides were selected across all of the sites. The mix and inventory of radionuclides varied from site to site; therefore, in order to provide a reasonable upper limit on the TRU waste radionuclide inventory, the radionuclide content of each drum was assumed to be ten times the overall average concentration of that radionuclide at all DOE sites. Only those radionuclides present at a site were evaluated for that site (see Table G-4).

Table G-4
Radionuclide Activity per Drum for Treatment Accident Analyses [a, b]

Radionuclide	Sites Where Radionuclide is a Major Dose Contributor [c]	CH-TRU Waste (Ci/drum) [d]	RH-TRU Waste (Ci/drum)	CH-TRU/RH-TRU Waste Activity Ratio
Pu-238	H, I, L, O, S, W	27.7	0.11	260
Pu-239	H, I, L, O, R, W	11.2	0.35	32
Pu-240	H, R, O	2.2	0.12	18
Pu-241	O	46.2	3.0	16
Am-241	H, I, L, R, O, S, W	7.5	0.3	25
Np-239	O	6.9E-04	-----	-----
Bi-214	O	2.5E-04	-----	-----
Co-60	I	2.0E-03	0.6	3E-3
Ba-137m	H, L	0.025	11.2	2E-3

[a] Maximum estimated drum activities are ten times the average drum activity of all sites.
[b] Analyses were based on 1995 stored volumes and integrated data base radionuclide inventories (DOE 1994b), also cited in Appendix A.
[c] H = Hanford, I = INEEL, L = LANL, R = RFETS, O = ORNL, S = SRS, W = WIPP. Waste treated at ORNL is all RH-TRU waste.
[d] Includes plutonium residue radionuclide inventories.

G.2.1.2 Hazardous Chemical Inventory

Hazardous chemicals that may be present in TRU waste are VOCs and heavy metals. Six VOCs and four metals were evaluated for potential human health consequences from treatment facility accidents.

Volatile Organic Compounds

VOCs were assumed to be present in all TRU waste entering the treatment facilities; therefore, screening calculations (see Section G.1.2.3) were used to determine those VOCs with the greatest potential consequence from treatment facility accidents (see Table G-5). VOC headspace concentration estimates were made using INEEL and RFETS sampling data from CH-TRU waste and applied to the various waste matrix categories at the different sites (Appendix A). The average concentration across all sites was then calculated and multiplied by 10 to account for the presence of maximum concentrations in individual drums. VOCs were assumed to be present in all waste treated to planning-basis WAC and the shred and grout process; no VOCs, however, would be present in waste after thermal treatment (Action Alternative 2). The presence of a maximum concentration of a specific VOC has no bearing on whether another VOC will be found in the same container at a high concentration. The VOC headspace concentrations assumed to be present for treatment accident analyses are presented in Table G-5.

Table G-5
VOC Headspace Concentrations for Treatment Accident Analyses [a]

VOC	Headspace Concentration (ppmv)
Carbon tetrachloride	1,849
Methylene chloride	6,621
1,1,2,2-tetrachloroethane	3,357
Benzene	76
Tetrachloroethene	71
Xylene	256

[a] VOC concentrations are ten times the overall average VOC concentrations of all sites.

Heavy Metals

The inventory of metals in TRU waste was derived from estimates developed for the WIPP Safety Analysis Report (SAR) (DOE 1995b). The SAR assumed a conservatively high concentration of metals in its analysis of a waste fire, and the waste forms used were the result of treatment to planning-basis WAC. These values were used as the basis for estimating the heavy metal inventories from thermally treated waste and waste that had been treated by the shred and grout process (see Appendix A.5.1). Inventories of heavy metals that were assumed to be uniformly mixed in each drum of TRU waste are presented in Table G-6.

G.2.2 Treatment Accident Analysis

Three accident scenarios were analyzed for each of the three treatment methods: two operational accidents and one natural disaster accident. Operational accidents were chosen to include a high-frequency/low-consequence scenario and a low-frequency/high-consequence scenario. The estimated annual frequencies of occurrence for treatment accidents were taken from source documents and are presented in Table G-7. When a frequency range was identified, the highest value (i.e., the greater probability) was used in the analysis.

Criticality concerns were not addressed by a formal analysis (see the text box on criticality in Chapter 5), because of the low concentration of radionuclides within these waste materials. A criticality event would require the possibility of a chain reaction for neutron generation, which can only occur if fissionable material in a critical geometry becomes available. With the waste materials at hand, there is not enough fissionable material in existence to achieve a critical

Table G-6
Heavy Metal Concentrations in TRU Waste for Treatment Accident Analyses [a]

Hazardous Metals	CH-TRU Waste (kilograms/drum)	RH-TRU Waste (kilograms/drum) [a]
Lead	1.0	97
Beryllium	0.025	0.025
Cadmium	4E-4	4E-4
Mercury	0.43	0.43

[a] Based on information presented in Table A-45. One drum-equivalent contains 0.208 cubic meters of waste.

Table G-7
Annual Frequencies of Occurrence for Treatment Accidents

SEIS-II Accident Scenario	Accident Description	Estimated Frequency
Waste Treated to Planning-Basis WAC		
T1	Waste Spill	1E-2
T2	Waste Drum Fire	1E-4
T3	Earthquake	1E-5 or less
Waste Thermally Treated		
T4	Waste Drum Failure	1E-2
T5	Steam Explosion in Glass Melter	1E-4
T6	Earthquake	1E-5 or less
Waste Treated by Shred and Grout		
T7	Waste Spill	1E-2
T8	Fire in Shredder	1E-4
T9	Earthquake	1E-5 or less

configuration. The criticality question has been previously addressed (DOE 1987) in the context of an environmental impact statement discussing disposal of high-level wastes, TRU wastes, and tank wastes at Hanford. It was concluded that there is no credible basis for a criticality potential. Earlier evaluations (Wallace et al. 1980) have come to the same conclusion.

G.2.2.1 Accidents During Treatment to Planning-Basis WAC

Treatment of TRU waste to planning-basis WAC is the treatment option for the Department's Proposed Action, Action Alternative 1, and the newly generated waste in No Action Alternative 2. Treatment to planning-basis WAC, under each of these alternatives, would be conducted at the site where the waste is currently stored or would be generated. Each site was assumed to have its own on-site waste treatment facility.

Treatment to planning-basis WAC may include some or all of the following waste management unit operations: receiving; monitoring and sampling waste for radioactive and hazardous chemicals; opening of drums or boxes; transfer of contents to a conveyor belt for sorting; cutting large objects to fit the shredder; shredding; transfer of contents to a conveyor belt for sorting; assaying; filling a drum; closing of a drum with a vented lid; labeling; frisking; and certifying that applicable packaging and transportation criteria have been met. Subsequently, the treated and repackaged material would be consolidated at the 10 largest generator-storage sites to await shipment to WIPP, or, in the case of No Action Alternative 2, would remain in storage at the 10 largest generator-storage sites.

As stated above, larger nonmetallic objects might be shredded during the treatment process so that a reduced volume could be stored in a drum. Thus, if shredding is performed, the sorting area might receive two feed streams: one directly from the drum emptying station and the other from the shredder. The sorting process would probably include coarse separation of metals from nonmetals. Magnets on the front end of the sorter would remove ferrous materials from the waste stream, reducing the risk of sparking in the shredder. Nonmetallic materials might be compressed in the final package drum while metallic parts, if not decontaminated and recycled as scrap, might be packaged without further volume reduction. For CH-TRU waste, the facility would probably use gloveboxes with HEPA (high efficiency particulate air) filters around the drum opening station, the

conveyor belt, the shredder, and the sorting area. Although numerous options for treatment processes exist (DOE 1995a), no decision on the process has been made.

The following discussion describes treatment accidents involving CH-TRU waste. Accident analyses for RH-TRU waste would be similar to those for CH-TRU waste except that treatment would be performed in a hotcell with an extra HEPA filter in place, thereby reducing the impact by a factor of 1×10^{-3}. This is a conservative estimate of releases for RH-TRU waste releases, because hotcells would be designed with multiple HEPA filters and enhanced structural integrity and thus would likely release far fewer contaminants to the environment. RH-TRU waste-specific concentrations were used in the RH-TRU waste analysis.

Accident Scenario T1 - Waste Spill

A waste spill is an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a drum about to be filled with TRU waste would be mispositioned, resulting in a spill of dry, sorted waste materials from the conveyor belt onto the operating floor. The spill volume was assumed to be an entire drum volume (DOE 1990).

The airborne fraction of solids and metals was estimated at 1×10^{-3}, with a respirable fraction of 0.1. The respirable fraction would be carried into the ventilation system, for which a filter transmission factor of 1×10^{-3} was assumed. Credit for only one HEPA filter is taken. In the design, it is likely that there would be several levels of HEPA filters, which would decrease the release by several orders of magnitude (i.e., 1×10^{-6} protection factor).

VOCs and other gaseous components previously attached to the material would have largely outgassed into the gloveboxes during the sorting process; still, a gaseous release fraction of 1.0 was assumed. All VOCs were assumed to be respirable and to completely pass through the HEPA filter.

The involved workers, positioned outside of the process enclosure, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T2 - Waste Drum Fire

A waste drum fire is not an anticipated event during the lifetime of any of the waste treatment facilities, with an estimated annual occurrence frequency of about 1×10^{-4}. In this accident scenario, a waste drum was postulated to spontaneously erupt into flames as it was opened but before it was emptied onto the conveyor belt for sorting.

It was postulated that 10 percent of the contents of the waste container would be combustible because all sites have average waste combustible fractions ranging from 4 to 12 percent. Of the combustible fraction, which conservatively includes all of the metals, 5×10^{-4} is assumed to become airborne, all of which is respirable. Of the noncombustible fraction (0.9), 6×10^{-3} becomes airborne, 0.01 of which is respirable (DOE 1994a). All of the metal was conservatively assumed to be combustible. A HEPA filter transmission factor of 1×10^{-3} was assumed. All VOCs were assumed to be consumed by the fire.

The involved workers, positioned outside of the process enclosure, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T3 - Earthquake

An earthquake was postulated to be a beyond-design-basis natural event, with an estimated annual frequency of 1 x 10^{-5} or less. In this accident scenario, an earthquake would cause the collapse of the waste treatment facility and the loss of electrical power.

The total material at risk for this accident scenario was the contents of 21 drums, half of one day's process inventory. Although some of the volatile gaseous components would have outgassed into the gloveboxes as the material moved through the treatment process facility, an in-facility release fraction of 1.0 was assumed for the volatile components. The solids and metals fraction of the entire in-process inventory becoming airborne was estimated at 1 x 10^{-3}, of which the respirable fraction is assumed to be 0.1 (DOE 1994a). A building removal factor of 0.5 was assumed (PNNL 1996), so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion, based on the above described total in-process inventory. During the events of this scenario, some involved workers would probably be killed during the collapse of the building.

A summary of the parameter values for the three accident scenarios during treatment to planning-basis WAC is shown in Table G-8.

Table G-8
Accident Analysis Parameters for Waste Treatment to Planning-Basis WAC for the Proposed Action, Action Alternative 1, and No Action Alternative 2

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Airborne Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Factors (R)
T1	Waste Spill	1	0.001 VOCs: 1.0	0.1 VOCs:1.0	0.001 VOCs: 1.0	N/A
T2	Waste Drum Fire (c) combustible (nc) non-combustible	1	5E-4 (c) [a] 6E-3 (nc) [a] VOCs: 0	1.0 (c) 0.01 (nc)	0.001	0.1 (c) 0.9 (nc)
T3	Earthquake	21	0.001 VOCs: 1.0	0.1 VOCs:1.0	N/A	0.5 VOCs: 1.0

[a] (c) = combustible fraction; (nc) = noncombustible fraction

N/A = Not Applicable

G.2.2.2 Accidents During Thermal Treatment

This treatment option applies to all of the subalternatives of Action Alternative 2 and both of the subalternatives of No Action Alternative 1, in which all CH-TRU and RH-TRU waste materials would be thermally treated to meet the LDRs.

The process temperature for thermal treatment would probably range from 2,000 to 3,000 degrees Celsius. At these temperatures, all organic constituents would be disassembled and reoxidized, and thereby converted into mineral (nonorganic) substances. Depending on how much glass frit is

added to this process, the resulting material might be predominantly glass or predominantly metal slag. If the glass configuration is selected, contiguous glass logs containing 25 percent by mass of waste oxides (Mishima et al. 1986) can be produced by pouring the melt directly into cylindrical carbon steel canisters, typically of 0.61-meter (2 feet) diameter and 3-meter (10 feet) length. A comprehensive compilation of the different vitrification processes (DOE 1995a) has been published, including vitrification with combustion melting; continuous vitrification; vitrification with electric arc melting; vitrification with electric resistance melter; vitrification with fossil fuel fired melting, induction melting, joule heated melting, or microwave melting; plasma arc furnace; and others.

As the feed stream enters the glass pool, evaporation renders the feed materials dry. In a calcining phase, all organic materials decompose to form oxides and enter the glass pool. The relatively cool blanket of freshly formed oxides and unreacted materials that cover the melt is expected to condense most of the escaping volatile radionuclides and refluxes them to the melt. The resulting gaseous effluent will contain all of the remaining moisture, oxides of nitrogen (NO_X), carbon dioxide (CO_2), and some of the oxides of sulfur (SO_X) in the melter feed and, during infrequent periods of abnormal blanket distribution, up to 5 percent of the cesium (Mishima et al. 1986).

The thermal treatment option involves the following waste management unit operations: cutting larger objects to fit the shredder; shredding, if required; mixing the glass frit into the feed stream; routing the feed stream into the glass melter; pouring the final glass melt into the log forms; letting the logs cool to ambient temperature; packaging; labeling; frisking; and certifying that applicable packaging and transportation criteria are being met. Subsequently, the treated materials would remain at the treatment sites to await shipment to WIPP or, in the case of No Action Alternative 1, would remain indefinitely stored at the treatment sites.

The following discussion describes treatment accidents involving CH-TRU waste. Accident analyses for RH-TRU waste would be similar to those for CH-TRU waste except that treatment would be performed in a hotcell with an extra HEPA filter in place, thereby reducing the impact by a factor of 1×10^{-3}. This is a conservative estimate of RH-TRU waste releases, because hotcells would be designed with multiple HEPA filters and enhanced structural integrity and thus would likely release far fewer contaminants to the environment. RH-TRU waste–specific concentrations were used in the RH-TRU waste analysis.

Accident Scenario T4 - Waste Drum Failure

A waste drum failure is an anticipated event during the lifetime of the thermal treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a waste drum would be breached (i.e., accidentally dropped in handling operations) before encapsulation (DOE 1982). DOE guidance (1994a) indicates that the potential release from vitrified waste would be negligible. For the purpose of this analysis, it was assumed that the rupture would be equivalent to a breach caused by the overpressurization of heated gases in the freespace of a container with cooled, vitrified waste.

In this scenario, a 14-drum equivalent batch of thermally treated waste was assumed to be placed in a container and, through operator error, ruptured by a concussive impact. A fraction (0.035 percent) of the fines surrounding the waste could be expelled during the breach. Of this fraction, 0.1 becomes airborne and 0.7 is respirable. A filter factor of 1×10^{-3} was assumed for the

ventilation system. The fines could be made up of radioactive or metal waste. No VOCs were assumed to be released in this scenario because they would have been consumed in the thermal treatment process.

The involved workers, positioned outside of the process enclosure, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T5 - Steam Explosion in Glass Melter

A steam explosion in a glass melter is not an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 1×10^{-4}. In this accident scenario, failure of a cooling system or human error would cause water to become entrapped in a space where molten glass is poured, resulting in a steam explosion. Thus, placing liquid water in contact with molten glass causes flashing of trapped water into vapor. This phenomenon might occur in the melter or when the glass melt is poured into the log form. The potential release from vitrified waste is close to negligible; however, for the purpose of this analysis, it was conservatively assumed that thermal stress on reactive substances would apply to this scenario (DOE 1994a).

In a scenario developed by Mishima et al. (1986) that had been evaluated previously (DOE 1982), a steam explosion was postulated to occur in the glass melter that was assumed to contain about 1,000 liters (5.6 drum equivalents) of molten product. The shock of the explosion would fragment the molten glass into a large number of small particles that would scatter throughout the operating area. It was assumed that a mass fraction of approximately 0.01 of the fragmented glass would become airborne, all be respirable, and be carried into the ventilation system, for which a filter factor of 1×10^{-3} was assumed. Although it is uncertain how volatile metals such as hot mercury and lead would be handled in this treatment train, 80 percent of the mercury and 10 percent of the lead were postulated to volatilize in the explosion. All VOCs were assumed to be consumed in the melting process.

Because of the serious nature of the accident, any involved workers present at the time of the accident were assumed to be fatally injured. No other type of consequences were calculated for involved workers.

Accident Scenario T6 - Earthquake

An earthquake was postulated to be a beyond-design-basis natural event, with an estimated annual frequency of 1×10^{-5} or less. In this accident scenario, an earthquake causes the collapse of the waste treatment facility and the loss of electrical power. The total material at risk was postulated to be the contents of 125 drums, which constitutes one half of the day's assumed process inventory. Of the 125 drums, 35 are assumed to be in a molten phase and 90 are assumed to be cooling in their canisters. Although some of the volatile gaseous components would have outgassed into the gloveboxes as the material moved through the treatment process facility, an in-facility release fraction of 1.0 was assumed for the volatile components in 63 of the 125 drums. Although the release would likely be negligible for molten glass, the airborne and respirable fractions were developed for the disturbed molten metal with high surface turbulence (DOE 1994a). The airborne solids fraction of the entire in-process inventory was estimated to be 0.01, of which the respirable fraction was assumed to be 1.0. The cooling fraction (90 drums) is not likely to release any glass solids; however, a fraction (0.035 percent) of the fines surrounding the waste was assumed to be expelled as a result of the earthquake. Of this fraction, 0.1 becomes airborne and 0.7 is respirable.

A building removal factor of 0.5 was assumed (PNNL 1996), so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion. During the events of this scenario, involved workers would probably be killed by falling debris as the building collapses.

A summary of the parameter values for the three accident scenarios during thermal treatment is shown in Table G-9.

Table G-9
Accident Analysis Parameters for Thermal Treatment of Waste for the Action Alternative 2 and No Action Alternative 1 Subalternatives

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Airborne Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Factors (R)
T4	Waste Drum Failure	14.0	0.1 VOCs: 0	0.7	0.001	3.5E-4
T5	Steam Explosion in Glass Melter	5.6	0.01 VOCs: 0	1.0	0.001	Lead: 0.1 Mercury: 0.8
T6	Earthquake	35 molten 90 cooled [a]	0.01 molten 0.1 cooled	1.0 molten 0.7 cooled	0.5	N/A molten 3.5E-4 cooled

[a] Half of the drums at risk were assumed to be unprocessed and awaiting treatment (still containing VOCs).

N/A = Not Applicable

G.2.2.3 Accidents During Shred and Grout Treatment

This treatment option requires shredding of the waste materials into relatively uniform small pieces, (about 4 centimeters [1.6 inches]) to ensure a reasonable measure of structural integrity of the grout blocks. Any particulates and free liquids in the waste material are immobilized in this process, and any pyrophoric or corrosive characteristics of the TRU waste are eliminated. Compared to the treatment to planning-basis WAC option, the shred and grout process offers the advantage of immobilizing the waste materials and significantly reducing the gas generation rate (as does the thermal treatment process) but without having to apply the energy intensive vitrification process. However, the disadvantage of this option is that the waste volume is significantly increased by adding the grout.

A site-specific NEPA review would be performed for each site if a specific shred and grout process were selected for TRU waste treatment. The accident analyses assumed that the process design is comparable to the commercially available technology which has been successfully demonstrated at Hanford.

The following discussion describes treatment accidents involving CH-TRU waste. Accident analyses for RH-TRU waste would be similar to those for CH-TRU waste except that treatment would be performed in a hotcell with an extra HEPA filter in place, thereby reducing the impact by a factor of 1×10^{-3}. This is a conservative estimate of RH-TRU waste releases because hotcells would be designed with multiple HEPA filters and enhanced structural integrity and thus would likely release far fewer contaminants to the environment. RH-TRU waste–specific concentrations were used in the RH-TRU waste analysis.

Accident Scenario T7 - Waste Spill

A waste spill is an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a malfunction of the automatic equipment causes a drum about to be filled to be mispositioned, resulting in a spill of wet grouted waste materials onto the operating floor. The involved workers, positioned outside of the process enclosure, were assumed to exit the facility immediately and thus would escape impact.

This scenario is described by parameters for a slurry of 40 percent solids (DOE 1994a). The fraction of solids and metals becoming airborne in this scenario was estimated at 5×10^{-5}, with a respirable fraction of 0.8. The respirable fraction would be carried into the ventilation system, for which a filter factor of 1×10^{-3} was assumed. For VOCs and other gaseous components, a gaseous release fraction of 1.0 was postulated.

Accident Scenario T8 - Fire in the Shredder

In this accident scenario, a fire would be initiated by either an explosion of fine particulates generated by the shredding process or a spontaneous combustion of occluded pyrophoric material exposed to air by the shredder action. Because sparks generated during shredding of metal would be anticipated to cause small fires in the shredder, a fire suppression system was assumed to be in place. Failure of the fire suppression system and subsequent fire involving all of the contents in the shredder was estimated to be an extremely unlikely event, with an estimated annual occurrence frequency of about 1×10^{-4}.

It was postulated that 20 drums of material would be in the shredder or in the hopper and that the fire would spread to include all 20 drums and their contents. Ten percent of the contents of the waste container were assumed to be combustible because all sites have average waste combustibles fractions ranging from 4 to 12 percent. Of the combustible fraction, 5×10^{-4} particulates would become airborne and respirable, while 6×10^{-3} of the noncombustible particulates would become airborne, 0.01 of which would be respirable (DOE 1994a). A filter transmission factor of 1×10^{-3} was assumed. All VOCs were assumed to be consumed by the fire.

The involved workers, positioned outside of the process enclosure, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T9 - Earthquake

An earthquake was postulated to be a beyond design-basis-natural event, with an estimated annual frequency of 1×10^{-5} or less. In this accident scenario, an earthquake would cause the collapse of the waste treatment facility and the loss of electrical power. The total material at risk for this accident scenario would be the contents of 66 drums, which constitutes the assumed process inventory, half of which is in the shredder and half is in a slurry form. The shredded fraction of the in-process inventory becoming airborne was estimated at 1×10^{-3}, of which the respirable fraction was assumed to be 0.1. The slurry fraction of the in-process inventory becoming airborne was estimated at 5×10^{-5}, of which the respirable fraction was assumed to be 0.8. A building removal factor of 0.5 was assumed (PNNL 1996), so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion, based on the above described total in-process inventory. All the metals were conservatively assumed to be in the shredder. Although some of

the volatile gaseous components would have outgassed into the process enclosures as the material moved through the treatment process facility, a release fraction of 1.0 was assumed for the volatile components. During the events of this scenario, it would be expected that some involved workers would be killed by falling debris.

A summary of the parameter values for the three accident scenarios during shred and grout treatment is shown in Table G-10.

Table G-10
Accident Analysis Parameters for Shred and Grout Treatment of Waste for Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Airborne Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Factors (R)
T7	Waste Spill	1	5E-05 VOCs: 1.0	0.8 VOCs: 1.0	0.001 VOCs: 1.0	N/A
T8	Fire in the Shredder	20	5E-04 (c) [a] 6E-03 (nc) [a] VOCs: 0	1.0 (c) [a] 1E-02 (nc) [a]	0.001	0.1 (c) [a] 0.9 (nc) [a]
T9	Earthquake	66	0.001 (shredder) 5E-5 (slurry) VOCs: 1.0	0.1 (shredder) 0.8 (slurry) VOCs: 1.0	0.5	0.5 (shredder) 0.5 (slurry) VOCs: 1.0

[a] (c) = combustible fraction; (nc) = noncombustible fraction.

N/A = Not Applicable

G.2.2.4 Source Term Analysis

The radionuclide and hazardous chemical source terms were estimated based on Equation G-1 shown below:

$$S = (N)(Q)(R)(f_{rel})(f_{resp})(f_{HEPA}) \qquad \text{(Equation G-1)}$$

where

S = source term (Curies [Ci] or kilograms)

N = number of containers involved

Q = radionuclide or heavy metal inventory of a waste container (from Appendix A)

R = factors accounting for other removal mechanisms, such as fraction of drum(s) at risk or volatilization of metals

f_{rel} = fraction of the contents released from the container(s)

f_{resp} = fraction of the spilled or resuspended contents that are respirable-sized particles

f_{HEPA} = fraction of material that passes through the treatment facility HEPA filters and is released to the environment

The number of waste drums or containers at risk during an accident (N) is specific to each scenario and is easily determined for the higher frequency accidents. In most cases, N equals 1 drum. Special consideration was given to the earthquake analyses because of the catastrophic nature of the disaster and the potentially large inventories at risk. It was necessary to find the alternative-specific site that would process the maximum inventory over the course of the 35-year treatment period. In all cases but Action Alternative 2C, the site with the maximum inventory would be Hanford. In Action Alternative 2C, WIPP would have the highest processing inventory. This inventory was then analyzed on a daily basis over the course of 35 years with assumed operational efficiencies of 75 percent for treatment to planning-basis WAC, 60 percent for thermal treatment, and 50 percent for the shred and grout process. It was then postulated that workers could on average open five drums an hour and add them to the treatment batches. From these assumptions, it could be determined that thermal treatment would require the most process lines and treatment to planning-basis WAC would require the least. Assuming further that two batches were treated each day for thermal and shred and grout treatments, that treatment to planning-basis WAC was continuous, and that an earthquake would only put one batch at a time at risk, it was possible to determine the number of drums in each earthquake scenario.

G.2.3 Exposure Analysis

As noted earlier, the potential inhalation doses would be much greater than the potential external doses, so only the doses from inhalation are presented here. Radiation doses were estimated at each site for radionuclides determined to be important dose contributors. Potential radiation doses to receptors were calculated using Equation G-2, then converted to the estimated number of LCFs in exposed populations or the estimated probability of an LCF for an individual.

$$\text{Dose}_{inh} = \sum_i \left(\text{DCF}_i \times S_i\right) \times \frac{E}{Q} \times 20 \times 1.0 \text{ x } 10^6 \times \frac{1}{86{,}400} \qquad \text{(Equation G-2)}$$

where

Dose_{inh} = total inhalation dose to a receptor from all radionuclides (rem)

DCF_i = inhalation dose conversion factor for radionuclide i (rem/microcurie [µCi] inhaled)

S_i = source term of radionuclide i released to the environment (Ci)

E/Q = atmospheric dispersion at a point downwind where the receptor is located (seconds/cubic meter)

20 = breathing rate (cubic meters/day)

1.0×10^6 = conversion factor (µCi/Ci).

1/86,400 = conversion factor (day/second).

Dose conversion factors (DCF) were taken from *Internal Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988) for internal dose rates. Where there was a choice, as in the case of inhalation DCFs, the highest value was used in the analysis.

Atmospheric dispersion (E/Q) values for acute elevated point-source releases were calculated using the GENII computer code (Napier et al. 1988). Near-field dispersion from acute diffuse ground-level releases (following earthquakes) was calculated using computer spreadsheets. E/Q values were calculated for the nearest public access point for the MEI, the maximum population-weighted sector for populations, and the point of highest concentration for the maximally exposed noninvolved worker. The consequences to exposed populations are presented in Table G-11, and the consequences to the MEIs and noninvolved workers are presented in Table G-12. Release heights from all facilities were assumed to be 10 meters (33 feet) from the ground surface for all accidents except the catastrophic earthquakes, where releases were assumed to be at ground level for the MEI and noninvolved worker receptors. The population weighted E/Q for the catastrophic accident was based on a release height of 10 meters (33 feet) because it was slightly more conservative. It was further assumed that the location of the facility did not depend on the treatment technology.

For consequences from an acute, diffuse, ground-level release following an earthquake to the maximally exposed noninvolved worker, the near-field atmospheric dispersion was calculated using a computer spreadsheet. Gaussian plume models sometimes used for such calculations assume a point source release and are not designed for such near-field (< 1 kilometer) calculations. Meteorological data were available only for elevated releases. Use of the Gaussian plume to calculate E/Q for these cases would result in unrealistically conservative (low) atmospheric dispersion, significantly overestimating consequences to the maximally exposed noninvolved worker.

Instead, contaminants were assumed to be released from the earthquake into an area representative of a small building cross-section (in this case, 30 meters [100 feet] wide by 10 meters [33 feet] high). The cross-sectional area of the contaminant plume was assumed to remain unchanged from these dimensions as it passed over the noninvolved worker at a windspeed of 1 meter (3.3 feet) per second. The worker was assumed to be present for the entire period of plume passage, breathing at

Table G-11
Exposed Population Locations, Sizes, and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis

Site	Population Sector	Population-Weighted E/Q (seconds/cubic meter)	80-kilometer (50-mile) Sector Population
Hanford	SE	1.1	98,865
INEEL	E	0.055	75,162
LANL	ENE	0.48	10,381
RFETS	SE	2.2	180,867
ORNL	E	1.6	214,419
SRS	WNW or NW	0.16	194,597 (WNW), 111,899 (NW)
WIPP	W	0.061	25,629

Table G-12
MEI and Noninvolved Worker Locations and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis

Site	Facility Location	MEI Location	Ground-Level E/Q [a]	10-meter E/Q [a]	Noninvolved Worker Location [b]	Ground-Level E/Q [a]	10-meter E/Q [a]
Hanford	200 W Area	4,200 meters WSW	6.2E-4	2.8E-4	100 meters S	3.3E-3	1.8E-3
INEEL	RWMC	4,000 meters ENE	2.9E-5	2.3E-5	100 meters S	3.3E-3	4.0E-4
LANL	TA54	500 meters NNE	9.2E-4	6.5E-4	100 meters W	3.3E-3	1.4E-3
RFETS	Center of Site	2,600 meters NNW	1.4E-4	1.3E-4	300 meters N	3.3E-3	6.4E-4
ORNL	Y-12	720 meters NNW	1.6E-3	1.2E-3	100 meters SW	3.3E-3	1.4E-3
SRS	E Area	12,000 meters NNW	1.8E-5	8.9E-6	100 meters WSW	3.3E-3	8.7E-4
WIPP	WIPP	300 meters S	2.7E-3	6.5E-4	300/100 m S (10 m/GL) m	3.3E-3	6.5E-4

[a] Units are in seconds per cubic meter.
[b] Location of the noninvolved worker changes with release height.

a rate of 3.33×10^{-4} cubic meters per second (1.18×10^{-2} cubic feet per second), the rate for light activity in ICRP 23 (ICRP 1975). The calculated E/Q is 3.3×10^{-3} seconds per cubic meter (0.12 seconds per cubic foot), as shown in Table G-12. The source term was determined as discussed in Sections G.2.1.1 and G.2.2.

Exposure to hazardous chemicals and metals was evaluated on both a carcinogenic and noncarcinogenic basis. The total risk summed over all carcinogens was analyzed for both chemicals and metals across populations or individuals. For noncarcinogenic impacts, the intake of a specific hazardous chemical was compared to the IDLH-equivalent intake and the ERPG-2 value.

For hazardous chemicals, both VOCs and heavy metals impacts were evaluated using Equation G-3 below for carcinogens and Equations G-4 and G-5 for noncarcinogens.

$$\text{CarcRisk} = \frac{E}{Q} \times S \times \text{SlopFctr} \times 20 \times \frac{1}{86{,}400} \times \frac{1}{(70 \times 70 \times 365.25)} \qquad \text{(Equation G-3)}$$

where

CarcRisk = Risk of contracting cancer due to exposure to carcinogenic materials

S = Source term or the total release of hazardous chemical (milligrams)

SlopFctr = Carcinogenic slope factor or the cancer risk per unit intake (kilograms-day/milligrams)

20 = breathing rate (cubic meters/day)

1/86,400	=	conversion factor (day/second)
70	=	mass of reference adult (kilograms)
70	=	lifespan of reference individual (years)
365.25	=	(days/year)

$$IDLHF = \frac{\left(\frac{E}{Q} \times S \times 20 \times \frac{1}{86{,}400}\right)}{IDLH_{eq}} \qquad \text{(Equation G-4)}$$

where

IDLHF	=	the comparison of a worker's intake to the level at which a hazardous material is immediately dangerous to life or health if exposed for 30 minutes
$IDLH_{eq}$	=	the equivalent amount that a worker would inhale if exposed for the entire 30-minute period at the IDLH level
20	=	breathing rate (cubic meters/day)
1/86,400	=	conversion factor (days/second)

$$ERPGF = \frac{\left(\frac{E}{Q} \times S\right)}{ERPG\text{-}X} \qquad \text{(Equation G-5)}$$

where

ERPGF	=	comparison of the air concentration at the worker's location to the level at which emergency response protection guides take effect
ERPG-X	=	the emergency response protection guide levels where X = 1, 2, or 3, and

where

ERPG-1	=	the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor

ERPG-2 = the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

ERPG-3 = the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects

Evaluation of the noncarcinogenic chemical impacts results in a value that is compared to 1.0. If the impact value is less than 1.0, then a noncarcinogenic impact is unlikely to occur. If the value is greater than 1.0, then a noncarcinogenic impact may occur and additional investigation or mitigation measures may be necessary.

G.2.4 Consequences of Treatment Accidents

Consequences of treatment accidents were calculated for the exposed off-site population, the MEI, and the maximally exposed noninvolved worker for each of the potentially affected CH-TRU and RH-TRU waste treatment sites (Hanford, INEEL, LANL, RFETS, ORNL, SRS, and, for Action Alternative 2C only, WIPP). Consequences to the maximally exposed involved worker were addressed qualitatively. As noted earlier, inhalation would be the dominant exposure pathway and was considered for consequences from exposure to radionuclides, VOCs, and heavy metals. Acute releases were assumed to be dispersed in one direction, so population impacts were estimated for a single, maximally exposed, 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally-impacted sector, considering both the change in air concentration over distance and the population distribution in the sector.

Radiological impacts would be greater than impacts from VOCs or heavy metals for all types of treatment accidents evaluated, due to increased potential for radiation-related LCFs. No cancer incidence would be expected from exposure to hazardous chemicals under any of the alternatives. Some life-threatening toxicological effects could occur to MEIs during the postulated earthquake events.

G.2.4.1 Treatment Accident Consequences for the Proposed Action, Action Alternative 1, and No Action Alternative 2

The consequences of treatment accident scenarios for waste treated to meet the planning-basis WAC are shown in Tables G-13 to G-15 and are discussed below for the population, MEI, noninvolved worker, and involved worker. These accident analyses apply to the Proposed Action, Action Alternative 1, and No Action Alternative 2. Radiological consequences from accidents during treatment to planning-basis WAC would be lower than consequences from the other two types of waste treatment. Potential consequences from hazardous chemicals, both carcinogenic and noncarcinogenic, would be low in all cases.

The potential radiological consequences from RH-TRU waste treatment accident scenarios would be the greatest at the ORNL site for all cases; however, they would be 4 to 5 orders of magnitude less than the consequences from CH-TRU waste treatment accidents.

Table G-13
Radiological Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC

Site		Accident Scenario T1 (Waste Spill)		Accident Scenario T2 (Drum Fire)		Accident Scenario T3 (Earthquake)	
CH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Hanford	0.5	2E-4	0.5	3E-4	5,200	3
	INEEL	0.03	1E-5	0.03	1E-5	300	0.1
	LANL	0.2	1E-4	0.2	1E-4	2,200	1
	RFETS	0.5	3E-4	0.6	3E-4	5,700	3
	SRS	0.05	2E-5	0.05	2E-5	500	0.2
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	1E-4	6E-8	1E-4	7E-8	3	1E-3
	INEEL	1E-5	6E-9	1E-5	6E-9	0.2	8E-5
	LANL	3E-4	1E-7	3E-4	1E-7	4	2E-3
	RFETS	3E-5	2E-8	3E-5	2E-8	0.4	2E-4
	SRS	3E-6	1E-9	3E-6	1E-9	0.06	3E-5
	Maximally Exposed Noninvolved Worker						
	Hanford	1E-3	4E-7	1E-3	4E-7	20	9E-3
	INEEL	2E-4	1E-7	3E-4	1E-7	30	0.01
	LANL	7E-4	3E-7	7E-4	3E-7	20	9E-3
	RFETS	2E-4	8E-8	2E-4	8E-8	10	5E-3
	SRS	3E-4	1E-7	3E-4	1E-7	10	6E-3
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text
RH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Hanford	1E-5	5E-9	1E-3	5E-7	0.1	6E-5
	INEEL	5E-7	2E-10	2E-3	1E-6	5E-3	3E-6
	LANL	3E-6	1E-9	4E-6	2E-9	3E-2	2E-5
	ORNL	3E-5	1E-8	5E-3	2E-6	0.3	1E-4
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	3E-9	1E-12	3E-7	1E-10	6E-5	3E-8
	INEEL	2E-10	1E-13	9E-7	5E-10	3E-6	1E-9
	LANL	4E-9	2E-12	5E-9	4E-12	6E-5	3E-8
	ORNL	2E-8	1E-11	3E-6	2E-9	3E-4	1E-7
	Maximally Exposed Noninvolved Worker						
	Hanford	2E-8	9E-12	2E-6	7E-10	5E-4	2E-7
	INEEL	4E-9	2E-12	2E-5	6E-9	4E-4	2E-7
	LANL	1E-8	4E-12	1E-8	5E-12	3E-4	1E-7
	ORNL	3E-8	1E-11	4E-6	2E-9	8E-4	3E-7
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text

Table G-14
Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC

Site	Accident Scenario T1 (Waste Spill)		Accident Scenario T2 (Drum Fire)		Accident Scenario T3 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	1E-7	3E-12	0	2E-11	2E-6	3E-8
INEEL	6E-9	2E-13	0	8E-13	1E-7	2E-9
LANL	5E-8	1E-12	0	7E-12	1E-6	1E-8
RFETS	2E-7	6E-12	0	3E-11	5E-6	6E-8
SRS	2E-8	4E-13	0	2E-12	3E-7	5E-9
MEI	**Probability of Cancer**		**Probability of Cancer**		**Probability of Cancer**	
Hanford	3E-11	8E-16	0	4E-15	1E-9	2E-11
INEEL	2E-12	6E-17	0	3E-16	6E-11	8E-13
LANL	7E-11	2E-15	0	9E-15	2E-9	3E-11
RFETS	1E-11	4E-16	0	2E-15	3E-10	4E-12
SRS	9E-13	2E-17	0	1E-16	4E-11	5E-13
Maximally Exposed Noninvolved Worker						
Hanford	2E-10	7E-15	0	4E-14	7E-9	1E-12
INEEL	4E-11	2E-15	0	8E-15	7E-9	1E-12
LANL	1E-10	6E-15	0	3E-14	7E-9	1E-12
RFETS	7E-11	3E-15	0	1E-14	7E-9	1E-12
SRS	9E-11	3E-15	0	2E-14	7E-9	1E-12
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	See Text	See Text

Table G-15
Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Waste Treated to the Planning-Basis WAC

Site	Accident Scenario T1 (Waste Spill)				Accident Scenario T2 (Drum Fire)				Accident Scenario T3 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]/3 [c]	IDLH [a]	ERPG-2 [b]/3 [c]
MEI												
Hanford	3E-8	0.03	3E-11	1E-4	0	0	1E-10	6E-4	7E-7	0.6	6E-7	3/0.2
INEEL	3E-9	2E-3	2E-12	1E-5	0	0	1E-11	5E-5	6E-8	0.05	3E-8	0.1
LANL	7E-8	0.06	6E-11	3E-4	0	0	3E-10	1E-3	2E-6	1/0.5	1E-6	4/0.2
RFETS	1E-8	0.01	1E-11	6E-5	0	0	6E-11	3E-4	3E-7	0.3	1E-7	0.6
SRS	1E-9	9E-4	9E-13	4E-6	0	0	4E-12	2E-5	2E-8	0.02	2E-8	0.08
Maximally Exposed Noninvolved Worker												
Hanford	2E-7	0.2	3E-10	8E-4	0	0	1E-9	4E-3	8E-6	6/0.3	5E-6	20/0.9
INEEL	5E-8	0.04	6E-11	2E-4	0	0	3E-10	9E-4	8E-6	6/0.3	5E-6	20/0.9
LANL	2E-7	0.1	2E-10	6E-4	0	0	1E-9	3E-3	8E-6	6/0.3	5E-6	20/0.9
RFETS	7E-8	0.06	9E-11	3E-4	0	0	5E-10	1E-3	8E-6	6/0.3	5E-6	20/0.9
SRS	1E-7	0.09	1E-10	4E-4	0	0	6E-10	2E-3	8E-6	6/0.3	5E-6	20/0.9
Maximally Exposed Involved Worker												
Any Site	0	0	0	0	0	0	0	0	See Text	See Text	See Text	See Text

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.
[c] The highest ERPG-3 ratio is listed for entries where the ERPG-2 ratio is greater than 1.

Impacts to Population

The potential radiological impacts to the populations surrounding any site would be greatest for RFETS (see Table G-13). This is due to a combination of the radionuclides determined to be significant at the RFETS site through screening calculations and the population-weighted dispersion factor for the population east of RFETS. No cancer fatalities would be expected from the operational accident scenarios T1 or T2 (a waste spill or waste drum fire during treatment to planning-basis WAC) at ORNL or any other site. Population consequences of Accident Scenarios T1 and T2 would range from 1×10^{-5} to 3×10^{-4} LCFs. For Accident Scenario T3 (an earthquake during treatment to planning-basis WAC), consequences would range from 0.1 to 3.0 LCFs at both RFETS and Hanford.

The potential hazardous chemical impacts to the population would be very small. No cancer fatalities would be expected in the populations surrounding the five treatment sites as a result of the hazardous chemical or metal releases from any analyzed accident scenario. Consequences would range from 2×10^{-13} to 2×10^{-7} cancers for Accident Scenario T1, 8×10^{-13} to 3×10^{-11} cancers for Accident Scenario T2, and 2×10^{-9} to 5×10^{-6} cancers for Accident Scenario T3 (see Table G-14).

Impacts to Maximally Exposed Individual

The potential radiological impacts to the MEI would be greatest for LANL for all three accidents scenarios analyzed for treatment to planning-basis WAC (see Table G-13). The magnitude of the consequences is due to a combination of the radionuclides determined to be significant at the LANL site through the screening calculations discussed above and to the MEI air dispersion factor. In Accident Scenario T1 (waste spill), radiation doses to the MEI would range from 3×10^{-6} to 3×10^{-4} rem TEDE, with a calculated probability of an LCF of 1×10^{-9} to 1×10^{-7}. In Accident Scenario T2 (waste drum fire), radiation doses to the MEI would range from 3×10^{-6} to 3×10^{-4} rem TEDE, with a calculated probability of an LCF of 1×10^{-9} to 1×10^{-7}. In Accident Scenario T3 (earthquake), radiation doses to the MEI would range from 0.06 to 4 rem TEDE, with an associated probability of an LCF of 3×10^{-5} to 2×10^{-3}.

The potential hazardous chemical consequences would be greatest at LANL for all three accident scenarios, because the MEI air dispersion factor is greater (less dispersion) at LANL than at any of the other sites and because the inventories of hazardous chemicals and metals are assumed to be the same at all of the sites.

Overall, however, the carcinogenic consequences from the accidents would be very small. Carcinogenic consequences would be no greater than a 7×10^{-11}, 9×10^{-15}, and 2×10^{-9} probability of contracting cancer for Accident Scenarios T1, T2, and T3, respectively (see Table G-14). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T3, the maximum ERPG-2 ratio would be 4.0 at LANL for both mercury and lead (see Table G-15). Therefore, some irreversible impacts may be expected, but no life-threatening effects would occur (the maximum ERPG-3 ratio is 0.2). The maximum IDLH-equivalent ratio for Accident Scenario T3 is 2×10^{-6} for the LANL MEI. For Accident Scenario T1, the maximum ERPG-2 ratio for the MEI is 0.06 and the maximum IDLH-equivalent ratio is 7×10^{-8}. Finally, for Accident Scenario T2, the maximum ERPG-2 ratio would be

1×10^{-3} and the IDLH-equivalent ratio would be 3×10^{-10}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident involving the earthquake.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts to the noninvolved worker would be greatest for Hanford for Accident Scenarios T1 and T2 and at INEEL for Accident Scenario T3 (see Table G-13). The noninvolved worker consequences are driven by the site-specific dispersion factor for this individual and by the radionuclides with the greatest consequence found to be at this site during the screening process. Under Accident Scenario T1 (waste spill), the radiation doses to the noninvolved worker would range from 2×10^{-4} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-8} to 4×10^{-7}. Under Accident Scenario T2 (waste drum fire), the radiation doses to the noninvolved worker would range from 2×10^{-4} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-8} to 4×10^{-7}. Under Accident Scenario T3 (earthquake), the radiation doses to the noninvolved worker would range from 10 to 30 rem TEDE to the noninvolved worker. The potential Accident Scenario T3 consequences to the LANL, INEEL, and Hanford noninvolved worker would be the most serious; the probability of an LCF for the individuals at these sites would range from 9×10^{-3} to 0.01.

The potential hazardous chemical consequences to the noninvolved worker would be greatest for the Hanford noninvolved worker for all accident scenarios evaluated (see Table G-14). However, the consequences would be very small. Hazardous chemical carcinogenic consequences would be no greater than a 2×10^{-10}, 4×10^{-14}, and 7×10^{-9} probability of contracting cancer for Accident Scenarios T1, T2, and T3, respectively. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T3, the maximum ERPG-2 ratio would be 20 at all sites for mercury and lead and 6 for 1,1,2,2-tetrachloroethane (see Table G-15). Some life-threatening effects may be expected (ERPG-3 ratios of 0.3 for 1,1,2,2-tetrachloroethane and 0.9 for beryllium at all sites). The maximum IDLH-equivalent ratio for Accident Scenario T3 would be 8×10^{-6} for the noninvolved worker. For Accident Scenario T1, the maximum ERPG-2 ratio for the noninvolved worker is 0.2 and the maximum IDLH-equivalent ratio would be 2×10^{-7}. For Accident Scenario T2, the maximum ERPG-2 ratio would be 4×10^{-3} and the maximum IDLH-equivalent ratio would be 1×10^{-9}. Hanford shows the maximum values for Accident Scenarios T1 and T2. Therefore, the only serious impacts would be expected under the beyond-design-basis earthquake accident scenario.

Impacts to Maximally Exposed Involved Worker

No radiological or chemical impacts to the maximally exposed involved worker would be anticipated from either the waste spill (Accident Scenario T1) or the drum fire (Accident Scenario T2). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial radiological and chemical consequences would be possible from a beyond-design-basis earthquake (Accident Scenario T3), ranging from workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste treatment and intakes of radionuclides, VOCs, and heavy metals. The involved worker would not be expected to survive the catastrophic earthquake: if not killed by falling debris, the involved worker could inhale high levels of radionuclides or hazardous materials.

G.2.4.2 Treatment Accident Consequences for Action Alternative 2 and No Action Alternative 1

The consequences of thermal treatment accidents are shown in Tables G-16 to G-18 and are discussed below for the population, MEI, maximally exposed noninvolved worker, and maximally exposed involved worker. These accident analyses apply to all of the subalternatives of Action Alternative 2 and No Action Alternative 1. Radiological consequences from thermal treatment accidents would be the highest of the three treatment methods examined. There would be no impacts from VOCs because they are destroyed during the treatment process. Carcinogenic impacts from heavy metals would be low in all cases, but some life-threatening toxicological effects could occur to MEIs during the postulated earthquake events.

The potential radiological consequences from RH-TRU waste treatment accidents would be greatest at the ORNL site for all accident scenarios and receptors; however, they are 4 to 5 orders of magnitude less than the consequences from CH-TRU waste treatment accidents.

Impacts to Population

Under Action Alternatives 2A and 2B, the potential radiation impacts to the populations surrounding any site would be greatest for RFETS and Hanford, respectively (see Table G-16). This is due to a combination of the radionuclides determined to be significant at the sites through screening calculations and to the population-weighted dispersion factor for the population near RFETS and Hanford. No cancer fatalities would be expected from the operational Accident Scenarios T4 or T5 (drum failure or steam explosion) at RFETS or any other facility. Accident Scenario T4 population consequences would range from 5×10^{-5} to 1×10^{-3} LCFs, and Accident Scenario T5 population consequences would range from 8×10^{-3} to 0.2 LCFs. For Accident Scenario T6 (earthquake during thermal treatment of waste), the consequences for all sites would range from 25 to 480 LCFs, with the greatest number of LCFs at RFETS.

Under Action Alternative 2C, where all of the CH-TRU waste would be treated at WIPP, the expected number of LCFs in the population for Accident Scenarios T4, T5, and T6 would be 5×10^{-5}, 9×10^{-3} and 28, respectively.

The potential hazardous chemical and heavy metal consequences to the population would be very small; therefore, no cancers would be expected in the populations surrounding the five treatment sites or at WIPP as a result of releases from any analyzed accident (see Table G-17). Consequences would range from 5×10^{-13} to 2×10^{-11} cancers for Accident Scenario T4, 8×10^{-11} to 3×10^{-9} cancers for Accident Scenario T5, and 3×10^{-7} to 1×10^{-5} cancers for Accident Scenario T6. The RFETS site would have the highest potential cancer incidence (1×10^{-5} cancers) under Action Alternative 2A, the Hanford site would have the highest potential cancer incidence (3×10^{-7} cancers) under Action Alternative 2B, and the WIPP site would have the highest potential cancer incidence (3×10^{-7} cancers) under Action Alternative 2C.

Table G-16
Radiological Consequences from Treatment Accidents for Thermally Treated Waste

Site		Accident Scenario T4 (Drum Failure)		Accident Scenario T5 (Steam Explosion)		Accident Scenario T6 (Earthquake)	
CH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Hanford	2	9E-4	280	0.1	880,000	440
	INEEL	0.1	5E-5	20	8E-3	50,000	25
	LANL	0.7	4E-4	110	0.06	360,000	180
	RFETS	2	1E-3	310	0.2	960,000	480
	SRS	0.2	8E-5	30	0.01	83,000	42
	WIPP	0.1	5E-5	20	9E-3	56,000	28
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	4E-4	2E-7	7E-2	4E-5	500	0.4
	INEEL	4E-5	2E-8	7E-3	3E-6	30	0.01
	LANL	1E-3	5E-7	0.2	8E-5	690	0.6
	RFETS	1E-4	6E-8	0.02	9E-6	60	0.03
	SRS	9E-6	5E-9	1E-3	7E-7	9	5E-3
	WIPP	2E-3	8E-7	0.3	1E-4	2,500	1
	Maximally Exposed Noninvolved Worker						
	Hanford	3E-3	1E-6	0.5	2E-4	3,800	1
	INEEL	9E-4	3E-7	0.1	6E-5	4,300	1
	LANL	2E-3	1E-6	0.4	2E-4	3,600	1
	RFETS	7E-4	3E-7	0.1	4E-5	2,100	1
	SRS	1E-3	4E-7	0.2	7E-5	2,500	1
	WIPP	2E-3	8E-7	0.3	1E-4	4,300	1
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text
Site		**Accident Scenario T4 (Drum Failure)**		**Accident Scenario T5 (Steam Explosion)**		**Accident Scenario T6 (Earthquake)**	
RH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Population						
	Hanford	4E-5	2E-8	6E-3	3E-6	20	0.01
	ORNL	9E-5	4E-8	1E-2	7E-6	40	0.02
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	1E-8	5E-12	2E-6	8E-10	1E-2	5E-6
	ORNL	6E-8	3E-11	1E-5	5E-9	4E-2	2E-5
	Maximally Exposed Noninvolved Worker						
	Hanford	8E-8	3E-11	1E-5	5E-9	8E-2	3E-5
	ORNL	9E-8	4E-11	1E-5	6E-9	0.1	5E-5
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text

Note: Annual doses above 20 rem TEDE to individuals do not include a DDREF (see Section G.1.1).

Table G-17
Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Thermally Treated Waste

Site	Accident Scenario T4 (Drum Failure)		Accident Scenario T5 (Steam Explosion)		Accident Scenario T6 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	0	1E-11	0	2E-9	0	5E-6
INEEL	0	5E-13	0	8E-11	0	3E-7
LANL	0	5E-12	0	7E-10	0	2E-6
RFETS	0	2E-11	0	3E-9	0	1E-5
SRS	0	2E-12	0	2E-10	0	8E-7
WIPP	0	6E-13	0	9E-11	0	3E-7
MEI	**Cancer Incidence**		**Cancer Incidence**		**Cancer Incidence**	
Hanford	0	3E-15	0	4E-13	0	3E-9
INEEL	0	2E-16	0	4E-14	0	1E-10
LANL	0	6E-15	0	1E-12	0	4E-9
RFETS	0	1E-15	0	2E-13	0	7E-10
SRS	0	8E-17	0	1E-14	0	9E-11
WIPP	0	8E-15	0	1E-12	0	2E-7
Maximally Exposed Noninvolved Worker						
Hanford	0	2E-14	0	4E-12	0	2E-8
INEEL	0	5E-15	0	9E-13	0	2E-8
LANL	0	2E-14	0	3E-12	0	2E-8
RFETS	0	9E-15	0	1E-12	0	2E-8
SRS	0	1E-14	0	2E-12	0	2E-8
WIPP	0	1E-14	0	2E-12	0	2E-8
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	See Text	See Text

Table G-18
Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Thermally Treated Waste

Site	Accident Scenario T4 (Drum Failure)				Accident Scenario T5 (Steam Explosion)				Accident Scenario T6 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]	IDLH [a]	ERPG-2 [b]/3 [c]
MEI												
Hanford	0	0	1E-10	4E-4	0	0	1E-8	0.05	0	0	1E-4	470/27
INEEL	0	0	8E-12	3E-5	0	0	1E-9	4E-3	0	0	5E-6	22/1
LANL	0	0	2E-10	1E-3	0	0	3E-8	0.1	0	0	2E-4	690/40
RFETS	0	0	4E-11	2E-4	0	0	6E-9	0.03	0	0	2E-5	110/6
SRS	0	0	3E-12	1E-5	0	0	4E-10	2E-3	0	0	3E-6	14/0.8
WIPP	0	0	3E-10	1E-3	0	0	4E-8	0.2	0	0	5E-4	2000/120
Maximally Exposed Noninvolved Worker												
Hanford	0	0	9E-10	3E-3	0	0	1E-7	0.3	0	0	8E-4	2500/150
INEEL	0	0	2E-10	6E-4	0	0	3E-8	0.08	0	0	8E-4	2500/150
LANL	0	0	7E-10	2E-3	0	0	9E-8	0.3	0	0	8E-4	2500/150
RFETS	0	0	3E-10	9E-4	0	0	4E-8	0.1	0	0	8E-4	2500/150
SRS	0	0	4E-10	1E-3	0	0	6E-8	0.2	0	0	8E-4	2500/150
WIPP	0	0	4E-10	1E-3	0	0	6E-8	0.2	0	0	8E-4	2500/150
Maximally Exposed Involved Worker												
Any Site			0	0	0	0	0	0	0	0	See Text	See Text

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.
[c] The highest ERPG-3 ratio is listed for entries where the ERPG-2 ratio is greater than 1.

Impacts to Maximally Exposed Individual

Under Action Alternative 2A, the potential radiological consequences for the MEI would be greatest for LANL (see Table G-16). Under Action Alternative 2B, the radiological consequences would be greatest at Hanford. This is a combination of the radionuclides determined to be significant at the sites through screening calculations and the MEI air dispersion factors. In a waste drum failure (Accident Scenario T4), radiation doses to the MEI would range from 9×10^{-6} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 5×10^{-9} to 5×10^{-7}. In a steam explosion (Accident Scenario T5), radiation doses to the MEI would range from 1×10^{-3} to 0.2 rem TEDE, with an associated probability of an LCF of 7×10^{-7} to 8×10^{-5}. In an earthquake (Accident Scenario T6), radiation doses to the MEI would range from 9 to 690 rem TEDE, with an associated probability of an LCF of 5×10^{-3} to 0.6.

WIPP would be the only treatment site for CH-TRU waste under Action Alternative 2C. In WIPP WIPP would be the only treatment site for CH-TRU waste under Action Alternative 2C. In Accident Scenario T4, radiation dose to the WIPP MEI would be 2×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-7}. In Accident Scenario T5, radiation dose to the WIPP MEI would be 0.3 rem TEDE, with an associated probability of an LCF of 1×10^{-4}. In Accident Scenario T6, radiation dose to the WIPP MEI would be 2,500 rem TEDE, with an associated probability of an LCF of 1.0.

Under Action Alternatives 2A and 2B, the potential hazardous chemical consequences for the MEI are greatest at LANL and Hanford, respectively, for Accident Scenarios T4, T5, and T6. This is because of the MEI air dispersion factors and because the inventories of hazardous chemicals and metals were assumed to be the same at all the sites. Overall, however, the carcinogenic consequences from the accidents would be very small. Carcinogenic consequences are no greater than a 6×10^{-15}, 1×10^{-12}, and 4×10^{-9} probability of contracting cancer for Accident Scenarios T4, T5, and T6, respectively (see Table G-17). Under Action Alternative 2C, all the consequences are to the WIPP MEI, but would be very low. The probability of contracting cancer from Accident Scenarios T4, T5, and T6 would be 8×10^{-15}, 1×10^{-12}, and 2×10^{-7}, respectively.

Ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T6 under Action Alternative 2A, the maximum ERPG-2 ratio was estimated to be 690 at LANL for both mercury and lead and 160 for beryllium (see Table G-18). The maximum ERPG-3 ratio is 40 for beryllium and 2 for mercury and lead; thus, these ratios indicate that life-threatening effects may be expected. The maximum IDLH-equivalent ratio for Accident Scenario T6 would be 2×10^{-4} for the LANL MEI. For Accident Scenario T4, the maximum ERPG-2 ratio for the MEI would be 1×10^{-3} and the maximum IDLH-equivalent ratio would be 2×10^{-10}, and for Accident Scenario T5, the maximum ERPG-2 ratio would be 0.1 and the IDLH-equivalent ratio would be 3×10^{-8}. Under Accident Scenario 2B, the maximum consequences would be at the Hanford site, but would be less than those described for Accident Scenario 2A. Therefore, for both Accident Scenarios 2A and 2B, the only serious consequences would be expected under the beyond-design-basis accident. The same holds true for Action Alternative 2C where all the consequences would be at WIPP. For Accident Scenario T4, the maximum ERPG-2 ratio for the WIPP MEI would be 1×10^{-3} and the maximum IDLH-equivalent ratio would be 3×10^{-10}. For Accident Scenario T5, the maximum ERPG-2 ratio would be 0.2 and the IDLH-equivalent ratio would be 4×10^{-8}. For Accident Scenario T6, the maximum ERPG-2 ratio is 2,000 for both mercury and lead and 50 for

beryllium, while the maximum ERPG-3 ratio is 120 for beryllium and 7 and 5 for mercury and lead, respectively. Thus, life-threatening effects would be expected to the MEI for Accident Scenario T6 at WIPP.

Impacts to Maximally Exposed Noninvolved Worker

Under Action Alternatives 2A and 2B, the potential radiological consequences for the noninvolved worker would be greatest at Hanford for Accident Scenarios T4 and T5, and would be greatest at INEEL for accident Scenario T6 (see Table G-16). The noninvolved worker consequences are driven by the site-specific dispersion factor for this individual and by the site-specific mix of radionuclides chosen for the evaluation. Under Accident Scenario T4, the radiation doses to the noninvolved worker would range from 7×10^{-4} to 3×10^{-3} rem TEDE, with an associated probability of an LCF of 3×10^{-7} to 1×10^{-6}. Under Accident Scenario T5, the radiation doses to the noninvolved worker would range from 0.1 to 0.5 rem TEDE, with a calculated probability of an LCF of 4×10^{-5} to 2×10^{-4}. Under Accident Scenario T6, the radiation doses to the noninvolved worker would range from 2,100 to 4,300 rem TEDE, with calculated probabilities of an LCF of 1.

Under Action Alternative 2C, all the consequences would be to the WIPP noninvolved worker. Under Accident Scenario T4, the radiation dose to the noninvolved worker would be 2×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-7} (see Table G-16). Under Accident Scenario T5, the radiation dose to the noninvolved worker would be 0.3 rem TEDE, with an associated probability of an LCF of 1×10^{-4}. Under Accident Scenario T6, the radiation dose to the noninvolved worker would be 4,300 rem TEDE. The calculated probability of an LCF for the WIPP noninvolved worker is 1.

Under Action Alternatives 2A and 2B, the potential hazardous chemical consequences would be greatest for the Hanford noninvolved worker for Accident Scenarios T4 and T5. The consequences for the noninvolved worker are the same across all sites for Accident Scenario T6. Hazardous chemical carcinogenic consequences would be no greater than a 2×10^{-14}, 4×10^{-12}, and 2×10^{-8} probability of contracting cancer for Accidents T4, T5, and T6, respectively (see Table G-17).

Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact (see Table G-18). For Accident Scenario T6, the maximum ERPG-2 ratio is equal to 2,500 at all sites for both mercury and lead. The ERPG-3 ratios are 150, 9, and 6 for beryllium, mercury, and lead, respectively; therefore, these ratios indicate that life-threatening effects would be expected for Accident Scenario T6. The maximum IDLH-equivalent ratio for Accident Scenario T6 is 8×10^{-4} for the noninvolved worker. For Accident Scenario T4, the maximum ERPG-2 ratio for the noninvolved worker is 3×10^{-3} with a maximum IDLH-equivalent ratio of 9×10^{-10} and for Accident Scenario T5, the maximum ERPG-2 ratio for the noninvolved worker is 0.3 and the maximum IDLH-equivalent ratio is 1×10^{-7}. Therefore, the only serious consequences would be expected under the beyond-design-basis accident.

Under Action Alternative 2C, the potential hazardous chemical consequences would be for the WIPP noninvolved worker for all accidents evaluated. Hazardous chemical carcinogenic consequences would be no greater than a 1×10^{-14}, 2×10^{-12}, and 2×10^{-8} probability of contracting cancer for accidents T4, T5, and T6, respectively (see Table G-17). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic consequence. For Accident

Scenario T6, the maximum ERPG-2 ratio is equal to 2,500 for both mercury and lead and the maximum ERPG-3 ratio is 150 for the WIPP site (see Table G-18). Therefore, these ratios indicate that life-threatening effects would be expected for Accident Scenario T6. The maximum IDLH-equivalent ratio for Accident Scenario T6 would be 8×10^{-4} for the WIPP noninvolved worker. For Accident Scenario T4, the maximum ERPG-2 ratio for the noninvolved worker would be 1×10^{-3} with a maximum IDLH-equivalent ratio of 4×10^{-10}. For Accident Scenario T5, the maximum ERPG-2 ratio for the noninvolved worker would be 0.2 and the maximum IDLH-equivalent ratio would be 6×10^{-8}. Therefore, the only serious consequences would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Involved Worker

No impacts to the maximally exposed involved worker would be anticipated from the waste spill (Accident Scenario T4). This accident is such that involved workers would be able to evacuate immediately or would not be affected by the event. The nature of the steam explosion (Accident Scenario T5) is such that an involved worker would be killed. Substantial consequences would be possible from a beyond-design-basis earthquake (Accident Scenario T6), ranging from workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated and intakes of radionuclides, VOCs, and heavy metals. If not killed by falling debris, the involved worker could inhale high levels of radionuclides or hazardous chemicals.

G.2.4.3 Treatment Accident Consequences for Action Alternative 3

The accident consequences of waste treatment by a shred and grout process are shown in Tables G-19 to G-21 and are discussed below for the population, MEI, maximally exposed noninvolved worker, and maximally exposed involved worker. These accident analyses apply only to Action Alternative 3. Radiological consequences from shred and grout treatment accidents are somewhat higher than those for treatment to planning-basis WAC accidents and substantially lower than thermal treatment accidents. Carcinogenic consequences from hazardous chemicals are low in all cases, but some life-threatening toxicological effects could occur in maximally exposed individuals during the postulated earthquake events.

The potential radiological consequences from RH-TRU waste treatment accidents are greatest at the ORNL site for all accident scenarios and receptors; however, they are 4 to 5 orders of magnitude less than the consequences from CH-TRU waste treatment accidents.

Impacts to Population

The potential radiological impacts to the populations surrounding any site would be greatest for RFETS (see Table G-19). This is due to a combination of the radionuclides determined to be significant at the RFETS site through screening calculations and the population-weighted dispersion factor for the population east of RFETS. No cancer fatalities would be expected from operational accident T7; population consequences from the waste spill would range from 6×10^{-6} to 1×10^{-4} LCFs. No LCFs would be expected under operational accident T8, a fire in the shredder; population consequences would range from 3×10^{-4} to 6×10^{-3} LCFs. Because of the severity of

Table G-19
Radiological Consequences from Treatment Accidents for Waste Treatment by Shred and Grout

Site		Accident Scenario T7 (Waste Spill)		Accident Scenario T8 (Fire in the Shredder)		Accident Scenario T9 (Earthquake)	
CH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Hanford	0.2	1E-4	10	5E-3	12,000	6
	INEEL	0.01	6E-6	0.6	3E-4	660	0.3
	LANL	0.08	4E-5	4	2E-3	4,700	2
	RFETS	0.2	1E-4	10	6E-3	13,000	6
	SRS	0.02	9E-6	1	5E-4	1,100	0.5
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	5E-5	3E-8	3E-3	1E-6	6.0	3E-3
	INEEL	5E-6	2E-9	2E-4	1E-7	0.3	2E-4
	LANL	1E-4	6E-8	6E-3	3E-6	9.0	5E-3
	RFETS	1E-5	6E-9	7E-4	3E-7	0.8	4E-4
	SRS	1E-6	5E-10	5E-5	3E-8	0.1	6E-5
	Maximally Exposed Noninvolved Worker						
	Hanford	4E-4	2E-7	0.02	8E-6	50	0.02
	INEEL	1E-4	4E-8	5E-3	2E-6	60	0.02
	LANL	3E-4	1E-7	0.01	6E-6	50	0.02
	RFETS	8E-5	3E-8	4E-3	2E-6	30	0.01
	SRS	1E-4	5E-8	6E-3	3E-6	30	0.01
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text
RH-TRU Waste	**Population**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
	Hanford	4E-6	2E-9	2E-4	1E-7	0.3	1E-4
	ORNL	1E-5	5E-9	5E-4	3E-7	0.6	3E-4
	MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
	Hanford	1E-9	6E-13	6E-8	3E-11	1E-4	7E-8
	ORNL	7E-9	4E-12	4E-7	2E-10	6E-4	3E-7
	Maximally Exposed Noninvolved Worker						
	Hanford	9E-9	3E-12	4E-7	2E-10	1E-3	4E-7
	ORNL	1E-8	4E-12	5E-7	2E-10	2E-3	7E-7
	Maximally Exposed Involved Worker						
	Any Site	0	0	0	0	See Text	See Text

the earthquake scenario (Accident Scenario T9), Hanford, LANL, and RFETS would have some LCFs. The greatest number of LCFs would be 6 at RFETS or Hanford; for all sites, Accident Scenario T9 consequences could range from 0.3 to 6 LCFs.

The potential hazardous chemical impacts to the population would be very small. No cancers would be expected in the populations surrounding the five treatment sites as a result of the hazardous chemical or metal releases from any analyzed accident. Consequences would range from 6×10^{-14} to 2×10^{-7} cancers for Accident Scenario T7, 2×10^{-11} to 6×10^{-10} cancers for Accident Scenario T8, and 5×10^{-9} to 1×10^{-5} cancers for Accident Scenario T9 (see Table G-20).

Impacts to Maximally Exposed Individual

The potential radiological consequences for the MEI would be greatest for LANL for all the accident scenarios analyzed (see Table G-19), due to the combination of radionuclides determined

Table G-20
Hazardous Chemical Carcinogenic Consequences from Treatment Accidents for Waste Treatment by Shred and Grout

Site	Accident Scenario T7 (Waste Spill)		Accident Scenario T8 (Fire in the Shredder)		Accident Scenario T9 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	1E-7	1E-12	0	3E-10	7E-6	1E-7
INEEL	6E-9	6E-14	0	2E-11	4E-7	5E-9
LANL	5E-8	5E-13	0	1E-10	3E-6	4E-8
RFETS	2E-7	2E-12	0	6E-10	1E-5	2E-7
SRS	2E-8	2E-13	0	4E-11	1E-6	1E-8
MEI	**Probability of Cancer Incidence**		**Probability of Cancer Incidence**		**Probability of Cancer Incidence**	
Hanford	3E-11	3E-16	0	8E-14	4E-9	6E-11
INEEL	2E-12	3E-17	0	6E-15	2E-10	3E-12
LANL	7E-11	7E-16	0	2E-13	6E-9	8E-11
RFETS	1E-11	1E-17	0	4E-14	9E-10	1E-11
SRS	9E-13	1E-17	0	2E-15	1E-10	2E-12
Maximally Exposed Noninvolved Worker						
Hanford	2E-10	3E-15	0	7E-13	2E-8	4E-10
INEEL	4E-11	6E-16	0	2E-13	2E-8	4E-10
LANL	1E-10	2E-15	0	6E-13	2E-8	4E-10
RFETS	7E-11	1E-15	0	3E-13	2E-8	4E-10
SRS	9E-11	1E-15	0	3E-13	2E-8	4E-10
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	See Text	See Text

Table G-21
Hazardous Chemical Noncarcinogenic Consequences from Treatment Accidents for Waste Treatment by Shred and Grout

Site	Accident Scenario T7 (Waste Spill)				Accident Scenario T8 (Fire in the Shredder)				Accident Scenario T9 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
MEI	**IDLH [a]**	**ERPG-2 [b]**	**IDLH [a]**	**ERPG-2 [b]**	**IDLH [a]**	**ERPG-2 [b]**	**IDLH [a]**	**ERPG-2 [b]**	**IDLH [a]**	**ERPG-2 [b]/3 [c]**	**IDLH [a]**	**ERPG-2 [b]/3 [c]**
Hanford	3E-8	0.03	1E-11	5E-5	0	0	3E-9	0.01	5E-6	4/0.2	2E-6	9/0.5
INEEL	3E-9	2E-3	9E-13	4E-6	0	0	2E-10	1E-3	2E-7	0.2	1E-7	0.4
LANL	7E-8	0.06	3E-11	1E-4	0	0	6E-9	0.03	7E-6	6/0.3	3E-6	10/0.8
RFETS	1E-8	0.01	5E-12	2E-5	0	0	1E-9	6E-3	1E-6	0.9	5E-7	2/0.1
SRS	1E-9	9E-4	4E-13	2E-6	0	0	9E-11	4E-4	1E-7	0.1	6E-8	0.3
Maximally Exposed Noninvolved Worker												
Hanford	2E-7	0.2	1E-10	3E-4	0	0	3E-7	0.08	3E-5	20/1	2E-5	50/3
INEEL	5E-8	0.04	2E-11	7E-5	0	0	6E-9	0.02	3E-5	20/1	2E-5	50/3
LANL	2E-7	0.1	8E-11	2E-4	0	0	2E-8	0.06	3E-5	20/1	2E-5	50/3
RFETS	7E-8	0.06	4E-11	1E-4	0	0	9E-9	0.03	3E-5	20/1	2E-5	50/3
SRS	1E-7	0.09	5E-11	1E-4	0	0	1E-8	0.04	3E-5	20/1	2E-5	50/3
Maximally Exposed Involved Worker												
Any Site			N/A	N/A	N/A	N/A	N/A	N/A	See Text	See Text	See Text	See Text

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.
[c] The highest ERPG-3 ratio is listed for entries where the ERPG-2 ratio is greater than 1.

N/A = Not Applicable

to be significant at the LANL site through screening calculations and the MEI air dispersion factor. In Accident Scenario T7, radiation doses to the MEI would range from 1×10^{-6} to 1×10^{-4} rem TEDE, with an associated probability of an LCF of 5×10^{-10} to 6×10^{-8}. In Accident Scenario T8, radiation doses to the MEI would range from 5×10^{-5} to 6×10^{-3} rem TEDE, with an associated probability of an LCF of 3×10^{-8} to 3×10^{-6}. In Accident Scenario T9, radiation doses to the MEI would range from 0.1 to 9 rem TEDE with an associated probability of an LCF of 6×10^{-5} to 5×10^{-3}.

The potential hazardous chemical consequences would be greatest at LANL for Accident Scenarios T7, T8, and T9, because the MEI air dispersion factor would be larger at LANL than at any of the other sites and the inventories of hazardous chemicals and metals are assumed to be the same at all the sites. Overall, however, the carcinogenic consequences from the accidents would be very small, with a 7×10^{-11}, 2×10^{-13}, and 6×10^{-9} probability of contracting cancer for Accidents Scenarios T7, T8, and T9, respectively (see Table G-20). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic consequence. For Accident Scenario T9, the maximum ERPG-2 ratio would be 10 at LANL for both mercury and lead (see Table G-21). Therefore, some irreversible consequences would be expected, but no life-threatening effects would occur (maximum ERPG-3 ratio of 0.8). The maximum IDLH-equivalent ratio for Accident Scenario T9 would be 3×10^{-6} for the LANL MEI. For Accident Scenario T7, the maximum ERPG-2 ratio for the MEI would be 0.06 and the maximum IDLH-equivalent ratio would be 7×10^{-8}. For Accident Scenario T8, the maximum ERPG-2 ratio would be 0.03 and the IDLH-equivalent ratio would be 6×10^{-9}. Therefore, the only serious consequences would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological consequences would be greatest for Accident Scenarios T7 and T8 for the Hanford maximally exposed noninvolved worker and would be highest for the INEEL noninvolved worker for Accident Scenario T9 (see Table G-19). The noninvolved worker consequences are driven by the site-specific dispersion factor for this individual and by the site-specific mix of radionuclides chosen for the evaluation. Under Accident Scenario T7, the radiation doses to the maximally exposed noninvolved worker would range from 8×10^{-5} to 4×10^{-4} rem TEDE, with an associated probability of an LCF of 3×10^{-8} to 2×10^{-7}. Under Accident Scenario T8, the radiation doses to the noninvolved worker would range from 4×10^{-3} to 0.02 rem TEDE, with an associated probability of an LCF of 2×10^{-6} to 8×10^{-6}. Under Accident Scenario T9, the radiation doses to the noninvolved worker would range from 30 to 60 rem TEDE to the noninvolved worker. The potential Accident Scenario T9 consequences for the LANL, ORNL, and Hanford noninvolved worker would be the most serious. The probability of an LCF for the individuals at these sites would range from 0.01 to 0.02.

The potential hazardous chemical consequences would be greatest for the Hanford maximally exposed noninvolved worker for all accidents evaluated (see Table G-20). Hazardous chemical carcinogenic consequences would be no greater than a 2×10^{-10}, 7×10^{-13}, and 2×10^{-8} probability of contracting cancer for Accident Scenarios T7, T8, and T9, respectively. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic consequence. For Accident Scenario T9, the maximum ERPG-2 ratio would be equal to 50 at all sites for both mercury and lead (see Table G-21). Therefore, some irreversible consequences would be expected

as well as life-threatening effects (ERPG-3 ratios of 3 at all sites). The maximum IDLH-equivalent ratio for Accident Scenario T9 would be 3×10^{-5} for the noninvolved worker. For Accident Scenario T7, the maximum ERPG-2 ratio for the noninvolved worker would be 0.2 with a maximum IDLH-equivalent ratio of 2×10^{-7}. For Accident Scenario T8, the maximum ERPG-2 ratio for the noninvolved worker would be 0.08 and the maximum IDLH-equivalent ratio would be 3×10^{-7}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Involved Worker

No consequences for the maximally exposed involved worker would be anticipated from either the waste spill (Accident Scenario T7) or the fire in the shredder (Accident Scenario T8) (see Table G-19). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial consequences would be possible from a beyond-design-basis accident, including workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated and intakes of radionuclides, VOCs, and heavy metals.

G.3 STORAGE ACCIDENT SCENARIOS

The storage accident analyses were conducted to evaluate the potential accident consequences of storing TRU waste. Generic CH-TRU and RH-TRU waste storage facilities were assumed for all waste forms under all alternatives because none of the facilities have yet been designed or constructed. Site-specific NEPA evaluations and safety assessments would be considered prior to facility construction and operation.

Under Action Alternative 1; Action Alternatives 2A, 2B, and 2C; Action Alternative 3; and No Action Alternative 2, waste storage activities would include moving the waste containers into storage, monitoring the waste for contamination on the outside of the containers, and relocating the waste while in storage to support monitoring and maintenance activities. Monitoring and maintenance activities would require workers to be near stored waste: monitoring activities would include visual inspections and swiping the outside of containers for contamination, and building maintenance activities would include maintaining roofs and preventing or removing build-up of combustibles at locations that could endanger the stored TRU waste. Accidents assessed during lag or indefinite storage included waste container breaches, a waste container fire, and a catastrophic event. All three accidents were evaluated for CH-TRU waste at each storage location under each of these alternatives.

In addition to the above activities, CH-TRU waste would be overpacked at 20-year intervals under No Action Alternatives 1A and 1B. No accidents were specifically evaluated for overpacking operations because consequences would be bounded by other storage accident analyses. For example, consequences for the maximally exposed involved worker would probably be lower than under other alternatives because this worker was assumed to wear a HEPA-filtered mask and, therefore, would not inhale particulate radionuclides in the event of an overpacking accident.

The accident analyses concentrated on the consequences of events involving CH-TRU waste. RH-TRU waste canisters were assumed to be substantially more robust (cylinders with 6-millimeter [0.24-inch] thick carbon-steel walls) than CH-TRU waste containers because of both the greater handling hazard (high external radiation dose rates) of RH-TRU waste and the reduced likelihood

that the canister would be breached during a minor consequence event. RH-TRU waste storage facilities were assumed to withstand severe conditions introduced by humans or a natural disaster. It was assumed there would be remote monitoring of the RH-TRU waste and that there would be no overpacking of RH-TRU waste canisters under No Action Alternatives 1A and 1B. Therefore, except for the beyond-design-basis natural disaster, no conditions were believed to exist that would lead to the environmental release of RH-TRU waste during storage operations. The most severe accidental exposure involving RH-TRU waste during storage would be that of an involved worker who remained for an extended period of time in an elevated radiation area near RH-TRU waste canisters.

Under the Proposed Action only RH-TRU waste would be stored. The RH-TRU waste storage facilities would be constructed to maintain waste containment during all but the most severe circumstances. The current RH-TRU waste containers are designed to result in only a minor breach during a significant consequence event. It was assumed that, at a minimum, a similar design would be used at Hanford and ORNL. Site-specific NEPA review and safety analyses conducted prior to facility construction and operation would require detailed accident risk calculations for the storage facility.

Accident Scenario S1, a drum puncture and lid failure, would be a relatively high-frequency incident. The estimated annual frequency of occurrence would be 1×10^{-2} to 1×10^{-4}. This estimated frequency, taken from DOE (1997), was developed for the handling of waste containers during WIPP disposal operations. Storage operations would require handling of waste during the year it enters storage, the year it leaves storage, and on an infrequent basis during the monitoring phase. Therefore, for waste containers that are in the storage facility for more than two years, the average frequency of occurrence would be expected to decrease somewhat over time. Accident Scenario S2, a drum fire, is not expected to occur, but was evaluated to address public concerns. The WIPP disposal operations frequency of occurrence estimate for a drum fire is 1×10^{-4} to 1×10^{-6} for planning-basis WAC waste for drums with less than 8 PE-Ci and less than 1×10^{-6} for drums with more than 8 PE-Ci (DOE 1997). This same estimate is applied to planning-basis WAC waste in interim storage. The accident is not applicable to thermally treated waste, which contains no combustible materials, and is likely not applicable to grouted waste, which has limited combustibility.

Accident Scenario S3, a beyond-design-basis earthquake, has an estimated annual frequency of occurrence of 1×10^{-5} or less. This accident frequency does not vary by waste treatment level.

G.3.1 Inventory

The inventory of materials in stored waste that could potentially cause human health consequences includes both radionuclides and hazardous chemicals. One purpose in developing the planning-basis WAC (DOE 1996b) was to ensure that all DOE sites package TRU waste to meet a minimum standard that assures the safe transport, handling, and disposal of TRU waste. Some key planning-basis WAC requirements that limit the inventory of high-risk constituents packaged in waste containers and, thereby, reduce the accident consequences are presented in Table G-22.

Accident consequences were estimated using bounding container inventories of radioactive and hazardous chemicals, when these inventories were defined by the planning-basis WAC. For some VOCs and all the heavy metals, container limits were not defined. In such cases, the container inventories were estimated as described below.

Table G-22
Planning-Basis WAC Requirements that Reduce Accident Risk

Requirement	Comment
Liquids- Waste shall contain as little residual liquid as is reasonably achievable.	This requirement reduces the risk of exposure to hazardous constituents in the event of a container breach and reduces the uncertainty associated with the long-term performance of the WIPP facility.
Pyrophoric materials - No nonradionuclide pyrophorics are permitted. Radionuclides in pyrophoric form are limited to < 1 percent by weight in each waste package.	This requirement increases the stability of the waste.
Explosives and Compressed Gases - No explosives or compressed gases are permitted.	This requirement increases the stability of the waste.
Ignitable, Corrosive, and Reactive Hazardous Materials – EPA-defined characteristic ignitable, corrosive, or reactive wastes are not permitted.	This requirement increases the stability of the waste.
Criticality - Acceptable package limits are less than 200 fissile-gram-equivalents (FGE) per drum and less than 325 FGEs per standard waste box.	This requirement eliminates the risk of a nuclear criticality during transport and storage.
PE-Ci Limits - CH-TRU waste packages: Drum: 80 PE-Ci Standard Waste Box: 130 PE-Ci Drum overpacked in a Standard Waste Box or a Ten-Drum-Overpack: 1,800 PE-Ci Solidified/vitrified waste: 1,800 PE-Ci RH-TRU waste packages: 1,000 PE-Ci	Since the major exposure pathway from a container breach is inhalation and the major constituents of concern are transuranics, this requirement limits the potential radiological consequences in the event of a container breach.
Gas generation - Numerous requirements limit the amount of explosive gases that could accumulate in the interior of a waste package, including the requirement to vent all TRU waste packages.	This requirement increases the stability of the waste.

G.3.1.1 Radionuclide Inventory

The quantity of radionuclides in waste containers was assumed to be the PE-Ci limits of the planning-basis WAC (DOE 1996b) for all accident scenarios, including those of the no action alternatives. Nonsolidified CH-TRU waste drums are limited to 80 PE-Ci, CH-TRU waste standard waste boxes are limited to 130 PE-Ci, and RH-TRU waste canisters are limited to 1,000 PE-Ci. Radionuclide activities at these limits were assumed to be present in all waste containers evaluated. Vitrified and solidified final waste forms under Action Alternatives 2A, 2B, and 2C and Action Alternative 3 are limited to 1,800 PE-Ci. Current TRUPACT-II thermal power limits, however, do not allow transport of waste drums with 1,800 PE-Ci so the nonsolidified limits were applied to waste under these alternatives.

Estimated average drum PE-Ci contents for the existing TRU waste inventory are much lower than the current planning-basis WAC limits. The average radionuclide PE-Ci contents at the major treatment sites and WIPP are presented in Tables G-23 and G-24 for CH-TRU and RH-TRU waste, respectively. Because the accident analyses are intended to evaluate reasonably bounding events, however, the planning-basis WAC inventory limit was used for events involving a small number of containers. Accidents involving a large number of containers (i.e., an earthquake) were evaluated using the site-specific PE-Ci container averages.

Table G-23
Average Radionuclide Content of CH-TRU Waste
(PE-Ci per drum-equivalent) at the Major Storage Sites and WIPP

Site	Proposed Action	Action Alternative 1	Action Alternative 2A & No Action Alternative 1A	Action Alternative 2B & No Action lternative 1B	Action Alternative 3	No Action Alternative 2
Hanford	2.2	1.9	5.3	5.3	1.6	1.9
INEEL	1.8	1.5	3.3	6.9	1.3	1.5
LANL	4.3	3.6	10.0	N/A	3.1	3.7
ORNL	2.0	2.0	N/A	N/A	N/A	1.7
RFETS	13.0	7.6	35	N/A	7.0	12
SRS	21.0	16.0	40.0	40.0	12.0	18.0
WIPP	5.0	3.2	8.4 [a]	8.4 [a]	2.5	4.3

[a] WIPP is the only storage site for CH-TRU waste, so this is the CH-TRU value used for Action Alternative 2C accidents at WIPP.

N/A = Not Applicable

Table G-24
Average Radionuclide Content of RH-TRU Waste
(PE-Ci per canister) at the Major Storage Sites and WIPP

Site	Proposed Action	Action Alternative 1	Action Alternative 2 & No Action Alternative 1	Action Alternative 3	No Action Alternative 2
Hanford	0.3	3.7	9.9	2.9	3.7
INEEL	0.6	0.6	N/A	N/A	0.6
LANL	0.9	0.9	N/A	N/A	0.9
ORNL	0.1	0.3	0.9	0.3	0.4
WIPP	0.3	3.0	8.6	2.5	N/A

N/A = Not Applicable

Comparison of Tables G-23 and G-24 shows that the average PE-Ci content of RH-TRU waste is typically lower than that of CH-TRU waste. RH-TRU waste contains greater quantities of fission and activation product radionuclides that emit penetrating radiation like X- or gamma radiation which produces the high external dose rates and requires the waste to be remotely handled. However, most of the potential radiation dose and radiological consequences from radionuclide releases would result from inhalation, not from external dose, so fission and activation product radionuclides are small contributors to the PE-Ci inventory compared to transuranic radionuclides. The fission and activation product contributing the most to external dose rates were Cs-137/ Ba-137m and Co-60, with smaller but important contributions from europium-152 (Eu-152) and europium-154 (Eu-154) at some consolidation sites.

G.3.1.2 Hazardous Chemical Inventory

Hazardous chemicals that may be present in TRU waste are volatile organic compounds and heavy metals, including lead, mercury, beryllium, and cadmium. The planning-basis WAC includes limits for several VOCs based on their flammability and their health risk, as determined by the RCRA Part B Application health impact analyses (DOE 1996a). No limits are included in the planning-basis WAC for the four heavy metals of concern.

Volatile Organic Compounds

VOCs were assumed to be present in all waste treated to planning-basis WAC and the shred and grout process; however, VOCs would not be present in waste after thermal treatment under Action Alternative 2 and No Action Alternative 1. Maximum headspace concentrations of VOCs were assumed for accidents involving relatively small numbers of waste containers. This is conservative since the presence of a maximum headspace concentration of a specific VOC would have no bearing on whether another VOC would be found in the same container at a high concentration. VOCs with specific planning-basis WAC limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be present at the maximum allowable headspace concentrations. Flammable VOCs (1,1-dichloroethylene, 1,2-dichloroethane, benzene, ethyl benzene, and xylene) were assumed to be present at a maximum concentration of 500 parts per million (ppm). Other VOCs likely to be present in the waste were assumed to be at concentrations equivalent to the maximum headspace concentration found in solidified organic samples. Solidified organics have the highest headspace concentrations of all waste matrix categories. Average VOC headspace concentrations were assumed for accidents involving a large number of waste containers, such as natural disasters. VOC headspace concentrations are presented in Table G-25. VOCs may be present in RH-TRU waste as well as CH-TRU waste. Because of the lack of sampling information, VOC concentrations in RH-TRU waste were assumed to be identical to those in CH-TRU waste.

Table G-25
VOC Headspace Concentrations in Treated TRU Waste

VOC [a]	Planning-Basis WAC Limit for Headspace Concentration (ppmv) [b]	Waste Treated to Meet Planning-Basis WAC (ppmv)		Treated by Shred and Grout (ppmv)	
		Weighted Average	Maximum [c]	Average	Maximum [d]
Carbon tetrachloride (6.39)	7,510	184.5	---	316.5	---
Chloroform (4.96)	6,325	13.7	---	1.2	---
1,1-dichloroethene (4.03)	500 [e]	8.4	---	2.5	---
1,2-dichloroethane (4.11)	500 [e]	5.6	---	1.1	---
Methylene chloride (3.53)	368,500	662.1	---	8.1	---
Chlorobenzene (4.68)	No Limit	8.4	4,368	1.3	260
Methyl ethyl ketone (3.0)	No Limit	40.4	39,311	6.8	130
1,1,2,2-tetrachloroethane (7.0)	No Limit	335.7	4,368	125.1	270
Toluene (3.83)	No Limit	5.7	6,992	1.3	320
Benzene (3.25)	500 [e]	7.6	---	22.4	---
Ethyl benzene (4.41)	500 [e]	8.5	---	31.6	---
Tetrachloroethene (6.89)	No Limit	7.1	2184	21.6	600
Xylene (4.41)	500 [e]	25.6	---	113.9	---

[a] Values in parentheses are milligram/cubic meter per ppm conversion factors.
[b] DOE 1996b.
[c] Maximum values for those VOCs without a maximum planning-basis WAC limit. Values are maximum concentrations found in any solidified organic sampled and were used for the bounding accident scenarios.
[d] Maximum concentration found in any solidified inorganic matrix for those VOCs without a planning-basis WAC limit.
[e] Flammable VOC limit.

A screening calculation was performed to identify VOCs with the greatest potential impacts from an acute exposure event. Impacts from acute hazardous chemical exposures were evaluated as potentially both carcinogenic and noncarcinogenic. As described in Section G.1.2.3, screening for carcinogenic impact was performed by multiplying the VOC headspace concentration by the EPA slope factor; noncarcinogenic impact screening was performed by comparing two different impacts measures, IDLH-equivalent intakes, and ERPG-2 values. Only the VOCs that would contribute to the major potential consequences from an accidental release (greater than 90 percent) were included in the detailed evaluation (see Table G-26). For waste treated to planning-basis WAC (Proposed Action, Action Alternative 1, No Action Alternative 2), methylene chloride would be the major contributor to toxicological consequences and 1,1,2,2-tetrachloroethane would be the main contributor to carcinogenic consequences. For grouted waste (Action Alternative 3), the major contributor to both toxicological and carcinogenic consequences would be methylene chloride. The scoping measure for which these VOCs would be the major contributor is also indicated in Table G-26.

Heavy Metals

The inventory of metals in the waste was derived from estimates developed for the WIPP SAR (DOE 1995b). The SAR assumed a conservatively high concentration of metals in the waste for analysis of a waste fire. The waste form used for the SAR was the planning-basis WAC. These values were used as the basis for estimating heavy metal inventories of thermally treated waste and waste treated by a shred and grout process (see Appendix A). Waste form and alternative-specific heavy metal inventories of lead, beryllium, cadmium, and mercury are presented in Table G-27. The metals were assumed to be uniformly mixed in the waste containers (see Appendix A).

Table G-26
VOCs with Major Consequence Contribution for Storage Accidents [a]

	Planning-Basis WAC Waste	Grouted Waste
VOCs	Methylene chloride (IDLH, ERPG-2)	Methylene chloride (slope factor, IDLH, ERPG-2)
	1,1,2,2-tetrachloroethane (slope factor)	Carbon tetrachloride
	Carbon tetrachloride	Chloroform
	Chloroform	1,1-dichloroethene
	Chlorobenzene	Benzene
	Benzene	Ethyl benzene
	Ethyl benzene	Tetrachloroethene
	Tetrachloroethene	

[a] The risk measure in parentheses identifies the VOC with the greatest screening value for that measure.

Table G-27
Heavy Metal Concentrations in Treated TRU Waste

Heavy Metals	Concentration (kilograms per drum-equivalent) [a]			
	Waste Treated to Planning-Basis WAC		Thermally Treated Waste	Waste Treated by Shred and Grout Process
	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3
Lead	1.0	0.97	2.6	0.81
Beryllium	0.025	0.025	0.065	0.021
Cadmium	3.6E-4	3.5E-4	9.3E-4	3.0E-4
Mercury	0.43	0.42	1.1	0.35

[a] One drum-equivalent contains 0.208 cubic meters of waste.

G.3.2 Storage Accident Analyses

This section describes the three storage accident scenarios for waste treated to meet the planning-basis WAC, with descriptions of the scenarios as they apply to thermally treated waste or waste that has been treated by a shred and grout process. Table G-28 summarizes the parameters used in the storage accident analyses.

Accident Scenario S1 - Container Puncture, Drop, and Lid Failure

In this accident scenario, operator error causes a forklift to strike and puncture two drums during placement or relocation of waste containers. As a result, a third drum falls from the stack and its lid is knocked off upon impact with the floor. It was assumed that 10 percent of the waste spills out of the punctured containers and 25 percent of the waste spills out of the lidless container; thus, 0.001 of the spilled fraction resuspends in the room air, 0.1 of which is respirable. Particulate releases from the facility were assumed to be HEPA-filtered, with a transmission factor of 1×10^{-3}. All headspace VOCs were assumed to be released.

For waste that has been thermally treated and waste that has been treated by a shred and grout process, no particulate release would be expected from the punctured drums. The lidless drum analyses assumed brittle fracture of the uniformly mixed mass as a result of the fall. Twenty-five percent of the fractured waste was assumed to spill from the container with a respirable resuspension fraction value of 1×10^{-5}, an appropriate value for fractured brittle material (DOE 1994a). VOCs are not present in the thermally treated waste, but all headspace VOCs in the waste treated by a shred and grout process were assumed to be released from all three involved containers.

Accident Scenario S2 - Container Fire

In this scenario, it was assumed that the contents of a single container undergo spontaneous combustion and the mechanism initiating this event is unknown. Past instances of spontaneous combustion at DOE sites have included pyrophoric or incompatible materials reacting in a container, static electricity, and nitric acid reactions (Silva 1991). Packaging activities should

Table G-28
Summary of Storage Accident Scenario Parameters

Scenario	Waste Treatment	*n* Drums Breached	Particulate Release Fraction	VOC Release Fraction	Airborne Respirable Particulate Resuspension Fraction	Other
S1	WAC	3	2 @ 0.1 1@0.25	1	1E-4	1E-3
	LDR	3	1@0.25 2 @ 0.00	0	1E-5	1E-3
	Grout	3	1@0.25 2 @ 0.00	1	1E-5	1E-3
S2	WAC	1	1	0	5E-4	1E-3
	Grout	1	0.22	0	6E-5	1E-3
S3	WAC CH-TRU Waste RH-TRU Waste	 V[a] V[a]	 0.25 0.05	 1 1	 2.5E-5 5E-6	 0.5 0.25
	LDR	V[a]	0.25	0	1E-6	0.5
	Grout	V[a]	0.25	1	1E-6	0.5

[a] V is the total site-specific waste volume (drum-equivalent for CH-TRU waste canisters for RH-TRU waste).

preclude this scenario, but an analysis was conducted on a "what-if" basis without regard to likelihood of initiation. It was assumed that 5×10^{-4} of the radioactive and heavy metals were resuspended as respirable particles, which is the more conservative value of the fraction of respirable particles expected from the burning of either combustible or noncombustible materials (DOE 1994a). Plateout of airborne particulates onto the cool building interior surfaces would be expected but was not considered in the analysis. Particulates released from the facility were assumed to be HEPA-filtered, with a transmission factor of 1×10^{-3}. VOCs were assumed to be consumed by the fire.

This scenario does not apply to thermally treated waste because it is not combustible. Waste treated by a shred and grout process is unlikely to combust, but calculations were performed to bound the accident case. It was assumed that 22 percent of the grouted waste would be transformed to a powder as a result of a 650+ degree Celsius fire (DOE 1994a). A respirable resuspension fraction of 6×10^{-5} was used and reflects the fraction of a heated powder resuspended by the vapor flux generated by an open fire. As with the accident analysis for waste treated to planning-basis WAC, all VOCs in the grouted waste headspace were assumed to be consumed by the fire.

Accident Scenario S3 - Earthquake

The storage facilities were assumed to withstand a certain magnitude of earthquake (i.e., a design-basis earthquake). This scenario, however, assumes a beyond-design-basis earthquake for each storage facility, resulting in loss of confinement capability and structural failure. Although the total site-specific volume of treated waste could be in the storage facility at the time of the seismic event, it was assumed the structure collapses on the waste containers and breaches 25 percent of the drums. Except for the thermally treated waste under No Action Alternative 1, it is unlikely that any site would have the total volume of treated waste in storage at any one point in time. In Appendix F, the cumulative impact analyses estimate that the amount of waste expected in lag storage would range from 0 to 10 percent for the Basic Inventory and 0 to 55 percent for the Total Inventory.

Release estimates were based on the site-specific average PE-Ci inventories (see Table G-23). Breached CH-TRU waste drums were assumed to release all headspace VOCs, and an average of 25 percent of the contents were assumed to spill from the breached drums. The respirable airborne fraction was assumed to be 2.5×10^{-5} of the particulates, half of which were assumed to escape the collapsed structural debris and be released to the environment. For the thermally treated waste and waste treated by a shred and grout process, a portion in the containers was assumed to brittle-fracture as a result of the building collapse. Again, 25 percent of the drum contents was assumed to spill out of the breached containers and a lower 1×10^{-6} airborne respirable fraction was assumed to be available for release.

Consequence estimates for this scenario are more limited than those of the other storage accident scenarios. For the hazardous chemical consequences, only carcinogenic consequences and the IDLH-equivalent ratio impacts were estimated. No ERPG ratios were calculated because of the catastrophic nature of the accident: physical injury or fatalities would be expected for those in the facility as a result of the structural failure, and significant amounts of particulates would be suspended in the air, making suspect any estimated ERPG-2 ratios.

This same scenario was applied to accident consequence analyses for the excess RH-TRU waste stored at Hanford and ORNL under the Proposed Action. This waste meets the planning-basis WAC and is stored in the more robust RH-72B canisters. For the analyses involving an RH-TRU waste storage facility during a beyond-design-basis earthquake analyses, 5 percent of the waste canisters were assumed to breach, an airborne respirable release fraction of 5×10^{-6} was assumed, and a smaller fraction of the airborne particulates was assumed to be released from the debris of the collapsed facility (0.25 for the earthquake involving RH-TRU waste as compared to the 0.5 assumed for the earthquake involving CH-TRU waste).

G.3.3 Consequences of Storage Accidents

Consequences of waste storage accidents were estimated for the MEI, the maximally exposed noninvolved worker, the maximally exposed involved worker, and the exposed off-site population around each of the possible storage sites. Inhalation was the only exposure pathway considered for radionuclides, heavy metals, and VOCs. Acute releases were assumed to be dispersed in one direction, so population consequences were estimated for a single, maximally exposed 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally impacted sector, considering both the change in air concentration over distance and the population distribution in the sector. Radiological consequences are reported as the TEDE, the number of LCFs in an exposed population, and the probability of an LCF in an individual. Carcinogenic hazardous chemical consequences are similarly reported as the number of cancers occurring in the exposed population and as the probability of cancer occurring in an individual. Noncarcinogenic consequences are presented as the ratio of receptor air concentration to ERPG-2 value for VOC exposures and as the ratio of receptor intake to IDLH-equivalent intake for both VOCs and heavy metals exposures. Ratios of 1.0 or higher are significant for a noncarcinogenic impact. Accident consequences were estimated using conservative or bounding input and parameter values and, thus, will likely overestimate the consequences that could occur.

G.3.3.1 Storage Accident Consequences for Action Alternative 1 and No Action Alternative 2

The consequences of storage accidents for waste treated to meet the planning-basis WAC are presented in Tables G-29 to G-31. Table G-29 indicates the radiological consequences. Table G-30 indicates the carcinogenic consequences as a result of the VOC and metals exposures. Table G-31 indicates the noncarcinogenic consequences, presented as the maximum IDLH-equivalent ratio and the maximum ERPG-2 ratio, for maximally exposed workers under Action Alternative 1 and No Action Alternative 2, assuming that newly generated waste under the latter would be packaged to meet the planning-basis WAC. Consequences presented in this section for Action Alternative 1 and No Action Alternative 2 would bound potential consequences of RH-TRU waste storage accidents under the Proposed Action.

Impacts to Population

The greatest potential radiological consequences to the population surrounding any site would be for RFETS (see Table G-29). This result is driven by the population-weighted dispersion factor of the area southeast of the RFETS site, which considers the distance from the population and plume dispersion at various distances. Locations with higher populations at closer distances would result in higher population-weighted dispersion factors. Containers with bounding radionuclide inventories involved in container breach (Accident Scenario S1) or container fire (Accident Scenario S2) accidents would not be expected to result in any LCFs at RFETS or any other site. Accident Scenario S1 population consequences could range from 1 x 10-5 to 5 x 10-4 LCFs, and

Table G-29
Radiological Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)			
					CH-TRU Waste		RH-TRU Waste	
Population	**Dose (person- rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
Hanford	0.47	2E-4	2.1	1E-3	450,000	200	1900	0.9
INEEL	0.023	1E-5	0.10	5E-5	13,000	6	1.2	6E-4
LANL	0.20	1E-4	0.91	5E-4	110,000	50	2.3	1E-3
RFETS	0.94	5E-4	4.2	2E-3	510,000	300	N/A	N/A
ORNL	0.68	3E-4	3.0	2E-3	12,000	6	5.1	3E-3
SRS	0.068	3E-5	0.30	2E-4	75,400	38	N/A	N/A
MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
Hanford	1.2E-4	6E-8	5.3E-4	3E-7	250	0.1	1.1	5E-4
INEEL	1.0E-5	5E-9	4.3E-5	2E-8	6.7	3E-3	6.3E-4	3E-7
LANL	2.8E-4	1E-7	1.2E-3	6E-7	210	0.1	4.3E-3	2E-6
RFETS	5.5E-5	3E-8	2.5E-4	1E-7	32	0.02	N/A	N/A
ORNL	5.1E-4	3E-7	2.3E-3	1E-6	12	6E-3	5.1E-3	3E-6
SRS	4.0E-6	2E-9	1.7E-5	8E-9	8.5	4E-3	N/A	N/A
Maximally Exposed Noninvolved Worker								
Hanford	1.1E-3	4E-7	4.9E-3	2E-6	1,900	1.0	8.1	3E-3
INEEL	2.4E-4	1E-7	1.1E-3	4E-7	1,100	0.6	0.1	4E-5
LANL	8.6E-4	3E-7	3.8E-3	2E-6	1,100	0.6	0.022	9E-6
RFETS	3.9E-4	2E-7	1.7E-3	7E-7	1,100	0.6	N/A	N/A
ORNL	8.6E-4	3E-7	3.8E-3	2E-6	36	0.01	0.015	6E-6
SRS	5.3E-4	2E-7	2.4E-3	9E-7	2,200	1.0	N/A	N/A
Maximally Exposed Involved Worker								
Any Site	140	0.6	See Text	See Text	See Text	See Text	See Text	See Text

Note: Annual doses above 20 rem TEDE to individuals do not include a DDREF (see Section G.1.1).

N/A = Not Applicable

Table G-30
Hazardous Chemical Carcinogenic Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)			
					CH-TRU Waste		RH-TRU Waste	
	VOCs	Metals	VOCs [a]	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	9E-7	1E-12	N/A	6E-12	2E-3	5E-5	1E-4	4E-7
INEEL	4E-8	7E-14		3E-13	6E-5	2E-6	5E-7	2E-9
LANL	4E-7	6E-13		3E-12	2E-4	7E-6	6E-7	2E-9
RFETS	2E-6	3E-12		1E-11	5E-4	2E-5	N/A	N/A
ORNL	1E-6	2E-12		9E-12	4E-5	1E-6	3E-5	1E-7
SRS	1E-7	2E-13		9E-13	3E-5	1E-6	N/A	N/A
MEI	**Cancer Incidence**		**Cancer Incidence**		**Cancer Incidence**		**Cancer Incidence**	
Hanford	2E-10	3E-16	N/A	2E-15	9E-7	3E-8	7E-8	2E-10
INEEL	2E-11	3E-17		1E-16	3E-8	1E-9	2E-10	8E-13
LANL	5E-10	8E-16		4E-15	4E-7	1E-8	1E-9	4E-12
RFETS	2E-10	2E-16		7E-16	3E-8	1E-9	N/A	N/A
ORNL	9E-10	1E-15		7E-15	4E-8	1E-9	3E-8	1E-10
SRS	7E-12	1E-17		5E-17	4E-9	1E-10	N/A	N/A
Maximally Exposed Noninvolved Worker								
Hanford	1E-9	3E-15	N/A	1E-14	5E-6	2E-7	4E-7	2E-9
INEEL	3E-10	7E-16		3E-15	4E-6	2E-7	3E-8	1E-10
LANL	1E-9	2E-15		1E-14	1E-6	7E-8	4E-9	2E-11
RFETS	5E-10	1E-15		5E-15	7E-7	3E-8	N/A	N/A
ORNL	1E-9	2E-15		1E-14	9E-8	4E-9	7E-8	3E-10
SRS	7E-10	2E-15		7E-15	7E-7	3E-8	N/A	N/A
Maximally Exposed Involved Worker								
Any Site	7E-8	4E-10	N/A	See Text	See Text	See Text	See Text	See Text

[a] VOCs are assumed to be consumed by the fire under Accident Scenario S2.

N/A = Not Applicable

Table G-31
Hazardous Chemical Noncarcinogenic Consequences from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)	
					CH-TRU Waste	RH-TRU Waste
	Maximum IDLH-Equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-Equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-Equivalent Ratio	
MEI						
Hanford	5E-7	1E-1	5E-11	2E-4	1E-3	7E-5
INEEL	4E-8	9E-3	4E-12	2E-5	4E-5	3E-7
LANL	1E-6	3E-1	1E-10	5E-4	5E-4	1E-6
RFETS	2E-7	5E-2	3E-11	1E-4	4E-5	N/A
ORNL	2E-6	5E-1	2E-10	1E-3	5E-5	4E-5
SRS	1E-8	4E-3	2E-12	7E-6	4E-6	N/A
Maximally Exposed Noninvolved Worker						
Hanford	3E-6	7E-1	5E-10	2E-3	8E-3	4E-4
INEEL	7E-7	2E-1	1E-10	3E-4	6E-3	3E-5
LANL	2E-6	6E-1	4E-10	1E-3	2E-3	4E-6
RFETS	1E-6	3E-1	2E-10	5E-4	1E-3	N/A
ORNL	2E-6	6E-1	4E-10	1E-3	1E-4	7E-5
SRS	1E-6	6E-1	2E-10	7E-4	1E-3	N/A
Maximally Exposed Involved Worker						
Any Site	2E-4	2	See Text	See Text	See Text	See Text

N/A = Not Applicable

Accident Scenario S2 population consequences could range from 5 x 10^{-5} to 2 x 10^{-3} LCFs. The catastrophic earthquake scenario (Accident Scenario S3) could result in up to 300 LCFs in the RFETS population. For all sites, Accident Scenario S3 consequences could range from 6 to 300 LCFs. The potential hazardous chemical consequences to the population would be very small: 7 x 10^{-14} to 2 x 10^{-6} cancers under Accident Scenario S1, 3 x 10^{-13} to 1 x 10^{-11} cancers under Accident Scenario S2, 1 x 10^{-6} to 2 x 10^{-3} cancers under Accident Scenario S3 with CH-TRU waste, and 2 x 10^{-9} to 1 x 10^{-4} cancers under Accident Scenario S3 with RH-TRU waste (see Table G-30). Therefore, no cancers would be expected in the populations surrounding the five major sites as a result of the hazardous chemical releases of any analyzed accident.

Impacts to Maximally Exposed Individual

The greatest potential radiological consequences for the MEI for Accident Scenarios S1 and S2 would be for ORNL, and the greatest potential radiological consequences for the MEI for Accident Scenario S3 would be for Hanford (see Table G-29). The site of maximum consequence changes for Accident Scenario S3 because these consequences are dependent on site-specific volumes of stored waste and average PE-Ci levels. Accidents Scenarios S1 and S2 assume the same waste volume and PE-Ci levels for each site-specific accident. In contrast to the population consequences discussed above, the change in the MEI dispersion factors for each site is less than the site-specific waste characteristics. Therefore, the MEI consequences are driven more by site-specific waste characteristic changes than by the dispersion factors. Under Accident Scenario S1, radiation doses to the MEI would range from 4 x 10^{-6} to 5 x 10^{-4} rem TEDE, with an associated probability of an LCF of 2 x 10^{-9} to 3 x 10^{-7}. Under Accident Scenario S2, radiation doses to the MEI would range from 2 x 10^{-5} to 2 x 10^{-3} rem TEDE, with an associated probability of an LCF of 8 x 10^{-9} to 1 x 10^{-6}. Catastrophic accident Scenario S3 with CH-TRU waste results in an estimated 7 to 250 rem TEDE to the MEI and a 3 x 10^{-3} to 0.1 probability of an LCF. Accident Scenario S3 with RH-TRU waste results in an estimated 6.3 x 10^{-4} to 1.1 rem TEDE to the MEI and a 3 x 10^{-7} to 5 x 10^{-4} probability of an LCF.

The greatest potential hazardous chemical consequences to the MEI would be for ORNL under Accident Scenarios S1 and S2, and the greatest potential chemical consequencesfor the MEI under Accident Scenario S3 would be for Hanford. The site of maximum hazardous chemical consequence changes for Accident Scenario S3 because of the site-specific parameters of the Accident Scenario S3 analyses. The hazardous chemical inventory of each site is assumed to be constant, but the affected volume changes. The waste volume affected at Hanford drives the Accident Scenario S3 consequence results.

The potential hazardous chemical consequences to the MEI would be very small: carcinogenic consequences would be no greater than a 9 x 10^{-10}, 7 x 10^{-15}, and 4 x 10^{-7} probability of contracting cancer for Accident Scenarios S1, S2, and S3 with CH-TRU waste, respectively (see Table G-30). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic consequence. For Accident Scenario S1 noncarcinogenic consequences, the maximum ERPG-2 ratio would be 0.5 for ORNL for both methylene chloride and 1,1,2,2-tetrachloroethane. Therefore, no serious or irreversible consequences would be expected. Also, no mild transient health consequences or objectionable odors would be expected for this ORNL MEI (maximum ERPG-1 ratio of 0.8 for 1,1,2,2-tetrachloroethane). The maximum IDLH-equivalent ratio for Accident Scenario S1 would be 2 x 10^{-6} (see Table G-31). Under Accident Scenario S2, the

maximum ERPG-2 ratio for the MEI would be 1×10^{-3} and the maximum IDLH-equivalent ratio would be 2×10^{-10}. Only ERPGs for metals are considered under the Accident Scenario S2 analyses. Under Accident Scenario S3, the maximum IDLH-equivalent ratio would be 1×10^{-3} for the Hanford MEI. Therefore, no serious noncarcinogenic consequences would be expected from hazardous chemical exposures under any of the three accident scenarios evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological consequences would be greatest for all accidents evaluated for the Hanford noninvolved worker (see Table G-29). Under Accident Scenario S1, radiological doses to the maximally exposed noninvolved worker would range from 2×10^{-4} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 1×10^{-7} to 4×10^{-7}. Under Accident Scenario S2, radiological doses to the noninvolved worker would range from 1×10^{-3} to 5×10^{3} rem TEDE with an associated probability of an LCF of 4×10^{-7} to 2×10^{-6}. Accident Scenario S3 with CH-TRU waste would result in an estimated 36 to 1,900 rem TEDE to the noninvolved worker. Potential consequences of Accident Scenario S3 from CH-TRU waste to Hanford, SRS, INEEL, LANL, and RFETS would be severe. The first-year dose at these sites was estimated to be greater than 20 rem (88 rem for SRS, 76 for Hanford, and 44 rem for INEEL, LANL and RFETS), which increases their LCF risk for that year by a factor of two (see Section G.1.1). The probability of an LCF for the individuals at these sites is 1.0 for Hanford and SRS and 0.6 for INEEL, LANL, and RFETS. Consequences of Accident Scenario S3 with RH-TRU waste for the noninvolved worker would be greatest at Hanford. Accident Scenario S3 with RH-TRU waste results in an estimated 0.02 to 8.1 rem TEDE with an associated probability of an LCF of 6×10^{-6} to 3×10^{-3}.

The potential carcinogenic hazardous chemical consequences would be greatest for the Hanford maximally exposed noninvolved worker for all accidents (see Table G-30). Rounding of Accident Scenarios S1 and S2 consequences for the LANL and ORNL noninvolved workers also gives carcinogenic consequences that are equivalent to those of the Hanford noninvolved worker. The potential hazardous chemical consequences to the noninvolved worker would be very small, with a 1×10^{-9}, 1×10^{-14}, and 5×10^{-6} probability of contracting cancer for Accident Scenarios S1, S2, and S3, respectively. The Accident Scenario S3 consequences are attributable to the 1,1,2,2-tetracholorethane releases (see Table G-30). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic consequence. For Accident Scenario S1 noncarcinogenic consequences, the maximum ERPG-2 ratio would be 0.7 for Hanford for both methylene chloride and 1,1,2,2-tetrachloroethane releases (see Table G-30). Therefore, no serious or irreversible consequences would be expected. Mild transient health consequences or objectionable odors would be expected for this Hanford noninvolved worker (maximum ERPG-1 ratio of 1.2 for 1,1,2,2-tetrachloroethane). The maximum IDLH-equivalent ratio for Accident Scenario S1 would be 3×10^{-6}. Under Accident Scenario S2, the maximum ERPG-2 ratio for the noninvolved worker would be 2×10^{-3} and the maximum IDLH-equivalent ratio would be 5×10^{-10}. Under Accident Scenario S3, the maximum IDLH-equivalent ratio would be 8×10^{-3} for the Hanford MEI. No serious noncarcinogenic consequences are expected from hazardous chemical exposures under any of the three accident scenarios evaluated.

Impacts to Maximally Exposed Involved Workers

Accident consequences were estimated quantitatively for the maximally exposed involved worker only for Accident Scenario S1. The drum drop was assumed to occur 3 meters (10 feet) from the worker and the estimated release of the three involved containers was assumed to expand in a uniform 5-meter (17-foot) radius hemisphere. The worker was assumed to inhale air at the concentration of the hemisphere for 60 seconds prior to exiting to a fresh air source (DOE 1997). For waste packaged to meet the planning-basis WAC, the worker would receive a dose of 140 rem TEDE with an associated probability of an LCF of 0.06. The maximum first-year dose from such an intake would be 6 rem. Carcinogenic consequences from VOC and heavy metal intakes would be a 7×10^{-8} and 4×10^{-10} probability of a cancer incidence, respectively. Releases could have irreversible, non-life-threatening consequences from exposure to 1,1,2,2-tetrachloroethane and methylene chloride (ERPG-2 ratio of 2 for both) (see Table G-31). Mild transient health consequences would be expected from lead and mercury exposures (ERPG-1 ratios of 1 for both) (see Table G-31). Noncarcinogenic consequences evaluated according to IDLH-equivalent intake ratios do not indicate that any consequence would result (maximum ratio of 2×10^{-4}).

If the maximally exposed involved worker were located next to a drum fire (Accident Scenario S2) when it erupted, the consequences would be severe. However, the probability that this scenario would occur is minute. The smoke would be apparent and the worker can be presumed to exit the facility immediately.

If the maximally exposed involved worker were present when the storage facility collapsed (Accident Scenario S3), consequences would be severe. If not killed by falling accident debris, the worker could inhale high levels of radionuclides and hazardous chemicals.

G.3.3.2 Storage Accident Consequences for Action Alternative 2 and No Action Alternative 1

Waste which has been thermally treated to a final waste form that meets land disposal restrictions is safer to store than waste packaged to meet the planning-basis WAC. Thermally treated waste is a feature of Action Alternative 2 and No Action Alternative 1, has no VOCs, and is solidified such that radioactive material and heavy metals are unlikely to disperse in the event of a containment breach. Radiological consequences are presented first, followed by hazardous chemical consequences. Consequence estimates for thermally treated waste are presented in Tables G-32 and G-33. The subalternatives under Action Alternative 2 and No Action Alternative 1 are not presented separately; however, the highest consequence that would occur under any of the subalternatives is presented in Tables G-32 and G-33. Accident Scenario S2 is not expected for waste treated to meet land disposal restictions.

Impacts to Population

The potential radiological consequences to the population surrounding any site would be highest around RFETS. Releases of radioactive materials from a container breach (Accident Scenario S1) would not be expected to result in any LCFs in the population (6×10^{-7} to 3×10^{-5}) (see Table G-32). The consequences from the catastrophic CH-TRU waste storage facility failure of Accident Scenario S3 would result in an estimated 0.8 to 10 LCFs. All major storage facility sites except INEEL would be expected to have at least 1 LCF from such an event. No LCFs would be expected from catastrophic failure of an RH-TRU waste storage facility at ORNL or Hanford (4×10^{-4} and 2×10^{-2} LCFs).

Table G-32
Radiological Consequences from Storage Accidents for Thermally Treated Waste
(Action Alternative 2 and No Action Alternative 1)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S3 (Earthquake)			
			CH-TRU Waste		RH-TRU Waste	
	Dose (person-rem or rem)	LCF	Dose (person-rem or rem)	LCF	Dose (person-rem or rem)	LCF
Population						
Hanford	2.6E-2	1E-5	18,000	9	39	2E-2
INEEL [a]	1.3E-3	6E-7	1,500	0.8	N/A	N/A
LANL [b]	1.1E-2	6E-6	4,200	2	N/A	N/A
RFETS [b]	5.2E-2	3E-5	21,000	10	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	0.86	4E-4
SRS	3.8E-3	2E-6	3,200	2	N/A	N/A
WIPP [c]	1.4E-3	7E-7	3,600	2	N/A	N/A
MEI		**Probability of an LCF**		**Probability of an LCF**		**Probability of an LCF**
Hanford	6.6E-6	3E-9	9.9	5E-3	2.2E-2	1E-5
INEEL [a]	5.4E-7	3E-10	0.81	4E-4	N/A	N/A
LANL [b]	1.5E-5	8E-9	8.0	4E-3	N/A	N/A
RFETS [b]	3.1E-6	2E-9	1.3	7E-4	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	8.6E-4	4E-7
SRS	2.1E-7	1E-10	0.35	2E-4	N/A	N/A
WIPP [c]	2.6E-5	1E-8	160	0.08	N/A	N/A
Maximally Exposed Noninvolved Worker		**Probability of an LCF**		**Probability of an LCF**		**Probability of an LCF**
Hanford	6.1E-5	2E-8	76	3E-2	0.17	7E-5
INEEL [a]	1.4E-5	5E-9	130	5E-2	N/A	N/A
LANL [b]	4.8E-5	2E-8	41	2E-2	N/A	N/A
RFETS [b]	2.2E-5	9E-9	45	2E-2	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	2.6E-3	1E-5
SRS	3.0E-5	1E-8	94	4E-2	N/A	N/A
WIPP [c]	2.6E-5	1E-8	280	0.1	N/A	N/A
Maximally Exposed Involved Worker		**Probability of an LCF**		**Probability of an LCF**		**Probability of an LCF**
Any Site	7.8	3E-3	See Text	See Text	See Text	See Text

[a] Consequences are greatest at INEEL under Action Alternative 2B.
[b] CH-TRU waste is stored at LANL and RFETS only under Action Alternative 2A.
[c] CH-TRU waste is stored WIPP only under Action Alternative 2C.

N/A = Not Applicable

The potential hazardous chemical carcinogenic consequences to populations would be very small. The population around RFETS and Hanford were estimated to be the most affected of any of the exposed populations. Only heavy metals would contribute any hazardous chemical consequences, and only cadmium and beryllium would be carcinogenic. Maximum potential carcinogenic consequences would range from 1×10^{-14} to 4×10^{-13} cancers for Accident Scenario S1, 5×10^{-8} to 2×10^{-6} cancers for Accident Scenario S3 with CH-TRU waste, and 2×10^{-9} to 8×10^{-9} cancers for Accident Scenario S3 with RH-TRU waste (see Table G-33).

Impacts to Maximally Exposed Individuals

The greatest potential radiological consequences for the MEI would be at WIPP for Accident Scenarios S1 and S3 (Action Alternative 2C only) (see Table G-32). The MEI doses for Accident Scenario S1 would range from 2×10^{-7} to 3×10^{-5} rem TEDE, with a 1×10^{-10} to 1×10^{-8}

Table G-33
Hazardous Chemical Carcinogenic and Noncarcinogenic Consequences from Storage Accidents for Thermally Treated Waste (Action Alternative 2 and No Action Alternative 1)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)			Accident Scenario S3 (Earthquake)			
				CH-TRU Waste		RH-TRU Waste	
	Cancer Incidence	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Cancer Incidence	Maximum IDLH-equivalent Ratio	Cancer Incidence	Maximum IDLH-equivalent Ratio
Population							
Hanford	2E-13			2E-6		8E-9	
INEEL	1E-14			1E-7		N/A	
LANL	9E-14			3E-7		N/A	
RFETS	4E-13	N/A	N/A	4E-7	N/A	N/A	N/A
ORNL	N/A			N/A		2E-9	
SRS	3E-14			5E-8		N/A	
WIPP	1E-14			3E-7		N/A	
MEI	**Probability of an LCF**			**Probability of an LCF**		**Probability of an LCF**	
Hanford	5E-17	2E-12	8E-6	1E-9	4E-5	5E-12	2E-7
INEEL	4E-18	1E-13	6E-7	7E-11	3E-6	N/A	N/A
LANL	1E-16	4E-12	2E-5	5E-10	2E-5	N/A	N/A
RFETS	2E-17	8E-13	4E-6	2E-11	8E-7	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	2E-12	7E-8
SRS	2E-18	6E-14	2E-7	5E-12	2E-7	N/A	N/A
WIPP	2E-16	6E-12	2E-5	2E-7	7E-3	N/A	N/A
Maximally Exposed Noninvolved Worker	**Probability of an LCF**			**Probability of an LCF**		**Probability of an LCF**	
Hanford	5E-16	2E-11	5E-5	9E-9	3E-4	3E-11	1E-6
INEEL	1E-16	4E-12	1E-5	1E-8	4E-4	N/A	N/A
LANL	4E-16	1E-11	4E-5	2E-9	9E-5	N/A	N/A
RFETS	2E-16	6E-12	2E-5	8E-10	3E-5	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	6E-12	2E-7
SRS	2E-16	8E-12	2E-5	1E-9	5E-5	N/A	N/A
WIPP	2E-16	6E-12	2E-5	2E-8	8E-4	N/A	N/A
Maximally Exposed Involved Worker	**Probability of an LCF**			**Probability of an LCF**		**Probability of an LCF**	
Any Site	6E-11	0.5	See Text	See Text	See Text	See Text	See Text

N/A = Not Applicable

probability of an LCF. For Accident Scenario S3 with CH-TRU waste, MEI doses would range from 0.35 to 160 rem TEDE, with a 2×10^{-4} to 0.08 probability of an LCF. For Accident Scenario S3 with RH-TRU waste, MEI doses would be 9×10^{-4} to 2×10^{-2} rem TEDE, with a 4×10^{-7} and 1×10^{-5} probability of an LCF.

The hazardous chemical impacts to the MEI would be extremely small. Carcinogenic consequences from exposure to hazardous chemicals would range from a 2×10^{-18} to 2×10^{-16} probability of a cancer and a 5×10^{-12} to 2×10^{-7} probability of a cancer, and 2×10^{-12} to 5×10^{-12} probability of cancer for Accident Scenarios S1 and S3 with CH-TRU waste with RH-TRU waste.

Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic consequence. For Accident Scenario S1, the maximum ERPG-2 ratio would be 2×10^{-5} and the maximum IDLH-equivalent ratio would be even smaller (6×10^{-12}). For Accident Scenario S3 with CH-TRU waste and RH-TRU waste, the maximum IDLH-equivalent ratio would be 7×10^{-3}. Therefore, no noncarcinogenic consequences would be expected under either of the two accidents evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological consequences would be greatest for the Hanford maximally exposed noninvolved worker for Accident Scenario S1 and for the WIPP maximally exposed noninvolved worker for Accident Scenario S3 (see Table G-32). Under Accident Scenario S1, radiological doses to the noninvolved worker would range from 1×10^{-5} to 6×10^{-5} rem TEDE, with a 5×10^{-9} to 2×10^{-8} probability of an LCF. Under Accident Scenario S3 with CH-TRU waste, the assumed storage of all waste at WIPP under Action Alternative 2C resulted in the bounding consequences. Doses under Accident Scenario S3 with CH-TRU waste would range from 41 to 280 rem TEDE, with a 0.02 to 0.1 probability of an LCF. Doses for Accident Scenario S3 with RH-TRU waste would be 3×10^{-3} and 0.2 rem TEDE with a 1×10^{-6} and 7×10^{-5} probability of an LCF.

The potential consequences to the maximally exposed noninvolved worker from exposures to hazardous chemicals as a result of the two accidents evaluated would be extremely small. Under Accident Scenario S1, carcinogenic consequences would be no greater than a 5×10^{-16} probability of cancer. Under Accident Scenario S3 for CH-TRU and RH-TRU waste, carcinogenic consequences would be no greater than a 2×10^{-8} probability of cancer. Accident Scenario S1 has a maximum ERPG-2 ratio of 5×10^{-5} and a maximum IDLH-equivalent ratio of 2×10^{-11}. Accident Scenario S3 has a maximum IDLH-equivalent ratio of 8×10^{-4}. Therefore, no noncarcinogenic consequences would be expected.

Impacts to Maximally Exposed Involved Worker

Accident consequences were estimated quantitatively for the maximally exposed involved worker only under Accident Scenario S1. The drum drop was assumed to occur 3 meters (10 feet) from the worker, and the estimated release of the three involved containers was assumed to expand in a uniform 5-meter (17-foot) radius hemisphere. The worker was assumed to inhale air at the concentration of the hemisphere for approximately 60 seconds prior to exiting to a fresh air source (DOE 1997). For thermally treated waste, the worker would receive a dose of 7.8 rem TEDE, with a 3×10^{-3} probability of an LCF. The maximum first-year dose from such an intake would be 0.3 rem TEDE. A carcinogenic consequence of a 6×10^{-11} probability of cancer would be expected from heavy metal intakes. No noncarcinogenic consequences would be expected.

If an involved worker were present when the storage facility collapsed (Accident Scenarios S3 with CH-TRU and RH-TRU waste), consequences would be severe. If not killed by falling accident debris, surviving workers could inhale high levels of transuranic radionuclides and hazardous chemicals.

G.3.3.3 Storage Accident Consequences for Action Alternative 3

The consequences from the potential accidental releases of waste treated by a shred and grout process are indicated in Tables G-34 through G-36. Because of the solidified waste form, these accident analyses, which apply only to Action Alternative 3, indicate fewer consequences than those calculated for the Proposed Action. Radiological consequences are discussed first, followed by hazardous chemical consequences. The Accident Scenario S1 radiological consequences are identical to those reported for the thermally treated waste. This is a consequence of the evaluation

Table G-34
Radiological Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)			
					CH-TRU Waste		RH-TRU Waste	
	Rem	LCF	Rem	LCF	Rem	LCF	Rem	LCF
Population								
Hanford	2.6E-2	1E-5	5.5E-2	3E-5	18,000	9	39	0.02
INEEL	1.3E-3	6E-7	2.7E-3	1E-6	530	0.3	N/A	N/A
LANL	1.1E-2	6E-6	2.4E-2	1E-5	4,400	2	N/A	N/A
RFETS	5.2E-2	3E-5	1.1E-1	5E-5	20,000	10	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	N/A	0.98	5E-4
SRS	3.8E-3	2E-6	8.0E-3	4E-6	3,200	2	N/A	N/A
MEI								
Hanford	6.6E-6	3E-9	1.4E-5	7E-9	10	5E-3	0.022	1E-5
INEEL	5.4E-7	3E-10	1.1E-6	6E-10	0.28	1E-4	N/A	N/A
LANL	1.5E-5	8E-9	3.2E-5	2E-8	8.5	4E-3	N/A	N/A
RFETS	3.1E-6	2E-9	6.5E-6	3E-9	1.3	6E-4	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	N/A	9.8E-4	5E-7
SRS	2.1E-7	1E-10	4.4E-7	2E-10	0.36	2E-4	N/A	N/A
Maximally Exposed Noninvolved Worker								
Hanford	6.1E-5	2E-8	1.3E-4	5E-8	79	3E-2	0.17	7E-5
INEEL	1.4E-5	5E-9	2.9E-5	1E-8	46	2E-2	N/A	N/A
LANL	4.8E-5	2E-8	1.0E-4	4E-8	44	2E-2	N/A	N/A
RFETS	2.2E-5	9E-9	4.6E-5	2E-8	44	2E-2	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	N/A	2.9E-3	1E-6
SRS	3.0E-5	1E-8	6.2E-5	2E-8	95	4E-2	N/A	N/A
Maximally Exposed Involved Worker								
Any Site	7.8	3E-3	See Text	See Text	See Text	See Text	See Text	See Text

N/A = Not Applicable

Table G-35
Hazardous Chemical Carcinogenic Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)	Accident Scenario S3 (Earthquake)			
				CH-TRU Waste		RH-TRU Waste	
	VOCs	Metals	Metals	VOCs	Metals	VOCs	Metals
Population							
Hanford	5E-7	6E-14	1E-13	1E-3	2E-6	8E-5	9E-9
INEEL	3E-8	3E-15	7E-15	4E-5	8E-8	N/A	N/A
LANL	2E-7	3E-14	6E-14	1E-4	3E-7	N/A	N/A
RFETS	1E-6	1E-13	3E-13	3E-4	6E-7	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	2E-5	2E-9
SRS	7E-8	9E-15	2E-14	2E-5	5E-8	N/A	N/A
MEI							
Hanford	1E-10	2E-17	3E-17	6E-7	1E-9	5E-8	5E-12
INEEL	1E-11	1E-18	3E-18	2E-8	4E-11	N/A	N/A
LANL	3E-10	4E-17	8E-17	3E-7	5E-10	N/A	N/A
RFETS	6E-11	7E-18	2E-17	2E-8	4E-11	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	2E-8	2E-12
SRS	4E-12	5E-19	1E-18	3E-9	6E-12	N/A	N/A
Maximally Exposed Noninvolved Worker							
Hanford	8E-10	1E-16	3E-16	3E-6	1E-8	2E-7	4E-11
INEEL	2E-10	3E-17	7E-17	2E-6	7E-9	N/A	N/A
LANL	6E-10	1E-16	2E-16	9E-7	3E-9	N/A	N/A
RFETS	3E-10	5E-17	1E-16	4E-7	1E-9	N/A	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	4E-8	6E-12
SRS	4E-10	7E-17	2E-16	5E-7	2E-9	N/A	N/A
Maximally Exposed Involved Worker							
Any Site	5E-8	2E-11	See Text	See Text	See Text	See Text	See Text

N/A = Not Applicable

Table G-36
Hazardous Chemical Noncarcinogenic Consequences from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)	
					CH-TRU Waste	RH-TRU Waste
	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-equivalent Ratio	Maximum IDLH-equivalent Ratio
MEI						
Hanford	5E-7	1E-1	1E-12	5E-6	6E-4	5E-5
INEEL	4E-8	9E-3	1E-13	4E-7	2E-5	N/A
LANL	1E-6	3E-1	3E-12	1E-5	2E-4	N/A
RFETS	2E-7	5E-2	6E-13	2E-6	2E-5	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	2E-5
SRS	1E-8	4E-3	4E-14	2E-7	3E-6	N/A
Maximally Exposed Noninvolved Worker						
Hanford	3E-6	7E-1	1E-11	3E-5	3E-3	2E-4
INEEL	7E-7	2E-1	2E-12	7E-6	2E-3	N/A
LANL	2E-6	6E-1	9E-12	3E-5	9E-4	N/A
RFETS	1E-6	3E-1	4E-12	1E-5	4E-4	N/A
ORNL	N/A	N/A	N/A	N/A	N/A	4E-5
SRS	1E-6	1E-1	5E-12	2E-5	5E-4	N/A
Maximally Exposed Involved Worker						
Any Site	2E-4	2	See Text	See Text	See Text	See Text

N/A = Not Applicable

of 80 PE-Ci containers for each solidified waste form. It is more likely, however, that consequences from randomly selected drums under the grouted waste alternative would be less than those of randomly selected drums under thermally treated waste alternatives because actual average PE-Ci levels of grouted waste are less than those of thermally treated waste (see Table G-23).

Impacts to Population

The potential radiological consequence to the population surrounding the waste storage sites would be greatest at RFETS. This result is driven by the population-weighted dispersion factor for the population southeast of the site. No LCFs would be anticipated for the RFETS or any other population as a result of Accident Scenario S1. Consequence estimates range from 6×10^{-7} to 3×10^{-5} LCFs. A waste container fire (Accident Scenario S2) would also not be expected to result in any LCFs in the surrounding population of any site (1×10^{-6} to 5×10^{-5} LCFs). The catastrophic CH-TRU waste storage facility failure (Accident Scenario S3 with CH-TRU waste) would potentially result in up to 10 LCFs in the RFETS population. Consequences from Accident Scenario S3 with CH-TRU and RH-TRU waste would range from 5.0×10^{-4} to 10 LCFs.

The potential hazardous chemical impacts would be very small; no incidences of cancer would be expected in the populations as a result of the hazardous chemical releases of the accidents analyzed. Estimates ranged from a 3×10^{-15} to 1×10^{-6} cancer incidences for Accident Scenario S1, 7×10^{-15} to 3×10^{-13} cancers for Accident Scenario S2, and 2×10^{-9} to 1×10^{-3} cancers for Accident Scenario S3 with CH-TRU and RH-TRU waste.

Impacts to Maximally Exposed Individual

The potential radiological consequences for the MEI would be greatest for LANL and Hanford. For Accident Scenario S1, estimated doses to the MEI would range from 2×10^{-7} to 2×10^{-5} rem

TEDE, with a 1×10^{-10} to 8×10^{-9} probability of an LCF. Under Accident Scenario S2, doses would range from 4×10^{-7} to 3×10^{-5} rem TEDE, with a 2×10^{-10} to 2×10^{-8} probability of an LCF. Accident Scenario S3 with CH-TRU waste would result in an estimated 0.3 to 10 rem TEDE, with a 1×10^{-4} to 5×10^{-3} probability of an LCF. Accident Scenario S3 with RH-TRU waste would result in an estimated 1×10^{-3} to 0.02 rem TEDE, with a 5×10^{-7} and 1×10^{-5} probability of an LCF, respectively.

The greatest potential hazardous chemical consequences for the MEI would be at LANL under Accident Scenarios S1 and S2 and at Hanford under Accident Scenario S3. Yet, the potential consequences overall would be very small: carcinogenic consequences would be no greater than a 3×10^{-10}, 8×10^{-17}, 6×10^{-7}, and 5×10^{-8} cancer incidence for Accident Scenarios S1, S2, and S3 with CH-TRU waste, and S3 with RH-TRU waste, respectively. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic consequence. For Accident Scenario S1, the maximum ERPG-2 ratios to the MEI would be 0.3 at LANL and 0.1 at Hanford, and the maximum IDLH-equivalent ratio would be 1×10^{-6} (see Table G-36). These consequences result from bounding methylene chloride inventories in the involved waste containers. For Accident Scenario S2, the maximum ERPG-2 ratio would be 1×10^{-5}, and the maximum IDLH-equivalent ratio would be 3×10^{-12}. Accident Scenario S3 with CH-TRU and RH-TRU waste calculations show a maximum IDLH-equivalent ratio of 6×10^{-4}. No noncarcinogenic consequences to the MEI would be expected for any of the accident scenarios evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological consequences were estimated to be greatest for the Hanford maximally exposed noninvolved worker. Under Accident Scenario S1, doses would range from 1×10^{-5} to 6×10^{-5} rem TEDE, with a 5×10^{-9} to 2×10^{-8} probability of an LCF. Under Accident Scenario S2, doses would range from 3×10^{-5} to 1×10^{-4} rem TEDE, with a 1×10^{-8} to 5×10^{-8} probability of an LCF. Accident Scenario S3 with CH-TRU waste would result in the most serious radiological consequences to the noninvolved worker, with doses ranging from 44 to 95 rem TEDE and a 2×10^{-2} to 4×10^{-2} probability of an LCF.

The potential hazardous chemical consequences to the noninvolved worker would be small: Carcinogenic consequences would be no greater than a 8×10^{-10}, 3×10^{-16}, and 3×10^{-6} cancer incidence for Accident Scenarios S1, S2, and S3 with CH-TRU waste, respectively. Noncarcinogenic consequences for Accident Scenario S1 would have a maximum ERPG-2 ratio of 0.7 at Hanford and 0.6 at LANL, which is attributable to bounding methylene chloride releases. The maximum IDLH-equivalent ratio for Accident Scenario S1 was estimated to be 3×10^{-6}. For Accident Scenario S2, the maximum ERPG-2 ratio is 3×10^{-5}, and the maximum IDLH-equivalent ratio would be 1×10^{-11}. For Accident Scenario S3 with CH-TRU waste, the maximum IDLH-equivalent ratio would be 3×10^{-3}. For Accident Scenario S3 with RH-TRU waste, the maximum IDLH-equivalent ratio would be 2×10^{-4}. Therefore, no noncarcinogenic consequences to the noninvolved worker would be expected from the hazardous chemical releases for the accidents evaluated.

Impacts to Maximally Exposed Involved Worker

Accident consequences were estimated quantitatively for the maximally exposed involved worker only for Accident Scenario S1. The drum drop was assumed to occur 3 meters (10 feet) from the worker and the estimated release of the three involved containers was assumed to expand in a uniform 5-meter (17- foot) radius hemisphere. The worker was assumed to inhale air at the concentrations of the hemisphere for approximately 60 seconds prior to exiting to a fresh air source (DOE 1997). For waste treated by a shred and grout process, the worker would receive a dose of 7.8 rem TEDE, with a 3×10^{-3} probability of an LCF. Carcinogenic consequences from VOC and heavy metal intakes would be a 5×10^{-8} and 2×10^{-11} probability of a cancer incidence, respectively. Releases could have irreversible, non-life-threatening consequences from bounding methylene chloride releases (ERPG-2 ratio of 1.6).

If an involved worker were located next to a drum fire when it erupted (Accident Scenario S2), consequences would be great. However, the probability that this scenario would occur is minute because an action by the worker does not initiate the accident. The smoke would be apparent and the worker can be presumed to exit the facility immediately.

If an involved worker were present when the storage facility collapsed (Accident Scenario S3 with CH-TRU and RH-TRU waste), consequences would be severe. If not killed by falling accident debris, surviving workers could inhale high levels of transuranic radionuclides and hazardous chemicals.

G.4 WIPP DISPOSAL ACCIDENT SCENARIOS

This section describes the accident scenarios evaluated for disposal operations at the WIPP site. Scenarios include accidents previously evaluated in *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990), and, for the roof fall (Accident Scenario W7), in both SARs (DOE 1995b; DOE 1997). Table G-37 presents the accident scenarios evaluated in this section with their specified SEIS-II identifying numbers and, for those scenarios that were also evaluated in SEIS-I, the corresponding SEIS-I identifier.

Table G-37
WIPP Disposal Accident Scenarios

SEIS-II Accident Scenario	Accident Description	Waste Type	Prior Analysis Reference
W1	Container Drop and Lid Seal Failure in the Waste Handling Building	CH-TRU	SEIS-I C2
W2	Container Puncture, Drop and Lid Seal Failure in the Waste Handling Building	CH-TRU	SEIS-I C3
W3	Container Drop and Lid Seal Failure in the Underground	CH-TRU	SEIS-I C4
W4	Container Puncture, Drop and Lid Seal Failure in the Underground	CH-TRU	SEIS-I C6
W5	Container Fire in the Underground	CH-TRU	SEIS-I C10
W6	Failure of the Waste Shaft Hoist	CH-TRU RH-TRU	SEIS-I C8 none [a]
W7	Roof Fall in a Disposal Room in the Underground	CH-TRU	SAR CH 11
W8	RH-TRU Waste Canister Breach in the Waste Handling Building	RH-TRU	SEIS-I R4

[a] Accident R5 in SEIS-I but no analysis was conducted.

Additional information on the accident scenarios is provided below. The base case descriptions assume that the waste is packaged to meet the minimum planning-basis WAC requirements. Additional cases are added to describe accidents for thermally treated waste (Action Alternative 2 and No Action Alternative 1) and waste treated by the shred and grout process (Action Alternative 3). The consequences of accident scenarios involving CH-TRU waste are reported for waste drum releases. For waste treated to planning-basis WAC, source-term information is also provided for waste contained in standard waste boxes (SWBs). The consequences of an SWB accident can be scaled from the reported consequences for a drum accident (under Proposed Action and Action Alternative 1), using the ratio of the source terms. The only scenario for which an SWB scenario results in a greater release than a drum scenario is the container fire; the SWB release is 160 percent of the drum release. Accident evaluations for all RH-TRU waste assumed that waste would be packaged in drums inside RH-TRU waste canisters.

G.4.1 Inventory

Waste container inventories for radionuclides, heavy metals, and VOCs are the same as the stored waste inventories in Section G.3.1. The quantity of any potentially hazardous constituents in waste to be disposed of at WIPP is limited by the planning-basis WAC. Radionuclides have greater potential consequence than hazardous chemicals; therefore, CH-TRU waste drums may contain no more than 80 PE-Ci, CH-TRU waste standard waste boxes may contain no more than 130 PE-Ci, and RH-TRU waste canisters may contain no more than 1,000 PE-Ci. Radionuclide activities at these limits were assumed to be present in waste containers evaluated for all accidents. Table G-38 shows the average radionuclide content of waste at WIPP, which are the same values shown in Tables G-23 and G-24. Drum headspace concentrations of VOCs would be the same as those shown in Table G-25, and drum heavy metal contents would remain the same as those shown in Table G-27.

Table G-38
Average WIPP Radionuclide Content of CH-TRU Waste and RH-TRU Waste (PE-Ci per waste container) [a]

Proposed Action		Action Alternative 1		Action Alternative 2		Action Alternative 3	
CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
3.5	0.3	2.9	3.0	7.7	8.6	2.5	2.5

[a] CH-TRU waste content is measured by PE-Ci per drum-equivalent (or 0.208 cubic meters). RH-TRU waste content is measured by PE-Ci per canister, each containing three drum-equivalents.

G.4.2 WIPP Disposal Accident Analysis

This section presents the accident analyses and estimated source terms for each of the eight WIPP disposal accident scenarios. TRU waste may be stored in either drums or standard waste boxes when treated to the planning-basis WAC. For thermally treated waste or waste treated by a shred and grout process, which has a greater density and mass, these waste forms would only be in drums. Initial analyses showed that potential consequences from accidents involving standard waste boxes could be about 60 percent higher than the same accident involving drums. However, only

consequences from waste in drums was analyzed in detail because drums were assumed to contain the majority of waste disposed of underground and are also expected to contain higher concentrations of radionuclides.

Estimates of particulate radionuclides and heavy metals released to the atmosphere outside a facility (the accident source term for members of the public and maximally exposed noninvolved workers) do not consider HEPA filtration of exhaust streams. The Waste Handling Building has continuous HEPA filtration. Therefore, consequences reported for the Waste Handling Building particulate releases (i.e., radioactive materials and heavy metals) may be overestimated by a factor of one thousand or more, assuming a filtration efficiency of at least 99.9 percent. The underground effluent is not normally HEPA-filtered; salt accumulation on the HEPA filter from filtration of the ambient underground air would degrade the filter. A system is in place that would allow air to be routed through HEPA filter banks in the event that radioactive material is detected in the underground exhaust effluent. Recent investigations by the Environmental Evaluation Group (EEG) (Bartlett 1993 and 1996) have questioned the ability of the detection system to operate appropriately because of salt build-up on and degradation of the detection probe. Therefore, excluding consideration of HEPA filtration for underground accidents would encompass potential consequences in the event that the detector fails to function properly. If the underground releases are HEPA-filtered, the consequence estimates from particulate releases would be reduced by a factor of as much as one million.

The entire VOC headspace volume was assumed to be released as a result of container failures for each accident scenario. An average of 0.147 cubic meters (5 cubic feet) of headspace was assumed per drum (DOE 1990). The same headspace volume was assumed for waste treated to planning-basis WAC and for grouted waste. Because the packing efficiency should improve as a result of the packaging and uniform waste matrix, this would be a conservative assumption for grouted waste under Action Alternative 3. For releases from the underground through the Exhaust Filter Building to the atmosphere, it was assumed that none of the VOCs would deposit on interior walls, exhaust ventilation walls, or the HEPA filtration system.

Descriptions of each of the WIPP accident scenarios for each of the three waste forms that may be disposed of underground are presented below. Scenario parameters, summarized in Tables G-39 and G-40, follow the scenario descriptions.

Accident Scenario W1 - Container Drop and Lid Seal Failure in the Waste Handling Building

Under this scenario, a package is dropped from a forklift (either a seven-pack of CH-TRU waste drums or a standard waste box) while being handled in the Waste Handling Building. Because the waste containers are Type A packages, per U.S. Nuclear Regulatory Commission (NRC) requirements, they are designed to withstand a 1-meter (4-foot) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this designed rating, it was assumed that the container drop and subsequent crushing causes the lid of a single container to be knocked off. No inner plastic liner was assumed to be present. A fraction of the respirable-sized particulates in the drum were assumed to be suspended inside the drum during the fall and released when a lid failed. Spilled contents would be released and the respirable particles resuspended from this material. Facility HEPA filtration was not considered for releases to the atmosphere. This method was applied to the quantities of particulate radionuclides and heavy metals (lead, mercury, beryllium, and cadmium) in the waste.

Table G-39
Accident Analysis Parameters for Waste Treated to Planning-Basis WAC for the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Parameter Values[a]		
		N	f_{rel}	f_{resp}
W1	Drop, Lid Failure in Waste Handling Building	D: 1 S: 1	0.25	1E-4
W2	Drop, Puncture, Lid Failure in Waste Handling Building	D: 3 S: 2	D: 2 @ 0.1 1 @ 0.25 S: 1 @ 0.1 1 @ 0.25	1E-4
W3	Drop, Lid Failure in Underground	D: 1 S: 1	0.25	1E-4
W4	Drop, Puncture, Lid Failure in Underground	D: 3 S: 2	D: 2 @ 0.1 1 @ 0.25 S: 1 @ 0.1 1 @ 0.25	1E-4
W5	Container Fire in the Underground	D: 1 S: 1	1	5E-4
W6	Hoist Failure CH-TRU Waste	D: 28 S: 4	D: 14 @ 1.0 14 @ 0.1 S: 2 @ 1.0 2 @ 0.1	1E-3
	RH-TRU Waste	1	0.7	5.5E-4
W7	Roof Fall	D: 18 S: 5	0.25	1E-4
W8	RH-TRU Waste Canister Breach	RH: 1	0.01	1E-4

[a] D = drum, S = standard waste box, RH = RH-TRU waste canister

Table G-40
Accident Analysis Parameters for Thermally Treated and Grouted Waste for the Action Alternative 2 Subalternatives and Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Parameter		
		N	f_{rel}	f_{resp}
W1	Drop, Lid Failure in Waste Handling Building	1	0.25	1E-5
W2	Drop, Puncture, Lid Failure in Waste Handling Building	3	1 @ 0.25 2 @ 0	1E-5
W3	Drop, Lid Failure in Underground	1	0.25	1E-5
W4	Drop, Puncture, Lid Failure in Underground	3	1 @ 0.25 2 @ 0	1E-5
W5[a]	Container Fire	1	0.22	6E-5
W6	Hoist Failure CH-TRU Waste RH-TRU Waste	 28 1	 1 0.7	 3E-3 3E-3
W7	Roof Fall	18	0.25	1E-5
W8	RH-TRU Waste Canister Breach	1	0	N/A

[a] Only applies to grouted waste under Action Alternative 3.

N/A = Not Applicable

All VOCs present in the container headspace were assumed to be released, with a total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Workers in the immediate vicinity of the accident were assumed to notice the container breach and exit the work area. The concentration of radionuclide and hazardous chemicals in the air that the worker inhales was determined by assuming that the worker is located 3 meters (10 feet) from the airborne release and the release expands in a uniform 5-meter (17-foot) radius hemisphere from ground level. The involved worker is assumed to breathe at a rate of 3.33×10^{-4} cubic meters per second (1.18×10^{-2} cubic feet per second) (ICRP 1975), which is the male light activity rate, for a period of 60 seconds. The 60-second period represents the length of time it is assumed for the worker to take to stop waste handling (10 seconds), examine the situation and note that containment has been breached (20 seconds), and exit the Waste Handling Building (30 seconds) (DOE 1997).

Case W1a: Waste Treated to Planning-Basis WAC

Either a seven-pack of CH-TRU waste drums or a standard waste box would be handled in the Waste Handling Building. Twenty-five percent of a single container contents were assumed to spill (DOE 1990). The fraction of the spilled contents that would become airborne was assumed to be 0.001 and the respirable fraction was assumed to be 0.1, based on material packaged in a drum that opens due to impact with the floor or falling debris (DOE 1994a). This value applies to the suspension of powder in a can due to debris impact. The total respirable release fraction for particulates would be 2.5×10^{-5}.

Case W1b: Thermally Treated Waste

Only drums would be handled in this accident scenario. The waste was assumed to be a solid vitrified mass, so that only a small amount of particulate material would be released. A respirable resuspension fraction of 1×10^{-5} was used (DOE 1994a), assuming a brittle fracture of the waste mass during the fall. Twenty-five percent of the resuspended material was assumed to be released from the container, so the total respirable release fraction would be 2.5×10^{-6} of the radionuclides and heavy metals in the container. No VOCs would be present in the thermally treated waste.

Case W1c: Waste Treated by a Shred and Grout Process

Only drums would be handled in this accident scenario. The grouted waste is a solid concrete-like mass. A respirable resuspension fraction value of 1×10^{-5} was used (DOE 1994a), assuming brittle fracture of the waste mass during the fall. Twenty-five percent of the respirable resuspended material was assumed to be released from the container, resulting in a total respirable release fraction of 2.5×10^{-6} (the same as for thermally treated waste).

Accident Scenario W2 - Container Puncture, Drop, and Lid Failure in the Waste Handling Building

A Waste Handling Building forklift operator error causes a forklift to strike and puncture either drums or a standard waste box. An additional drum or standard waste box is knocked off and the lid fails. Because the waste containers are Type A packages, per NRC requirements, they are designed to withstand a 1-meter (3.3-foot) drop onto an unyielding surface without damage.

However, because the vertical lift can exceed this designed rating, it was assumed that the container drop and subsequent crushing causes the lid of a single container to be knocked off. No inner plastic liner was assumed to be present. A fraction of the respirable-sized particulates in the drum was assumed to be suspended inside the drum during the fall. A fraction of these would then be released when the lid failed, or the contents may be released and respirable particles resuspended from this material. Facility HEPA filtration was not considered for releases to the atmosphere. This method was applied to the quantities of particulate radionuclides and heavy metals (lead, mercury, beryllium, and cadmium) in the waste.

All VOCs present in the container headspace were assumed to be released, with total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Involved worker intakes were calculated in the same manner as Accident Scenario W1.

Case W2a: Waste Treated to Planning-Basis WAC

Both waste drum and standard waste box accident scenarios were evaluated. For the drum scenario, an error by a Waste Handling Building forklift operator causes a forklift to strike and puncture two drums. As a result of the impact, a third drum falls from the stack and its lid is knocked off upon impact with the floor. It was assumed that 10 percent of the waste spills out of the two punctured drums and 25 percent spills out of the lidless drum. For the standard waste box scenario, one standard waste box is punctured, and the one stacked above it falls to the ground. The lid seal of the fallen standard waste box is assumed to fail as a result of the impact and 25 percent of the contents are released. As in Accident Scenario W1 for both drums and standard waste boxes, 0.001 of the spilled fraction was assumed to be resuspended in the room air and 0.1 of this resuspended fraction was assumed to be respirable.

Case W2b: Thermally Treated Waste

Only drums were assumed to be used under this treatment option. Consequences from particulate releases of Case W2b would be identical to those of Case W1b, with material released only from the drum with lid failure. No releases of particulates from the punctured drums would occur. No VOCs would be present in thermally treated waste.

Case W2c: Waste Treated by Shred and Grout Process

Only drums were assumed to be used under this treatment option. Consequences from particulate releases for Case W2c would be identical to those of Case W1c, with material released only from the drum with lid failure. No particulate releases from the punctured containers would occur. Headspace VOCs from all three of the damaged drums were assumed to be released, so VOC-related consequences would be three times higher than for Case W1c.

Accident Scenario W3 - Container Drop and Lid Seal Failure in the Underground

Accident Scenario W3 and its container releases are identical to those described for Accident Scenario W1 except that the accident occurs underground. Particulate radionuclide and heavy metal releases to the atmosphere from the underground ventilation system would likely be reduced compared to similar Waste Handling Building releases because of particle depletion and plateout

over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building. However, plateout was not considered.

All VOCs present in the container headspace were assumed to be released, with a total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption or plateout onto internal building surfaces would occur.

Involved worker intakes underground were calculated in the same manner as for Accident Scenario W1. The worker is assumed to require 60 seconds to move into the upstream ventilation air. This underground worker exposure is extremely conservative given the high ventilation rate of the underground air.

Case W3a: Waste Treated to Planning-Basis WAC

Case W3a is identical to Case W1a. Depletion of the source term would be expected but was not considered. As a result, releases from Case W3a are identical to those of Case W1a.

Case W3b: Thermally Treated Waste

Case W3b is identical to Case W1b. Depletion of the source term would be expected but was not considered. As a result, releases from Case W3b are identical to those of Case W1b.

Case W3c: Waste Treated by a Shred and Grout Process

Case W3c is identical to Case W1c. Depletion of the source term would be expected but was not considered. As a result, releases from Case W3c are identical to those of Case W1c.

Accident Scenario W4 - Container Puncture, Drop, and Lid Seal Failure in the Underground

Accident Scenario W4 and its container releases are identical to those described for Accident Scenario W2 except that the accident occurs underground. All VOCs present in the container headspace were assumed to be released with a total release fraction equal to one. Calculation of VOCs released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Involved worker intakes underground were calculated in the same manner as for Accident Scenario W3.

Case W4a: Waste Treated to Planning-Basis WAC

Case W4a is identical to Case W2a. Depletion of the source term would be expected but was not considered. As a result, releases from Case W4a are identical to those of Case W2a.

Case W4b: Thermally Treated Waste

Case W4b is identical to Case W2b. Depletion of the source term would be expected but was not considered. As a result, releases from Case W4a are identical to those of Case W2b.

Case W4c: Grouted Waste

Case W4c is identical to Case W2c. Depletion of the source term would be expected but was not considered. As a result, releases from Case W4c are identical to those of Case W2c.

Accident Scenario W5 - Container Fire in the Underground

A fire was assumed to start inside a closed waste container and involve only the single container. Only a fire in the underground was evaluated because of the relatively short period of time any one drum would be present in the Waste Handling Building. Released particulates would likely be subject to a high amount of deposition due to the heated aerosol reacting with the relatively cool surfaces within the facility (DOE 1990). However, depletion was not considered in the analysis. The VOCs in the waste container were assumed to be consumed by the fire. Because an individual worker's actions do not initiate the accident, involved worker exposures were not calculated.

The EEG investigated the history of hazardous waste drum fires, explosions, and other pressurizations at DOE facilities (Silva 1991). The incidents were attributed to the discharge of static electricity, spontaneous ignition of pyrophoric materials, and reactions involving nitric acid. Other contributing circumstances included the drums being painted black, exposure to direct sunlight, and improper packaging material. At WIPP, such incidents would be limited by the fact that containers would be painted white, would not be exposed to direct sunlight, and would be certified to the planning-basis WAC, which limits combustion initiators in the waste containers.

Case W5a: Waste Treated to Planning-Basis WAC

Waste drum and standard waste box accident scenarios were evaluated. It was assumed that 5×10^{-4} of the radioactive and heavy metals would be resuspended as respirable particles, a conservative value of the fraction of respirable particles expected from the burning of either combustible or noncombustible materials (DOE 1994a).

Case W5b: Thermally Treated Waste

There would be no combustible materials in the waste after thermal treatment, so a fire would be an unlikely scenario.

Case W5c: Waste Treated by a Shred and Grout Process

Only drums were assumed to be used under this treatment option. Although the waste would be uniformly mixed within a noncombustible grout matrix, accident consequences were calculated for this scenario. Twenty-two percent of a concrete mass would be transformed to a powder as a result of fire temperatures of at least 650 degrees Celsius (1,200 degrees Fahrenheit) (DOE 1994a); therefore, it was assumed that 22 percent of the grouted waste would be transformed to a powder as a result of a container fire. A respirable resuspension fraction of 6.0×10^{-5} for particulates was used (DOE 1994a), which reflects the fraction of heated powder resuspended by the vapor flux generated by an open fire.

Accident Scenario W6 - Failure of the Waste Shaft Hoist

The waste hoist braking system was assumed to fail when the hoist was fully loaded and at the top of the shaft. The hoist was assumed to fall 655 meters (2,150 feet) to the bottom of the waste hoist shaft. Depending on its physical form, material dropped from great heights will generally exhibit plastic properties or will shatter on impact. The respirable fraction differs for each type of material; for example, material that shatters produces the greatest quantity of respirable-sized articles. The maximum estimated respirable resuspended particulate fraction for a brittle material that drops 655 meters (2,150 feet) is 3×10^{-3} (DOE 1994a). The waste hoist was assumed to be fully loaded with either 28 drums or four standard waste boxes containing CH-TRU waste or one RH-TRU waste canister.

Releases of particulate radionuclides and heavy metals to the atmosphere from the underground ventilation system would likely be reduced because of particle depletion and plateout while traveling over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building (DOE 1990). However, plateout was not considered in the analysis. All headspace VOCs in CH-TRU and RH-TRU waste were assumed to be released, with a total release fraction equal to one.

This accident would require simultaneous failure of six hoisting cables or loss of power and failure of the hoist braking system. The probability of failure of the waste shaft hoist has been investigated by EEG (Greenfield and Sargent 1995). The most critical element for this accident was determined to be failure of the hoist hydraulic brake system. The 95th percentile annual probability of this incident occurring is 4.5×10^{-7}, updating the previous 1×10^{-4} to 1×10^{-6} annual probability estimate, which resulted from the absence of preoperational checks of the hoist system at the start of each shift in WIPP operating procedures. Because of this low probability, this accident scenario is comparable to the beyond-design-basis earthquakes evaluated for treatment and storage.

Case W6a: Waste Treated to Planning-Basis WAC

The source terms resulting from both waste drums and standard waste boxes containing CH-TRU waste were evaluated. All radionuclides and heavy metals were assumed to be released from half of the waste containers upon impact and to completely escape the accident debris for a release fraction of one. Material in the other half of the CH-TRU waste containers involved in the accident was assumed to have an overall release fraction of 0.1, with 90 percent of the material either not released or contained within the accident debris. The particulate resuspension fraction for all of the released radionuclides and heavy metals was assumed to be 1×10^{-3}, and all of this material was assumed to be of respirable size.

Under the same accident scenario, 70 percent of the radionuclides and heavy metals in RH-TRU waste would be released, with 30 percent contained by the accident debris at the bottom of the shaft. The released radionuclides and heavy metals were assumed to have a resuspension fraction of 5.5×10^{-4} (half of the waste having a resuspension fraction of 1×10^{-4} and the other half of the waste having a resuspension fraction of 1×10^{-3}).

Case W6b: Thermally Treated Waste

Only waste drums were assumed to be used under this treatment option. Vitrified CH-TRU waste would shatter on impact and all radionuclides and heavy metals would be released. The bounding

respirable resuspension fraction of 3×10^{-3} for a shattering material was assumed. No VOCs would be present in thermally treated waste.

Under the same accident scenario, 70 percent of radionuclides and heavy metals in RH-TRU waste would be released, with 30 percent contained by the accident debris at the bottom of the shaft. The released radionuclides and heavy metals were assumed to have the bounding respirable resuspension fraction of 3×10^{-3}. No VOCs would be present in thermally treated waste.

Case W6c: Waste Treated by a Shred and Grout Process

For particulate radionuclides and heavy metals in CH-TRU and RH-TRU waste, the analysis would be identical to that of Case W6b, assuming the grouted waste would shatter on impact. Grouted waste containing VOCs and the entire headspace volume were assumed to be released.

Accident Scenario W7 - Roof Fall in a Disposal Room in the Underground

A portion of the roof in a disposal room of a waste panel was assumed to fall during waste emplacement. Roofs are more likely to fall when panels have been open a long time. This accident would have a higher probability of occurring in Panel 1, because it would have been open the longest. The roof fall scenario was based on the same scenario evaluated in the WIPP SAR (DOE 1995b). Although DOE subsequently updated this analysis (DOE 1997), the results of the SEIS-II analyses are more conservative and have been retained.

The CH-TRU waste containers in disposal rooms would be stacked three high with a maximum of five groups of seven-packs across the width of the room. The drums directly under the fallen roof section were assumed to be crushed. The crushed drums shift and deform adjoining waste stacks, and several of the stacks at the working end of the emplacement operations would fall. The roof collapse was assumed to occur when a disposal room was more than half full, and the roof section that falls was assumed to crush the equivalent of half of a disposal room of drums (approximately 2,100). All five seven-packs (35 drums total) on the upper level of the working end of the stack were assumed to fall to the panel floor. Lid failure was assumed for half of the drums in the seven-packs (18 drums) as a result of the drop. The seven-packs in the bottom two levels of the stack were assumed to shift and deform, but not fall or breach. The RH-TRU waste, placed in the panel walls, would not be affected by a roof fall. The particulates in crushed drums were assumed to be contained by the fallen roof section and not be released. The fallen roof section was assumed not to be thick enough to halt the ventilation flow through the disposal room and panel. No facility HEPA filtration of particulate releases was considered. All VOCs in the crushed container headspace were assumed to be released, with a total release fraction equal to one.

Case W7a: Treatment of Waste to Planning-Basis WAC

Drum and standard waste box accident scenarios were evaluated, with either 18 drums or five standard waste boxes breached. Twenty-five percent of the waste was assumed to spill out of the fallen drums, with a respirable resuspension fraction of 1×10^{-4} of the radioactive materials and heavy metals.

Case W7b: Thermally Treated Waste

Only drums would be emplaced, and only about half of the volume of CH-TRU waste of the other alternatives can be disposed of in each panel because of thermal power limitations. Therefore, a smaller total volume of waste containers would be impacted by the roof fall. This assumption does not affect accident consequences because the number of breached containers at the working end of the stack was assumed to be the same as described above, with 18 drums breached. A respirable resuspension fraction of 1×10^{-5} was used (DOE 1994a), assuming a brittle fracture of the waste mass during the fall. Twenty-five percent of the resuspended material was assumed to be released from the container, so the total respirable release fraction would be 2.5×10^{-6} of the radionuclides and heavy metals in the container. No VOCs would be present in the thermally treated waste.

Case W7c: Waste Treated by a Shred and Grout Process

Only drums would be emplaced, and 18 drums were assumed to breach. A respirable resuspension fraction value of 1×10^{-5} was used (DOE 1994a), assuming brittle fracture of the waste mass during the fall. Twenty-five percent of the respirable resuspended material was assumed to be released from the container, resulting in a total respirable release fraction of 2.5×10^{-6}, the same as for thermally treated waste. All container headspace VOCs were assumed to be released.

Accident Scenario W8 - RH-TRU Waste Canister Breach in the Waste Handling Building

This scenario is similar to one evaluated in SEIS-I (DOE 1990). An RH-TRU waste canister is dropped into the transfer cell from the hot cell (a distance of 11 meters [36 feet]) when a grapple fails. It was assumed that the canister is breached in the fall. No facility HEPA filtration was considered.

All VOCs in the container headspace were assumed to be released, with a total release fraction of 1.0.

No consequences to involved workers were calculated because the accident is assumed to occur inside the shielded transfer cell.

Case W8a: Waste Treated to Planning-Basis WAC

One percent of the waste spills from the canister and 1×10^{-4} of the spilled material is resuspended in the room air as respirable particulates.

Case W8b: Thermally Treated Waste

No particulates would be spilled from the breached container because of the solidified waste form. No VOCs would be present in the thermally treated waste.

Case W8c: Waste Treated by a Shred and Grout Process

Accident Scenario Parameter Summary

The radionuclide and heavy metal source term for each accident was calculated using Equation G-6, shown below. The source term, S, was specified in terms of the number of respirable PE-Ci that

would be released for radionuclides and as the number of kilograms released. No particulates would be spilled from the breached container because of the solidified waste form. All of the headspace VOCs would be released.

For many of the accidents, use of this equation and these parameters may be conservative for lead or mercury, which can be highly malleable and less subject to particulate rupture as a result of accident impact shocks.

$$S = (N)(Q)(f_{rel})(f_{resp}) \qquad \text{(Equation G-6)}$$

where

S = source term (PE-Ci or kilograms)

N = number of containers involved

Q = radionuclide or hazardous material inventory of a waste container (PE-Ci or kilograms)

f_{rel} = fraction of the contents released from the container

f_{resp} = fraction of released contents that becomes airborne as a respirable-sized particle

Parameter values are described in the accident scenario descriptions. The parameter values used to estimate the radionuclide and heavy metal source terms are presented in Table G-39 for the Proposed Action and Action Alternative 1 and in Table G-40 for Action Alternatives 2 and 3. In Table G-39, parameter values for both drums and standard waste boxes are presented although consequence estimates are presented in Section G.4.3 only for waste in drums. Consequences may be slightly higher for standard waste box accident scenarios, but consequences for waste stored in drums are a more appropriate comparison for consequences of Action Alternatives 2 and 3.

The radionuclide accident source term (in PE-Ci) following release from the stack is presented in Table G-41. The quantity of radionuclides that would be inhaled by an involved worker, also in PE-Ci, is presented in Table G-42. No analyses were performed to estimate consequences to involved workers for Accident Scenarios W5, W6, W7, and W8, because consequences could range from negligible to catastrophic. The range of consequences is discussed further in Section G.4.3.

G.4.3 Consequences of WIPP Disposal Accidents

Consequences from WIPP disposal accidents were calculated for the exposed off-site population around WIPP, the MEI, the maximally exposed noninvolved worker, and the maximally exposed involved worker. Acute releases were assumed to be dispersed in one direction, so population consequences were estimated for a single, maximally exposed 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally impacted sector, considering both the change in air concentration over distance and the population distribution in the sectors of various distances. The population west of the WIPP site, including the nearest population center at Carlsbad, New Mexico, would receive the greatest

Table G-41
Source Terms for Off-site Releases from WIPP Disposal Accidents (PE-Ci) [a]

SEIS-II Accident Scenario	Accident Description	Proposed Action	Action Alternative 1	Action Alternative 2 Subalternatives	Action Alternative 3
W1 or W3	Drop, Lid Failure in Waste Handling Building or Underground	2E-3 3.25E-3 (S)	2E-3 3.25E-3 (S)	2E-4	2E-4
W2 or W4	Drop, Puncture, Lid Failure in Waste Handling Building or Underground	3.6E-3 4.55E-3 (S)	3.6E-3 4.55E-3 (S)	2E-4	2E-4
W5	Container Fire	4E-2 6.5E-2 (S)	4E-2 6.5E-2 (S)	N/A	1.1E-3
W6	Hoist Failure CH-TRU Waste RH-TRU Waste	 1.2 0.5 (S) 0.3	 1.2 0.5 (S) 0.3	 6.7 2.1	 6.7 2.1
W7	Roof Fall	0.036 0.016 (S)	0.036 0.016 (S)	3.6E-3	3.6E-3
W8	RH-TRU Waste Canister Breach	0.001	0.001	0	0

[a] Releases are those resulting from scenarios involving drums unless otherwise noted with an "(S)", indicating SWB scenarios.

N/A = Not Applicable

Table G-42
Involved Worker Intakes from WIPP Disposal Accidents (PE-Ci)

SEIS-II Accident Scenario	Accident Description	Proposed Action	Action Alternative 1	Action Alternative 2 Subalternatives	Action Alternative 3
W1	Drop, Lid Failure in Waste Handling Building	1.5E-7	1.5E-7	1.5E-8	1.5E-8
W2	Drop, Puncture, Lid Failure in Waste Handling Building	2.7E-7	2.7E-7	1.5E-8	1.5E-8
W3	Drop, Lid Failure in Underground	1.5E-7	1.5E-7	1.5E-8	1.5E-8
W4	Drop, Puncture, Lid Failure in Underground	2.7E-7	2.7E-7	1.5E-8	1.5E-8

potential consequence from an accidental WIPP release. The MEI was assumed to be at the WIPP fenceline location where the atmospheric dispersion would be minimized, resulting in maximum air concentrations. This location is 300 meters (1,000 feet) south of the Exhaust Filter Building at the Exclusive Use Area boundary.

The same location was used to calculate consequences to the maximally exposed noninvolved worker because this would be the point of highest consequence of any on-site location. The maximally exposed worker is a worker who handles the waste directly. All accident evaluations assumed the noninvolved worker, MEI, and population remained in the plume during its entire time of passage. Impacts from the inhalation pathway dominate those of all other exposure pathways.

The estimated annual frequencies of occurrence for WIPP disposal accidents (Accident Scenarios W1 through W8) are presented in Table G-43. When a frequency range was identified, the highest value (i.e., the greater frequency) is presented in the table. Occurrence frequencies for the Action Alternative 2 subalternatives were assumed to be half of the values for waste treated to planning-basis WAC and waste treated by a shred and grout process because waste would not need to be stacked as high in the underground, thereby reducing the probability of lid failure in the event of a container drop. The mass of waste containers under the Action Alternative 2 subalternatives is potentially at the maximum drum limit of 450 kilograms (1,000 pounds). This may affect the likelihood of an accident, but this effect was not considered.

Table G-43
Annual Frequencies of Occurrence for WIPP Disposal Accidents

SEIS-II Accident Scenario	Accident Description	Proposed Action[a]	Action Alternative 1[b]	Action Alternative 2 Subalternatives[b]	Action Alternative 3[b]
W1	Drop, Lid Failure in Waste Handling Building	0.01	0.01	5E-3	0.01
W2	Drop, Puncture, Lid Failure in Waste Handling Building	0.01	0.01	5E-3	0.01
W3	Drop, Lid Failure in Underground	0.01	0.01	5E-3	0.01
W4	Drop, Puncture, Lid Failure in Underground	0.01	0.01[a]	5E-3[a]	0.01[a]
W5	Container Fire: < 8PE-Ci Container Fire: > 8PE-Ci	1E-4 < 1E-6	1E-4 < 1E-6	N/A	1E-4 < 1E-6
W6	Hoist Failure	< 1E-6[c]	< 1E-6	< 1E-6	< 1E-6
W7	Roof Fall: Panel 1 Roof Fall: other panels	0.01[d] < 1E-6	0.01 < 1E-6	5E-3 < 1E-6	0.01 < 1E-6
W8	RH-TRU Waste Canister Breach	1E-4 to 1E-6 [d]	1E-4 to 1E-6	5E-5 to 5E-7	1E-4 to 1E-6

[a] Taken from the1996 Final WIPP SAR (DOE 1997) except where noted.
[b] The same as or extrapolated from the Proposed Action value.
[c] Taken from EEG-59 (Greenfield and Sargent 1995).
[d] Taken from the WIPP SAR (DOE 1995b).

N/A = Not Applicable

G.4.3.1 Accident Consequences for Proposed Action and Action Alternative 1

Consequences of accidents under the Proposed Action and Action Alternative 1 would be the same because waste is treated to planning-basis WAC. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from VOCs and heavy metals for all accidents. Only one accident, the hoist failure (Accident Scenario W6), would result in radiation-related LCFs in the exposed population around WIPP. Up to five LCFs could occur in an exposed sector-population from a hoist failure involving CH-TRU waste, and two LCFs could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.08 for the CH-TRU waste accident scenario, and 0.03 for the RH-TRU waste accident scenario. Table G-44 presents the radiological consequences from WIPP disposal accidents under the Proposed Action and Action Alternative 1.

Table G-44
Radiological Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)		MEI (rem, probability of LCF)		Maximally Exposed Noninvolved Worker (rem, probability of LCF)		Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in Waste Handling Building	17 9E-3		0.26 1E-4		0.26 1E-4		7.8 0.03
W2	Drop, Puncture, Lid Failure in Waste Handling Building	31 0.02		0.47 2E-4		0.47 2E-4		140 0.06
W3	Drop, Lid Failure in Underground	17 9E-3		0.26 1E-4		0.26 1E-4		78 0.03
W4	Drop, Puncture, Lid Failure in Underground	31 0.02		0.47 2E-4		0.47 2E-4		140 0.06
W5	Container Fire	565 0.3		8.5 4E-3		8.5 3E-3		N/A
W6	Hoist Failure	CH-TRU 11,000 5	RH-TRU 3,400 2	CH-TRU 160 0.08	RH-TRU 50 0.03	CH-TRU 160 0.06	RH-TRU 50 0.02	See Text
W7	Roof Fall	310 0.2		4.7 2E-3		4.7 2E-3		See Text
W8	RH-TRU Waste Canister Breach	9 5E-3		0.13 7E-5		0.13 5E-5		0.0 0

N/A = Not Applicable

Potential carcinogenic consequences from exposure to VOCs and heavy metals released during WIPP disposal accidents are presented in Table G-45. As noted above, no incidences of cancer would be expected in the exposed population, and consequences for individuals would be very low.

Potential noncarcinogenic consequences from exposure to VOCs and heavy metals released during an accident are presented in Tables G-46 and G-47. No noncarcinogenic health effects would be expected. The majority of the small noncarcinogenic impact is from tetrachloroethene and 1,1,2,2-tetrachloroethane releases. No life-threatening impacts are expected based on the IDLH-equivalent intake analyses. Some impacts are expected based on the ERPG analyses.

The highest air concentration to which the MEI, maximally exposed noninvolved worker, and maximally exposed involved worker could be exposed were estimated and compared to ERPG values (see Table G-3). The ratios of the air concentration and the ERPG-2 value are presented in Table G-47. Heavy metal and VOC releases of hoist failure and roof fall scenarios potentially adversely affect the MEI and noninvolved workers based on the ERPG analyses. Some VOC releases from scenarios W2 and W4 could adversely affect the involved worker.

Bounding consequence estimates to the MEI and noninvolved worker for the CH hoist failure scenario (W6-CH) could be severe. Bounding methylene chloride and beryllium releases could seriously threaten these individuals (ERPG-3 ratios of 1 and 3, respectively). Releases of 1,1,2,2-tetrachloroethane, lead, and mercury could have irreversible, non-life-threatening consequences (ERPG-2 ratios of 3, 54, and 58, respectively). These consequence estimates reflect upper bound consequences. It is unlikely that the individuals would be exposed to the high air concentrations for the length of time required to experience such severe effects. Mild transient consequences might be experienced from carbon tetrachloride releases (ERPG-1 ratio of 1).

Table G-45
Hazardous Chemical Carcinogenic Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in Waste Handling Building	VOCs Metals	2E-8 4E-11	2E-10 6E-13	2E-10 6E-13	9E-8 2E-10
W2	Drop, Puncture, Lid Failure in Waste Handling Building	VOCs Metals	5E-8 8E-11	7E-10 1E-12	7E-10 1E-12	3E-7 4E-10
W3	Drop, Lid Failure in Underground	VOCs Metals	2E-8 4E-11	2E-10 6E-13	2E-10 6E-13	9E-8 2E-10
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	5E-8 8E-11	7E-10 1E-12	7E-10 1E-12	3E-7 4E-10
W5	Container Fire	VOCs Metals	0.0 2E-10	0.0 2E-12	0.0 2E-12	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	54E-7 3E-8	6E-9 4E-10	6E-9 4E-10	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	5E-8 4E-9	7E-10 6E-11	7E-10 6E-11	See Text
W7	Roof Fall	VOCs Metals	1E-6 8E-10	2E-8 1E-11	2E-8 1E-11	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	5E-8 5E-12	7E-10 7E-14	7E-10 7E-14	3E-7 0

N/A = Not Applicable

Table G-46
Hazardous Chemical Noncarcinogenic Consequences of WIPP Disposal Accidents for the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	MEI (maximum IDLH-equivalent ratio)	Maximally Exposed Noninvolved Worker (maximum IDLH-equivalent ratio)	Maximally Exposed Involved Worker (maximum IDLH-equivalent ratio)
W1	Drop, Lid Failure in Waste Handling Building	VOCs Metals	5E-7 2E-8	5E-7 2E-8	2E-4 8E-6
W2	Drop, Puncture Lid Failure in Waste Handling Building	VOCs Metals	1E-6 4E-8	1E-6 4E-8	5E-4 1E-5
W3	Drop, Lid Failure in Underground	VOCs Metals	5E-7 2E-8	5E-7 2E-8	2E-4 8E-6
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	1E-6 4E-8	1E-6 4E-8	5E-4 E-5
W5	Container Fire	VOCs Metals	0.0 9E-8	0.0 9E-8	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	1E-5 1E-5	1E-5 1E-5	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	1E-6 2E-6	1E-6 2E-6	See Text
W7	Roof Fall	VOCs Metals	2E-5 4E-7	2E-5 4E-7	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	1E-6 3E-9	1E-6 3E-9	0 0

N/A = Not Applicable

Table G-47
Ratios of Exposure Air Concentrations to ERPG-2 Values for WIPP Disposal Accidents for the Proposed Action and Action Alternative 1 [a]

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker: Air Concentration to ERPG-2 Ratio	Maximally Exposed Involved Worker: Air Concentration to ERPG-2 Ratio
W1	Container Drop and Lid Seal Failure	VOC Metals	0.1 0.1	0.5 0.01
W2	Container Puncture, Crop and Lid Seal Failure	VOC Metals	0.4 0.2	2 0.7
W3	Container and Lid Seal Failure	VOC Metals	0.1 0.1	0.5 0.01
W4	Container Puncture, Drop, and Lid Seal Failure	VOC Metals	0.4 0.2	2 0.7
W5	Container Fire	Metals	2	N/A
W6	Failure of the Waste Shaft Hoist (CH-TRU Waste)	VOC Metals	3 58	See Text
W6	Failure of the Waste Shaft Hoist (RH-TRU Waste)	VOC Metals	0.4 9	See Text
W7	Roof Fall	VOC Metals	18 2	See Text
W8	RH-TRU Waste Canister Breach	VOC Metals	0.4 0.01	0 0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

The RH hoist failure scenario (W6-RH) consequences to the MEI and noninvolved worker could result in irreversible, non-life-threatening consequences from bounding beryllium, lead, and mercury releases (ERPG-2 ratios of 2, 8, and 9, respectively).

Consequences to the MEI and noninvolved worker could result from the roof fall scenario (W7). Irreversible, non-life-threatening consequences from 1,1,2,2-tetrachloroethane, lead, and mercury releases could result (ERPG-2 ratios of 18, 2, and 2). Mild transient consequences could result from carbon tetrachloride releases (ERPG-1 ratio of 2).

The hoist failure and roof fall scenarios could have consequences ranging from negligible to lethal effects for any involved worker in the underground disposal area. Typically, four underground workers are involved in emplacement operations. Some or all of these workers could be killed if they were in the immediate area when the accidents occurred. ERPG ratios were estimated for involved workers for Accident Scenarios W1 through W4. Accident Scenarios W2 and W4 result in the same exposures. Irreversible, non-life-threatening consequences from bounding methylene chloride and 1,1,2,2-tetrachloroethane releases could result from these accidents (ERPG-2 ratios of 2 for both).

G.4.3.2 Accident Consequences for the Action Alternative 2 Subalternatives

The thermally treated waste form in the Action Alternative 2 subalternatives would reduce the consequences of WIPP disposal accidents. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from heavy metals for all accidents (there would be no VOCs in thermally treated waste). As for the Proposed Action and Action Alternative 1, only the hoist failure (Accident Scenario W6) would result in radiation-related LCFs in the exposed population around WIPP. The radiological consequence is greater for the Action Alternative 2 subalternatives than for the Proposed Action and Action Alternative 1 because the thermally treated waste is more likely to completely brittle-fracture upon impact and create a larger quantity of respirable particles than is the waste treated to planning-basis WAC. Up to 29 LCFs could occur in an exposed sector-population from a hoist failure involving CH-TRU waste, and 9 LCFs could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.6 for the CH-TRU waste accident scenario and 0.1 for the RH-TRU waste accident scenario. Table G-48 presents the radiological consequences from WIPP disposal accidents under Action Alternative 2.

Potential carcinogenic consequences from exposure to VOCs and heavy metals released during WIPP disposal accidents are presented in Table G-49. As noted above, no cancers would be expected in the exposed population, and consequences to individuals would be very low.

Potential noncarcinogenic consequences from exposure to heavy metals released during an accident are presented in Tables G-50 and G-51. No life-threatening consequences are expected based on the IDLH-equivalent intake analyses, although some consequences are expected based on the ERPG analyses.

Table G-48
Radiological Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)		MEI (rem, probability of LCF)		Maximally Exposed Noninvolved Worker (rem, probability of LCF)		Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W2	Drop, Puncture, Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W3	Drop, Lid Failure in Underground	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W4	Drop, Puncture, Lid Failure in Underground	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W5	Container Fire	N/A		N/A		N/A		N/A
W6	Hoist Failure	CH-TRU 58,000 29	RH-TRU 18,000 9	CH-TRU 870 0.6 [a]	RH-TRU 270 0.1	CH-TRU 870 0.5 [a]	RH-TRU 270 0.1	See Text
W7	Roof Fall	31 0.02		0.47 2E-4		0.47 2E-4		See Text
W8	RH-TRU Waste Canister Breach	0		0		0		0

[a] Maximum annual dose is 37 rem and remains above 20 rem per year for the first 11 years; therefore, annual carcinogenic risk for the first 11 years is calculated without using the low dose-rate dose-reduction factor of two.

N/A = Not Applicable

Table G-49
Heavy Metal Carcinogenic Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in WHB	1E-11	2E-13	2E-13	6E-11
W2	Drop, Puncture, Lid Failure in WHB	1E-11	2E-13	2E-13	6E-11
W3	Drop, Lid Failure in Underground	1E-11	2E-13	2E-13	6E-11
W4	Drop, Puncture, Lid Failure in Underground	1E-11	2E-13	2E-13	6E-11
W5	Container Fire	N/A	N/A	N/A	N/A
W6	Hoist Failure (CH-TRU Waste)	4E-7	5E-9	5E-9	See Text
W6	Hoist Failure (RH-TRU Waste)	3E-8	4E-10	4E-10	See Text
W7	Roof Fall	2E-10	3E-12	3E-12	See Text
W8	RH-TRU Waste Canister Breach	0	0	0	0

N/A = Not Applicable

Table G-50
Heavy Metal Noncarcinogenic Consequences of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	MEI (maximum IDLH-equivalent ratio)	Maximally Exposed Noninvolved Worker (maximum IDLH equivalent ratio)	Maximally Exposed Involved Worker (maximum IDLH-equivalent ratio)
W1	Drop, Lid Failure in WHB	6E-9	6E-9	2E-6
W2	Drop, Puncture, Lid Failure in WHB	6E-9	6E-9	2E-6
W3	Drop, Lid Failure in Underground	6E-9	6E-9	2E-6
W4	Drop, Puncture, Lid Failure in Underground	6E-9	6E-9	2E-6
W5	Container Fire	N/A	N/A	N/A
W6	Hoist Failure (CH-TRU Waste)	2E-4	2E-4	See Text
W6	Hoist Failure (RH-TRU Waste)	1E-5	1E-5	See Text
W7	Roof Fall	1E-7	1E-7	See Text
W8	RH-TRU Waste Canister Breach	0	0	0

N/A = Not Applicable

Table G-51
Ratios of Exposure Air Concentrations
to ERPG-2 Values for the Action Alternative 2 Subalternatives [a]

SEIS-II Accident Scenario	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker Air Concentration to ERPG-2 Ratio	Maximally Exposed Involved Worker Air Concentration to ERPG-2 Ratio
W1	Metals	0.1	0.1
W2	Metals	0.02	0.1
W3	Metals	0.1	0.1
W4	Metals	0.02	0.1
W5	Metals	N/A	N/A
W6 (CH-TRU Waste)	Metals	810	See Text
W6 (RH-TRU Waste)	Metals	61	See Text
W7	Metals	0.4	See Text
W8	Metals	0.01	0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

The highest air concentrations to which the MEI, the maximally exposed noninvolved worker, and the maximally exposed involved worker could be exposed were estimated and compared to ERPG values (see Table G-3). Ratios of exposure air concentrations to ERPG-2 values are presented in Table G-51. Heavy metal releases from a hoist failure (Accident Scenario W6) could result in severe consequences to the MEI and the noninvolved worker.

Bounding releases of beryllium, lead, and mercury from the hoist failure scenario involving CH-TRU waste (W6-CH) could seriously threaten the MEI and the maximally exposed noninvolved worker (ERPG-3 ratios of 48, 2, and 3, respectively). Bounding releases of beryllium from the hoist failure scenario involving RH-TRU waste (W6-RH) could seriously threaten these individuals (ERPG-3 ratio of 4). Irreversible, non-life-threatening consequences from bounding lead and mercury releases could result from W6-RH releases (ERPG-2 ratios of 58 and 61, respectively).

The hoist failure and roof fall scenarios could have consequences ranging from negligible to lethal effects for any involved worker in the underground disposal area. Typically, four underground workers are involved in emplacement operations. Some or all of these workers could be killed if they were in the immediate area when the accidents occurred. ERPG ratios were estimated for involved workers for Accident Scenarios W1 through W4. The ERPG analyses do not indicate any consequence to the involved workers for these four accident scenarios.

G.4.3.3 Accident Consequences for Action Alternative 3

Compared to accidents involving waste packaged to meet the planning-basis WAC, the consolidated waste form in Action Alternative 3 would reduce the consequences of most WIPP disposal accident scenarios. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from VOCs and heavy metals for all accidents. As with the Proposed Action, Action Alternative 1, and Action Alternative 2 only, the hoist failure (Accident Scenario W6) would result in radiation-related LCFs in the exposed population around

WIPP. The radiological consequence is identical to that of Action Alternative 2 and greater than for the Proposed Action and Action Alternative 1 because the grouted waste form also is assumed to brittle-fracture upon impact and create a larger quantity of respirable particles than is the waste treated to planning-basis WAC. Up to 29 LCFs could occur in an exposed sector-population from a hoist failure involving CH-TRU waste, and 9 LCFs could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.6 for the CH-TRU waste accident scenario and 0.1 for the RH-TRU waste accident scenario. Table G-52 presents the radiological consequences from WIPP disposal accidents under Action Alternative 3.

Table G-52
Radiological Consequences of WIPP Disposal Accidents for Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)		MEI (rem, probability of LCF)		Maximally Exposed Noninvolved Worker (rem, probability of LCF)		Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W2	Drop, Puncture Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W3	Drop, Lid Failure in Underground	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W4	Drop, Puncture, Lid Failure in Underground	1.7 9E-4		0.026 1E-5		0.026 1E-5		7.8 3E-3
W5	Container Fire	9.2 5E-3		0.14 7E-5		0.14 6E-5		N/A
W6	Hoist Failure	CH-TRU 58,000 29	RH-TRU 18,000 9	CH-TRU 870 0.6 [a]	RH-TRU 270 0.1	CH-TRU 870 0.5 [a]	RH-TRU 270 0.1	See Text
W7	Roof Fall	31 0.02		0.47 2E-4		0.47 2E-4		See Text
W8	RH-TRU Waste Canister Breach	0		0		0		0

[a] Maximum annual dose is 37 rem and remains above 20 rem per year for the first 11 years. Therefore, annual carcinogenic risk for the first 11 years was calculated without using the low dose rate dose reduction factor of 2.

N/A = Not Applicable

Potential carcinogenic consequences from exposure to VOCs and heavy metals released during WIPP disposal accidents are presented in Table G-53. As noted above, no cancer incidence would be expected in the exposed population, and consequences to individuals would be very low.

Potential noncarcinogenic consequences from exposure to VOCs and heavy metals released during an accident are presented in Table G-54. No life-threatening consequences are expected based on the IDLH-equivalent intake analyses; however, some consequences are expected based on the ERPG analyses.

The highest air concentration to which the MEI, maximally exposed noninvolved worker, and maximally exposed involved worker could be exposed were estimated and compared to ERPG values (see Table G-3). Ratios of exposure air concentrations to ERPG-2 values are presented in Table G-55. Heavy metal and VOC releases from a hoist failure and a roof fall could adversely affect the MEI and noninvolved workers based on the ERPG analyses. Some VOC releases from scenarios W2 and W4 could adversely affect the involved worker.

Table G-53
Hazardous Chemical Carcinogenic Consequences of WIPP Disposal Accidents for Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in WHB	VOCs Metals	9E-9 4E-12	1E-10 5E-14	1E-10 5E-14	5E-8 2E-11
W2	Drop, Puncture, Lid Failure in WHB	VOCs Metals	3E-8 4E-12	4E-10 5E-14	4E-10 5E-14	2E-7 2E-11
W3	Drop, Lid Failure in Underground	VOCs Metals	9E-9 4E-12	1E-10 5E-14	1E-10 5E-14	5E-8 2E-11
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	3E-8 4E-12	4E-10 5E-14	4E-10 5E-14	2E-7 2E-11
W5	Container Fire	VOCs Metals	0.0 4E-12	0.0 5E-14	0.0 5E-14	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	3E-7 1E-7	4E-9 2E-9	4E-9 2E-9	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	3E-8 9E-9	4E-10 1E-10	4E-10 1E-10	See Text
W7	Roof Fall	VOCs Metals	7E-7 6E-11	1E-8 9E-13	1E-8 9E-13	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	3E-8 0	4E-10 0	4E-10 0	0 0

N/A = Not Applicable

Table G-54
Hazardous Chemical Noncarcinogenic Consequences of WIPP Disposal Accidents for Action Alternative 3

Accident Scenarios	Accident Description	Hazardous Constituents	MEI (maximum IDLH-equivalent ratio)	Maximally Exposed Noninvolved Worker (maximum IDLH-equivalent ratio)	Maximally Exposed Involved Worker (maximum IDLH-equivalent ratio)
W1	Drop, Lid Failure in WHB	VOCs Metals	5E-7 2E-9	5E-7 2E-9	2E-4 7E-7
W2	Drop, Puncture, Lid Failure in WHB	VOCs Metals	1E-6 2E-9	1E-6 2E-9	5E-4 7E-7
W3	Drop, Lid Failure in Underground	VOCs Metals	5E-7 2E-9	5E-7 2E-9	2E-4 7E-7
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	1E-6 2E-9	1E-6 2E-9	2E-4 7E-7
W5	Container Fire	VOCs Metals	0.0 2E-9	0.0 2E-9	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	1E-5 6E-5	1E-5 6E-5	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	1E-6 4E-6	1E-6 4E-6	See Text
W7	Roof Fall	VOCs Metals	1E-5 3E-8	1E-5 3E-8	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	1E-6 0	1E-6 0	0 0

N/A = Not Applicable

Table G-55
Ratios of Exposure Air Concentrations
to ERPG-2 Values for WIPP Disposal Accidents for Action Alternative 3 [a]

SEIS-II Accident Scenario	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker	Maximally Exposed Involved Worker
		Air Concentration to ERPG-2 Ratio	Air Concentration to ERPG-2 Ratio
W1	VOC Metals	0.1 0.01	0.5 0.03
W2	VOC Metals	0.4 0.01	1.6 0.03
W3	VOC Metals	0.1 0.01	0.5 0.03
W4	VOC Metals	0.4 0.01	1.6 0.03
W5	Metals	0.04	N/A
W6 (CH-TRU Waste)	VOC Metals	3 260	See Text
W6 (RH-TRU Waste)	VOC Metals	0.4 19	See Text
W7	VOC Metals	7 0.1	See Text
W8	VOC Metals	0.4 0.01	0 0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

Bounding consequence estimates for the MEI and noninvolved worker for the hoist failure scenario involving CH-TRU waste (W6-CH) could be severe. Releases of bounding methylene chloride concentrations and beryllium could seriously threaten these individuals (ERPG-3 ratios of 1 and 16, respectively). Irreversible, non-life-threatening consequences from releases of lead and mercury (ERPG-2 ratios of 240 and 260) could also result from this accident scenario. Transient consequences could result from carbon tetrachloride releases (ERPG-1 ratio of 1).

The hoist failure scenario involving RH-TRU waste (W6-RH) could also result in consequences to the MEI and maximally-exposed noninvolved worker under bounding release and exposure conditions, including life-threatening consequences from beryllium (ERPG-ratio of 3). Releases of lead and mercury could also result in irreversible, non-life-threatening consequences to these individuals (ERPG-2 ratios of 58 and 61, respectively).

The roof fall scenario (W7) could result in irreversible, non-life-threatening consequences to the MEI and noninvolved worker from 1,1,2,2-tetrachloroethane releases (ERPG-2 ratio of 7). Transient consequences to these individuals could result from carbon tetrachloride releases (ERPG-1 ratio of 4).

The hoist failure and roof fall scenarios could have consequences ranging from negligible to lethal effects for any involved worker in the underground disposal area. Typically, four underground workers are involved in emplacement operations. Some or all of these workers could be killed if in the immediate area when the accidents occurred. ERPG ratios were estimated for involved workers for Accident Scenarios W1 through W4. Irreversible, non-life-threatening consequences to the maximally-exposed involved worker could result from the Accident Scenarios W2 and W4, with releases of methylene chloride and 1,1,2,2-tetrachloroethane (ERPG-2 ratios of 2 for both).

G.5 REFERENCES CITED IN APPENDIX G

ACGIH (American Conference of Governmental Industrial Hygienists), 1995, *Threshold Limit Values*, Cincinnati, OH.

Bartlett, W.T., 1993, *An Evaluation of Air Effluent and Workplace Radioactivity Monitoring at the Waste Isolation Pilot Plant*, EEG-52, Environmental Evaluation Group, New Mexico.

Bartlett, W.T., 1996, *The Influence of Salt Aerosol on Alpha Radiation Detection by WIPP Continuous Air Monitors*, EEG-60, Environmental Evaluation Group, New Mexico.

Craig, D., et al., 1994, *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for use in DOE Facilities (U)*, WSRC-MS-92-206, Westinghouse Savannah River Company, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1982, *Final Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina*, DOE/EIS-0082, Washington, D.C.

DOE (U.S. Department of Energy), 1987, *Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Final Environmental Impact Statement*, DOE/EIS-0113, December, Washington, D.C.

DOE (U.S. Department of Energy), 1988, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, DOE, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1994a, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, Washington, D.C.

DOE (U.S. Department of Energy), 1994b, *Integrated Data Base Report-1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Revision 11, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DOE (U.S. Department of Energy), 1995a, *Radioactive Waste Processing and Volume Reduction Technology Study*, DOE/CAO-95-3102, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 0, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, Revision 5.2, DOE/WIPP 91-005, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

EPA (U.S. Environmental Protection Agency), 1996, *IRIS - Integrated Risk Information System*, in TOMES®-Toxicology, Occupational Medicine, and Environmental Series (CD-ROM). Database used: IRIS.

Greenfield, M.A., and T.J. Sargent, 1995, *An Analysis of the Annual Probability of Failure of the Waste Hoist Brake System at the Waste Isolation Pilot Plant (WIPP)*, EEG-59, Environmental Evaluation Group, New Mexico.

HEHF (Hanford Environmental Health Foundation), 1995, *Hanford Emergency Response Planning Guidelines for Chemicals*, July, Richland, WA.

ICRP (International Commission on Radiological Protection), 1975, *Report of the Task Group on Reference Man*, ICRP Publication 23, Pergamon Press, Oxford, England.

ICRP (International Commission on Radiological Protection), 1991, *1990 Recommendation of the International Commission on Radiological Protection*, ICRP Publication 60, Pergamon Press, Oxford, England.

Mishima, J., et al., 1986, *Potential Radiological Impacts of Upper Bound Operational Accidents During Proposed Waste Disposal Alternatives for Hanford Defense Waste*, PNL-5356, Pacific Northwest National Laboratory, Richland, Washington.

Napier, B.A., et al, 1988, *GENII - The Hanford Environmental Radiation Dosimetry Software System*, Vols. 1 and 2, Pacific Northwest Laboratory, Richland, Washington

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, NCRP, Bethesda, Maryland.

NIOSH (National Institute for Occupational Safety and Health), 1995, *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, Washington D.C.

NIOSH (National Institute for Occupational Safety and Health), 1996, *NIOSH Pocket Guide to Chemical Hazards*, in TOMES® - Toxicological, Occupational Medicine, and Environmental Series (CD-ROM), Database used: NIOSH Pocket Guide.

PNNL (Pacific Northwest National Laboratory), 1996, *The 324 Building Safety Analysis Report*, PNL-SAR-324, Pacific Northwest National Laboratory, Richland, Washington.

Silva, M., 1991, *An Assessment of the Flammability and Explosion Potential of TRU Waste*, EEG-48, Environmental Evaluation Group, New Mexico.

Wallace, R. W., et al., 1980, *Topical Report on Release Scenario Analysis of Long Term Management of High Level Defense Waste at the Hanford Site*, PNL-3363, Pacific Northwest National Laboratory, Richland, Washington.

APPENDIX H
LONG-TERM CONSEQUENCE ANALYSIS FOR PROPOSED ACTION AND ACTION ALTERNATIVES

H.1 INTRODUCTION

This appendix describes the methods used in the performance assessment to estimate the potential for long-term migration of radionuclides, heavy metals, and volatile organic compounds (VOCs) from the Waste Isolation Pilot Plant (WIPP) repository disposal system (including natural and engineered barriers), transport to the accessible environment, and human health impacts from exposure to these materials. As described in Chapter 3, transuranic (TRU) waste would be disposed of at WIPP under the Proposed Action and Action Alternatives 1, 2, and 3. The potential for contaminant migration and human health impacts was evaluated for 10,000 years after closure for each of these alternatives.

This appendix presents an overview of the changes from earlier performance assessment analyses, summary descriptions of conceptual models used for the disposal system and waste source-term release, the computer codes used to estimate the extent and rate of contaminant transport, descriptions of the exposure scenarios and methods used to estimate the exposures, intakes, and potential impacts to human health from radionuclides and heavy metals. Detailed background information on the WIPP repository disposal system, detailed descriptions of the conceptual release models, and selected data input parameters may be found in supporting regulatory compliance documents completed or under development by the U.S. Department of Energy (DOE or the Department).

H.2 CHANGES IN PERFORMANCE ASSESSMENT ANALYSIS SINCE THE 1990 *FINAL SUPPLEMENT ENVIRONMENTAL IMPACT STATEMENT FOR THE WASTE ISOLATION PILOT PLANT* (SEIS-I)

The potential long-term impacts from the release of contaminants from the WIPP repository disposal system were analyzed in SEIS-I. However, new analyses were deemed necessary for this *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II) because of (1) different alternatives and their associated waste volumes and inventories, (2) new data gathered on the repository environment and disposal system performance, and (3) substantial changes in WIPP performance assessment approaches and computational tools. A discussion of these new developments is summarized below. The SEIS-II alternatives and associated waste volumes and inventories are discussed in detail in Chapter 3 and Appendix A.

H.2.1 Pre-Disposal and Disposal Phase Experimental Programs

Since the WIPP site was selected and developed in the late 1970s and early 1980s, DOE has been conducting experiments and investigations to provide technical justification for major components of the conceptual model at the WIPP repository disposal system. During the pre-disposal phase, which began in 1990, experiments and studies at the WIPP site have evolved into major programs in the areas of rock mechanics and seal system performance, disposal room interactions, fluid flow

and transport, and system response to human-initiated activities. The following is a brief description of studies being conducted at the WIPP site in each of these areas.

Rock Mechanics and Seal System Performance

The WIPP program has conducted experimental measurements of creep and fracture properties to gain a better understanding of the fundamental processes of salt creep closure of underground openings, the development of a disturbed rock zone (DRZ) and underground openings, and the healing of the DRZ by creep closure around emplaced wastes and shaft seal systems.

Investigations have shown that creep closure begins immediately after excavation because of excavation-induced deviatoric stresses. The effect of the creep closure phenomena on the two-phase flow of brine and gases through waste is addressed in the *Title 40 Code of Federal Regulations* (CFR) *Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (CCA) performance assessment, as described in Appendix PORSURF (DOE 1996f). This appendix explains the mathematical basis of the halite creep model, waste consolidation, and the constitutive model used to simulate the inelastic behavior of anhydrite marker beds (See Appendix PORSURF, Attachment 1).

Gas generation in the repository caused by decomposing wastes can result in expansion of the excavated region and possibly the fracturing of anhydrite beds. Performance assessment models incorporate the effect of gas-driven hydrofracture through changes in porosity and permeability in marker beds intersecting the repository DRZ at pressure levels consistent with in-situ experiments, laboratory experiments, and the Linear Elastic Fracture Model (DOE 1996f, Appendix MASS, Attachment 13.2).

The conceptual design of the shaft seals, which evolved during the 1980s, provides the long-term ability to isolate the repository from overlying units. The key design feature included a salt component that would be emplaced throughout the Salado, consolidate under the pressure of salt creep over a period of a hundred to several hundred years, and help the shaft seal system develop properties similar to intact salt. Concerns have been raised that brine flow to the salt seal from upper water-bearing units could delay and even prevent creep consolidation of the long-term seal components of the crushed salt. Early concepts of the shaft seal system, which used concrete and concrete-grout plugs to protect the salt component, were not thought to be robust enough to control brine flow. These concerns led to the development of the current shaft seal system concept, which is based on the principle that multiple components and materials can provide a demonstrable level of protection of key components from downward brine flow.

The seal system program has included measurements of shaft seal component properties and performance, studies of shaft seal designs, and characterization of seal behavior, including measurements of creep closure and DRZ development around the shaft. The results of these studies and the current understanding of the shaft seal system have been incorporated into current performance assessment models and calculations. Details of the shaft seal performance studies are described in Appendix SEAL of the CCA (DOE 1996f).

During the disposal phase of the WIPP site, which would begin when the WIPP site opens, rock mechanics and seal system performance studies will continue to be used to enhance the disposal system operations and maintain certification compliance. According to the *Disposal Phase Experimental Program Plan* (DOE 1997), planned activities include:

- Geomechanical and subsidence monitoring of the development and healing of the DRZ surrounding the air intake shaft and disposal horizon

- Optimizing the component specification of the shaft seal system to enhance compaction of crushed salt, evaluate construction of clay components, tailor specifications of selected clay mixtures to field application, evaluate the longevity of concrete under WIPP conditions, and examine emplacement methodologies for asphaltic seal components

Disposal Room Interactions

To support its understanding of disposal room interactions, the Department has been investigating a variety of processes including creep closure in the disposal rooms, waste consolidation, and chemical interactions of the wastes with the host rock and brine that may flow into the disposal facilities from the surrounding Salado or Castile Formations. These units are a potential source of brine to the repository horizon. Actinide solubilities, which were not considered important in the early 1980s with the initial conceptual model of dry salt beds, became increasingly important in release pathways involving brine flow. Transport of actinides in colloidal form was also considered important. Chemical interactions under investigation include studies of actinide mobility such as the determination of actinide solubilities and oxidation states in brine at the WIPP horizon, and the quantities of actinide that could be mobilized in stable colloid forms found at WIPP. The results of these investigations provide the basis of the transport models and parameters being used in the current performance assessment calculations. Details of how actinide studies are used in the CCA are described in Appendix SOTERM of the CCA (DOE 1996f).

The Department has also conducted numerous experiments and investigations aimed at assessing the gas generation rates from anoxic corrosion of metals, anaerobic microbial decomposition of cellulosic materials found in disposed wastes, and radiolysis of brine coming into contact with wastes. These studies led to the development of gas generation models and relevant parameters currently used in performance assessment models and calculations to evaluate the effects of gas generation. Details of the gas generation studies used in the CCA are described in Appendices SOTERM and MASS of the CCA (DOE 1996f).

Studies of chemical interactions also led to the concept of using a magnesium oxide backfill in the disposal rooms to react with carbon dioxide created by microbial degradation, buffer the acidity of brine present in the repository, and control the solubility of actinides. Details of the basis for the selection of the magnesium oxide backfill as a chemical control component of the disposal system are described in Chapter 3 and Appendix BACK of the CCA (DOE 1996f).

During the disposal phase period, studies on disposal room interactions will be used to support certification compliance and system operations. Planned activities, as outlined in the *Disposal Phase Experimental Program Plan* (DOE 1997), include:

- Studies of actinide solubilities and geochemistry using experiments and tests with actual waste

- Continued gas generation experiments to evaluate the impact of major waste constituents that contribute to gas generation

- Additional laboratory tests to enhance the effectiveness of a magnesium oxide backfill, to examine the optimal amount of magnesium oxide required for the backfill, and to evaluate the cost-effectiveness and performance of backfill packaging

- Continued waste characterization studies to reduce the uncertainty in waste components and characteristics significant to long-term performance

Fluid Flow and Transport

Studies of fluid flow and transport at the WIPP site have focused on the presence and flow of brines in the Salado Formation, the overlying Rustler Formation, and the underlying Castile Formation.

During the early excavations of the WIPP site, observations of brine seeping into the repository from boreholes and freshly excavated surfaces led to significant changes in the conceptual models of WIPP performance. However, information about the rate of brine inflow showed that concerns about the waste becoming fluidized were unrealistic because consolidation to a sufficiently low porosity would occur before significant amounts of brine could accumulate. A series of tests, including the small-brine inflow, Brine Sampling and Evaluation Program (BSEP), Room Q, in-situ permeability tests, and laboratory flow tests were instituted to help validate the understanding of the interaction of brine inflow and the hydraulic properties of the Salado Formation.

Investigations of the Salado Formation have also provided an extensive set of measurements of the Salado's hydraulic properties within and adjacent to the WIPP site. These measurements have been incorporated into current performance assessment models and calculations and have been used to estimate the amount of brine that would enter into the repository, contribute to gas-generating reactions, and provide a medium for transport actinides released from wastes. Details of the Salado Formation studies are described in Chapter 2 and Appendix MASS of the CCA (DOE 1996f).

Investigations in the Rustler Formation have focused on the flow and transport properties of the Culebra Dolomite. Field measurements (hydraulic and tracer tests) have been used to characterize diffusion and fracture flow properties of the Culebra at multiple locations near the repository, which provide the basis for flow and transport models and related parameters used in the current performance assessment calculations. In the 1980s and 1990s, the interest has focused on a variety of field and laboratory investigations designed to increase the Department's understanding of the flow and transport characteristics of the Culebra. These investigations have included multi-well tracer tests and regional pumping tests, resulting in the recent seven-well tracer tests conducted at H-19, multi-well retesting at H-11, and single-well injection and withdrawal tests at both H-19 and H-11. Details of the Culebra Dolomite studies are described in Chapter 2 and in Appendices MASS and HYDRO of the CCA (DOE 1996f).

Properties of the Castile Formation have been primarily derived from hydraulic measurements obtained at boreholes that have penetrated pressurized brine reservoirs found in the Castile. Geophysical studies have helped resolve whether brine reservoirs encountered in WIPP-12 might exist under waste panels. Investigations in the late 1980s indicated that a zone of lower resistivity, which can be interpreted as brine, exists under a portion of the panels. Details of the Castile Formation studies are described in Chapter 2 and in Appendices MASS and HYDRO in the CCA (DOE 1996f).

During the disposal phase period, monitoring of fluid flow in all major hydrogeologic units of concern in the vicinity of WIPP will continue to support certification compliance and system operations. Planned activities, as outlined in the *Disposal Phase Experimental Program Plan* (DOE 1997), include groundwater surveillance of the existing monitoring network for routine water-level and water quality monitoring, and maintenance of a database on the location and properties of brine reservoirs in the Castile Formation.

System Response to Human-Related Activities

As part of the studies to examine system response to human-related activities, the WIPP program has developed passive institutional controls designed to reduce the possibility of human intrusion into the disposal facility during the 10,000-year regulatory time frame. Components of this control system include: (1) physical markers that would warn of the presence of buried nuclear wastes and identify the boundary of the disposal area and the controlled area, (2) external records about the WIPP repository, and (3) continued federal control. Details of the passive institutional control system are described in Section 7.1.3.2 and Appendices EPIC and PIC of the CCA (DOE 1996f).

The Department has also conducted a number of studies to evaluate the critical processes associated with the direct release of waste materials and brine as the result of human intrusion by exploratory boreholes into the repository. Early analyses of inadvertent penetration of the repository by deep drilling were initially treated deterministically until 40 CFR Part 194 required the analysis of multiple borehole intrusions and their interactions to be considered. The combination of postulated brine saturation and high pressures in the repository led to a need for the development of gas spallings and for direct brine release models to be considered with the cuttings and caving releases that were previously modeled.

Additional studies examined the potential for releases to occur from drill cuttings, material eroded from a borehole wall from circulation of drilling fluid, material spalled or forced into the borehole by pressurized fluid, and release of radionuclides dissolved in pressurized brine. Calculations and measurements have also examined the heterogeneity and uncertainty in the properties of consolidated wastes and how they could contribute to direct releases from intrusion. Modeling of cuttings, cavings, and direct brine releases is described in Appendices MASS and CUTTINGS_S of the CCA (DOE 1996f).

The Department has also conducted studies to evaluate the hydraulic characteristics of plugs used in standard borehole plugging practices and their potential for degradation after abandonment. The data collected during these studies, combined with studies of pressurized brine reservoirs in the Castile Formation and flow and transport properties of the Culebra Dolomite, provided the technical basis for the development of performance assessment codes and conceptual models of disturbed conditions described in Appendix DEL of the CCA (DOE 1996f).

During the disposal phase period, studies of system response to human-related activities will continue to support certification compliance and system operations. Planned activities, as outlined in the *Disposal Phase Experimental Program Plan* (DOE 1997), include:

- Continued development and enhancement of the passive institutional control system
- Maintenance of a database on oil and gas drilling and potash mining activities in the Delaware Basin, and the location of pressurized brine reservoirs in the Castile Formation

- Additional laboratory and modeling studies to investigate and reduce the uncertainty of sensitive parameters used to estimate direct releases from the repository as the result of human intrusion. Gas generation, backfill, and waste characterization studies will provide critical information for improving estimates of releases from borehole intrusions

H.2.2 Computational Tools and Codes

The computer codes and databases used to assess the long-term performance of the WIPP repository disposal system have evolved substantially since the SEIS-I analysis was completed. A major development effort accompanied the preliminary performance assessment of WIPP in 1992. The primary areas of enhancement include the development of models to simulate coupled gas generation, brine migration, and salt creep (SNL 1992). Conceptual models and databases supporting performance assessment calculations were modified and enhanced for the Systems Prioritization Methodology (SPM) process conducted in 1994 and 1995. Further code development and enhancement have continued to support more recent regulatory compliance efforts associated with the development of the CCA (DOE 1996f). The following is a description of key developments since SEIS-I.

In the SEIS-I analysis, long-term radiological and hazardous chemical impacts of the WIPP repository disposal system were determined by accepted conceptual models and computer codes implemented by DOE in performance assessment programs. The two principal codes in use at that time were the NEFTRAN and SWIFT II codes.

NEFTRAN, a groundwater flow and radionuclide transport code developed by Sandia National Laboratories (SNL) for the U.S. Nuclear Regulatory Commission, was used to calculate radionuclide releases from an undisturbed repository (Longsine et al. 1987). NEFTRAN was designed with the assumption that all substantial groundwater flow and radionuclide transport would progress along discrete one-dimensional legs or paths. A flow field is represented by a network of these legs. The solution of the flow equations in NEFTRAN requires pressure boundary conditions specified in the input data.

SWIFT II is a fully transient, three-dimensional code that solves equations for groundwater flow and radionuclide transport in both porous and fractured media. In SEIS-I (DOE 1990), SWIFT II was used to calculate releases from a disturbed repository. Also, SWIFT II was used to establish the groundwater flow field in the Culebra Dolomite and to simulate the injection of pressurized brine from the Castile Formation into the Culebra Dolomite.

The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) used a suite of new codes and modules that substantially improved simulation capabilities from those in SEIS-I. Improvements were made in the areas of simulating two-phase flow and salt creep in the vicinity of the repository within the Salado Formation and in the representation of transmissivity fields, flow fields, and transport calculations within the Culebra Dolomite of the Rustler Formation. Table H-1 briefly describes the key modules that were used for the first time in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations and are relevant to this analysis.

Table H-1
Summary of Computer Codes Used in the 1992 WIPP Performance Assessment

Computer Code	Description
BRAGFLO	Module used to simulate two-phase flow of gas and brine through a porous, heterogeneous reservoir. This module is used to simulate two-phase (gas and brine) flow through the repository, shaft seals, and surrounding environment.
PANEL	Module used to calculate radionuclide concentrations in the brine phase with an equilibrium-mixing cell approach. This module calculates the rate of discharge and cumulative discharge of radionuclides from a repository panel through an intrusion borehole. Discharge is a function of the fluid flow rate, nuclide solubility, and remaining inventory.
SANTOS	Module used to simulate quasi-static, large-deformation, inelastic response of halite. These simulations are used in the calculation of waste porosity as a function of time and moles of gas generated.
CUTTINGS_S	Module used to calculate the quantity of radioactive material brought to the surface as cuttings and cavings as a result of an exploratory drilling operation that penetrates a waste panel.
SECOFL2D **SECOTP2D**	Modules are groundwater flow and transport models used to calculate subsurface transport through the Culebra Dolomite of the Rustler Formation to the Land Withdrawal Boundary. Flow calculations assumed a single matrix, porous medium (dolomite). Transport calculations modeled single- or dual-porosity transport through an idealized fractured medium. Retardation in the dolomite matrix and in the fracture-lining clay could be included simultaneously or separately.
GRASP-INV	Module used to generate multiple, plausible transmissivity fields for use by SECOFL2D. This module was an improvement, in that it produced calibrated transmissivity fields that reproduced measured values at well locations.
GENII-S	Module used to estimate potential radiation doses to humans from radionuclides in the environment.

The SPM, initiated by DOE in March 1994, was the result of an effort to define the most viable combinations of scientific investigation, engineering alternatives, and the planning-basis Waste Acceptance Criteria (WAC) (DOE 1996c) for supporting WIPP compliance applications. As a part of this SPM development process, DOE established a technical baseline by which to summarize the conceptual models of disposal system performance and to assemble new information from technical position papers for use in the SPM process.

To the extent possible, the SPM process implemented the computer codes used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) with modifications for conceptual model enhancements and new information identified in the development of the technical baseline. Details of the modifications and new information are described in *The Second Iteration of the Systems Prioritization Method: A Systems Prioritization and Decision-Aiding Tool for the Waste Isolation Pilot Plant: Final Report Revision 1* (SPM-2) (SNL 1995).

With a few exceptions, the same codes used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) are being used in the current regulatory performance assessment application and related documentation. Key new developments included the following: (1) the SANTOS (formerly the SANCHO) module that was used to simulate quasi-static, large-deformation, inelastic response of halite has now been incorporated and integrated in the computational framework of the BRAGFLO module (described in Section H.3.3.1), and (2) the NUTS module is currently being used to simulate the transport and decay of multiple radioactive components in three dimensions through the fracture and matrix continuum. The NUTS module (described in Section H.3.3.2) is now used to simulate long-term transport of contaminants in brine within the repository to the surrounding rock and up intrusion boreholes, providing a source-term for the SECOTP2D code. The PANEL code is now used only to simulate scenarios involving two intrusion boreholes. These scenarios were not analyzed in SEIS-II.

H.3 DESCRIPTION OF APPROACH

The purpose of the SEIS-II performance assessment was to estimate the potential for long-term migration of radionuclides, heavy metals, and VOCs from the WIPP repository disposal system, evaluate transport to the accessible environment, and assess potential human health impacts from exposure to those contaminants released. SEIS-II analyses of the Proposed Action and Action Alternatives 1, 2, and 3 evaluated the potential impacts for 10,000 years beginning with the end of active institutional control, which is assumed to occur 100 years after the closure of WIPP.

SEIS-I analyses (DOE 1990) evaluated the performance of the WIPP repository for both undisturbed and disturbed (human intrusion by exploratory drilling) scenarios. For undisturbed and disturbed performance cases, SEIS-I evaluated the impacts of variations in selected parameters that would lead to expected (realistic) and less than expected (degraded) repository performance. In an undisturbed, degraded performance scenario (Case IB), SEIS-I analyzed the impact of changing some parameters, including the solubilities of key radionuclides, by factors of 100 and reducing the resistance to flow in the shaft and panel seals by a factor of 100. In a second undisturbed, degraded performance scenario (Case IC), leakage through marker bed 139 (MB 139) via accessway seals was assumed to increase marker bed permeability by a factor of 10 beyond those used in Case IB. The permeability of the lower shaft seal was also increased by a factor of 100 above what was assumed in Case IB. Disturbed scenarios examined the impacts of a hypothetical intrusion into the repository by a borehole drilled through the repository into a pressurized brine reservoir below. Disturbed, degraded repository performance scenarios (IIB, IIC, and IID) included parameter adjustments similar to those for undisturbed cases but also examined other parameter changes such as the amount of waste compaction. Descriptions of specific parameter changes considered in SEIS-I are provided in Section 5.4.2.2 and Appendix I of SEIS-I.

The SEIS-II analyses of long-term performance of the WIPP repository used an approach similar to SEIS-I but incorporated current computer codes and data developed since SEIS-I (DOE 1996f). Key features of the SEIS-II performance assessment approach were as follows:

- Detailed mathematical models to simulate key physical and chemical processes beginning with repository closure
- Deterministic analyses using current computational codes
- Updated parameter databases
- Performance evaluated for undisturbed and disturbed (human intrusion by exploratory drilling) scenarios over the 10,000-year period following site closure. Disturbed scenarios were assumed not to take place until after the end of the active institutional control period 100 years after repository closure.
- Analyses of repository releases and transport performed using cases of median and 75th percentile values for those parameters where statistical distributions were available. Median values were considered to be realistic estimates of performance and 75th percentile values were considered indicative of degraded or pessimistic repository performance that would result in greater contaminant release and transport. Values for some parameters,

such as Kd's in the Culebra, were chosen at the 25th rather than 75th percentile in order to simulate faster transit times. However, the general terminology "75th percentile" is used to describe this parameter selection process.

H.3.1 Data Sources and Parameter Selection

Data used in the long-term performance analysis were derived primarily from the CCA (DOE 1996f). The electronic database used by the CCA and documented in Appendix PAR of the CCA was also used to derive the parameters for this analysis.

Values for individual parameters in the computer codes were selected using the following approach:

- Median values chosen from the statistical distribution defining the parameter. These values were selected to represent expected repository performance.

- Seventy-fifth percentile values chosen from the statistical distribution defining the parameter. The value of the parameter was chosen to represent degraded performance, such that it would lead to higher releases than when the median value of the parameter was used.

Although many parameters in the models were employed for the long-term performance assessment, few have a substantial impact on the amount of material released. Some of the important parameters include the solubility of contaminants in the waste form, sorption of contaminants on the host salt, and hydraulic conductivity of the salt units near the repository. Relative to a probabilistic analysis, if (1) these parameters account for most of the variability in the computed release (or risk) values, and (2) values for these sensitive parameters were chosen at the 75th percentile of their respective distributions, the resulting single output realization would be expected to approach the maximum release expected if 100 realizations were run.

H.3.2 Release Scenarios Analyzed

Two conditions were considered in this study: the undisturbed repository performance and disturbed performance as affected by human intrusion. The undisturbed condition considers the performance of WIPP after closure for a period of 10,000 years without human contact. Two scenarios were considered for the disturbed condition.

- A drilling event that breaches the repository

- A drilling event that breaches the repository and penetrates a hypothetical pressurized brine reservoir in the Castile Formation below the repository horizon

Analyses of the impacts of each intrusion event are reported as the consequence of a single event and not as the combined impacts from a probabilistic set of drilling events over 10,000 years. The uncertainty inherent in some of the physical parameters that control flow and transport calculations was treated by considering the median and 75th percentile values of the parameters for both undisturbed cases and human-intrusion scenarios.

A total of sixteen cases, outlined in Table H-2, were used to estimate the impacts of undisturbed and disturbed performance for the Proposed Action and Action Alternatives 1, 2, and 3. The notable differences among the Proposed Action and Action Alternatives 1, 2, and 3 include their differing inventory loadings, changes in disposal room concentrations of radionuclides and heavy metals given thermal treatment of the waste, and inventory porosity and permeability changes. The main difference between alternatives is related to the total radionuclide and heavy metal inventory and the repository area (number of panels). The pathways for release and associated models used to quantify flow and transport in the subsurface environment for the Proposed Action and all action alternatives are illustrated in Figure H-1. Brine and gas flow depicted in the repository and disposal system was modeled using the BRAGFLO computer code. The distribution of fluid flow velocities and other quantities obtained from BRAGFLO simulations were then used to develop the necessary input parameters for the NUTS computer code, a subsurface contaminant transport simulator code.

Table H-2
Cases Considered in Long-term Performance Analysis of the Proposed Action and Action Alternatives

Alternative	Case Number	Case/Scenario	Data Selection
Proposed Action	1	Undisturbed	Median values
	2	Disturbed (Borehole Intrusion)	Median values
	3	Undisturbed	75th percentile values
	4	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 1	6	Undisturbed	Median values
	7	Disturbed (Borehole Intrusion)	Median values
	8	Undisturbed	75th percentile values
	9	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 2	11	Undisturbed	Median values
	12	Disturbed (Borehole Intrusion)	Median values
	13	Undisturbed	75th percentile values
	14	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 3	16	Undisturbed	Median values
	17	Disturbed (Borehole Intrusion)	Median values
	18	Undisturbed	75th percentile values
	19	Disturbed (Borehole Intrusion)	75th percentile values

Note: Cases 5, 10, 15, and 20 were dropped because backfill was incorporated into the repository design rather than modeled as a mitigation measure.

The SECOFL2D and SECOTP2D computer codes were used in SEIS-II to simulate the migration of radionuclides and heavy metals for disturbed conditions where releases to the Culebra Dolomite were predicted. The SECOTP2D computer code was used to model contaminant transport in the Culebra. This model of the Culebra Dolomite is a two-dimensional system that relies on flow fields calculated by the SECOFL2D code. Additional information is provided in Section H.8.

H.3.2.1 Undisturbed Conditions

For undisturbed conditions (i.e., no human intrusion), the release of radionuclides, heavy metals, and VOCs would occur only through dilute aqueous-phase and gas-phase transport from the WIPP repository into the Salado Formation and up the shaft seal system. The probabilistic analysis

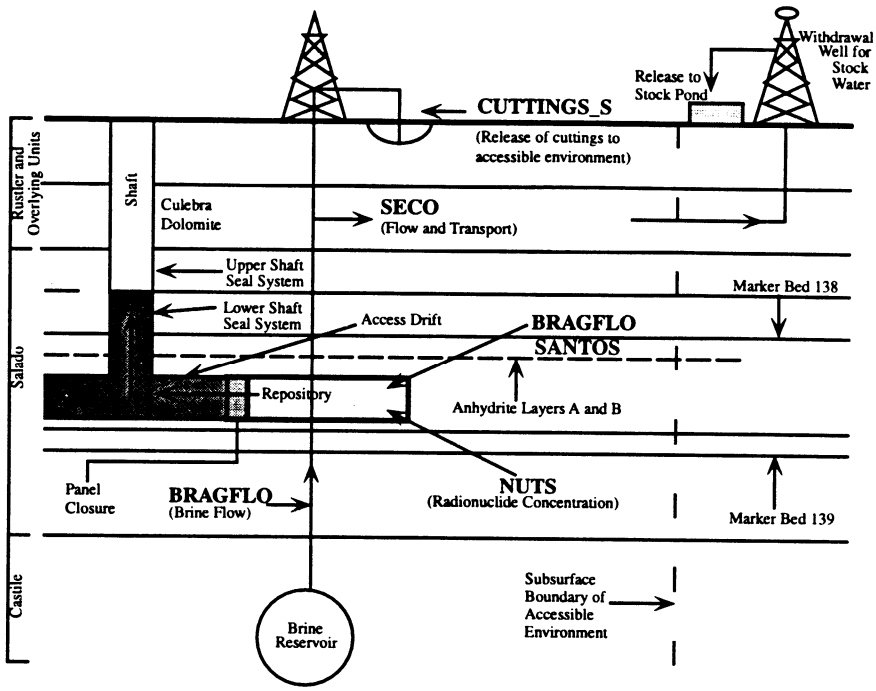


Figure H-1
Schematic Side View of the Repository and Disposal System Associating Major Performance Assessment Codes with Principal Components

conducted in the CCA (DOE 1996f) shows rapid reduction of waste panel porosity during the first 300 to 500 years, at which point the waste panels are near their final state (SNL 1996). The waste is expected to compact to an estimated final porosity of 1 to 5 percent, depending on the amount of gas generation (SNL 1996).

H.3.2.2 Disturbed Conditions

This section describes two release scenarios for disturbed conditions.

Surface Release Caused by Drilling into the Repository

In this disturbed condition, a hypothetical exploratory drilling operation inadvertently penetrates a waste panel in the repository. As a result, the drilling brings waste originating in the repository to the land surface and exposes individuals involved in the drilling operation to radionuclides and heavy metals. Three separate physical processes (Cole and Simmons 1995) are assumed to influence the quantity of repository waste brought to the ground surface as a result of a drilling intrusion (Figure H-2):

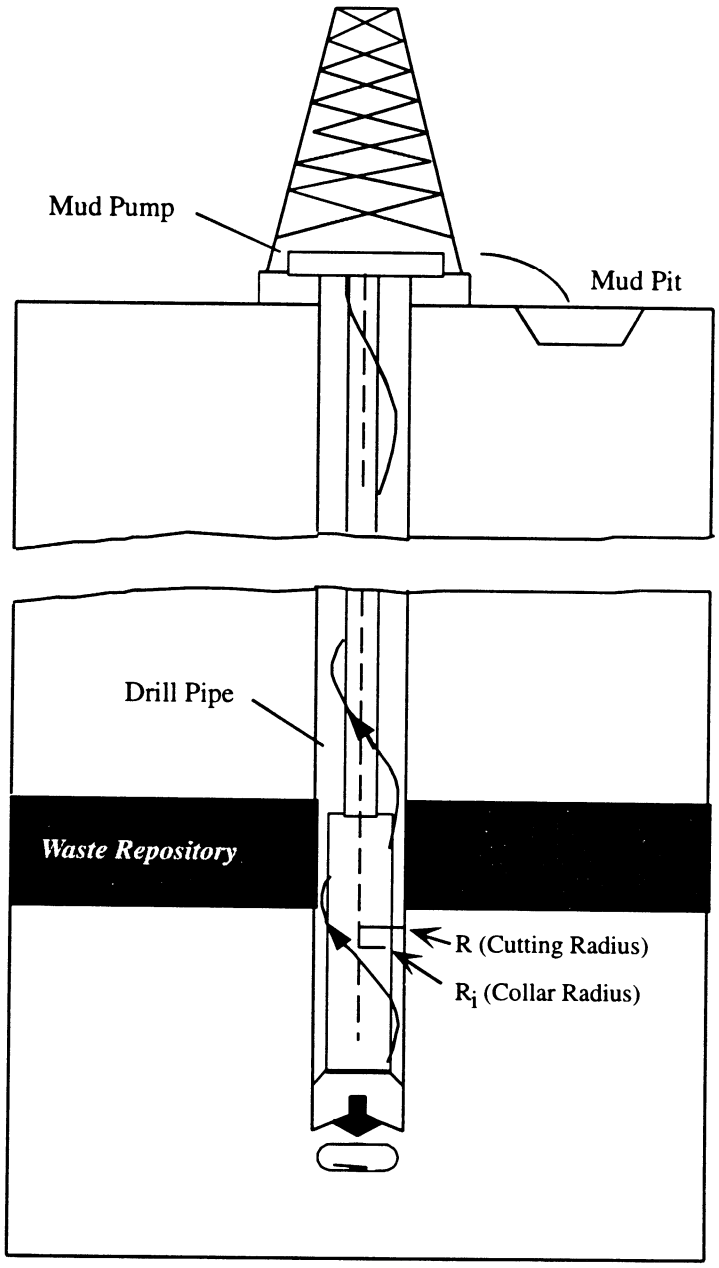


Figure H-2
Illustration of Exploratory Drilling Equipment for Human-Intrusion Scenario

- Cuttings - waste in the cylindrical volume created by the cutting action of the drill bit passing through the emplaced waste

- Cavings - waste that erodes from the borehole in the response to the upward-flowing drilling fluid within the annulus

- Spallings - release of solid materials into the drilling fluid as a result of the release of waste-generated gas escaping to the lower-pressure borehole. This process requires a repository gas pressure in excess of the hydrostatic pressure of the drilling mud to contribute to the releases.

A fourth release model, termed "direct brine release," accounts for the release of brine fractions of material introduced in a spallings event. Radionuclides and heavy metals released at the surface by cuttings, cavings, and spallings are modeled in this document. Direct brine releases are not considered in the SEIS-II analyses due to their relatively minor contribution to surface releases in the CCA (DOE 1996f).

The relationship of repository pressure to the release processes has been quantified and provides the basis for calculations of direct releases of wastes for the CUTTINGS_S computer code, as depicted in Figure H-3. The spallings release mode includes a blowout, gas erosion, and stuck pipe release mode. Because of the higher waste permeabilities considered in the SEIS-II analyses, only the blowout mode was relevant. More detailed information about these release modes are provided in Appendix CUTTINGS_S of the CCA (DOE 1996f). The values of brine and gas pressure in the repository and the permeability of the waste used to determine the release process under this model were obtained from the fluid flow simulations performed with the BRAGFLO computer code. Simulated brine and gas pressures were derived for undisturbed conditions calculated for expected (median values) and degraded (75th percentile values) cases. Disturbed and undisturbed repository pressure histories are considered identical until the time of intrusion, with the undisturbed cases being the basis on which pressure is estimated at any given intrusion time. The calculations of direct releases for the simulated BRAGFLO conditions were carried out using the CUTTING_S code.

Drilling Through the Repository into a Pressurized Brine Reservoir

Under this scenario a borehole is drilled through the repository and penetrates a pressurized brine reservoir in the Castile Formation below the repository horizon. Brine in the reservoir is assumed to come into contact with wastes in the repository and move further up the borehole to more permeable units lying above the repository horizon, like the Culebra Dolomite in the Rustler Formation. Should it occur, a release to the Culebra Dolomite could then be transported downgradient and become available for withdrawal through a well.

Future conditions of groundwater flow used in the transport analysis were based on the assumption that mining of potash reserves near the WIPP site would occur. Regulatory guidance, provided in 40 CFR Part 194 on the assessment of potash mining, directs that the effect of mining can be considered in evaluating off-site impacts by increasing the hydraulic conductivities of key hydrogeologic units, e.g., the Culebra Dolomite. These increases in hydraulic conductivity (to approximate the hydraulic effect of potash mining) can affect the transport of contaminants released from the repository if and only if these contaminants reach the Culebra Dolomite.

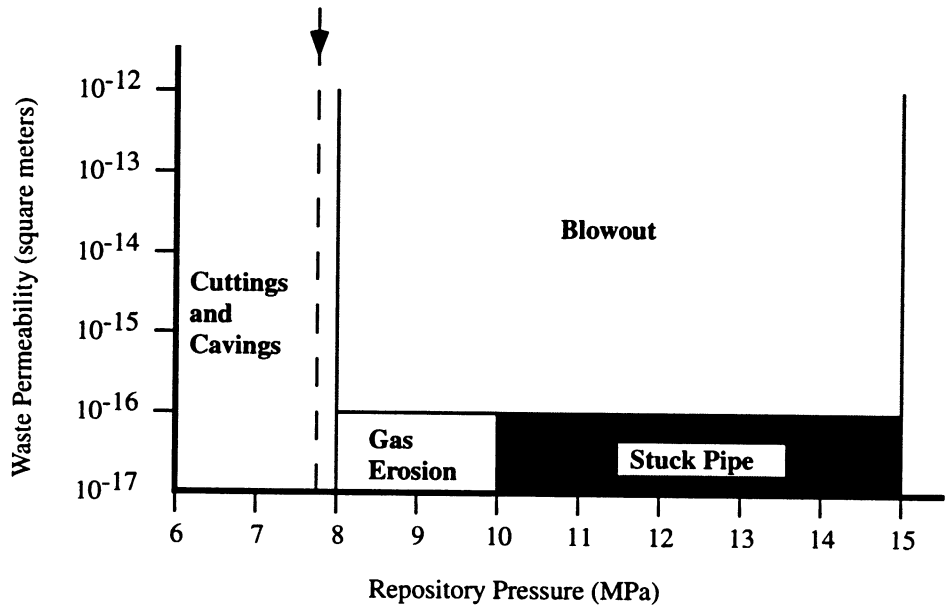


Figure H-3
Release Processes for Inadvertent Drilling Intrusion at Varying Repository Pressure and Waste Permeability

Following guidance provided in 40 CFR Part 194, hydraulic conductivities of the Culebra Dolomite in the areas impacted by mining were changed by a factor ranging from 1 to 1,000. SEIS-II analyses use the flow field results developed for the CCA (DOE 1996f): one with mining outside the Land Withdrawal Area boundary (partial mining) and one with all regions mined (full mining). Additional information on how these flow fields are used in modeling transport of contaminants in the Culebra Dolomite is provided in Section H.7.

H.3.3 Source-Term Release and Transport Codes

Computer codes used in this analysis include those used by DOE in the CCA (DOE 1996f). A schematic cross-section of the repository and the disposal system, associating major performance assessment codes with the principal components of the disposal system they simulate, is presented in Figure H-1. A brief description of each code used is provided below.

H.3.3.1 BRAGFLO

The BRAGFLO code in the CCA (Appendix BRAGFLO of DOE 1996f) was used to quantify the effects of gas and brine flow on radionuclide transport for undisturbed conditions. The code incorporates the effects of disposal room consolidation and closure, gas generation, and interbed fracturing in response to gas pressurization of the repository. BRAGFLO simultaneously solves partial differential equations that describe the mass conservation of mobile gas and brine

components, using appropriate initial conditions, boundary conditions, and other constraints. The important features of BRAGFLO include the following:

- Uses a finite difference approach to simultaneously solve partial differential equations that describe mass and energy conservation of mobile components of gas and brine with appropriate constraint equations, initial conditions, and boundary conditions
- Simulates a porous medium that can be occupied by brine, gas, or both brine and gas where the brine and gas are assumed to be immiscible
- Considers formation permeability simulations to be anisotropic
- Uses relative permeability and capillary pressure equation models available, including van Genuchten-Parker, original Brooks-Corey, and modified Brooks-Corey (Appendix BRAGFLO in DOE 1996f)
- Calculates the overall movement of gas and brine in the disposal unit and surrounding formations and defines the flow fields for contaminant migration postprocessing codes
- Contains the submodels for estimating gas generation in the repository, disposal room closure and consolidation, and interbed fracturing
- Simulates gas generation by creating gas in the waste disposal panels from the corrosion of waste containers and by microbial degradation of cellulose materials in the disposed wastes
- Changes in permeability and gas-storage volume of the waste resulting from creep closure are coupled to BRAGFLO through SANTOS, a code that provides a “porosity surface” used as a reference to track changes in room volume. SANTOS results are included in BRAGFLO through a series of tables that provide data to BRAGFLO describing dynamic changes in porosity as a function of time and pressure
- Allows fracture treatment for pressure-induced alterations to material porosity by introducing a pressure-dependent compressibility using a piecewise linear rock compressibility function
- Includes boundary conditions such as (1) Dirichlet (constant pressure), (2) inhomogeneous Neuman (fixed-pressure gradient), and (3) mixed boundaries (mix of Dirichlet and Neuman). For this analysis, a no-flow boundary condition is used for all exterior grid boundaries except at the far-field boundaries of the Culebra and Magenta Members and the top of the grid (i.e., the surface ground). The boundaries of the Culebra and Magenta are assigned constant pressure conditions used in those Members. The ground surface elements are maintained at one atmosphere (Appendix BRAGFLO in DOE 1996f).

For detailed information of the governing equations, initial and boundary conditions, and submodels used by BRAGFLO, refer to the CCA (Appendix BRAGFLO in DOE 1996f).

H.3.3.2 NUTS

The NUTS code in the CCA (Appendix NUTS of DOE 1996f) was used to track brine that has been in contact with waste in the repository. NUTS uses the calculated gas and brine flow fields

computed by BRAGFLO to transport the radionuclides in solution in the brine from the repository into the surrounding halite and anhydrite beds of the Salado Formation. These calculations also include the transport of radionuclides up a borehole or repository shaft to determine the quantity of radionuclides that could potentially reach the overlying Culebra Dolomite of the Rustler Formation. The important features of NUTS include the following:

- Uses finite difference techniques to simulate the decay and transport of multiple radionuclide components in three dimensions in fractured or unfractured media. Simulations can be performed using single-porosity, dual-porosity, and dual-permeability models.
- Simulates transport of both radioactive and nonradioactive contaminants
- Considers transport of radionuclides with chain decay
- Simulates sorption using three different sorption isotherms: linear, Freundlich, and Langmuir equilibrium isotherms
- Considers transport with solubility limits of individual contaminants and their precipitation. The precipitate can be decayed or redissolved in calculated concentrations that drop below solubility limits.
- Considers transport with multiradioactive site representations, a variety of source and sink terms, and the implementation of temperature dependency of certain parameters (temperature-dependent solubility, molecular diffusion, and sorption)

For more information regarding the underlying theory, governing equations, initial and boundary conditions, and submodels used by NUTS, refer to the CCA (Appendix NUTS of DOE 1996f).

H.3.3.3 CUTTINGS_S

The CUTTINGS_S code was used with the results calculated by BRAGFLO to determine radionuclide releases to the land surface by inadvertent repository intrusion by an exploratory borehole. CUTTINGS_S estimates the effect of separate physical processes that can influence the quantity of wastes brought to the ground surface by an exploratory borehole. These processes are:

- Generation of cuttings - wastes in the cylindrical volume created by the cutting action of the drill bit
- Cavings - wastes that erode from the borehole wall in response to the upward-flowing drilling fluid within the borehole annulus
- Spallings – solid particulate materials introduced into the drilling fluid by the release of waste-generated gas escaping into the lower-pressure borehole

For more information regarding the underlying theory, governing equations, and utilities used by CUTTINGS_S, refer to the CCA (Appendix CUTTINGS_S of DOE 1996f).

H.3.3.4 SECOFL2D and SECOTP2D

The SECOFL2D and SECOTP2D computer codes were used to simulate the migration of radionuclides and metals released into the Culebra Dolomite for selected cases of disturbed conditions. These codes are part of the suite of codes used to simulate groundwater flow, particle tracking, and solute transport in the Culebra Dolomite in support of the CCA (DOE 1996a). The SECOFL2D code is a two-dimensional, finite difference groundwater flow model capable of simulating transient or steady-state flow in saturated or unsaturated porous media. The SECOTP2D code is a two-dimensional, dual porosity transport model developed to simulate radionuclide transport in fractured porous media. The SECOTP2D code is also capable of simulating non-radioactive solutes such as the suite of heavy metals being considered in this analysis. The code assumes parallel plate type fracturing where fluid flow is restricted to the advective component of the flow system (i.e. in the fractures), and mass is transferred between the advective and diffusive parts of the flow system by molecular diffusion. SECOTP2D assumes linear equilibrium sorption isotherms in modeling retardation between the advective and diffusive components of the flow system. Radioactive decay is accounted for in the model through the use of multiple straight decay chains. Additional information on both codes and their governing equations is provided in SNL (1996) and Appendices SECOFL2D and SECOTP2D of the CCA (DOE 1996a).

H.4 CONCEPTUAL MODEL OF THE REPOSITORY DISPOSAL SYSTEM

Existing conceptual models of the WIPP repository disposal system developed for regulatory compliance analysis in the CCA (DOE 1996f) provided the basis for the SEIS-II analysis of long-term performance. The following is a synopsis of key conceptual models of the repository disposal system drawn from the CCA.

The disposal system is defined as the combination of engineered and natural barriers that isolate disposed waste from events and processes that are capable of affecting isolation of the waste. The key feature of the disposal system is the Salado Formation which provides a critical natural barrier to contaminant migration from the repository. The engineered barrier system includes materials emplaced as backfill and seal closures installed in drifts, shafts, and boreholes. The following overview of the conceptual model covers some of the principal aspects of the disposal system assumed for this analysis. A summary of critical assumptions regarding brine and gas migration taken from the CCA (Appendix MASS, DOE 1996f) is provided in Table H-3.

H.4.1 Repository System

The repository system contains a number of key elements that contribute to its overall long-term performance. Brief descriptions of these elements are described in Sections H.4.1.1 to H.4.1.7.

H.4.1.1 Salt Creep

Salt creep is an important process in the conceptual model of the disposal system. It occurs naturally in Salado Formation halite in response to deviatoric stress created by the excavation of the repository. Closure of the waste disposal panels by salt creep will eventually consolidate waste in the disposal areas until an equilibrium with the surrounding rock is reached. The shaft and repository excavation have resulted in a system of fractures caused by stress relief within the salt.

Table H-3
Brine and Gas Migration Modeling Assumptions

MODELING AREA	MODELING ASSUMPTIONS
General Assumptions	1. Flow is governed by mass conservation and Darcy's Law in porous media. Flow is laminar and fluids are Newtonian. 2. Two-phase flow in the porous media is by simultaneous immiscible displacement. 3. The Brooks-Corey or Van Genuchten/Parker equations represent interaction between brine and gas. 4. The Klinkenberg effect is included for flow of gases at low pressures. 5. Threshold displacement pressure for flow of gas into brine is constant. 6. Fluid composition and compressibility are constant. 7. The gas phase is assigned the density and viscosity properties of hydrogen. 8. All liquid physical properties are assigned the properties of Salado brine.
Model Geometries	The disposal system is represented by a two-dimensional, north-south, vertical cross section.
Disposal System Geometry	Flow in the disposal system is radially convergent or divergently centered on the repository, shaft, and borehole for disturbed performance. Variable dip in the Salado is approximated by a 1 degree dip to the south. Stratigraphical layers are parallel. The stratigraphy consists of units above the Dewey Lake, the Dewey Lake, the Forty-niner, the Magenta, the Tamarisk, the Culebra, the Unnamed lower member, and the Salado (comprising impure halite, MB 138, anhydrites a and b [lumped together], and MB 139). The dimensions of these units are constant. A Castile brine reservoir is included in all scenarios.
Culebra Geometry	The Culebra is represented by a two-dimensional, horizontal geometry for groundwater flow and radionuclide transport simulation. Transmissivity varies spatially. There is no vertical flow to or from the Culebra. The regional flow field provides boundary conditions for local transport calculations.
The Repository	The repository comprises five regions: a waste panel, the panel closures, the remainder of the panels and the access drifts, the operations region, and the experimental region. Also, a single shaft region is modeled, and a borehole region is included for a borehole that intersects the separate waste panel. The dimensions of these regions are constant. Long-term flow up plugged and abandoned boreholes is modeled as if all intrusions occur into a down-dip (southern) panel. For each repository region the model geometry preserves design volume. Pillars and individual drifts and rooms and panel closures in the nine lumped panels are not modeled for long-term performance, and containers provide no barrier to fluid flow. The distance from the south end of the modeled waste panel to the modeled shaft is the true distance from the south end of the waste disposal region to the waste handling shaft. Long-term flow is radial to and from the borehole that intersects the waste disposal panel during disturbed performance. Panel closures are modeled with the same properties as the surrounding DRZ.
Creep Closure	Creep closure is modeled using a two-dimensional model of a single room. Room interactions are insignificant. Creep closure causes a decrease in room volume which decreases waste porosity. The amount of creep closure is a function of time, gas pressure, and waste matrix strength. Porosity of operations and experimental areas is fixed at a value representative of consolidated material.

Table H-3
Brine and Gas Migration Modeling Assumptions — Continued

MODELING AREA	MODELING ASSUMPTIONS
Repository Fluid Flow	General Assumptions 1 through 8. The waste disposal region is assigned a constant permeability representative of average consolidated waste without backfill. The experimental and operations regions are assigned a constant permeability representative of unconsolidated material and a constant porosity representative of consolidated material. For gas generation calculations, the effects of wicking are accounted for by assuming that brine in the repository contacts waste to an extent greater than that calculated by the Darcy flow model used.
Gas Generation	Gas generation occurs by anoxic corrosion of steel containers and Fe and Fe-base alloys in the waste, giving H_2, and microbial degradation of cellulosics and, perhaps, plastics and rubbers, giving mainly CO_2 and CH_4. Radiolysis, toxic reactions, and other gas generation mechanisms are insignificant. Gas generation is calculated using the Average Stoichiometry model and is dependent on brine availability. The anoxic corrosion rate is dependent on liquid saturation. Anoxic corrosion of steel continues until all the steel is consumed. Steel corrosion will not be passivated by microbially generated gases CO_2 or $H2_S$. Brine is consumed by the corrosion reaction. Laboratory-scale experimental measurements of gas generation rates at expected room temperatures are used to account for the effects of biofilms and chemical reactions. The rate of biodegradation is dependent on the amount of liquid present. It is assumed that biodegradation neither produces nor consumes water. Gas generation by microbial degradation takes place in half the simulations. In half of the simulations with microbial gas generation, microbes consume all of the cellulosics but none of the plastics and rubbers. In the other half of the simulations with microbial gas generation, microbes consume all of the cellulosics and all of the plastics and rubbers. Microbial gas generation will continue until all biodegradable organic materials are consumed if brine is present. The MgO backfill will react with CO_2 and remove it from the gas phase. Gas dissolution in brine is of negligible consequence. The gas phase is assigned the properties of hydrogen.
Chemical Conditions in the Repository [a]	Chemical conditions in the repository will be constant. Chemical equilibrium is assumed for all reactions that occur between brine in the repository, waste, and abundant minerals, with the exceptions of gas generation and redox reactions. Brine and waste in the repository will contain a uniform mixture of dissolved and solid-state species. No microenvironments that influence the overall chemical environment will persist. For the undisturbed performance and exploratory borehole scenarios, brine in the waste panels has the composition of Salado brine. For scenarios penetrating the repository and pressurized brine reservoir, all brine in the waste panel intersected by the borehole has the composition of Castile brine. Chemical conditions in the waste panels will be reducing; however, a condition of redox disequilibrium will exist between the possible oxidation states of the actinide elements. The pmH and pCO_2 in the waste panels will be controlled by the equilibrium between brucite and magnesite. (A result of this assumption is low pCO_2 and alkaline conditions.)
Dissolved Actinide Source Term [b, c]	Radionuclide dissolution to solubility limits is instantaneous. Six actinides (Th, U, Np, Pu, Cm, and Am) are considered for calculations of radionuclide transport of brine. Choice of radionuclides is discussed in Appendix H. The reducing conditions in the repository will eliminate significant concentrations of Am(V), Pu(V), Pu(VI), and NP(VI) species. Am and Cm will exist predominantly in the III oxidation state, Th in the IV oxidation state. It is assumed that the solubilities and Kds of Pu, Np, and U will be dominated by one of the remaining oxidation states: Pu(III) or Pu(IV), Np(IV) or NP(V), U(IV) or U(VI). For a given oxidation state, the different actinides exhibit similar chemical behavior and thus have similar solubilities. Organic ligands will not significantly affect solubility. For undisturbed performance and for all aspects of disturbed performance except for cuttings and cavings releases, radionuclide-bearing compounds are distributed evenly throughout the disposal panel. Mobilization of actinides in the gas phase is negligible. Actinide concentrations in the repository will be inventory limited when the mass of an actinide becomes depleted such that the predicted solubilities cannot be achieved.

Table H-3
Brine and Gas Migration Modeling Assumptions — Continued

MODELING AREA	MODELING ASSUMPTIONS
Source Term for Colloidal Actinides	Four types of colloids comprise the source term for colloidal actinides: microbes, humic substances, intrinsic colloids, and mineral fragments. The only intrinsic colloids that will form are those of the plutonium Pu(IV) polymer. Concentrations of intrinsic colloids and mineral fragment colloids are modeled as constants that were based on experimental observations. Humic and microbe colloid actinide concentrations are modeled as proportional to dissolved actinide concentrations. The maximum concentration of each actinide associated with each colloid type is constant.
Shafts and Shaft Seals	General Assumptions 1 to 8. The four shafts connecting the repository to the surface are represented by a single shaft with a cross section and volume equal to the total volume of the four real shafts and separated from the waste by the distance of the nearest real shaft. The seal system is represented by nine materials occupying eleven model regions. The shaft is surrounded by a DRZ which heals with time. The DRZ is represented through the permeabilities of the shaft system itself, rather than as a discrete zone. The effective permeability of shaft salt, clay, and concrete seals are adjusted several times after closure to reflect consolidation and possible degradation. Permeabilities are constant for asphalt and earthen-fill components. Concrete shaft components are modeled as if they degrade 400 years after emplacement. Radionuclides are not retarded by the seals.
Salado Formation	General Assumptions 1 to 8.
Impure Halite	Rock and hydrologic properties are constant.
Salado Interbeds	Interbeds have a fracture-initiation pressure above which local fracturing and changes in porosity and permeability occur in response to changes in pore pressure. A power function relates the permeability increase to the porosity increase. A pressure is specified above which porosity and permeability do not change. Interbeds have identical physical properties; they differ only in position, thickness, and some fracture parameters.
Disturbed Rock Zone	The permeability of the DRZ is constant and higher than intact Salado. The DRZ porosity is equal to the porosity of impure halite to +0.29 percent.
Actinide Transport in the Salado	Dissolved actinides and colloidal actinides are transported by advection in the Salado. Diffusion and dispersion are assumed negligible. Sorption of actinides in the anhydrite interbeds, colloid retardation, colloid transport at higher than average velocities, co-precipitation of minerals containing actinides, channeled flow, and viscous fingering are not modeled. Sorption of actinides in the borehole is not modeled.
Units Above the Salado	Above the Salado, lateral actinide transport to the accessible environment can occur only through the Culebra.
Unnamed Lower Member	The Unnamed lower member is assumed to be impermeable.

Table H-3
Brine and Gas Migration Modeling Assumptions — Continued

MODELING AREA	MODELING ASSUMPTIONS
Culebra Dolomite Member	General Assumptions 1, 6, and 8. For fluid flow, the Culebra is modeled as a uniform (single-porosity) porous medium. For radionuclide transport, a double-porosity model is used (advection in high permeability features and diffusion and sorption in low-permeability features). The Culebra flow field is determined from the observed hydraulic conditions and estimates of the effects of potash mining outside the controlled area and does not change with time unless mining is predicted to occur in the disposal system in the future. The Culebra is assigned a single permeability to calculate brine flow into the unit from an intrusion borehole. Gas flow in the Culebra is not modeled. Gas from the repository does not affect fluid flow in the Culebra. Different thicknesses of the Culebra are assumed for BRAGFLO, SECOFL-2D, and SECOTP-2D calculations, although the transmissivities are consistent. Uncertainty in the spatial variability of the Culebra transmissivity is accounted for by statistically generating many transmissivity fields. Potentiometric heads are set on the edges of the regional grid to represent flow in a portion of a much larger hydrologic system.
- *Transport of Dissolved Actinides in the Culebra*	Dissolved actinides are transported by advection in high-permeability features and diffusion in low permeability features. Sorption occurs on dolomite in the matrix. Sorption on clays present in the Culebra is not modeled. Sorption is represented using a linear isotherm model. The possible effects on sorption of the injection of brines from the Castile and Salado into the Culebra are accounted for in the distribution of actinide Kds. Hydraulically-significant fractures are assumed to be present everywhere in the Culebra.
- *Transport of Colloidal Actinides in the Culebra*	Humic actinides are chemically retarded identically to dissolved actinides and are treated as dissolved actinides. The concentration of intrinsic colloids is sufficiently low to justify elimination from performance assessment transport calculations. Microbial colloids and mineral fragments are too large to undergo matrix diffusion. Filtration of these colloids occurs in high permeability features (which is modeled using a decay approach). Attenuation is so effective that associated actinides are assumed to be retained within the disposal system and are not transported in SECOTP-2D
- *Potash Mining*	Subsidence due to potash mining increases the hydraulic conductivity in the Culebra by a factor from 1 to 1,000.
Tamarisk Member	The Tamarisk is assumed to be impermeable.
Magenta Member	General Assumptions 1 to 8. The Magenta permeability is set to the lowest value measured near to the center of the WIPP site. This increases the flow into the Culebra. No radionuclides entering the Magenta will reach the accessible environment. However, the volumes of brine and actinides entering and stored in the Magenta are modeled.
Forty-niner Member	The Forty-niner is assumed to be impermeable.

Table H-3
Brine and Gas Migration Modeling Assumptions — Continued

MODELING AREA	MODELING ASSUMPTIONS
Dewey Lake Member	General Assumptions 1 to 8. The sorptive capacity of the Dewey Lake is large enough to prevent any release over 10,000 years.
Supra-Dewey Lake Units	General Assumptions 1 to 8. The units above the Dewey Lake (the Gatuno and Santa Rosa Formations) are a single hydrostratigraphic unit. The units are thin and predominantly unsaturated.
The Intrusion Borehole	Any actinides that enter the borehole are assumed to reach the surface.
Cuttings, Cavings, and Spall Releases during Drilling	Future drilling practices will be the same as they are at present. Releases of particulate waste material are modeled (cuttings, cavings, and spallings). Releases are corrected for radioactive decay until the time of intrusion. Particle waste shear based on properties of marine clay, considered a worst case.
Long-Term Releases Following Drilling	Plugging and abandonment of future boreholes are assumed to be consistent with practices in the Delaware Basin. A two-plug configuration was assumed. A lower plug is located between the Castile brine reservoir and underlying formations. A second plug is located immediately above the Salado. The brine reservoir and waste panel are in direct communication though an open-cased hole. The casing and upper concrete plug are assumed to fail after 200 years, and the borehole is assumed to be filled with silty sand-like material. At 1,200 years after abandonment, the permeability of the borehole below the waste panel is decreased by one order of magnitude as a result of salt creep. The diameter of the intrusion borehole is constant at 12.25 inches (31.12 centimeters).
Castile Brine Reservoir	The Castile region is assigned a low permeability, which prevents fluid flow. Brine occurrences in the Castile are bounded systems. Brine reservoirs under the waste panels are assumed to have limited extent and interconnectivity, with effective radii on the order of several hundred meters.
Initial and Boundary Conditions for Disposal System Modeling	There are no gradients for flow in the far-field of the Salado, and pressures are above hydrostatic but below lithostatic. Excavation and waste emplacement result in partial drainage of the DRZ. Initial and boundary conditions for other computational models were interpolated from previously executed BRAGFLO calculations.
Disposal System Flow and Transport Modeling	An initial water table surface is set in the Dewey Lake at an elevation of 3,215 feet (980 meters) above mean sea level. The initial pressures in the Salado are extrapolated from a sampled pressure in MB 139 at the shaft and are in hydrostatic equilibrium. The excavated region is assigned an initial pressure of one atmosphere. The liquid saturation of the waste-disposal region is consistent with the liquid saturation of emplaced waste. Other excavated regions are assigned zero liquid saturation, except the shaft which is fully saturated. Molecular transport boundary conditions are no diffusion or dispersion in the normal direction across far-field boundaries. Initial actinide concentrations are zero everywhere except in the waste.
Culebra Flow and Transport Modeling	Constant head boundary conditions are set on the far-field boundaries of the regional flow model. Constant head boundary conditions are also set on the boundaries of the local domain, and are derived by interpolating the solution of the regional domain. Initial actinide concentrations in the Culebra are zero.

[a] The terms pmH and pCO_2 represent the $\log_{10}$ of the molality of the hydrogen ion and the partial pressure of carbon dioxide, respectively.
[b] Roman numerals represent different oxidation states for the radionuclides.
[c] The term "Kds" represents the distribution coefficients.

These fractures, which surround the shaft and excavation, create what is referred to as a "disturbed" rock zone. The DRZ will develop within the Salado Formation around shafts connecting the repository to the surface. The process of salt creep will partially heal fractures in the Salado Formation halites, leading to a general reduction in the overall permeability and porosity within the DRZ over time.

H.4.1.2 Brine Flow

Pressure gradients created by the excavation of the repository will cause brine in the surrounding rocks to flow into the waste disposal panels. Brine flow into the repository decreases as the repository pressure increases, as a result of the generation of gas from waste degradation. Conceptually, brine could be expelled from the repository should pressure in the repository exceed the brine pressure in the surrounding rock.

H.4.1.3 Gas Generation

Gases such as hydrogen gas, carbon dioxide (CO_2), and methane will be generated as waste stored in the repository comes into contact with inflowing brine and degrades via a variety of chemical and microbial processes. These processes are expected to degrade metals, cellulose and similar materials (cellulosics), and plastics and rubber materials contained within the disposed waste. The dominant gas-generating processes are anoxic corrosion of ferrous metals in the waste and waste containers and the microbial degradation of cellulosics, plastic, and rubber in the waste. In general, as gas pressure rises as a result of repository closure and gas generation, increased pressure will impede creep closure and consolidation of the waste region. Gas generation is expected to cause fracturing or increase the porosity of existing fractures of anhydrites beyond the DRZ as repository pressures approach lithostatic levels.

H.4.1.4 Source-Term Release Mechanisms

As rooms and access drifts are closed by the process of salt creep, waste containers will be crushed and breached. In the absence of backfill which would slow this process, the chemical conditions in the after closure environment would rapidly become reduced (anoxic) as oxygen is consumed by initially toxic reactions, as gas is generated by waste degradation, and as brine fills the void volume in the waste disposal region. Radioactive and hazardous constituents would be released as waste drums are breached and waste comes into contact with brine and gas. For liquid-phase contaminants to be generated, sufficient brine inflow must occur to dissolve the waste constituents in the solid phase or serve as a medium for partitioning of vapor-phase organics into the brine. Furthermore, repository conditions (pressure and temperature) and chemical conditions (pH and Eh) must be suitable to dissolve and mobilize metals existing as elemental metals or salts. For this SEIS-II analysis, as in the CCA (DOE 1996f) analyses, it was conservatively assumed that instantaneous dissolution of waste containers and immediate mobility of radioactive and hazardous constituents in the gas and liquid phases at WIPP closure would occur.

H.4.1.5 Dilation and Fracturing of the Anhydrite Interbeds

Gas generated by waste degradation approaching lithostatic pressure is expected to fracture the anhydrite interbeds and dilate the existing fractures in the vicinity of the repository and, thus, enhance flow and mass transport of contaminants. Potential transport processes within the fractured interbeds include advection, diffusion, dispersion, fracture-matrix flow, channeling and

fingering, retardation, and sieving. Mass transport in gas and brine flow in unfractured anhydrite beds is possible; however, because of their low permeability, transport in these beds is not likely to be important.

H.4.1.6 Repository Features

The reference design of the repository under the Proposed Action contains 10 panel equivalents. Each panel consists of seven disposal rooms and connecting access drifts. These areas will be sequentially filled with waste and then sealed. The repository size for Action Alternatives 1, 2, and 3 are 68, 75, and 71 panel equivalents, respectively. The repository size is embedded in the grid geometry for BRAGFLO that simulate brine and gas flow in the repository and surrounding region.

H.4.1.7 Engineered Components

Current plans make use of cylindrical seals consisting of salt columns interleaved with concrete plugs, clay, and other engineered materials to seal the repository access drifts and shafts from inflowing groundwater and to reduce the migration of contaminants through the repository and shaft system. The seals will be emplaced in the four shafts connecting the repository to the surface.

Use of magnesium oxide backfill is also planned to provide chemical control of the solubility of radionuclides in the after closure repository environment. Long-term performance calculations for the Proposed Action and action alternatives include the effects of the magnesium oxide backfill. Actinide solubility in the repository is highly dependent on pH conditions and the oxidation state of the actinide. Gas generation resulting from microbial degradation of carbon in waste materials is expected to generate CO_2, lower pH, and generate carbonate species that bind very strongly to actinides, as complexes, to form relatively highly soluble actinide species. The presence of appropriate amounts of magnesium oxide is expected to react with brine that may reach the repository and any CO_2 gas generated as a result of microbial action to maintain a sufficiently high pH and minimize the formation of carbonate complexes that result in higher actinide solubilities. More details on the theory behind the current plans for this backfill are described in Appendix BACK of the CCA (DOE 1996f).

H.4.2 Salado Formation

The Salado Formation is the principal natural barrier to fluid flow between the repository and the accessible environment. For the purpose of this analysis, the Salado is conceptualized as a porous medium composed of several rock types arranged in layers, except in the vicinity of the repository where stress-relief fractures have disrupted the continuous layers. Near the repository, the DRZ in the Salado is conceptualized as a zone of increased permeability and porosity, offering little resistance to flow between the repository and the surrounding rocks. The intact Salado consists of sequences of two rock types, impure halite and anhydrite. These rock types are assumed to be a homogeneous porous medium with spatially constant properties. Specific information and model inputs used in this analysis to represent the major rock types and the DRZ in the numerical models of the repository are summarized in Section H.6.

H.4.3 Units Above and Below the Salado Formation

Elements of the disposal system model conceptualized above and below the Salado Formation include units within the Rustler Formation, the Dewey Lake Formation (also called the Redbeds) and supra-Dewey Lake units, and the Castile Formation with associated brine reservoirs. Brief descriptions of each of these elements are provided below.

H.4.3.1 Rustler Formation

The Rustler Formation is conceptualized as having five recognized members: the Unnamed lower, the Culebra Dolomite, the Tamarisk, the Magenta, and the Forty-Niner. The Unnamed lower member of the Rustler Formation is characterized by relatively low transmissivity and thus is treated as an impermeable unit.

The Culebra Dolomite is conceptualized as the most permeable unit within the Rustler Formation and, therefore, the most notable unit when considering the long-term release from WIPP to the accessible environment. It may be possible for radionuclides and other hazardous constituents to travel up the sealed shafts, through gas or brine flow, into the Culebra as a result of high repository pressure. Gas and/or brine flowing up either exploratory boreholes that have penetrated the repository or deeper pressurized brine pockets below the repository could also be introduced into the Culebra.

Human-intrusion scenarios may introduce gas into the boreholes either from such sources as the Castile Formation brine reservoirs or from gas in the repository generated in the waste. Because of the lower pressures in the units above the Salado Formation, the gas volume will expand over the volume occupied in the reservoir. Gas bubbles could alter the natural flow patterns and velocities of the brine because of flow blockage and density differences, and the gas bubbles could migrate differently than the brine. Fracture-matrix flow could be considerably changed with the introduction of gas as a result of capillary pressure difference between the phases, possibly resulting in gas flow primarily in fractures and brine flow restricted to the matrix. Chemistry could also be changed by the introduction of gas into the non-Salado Formation units. For the purpose of this analysis, the Culebra Dolomite was analyzed using single-phase or fully saturated approaches for flow and transport, assuming that two-phase conditions associated with gas release do not substantially impact transport calculations.

According to the CCA (DOE 1996f), an intrusion borehole connecting the Culebra with the Salado and a Castile brine reservoir could allow brine to flow into the Culebra which, in turn, could cause hydraulic head in the Culebra to increase, locally inducing radial flow from the borehole. The area affected would depend on the transmission and storage capabilities of the Culebra, and on the flow rate into the Culebra. The study by Reeves et al. (1991) indicated that, for much of the range of brine reservoir and breach borehole parameters, the fluid disturbance created in the Culebra by the borehole had minimal impact on the flow field. In addition, transport calculations under these conditions need not include the transient impact of locally increased hydraulic head near the breach borehole. This study also found that, for extreme conditions at the high end of the brine reservoir volume, pressure range, and borehole permeabilities, travel time for a conservative solute can be reduced by as much as 7.4 percent because of increased heads in the vicinity of the borehole. This effect can be implemented in an undisturbed flow field by increasing hydraulic heads in the vicinity of the borehole. The fluid from an intrusion borehole could have the following four effects on flow and transport in the Culebra:

- Increase in hydraulic gradients and flow velocities in the vicinity of the borehole
- Change in the density of the Culebra fluid
- Result in rock/water interactions that locally alter flow and transport properties in the Culebra
- Result in local multiphase flow conditions in the Culebra

For the purpose of this analysis, SEIS-II did not consider any of these specific processes in analyzing the impacts of a borehole intrusion on the Culebra.

If radionuclides reach the Culebra, they may be transported to off-site receptors from the point of introduction by groundwater flowing through the Culebra. Radionuclide transport in the Culebra is represented in this analysis by two-dimensional flow through a horizontal, confined aquifer containing fractures and spatially variant transmissivity.

According to the CCA (DOE 1996f), the Culebra Dolomite is a double-porosity medium at some locations on and around WIPP. Double-porosity simply means that the Culebra has a porosity attributable to its rock matrix and another attributable to fractures. Allowing flow and transport in fractures within the Culebra generally overestimates transport in those areas where the Culebra has a low transmissivity and has been interpreted as a single-porosity, matrix-only medium. In a double-porosity, fractured medium, flow is generally conceptualized as occurring primarily in the fractures, because flow velocities are usually orders of magnitude higher in the fractures than in the matrix. However, the process of diffusive (or advective) transport of radionuclides or contaminants from fractures into the matrix can physically retard these substances.

For the purpose of this analysis, SEIS-II has adopted the conceptual model for Culebra flow and transport used in previous WIPP performance assessments. The double-porosity conceptualization used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) and, more recently, in the CCA (DOE 1996f) analyses assume that advective transport occurs only in fractures, with diffusion of radionuclides and other contaminants occurring between the fractures and matrix.

Interactions of brines containing radionuclides and hazardous contaminants with the Culebra Dolomite and, in particular, clay mineral linings on fracture surfaces have been postulated as having the potential to cause chemical retardation. The CCA (DOE 1996f) reports that, for the purpose of estimating contaminant transport in groundwater, the Culebra is best characterized as a double-porosity medium. Groundwater flow and advective transport of dissolved species or colloidal particles occur primarily in a small fraction of the total rock porosity, which corresponds to the open and interconnected fractures and vugs. Diffusion and slower flow occur in the remainder of the porosity that is associated with the low-permeability dolomite matrix. Transported species, including actinides if present, will diffuse into this porosity. Diffusion out of the advective porosity into the dolomite matrix will retard actinide transport. Physical retardation occurs when actinides that diffuse into the matrix are no longer transported with the flowing groundwater, and transport is interrupted until they diffuse back into the advective porosity. In situ tracer tests have been conducted to demonstrate this phenomenon. Chemical retardation occurs within the matrix as actinides are sorbed onto dolomite grains. The relationship between sorbed

and liquid concentrations is assumed to be linear, and the distribution coefficients (K_ds) that characterize the extent to which actinides will sorb on dolomite are based on experimental data (Appendix MASS.15, DOE 1996f).

The Tamarisk Member rests between the more transmissive Culebra Dolomite and Magenta Dolomite Members of the Rustler Formation. Like the Unnamed lower member, the Tamarisk Member does not have a high transmissivity. For the purpose of this analysis, this member was treated as impermeable.

Although the Magenta Dolomite Member is transmissive, transport of radionuclides within this unit was not considered because it has been shown that any radionuclides within the Magenta will not reach the site boundary in 10,000 years (Barr 1983).

Because of its low permeability, the Forty-Niner Member is considered to be relatively unimportant for flow and transport analysis (Beauheim [1986] and Beauheim et al. [1991]). For the purpose of this analysis, the Forty-Niner Member is considered impermeable.

H.4.3.2 Dewey Lake (Redbeds) Member and Supra-Dewey Lake Units

The Dewey Lake (Redbeds) Member is conceptualized as having a low permeability compared to that of the Culebra Dolomite Member. Because of the high adsorptive capacity of the redbeds, transport of radionuclides in this member is assumed to be negligible.

For the purpose of this analysis, all units above the Dewey Lake (Redbeds) Member, the Gatuna and Santa Rosa Formations, were assumed to behave as a single hydrogeologic unit of relatively high permeability.

H.4.3.3 Castile Formation and Brine Reservoirs

The Castile Formation is postulated to have a very low permeability because of its evaporite content. However, brine under high pressure has been encountered in the Castile Formation (the WIPP-12 borehole) within the disposal system boundary and the U.S. Energy Research and Development Administration borehole number 6 (ERDA-6 borehole). The connection of a brine reservoir in the Castile with the waste panels at the repository level and overlying units by an exploratory borehole has been postulated as a possible human-intrusion scenario (Appendix MASS.18, DOE 1996f).

H.5 CONCEPTUAL MODEL OF THE SOURCE-TERM RELEASE

The TRU waste to be disposed of at WIPP includes radionuclides, heavy metals, and VOCs. TRU waste is primarily packaged at the generator-storage sites in metal drums or containers. The containers may also include several internal barriers: layers of plastic; plastic, metal, and glass containers; and adsorbents in the void spaces. VOCs and semivolatile organic compounds are present within solidified liquids and sludges and in trace quantities sorbed onto cellulosics and other solid waste materials. A VOC gas/vapor phase dominates void spaces within the container and within the inner layers of confinement. Heavy metals, mainly lead used for radiation shielding, will exist in the solid phase. Other regulated metals may occur as trace contaminants in soil, debris, sludges, and solidified liquids and as components of metal tools, equipment, and machinery. The planning-basis WAC are designed to preclude the presence of free liquids;

therefore, a large initial liquid phase is not a feature of the conceptual model. Conceptually, the liquid phase would result from brine inflow and waste dissolution in the closed repository.

DOE has considered the potential effects of a number of possible chemical and thermal processes in the disposal system environment. These processes include corrosion, microbial activity, radiolysis, dissolution reactions, reactions with cementitious materials, and adsorption/desorption. These processes can either immobilize or enhance the mobility of radionuclides, metals, and VOCs. For practical purposes, not enough information is known about many long-term chemical processes in the WIPP environment to accurately model the potential effects of each of these processes. In cases where information was limited, assumptions were made that increased the mobility of radionuclides and metals, increasing the extent of contaminant migration and the potential for reaching the accessible environment.

H.5.1 Key Assumptions for Source-Term Release

The assumptions presented below on the source-term conceptual model used in the SEIS-II analyses are consistent with many of the assumptions on the source-term release conceptual models used in the CCA (DOE 1996f).

- Waste containers were assumed to lose their capacity to isolate waste at the time of repository closure. In addition, radionuclides and heavy metals were assumed to instanteously dissolve up to the solubility limit for each element in brine. Thus, contaminants in the gas and liquid phases would be mobile at repository closure. This is a conservative assumption because the pressure, temperature, and chemical conditions (such as pH and Eh) may not be sufficient to completely dissolve and mobilize constituents. It is also conservative because a number of time-dependent mechanisms would decrease the initial source-term concentrations of contaminants.

- Some radionuclides are mobilized either by dissolution in brine as intrinsic colloids or by adsorption onto colloidal particles carried by the brine. Such radionuclides exist primarily in the liquid phase, decrease in radioactivity through radioactive decay, and may decay into one or a chain of radioactive progeny. For the purpose of these analyses, solubility-controlled releases of key actinides were considered but adsorption processes were not considered in the transport of radionuclides vertically from the repository to the Culebra. However, adsorption processes were modeled in the horizontal movement of radionuclides through the Culebra. This is a conservative assumption because adsorption will retard the near-field release and transport of radionuclides. Colloids and organic-complexing agents capable of enhancing or inhibiting constituent mobility and transport are not modeled because of a lack of waste-specific and repository-specific information.

- Metals exist in each phase in the waste disposal panels at constant concentration over time. This is a conservative assumption because it assumes an infinite source and complete persistence. In reality, however, some metals and organics will migrate from the source-term region and organics will likely degrade. Gas generation can deplete the metals of cellulose.

- Migration of metals from the repository does not decrease the initial source-term concentration. In reality, however, some of these constituents would likely migrate away from the waste disposal panels and the source term should decrease with time.

- The waste-loading strategy for both contact-handled (CH) and remote-handled (RH) TRU wastes limits the heat-generation rate to less than 24 kilowatts per hectare (10 kilowatts per acre) (DOE 1996b). At this level, heat generation is expected to have inconsequential effects on flow and transport processes and is not considered in this analysis.

For more details of the conceptual model for source-term release, see the Appendix SOTERM of the CCA (DOE 1996f) where model descriptions for the liquid-phase source-term are provided.

H.5.2 Source-Term Constituents

As noted above, the TRU waste source term disposed of at WIPP includes radionuclides, heavy metals, and VOCs. SEIS-II performance assessment analyses evaluated the release, transport, and exposure potential for constituents of each of these categories. The inventory on which these analyses were performed is described in Appendix A. These analyses differed from those performed for the CCA (DOE 1996f).

H.5.2.1 Screening and Selection of Radionuclides

Screening calculations were performed to determine which radionuclides were significant contributors to radiological impacts. A total of 52 radionuclides were evaluated for potential dose from groundwater ingestion. The relative contribution to radiation dose was determined considering the radionuclide-specific ingestion dose factor, the solubility of the element in water, and the inventory of the radionuclide in the WIPP repository. The solubilities for each element were taken from published performance assessments (SNL 1992); if the solubility was not available in published literature, a value of 1×10^{-6} molar was used. The amount of water available for dissolution was assumed to be the repository volume adjusted for a waste and backfill porosity of 0.25. The total inventory of each radionuclide was assumed to go into solution. Radionuclides with the highest inventory (in curies [Ci]) for Action Alternative 1 are shown in Table H-4. Because active institutional controls are assumed to be in place for the first 100 years after closure and no disturbance of the repository is anticipated, the radionuclide screening was performed using the inventory at 100 years after closure rather than using the emplaced inventory.

The relative contribution to radiological impacts for key radionuclides at 100 and 1,000 years after closure is presented in Table H-5. These two cases were evaluated to reflect exposure scenarios for human intrusion and long-term performance assessment discussed in Section H.8 and to illustrate the effect radionuclide half-life. For example, cobalt-60 (Co-60) has a 5.26-year half-life. Although over 50,000 Ci of Co-60 may be emplaced in the WIPP repository, it will have decayed to a small amount within 100 years. Therefore, radionuclides with a short half-life, no parent radionuclide in the inventory, and no long-lived radioactive progeny were eliminated from consideration. The radionuclides shown in Table H-5 contribute greater than 99 percent of the total dose from the ingestion pathway. A number of them, particularly for 1,000 years after closure, are radioactive progeny produced by radioactive decay of a parent radionuclide. Because element solubilities were uncertain or unknown and conservative (high solubility) values were used, the entire inventories of radionuclides could be dissolved in small quantities of water. Therefore, the list of contributing radionuclides is more dependent on each radionuclide's

Table H-4
Radionuclides with Highest Inventories (curies) for Action Alternative 1

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**Inventory (Ci)**	**Radionuclide**	**Inventory (Ci)**
Pu-241	2,623,553	Cs-137	1,085,025
Pu-238	2,413,581	Y-90	1,056,299
Pu-239	923,975	Sr-90	1,056,096
Am-241	575,924	Ba-137m	1,026,566
Pu-240	204,657	Pu-241	706,676
Y-90	8,937	Co-60	52,221
Sr-90	8,935	Pu-239	51,455
Cs-137	7,045	Am-241	29,911
Cm-244	6,843	Pu-240	25,318
Ba-137m	6,664	Pu-238	7,509
U-233	4,019	Eu-152	7,308
Pu-242	1,550	Eu-154	3,550

Table H-5
Radionuclide Screening of Dose Contribution for Long-term Performance Assessment

100 Years After Closure		1,000 Years After Closure	
Radionuclide	**Percent Contribution**	**Radionuclide**	**Percent Contribution**
Sr-90	72.2	Ac-227	32.6
Cs-137	7.7	Pa-231	26.4
U-233	6.5	U-233	21.3
Cm-244	3.0	Pu-238	6.5
Cm-243	2.9	U-234	3.9
Pu-238	2.0	Am-241	2.6
Ac-227	1.1	Ra-225	2.3
Pa-231	1.1	Ra-223	1.3
U-234	0.9	Pb-210	1.0
Am-241	0.8	Ac-225	0.7
Pb-210	0.4	Po-210	0.3
Pu-241	0.3	Ra-226	0.2
U-232	0.2	---	---

inventory rather than on its solubility. Moderate changes in the solubilities would likely yield the same of radionuclides. All radionuclides would be expected to migrate slowly under undisturbed repository conditions.

The initial set of radionuclides considered for performance assessment analysis included nine having the highest inventory: plutonium (Pu)-238, Pu-239, Pu-240, Pu-241, americium (Am)-241, cesium (Cs)-137, barium (Ba)-137m, yttrium (Y)-90, and strontium (Sr)-90. Y-90 and Ba-137m were subsequently dropped from the list because of their short half-life; however, their impacts are included in the reported dose values because the dose factors used for Sr-90 and Ba-137m include the decay energies of Y-90 and Ba-137m. Based on the results of the radionuclide screening, actinium (Ac)-227, protactinium (Pa)-231, uranium (U)-233, U-234, curium (Cm)-243, Cm-244, and lead (Pb)-210 were also added to the list.

The final list of radionuclides for long-term performance assessment analyses consisted of 15 radionuclides: Ac-227, Am-241, Cs-137, Cm-243, Cm-244, Pa-231, Pb-210, Pu-238, Pu-239, Pu-240, Pu-241, U-232, U-233, U-234, and Sr-90. Two of the radionuclides, Cs-137 and Sr-90, are fission products; the remainder are uranium isotopes, transuranic radionuclides, or radioactive progeny from the decay of uranium or transuranic radionuclides. For impacts beyond 100 years, essentially all of the Cm-243 and Cm-244 will have decayed into Pu-239 and Pu-240, respectively. A total of 30 radionuclides were carried in several decay chains in the computer codes NUTS and CUTTINGS_S to maintain correct inventories of the chosen radionuclides.

H.5.2.2 Heavy Metals

Four heavy metals (lead, mercury, cadmium, and beryllium) were included in SEIS-II analyses of WIPP long-term performance. The inventory of these metals for each alternative is shown in Table A-45 of Appendix A. As noted in Section A.5.1, the selection of these metals and their estimated inventory was based on information presented in the *Waste Isolation Pilot Plant Safety Analysis Report* (SAR) (DOE 1995, Table 5.1-2) because the *Transuranic Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996e) does not contain detailed information on hazardous constituents in TRU waste.

H.5.2.3 VOCs

VOCs were not included in SEIS-II long-term performance assessment calculations for WIPP because these chemicals were not included in parameter databases and analyses performed as part of the WIPP Compliance Certification Application (DOE 1996f). In the *Final No-Migration Variance Petition* (DOE 1996d), the Department evaluated the potential for migration of hazardous constituents of TRU waste, including VOCs, from the disposal system for undisturbed conditions. Simulation of the migration of gaseous compounds based on conservatively high gas generation rates from waste degradation demonstrated zero gas saturation at all subsurface disposal unit boundaries except for the shaft. Less than one cubic meter of potentially contaminated gas was predicted to occur at the unit boundary of the shaft. Calculated bounding soil-based concentrations based on estimated gas-available porosity within the shaft seals and within anhydrite marker beds were found to be orders of magnitude below U.S. Environmental Protection Agency (EPA) approved health based levels. The Department was able to demonstrate that, for undisturbed conditions, there would be no migration of VOCs to the accessible environment. For the purposes of SEIS-II, potential impacts from exposure to VOCs released from the repository were assumed to be bounded by quantitative estimates of impacts to the maximally exposed noninvolved worker or

involved worker calculated for WIPP routine operations (Appendix F) and WIPP accident scenarios (Appendix G). Additional information is presented in Section H.8.

H.6 REPOSITORY DISPOSAL SYSTEM NUMERICAL MODEL

The following sections describe the methods, parameters, and data used to model the release and transport of radionuclides and heavy metals from the WIPP repository disposal system.

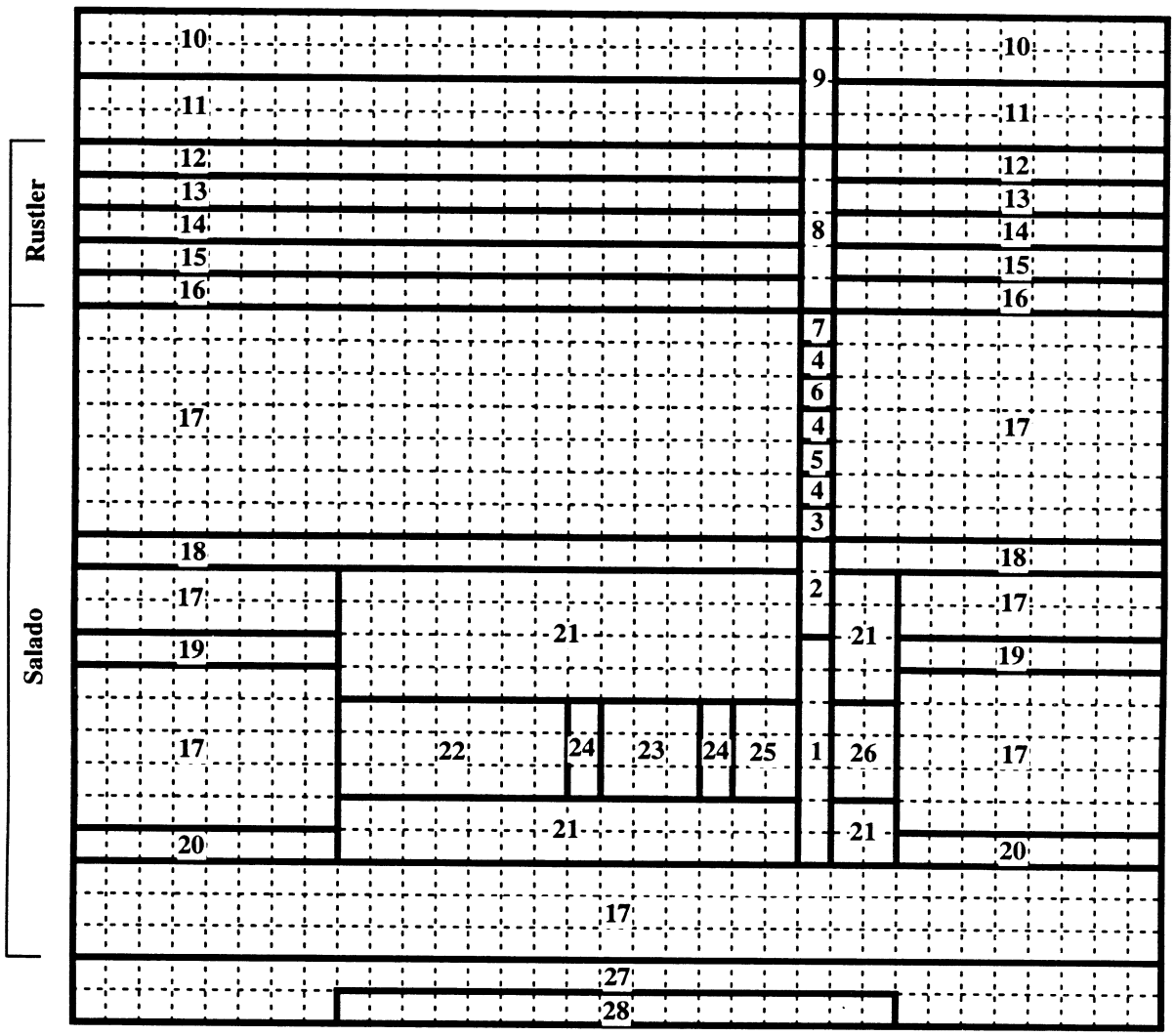
H.6.1 Model Geometry

A quasi-two-dimensional repository grid geometry implemented with the BRAGFLO code for the CCA (DOE 1996f), shown in Figure H-4, was used to represent the three-dimensional geometry of the disposal system for analysis of undisturbed conditions. This grid represents a vertical north-south cross-section through the disposal system and shows the distribution of grid blocks associated with important features of the disposal system and the major hydrostratigraphic units overlying the Salado Formation. Associations between grid blocks and material properties of major features and units are shown in Figure H-4 by pattern and number.

While the equidimensional grid system (Figure H-4) shows the relationship among material regions in the model and how connections are made within the finite-difference scheme of the BRAGFLO code, the grid greatly distorts the volumetric relationship between grid blocks. The grid system measures about 1,000 meters (3,280 feet) in vertical thickness, but the relatively thin waste panel area appears disproportionately thick. The modeled system extends approximately 23.3 kilometers (14.5 miles) to the north and south from the center of the grid system. The same BRAGFLO mesh, shown in Figure H-5, had a slightly different material property distribution to represent an intrusion borehole (material zones 29 to 31) and was used to simulate the disposal system for disturbed conditions.

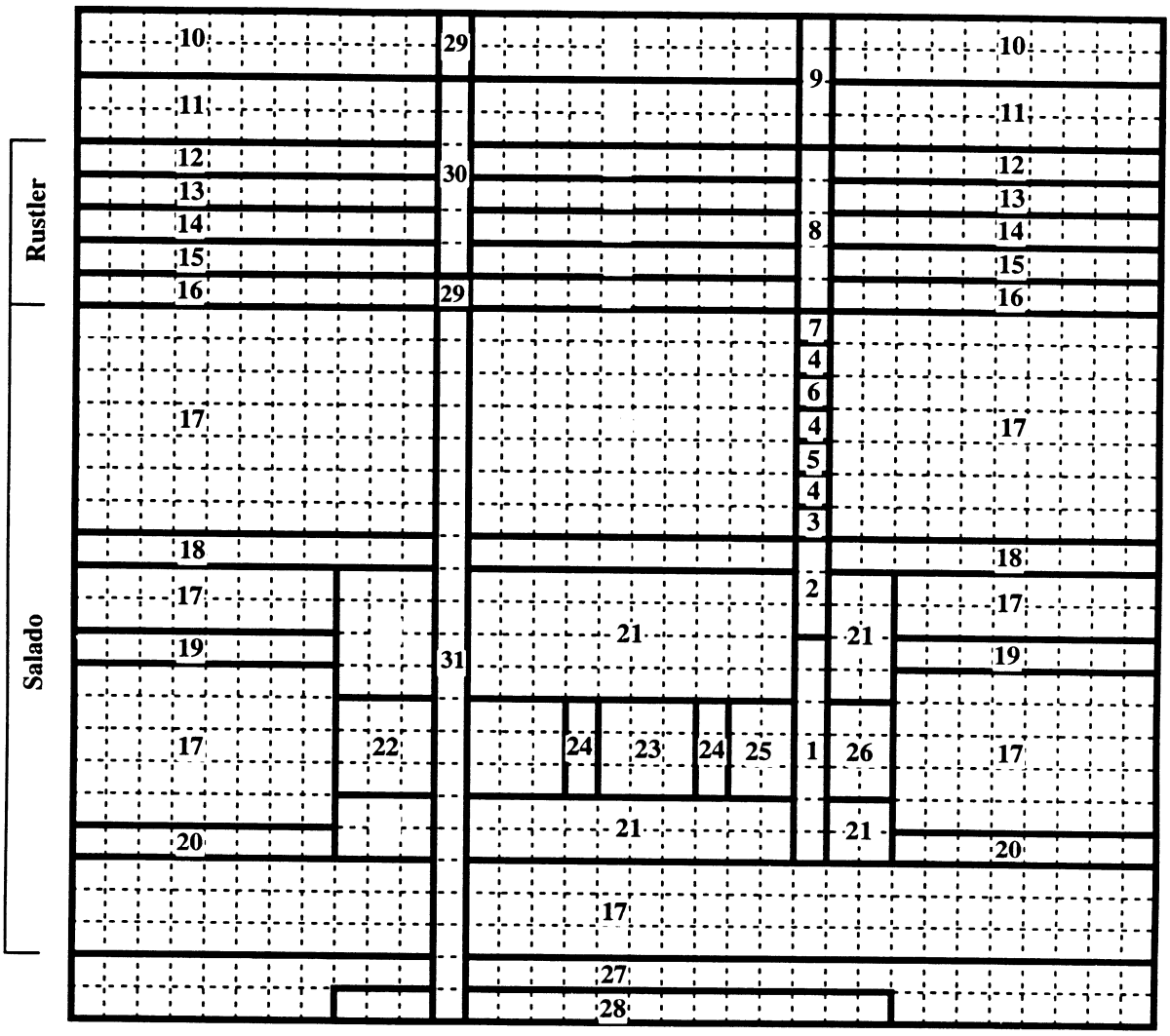
The top-down (plan) view of the model shown in Figure H-6 illustrates the dimension of the grid system in the orthogonal (out-of-plane) direction to the grid depicted in Figures H-4 and H-5. This view shows the approach adopted to simulate radially convergent or divergent flow. Effects of flow in the third (out-of-plane) dimension are approximated with a two-dimensional element configuration that simulates radially convergent or divergent flow in two directions, centered on the repository, in intact rocks, and laterally away from the repository. The effects of the grid assumptions on fluid-flow processes in the Salado Formation are discussed in Section H.6 (Appendix MASS.4, DOE 1996f).

To simulate long-term performance of Action Alternatives 1, 2, and 3, adjustments were made to the model geometry to reflect the changes in waste volumes defined for the action alternatives. Waste volumes are distributed between two sets of grid blocks, the panel and the rest of the repository grid spaces, as shown in Figure H-7. To accommodate the prescribed volumes, only the z dimension of grid spaces, representing the rest of the repository, were adjusted. A summary of these adjustments is provided in Table H-6. The x and y dimensions of these same grid spaces and the x, y, and z dimensions of the other grid spaces, representing the panel and all other elements of the disposal system, remained the same for all simulations.



1. Concrete Monolith
2. Lower Clay Component
3. Lower Salado Compacted Clay
4. Concrete
5. Crushed Salt (Salado Salt Column)
6. Upper Salado Compacted Clay
7. Asphalt
8. Rustler Clay Component
9. Earth Fill
10. Units Above the Dewey Lake
11. Dewey Lake Formation
12. Forty-Niner Member
13. Magenta Dolomite Member
14. Tamarisk Member
15. Culebra Dolomite Member
16. Unnamed Lower Member
17. Salado Halite
18. Marker Bed 138
19. Anhydrite Layer A & B
20. Marker Bed 139
21. Disturbed Rock Zone
22. Waste Panel
23. Rest of Repository
24. Panel Seals
25. Operation Region
26. Experimental Area
27. Castile Formation
28. Hypothetical Castile Brine Reservoir

Figure H-4
Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Undisturbed Cases



1. Concrete Monolith
2. Lower Clay Component
3. Lower Salado Compacted Clay
4. Concrete
5. Crushed Salt (Salado Salt Column)
6. Upper Salado Compacted Clay
7. Asphalt
8. Rustler Clay Component
9. Earth Fill
10. Units Above the Dewey Lake
11. Dewey Lake Formation
12. Forty-Niner Member
13. Magenta Dolomite Member
14. Tamarisk Member
15. Culebra Dolomite Member
16. Unnamed Lower Member
17. Salado Halite
18. Marker Bed 138
19. Anhydrite Layer A & B
20. Marker Bed 139
21. Disturbed Rock Zone
22. Waste Panel
23. Rest of Repository
24. Panel Seals
25. Operation Region
26. Experimental Area
27. Castile Formation
28. Hypothetical Castile Brine Reservoir
29. Borehole Concrete Plug
30. Upper Unrestricted Borehole
31. Lower Unrestricted Borehole

Figure H-5
Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Disturbed Cases

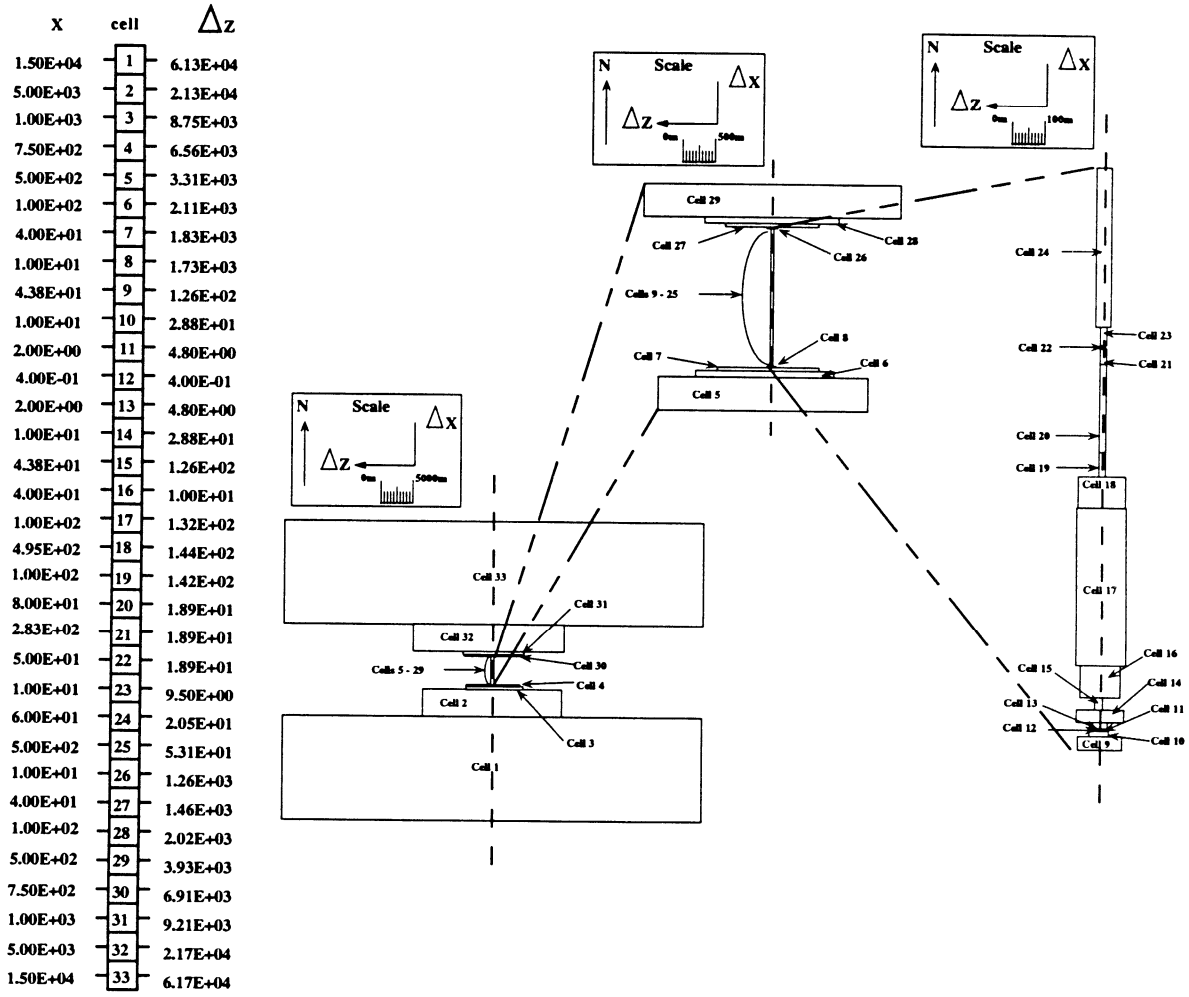


Figure H-6
Top-Down (Plan) View of the Model Through the Disposal System

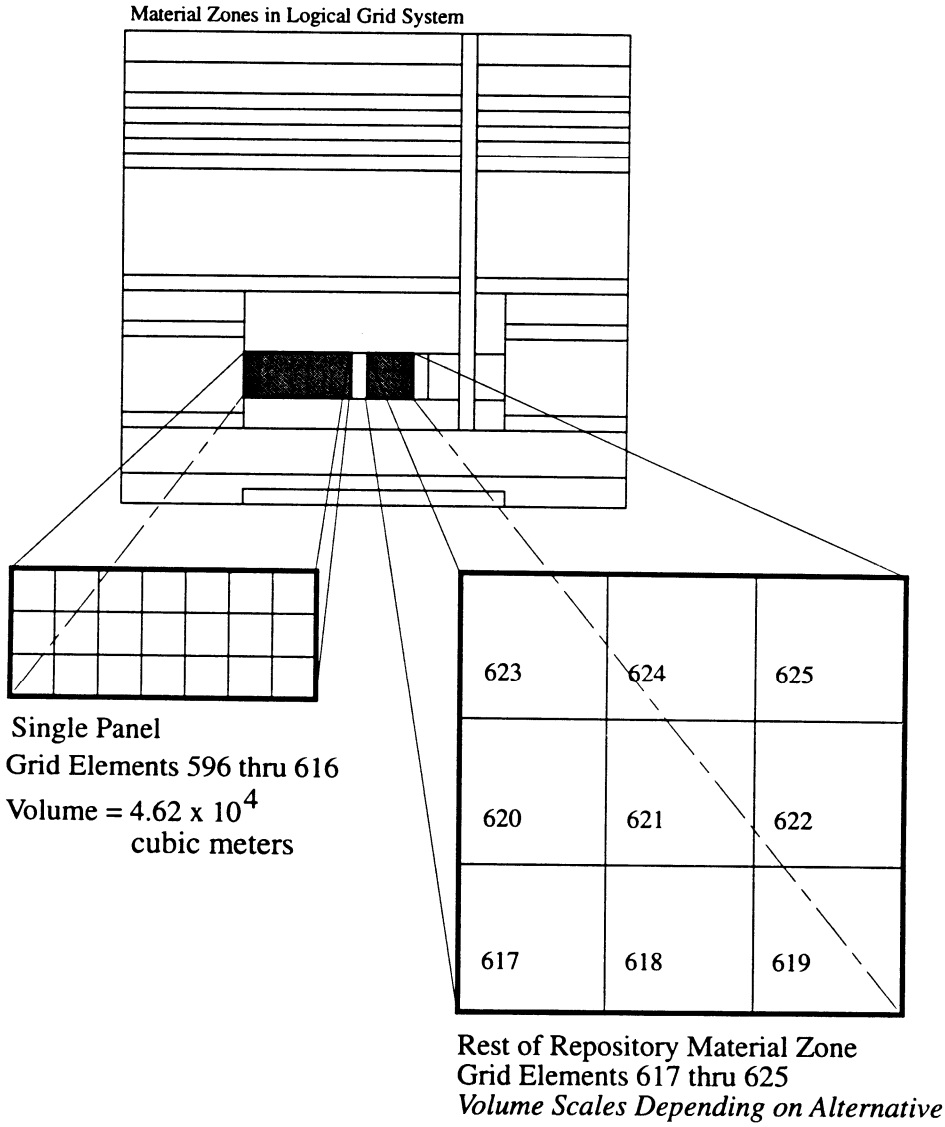


Figure H-7
Grid Spaces Representing the Rest of the Repository
Adjusted for Simulation of Action Alternatives 1, 2, and 3

Table H-6
Dimensional Lengths of Rest-of-Repository Material Zone Grid Elements for the Proposed Action; Action Alternatives 1, 2, 3; and Resulting Grid Element and Material Zone

Grid Element	x and y Element Length		Proposed Action		Action Alternative 1		Action Alternative 2		Action Alternative 3	
Index	x Depth (meters)	y Depth (meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)
617	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
618	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
619	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
620	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
621	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
622	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
623	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
624	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
625	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
Rest of Repository Volume (cubic meters)				3.9E+5	- - -	2.9E+6	- - -	3.2E+6	- - -	3.1E+6
Separately Modeled Panel Volume (cubic meters)				4.6E+4	- - -	4.6E+4	- - -	4.6E+4	- - -	4.6E+4
Total Repository Volume (cubic meters)				4.4E+5	- - -	3.0E+6	- - -	3.3E+6	- - -	3.1E+6

The characteristics of the hydrostratigraphic units depicted in Figures H-4 and H-5 at elevations near the repository horizon are based on the observed differences in permeability between anhydrite-rich interbeds and halite-rich intervals. Although not depicted in Figures H-4 and H-5, a 1-degree dip to the south in the BRAGFLO computational mesh has been incorporated to approximate the variable southerly dip observed in the Salado Formation.

H.6.2 Boundary and Initial Conditions

Initial conditions for a number of parameters used in the BRAGFLO model, such as liquid pressure, liquid saturation, ferrous metal, and biodegradable content in the waste disposal region, are assigned at the start of the long-term performance simulations for the modeled regions. Initial conditions for the repository and the Salado Formation used in SEIS-II analysis are consistent with the CCA (DOE 1996f) and include the following:

- No gradients for lateral flow exist in the Salado Formation.
- Assumed pore pressures in the Salado Formation are elevated above hydrostatic from the surface but below lithostatic.
- Assumed permeability and porosity in the Salado Formation are low.

- Excavation and waste emplacement result in partial drainage of the DRZ and subsequent evaporation of drained brine into mine air, which is then removed by air exchanged to the surface.

No-flow boundary conditions are assigned along all of the exterior boundaries of the computational mesh, except at the far-field boundaries of the Culebra and Magenta Members and the top of the grid (i.e., the surface of the ground). The far-field boundaries of the Culebra and Magenta Members are maintained at pressures of 0.822 and 0.917 megapascal, respectively, corresponding to the initial pressure conditions used in the Culebra and Magenta Members. The ground-surface grid blocks are maintained at 1 atmosphere, 0.10 megapascal; liquid saturations in these blocks are held constant at 20 percent.

Initial Conditions in the Salado Formation and DRZ

A five-year initial simulation was performed prior to the long-term simulation of the repository. The purpose of the five-year simulation was to estimate initial conditions for the near-repository, partially drained DRZ conditions. The initial liquid pressures in the Salado are based on marker bed (MB) 139 pressure of 12.5 megapascal at the shaft and adjusted throughout the Salado to account for a 1-degree dip, assuming hydrostatic equilibrium. The DRZ permeability is set to 1×10^{-17} square meters (1×10^{-16} square feet) for the startup simulation and then held constant at 1×10^{-15} square meters (1×10^{-14} square feet) for the rest of the simulation. The porosity of the DRZ is assumed as the value of impure halite. Porosity in all other lithologic units is initially 100 percent liquid-saturated during the initial simulation.

Initial Conditions in the Waste Disposal Region

In this analysis, the individual panels were assumed to remain open for 5 years to allow for waste emplacement. An initial period of 5 years is used to allow depressurization around the excavated regions to atmospheric pressure. After the initial 5-year period, the waste is placed at a liquid saturation of 0.015 and a pressure of 1 atmosphere. The remaining excavations outside the waste disposal area are assigned a gas saturation of 100 percent and an initial pressure of 1 atmosphere. Corrosion and/or biodegradation reactions that produce gas are modeled to begin at time zero, $T = 0$ years. For the purpose of this analysis, waste emplacement is assumed to occur instantaneously throughout the repository. The concentrations of ferrous metals and biodegradables in the waste regions are assigned initial parameter values of 158 and 92.5 kilograms per cubic meter (10 and 6 pounds per cubic foot), respectively.

Initial Conditions in the Shaft

After the initial 5-year period, shaft materials are assumed to be emplaced. The initial pressure in the shaft was set at 1 atmosphere, and the initial liquid saturation of all shaft materials was assumed to be at 100 percent. The exception is the asphalt region, which was set at 0 percent.

H.6.3 Repository and Panel Parameters

The repository is represented by regions 22 to 26 in Figures H-4 and H-5. These regions include an isolated waste disposal panel (22), panel closures (24), panels and access drifts in the rest of the waste disposal region (23), operations region (25), and an experimental region at the north end of the repository (26). The four shafts connecting the repository to the surface are represented by a

single shaft in regions 1 through 9 in Figures H-4 and H-5. The lower shaft region (1) intersects the repository between the operations and experimental regions.

As mentioned in the CCA (DOE 1996f), the geometry depicted in the BRAGFLO model is a simplification of reality. The model geometry attempts to preserve the true excavated volume. Lateral dimensions have been defined to approximate the true excavated volume and retain important cross-sectional areas and distances between defined regions, as discussed below. These simplifications are conservative, with respect to fluid contact with waste, and are critical factors in determining the quantity of contaminants dissolved in the aqueous phase. The simplifications are also conservative because (1) all pillars have been removed from panels, resulting in homogeneous waste regions through which fluid can flow directly; (2) panel closures are included to retain the effects of their dimensions on fluid flow and are modeled with a higher permeability than they are expected to have; and (3) panels in the rest of the repository have neither pillars nor closures, resulting in a very large region of homogeneous waste that is assigned transmissive properties.

The panel closure has a cross-sectional area for fluid flow equal to the cross-sectional area of the drifts between panels. The panel closure between the rest of the repository and the operations region has a cross-sectional area for fluid flow equal to the cross-sectional area of the drifts between the north end of the waste disposal region and the operations region. Because two sets of closures exist between the waste disposal region and the shafts in the operations region, the panel closures between the rest of the repository and the operations region have a length equal to two sets of panel closures.

Fluid properties used for the BRAGFLO model are presented in Table H-7. Median and 75th percentile performance values used for repository and panel seal parameters in this analysis are summarized in Table H-8. The values used for the gas-generation model in this analysis are provided in Table H-9. The reader is referred to the CCA (DOE 1996f) for the relationship of these parameters in modeling salt creep, brine inflow, and gas generation in the repository system.

Table H-7
Fluid Property Parameter Values [a, b]

Parameters (units)	Values
Reference Temperature (Kelvin)	300.15
Liquid Density (kilograms per cubic meter) at:	
Atmospheric Pressure	1220.0
8 megapascal	1223.0
15 megapascal	1225.7
Liquid Viscosity (pascal second)	2.1E-3
Liquid Compressibility (1/pascal)	3.1E-10
Gas Density (kilograms per cubic meter) at:	
Atmospheric Pressure	0.0818
8 megapascal	6.17
15 megapascal	11.1
Gas Viscosity (pascal second)	8.93E-6

[a] See Appendix BRAGFLO (DOE 1996f) for equations of state.
[b] These values applied to all fluids in all material regions in BRAGFLO model.

Table H-8
Repository and Panel Seal Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Repository		
Permeability (square meter)	1.70E-13	
Effective Porosity (percent)	84.8	
Threshold Pressure P_t (pascal) [b]	0	
Residual Brine Saturation S_{br} (unitless) [c]	0.276	0.138
Residual Gas Saturation S_{gr} (unitless) [c]	0.075	0.0375
Pore Shape Distribution Parameter (unitless) [c]	2.89	2.165
Maximum Capillary Pressure (pascal)	1.0E+8	
Rock Compressibility (1/pascal)	0	
Panel Seals		
Permeability (square meter) – Panel Seals	1.0E-15	
Effective Porosity (percent) – Panel Seals	7.5	
Threshold Pressure P_t (pascal) [b] – Panel Seals	8.7E+4	
Residual Brine Saturation S_{br} (unitless) [c]	0.20	
Residual Gas Saturation S_{gr} (unitless) [c]	0.20	
Pore Shape Distribution Parameter (unitless) [c]	0.94	
Maximum Capillary Pressure (pascal)	1.0E+8	
Rock Compressibility (1/pascal)	2.64E-9	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

H.6.4 Shaft and Seal Parameters

The four shafts connecting the repository to the surface are represented with a single shaft in Figures H-4 and H-5. This single shaft has a cross-section and volume equal to the four real shafts it represents, and it is separated from the waste disposal region in the model by the true north-south distance from the waste to the nearest shaft (the Waste Shaft). On closure of the repository, the shafts will be sealed, as described in Chapter 3 of the CCA (DOE 1996f).

Values for shaft component materials and properties used in the simulation are given in Table H-10. From top to bottom, the system is represented in the simulation by the following materials:

- An earthen fill region above the Rustler Formation
- A clay region in the Rustler Formation (designated Rustler clay)
- Three concrete sections (upper, middle, lower) within the Salado, consolidated for modeling purposes into a single concrete region with the same total thickness
- A thick section of compacted crushed salt within the Salado
- An upper compacted clay region within the Salado (designated upper Salado compacted clay)

Table H-9
Parameter Values for the Average Stoichiometry Gas-Generation Model [a]

Parameter (units)	Median Values	75th Percentile Values
Iron Corrosion Rate under Inundated Conditions with MgO Backfill Added (thickness of steel corroded per second, meters/second)	7.937E-15	1.19025E-14
Iron Corrosion Rate under Humid Conditions (meters/second)	0	
Rate of Inundated Cellulosics Degradation (moles of carbon per kilogram of cellulose biodegraded per second)	4.915E-09	7.214E-09
Rate of Humid Cellulosics Biodegradation (moles of carbon per kilogram of cellulose biodegraded per second)	6.342E-10	9.513E-10
Scaling Factor for the Average Stoichiometric Factor Y in the Microbial Reaction (unitless)	0.5	0.75
Stoichiometric Factor for Iron Corrosion (moles of gas generated per mole of iron consumed due to corrosion reaction, moles/moles)	1.0	
Fraction of Plastics and Rubbers that are Biodegradable (unitless)	1	
Average Density of Iron-Based Materials in CH-TRU Waste (kilogram/cubic meter)	170	
Average Density of Iron-Based Materials in RH-TRU Waste (kilogram/cubic meter)	100	
Average Density of Plastics in CH-TRU Waste (kilogram/cubic meter)	34	
Average Density of Plastics in RH-TRU Waste (kilogram/cubic meter)	15	
Average Density of Rubber in CH-TRU Waste (kilogram/cubic meter)	10	
Average Density of Rubber in RH-TRU Waste (kilogram/cubic meter)	3.3	
Average Density of Cellulose in CH-TRU Waste (kilogram/cubic meter)	54	
Average Density of Cellulose in RH-TRU Waste (kilogram/cubic meter)	17	
Average Density of Iron Containers, CH-TRU Waste (kilogram/cubic meter)	280	
Average Density of Iron Containers, RH-TRU Waste (kilograms/cubic meter)	2,650	
Average Density of Plastic in CH-TRU Waste Containers (kilograms/cubic meter)	26	
Average Density of Plastic in RH-TRU Waste Containers (kilograms/cubic meter)	3.1	
Average Density of Iron in CH-TRU Waste Containers (kilograms/cubic meter)	139	
Average Density of Iron in RH-TRU Waste Containers (kilograms/cubic meter)	2,591	
Total Volume of RH-TRU Waste (cubic meters)	7,080	
Total Volume of CH-TRU Waste (cubic meters)	168,500	
Index for Computing Wicking (unitless)	0.50	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.

- A lower compacted clay region within the Salado (designated lower Salado compacted clay)
- A basal clay component below MB 138 (designated bottom clay)
- A lower concrete section at the repository horizon (designated shaft station concrete monolith)
- An asphalt region at the top of the Salado Formation

Additional documentation of the shaft material parameters and their use in the BRAGFLO analysis are described in the CCA (Chapter 6 of DOE 1996f).

Table H-10
Shaft Materials Parameter Values [a]

Parameters (units)	Median Values	75th Percentile Values
Clay Shaft Materials		
Permeability (square meter), Rustler Clay	5.000E-19	
Permeability (square meter), Upper Salado Compacted Clay (0 to 1 year)	8.598E-17	
Permeability (square meter), Upper Salado Compacted Clay (1 to 3 years)	5.629E-17	
Permeability (square meter), Upper Salado Compacted Clay (3 to 5 years)	3.381E-17	
Permeability (square meter), Upper Salado Compacted Clay (5 to 100 years)	1.297E-17	
Permeability (square meter), Upper Salado Compacted Clay (After 100 years)	5.000E-19	
Permeability (square meter), Lower Salado Compacted Clay (0 to 1 year)	1.048E-16	
Permeability (square meter), Lower Salado Compacted Clay (1 to 3 years)	1.944E-17	
Permeability (square meter), Lower Salado Compacted Clay (3 to 5 years)	7.317E-19	
Permeability (square meter), Lower Salado Compacted Clay (After 5 years)	5.000E-19	
Permeability (square meter), Bottom Clay	5.000E-19	
Thickness (meter), Rustler Clay	94.3	
Thickness (meter), Upper Salado Compacted Clay	104.85	
Thickness (meter), Lower Salado Compacted Clay	23.9	
Thickness (meter), Bottom Clay	0.18	
Effective Porosity (percent), Rustler, Upper, Lower, and Bottom Clays	24	
Residual Brine Saturation S_{br} (unitless) [b], Rustler, Upper, Lower, and Bottom Clays	0.20	
Residual Gas Saturation S_{gr} (unitless) [b], Rustler, Upper, Lower, and Bottom Clays	0.20	
Threshold Pressure P_t (pascal) [c], Rustler, Upper, Lower, and Bottom Clays	0	
Pore Shape Distribution Parameter (unitless) [b], Rustler, Upper, Lower, and Bottom	0.94	
Maximum Capillary Pressure (pascal), Rustler, Upper, Lower, and Bottom Clays	1.0E+8	
Rock Compressibility (1/pascal), Rustler Clay	1.96E-9	
Rock Compressibility (1/pascal), Upper Salado Compacted Clay	1.81E-9	
Rock Compressibility (1/pascal), Lower Salado Compacted Clay	1.59E-9	
Rock Compressibility (1/pascal), Bottom Clay	1.59E-9	
Salt Shaft Materials		
Permeability (square meter), Salt (0 to 1 year)	1.748E-15	
Permeability (square meter), Salt (1 to 3 years)	1.662E-15	
Permeability (square meter), Salt (3 to 5 years)	1.649E-15	
Permeability (square meter), Salt (5 to 100 years)	1.486E-18	
Permeability (square meter), Salt (100 to 200 years)	6.108E-20	
Permeability (square meter), Salt (After 200 years)	5.349E-21	
Thickness (meter), Salt	171.37	
Effective Porosity (percent), Salt	5.0	
Residual Brine Saturation S_{br} (unitless) [b], Salt	0.20	
Threshold Pressure P_t (pascal) [c], Salt	0.0	
Pore Shape Distribution Parameter (unitless) [b], Salt	0.94	0.50
Maximum Capillary Pressure (pascal), Salt	1.0E+8	
Rock Compressibility (1/pascal), Salt	1.60E-9	
Residual Gas Saturation S_{gr} (unitless) [b], Salt	0.20	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).
[c] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.

Table H-10
Shaft Materials Parameter Values — Continued [a]

Parameters (units)	Median Values	75th Percentile Values
Concrete Shaft Materials		
Permeability (square meter), Concrete (0 to 400 year)	1.780E-19	
Permeability (square meter), Concrete (After 400 year)	1.0E-14	
Thickness (meter), Upper, Middle, and Lower Concrete (each)	15.24	
Thickness (meter), Shaft Station Monolith Concrete	9.08	
Effective Porosity (percent), Concrete	5.0	
Residual Brine Pressure S_{br} (unitless) [b], Concrete	0.20	0.10
Residual Gas Pressure S_{gr} (unitless) [b], Concrete	0.20	0.10
Threshold Pressure P_t (pascal) [c], Concrete	0	
Pore Shape Distribution Parameter (unitless) [b], Concrete	0.94	0.50
Maximum Capillary Pressure (pascal), Concrete	1.0E+8	
Rock Compressibility (1/pascal), Concrete	1.20E-9	
Asphalt Shaft Materials		
Permeability (meters squared), Asphalt	1.0E-20	
Thickness (meter), Asphalt	23.9	
Effective Porosity (percent) Asphalt	1	
Residual Brine Saturation S_{br} (unitless) [b], Asphalt	0.20	0.10
Residual Gas Saturation S_{gr} (unitless) [b], Asphalt	0.20	0.10
Threshold Pressure P_t (pascal) [c], Asphalt	0	
Pore Shape Distribution Parameter (unitless) [b], Asphalt	0.94	0.50
Maximum Capillary Pressure (pascal) , Asphalt	1.0E+8	
Rock Compressibility (1/pascal) , Asphalt	2.97E-8	
Earth Fill Shaft Materials		
Permeability (square meter), Earth	1.0E-14	2.62E-14
Thickness (meter), Earth	165.06	
Effective Porosity (percent), Earth	32	
Residual Brine Saturation S_{br} (unitless) [b], Earth	0.20	0.10
Residual Gas Saturation S_{gr} (unitless) [b], Earth	0.20	0.10
Threshold Pressure P_t (pascal) [c], Earth	0	
Pore Shape Distribution Parameter (unitless) [b], Earth	0.94	0.50
Maximum Capillary Pressure (pascal), Earth	1.0E+8	
Rock Compressibility (1/pascal), Earth	3.1E-8	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).
[c] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.

H.6.5 Salado Formation

The Salado Formation is modeled as a porous medium composed of several layered rock types, through which flow takes place according to Darcy's law (see description in Chapter 6 of the CCA [DOE 1996f]). Two rock types, impure halite and anhydrite, are used to represent the intact Salado. The DRZ near the repository is assumed to have increased permeability compared to intact rock and offers little resistance to flow between anhydrite interbeds and the repository. Conceptually, properties for Salado rock are assumed to be constant, based on observations of compositional and structural regularity in layers exposed by the repository. The inference from this assumption is that there is little variation in large-scale averages of rock or flow properties across the disposal system.

H.6.5.1 Impure Halite

In this analysis, a single, porous medium with spatially constant rock and hydrologic properties (see region 17 in Figures H-4 and H-5) is used to represent intact, halite-rich layers in the Salado. Minor interbeds are contained within those layers that are not explicitly represented. Table H-11 shows median and 75th percentile parameter values used in modeling the Salado impure halite. Additional information on the use of these parameter values in BRAGFLO simulations is contained in Appendix PAR of the CCA (DOE 1996f).

Table H-11
Parameter Values for Salado Formation Halite [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	3.16E-23	1.778E-22
Effective Porosity (percent)	1.0	0.55
Specific Storage (1/meter)	1.0E-6	
Threshold Pressure P_t (pascal) [b]	3.4E+7	1.9E+7
Residual Brine Saturation (unitless) [c]	0.30	0.20
Residual Gas Saturation (unitless) [c]	0.20	0.10
Pore Shape Distribution Parameter (unitless) [c]	0.70	0.50
Maximum Capillary Pressure (pascal)	1.0E+8	
Pore Compressibility (1/pascal)	9.75E-9	2.63E-08

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR of DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

H.6.5.2 Anhydrite Interbeds

Three distinct anhydrite interbeds are modeled in this BRAGFLO simulation, representing MB 138 (region 18), anhydrite layers a and b (region 19), and MB 139 (region 20), all shown in Figures H-4 and H-5. The three interbeds have the same set of model parameters, which are initially held constant. During a simulation, porosity and permeability can vary spatially with simulated interbed fracturing. The three interbeds are included because they exist in the disturbed region around the repository, within which fluid is expected to flow with relative ease compared to the surrounding formation. MB 139 and anhydrite layers a and b are present within the DRZ that forms around excavations; MB 138 may be above the DRZ but is below the long-term seal

components that will be constructed in the shafts. MB 138 is included because of its uncertainty in the long-term isolation from the repository. Median and 75th percentile values used for parameters associated with the interbeds are shown in Table H-12. Table H-13 lists values of parameters used in the model for interbed dilation and fracture. Documentation on the selection and use of these parameters in BRAGFLO simulations are found in the CCA (Appendix PAR in DOE 1996f).

Table H-12
Parameter Values for the Salado Formation
Anhydrite Interbeds A and B and Marker Beds 138 and 139 [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.288E-19	3.162E-19
Effective Porosity (percent)	1.1	0.895
Threshold Pressure P_t (pascal) [b]	9.7E+5	7.1E+5
Residual Brine Saturation S_{br} (unitless) [c]	0.08363	0.04986
Residual Gas Saturation S_{gr} (unitless) [c]	0.07711	0.03390
Pore Shape Distribution Parameter (unitless) [c]	0.6436	0.5704
Maximum Capillary Pressure (pascal)	1.0E+8	
Pore Compressibility (1/pascal)	7.512E-9	1.444E-8

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-13
Parameter Values for the Salado Formation
Anhydrite Interbeds A and B and Marker Beds 138 and 139 Fracture [a]

Parameter (units)	Values
Fracture Initiation Pressure (pascal)	1.4E+6
Increment to Give Full Fracture Porosity (percent)	1.0
Maximum Permeability (square meter)	1.0E-9
Increment of Lithostatic Pressure to Obtain Maximum Fracture Pressure (pascal)	2.5E+6
Brine Far-Field Pore Pressure (pascal)	1.3E+7

[a] Values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f).

H.6.5.3 Disturbed Rock Zone

Near the repository at the Salado Formation, the permeability and porosity of the DRZ salt are expected to increase over that of intact salt. The increases in the permeability and porosity of salt in interbeds are not expected to be completely reversible with creep closure of the disposal rooms. The increase in DRZ permeability affects the ability of fluid to flow from interbeds to the waste disposal region.

The increase in DRZ porosity provides a volume in which some fluid could be retained so that it does not contact waste. DRZ pore volume can also slow radionuclide and hazardous constituent migration.

In this analysis, the permeability of a region around the repository is increased relative to intact Salado rock for the duration of the simulation and the threshold pressure is set to zero. The porosity of this region is left equal to the porosity of Salado halite to prevent reduced fluid retention in the DRZ. The DRZ extends above and below the repository from the base of MB 138 to MB 139. Defining the DRZ in this manner creates a permanent, highly permeable region that does not impede flow between the repository and interbeds. Median values of the parameters used in the representation of the DRZ are summarized in Table H-14.

Table H-14
Parameter Values for the Disturbed Rock Zone [a]

Parameter (units)	Values
Permeability (square meter)	1.0E-15
Effective Porosity (percent)	1.29
Threshold Pressure P_t (pascal) [b]	0
Residual Brine Saturation S_{br} (unitless) [c]	0
Residual Gas Saturation S_{gr} (unitless) [c]	0
Pore Shape Distribution Parameter (unitless) [c]	0.70
Maximum Capillary Pressure (pascal)	1.0E+8
Pore Compressibility (1/pascal)	5.744E-8

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). All parameters in this table were held constant.
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

H.6.5.4 Units Above the Salado Formation

The BRAGFLO simulations used in this analysis consider the Unnamed Lower, Culebra, Tamarisk, Magenta, and Forty-Niner Members of the Rustler Formation, the Dewey Lake Formation, the Gatuna Formation, and the Santa Rosa Formation. For modeling purposes, the Gatuna and Santa Rosa Formations were combined as units above the Dewey Lake Formation. BRAGFLO separates and calculates flow in these units to establish the pressure gradient in the disposal system. The other three Rustler Formation members are modeled as effectively impermeable. These units are represented in the BRAGFLO element mesh by regions 10 through 16 (shown in Figures H-4 and H-5).

In this analysis, the water table was set equal to 59 meters (194 feet) below the ground surface at an elevation of 980 meters (3,215 feet) within the Dewey Lake Formation. For regions above the water table, the initial liquid saturation of 20 percent (the residual liquid saturation of the Dewey Lake, the Gatuna, and Santa Rosa Formations) was used. For regions above the water table, the initial liquid pressure is assumed to be 1 atmosphere. For the portion of the Dewey Lake Formation below the water table and the Rustler Formation regions (excluding the Culebra and Magenta Members, which are specified at 0.82 and 0.91 megapascal, respectively), a hydrostatic gradient is assumed for specifying the initial pressure conditions. For the time period -5 to 0 years, all regions above the Salado are treated as impermeable. Conceptually, this corresponds to the time periods when liners are emplaced in the shafts. Parameter values for these units are presented in Tables H-15, H-16, H-17, H-18, and H-19. Documentation of the selection and use of these parameters is described in more detail in Appendix PAR of the CCA (DOE 1996f).

Table H-15
Parameter Values for the Culebra Member of the Rustler Formation [a]

Parameter (units)	Values
Permeability (square meter)	2.1E-14
Effective Porosity (percent)	15.1
Threshold Pressure P_t (pascal) [b]	1.50E+4
Residual Brine Saturation S_{br} (unitless) [c]	0.08363
Residual Gas Saturation S_{gr} (unitless) [c]	0.07711
Pore Shape Distribution Parameter (unitless) [c]	0.6436
Maximum Capillary Pressure (pascal)	1.0E+8
Pore Compressibility (1/pascal)	6.6225E-10

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). All parameters in this table were held constant.
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-16
Parameter Values for the Magenta Member of the Rustler Formation [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	6.310E-16	
Effective Porosity (percent)	13.8	8.23
Threshold Pressure P_t (pascal) [b]	5.06E+4	
Residual Brine Saturation S_{br} (unitless) [c]	0.08363	
Residual Gas Saturation S_{gr} (unitless) [c]	0.07711	
Pore Shape Distribution Parameter (unitless) [c]	0.6436	
Maximum Capillary Pressure (pascal)	1.0E+8	
Pore Compressibility (1/pascal)	1.916E-9	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-17
Parameter Values for the Forty-Niner, Tamarisk, and Unnamed Lower Members of the Rustler Formation [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.0E-35	
Effective Porosity (percent) - Forty Niner Member	8.2	1.26
Effective Porosity (percent) - Tamarisk Member	6.4	4.3
Effective Porosity (percent) - Unnamed Lower Member	18.1	9.6
Threshold Pressure P_t (pascal) [b]	0	
Residual Brine Saturation S_{br} (unitless) [c]	0.20	
Residual Gas Saturation S_{gr} (unitless) [c]	0.20	
Pore Shape Distribution Parameter (unitless) [c]	0.70	
Maximum Capillary Pressure (pascal)	1.0E + 8	
Pore Compressibility (1/pascal)	0	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-18
Parameter Values for the Dewey Lake Formation [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	5.0E-17	
Effective Porosity (percent)	14.3	9.1
Threshold Pressure P_t (pascal) [b]	0	
Residual Brine Saturation S_{br} (unitless) [c]	0.08363	
Residual Gas Saturation S_{gr} (unitless) [c]	0.07711	
Pore Shape Distribution Parameter (unitless) [c]	0.6436	
Maximum Capillary Pressure (pascal)	1.0E + 8	
Pore Compressibility (1/pascal)	6.993E-8	
Thickness (meter)	149.3	
Initial Pressure (pascal)	Hydrostatic; water table at 980 meters, 43.3 meters below top of formation	
Initial Pressure (atm) 20 percent Liquid Saturation, Above Water Table	1.0	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-19
Parameter Values for the Units Above the Dewey Lake Formation [a]

Parameter (units)	Values
Permeability (square meter)	1.0E-10
Effective Porosity (percent)	17.5
Threshold Pressure P_t (pascal) [b]	0
Residual Brine Saturation S_{br} (unitless) [c]	0.08363
Residual Gas Saturation S_{gr} (unitless) [c]	0.07711
Pore Shape Distribution Parameter (unitless) [c]	0.06436
Maximum Capillary Pressure (pascal)	1.0E+8
Pore Compressibility (1/pascal)	5.714E-8
Thickness (meter)	15.76
Initial Pressure (atm) 20 percent Liquid Saturation, Above Water Table	1.0

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). All parameters in this table were held constant.
[b] Threshold pressure (P_t) was determined from the relationship: P_t = PCT_A $k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

H.6.6 The Castile Formation

The BRAGFLO simulations used in both the undisturbed and disturbed analyses considered the Castile Formation to incorporate the effects of brine pocket pressure below the Salado Formation. The Castile Formation is represented in the BRAGFLO element mesh by region 27 (shown in Figures H-4 and H-5).

The brine pocket pressure represented in the BRAGFLO element mesh by region 28 (see Figures H-4 and H-5) was represented in median parameter cases by an initial pressure of 12.5 megapascal and in 75th percentile parameter cases by 14.4 megapascal. For undisturbed cases, this initial pressure has little impact on the predicted pressure field. For the disturbed cases, however, this unit is penetrated by an intrusion borehole, allowing its hydraulic impact to be transmitted to other units within the modeled domain, most notably the repository and the Culebra Dolomite Member.

Median and 75th percentile values of important parameters for the Castile Formation and Brine Reservoir are presented in Tables H-20 and H-21. Documentation of the selection and use of these parameters is described in more detail in Chapter 6 of the CCA (DOE 1996f).

H.6.7 Intrusion Borehole Parameters

For the disturbed cases, BRAGFLO simulations considered an intrusion borehole that penetrates the entire sequence of units in the modeled domain. The borehole is represented in the BRAGFLO element mesh by region 29-31 (see Figure H-5). The intrusion borehole was assumed to be an exploratory borehole that penetrates the WIPP repository and extends through a pressurized brine reservoir in the Castile Formation, creating a potential pathway between the brine reservoirs and

Table H-20
Parameter Values for the Castile Formation [a]

Parameter (units)	Values
Permeability (square meter)	1.0E-35
Effective Porosity (percent)	0.5
Threshold Pressure P_t (pascal) [b]	0
Residual Brine Saturation S_{br} (unitless) [c]	0
Residual Gas Saturation S_{gr} (unitless) [c]	0
Pore Shape Distribution Parameter (unitless) [c]	0.7
Maximum Capillary Pressure (pascal)	1.0E+8
Pore Compressibility (1/pascal)	0

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (Appendix PAR in DOE 1996f). All parameters in this table were held constant.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-21
Parameter Values for the Brine Reservoir [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.585E-12	1.738E-12
Effective Porosity (percent)	0.696	1.40
Threshold Pressure P_t (pascal) [b]	6.776E+3	6.564E+3
Residual Brine Saturation S_{br} (unitless) [c]	0.20	
Residual Gas Saturation S_{gr} (unitless) [c]	0.20	
Pore Shape Distribution Parameter (unitless) [c]	0.70	
Maximum Capillary Pressure (pascal)	1.0E+8	
Pore Compressibility (1/pascal)	1.149E-8	3.710E-9
Initial Brine Pressure (pascal)	1.27E+7	1.44E+7
Volume (cubic meter)	4.0E+6	

[a] Median and 75th percentile values were based on data and parameter distributions contained in CCA (DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

the repository. This pathway could inundate the repository and flush water material from the repository to overlying water-bearing units in the Rustler Formation and other near-surface units.

Under this scenario, it was assumed that the borehole would be drilled and plugged at abandonment using standard regulatory requirements and practices. The parameters used to represent this scenario were based on intrusion borehole permeability studies described in Thompson et al. (1996). These studies evaluated two parameters: the long-term estimates of permeabilities in exploratory borehole materials, and the dimensions from the review of current regulatory requirements and drilling and borehole plugging practices. Using models and data for steel corrosion and concrete alteration, estimates of long-term changes in borehole permeabilities for three different borehole plugging configurations were made. The three configurations considered were:

- Borehole with a continuous plug - For this scenario, a single continuous plug is emplaced through the entire sequence of evaporites in the Castile and Salado Formations. In current practices, this approach to plugging a borehole represents the maximum standards for plugging in the Delaware Basin.

- Borehole with two plugs - For this scenario, a cement plug is placed in the Bell Canyon below the depth of the Castile Formation brine pockets, and a second plug is placed in the Rustler Formation between the Culebra Dolomite and the repository. This configuration represents the minimum standards for plugging in the Delaware Basin.

- Borehole with multiple plugs - For this configuration, plugs are emplaced as in the two-plug scenario. An additional plug is emplaced in the Salado Formation between the repository and the Castile formation brine pockets. This multiplugging scheme represents a more typical approach to borehole plugging in the Delaware Basin.

Over the 10,000-year period of interest, properties of boreholes and plugging materials will change and degrade by a variety of degradation mechanisms including (1) iron corrosion of well steel casing, (2) concrete degradation, and (3) salt creep. According to Thompson et al. (1996), borehole plugs would initially be expected to have a permeability of 5×10^{-17} square meters (5×10^{-16} square feet). In the continuous plug scenario, the borehole permeability is expected to remain largely undiminished. For the other plugging configurations, the properties of various sections of the borehole would be expected to change with time. Casing in upper parts of the borehole above the Rustler Formation are estimated to degrade completely within a 200-year period. This degradation would cause the plug in the Rustler to fail over time, and the corroded casing and plug would likely spill into the borehole, filling it with material that would likely have a permeability similar to silty sand (1×10^{-11} to 1×10^{-14} square meters [1×10^{-10} to 1×10^{-13} square feet]). Over time, salt creep would compress this material into the borehole, creating a permeability about one order of magnitude less. For deeper plugs in the borehole, the casing would not corrode as extensively, and the plugs at that depth would not fail for an estimated time of 500 years.

For the purpose of this analysis, the two-plug configuration was selected for the disturbed cases since it is the minimal plugging practice in the Delaware Basin. Parameter values used to represent the intrusion borehole for all disturbed cases are presented in Table H-22. Selected parameters used in the CUTTINGS_S code to model direct releases associated with the hypothetical exploratory drilling operation to the ground surface are provided in Table H-23.

Table H-22
Exploratory Borehole Parameter Values Used After Intrusion

Parameter (units)	Values [a]
Borehole Plug Permeability (square meter) (0 to 200 years after intrusion)	5.0E-17
Borehole Permeability (square meter) (0 to 200 years after intrusion)	1.0E-9
Borehole Permeability (square meter) (after 200 years after intrusion)	3.162E-13
Permeability (square meter), Borehole Permeability Below WIPP (square meter) (After 1200 years after intrusion)	3.162E-14
Effective Porosity (percent)	32
Threshold Pressure P_t (pascal) [b]	0
Residual Brine Saturation S_{br} (unitless) [c]	0
Residual Gas Saturation S_{gr} (unitless) [c]	0
Pore Shape Distribution Parameter (unitless) [c], Borehole Plugs (0 to 100 years after intrusion), Borehole (After 200 years after intrusion), and Borehole below WIPP (After 1200 years after intrusion)	0.70
Pore Shape Distribution Parameter (unitless) [c], Borehole (0 to 200 years after intrusion)	0.94
Maximum Capillary Pressure (pascal)	1.0E + 8
Rock Compressibility (1/pascal), Concrete Borehole Plug	1.20E-9
Rock Compressibility (1/pascal), Borehole	0

[a] Values were based on data contained in the CCA (DOE 1996f) and Thompson et al (1996).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1996f).

Table H-23
Select Parameter Values Used in CUTTINGS_S Code [a]

Parameter (units)	Median Values	75th Percentile Values
Intrusion Time (years)	400	300
Brine Density (kilograms per cubic meter)	1210	
Viscosity of H_2 gas at 27 degrees Celsius and 0.101325 megapascal (pascal second)	9.17E-3	
Yield Stress Point (pascal)	4.40	
Logarithm of Waste Particle Diameter (meters)	2.8E-3	3.4E-4
Drill string angular velocity (radians per second)	7.80	
Effective Shear Strength for Erosion (pascal)	5.0300	2.5375
Exploratory Borehole Diameter (meters)	0.3115	

[a] Median and 75th percentile values were based on data and parameter distributions contained in CCA (DOE 1996f). If a parameter value was constant, none is shown for the 75th percentile value.

Estimates of median and 75th percentile concentrations of individual nuclides were developed for use in the drilling intrusion into CH-TRU wastes scenarios. Values presented are representative of uncompacted waste from 457 waste streams. The methodology used to develop these estimates is described in Section A.4.8. Only a limited amount of information was available for RH-TRU waste streams so concentrations used for drilling intrusions into RH-TRU wastes used average results with no differentiation between median and 75th percentile values.

H.6.8 Solubility-Controlled Release Model Parameters

Solubility-controlled release models available in the NUTS code were used in the source-term release models for the Proposed Action and Action Alternative 1, 2, and 3 inventories for all undisturbed and disturbed cases. Data used in the analyses were selected from the probabilistic distributions of solubility of key radionuclides, which are available in SNL model databases for performance assessment calculations supporting the *Final No-Migration Variance Petition* and the CCA. Median and 75th percentile values of solubility for selected radionuclides simulated in transport modeling using the NUTS code are presented in Table H-24. The solubilities for metals included in this analysis were set to a value of one. For some radionuclides, the CCA has different solubilities for the Salado and Castile formations. The higher of these two solubilities were assigned to both formations for the SEIS-II.

Table H-24
Log Solubility Values for Elements [a, b]

Element	Median Values	75th Percentile Values
Actinium (Ac)	-4.256	-4.023
Americium (Am) [c]	-5.548	-5.315
Beryllium (Be)	0	
Bismuth (Bi)	0	
Cadmium (Cd)	0	
Cesium (Cs)	0	
Curium (Cu)	-4.256	-4.023
Mercury (Hg)	0	
Neptunium (Np)	-4.256	-4.023
Protactinium (Pa)	-4.256	-4.023
Lead (Pb)	0	
Polonium (Po)	0	
Plutonium (Pu)	-4.866	-4.633
Radium (Ra)	0	
Radon (Rn)	0	
Strontium (Sr)	0	
Thorium (Th)	-4.627	-4.394
Uranium (U)	-4.901	-4.668
Yttrium (Y)	0	

[a] Median and 75th percentile values were based on the data and parameter distributions contained in the CCA (DOE 1996a). If a parameter value was constant, none is shown for the 75th percentile value. Elements without project-specific solubility data -– Cs, Pb, Ra, Sr -- were assigned a value of zero.
[b] Values include the effects of magnesium oxide (MgO) backfill.
[c] Except for Action Alternative 2, in which case the median value for Americium was -5.641 and the 75th value was -5.408.

H.7 CULEBRA DOLOMITE MODEL

In the SEIS-II analyses, contaminants were found to be released to the Culebra Dolomite under 75th percentile parameter value cases of drilling through the repository and into a pressurized brine reservoir. Transport of contaminants was analyzed using the flow and transport model developed for the Culebra Dolomite to support the CCA performance assessment calculations (DOE 1996f). Basic information on this model and its application in the SEIS-II analysis is briefly described in the following sections.

H.7.1 Model Geometry, Boundaries, and Assumed Flow Conditions

The flow and transport model of the Culebra Dolomite used in the SEIS-II analysis was based on the implementation of the SECOFL2D and SECOTP2D flow and transport codes for regional and local hydrogeologic conditions of the WIPP site as described in Chapter 6 of the CCA (DOE 1996f). This model consists of a regional-scale flow model and local-scale transport submodel. The regional-scale model is based on a finite difference grid which covers about 660 square kilometers (266 square miles). The grid is oriented with its long dimension in a southwest to northeast direction and the WIPP site approximately at its center. The grid boundaries extend out to distant topographic and hydrologic features that control the distribution of hydraulic head in the WIPP region. The overall grid dimensions are approximately 22 kilometers (14 miles) in a northwest to southeast direction by 30 kilometers (19 miles) in a southwest to northeast direction.

Evaluation of radionuclide and heavy metal transport was evaluated in the more refined local-scale submodel that covers an area of 49 square kilometers (16 square miles) and is about 7 kilometers (4 miles) on a side. The local-scale model grid is approximately oriented in a north-south direction and is designed to examine the transport of key radionuclides from the repository area in the principal direction of groundwater movement south of the Land Withdrawal Area boundary. Hydraulic boundary conditions used in the local submodel were obtained from the interpolation of predicted hydraulic head distributions defined in the regional flow model. Additional information on the regional-scale flow and local-scale transport model grids is provided in Chapter 6 of the CCA (DOE 1996f).

Different thicknesses of the Culebra Dolomite were assumed in the various flow and transport models used in the SEIS-II analysis. In the repository and disposal system model using BRAGFLO (Section H.6), a thickness of 7.7 meters (25.3 feet) was used, which is representative of the Culebra thickness over the waste disposal panels. For calibrating transmissivity fields (see Appendix TFIELD, Section 4.4.1, DOE 1996f) and calculating flow conditions in the regional flow model of the Culebra, a thickness of 7.75 meters (25.4 feet) was assumed, consistent with the average thickness of the Culebra over the regional model area. For transport calculations using the local submodel of the Culebra, a thickness of 4 meters (13 feet) was used, consistent with observations of the Culebra thickness where transport is active. The details behind these assumptions are discussed at length in Section 6.4.6.2 of the CCA (DOE 1996f).

In the CCA analysis, variation in the hydraulic properties of the Culebra Dolomite were incorporated in the regional model by assigning different transmissivity values to every computational cell in the model grid. Because uncertainty in the estimated value of the Culebra transmissivity exists in areas where measurements have not been made, a large set of transmissivity fields were developed. Each transmissivity field was assumed to be a statistical representation of

the natural variation in transmissivity that honors measured data that is equally likely to represent actual conditions. Details of the generation and use of transmissivity fields are described Section 4.1 of Appendix TFIELD of the CCA (DOE 1996f).

Flow conditions assumed in the local transport analysis performed for SEIS-II were based on transmissivity fields that incorporated the hydraulic impacts of future potash mining within the modeled region. Two conditions were considered: a partial mining scenario which considered the impacts of mining all potash reserves within the modeled region but outside of the Land Withdrawal Area, and a full mining scenario which considered the impact of mining all potash reserves within the modeled region including those found within the Land Withdrawal Area. Details of implementation of these scenarios are described in Chapter 6 of the CCA (DOE 1996f).

For purposes of the SEIS-II analysis, a 75th percentile flow field was selected from each set of the one hundred flow fields generated from the calibrated regional two-dimensional flow model developed to approximate partial and full potash mining conditions in the CCA (Appendix TFIELD, DOE 1996f). The ranking of flow fields was based on their predicted travel times from the WIPP to the Land Withdrawal Area boundary. The velocity fields generated from the 75th percentile flow fields for partial and full potash mining conditions provided the basis for transport calculations made using the SECOTP2D model of the Culebra Dolomite to a stock well located 3 kilometers (2 miles) downgradient from the point of intrusion.

H.7.2 Radionuclide and Heavy Metal Transport

Transport and retardation of contaminants introduced into the Culebra Dolomite under the75th percentile parameter values cases of drilling through the repository into a pressurized brine reservoir were simulated for four radionuclides previously considered in the CCA analyses: Am-241, Pu-239, Th-230, and U-234. The SEIS-II analyses used parameter values from the CCA for radionuclide transport in the SECOTP2D model of the Culebra Dolomite. Parameters values are provided in Section MASS.15.2 of Appendix MASS and Appendix PAR (see Parameters 49 through 57) of the CCA (DOE 1996f).

The distribution coefficients (K_d) used in the SEIS-II analyses were based on the linear adsorption isotherm used in the CCA to represent the retardation that occurs as dissolved radionuclides and heavy metals are sorbed onto different minerals (primarily dolomite) lining pore walls and fractures. The linear isotherm uses a single parameter, K_d, to express the relationship between sorbed concentration and liquid concentration. For the SEIS-II analysis, K_ds were selected to conservatively represent the K_d distributions used in the CCA, which were derived from experimental data. K_ds for these radionuclides were as follows: Am-241, 0.14 cubic meters per kilogram; Pu-239, 0.14 cubic meters per kilogram; Th-230, 5.675 cubic meters per kilogram; and U-234, 7.52 x 10^{-3} cubic meters per kilogram. The assumed oxidation states for these radionuclides were +III, +III, +IV, and +VI, respectively.

Transport results for U-234, the most mobile of the four radionuclides evaluated, were assumed to be representative of transport for seven other radionuclides — Ac-227, Np-237, Pa-231, Pa-233, Pb-210, Pu-240, and Ra-226— and four heavy metals— beryllium, cadmium, lead, and mercury. This assumption was made because these radionuclides and elements were not included in CCA analyses; thus, complete sets of WIPP-specific transport parameters were not available for them. Dose adjustment factors were developed for each radionuclide that allowed the calculated U-234 dose to be adjusted based on each radionuclide's specific ingestion dose factor, radioactive

half-life, and release rate into the Culebra at the point of intrusion (due to the inventory differences between each of the radionuclides and U-234). Potential health impacts from heavy metals were estimated in a similar manner, using the predicted concentration of U-234 to estimate a concentration for each of the heavy metals. Estimated concentrations were then used with appropriate metal-specific slope factors and reference doses to estimate carcinogenic and noncarcinogenic impacts.

H.8 ANALYSIS AND RESULTS OF LONG-TERM PERFORMANCE ASSESSMENT

Analysis and results of the long-term performance assessment analysis conducted for the Proposed Action and Action Alternatives 1, 2, and 3 are provided in this section.

H.8.1 Exposure Scenarios

This section describes the exposure scenarios used to evaluated the potential impacts of undisturbed and disturbed conditions for long-term performance assessment.

H.8.1.1 Undisturbed Conditions

For all cases of undisturbed conditions evaluated for the Proposed Action and Action Alternatives 1, 2, and 3, radionuclides and metals did not reach the accessible environment. There were no postulated scenarios in which individuals or populations could be exposed. Therefore, results of undisturbed cases are presented as the extent of radionuclide and heavy metal migration away from the repository and were analyzed over the 10,000 years after closure.

H.8.1.2 Disturbed Conditions

Exposure scenarios for disturbed conditions evaluated the potential impacts to individuals who could be directly exposed by drilling an exploratory borehole and indirectly exposed by drilling through the repository into a pressurized brine reservoir. The later exposure scenario could allow contaminants to reach the accessible environment under unfavorable conditions, using 75th percentile parameter values as discussed in Section H.6. There were no postulated scenarios in which populations could be exposed.

Human health impacts from disturbed conditions evaluated for long-term performance assessment use the same metrics as those for individual exposures for human health (Appendix F) and facility accidents (Appendix G). Impacts from radiation exposure or intakes of radionuclides are presented as the probability of a latent cancer fatality (LCF) for an exposed individual. Impacts were based on the calculated radiation dose to the individual (external dose or committed effective dose equivalent). Carcinogenic impacts of exposure to metals are presented as the probability of cancer incidence for an exposed individual. Noncarcinogenic impacts of exposure to metals are presented as a hazard index (HI) for the exposed individual.

As noted in Section H.5.2.3, exposure to VOCs was not included in long-term performance assessment calculations. Impacts from acute exposures from surface releases caused by drilling through the repository were considered to be bounded by impacts from WIPP disposal accidents (Appendix G). A drilling crew member could be exposed to VOCs if the drilling occurred when high gas pressures caused a mud blowout. The concentration and duration of VOC exposure would not be higher than those of WIPP disposal accidents. The probability of cancer incidence would be no more than 3×10^{-7} from exposure to VOCs. Toxicololgical impacts were estimated to

RELEASE SCENARIOS CONSIDERED BUT NOT ANALYZED

During the comment response period for the Draft SEIS-II, the public expressed significant interest in the potential impacts of a number of release scenarios not considered by DOE in the long-term performance assessment analysis of the WIPP site. The following summarizes the reasons why certain release scenarios were not analyzed in SEIS-II.

Fluid Injection: The potential impacts of fluid injection in the form of water flooding and salt water disposal are evaluated in the Compliance Certification Application (CCA). The results provided in Section SCR.3.3.1.3.1 of the CCA indicate that fluid injection would not have a significant impact on repository performance. Even when the least favorable rock properties were specifically considered, the amount of brine reaching the repository over 10,000 years would be well within the range of volumes expected to flow into the repository during normal, undisturbed performance. Therefore, fluid injection was screened out for consideration in the SEIS-II analysis on the basis of a low consequence to the long-term performance of the disposal system.

Karst and Dissolution Processes: For nearly 20 years, DOE has investigated the hydrology of important geologic units overlying the WIPP facility and the importance of karst features and related dissolution processes in defining the surface features in the region surrounding the WIPP site. A description of the current understanding of the extent, timing, and features related to dissolution, including a brief history of past project studies related to karst in the area surrounding WIPP, is presented in Section 2.1.6.2.1 of the CCA. These studies have shown that while there is considerable evidence of dissolution and karst features at shallow depths, no evidence has been collected to date that would suggest that shallow dissolution processes are active within the deeper Salado Formation. Deep dissolution at the WIPP site has been eliminated from the SEIS-II performance assessment calculations on the basis of low probability of occurrence over the next 10,000 years. Additional information supporting this conclusion is provided in Section SCR.1.1.5.1 of Appendix SCR of the CCA (DOE 1996f).

Climate Change: The uncertainties of possible climate changes, including the effects on groundwater flow and potential radionuclide transport in groundwater, have been incorporated into the performance assessment analyses of the CCA (Section 2.5 and Appendix CLI). Overall, the results suggest that if an intrusion were to cause a release of radionuclides to one of the significant water-bearing units (e.g., the Culebra Dolomite) above the repository, radionuclides would be transported at a faster rate to the accessible environment but would be diluted to lower concentrations by increased groundwater flow. Direct effects that do not involve groundwater (e.g., wind) are not likely to affect the long-term performance of WIPP because of its depth below the land surface. Thus, the impact of climatic change on the long-term performance of the repository would be minimal.

Multiple Borehole Intrusions: The single scenario involving borehole intrusion described in SEIS-II was used to bound the impacts from an exploratory borehole into the repository. For a multiple intrusion scenario, the impacts after the first intrusion would be expected to decrease as the result of dissipating gas pressure and the diminishing amount of material that could be released at any one borehole. Thus, the dose from materials released in future intrusions would be well below the dose estimated from the first intrusion because of the overall decay in the available inventory.

Explosions and Criticalities: The potential for explosions (specifically, gas explosions) of hydrogen and methane generated by waste degradation are extremely unlikely in the long term because of the anoxic environment in the repository. Should such explosions occur, the effect would be limited to the disruption of rock units in the immediate vicinity of the disposal region and the possible creation of pathways for fluid migration above and below the disposed of waste. While this type of impact was not explicitly evaluated, SEIS-II simulated conditions representing the highly permeable DRZ (e.g., see Case 3 for the Proposed Action in Section H.8). The planning-basis WAC establish nuclear criticality criteria for TRU waste that define the maximum allowable quantity of fissile material as two times the measurement error when the waste packages are assayed. Because of these limitations, the formation of a critical mass in the geometry necessary to achieve a self-sustaining nuclear chain reaction in the WIPP environment is considered to be an “incredible” event. Additional information is provided in the CCA (DOE 1996f).

Thermal Impacts: The planning-basis WAC include thermal-loading design limits of 10 kilowatts per surface acre, which would preclude any significant thermal impacts as the result of emplaced TRU wastes in WIPP. DOE has found that the average increase in temperature at depth due to radioactive decay of emplaced CH-TRU and RH-TRU waste would be less than 2ºC, which is insufficient to induce significant thermal convection and thermal stresses and strain and modify anticipated chemical reactions. Increased temperatures from the heat of geothermal origin and compression of gas as a result of salt creep inward are predicted to be similarly insignificant in the CCA (Section SCR.2) and were not analyzed in detail in SEIS-II.

be a small fraction of the immediately dangerous to life or health (IDLH) values, but some serious but non-life-threatening health impacts could occur based on calculated comparisons to Emergency Response Planning Guidelines (ERPGs). Impacts from chronic exposures were considered to be bounded by impacts from routine WIPP disposal operations (Appendix F), with a lifetime probability of cancer incidence no higher than 9×10^{-8} for any alternative.

Estimates of radiation doses were calculated using the GENII code, and estimates of impacts from heavy metal exposures were calculated using the MEPAS® code. Descriptions of these codes and their uses are provided in Appendix F.

Surface Release Caused by Drilling Into the Repository

For this scenario, a hypothetical exploratory drilling operation inadvertently penetrates a waste panel in the repository. As a result, the drilling brings waste originating in the repository to the land surface and exposes individuals involved in the drilling operation to radionuclides and hazardous chemicals. Impacts from radiation and heavy metal exposure were evaluated using two exposure scenarios for individuals associated with the drilling process. These exposure scenarios were:

- A drill crew member directly involved in the drilling of the exploratory borehole. This individual was assumed to be exposed to external radiation from materials at the drill head and in the drill cutting pond and assumed to inadvertently ingest small amounts of borehole material releases. Ingestion was assumed to be 100 milligrams of cuttings per day at an average concentration derived from all of the heavy metals in the top 15 centimeters (6 inches) of a 10 meter by 10 meter (33 foot by 33 foot) cuttings disposal pile. The drill crew member was assumed to be exposed to the materials for a period of 168 hours (i.e., 21 working days).

- A well-site geologist involved in the periodic examination of cuttings generated by the drilling process. This individual would be exposed to external radiation only through the direct handling of an exhumed fragment of waste. The geologist was assumed to pick up a cylindrical waste fragment 5 centimeters (2 inches) in radius, with a volume of 524 cubic centimeters (32 cubic inches). A maximum exposure time of one hour was assumed.

Drilling was assumed to occur sometime after the end of the active institutional control period and was timed to coincide with the maximum potential health impact to exposed individuals. The concentration of radionuclides in the exhumed waste was assumed to be the emplacement concentration decayed to the time of intrusion. Because results of BRAGFLO calculations showed a steady increase in brine pressures in the repository (approximately 5 to 14 megapascal) over the initial 2,000 years following repository closure, the potential impact of repository pressure conditions on the release of materials up the borehole was examined. Given the range of potential release processes involved in the CUTTINGS_S code (see Figure H-3) for these pressure ranges, the potential impact of the repository pressure on the release of materials through the borehole and its impacts on exposed individuals at various intrusion times were examined.

Calculations with the CUTTINGS_S code were performed using repository pressures simulated with BRAGFLO code calculations and various intrusion times for undisturbed conditions (Cases 1 and 3 described below) of the Proposed Action. These calculations estimated the amount of material and the associated radionuclide activity that would be released through the borehole to the

ground surface. The radionuclide activities were then used to calculate impacts to an exposed individual. Details of the random sampling technique used to select the radionuclide inventory for drilling intrusions are provided in Section A.4.8 of Appendix A.

Radionuclide and heavy metal releases were calculated with the CUTTINGS_S code at 100, 200, 300, 400, 500, 800, 1,200 and 2,000 years after repository closure. Results show that, although the amount of material released up the borehole from potential intrusions later increases, the released radionuclide activity would decrease because the radionuclides with short half-lives (which would contribute significantly to early doses) would have decayed. Calculations showed the maximum dose would occur at 400 years after closure for median parameter cases (Proposed Action Case 2) and 300 years after closure for 75th percentile parameter cases (Proposed Action Case 4), when the repository pressure would exceed the 8 megapascal threshold in the CUTTINGS_S model that divides the cuttings and cavings release mode from the more significant spallings release mode. For the Proposed Action (and extrapolated to Action Alternatives 1, 2, and 3), the drilling intrusion scenario was assumed to occur at 400 years after closure for median parameter cases and 300 years after closure for 75th percentile parameter cases. Use of 75th percentile parameter values resulted in material releases approximately 40 percent higher than did the use of median parameter values, with correspondingly higher impacts.

Drilling Through the Repository into a Pressurized Brine Reservoir

A hypothetical drilling event was assumed to breach the repository and penetrate a hypothetical pressurized brine reservoir in the Castile Formation below the repository horizon. For this condition, brine in the reservoir has the potential to come into contact with wastes in the repository and move further up the borehole to more permeable units lying above the repository horizon, such as the Culebra Dolomite or Rustler Formation. Effects of the migration to the accessible environment were evaluated at a well located 3 kilometers (2 miles) downgradient from WIPP. This well was assumed to pump the contaminated water to the stock ponds used by cattle. Direct uses by humans were not considered because of the high salinity of groundwater in the area. Beef from cattle using this water was assumed to be consumed by an individual such as a cattle rancher at a rate of 42 kilograms (93 pounds) of beef annually (approximately 4 ounces a day) over a 70-year lifetime.

H.8.2 Results for the Proposed Action

The four cases below were analyzed for the Proposed Action. The cases considered the following conditions:

- Case 1 considered undisturbed repository performance. Median parameter values were used for all input variables where probability distributions had been defined.

- Case 2 considered an intrusion resulting from exploratory drilling. It was assumed that the repository would be penetrated and the drill would intercept a pressurized brine pocket in the Castile Formation. Median parameter values were used.

- Case 3 considered undisturbed repository performance. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.

- Case 4 considered the same disturbed conditions as Case 2. Seventy-fifth percentile parameter values were used.

Cases 1 through 4 were simulated with the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of time after closure, are depicted in Figure H-8. The pressure release of the waste panel, as a result of the exploratory drilling event at 400 years after closure in Case 2 and 300 years after closure in Case 4, are clearly evident. Brine pressures in the panel remain below lithostatic conditions at 10,000 years after closure for the intrusion cases. Biodegradable material is completely consumed in the gas generation process for all four cases, and the iron inventory is completely consumed in the gas generation process for both of the intrusion cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

H.8.2.1 Impacts of Undisturbed Conditions

The extent of radionuclide migration for undisturbed conditions at 10,000 years after closure for Case 3 (using 75th percentile parameter values) over the model domain is presented in Figure H-9. Case 3 resulted in slightly more extensive migration than Case 1. The figure shows the locations in the modeled region where the total radionuclide activity concentration in brine (summed over

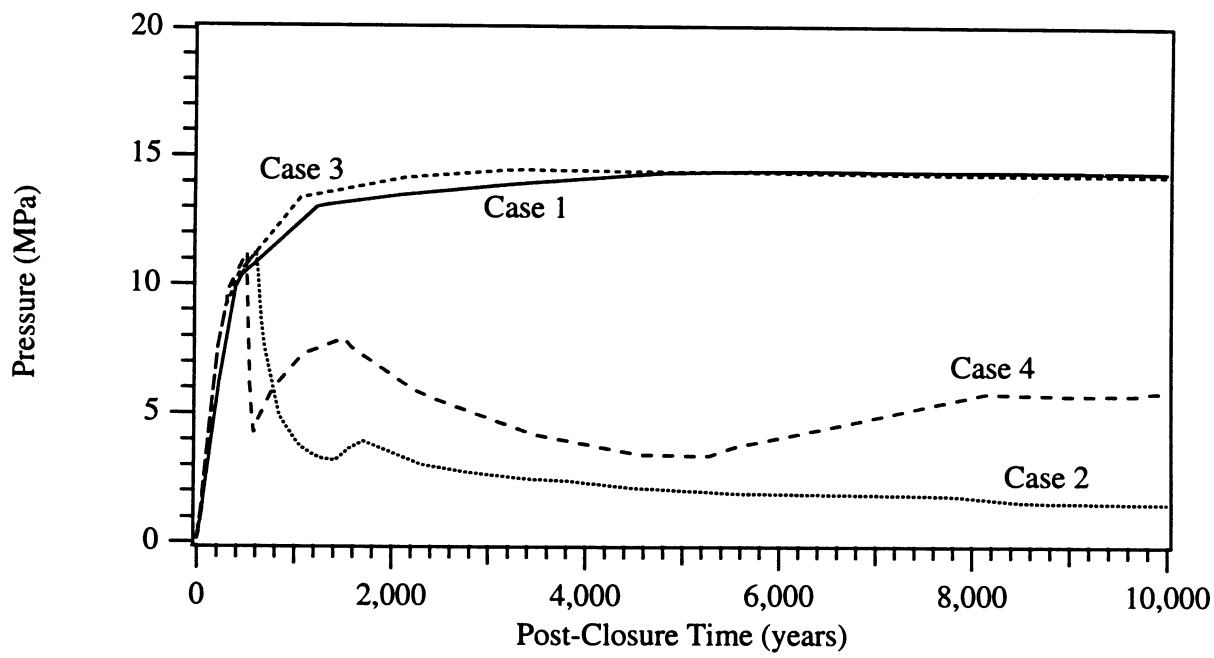


Figure H-8
Volume-Averaged Brine Pressures in a Waste Panel for the Proposed Action

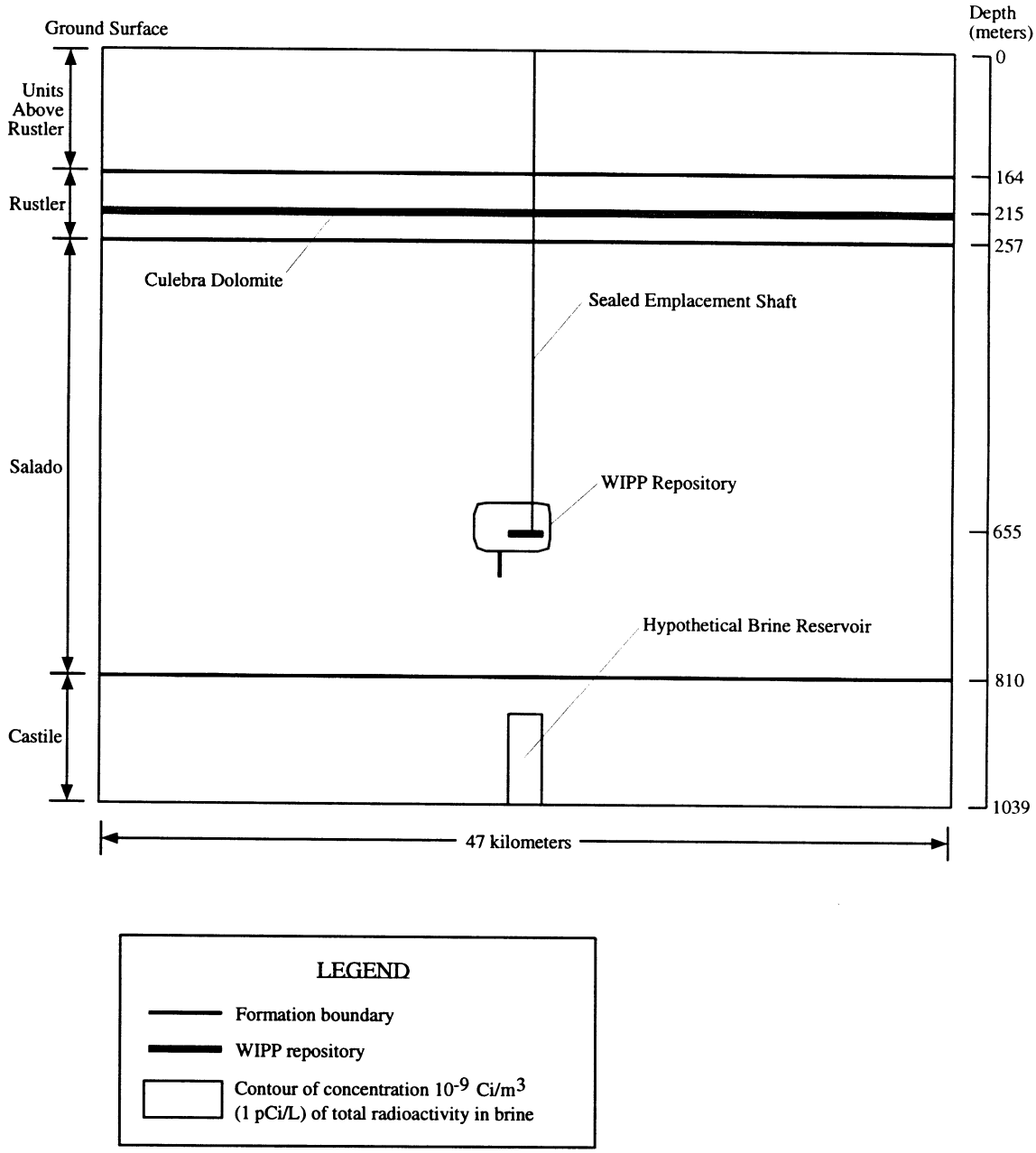


Figure H-9
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) for the Proposed Action

30 radionuclides) is equal to 1 pCi per liter (1 x 10^{-9} curies per cubic meter). Migration of heavy metals (lead, mercury, beryllium, and cadmium) was also simulated. For Case 3, the extent of total heavy metal concentrations of one part per billion (1 x 10^{-3} milligrams per cubic meter) of brine is approximately the same as the one pCi per liter level of total radionuclide activity concentration.

Because lead is by far the predominant heavy metal in the analyzed inventory (see Appendix A), the total heavy metal concentration can be interpreted to approximate the predicted concentration of lead only.

The total vertical scale of the modeled region in Figure H-9 is 1,039 meters (3,409 feet), with the horizontal extent approximating 47 kilometers (29 miles). For Case 3, migration of total radionuclide concentrations at one pCi per liter extended vertically below the repository 60 meters (200 feet) and above the repository 40 meters (130 feet). The furthest extent of lateral migration at this same concentration was to 1,900 meters (6,200 feet) from the south (left) edge of the repository. Migration of heavy metals at a concentration of one part per billion were approximately the same as radionuclides at 1 pCi per liter.

H.8.2.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of the Proposed Action.

Surface Release Caused by Drilling into the Repository

Under the Proposed Action, the estimated releases to the ground surface from a drilling intrusion 400 years after closure would be 3.1 curies for Case 2 (median parameter values) and 4.5 curies for a drilling intrusion at 300 years after closure for Case 4 (75th percentile parameter values). In both cases, releases were mainly from Am-241, Pu-239, and Pu-238. Heavy metal releases from an intrusion were estimated at 24 and 2.1 kilograms (53 and 4.6 pounds) of lead and mercury, respectively, for Case 2. For Case 4, 31 and 2.7 kilograms (67 and 6.0 pounds) of lead and mercury, respectively, were released in Case 4. Results of these analyses are provided in Tables H-25 and H-26.

For Case 2 (median parameter values), radiological impacts to the drilling crew member from a drilling intrusion resulted in a 1.8 x 10^{-4} probability of an LCF. For Case 4 (75th percentile parameter values), the radiological impacts were higher at a 4.4 x 10^{-4} probability of an LCF. The dominant exposure pathway was by ingestion of drill cuttings, and Am-241 was the most significant radionuclide, contributing approximately 97 percent of the total dose. Results are presented in Table H-27. The drilling crew member may also ingest heavy metals (lead, beryllium, cadmium, and mercury) in the drill cuttings. There would be a 2.2 x 10^{-8} probability of a cancer incidence to the drill crew member. There would be no noncarcinogenic impacts expected from the ingestion of the metals because all hazard indices would be much less than one. Impacts from the ingestion of heavy metals are shown in Table H-28.

Table H-25
Radionuclide Releases (curies)
to the Ground Surface from Drilling Intrusions for the Proposed Action

Radionuclide	Case 2 (Median Parameters) Intrusion at 400 Years After Closure	Case 4 (75th Percentile Parameters) Intrusion at 300 Years After Closure
Ac-227	8.60E-06	6.25E-06
Am-241	1.04E+00	2.47E+00
Cm-243	3.59E-09	5.89E-07
Cm-244	1.54E-10	5.82E-07
Cs-137	5.34E-06	7.17E-04
Pa-231	9.17E-06	6.97E-06
Pb-210	1.69E-06	1.99E-06
Pu-238	1.53E-01	2.79E-01
Pu-239	1.89E+00	1.69E+00
Pu-240	8.28E-05	1.52E-04
Pu-241	4.45E-10	6.53E-06
Sr-90	4.30E-06	6.58E-04
U-232	5.74E-06	7.45E-05
U-233	2.12E-02	4.01E-02
U-234	3.00E-03	1.22E-03
Y-90	4.30E-06	6.58E-04
Total	3.11	4.48

Table H-26
Releases (kilograms) of Heavy Metals
to the Ground Surface from Drilling Intrusions for the Proposed Action

Heavy Metal	Case 2 (Median Parameters) Intrusion at 400 Years After Closure	Case 4 (75th Percentile Parameters) Intrusion at 300 Years After Closure
Lead	2.4 E+01	3.05E+01
Beryllium	1.3E-01	1.59E-01
Cadmium	1.8E-03	2.27E-03
Mercury	2.1E+00	2.69E+00
Total	2.6E+01	3.33E+01

Radiological impacts to a well-site geologist from external radiation exposure for Case 2 (median parameter values) would result in a 2.8 x 10^{-9} probability of an LCF from CH-TRU waste and a 8.9 x 10^{-10} probability of an LCF from RH-TRU waste. For Case 4 (75th percentile parameter values), the radiological impacts would be a 3.2 x 10^{-9} probability of an LCF from CH-TRU waste and a 3.3 x 10^{-9} probability of an LCF from RH-TRU waste. Results of these analyses are presented in Table H-29.

Drilling Through the Repository into a Pressurized Brine Reservoir

Performance assessment analyses of the Proposed Action indicated that releases of radionuclides and heavy metals from the WIPP repository would not reach the accessible environment or the Culebra Dolomite for Case 2 (median parameter values). However, the results of Case 4 (75th percentile parameter values) analyses indicated the potential for a release to the Culebra and the accessible environment. Radionuclide migration with disturbed conditions at 10,000 years after closure for Case 2 (median parameter values) and Case 4 (75th percentile parameter values)

Table H-27
Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for the Proposed Action

Case 2 (Median Parameters) Intrusion at 400 Years After Closure				Case 4 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
Radionuclide	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**	**Radionuclide**	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**
Am-241	3.4E-01	1.0E-02	3.5E-01	Am-241	8.4E-01	2.6E-02	8.6E-01
Pu-239	9.5E-03	2.1E-04	9.7E-03	Pu-239	7.5E-03	1.7E-04	7.6E-03
Pu-238	6.7E-04	7.4E-06	6.8E-04	Pu-238	1.3E-03	1.4E-05	1.3E-03
U-233	5.2E-05	7.8E-06	6.0E-05	Cs-137	3.2E-06	1.0E-03	1.0E-03
Ac-227	1.1E-05	1.7E-09	1.1E-05	U-233	1.0E-04	1.5E-05	1.1E-04
Pa-231	9.1E-06	6.5E-07	9.7E-06	Y-90	6.7E-07	1.0E-05	1.1E-05
Cs-137	2.4E-08	7.8E-06	7.8E-06	Ac-227	8.3E-06	1.2E-09	8.3E-06
U-234	7.2E-06	4.3E-07	7.7E-06	Sr-90	7.5E-06	1.8E-07	7.7E-06
Pb-210	8.6E-07	1.4E-09	8.6E-07	Pa-231	6.9E-06	4.9E-07	7.4E-06
Pu-240	3.9E-07	4.0E-09	3.9E-07	U-234	2.8E-06	1.8E-07	3.0E-06
Y-90	4.4E-09	6.7E-08	7.2E-08	Pb-210	1.0E-06	1.6E-09	1.0E-06
Sr-90	5.0E-08	1.2E-09	5.1E-08	Pu-240	7.0E-07	7.3E-09	7.1E-07
U-232	3.6E-08	1.3E-09	3.7E-08	U-232	4.8E-07	1.8E-08	4.9E-07
Cm-243	8.5E-10	8.2E-10	1.7E-09	Cm-243	1.4E-07	1.3E-07	2.7E-07
Cm-244	2.8E-11	6.0E-15	2.8E-11	Cm-244	1.1E-07	2.3E-11	1.1E-07
Pu-241	3.2E-14	4.0E-20	3.2E-14	Pu-241	4.7E-10	5.9E-16	4.7E-10
Total Dose	3.5E-01	1.0E-02	3.6E-01	Total Dose	8.5E-01	2.7E-02	8.7E-01
Probability of LCF	1.8E-04	5.1E-06	1.8E-04	**Probability of LCF**	4.2E-04	1.4E-05	4.4E-04

Table H-28
Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals for Drilling Intrusion into the Repository for the Proposed Action

	Case 2 (Median Parameters)		Case 4 (75th Percentile Parameters)	
Heavy Metal	**Probability of Cancer Incidence**	**Hazard Index**	**Probability of Cancer Incidence**	**Hazard Index**
Beryllium	2.2E-08	1.0E-06	2.2E-08	1.0E-06
Cadmium	4.6E-10	1.5E-07	4.6E-10	1.4E-07
Lead	-	7.0E-04	-	6.9E-04
Mercury	-	2.9E-04	-	2.9E-04

Table H-29
Radiation Dose to the Well-Site Geologist
from Drilling Intrusions for the Proposed Action

Case 2 (Median Parameters) Intrusion at 400 Years After Closure				Case 4 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
CH-TRU Waste		**RH-TRU Waste**		**CH-TRU Waste**		**RH-TRU Waste**	
Radionuclide	**External Dose (rem)**	**Radionuclide**	**External Dose (rem)**	**Radionuclide**	**External Dose (rem)**	**Radionuclide**	**External Dose (rem)**
Am-241	3.7E-06	Am-241	7.3E-07	Am-241	4.5E-06	Sr-90	3.6E-06
U-234	1.8E-06	U-234	5.4E-07	U-234	1.7E-06	Cs-137	1.6E-06
Pu-239	7.4E-08	Sr-90	3.0E-07	Pu-239	7.6E-08	Am-241	8.6E-07
U-233	4.5E-08	Cs-137	1.6E-07	U-233	4.5E-08	U-234	5.4E-07
Pu-240	1.5E-08	U-233	2.6E-08	Pu-238	1.9E-08	U-233	2.6E-08
Pu-238	8.5E-09	Pu-239	1.0E-08	Pu-240	1.5E-08	Pu-239	1.0E-08
Ac-225	7.5E-09	Pu-240	3.6E-09	Sr-90	8.9E-09	Pu-240	3.9E-09
Sr-90	8.3E-10	Ac-225	2.5E-09	Ac-225	5.7E-09	Ac-225	1.9E-09
Cs-137	3.0E-10	Pa-231	3.6E-10	Cs-137	3.0E-09	Y-90	5.2E-10
Pb-210	1.3E-11	Pu-238	6.0E-11	Pb-210	1.3E-11	Pa-231	2.5E-10
Pa-231	1.1E-12	Y-90	4.4E-11	Y-90	1.3E-12	Pu-238	1.3E-10
Y-90	1.2E-13	U-232	8.8E-14	Pa-231	7.8E-13	U-232	2.4E-13
U-232	8.1E-14	Pb-210	7.1E-18	U-232	2.0E-13	Pb-210	2.8E-18
Pu-241	1.8E-17	Pu-241	9.7E-22	Pu-241	1.8E-17	Pu-241	1.2E-19
Total Dose	5.7E-06	Total Dose	1.8E-06	Total Dose	6.4E-06	Total Dose	6.6E-06
Probability of LCF	2.8E-09	**Probability of LCF**	8.9E-10	**Probability of LCF**	3.2E-09	**Probability of LCF**	3.3E-09

showed migration of total radionuclide concentrations of one pCi per liter migrating upward and downward in the exploratory borehole. Results for Case 4 are shown in Figure H-10. Heavy metal concentrations equal to one part per billion showed similar patterns of migration. In both cases, contaminants at these levels penetrated a short distance into the surrounding rock and down into the Castile Formation and the hypothetical brine reservoir. Transport analyses of releases to the Culebra showed that contaminants would be highly sorbed and only small amounts would migrate from the point of intrusion over 10,000 years.

The estimated maximum release rate for Case 4 of 0.65 Ci per year (predominantly Am-241, Pu-239, and Pu-240) and 23.1 kilograms per year (50.9 pounds per year) of heavy metals (predominantly lead) would occur at approximately 1,600 years after closure. The estimated total release to the Culebra Dolomite would be 523 Ci and 20,960 kilograms (46,220 pounds) of heavy metals, with the release occurring from 700 years to 2,200 years after closure.

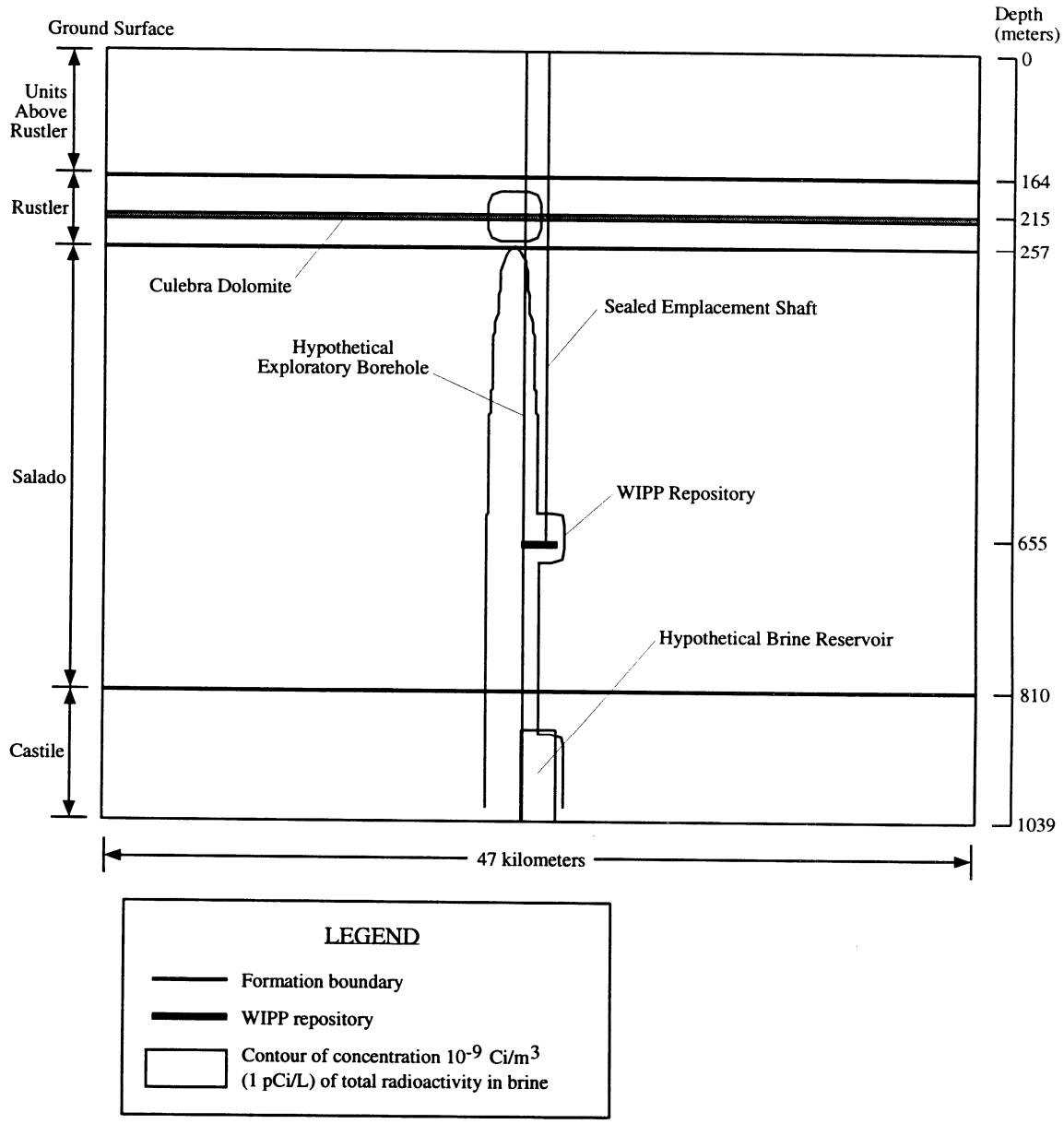


Figure H-10
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) for the Proposed Action

The potential for off-site human health impacts due to migration of contaminants through the Culebra was evaluated. Two flow-field conditions were evaluated: one to represent partial mining and one to represent full mining. Changing the hydraulic conductivity of the Culebra to reflect the hydrogeologic impacts of future potash mining would result in an overall increase in travel times to locations downgradient of the WIPP site. This effect has been attributed to the increases in hydraulic conductivity in the postulated mined areas, causing groundwater flow paths to change from areas of higher transmissivity south and east of the WIPP site to a more westerly path into areas of lower transmissivity. Calculated travel times for the full mining scenarios were nearly two orders of magnitude higher than those calculated for the partial mining scenario, resulting in lower potential impacts.

For partial and full potash mining conditions, impacts were calculated to an individual, such as a rancher, who consumed beef from cattle that had consumed water from a stock well located downgradient at the Land Withdrawal Area boundary 3 kilometers (2 miles) from the point of intrusion. Radiological impacts would be higher under partial mining but would be negligible, with a 7×10^{-28} probability of an LCF. The principal dose contributor was Pu-239 with all 10 other radionuclides considered less than 0.02 percent of Pu-239. Ingestion of heavy metals from consumption of contaminated beef was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-27}. Impacts under full mining conditions would be significantly lower than those under partial mining, with radiological impacts of a 4×10^{-41} probability of an LCF and ingestion of heavy metals resulting in a probability of cancer incidence of 3×10^{-37}.

H.8.3 Results for Action Alternative 1

Long-term performance assessment analyses were conducted for Action Alternative 1 using the same methods as were used for the Proposed Action. The radionuclide and heavy metal inventories were increased from those used in the Proposed Action to account for the increased inventory destined for WIPP under this alternative. Total radionuclide activities of 7.3×10^{6} Ci in CH-TRU waste and 5.1×10^{6} Ci in RH-TRU waste were included for this alternative. Detailed information on the radionuclide and heavy metal inventories are provided in Appendix A. The repository size was adjusted from 10 panels (for the Proposed Action) to 68 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 1. The cases considered the following conditions:

- Case 6 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions had been defined.

- Case 7 considered disturbed conditions where a borehole from exploratory drilling is assumed to breach the repository and penetrate a pressurized brine pocket in the Castile Formation. Median parameters values were used.

- Case 8 considered undisturbed repository conditions. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.

- Case 9 considered the same disturbed conditions as Case 7. Seventy-fifth percentile parameter values were used.

Cases 6 through 9 were simulated with the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of time after closure, are depicted in Figure H-11. The pressure release of the waste panel, as a result of the exploratory drilling events at 400 years after closure for Case 7 and 300 years after closure for Case 9, respectively, is clearly evident in this figure. Brine pressures in the panel remain below lithostatic conditions at 10,000 years after closure for the intrusion cases. The biodegradable material is completely consumed in the gas generation process for all four cases. The iron inventory is completely consumed in the gas generation process for both of the intrusion cases and for the median undisturbed case. The gas generation for the undisturbed 75th percentile parameter case is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

H.8.3.1 Impacts of Undisturbed Conditions

The extent of radionuclide migration for undisturbed conditions at 10,000 years after closure for Case 8 (75th percentile parameter values) is presented in Figure H-12. Case 8 is presented because it resulted in slightly more extensive migration than Case 6. For undisturbed conditions, results from Action Alternative 1 simulations showed about the same downward and lateral radionuclide and heavy metal migration as the Proposed Action. Migration of total radionuclide concentrations of one pCi per liter extends 20 meters (65 feet) below the repository. The maximum distance of lateral migration of the same concentration levels was about 1,900 meters (6,200 feet). The maximum extent of vertical upward migration was calculated to be about 40 meters (130 feet) above the top of the repository. The extent of total heavy metal migration to a concentration to one part per billion was approximately the same as the one pCi per liter total radionuclide level.

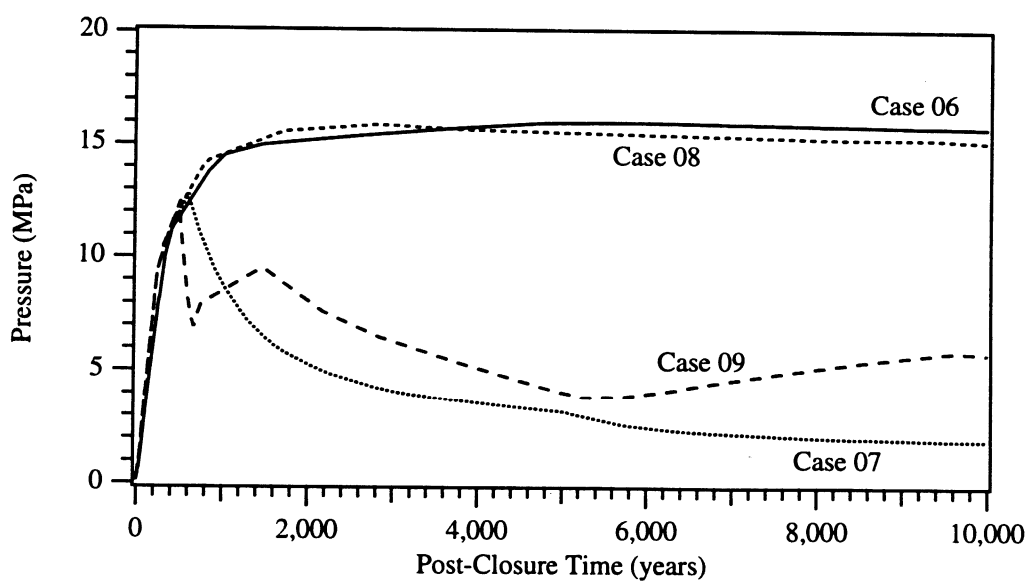


Figure H-11
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 1

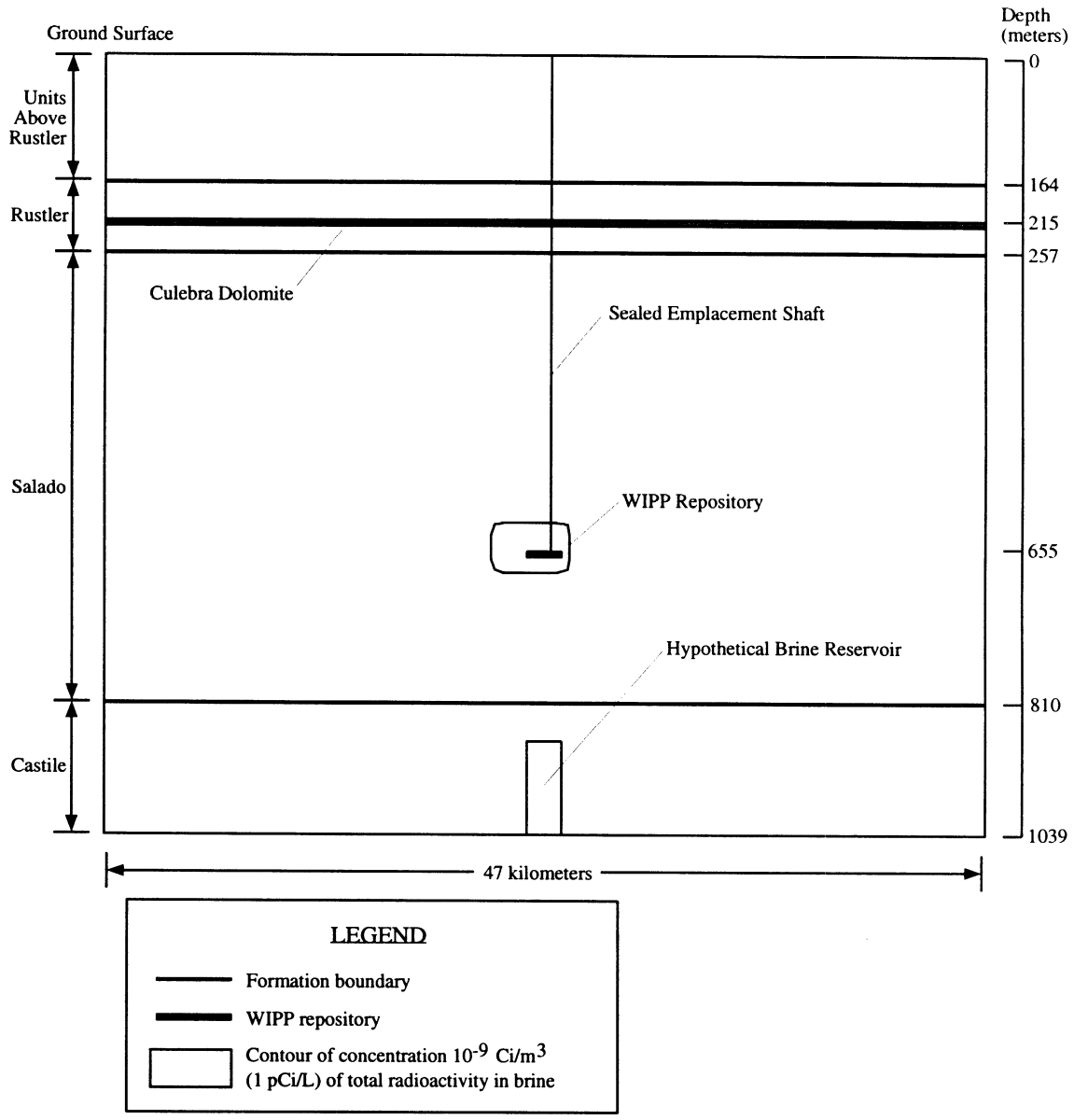


Figure H-12
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) for Action Alternative 1

H.8.3.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of Action Alternative 1.

Surface Release Caused by Drilling into the Repository

Under Action Alternative 1, the estimated release to the ground surface from a drilling intrusion depends on the kind of waste intercepted by the drilling equipment. For Case 7 (median parameter values), the estimated total radioactivity releases would be 2.6, 0.1, and 2.7 curies for drilling into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste, respectively. For Case 9 (75th percentile parameter values), the releases would be 3.5, 0.15, and 3.6 curies for drilling into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste, respectively. Major radionuclides were Am-241, Pu-239, and Pu-238.

Heavy metal releases from an intrusion were estimated at 6, 22, and 23 kilograms (13.2, 48.4, and 50.6 pounds) for drilling into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste, respectively, for Case 7 (median parameter values). For Case 9 (75th percentile parameter values), the releases would be 8, 30, and 31 kilograms (18, 66, and 68 pounds) for drilling into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste, respectively. Results are presented in Tables H-30 and H-31.

Radiological impacts to the drilling crew member would be 1.9×10^{-4}, 6.8×10^{-6}, and 1.7×10^{-4} probability of an LCF, respectively, for drilling into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste for Case 7 (median parameter values). For Case 9 (75th percentile parameter values), the impacts would be somewhat higher at a 3.6×10^{-4}, 1.2×10^{-5}, and 3.6×10^{-4} probability of an LCF, respectively. The dominant exposure pathway was ingestion of drill cuttings, with Am-241 contributing 87 to 98 percent of the total dose. Results are presented in Table H-32. Ingestion of heavy metals for this scenario would result in a 1.7×10^{-8}, 1.0×10^{-9}, and 1.8×10^{-8} probability of cancer incidence, respectively. There would be no noncarcinogenic impacts expected from ingestion of the metals because all hazard indices would be much less than one. Impacts from ingestion of heavy metals are shown in Table H-33.

Radiological impacts to the well-site geologist from external radiation exposure for Case 7 (median parameter values) would result in a 2.4×10^{-9} probability of an LCF from CH-TRU waste and a 1.5×10^{-9} probability of an LCF for RH-TRU waste. For Case 9 (75th percentile parameter values), the radiological impacts would be a 2.7×10^{-9} probability of an LCF from CH-TRU waste and a 4.9×10^{-9} probability of an LCF from RH-TRU waste. Results of these analyses are presented in Table H-34.

Drilling Through the Repository into a Pressurized Brine Reservoir

Radionuclide migration under disturbed conditions at 10,000 years after closure for Case 7 (median parameter values) and Case 9 (75th percentile parameter values) showed migration of total radionuclide concentrations of one pCi per liter migrating upward and downward in the exploratory borehole. Heavy metal concentrations equal to one part per billion showed similar patterns of migration. In both cases, contaminants at these levels penetrated a short distance into the surrounding rock and down into the Castile Formation and the hypothetical brine reservoir. The

Table H-30
Radionuclide Releases (curies)
to the Ground Surface from Drilling Intrusions for Action Alternative 1

Radionuclide	Case 7 (Median Parameters) Intrusion at 400 Years After Closure			Case 9 (75th Percentile Parameters) Intrusion at 300 Years After Closure		
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste
Ac-227	1.70E-08	3.77E-06	2.55E-06	1.29E-08	3.65E-06	2.47E-06
Am-241	9.07E-01	3.53E-02	9.31E-01	1.93E+00	5.51E-02	1.97E+00
Cm-243	1.80E-11	2.18E-08	1.47E-08	4.08E-10	3.29E-07	2.22E-07
Cm-244	4.45E-09	5.53E-10	4.82E-09	4.07E-07	3.38E-08	4.30E-07
Cs-137	4.16E-06	1.30E-04	9.15E-05	7.97E-05	1.74E-03	1.25E-03
Pa-231	1.86E-08	4.09E-06	2.77E-06	1.45E-08	4.08E-06	2.76E-06
Pb-210	1.03E-06	6.14E-08	1.07E-06	1.56E-06	4.42E-08	1.59E-06
Pu-238	2.52E-01	3.94E-04	2.52E-01	2.19E-01	1.15E-03	2.20E-01
Pu-239	1.41E+00	6.28E-02	1.45E+00	1.31E+00	8.38E-02	1.37E+00
Pu-240	5.27E-05	6.57E-06	5.72E-05	1.06E-04	8.83E-06	1.12E-04
Pu-241	4.02E-08	3.79E-09	4.27E-08	5.00E-06	6.21E-07	5.42E-06
Sr-90	2.89E-06	9.56E-05	6.72E-05	5.93E-05	1.37E-03	9.84E-04
U-232	1.11E-05	9.22E-08	1.12E-05	5.83E-05	3.21E-07	5.85E-05
U-233	1.57E-02	2.20E-04	1.59E-02	3.13E-02	2.93E-04	3.15E-02
U-234	2.14E-03	2.45E-04	2.30E-03	8.80E-04	3.26E-04	1.10E-03
Y90	2.89E-06	9.57E-05	6.72E-05	5.93E-05	1.38E-03	9.84E-04
Total	2.58	0.099	2.65	3.49	0.145	3.59

Table H-31
Releases (kilograms) of Heavy Metals
to the Ground Surface from Drilling Intrusions for Action Alternative 1

Heavy Metal	Case 7 (Median Parameters) Intrusion at 400 Years After Closure			Case 9 (75th Percentile Parameters) Intrusion at 300 Years After Closures		
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste
Lead	4.15	22.23	20.98	5.52E+00	2.96E+01	2.79E+01
Beryllium	0.0974	0.0058	0.1013	1.30E-01	7.72E-03	1.35E-01
Cadmium	0.0015	0.0001	0.0016	2.00E-03	1.10E-04	2.08E-03
Mercury	1.7784	0.0984	1.8445	2.37E+00	1.31E-01	2.45E+00
Total	6.03	22.33	22.93	8.02	29.70	30.50

Table H-32
Radiation Dose to a Member of the Drilling Crew for a Drilling Intrusion for Action Alternative 1

Case 7 (Median Parameters) Intrusion at 400 Years After Closure				Case 9 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
Radionuclide	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**	**Radionuclide**	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**
CH-TRU Waste							
Am-241	3.1E-01	9.8E-03	3.1E-01	Am-241	6.9E-01	2.2E-02	7.1E-01
Pu-239	6.5E-02	1.5E-03	6.6E-02	Pu-239	6.0E-03	1.4E-04	6.1E-03
Pu-238	1.1E-03	1.2E-05	1.2E-03	Pu-238	1.1E-03	1.1E-05	1.1E-03
U-233	3.7E-05	5.7E-06	4.2E-05	Cs-137	3.6E-07	1.2E-04	1.2E-04
Cs-137	1.8E-08	6.1E-06	6.1E-06	U-233	7.9E-05	1.2E-05	9.0E-05
U-234	5.2E-06	3.0E-07	5.5E-06	U-234	2.1E-06	1.3E-07	2.3E-06
Pb-210	5.0E-06	7.6E-09	5.0E-06	Y-90	6.1E-08	9.2E-07	9.8E-07
Ac-227	2.3E-06	3.4E-10	2.3E-06	Pb-210	7.5E-07	1.2E-09	7.5E-07
Pa-231	1.8E-06	1.3E-07	1.9E-06	Sr-90	6.8E-07	1.6E-08	7.0E-07
Pu-240	2.5E-07	2.5E-09	2.5E-07	Pu-240	5.0E-07	5.0E-09	5.0E-07
U-232	6.8E-08	2.5E-09	7.0E-08	U-232	3.7E-07	1.4E-08	3.9E-07
Y-90	2.9E-09	4.4E-08	4.7E-08	Cm-244	7.6E-08	1.6E-11	7.6E-08
Sr-90	3.3E-08	7.8E-10	3.4E-08	Ac-227	1.7E-08	2.6E-12	1.7E-08
Cm-243	4.3E-10	4.1E-10	8.4E-10	Pa-231	1.5E-08	1.1E-09	1.6E-08
Cm-244	8.4E-11	1.8E-14	8.4E-11	Pu-241	3.6E-10	4.4E-16	3.6E-10
Pu-241	2.9E-14	3.6E-20	2.9E-14	Cm-243	9.5E-11	9.1E-11	1.9E-10
Total Dose (rem)	3.8E-01	1.1E-02	3.8E-01	**Total Dose (rem)**	7.0E-01	2.2E-02	7.2E-01
Probability of LCF	1.9E-04	5.7E-06	1.9E-04	**Probability of LCF**	3.5E-04	1.1E-05	3.6E-04
RH-TRU Waste							
Am-241	1.2E-02	4.0E-04	1.3E-02	Am-241	1.9E-02	6.1E-04	2.0E-02
Pu-239	2.9E-04	6.7E-06	3.0E-04	Cs-137	8.1E-06	2.6E-03	2.6E-03
Cs-137	5.7E-07	1.9E-04	1.9E-04	Pu-239	3.9E-04	9.0E-06	4.0E-04
Ac-227	5.1E-06	7.5E-10	5.1E-06	Y-90	1.4E-06	2.2E-05	2.3E-05
Pa-231	4.0E-06	2.9E-07	4.3E-06	Sr-90	1.6E-05	3.9E-07	1.6E-05
Pu-238	1.8E-06	1.9E-08	1.8E-06	Pu-238	5.3E-06	6.0E-08	5.3E-06
Y-90	9.7E-08	1.5E-06	1.6E-06	Ac-227	4.8E-06	7.2E-10	4.8E-06
Sr-90	1.1E-06	2.6E-08	1.1E-06	Pa-231	4.0E-06	2.9E-07	4.3E-06
U-233	5.8E-07	8.5E-08	6.6E-07	U-234	8.0E-07	4.7E-08	8.5E-07
U-234	5.9E-07	3.5E-08	6.3E-07	U-233	7.3E-07	1.1E-07	8.4E-07
Pb-210	3.0E-08	4.9E-11	3.1E-08	Cm-243	7.8E-08	7.3E-08	1.5E-07
Pu-240	3.1E-08	3.2E-10	3.1E-08	Pu-240	4.1E-08	4.3E-10	4.2E-08
Cm-243	5.5E-09	5.2E-09	1.1E-08	Pb-210	2.2E-08	3.5E-11	2.2E-08
U-232	5.8E-10	2.2E-11	6.1E-10	Cm-244	6.6E-09	1.4E-12	6.6E-09
Cm-244	1.1E-10	2.2E-14	1.1E-10	U-232	2.0E-09	7.5E-11	2.1E-09
Pu-241	2.7E-13	3.3E-19	2.7E-13	Pu-241	4.4E-11	5.5E-17	4.4E-11
Total Dose (rem)	1.2E-02	6.0E-04	1.4E-02	**Total Dose (rem)**	1.9E-02	3.2E-03	2.3E-02
Probability of LCF	6.2E-06	3.0E-07	6.8E-06	**Probability of LCF**	9.7E-06	1.6E-06	1.2E-05
CH-TRU and RH-TRU Waste							
Am-241	3.2E-01	1.0E-02	3.3E-01	Am-241	6.9E-01	2.2E-02	7.1E-01
Pu-239	7.0E-03	1.6E-04	7.1E-03	Pu-239	6.5E-03	1.5E-04	6.6E-03
Pu-238	1.1E-03	1.2E-05	1.2E-03	Cs-137	5.2E-06	1.8E-03	1.8E-03
Cs-137	4.1E-07	1.3E-04	1.3E-04	Pu-238	1.1E-03	1.1E-05	1.1E-03
U-233	4.2E-05	6.4E-06	4.8E-05	U-233	7.9E-05	1.2E-05	9.0E-05
U-234	5.7E-06	3.3E-07	6.0E-06	Y-90	1.0E-06	1.5E-05	1.6E-05
Ac.-227	3.4E-06	5.1E-10	3.4E-06	Sr-90	1.1E-05	2.6E-07	1.2E-05
Pa-231	2.7E-06	1.9E-07	2.9E-06	Ac-227	3.2E-06	4.7E-10	3.2E-06
Y-90	6.9E-08	1.0E-06	1.1E-06	Pa-231	2.7E-06	1.9E-07	2.9E-06
Sr-90	7.8E-07	1.9E-08	7.9E-07	U-234	2.6E-06	1.5E-07	2.7E-06
Pb-210	5.3E-07	8.4E-10	5.4E-07	Pb-210	8.6E-07	1.4E-09	8.6E-07
Pu-240	2.6E-07	2.7E-09	2.7E-07	Pu-240	5.0E-07	5.0E-09	5.0E-07
U-232	6.8E-08	2.5E-09	7.0E-08	U-232	3.7E-07	1.4E-08	3.9E-07
Cm-243	3.5E-09	3.5E-09	7.0E-09	Cm-243	5.3E-08	5.0E-08	1.0E-07
Cm-244	9.0E-10	1.9E-13	9.0E-10	Cm-244	8.2E-08	1.7E-11	8.2E-08
Pu-241	3.0E-12	3.8E-18	3.0E-12	Pu-241	3.9E-10	4.8E-16	3.9E-10
Total Dose (rem)	3.3E-01	1.0E-02	3.4E-01	**Total Dose (rem)**	7.0E-01	2.4E-02	7.2E-01
Probability of LCF	1.6E-04	5.2E-06	1.7E-04	**Probability of LCF**	3.5E-04	1.2E-05	3.6E-04

Table H-33
Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals for Drilling Intrusion into the Repository for Action Alternative 1

Heavy Metal	Case 7 (Median Parameters)		Case 9 (75th Percentile Parameters)	
	Probability of Cancer Incidence	Hazard Index	Probability of Cancer Incidence	Hazard Index
CH-TRU Waste				
Beryllium	1.7E-08	8.0E-07	1.7E-08	8.0E-07
Cadmium	3.9E-10	1.2E-07	3.9E-10	1.2E-07
Lead	0	1.2E-04	0	1.2E-04
Mercury	0	2.4E-04	0	2.4E-04
RH-TRU Waste				
Beryllium	1.0E-09	4.8E-08	1.0E-09	4.8E-08
Cadmium	2.1E-11	6.8E-09	2.1E-11	6.8E-09
Lead	0	6.5E-04	0	6.5E-04
Mercury	0	1.4E-05	0	1.3E-05
CH-TRU and RH-TRU Waste				
Beryllium	1.8E-08	8.3E-07	1.8E-08	8.3E-07
Cadmium	4.0E-10	1.3E-07	4.0E-10	1.3E-07
Lead	0	6.2E-04	0	6.1E-04
Mercury	0	2.5E-04	0	2.5E-04

Table H-34
Radiation Dose to the Well-Site Geologist from Drilling Intrusions for Action Alternative 1

Case 7 (Median Parameters) Intrusion at 400 Years After Closure				Case 9 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
CH-TRU Waste		RH-TRU Waste		CH-TRU Waste		RH-TRU Waste	
Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)
Am-241	3.2E-06	Am-241	1.3E-06	Am-241	3.7E-06	Sr-90	4.7E-06
U-234	1.5E-06	U-234	9.6E-07	U-234	1.5E-06	Cs-137	2.6E-06
Pu-239	6.1E-08	Sr-90	4.4E-07	Pu-239	6.1E-08	Am-241	1.5E-06
U-233	5.2E-08	Cs-137	2.6E-07	U-233	5.2E-08	U-234	9.6E-07
Pu-240	1.1E-08	Pu-239	1.6E-08	Pu-238	1.5E-08	Pu-239	1.6E-08
Ac-225	8.8E-09	U-233	1.2E-08	Pu-240	1.1E-08	U-233	1.2E-08
Pu-238	6.6E-09	Pu-240	6.7E-09	Sr-90	8.0E-09	Pu-240	6.7E-09
Sr-90	7.2E-10	Ac-225	8.8E-10	Ac-225	6.7E-09	Y-90	6.8E-10
Cs-137	3.1E-10	Pa-231	1.2E-10	Cs-137	3.3E-09	Ac-225	6.4E-10
Pb-210	7.5E-12	Pu-238	8.9E-11	Pb-210	7.7E-12	Pu-238	2.1E-10
Pa-231	1.1E-12	Y-90	6.4E-11	Y-90	1.2E-12	Pa-231	8.7E-11
U-232	1.2E-13	U-232	2.9E-14	Pa-231	8.2E-13	U-232	7.4E-14
Y-90	1.0E-13	Pb-210	2.7E-18	U-232	3.1E-13	Pb-210	1.1E-18
Pu-241	1.9E-17	Pu-241	1.8E-21	Pu-241	1.9E-17	Pu-241	2.2E-19
Total Dose (rem)	4.8E-06	**Total Dose (rem)**	3.0E-06	**Total Dose (rem)**	5.4E-06	**Total Dose (rem)**	9.8E-06
Probability of LCF	2.4E-09	**Probability of LCF**	1.5E-09	**Probability of LCF**	2.7E-09	**Probability of LCF**	4.9E-09

migration down to the brine would occur as the initial pressure in the reservoir dissipates and equilibrates with pressures in the repository and the surrounding units penetrated by the borehole.

Radionuclide migration for Case 9, shown in Figure H-13, resulted in greater vertical upward migration than Case 7 and a release of contaminants into the Culebra Dolomite. The estimated maximum release rate of 0.99 Ci per year (predominantly Pu-239, Am-241, and Pu-240) and 50.3 kilograms (111 pounds) per year of heavy metals (predominantly lead) would occur at approximately 1,600 years after closure. The estimated total release to the Culebra Dolomite would be 1,090 Ci and 60,250 kilograms (133,000 pounds) of heavy metals, with the release occurring from 600 years to 3,900 years after closure. Analyses of releases to the Culebra showed that contaminants would be highly sorbed and only small amounts would migrate from the point of intrusion over 10,000 years. Transport calculations for Case 9 releases to the Culebra were made with the SECOTP2D model of the Culebra developed for the CCA (DOE 1996f).

Radiological impacts were calculated to an individual, such as a rancher, who consumed beef from cattle that had consumed water from a stock well located downgradient at the Land Withdrawal Area boundary 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions, since calculated impacts for full mining conditions were significantly lower (see Section H.8.2). Radiological impacts would be negligible, with a 2×10^{-27} probability of an LCF. The principal dose contributor was Pu-239 with the 10 other radionuclides considered no more than 0.1 percent of Pu-239. Ingestion of heavy metals from consumption of contaminated beef, was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-27}.

H.8.4 Results for Action Alternative 2

Long-term performance assessment analyses were conducted for Action Alternative 2 using the same methods as were used for other alternatives. The radionuclide and heavy metal inventories were increased slightly over those of Action Alternative 1 to account for the small additional volume of polychlorinated biphenyl (PCB)-commingled TRU waste (see Chapter 3 and Appendix A). Total radionuclide activities of 7.3×10^{6} Ci in CH-TRU waste and 5.1×10^{6} Ci in RH-TRU waste were included for this alternative. Detailed information on the radionuclide and heavy metal inventories is provided in Appendix A. Only radiological impacts would result from disposal operations at WIPP because VOCs would be removed by thermal treatment. The repository size was adjusted from 10 panels (for the Proposed Action) to 75 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action and other alternatives.

The four cases below were analyzed for Action Alternative 2. The cases considered the following conditions:

- Case 11 considered undisturbed repository performance. Median parameter values were used for all input variables where probability distributions had been defined.

- Case 12 considered disturbed conditions where a borehole from exploratory drilling is assumed to breach the repository and penetrate a pressurized brine pocket in the Castile Formation. Median parameter values were used.

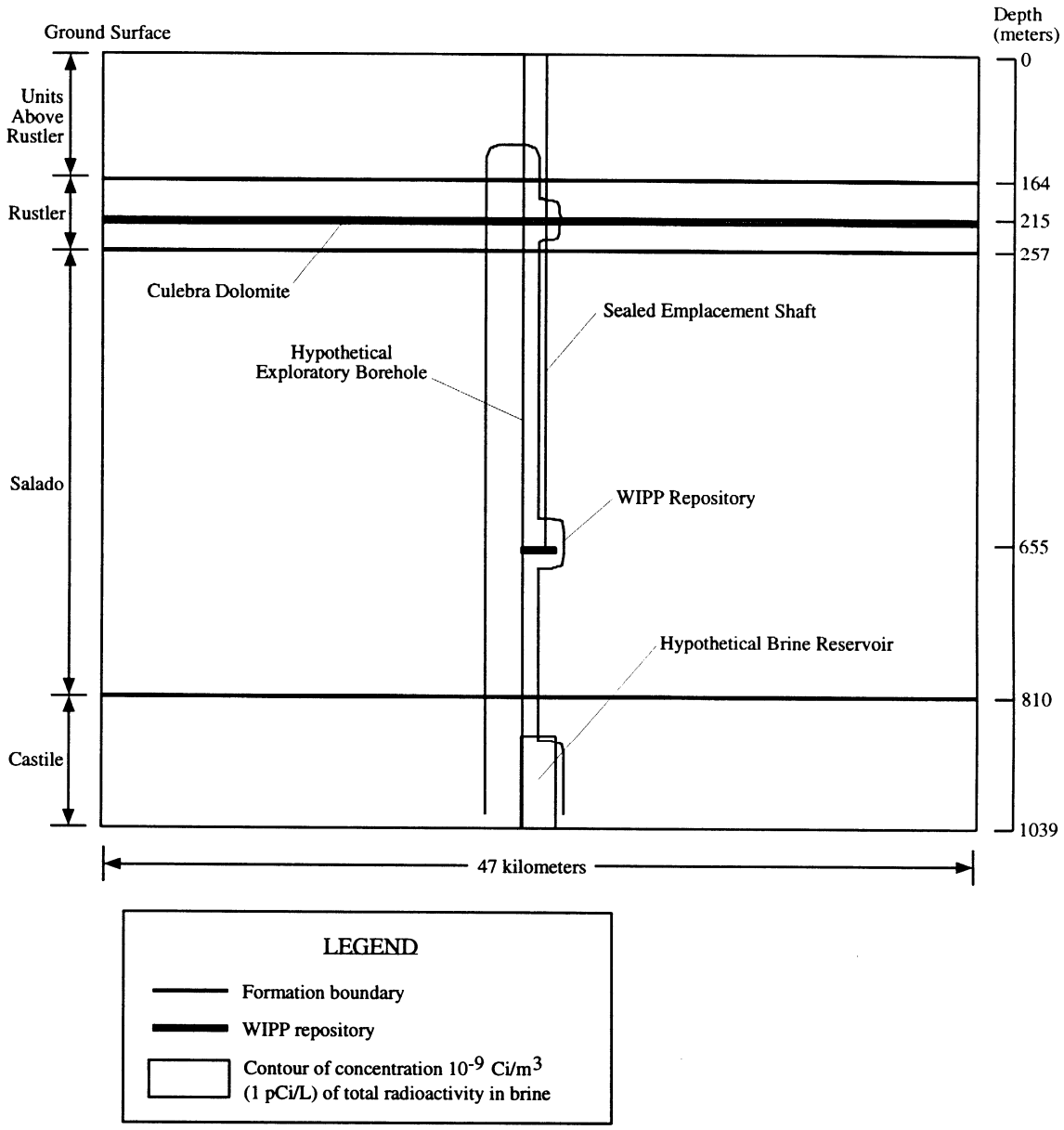


Figure H-13
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 9) for Action Alternative 1

- Case 13 considered undisturbed repository performance. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.

- Case 14 considered the same disturbed conditions as Case 12. Seventy-fifth percentile parameter values were used.

Cases 11 through 14 were simulated using the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of time after closure, are depicted in Figure H-14. The pressure release of the waste panel as a result of the exploratory drilling event at 400 years after closure for Case 12 and 300 years after closure for Case 14 is clearly evident in this figure. The secondary perturbations in the pressure curves (approximately 700 years and 1,700 years after closure) in the disturbed cases are due to the material property changes imposed in BRAGFLO that account for the degradation of the exploratory borehole concrete plugs (200 years following intrusion) and backfill (1,200 years following intrusion). Brine pressures in the panel remain below lithostatic conditions at 10,000 years after closure for all cases. The notable change for this alternative relative to all the other alternatives was that the thermal processing was assumed to destroy all of the biodegradable material that contributes to gas generation. The iron corrosion was assumed to still occur. The iron inventory is not completely consumed in the gas generation process for any of the cases (disturbed or undisturbed), and a substantial amount of iron remained at 10,000 years after closure. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

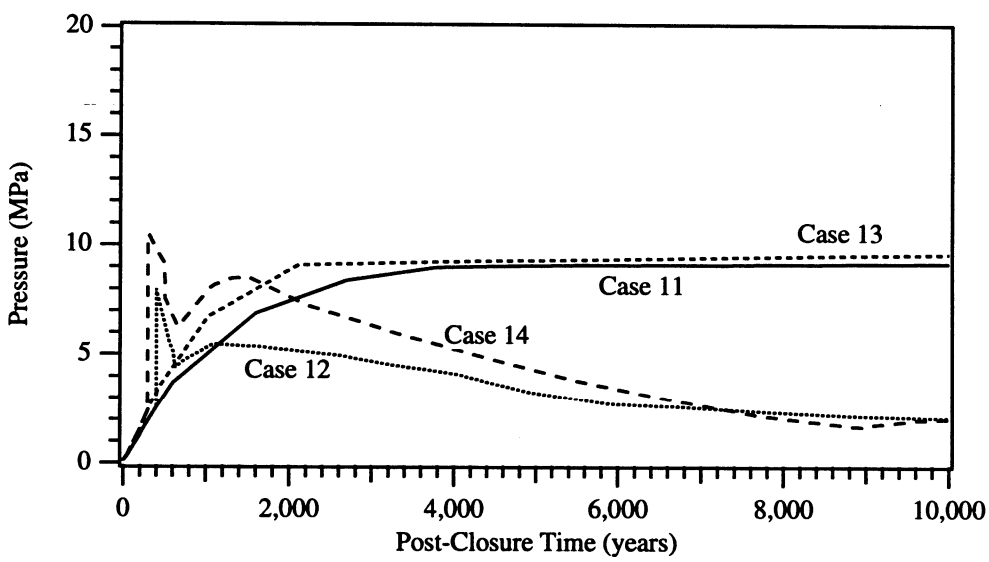


Figure H-14
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 2

H.8.4.1 Impacts of Undisturbed Conditions

The extent of radionuclide migration for undisturbed conditions at 10,000 years after closure for Case 13 (using 75th percentile parameters) is presented in Figure H-14. Case 13 is presented because it resulted in slightly more extensive migration than Case 11. Simulation results showed similar migration to that presented for Case 8 of Action Alternative 1. Vertical migration of total radionuclide concentrations of one pCi per liter was estimated at about 40 meters (130 feet) above the top of the repository and about 20 meters (65 feet) below the bottom of the repository. Lateral migration at these concentration levels extended 1,900 meters (6,200 feet) from the repository edge. The extent of total heavy metal migration to a concentration of one part per billion was approximately the same as the one pCi per liter total radionuclide level (see Figure H-15).

H.8.4.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of Action Alternative 2.

Surface Release Caused by Drilling into the Repository

Under Action Alternative 2, the estimated release to the ground surface from a drilling intrusion depends on the kind of waste panel intercepted by the drilling equipment. The predicted release would be 0.8 Ci from CH-TRU waste and 0.02 Ci from RH-TRU waste using the median parameter values of Case 12. Using the 75th percentile parameter values of Case 14, the predicted release would be 1.0 and 0.02 curies from CH-TRU waste and RH-TRU waste, respectively. Releases were mainly of Am-241, Pu-239, and Pu-238. Heavy metal releases from an intrusion were estimated at 1.9 and 3.4 kilograms (4.2 and 7.5 pounds) from CH-TRU waste and RH-TRU waste, respectively, using median parameter values of Case 12 and 2.3 and 4.2 kilograms (5.1 and 9.2 pounds) using 75th percentile parameter values of Case 14. Results of these analyses are presented in Tables H-35 and H-36.

Radiological impacts to the drilling crew member from a drilling intrusion under Case 12 (median parameter values) resulted in a 5.1×10^{-5} and 9.9×10^{-7} probability of an LCF for CH-TRU and RH-TRU waste, respectively. For Case 14 (75th percentile parameter values), the impacts were higher, with a 1.0×10^{-4} and 1.6×10^{-6} probability of an LCF for CH-TRU and RH-TRU waste, respectively. The dominant exposure pathway was by ingestion of drill cuttings, with Am-241 contributing 87 to 99 percent of the total dose. Results are presented in Table H-37. Ingestion of heavy metals for this scenario would result in a 3.2×10^{-8} and 8.5×10^{-10} probability of cancer incidence for intrusions in CH-TRU and RH-TRU waste, respectively. There would be no noncarcinogenic impacts expected from ingestion of the metals because all hazard indices would be much less than one. Impacts from ingestion of heavy metals are shown in Table H-38.

Radiological impacts to the well-site geologist for Case 12 (median parameter values) from external radiation would result in a 6.3×10^{-9} probability of an LCF for CH-TRU waste and a 4.2×10^{-9} probability of an LCF for RH-TRU waste. For Case 14 (75th percentile parameter values), the radiological impacts would be a 7.0×10^{-9} probability of an LCF for CH-TRU waste and a 1.4×10^{-8} probability of an LCF for RH-TRU waste. Results of these analyses are presented in Table H-39.

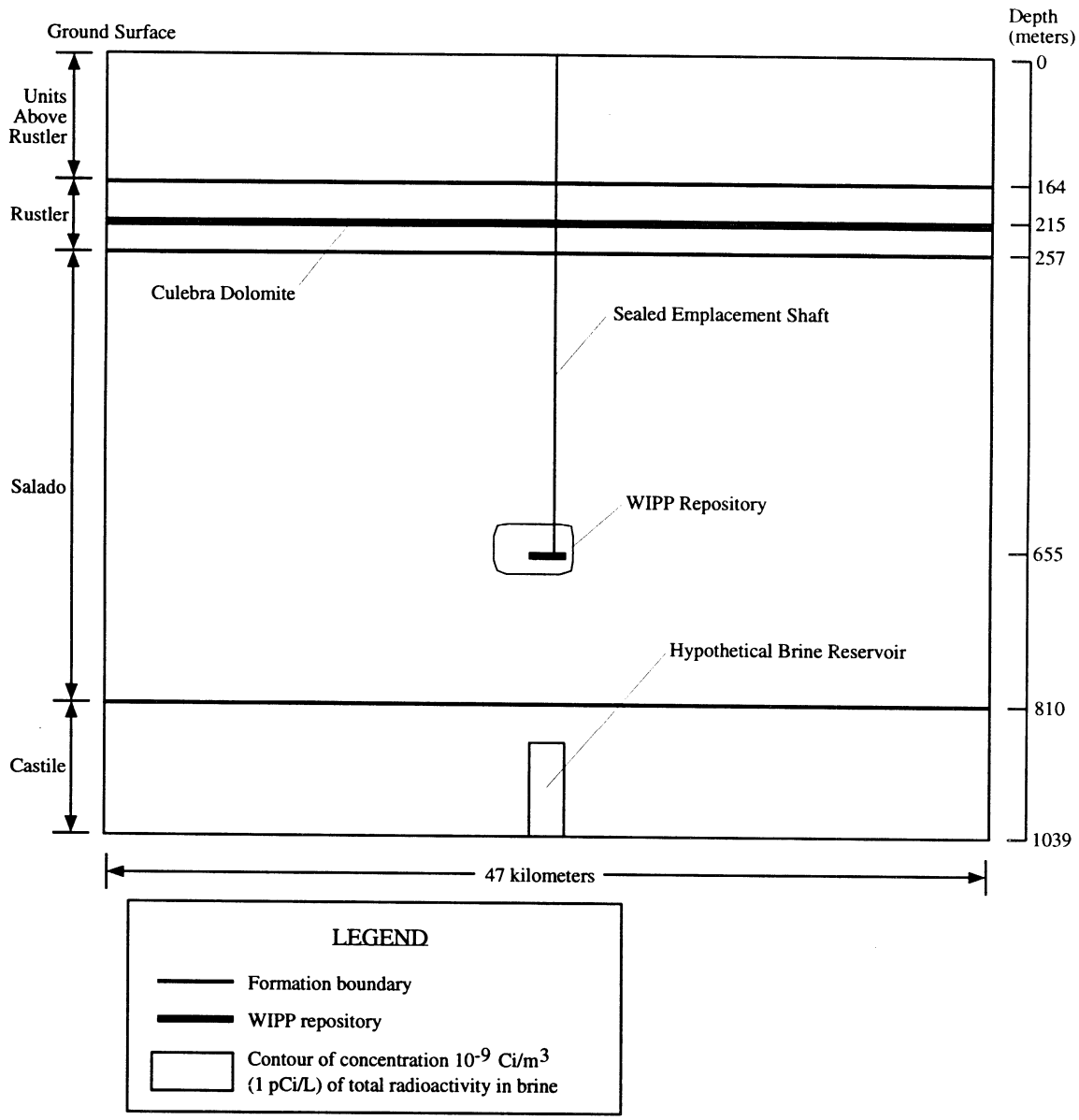


Figure H-15
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) for Action Alternative 2

Table H-35
Radionuclide Releases (curies) to the Ground Surface from Drilling Intrusions for Action Alternative 2

Radionuclide	Case 12 (Median Parameters) Intrusion at 400 Years After Closure		Case 14 (75th Percentile Parameters) Intrusion at 300 Years After Closure	
	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
Ac-227	5.28E-09	5.70E-07	3.75E-09	5.18E-07
Am-241	2.81E-01	5.34E-03	5.61E-01	7.81E-03
Cm-243	5.57E-12	3.29E-09	1.19E-10	4.67E-08
Cm-244	1.38E-09	8.37E-11	1.18E-07	4.80E-09
Cs-137	1.29E-06	1.96E-05	2.32E-05	2.47E-04
Pa-231	5.78E-09	6.18E-07	4.22E-09	5.79E-07
Pb-210	3.20E-07	9.29E-09	4.53E-07	6.26E-09
Pu-238	7.82E-02	5.96E-05	6.38E-02	1.64E-04
Pu-239	4.36E-01	9.51E-03	3.81E-01	1.19E-02
Pu-240	1.64E-05	9.93E-07	3.09E-05	1.25E-06
Pu-241	1.25E-08	5.73E-10	1.45E-06	8.80E-08
Sr-90	8.96E-07	1.45E-05	1.72E-05	1.95E-04
U-232	3.46E-06	1.40E-08	1.69E-05	4.56E-08
U-233	4.87E-03	3.33E-05	9.10E-03	4.15E-05
U-234	6.63E-04	3.71E-05	2.56E-04	4.62E-05
Y-90	8.96E-07	1.45E-05	1.73E-05	1.95E-04
Total	0.80	0.02	1.02	0.02

Table H-36
Releases (kilograms) of Heavy Metals to the Ground Surface from Drilling Intrusions for Action Alternative 2

Heavy Metal	Case 12 (Median Parameters) Intrusion at 400 Years After Closure		Case 14 (75th Percentile Parameters) Intrusion at 300 Years After Closure	
	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
Lead	1.29E + 00	3.36E + 00	1.60E + 00	4.19E + 00
Beryllium	3.25E-02	8.78E-04	4.06E-02	1.09E-03
Cadmium	4.67E-04	1.25E-05	5.82E-04	1.56E-05
Mercury	5.52E-01	1.49E-02	6.88E-01	1.86E-02
Total	1.87	3.38	2.33	4.21

Table H-37
Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for Action Alternative 2

Case 12 (Median Parameters) Intrusion at 400 Years After Closure				Case 14 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
Radionuclide	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**	**Radionuclide**	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**
CH-TRU Waste							
Am-241	9.8E-02	3.1E-03	1.0E-01	Am-241	1.9E-01	6.1E-03	2.0E-01
Pu-239	2.0E-03	4.7E-05	2.1E-03	Pu-239	1.8E-03	4.1E-05	1.8E-03
Pu-238	3.5E-04	3.7E-06	3.5E-04	Pu-238	2.9E-04	3.1E-06	2.9E-04
U-233	1.2E-05	1.8E-06	1.4E-05	Cs-137	1.0E-07	3.3E-05	3.3E-05
Cs-137	5.7E-09	1.9E-06	1.9E-06	U-233	2.2E-05	3.4E-06	2.6E-05
U-234	1.6E-06	9.6E-08	1.7E-06	U-234	6.2E-07	3.7E-08	6.6E-07
Pb-210	1.6E-07	2.5E-10	1.6E-07	Y-90	1.8E-08	2.8E-07	3.0E-07
Pu-240	8.0E-08	8.3E-10	8.1E-08	Pb-210	2.2E-07	3.6E-10	2.2E-07
U-232	2.2E-08	8.5E-10	2.3E-08	Sr-90	1.9E-07	4.7E-09	2.0E-07
Y-90	9.1E-10	1.4E-08	1.5E-08	Pu-240	1.5E-07	1.5E-09	1.5E-07
Sr-90	1.0E-08	2.5E-10	1.0E-08	U-232	1.1E-07	4.1E-09	1.1E-07
Ac-227	7.0E-09	1.0E-12	7.0E-09	Cm-244	2.2E-08	4.8E-12	2.2E-08
Pa-231	5.9E-09	4.3E-10	6.3E-09	Ac-227	4.9E-09	7.4E-13	4.9E-09
Cm-244	2.6E-10	5.6E-14	2.6E-10	Pa-231	4.2E-09	3.0E-10	4.5E-09
Cm-243	1.3E-12	1.3E-12	2.6E-12	Pu-241	1.1E-10	1.4E-16	1.1E-10
Pu-241	8.4E-13	1.1E-18	8.4E-13	Cm-243	2.8E-11	2.8E-11	5.6E-11
Total Dose (rem)	1.0E-01	3.2E-03	1.0E-01	**Total Dose (rem)**	1.9E-01	6.2E-03	2.0E-01
Probability of LCF	5.0E-05	1.6E-06	5.1E-05	**Probability of LCF**	9.6E-05	3.1E-06	1.0E-04
RH-TRU Waste							
Am-241	1.9E-03	5.9E-05	1.9E-03	Am-241	2.7E-03	8.5E-05	2.7E-03
Pu-239	4.4E-05	1.0E-06	4.5E-05	Cs-137	1.1E-06	3.5E-04	3.5E-04
Cs-137	9.0E-08	2.9E-05	2.9E-05	Pu-239	5.5E-05	1.3E-06	5.6E-05
Ac-227	7.5E-07	1.1E-10	7.5E-07	Y-90	2.1E-07	3.1E-06	3.3E-06
Pa-231	6.2E-07	4.5E-08	6.6E-07	Sr-90	2.3E-06	5.5E-08	2.4E-06
Pu-238	2.7E-07	2.9E-09	2.7E-07	Pu-238	7.6E-07	8.3E-09	7.7E-07
Y-90	1.5E-08	2.3E-07	2.5E-07	Ac-227	6.9E-07	1.0E-10	6.9E-07
Sr-90	1.6E-07	3.9E-09	1.6E-07	Pa-231	5.9E-07	4.3E-08	6.3E-07
U-234	9.3E-08	5.5E-09	9.9E-08	U-234	1.1E-07	6.7E-09	1.2E-07
U-233	8.1E-08	1.2E-08	9.3E-08	U-233	1.0E-07	1.6E-08	1.2E-07
Pb-210	4.7E-09	7.4E-12	4.7E-09	Cm-243	1.1E-08	1.1E-08	2.2E-08
Pu-240	4.6E-09	4.6E-11	4.7E-09	Pu-240	5.5E-09	6.0E-11	5.5E-09
Cm-243	7.8E-10	7.3E-10	1.5E-09	Pb-210	3.2E-09	5.0E-12	3.2E-09
U-232	8.8E-11	3.4E-12	9.2E-11	Cm-244	9.0E-10	1.9E-13	9.0E-10
Cm-244	1.6E-11	3.3E-15	1.6E-11	U-232	2.9E-10	1.1E-11	3.0E-10
Pu-241	4.0E-14	5.0E-20	4.0E-14	Pu-241	6.3E-12	7.9E-18	6.3E-12
Total Dose (rem)	1.9E-03	8.9E-05	2.0E-03	**Total Dose (rem)**	2.8E-03	4.4E-04	3.1E-03
Probability of LCF	9.7E-07	4.5E-08	9.9E-07	**Probability of LCF**	1.4E-06	2.2E-07	1.6E-06

Table H-38
Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals from Drilling Intrusion into the Repository for Action Alternative 2

Heavy Metals	Case 12 (Median Parameters)		Case 14 (75th Percentile Parameters)	
	Probability of Cancer Incidence	Hazard Index	Probability of Cancer Incidence	Hazard Index
CH-TRU Waste				
Beryllium	3.2E-08	1.5E-06	3.2E-08	1.5E-06
Cadmium	6.7E-10	2.1E-07	6.7E-10	2.1E-07
Lead	0	2.1E-04	0	2.1E-04
Mercury	0	4.2E-04	0	4.2E-04
RH-TRU Waste				
Beryllium	8.5E-10	4.0E-08	8.5E-10	4.0E-08
Cadmium	1.8E-11	5.7E-09	1.8E-11	5.7E-09
Lead	0	5.4E-04	0	5.4E-04
Mercury	0	1.1E-05	0	1.1E-05

Table H-39
Radiation Dose to the Well-Site Geologist from Drilling Intrusions for Action Alternative 2

Case 12 (Median Parameters) Intrusion at 400 Years After Closure				Case 14 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
CH-TRU Waste		RH-TRU Waste		CH-TRU Waste		RH-TRU Waste	
Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)
Am-241	8.2E-06	Am-241	3.7E-06	Am-241	9.5E-06	Sr-90	1.3E-05
U-234	4.0E-06	U-234	2.6E-06	U-234	4.0E-06	Cs-137	7.2E-06
Pu-239	1.6E-07	Sr-90	1.2E-06	Pu-239	1.6E-07	Am-241	4.1E-06
U-233	1.4E-07	Cs-137	7.2E-07	U-233	1.4E-07	U-234	2.6E-06
Pu-240	2.8E-08	Pu-239	4.8E-08	Pu-238	3.7E-08	Pu-239	4.8E-08
Ac-225	2.4E-08	U-233	3.2E-08	Pu-240	3.0E-08	U-233	3.2E-08
Pu-238	1.8E-08	Pu-240	1.9E-08	Sr-90	2.1E-08	Pu-240	2.0E-08
Sr-90	1.9E-09	Ac-225	2.5E-09	Ac-225	1.8E-08	Y-90	1.9E-09
Cs-137	8.4E-10	Pa-231	3.2E-10	Cs-137	8.4E-09	Ac-225	1.8E-09
Pb-210	2.0E-11	Pu-238	2.5E-10	Pb-210	2.0E-11	Pu-238	5.6E-10
Pa-231	2.9E-12	Y-90	1.8E-10	Y-90	3.0E-12	Pa-231	2.5E-10
U-232	3.3E-13	U-232	7.9E-14	Pa-231	2.2E-12	U-232	2.0E-13
Y-90	2.7E-13	Pb-210	7.7E-18	U-232	8.6E-13	Pb-210	3.0E-18
Pu-241	4.8E-17	Pu-241	5.1E-21	Pu-241	4.8E-17	Pu-241	6.3E-19
Total Dose (rem)	1.3E-05	**Total Dose (rem)**	8.3E-06	**Total Dose (rem)**	1.4E-05	**Total Dose (rem)**	2.7E-05
Probability of LCF	6.3E-09	**Probability of LCF**	4.2E-09	**Probability of LCF**	7.0E-09	**Probability of LCF**	1.4E-08

Drilling Through the Repository into a Pressurized Brine Reservoir

Radionuclide migration for disturbed conditions at 10,000 years after closure for Case 12 (median parameter values) and Case 14 (75th percentile parameter values) showed the migration of total radionuclide concentrations of one pCi per liter migrating upward and downward in the exploratory borehole. Heavy metal (predominantly lead) concentrations of one part per billion exhibited a similar pattern of migration. In both cases, contaminants at these levels penetrated a short distance into the surrounding rock and down into the Castile Formation and the hypothetical brine reservoir. The migration down to the brine would occur as the initial pressure in the brine reservoir dissipates and equilibrates with pressures in the repository and the surrounding units penetrated by the borehole.

Radionuclide migration for Case 14, shown in Figure H-16, resulted in a higher vertical upward migration than Case 12 and a release of contaminants into the Culebra Dolomite. The estimated maximum release rate of 2.5 Ci per year (predominantly Am-241, Pu-239 and Pu-240) and 49 kilograms (108 pounds) per year of heavy metals (predominantly lead) would occur at approximately 500 years after closure. The estimated total release to the Culebra Dolomite would be 286 Ci and 20,890 kilograms (46,050 pounds) of heavy metals, with the release occurring from 500 years to 4,500 years after closure. Analyses of releases to the Culebra showed that contaminants would be highly sorbed and only small amounts would migrate from the point of intrusion over 10,000 years. Transport calculations for Case 14 releases to the Culebra were made with the SECOTP2D model of the Culebra developed for the CCA (DOE 1996f).

Radiological impacts were calculated to an individual, such as a rancher, who consumed beef from cattle that had consumed water from a stock well located downgradient at the Land Withdrawal Area boundary 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions, since calculated impacts for full mining conditions were significantly lower. Radiological impacts would be negligible, with a 7×10^{-28} probability of an LCF. The principal dose contributor was Pu-239, with the 10 other radionuclides contributing no more than 0.2 percent of Pu-239. Ingestion of heavy metals from consumption of contaminated beef, was also found to result in negligible impacts, with a probability of cancer incidence of 3×10^{-27}. No noncarcinogenic impacts would be expected.

H.8.5 Results for Action Alternative 3

Long-term performance assessment analyses were conducted for Action Alternative 3 using the same methods as were used for other alternatives. The radionuclide and heavy metal inventories were similar to those of Action Alternatives 1 and 2 (see Chapter 3 and Appendix A). Total radionuclide inventories of 7.3×10^{6} Ci in CH-TRU waste and 5.1×10^{6} Ci in RH-TRU waste were included. Detailed information on the radionuclide and heavy metal inventories is provided in Appendix A. The repository size was adjusted from 10 panels (for the Proposed Action) to 71 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action and other alternatives.

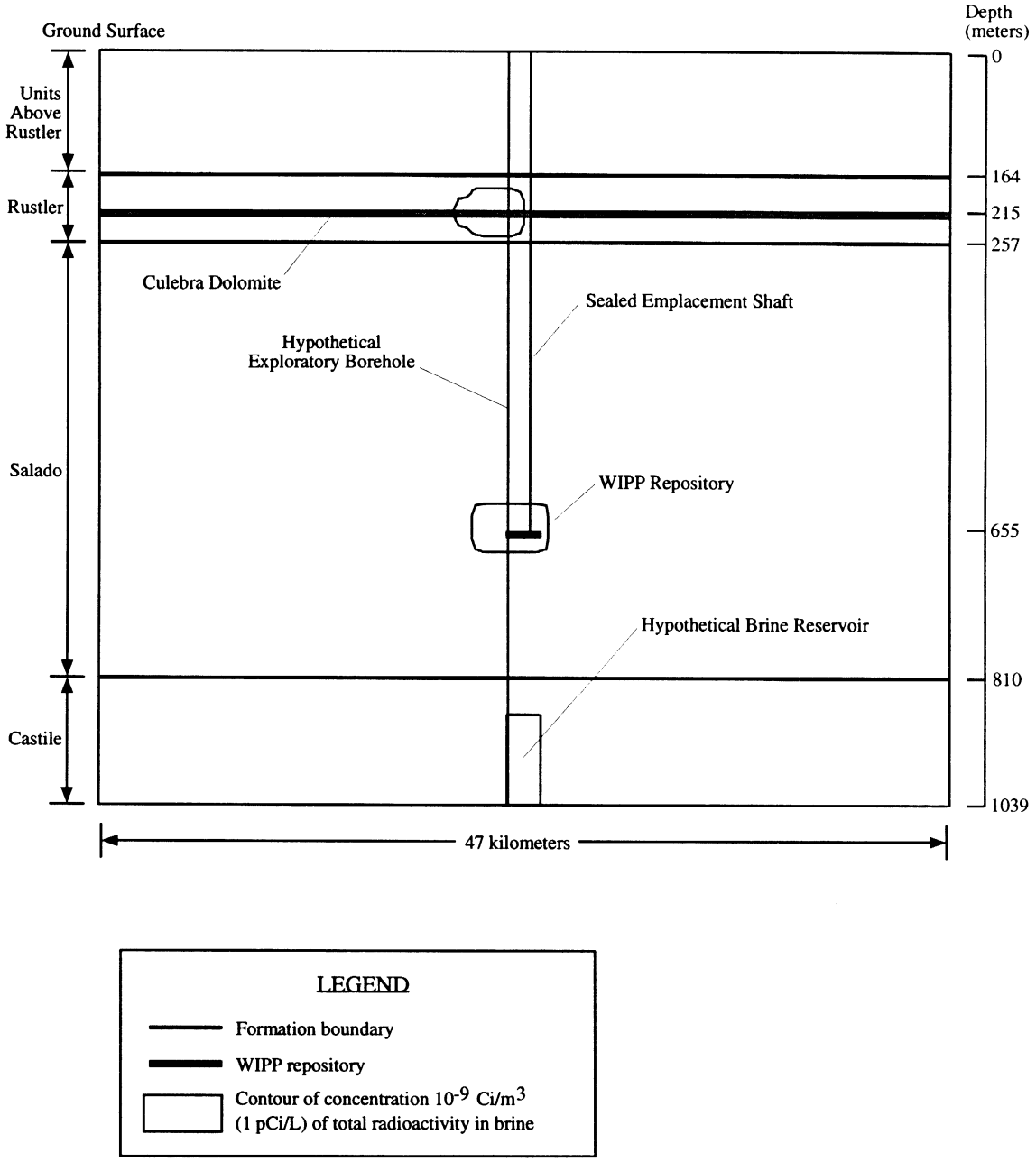


Figure H-16
Extent of Radionuclide Migration at 10,000 Years with Disturbed Conditions Using 75th Percentile Parameter Values (Case 14) for Action Alternative 2

The four cases below were analyzed for Action Alternative 3. The cases considered the following conditions:

- Case 16 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions have been defined.
- Case 17 considered an intrusion resulting from exploratory drilling. It was assumed that the repository would be penetrated and the drill would intercept a pressurized brine pocket in the Castile Formation. Median parameter values were used.
- Case 18 considered undisturbed repository conditions. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.
- Case 19 considered the same disturbed conditions as Case 17. Seventy-fifth percentile parameter values were used.

Cases 16 through 19 were simulated in BRAGFLO to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of time after closure, are depicted in Figure H-17. The pressure release of the waste panel as a result of the exploratory drilling event at 400 years after closure for Case 17 and 300 years after closure for Case 19 is clearly evident in this figure. Secondary pertubations in the pressure curves at approximately 700 and 1,700 years after closure are due to material property changes imposed in the BRAGFLO simulation, to account for degradation of the exploratory borehole concrete plug (200 years following intrusion) and the degradation of the borehole backfill (1,200 years after intrusion). Brine pressures in the

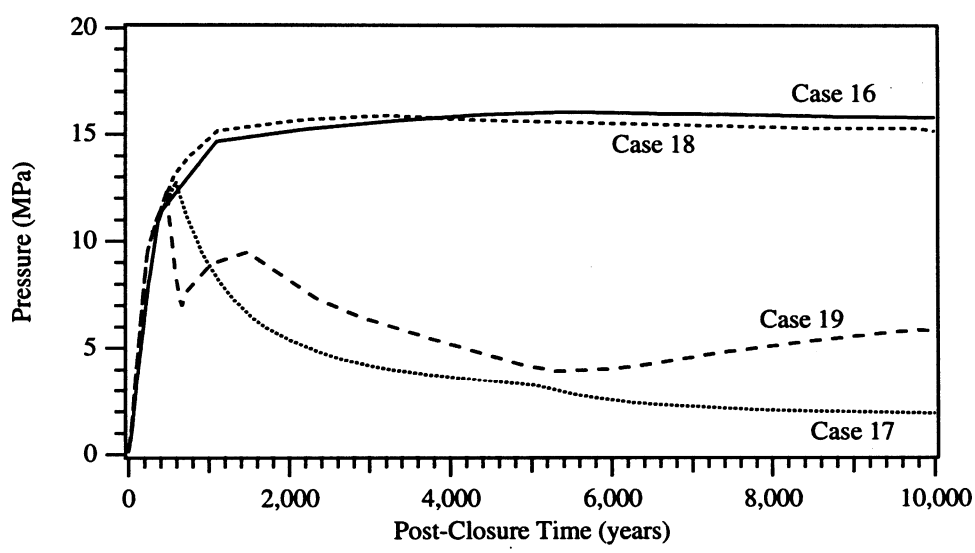


Figure H-17
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 3

panel remain below lithostatic conditions at 10,000 years after closure for the intrusion cases. The biodegradable material is completely consumed in the gas generation process for all four cases. The iron inventory is completely consumed in the gas generation process for both of the intrusion cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

H.8.5.1 Impacts of Undisturbed Conditions

The extent of radionuclide and heavy metal (predominantly lead) migration for undisturbed conditions at 10,000 years after closure for Case 18 (using 75th percentile parameter values) was very similar to that shown for Case 8 of Action Alternative 1. Migration of total radionuclide concentrations of one pCi per liter extend about 20 meters (65 feet) below the repository. The maximum distance of lateral migration at the same concentration level was about 1,900 meters (6,200 feet). The maximum extent of vertical upward migration was calculated to be about 40 meters (130 feet) above the top of the repository. The extent of total heavy metal migration to a concentration to one part per billion was also approximately the same as the one pCi per liter total radionuclide level calculated for Case 8 of Action Alternative 1.

H.8.5.2 Impacts of Disturbed Conditions

This section presents the impacts of two exposure scenarios evaluated for disturbed conditions of Action Alternative 3.

Surface Release Caused by Drilling into the Repository

For Action Alternative 3, the release of radionuclides to the ground surface from a drilling intrusion for Case 17 (median parameter values) would be 2.2, 0.1, and 2.3 Ci, respectively, for intrusions into a panel containing CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. For Case 19 (75th percentile parameter values), the radionuclide release would be 3, 0.15, and 3 Ci for the same respective intrusions. Radionuclides released were mainly Am-241, Pu-239, and Pu-238. Under Case 17, heavy metal releases from an intrusion were estimated at 5, 22, and 18 kilograms (11, 48, and 39 pounds), respectively. Under Case 19, the heavy metal releases were estimated at 7, 30, and 23 kilograms (15, 66, and 51 pounds) for the same respective intrusions. Results of these analyses are presented in Tables H-40 and H-41.

Radiological impacts to the drilling crew member from the drilling intrusion for Case 17 (median parameter values) would result in a 1.4×10^{-4}, 6.8×10^{-6}, and 1.4×10^{-4} probability of an LCF, respectively, for intrusions into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. For Case 19 (75th percentile parameter values), the impacts would be higher, at a 2.8×10^{-4}, 1.2×10^{-5}, and 2.8×10^{-4} probability of an LCF for the same respective intrusions. The dominant exposure pathway was by ingestion of drill cuttings, with Am-241 contributing 87 to 98 percent of the total dose. Results are presented in Table H-42.

Table H-40
Radionuclide Releases (curies)
to the Ground Surface from Drilling Intrusions for Action Alternative 3

Radionuclide	Case 17 (Median Parameters) Intrusion at 400 Years After Closure			Case 19 (75th Percentile Parameters) Intrusion at 300 Years After Closure		
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste
Ac-227	1.45E-08	3.77E-06	2.12E-06	1.09E-08	3.64E-06	2.05E-06
Am-241	7.72E-01	3.53E-02	7.91E-01	1.64E+00	5.49E-02	1.67E+00
Cm-243	1.53E-11	2.18E-08	1.22E-08	3.46E-10	3.28E-07	1.84E-07
Cm-244	3.78E-09	5.54E-10	4.09E-09	3.45E-07	3.37E-08	3.64E-07
Cs-137	3.53E-06	1.30E-04	7.61E-05	6.76E-05	1.74E-03	1.04E-03
Pa-231	1.58E-08	4.09E-06	2.30E-06	1.23E-08	4.07E-06	2.29E-06
Pb-210	8.77E-07	6.14E-08	9.11E-07	1.32E-06	4.41E-08	1.35E-06
Pu-238	2.14E-01	3.94E-04	2.15E-01	1.86E-01	1.15E-03	1.87E-01
Pu-239	1.20E+00	6.28E-02	1.23E+00	1.11E+00	8.36E-02	1.16E+00
Pu-240	4.48E-05	6.57E-06	4.85E-05	9.01E-05	8.80E-06	9.51E-05
Pu-241	3.41E-08	3.79E-09	3.63E-08	4.24E-06	6.19E-07	4.58E-06
Sr-90	2.46E-06	9.56E-05	5.59E-05	5.03E-05	1.37E-03	8.16E-04
U-232	9.48E-06	9.22E-08	9.53E-06	4.94E-05	3.20E-07	4.96E-05
U-233	1.34E-02	2.20E-04	1.35E-02	2.66E-02	2.92E-04	2.67E-02
U-234	1.82E-03	2.45E-04	1.95E-03	7.46E-04	3.25E-04	9.28E-04
Y-90	2.46E-06	9.57E-05	5.59E-05	5.03E-05	1.37E-03	8.17E-04
Total	2.20	0.099	2.25	2.96	0.145	3.04

Table H-41
Releases (kilograms) of Heavy Metals
to the Ground Surface from Drilling Intrusions for Action Alternative 3

Heavy Metal	Case 17 (Median Parameters) Intrusion at 400 Years After Closure			Case 19 (75th Percentile Parameters) Intrusion at 300 Years After Closure		
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste
Lead	3.53E+00	2.22E+01	1.60E+01	4.68E+00	2.95E+01	2.12E+01
Beryllium	8.29E-02	5.80E-03	8.61E-02	1.10E-01	7.70E-03	1.14E-01
Cadmium	1.28E-03	8.28E-05	1.33E-03	1.70E-03	1.10E-04	1.76E-03
Mercury	1.51E+00	9.84E-02	1.57E+00	2.01E+00	1.31E-01	2.08E+00
Total	5.13	22.33	17.61	6.80	29.61	23.35

Table H-42
Radiation Dose to a Member of the Drilling Crew from Drilling Intrusions for Action Alternative 3

Case 17 (Median Parameters) Intrusion at 400 Years After Closure				Case 19 (75th Percentile Parameters) Intrusion at 300 Years After Closure			
Radionuclide	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**	**Radionuclide**	**Ingestion Dose (rem)**	**External Dose (rem)**	**Total Dose (rem)**
CH-TRU Waste							
Am-241	2.6E-01	8.4E-03	2.7E-01	Am-241	5.4E-01	1.8E-02	5.6E-01
Pu-239	5.5E-03	1.3E-04	5.6E-03	Pu-239	5.0E-03	1.1E-04	5.1E-03
Pu-238	9.6E-04	1.0E-05	9.7E-04	Pu-238	8.1E-04	8.8E-06	8.2E-04
U-233	3.1E-05	5.0E-06	3.6E-05	Cs-137	3.0E-07	9.9E-05	9.9E-05
Cs-137	1.6E-08	5.3E-06	5.3E-06	U-233	6.6E-05	9.9E-06	7.6E-05
U-234	4.4E-06	2.6E-07	4.7E-06	U-234	1.8E-06	1.1E-07	1.9E-06
Pb-210	4.4E-07	7.0E-10	4.4E-07	Y-90	5.2E-08	7.7E-07	8.3E-07
Pu-240	2.1E-07	2.2E-09	2.1E-07	Pb-210	6.4E-07	1.1E-09	6.4E-07
U-232	6.0E-08	2.3E-09	6.3E-08	Sr-90	5.8E-07	1.4E-08	6.0E-07
Y-90	2.5E-09	3.7E-08	3.9E-08	Pu-240	4.2E-07	4.3E-09	4.2E-07
Sr-90	2.8E-08	6.5E-10	2.9E-08	U-232	3.1E-07	1.2E-08	3.2E-07
Ac-227	2.0E-08	3.0E-12	2.0E-08	Cm-244	6.6E-08	1.4E-11	6.6E-08
Pa-231	1.6E-08	1.2E-09	1.7E-08	Ac-227	1.4E-08	2.1E-12	1.4E-08
Cm-244	7.0E-10	1.5E-13	7.0E-10	Pa-231	1.2E-08	8.9E-10	1.3E-08
Cm-243	3.5E-12	3.5E-12	7.0E-12	Pu-241	3.0E-10	3.8E-16	3.0E-10
Pu-241	2.5E-12	3.2E-18	2.5E-12	Cm-243	8.3E-11	8.0E-11	1.6E-10
Total Dose (rem)	2.7E-01	8.6E-03	2.8E-01	**Total Dose (rem)**	5.5E-01	1.8E-02	5.7E-01
Probability of LCF	1.3E-04	4.3E-06	1.4E-04	**Probability of LCF**	2.7E-04	9.1E-06	2.8E-04
RH-TRU Waste							
Am-241	1.2E-02	4.0E-04	1.3E-02	Am-241	1.9E-02	6.1E-04	2.0E-02
Pu-239	2.9E-04	6.7E-06	3.0E-04	Cs-137	8.1E-06	2.6E-03	2.6E-03
Cs-137	5.7E-07	1.9E-04	1.9E-04	Pu-239	3.9E-04	9.0E-06	4.0E-04
Ac-227	5.1E-06	7.5E-10	5.1E-06	Y-90	1.4E-06	2.2E-05	2.3E-05
Pa-231	4.0E-06	2.9E-07	4.3E-06	Sr-90	1.6E-05	3.9E-07	1.6E-05
Pu-238	1.8E-06	1.9E-08	1.8E-06	Pu-238	5.3E-06	6.0E-08	5.3E-06
Y-90	9.7E-08	1.5E-06	1.6E-06	Ac-227	4.8E-06	7.2E-10	4.8E-06
Sr-90	1.1E-06	2.6E-08	1.1E-06	Pa-231	4.0E-06	2.9E-07	4.3E-06
U-233	5.8E-07	8.5E-08	6.6E-07	U-234	8.0E-07	4.7E-08	8.5E-07
U-234	5.9E-07	3.5E-08	6.3E-07	U-233	6.8E-07	1.0E-07	7.8E-07
Pb-210	3.0E-08	4.9E-11	3.1E-08	Cm-243	7.8E-08	7.3E-08	1.5E-07
Pu-240	3.1E-08	3.2E-10	3.1E-08	Pu-240	4.1E-08	4.3E-10	4.2E-08
Cm-243	5.5E-09	5.2E-09	1.1E-08	Pb-210	2.2E-08	3.5E-11	2.2E-08
U-232	5.8E-10	2.2E-11	6.1E-10	Cm-244	6.2E-09	1.3E-12	6.2E-09
Cm-244	1.1E-10	2.2E-14	1.1E-10	U-232	2.0E-09	7.5E-11	2.1E-09
Pu-241	2.7E-13	3.3E-19	2.7E-13	Pu-241	4.4E-11	5.5E-17	4.4E-11
Total Dose (rem)	1.2E-02	6.0E-04	1.4E-02	**Total Dose (rem)**	1.9E-02	3.2E-03	2.3E-02
Probability of LCF	6.2E-06	3.0E-07	6.8E-06	**Probability of LCF**	9.7E-06	1.6E-06	1.2E-05
CH-TRU and RH-TRU Waste							
Am-241	2.7E-01	8.8E-03	2.8E-01	Am-241	5.4E-01	1.8E-02	5.6E-01
Pu-239	5.5E-03	1.3E-04	5.6E-03	Pu-239	5.5E-03	1.3E-04	5.6E-03
Pu-238	9.6E-04	1.0E-05	9.7E-04	Cs-137	4.5E-06	1.4E-03	1.4E-03
Cs-137	3.4E-07	1.1E-04	1.1E-04	Pu-238	8.1E-04	8.8E-06	8.2E-04
U-233	3.4E-05	5.3E-06	3.9E-05	U-233	6.6E-05	9.9E-06	7.6E-05
U-234	4.9E-06	2.9E-07	5.2E-06	Y-90	8.2E-07	1.2E-05	1.3E-05
Ac-227	2.8E-06	4.2E-10	2.8E-06	Sr-90	9.2E-06	2.2E-07	9.4E-06
Pa-231	2.3E-06	1.6E-07	2.5E-06	Ac-227	2.8E-06	4.2E-10	2.8E-06
Y-90	5.7E-08	8.5E-07	9.0E-07	Pa-231	2.3E-06	1.6E-07	2.5E-06
Sr-90	6.4E-07	1.5E-08	6.6E-07	U-234	2.3E-06	1.3E-07	2.4E-06
Pb-210	4.6E-07	7.3E-10	4.6E-07	Pb-210	7.0E-07	1.1E-09	7.0E-07
Pu-240	2.2E-07	2.3E-09	2.3E-07	Pu-240	4.4E-07	4.5E-09	4.5E-07
U-232	6.1E-08	2.3E-09	6.3E-08	U-232	3.1E-07	1.2E-08	3.2E-07
Cm-243	2.8E-09	2.8E-09	5.6E-09	Cm-243	4.3E-08	4.1E-08	8.4E-08
Cm-244	7.6E-10	1.6E-13	7.6E-10	Cm-244	6.8E-08	1.4E-11	6.8E-08
Pu-241	2.6E-12	3.2E-18	2.6E-12	Pu-241	3.4E-10	4.2E-16	3.4E-10
Total Dose (rem)	2.8E-01	9.1E-03	2.9E-01	**Total Dose (rem)**	5.5E-01	2.0E-02	5.7E-01
Probability of LCF	1.4E-04	4.5E-06	1.4E-04	**Probability of LCF**	2.7E-04	9.8E-06	2.8E-04

Ingestion of heavy metals under this scenario would result in a 1.5 x 10^{-8}, 1.0 x 10^{-9}, and 1.5 x 10^{-8} probability of cancer incidence, respectively, for intrusions into CH-TRU waste, RH-TRU waste, and both CH-TRU and RH-TRU waste. There would be no noncarcinogenic impacts expected from ingestion of the metals because all hazard indices would be much less than one. Impacts from ingestion of heavy metals are shown in Table H-43.

Radiological impacts to the well-site geologist from external radiation exposure for Case 17 (median parameter values) would be a 2.1 x 10^{-9} probability of an LCF from CH-TRU waste and a 1.2 x 10^{-9} probability of an LCF from RH-TRU waste. For Case 19 (75th percentile parameter values), the radiological impacts would be a 2.2 x 10^{-9} probability of an LCF from CH-TRU waste and a 4.0 x 10^{-9} probability of an LCF from RH-TRU waste. Results of these analyses are presented in Table H-44.

Drilling Through the Repository into a Pressurized Brine Reservoir

Radionuclide migration for disturbed conditions at 10,000 years after closure for Case 17 (median parameter values) and Case 19 (75th percentile parameter values) showed migration of total radionuclide concentrations of one pCi per liter migrating upward and downward in the exploratory borehole. In both cases, contaminants at these levels penetrated a short distance into the surrounding rock and down into the Castile Formation and the hypothetical brine reservoir. The migration down to the brine would occur as the initial pressure in the reservoir dissipates and equilibrates with pressures in the repository and the surrounding units penetrated by the borehole. Heavy metal concentrations of one part per billion were similar to those calculated for Case 9 of Action Alternative 1.

Table H-43
Carcinogenic and Noncarcinogenic Impacts from Ingestion of Metals from Drilling Intrusions into the Repository for Action Alternative 3

Hazardous Metal	Case 17 (Median Values)		Case 19 (75th Percentile Values)	
	Probability of Cancer Incidence	Hazard Index	Probability of Cancer Incidence	Hazard Index
CH-TRU Waste				
Beryllium	1.5E-08	6.8E-07	1.5E-08	6.8E-07
Cadmium	3.3E-10	1.1E-07	3.3E-10	1.1E-07
Lead	0	1.0E-04	0	1.0E-04
Mercury	0	2.1E-04	0	2.1E-04
RH-TRU Waste				
Beryllium	1.0E-09	4.8E-08	1.0E-09	4.8E-08
Cadmium	2.1E-11	6.8E-09	2.1E-11	6.8E-09
Lead	0	6.5E-04	0	6.5E-04
Mercury	0	1.3E-05	0	1.3E-05
CH-TRU and RH-TRU Waste				
Beryllium	1.5E-08	7.1E-07	1.5E-08	7.1E-07
Cadmium	3.4E-10	1.1E-07	3.4E-10	1.1E-07
Lead	0	4.7E-04	0	4.7E-04
Mercury	0	2.1E-04	0	2.1E-04

Table H-44
Radiation Dose to the Well-Site Geologist
from Drilling Intrusions for Action Alternative 3

Case 17 (Median Values) Intrusion at 400 Years After Closure				Case 19 (75th Percentile Values) Intrusion at 300 Years After Closure			
CH-TRU Waste		RH-TRU Waste		CH-TRU Waste		RH-TRU Waste	
Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)	Radionuclide	External Dose (rem)
Am-241	2.8E-06	Am-241	1.1E-06	Am-241	3.0E-06	Sr-90	3.9E-06
U-234	1.3E-06	U-234	7.9E-07	U-234	1.3E-06	Cs-137	2.0E-06
Pu-239	5.2E-08	Sr-90	3.6E-07	Pu-239	5.2E-08	Am-241	1.3E-06
U-233	4.5E-08	Cs-137	2.0E-07	U-233	4.5E-08	U-234	7.9E-07
Pu-240	9.0E-09	Pu-239	1.4E-08	Pu-238	1.2E-08	Pu-239	1.4E-08
Ac-225	7.2E-09	U-233	1.0E-08	Pu-240	9.1E-09	U-233	1.0E-08
Pu-238	5.5E-09	Pu-240	5.6E-09	Sr-90	6.7E-09	Pu-240	5.6E-09
Sr-90	6.1E-10	Ac-225	7.2E-10	Ac-225	5.6E-09	Y-90	5.6E-10
Cs-137	2.7E-10	Pa-231	9.7E-11	Cs-137	2.7E-09	Ac-225	5.3E-10
Pb-210	6.2E-12	Pu-238	7.5E-11	Pb-210	6.4E-12	Pu-238	1.8E-10
Pa-231	9.2E-13	Y-90	5.2E-11	Y-90	9.6E-13	Pa-231	7.1E-11
U-232	1.0E-13	U-232	2.4E-14	Pa-231	6.8E-13	U-232	6.3E-14
Y-90	8.8E-14	Pb-210	2.3E-18	U-232	2.8E-13	Pb-210	9.1E-19
Pu-241	1.6E-17	Pu-241	1.5E-21	Pu-241	1.6E-17	Pu-241	1.9E-19
Total Dose (rem)	4.2E-06	**Total Dose (rem)**	2.5E-06	**Total Dose (rem)**	4.4E-06	**Total Dose (rem)**	8.0E-06
Probability of LCF	2.1E-09	**Probability of LCF**	1.2E-09	**Probability of LCF**	2.2E-09	**Probability of LCF**	4.0E-09

Radionuclide and heavy metal migration for Case 19 (75th percentile parameter values) is essentially the same as shown in Figure H-13 for Case 9. Case 19 resulted in higher vertical upward migration than Case 17 and an actual release of contaminants into the Culebra Dolomite. The estimated maximum release rate of 1.3 Ci per year of radionuclides (predominantly Pu-239, Am-241, and Pu-240) and 57 kilograms (127 pounds) per year of heavy metals (predominantly lead) would occur at approximately 1,000 years after closure. The estimated total release to the Culebra Dolomite would be 1,090 Ci and 59,760 kilograms (131,700 pounds) of heavy metals, with the release occurring from 700 years to 3,900 years after closure. Analyses of releases to the Culebra showed that contaminants would be highly sorbed and only small amounts would migrate from the point of intrusion over 10,000 years. Transport calculations for Case 19 releases to the Culebra were made with the SECOTP2D model of the Culebra developed for the CCA (DOE 1996f).

Radiological impacts were calculated to an individual, such as a rancher, who consumed the beef of cattle that had consumed water from a stock well located downgradient at the land withdrawal area boundary 3 kilometers (2 miles) from the point of intrusion. Results are presented only for partial mining conditions, since calculated impacts for full mining conditions were significantly lower. Radiological impacts would be negligible, with a 2×10^{-27} probability of an LCF. The principal dose contributor was Pu-239 with all of the 10 other radionuclides contributing no more than 0.2 percent of Pu-239. Ingestion of heavy metals from consumption of contaminated beef was

also found to result in negligible impacts, with a maximum probability of cancer incidence of 3×10^{-25}. No noncarcinogenic impacts would be expected.

H.9 ALTERNATIVE CONCEPTUAL MODELS AND VIEWS OF DISPOSAL PERFORMANCE

Several qualified and respected organizations and individuals, including members and contractors of the EPA, the Environmental Evaluation Group (EEG), the Office of the Attorney General of New Mexico, and others have participated in critical review of major WIPP compliance documents that are an important part of the compliance process. Key compliance documents include the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), and the CCA (DOE 1996f). These document reviews have given rise to a number of alternative conceptual models and views regarding WIPP repository disposal system performance that are relevant to this analysis. This discussion is included to present other viewpoints of WIPP performance assessment and to discuss how SEIS-II analyses consider them in its calculations.

Most of the review comments pertain to the performance assessment process and scenario screening and selection. Primary concerns appear to lie with characteristics and processes of the Culebra Dolomite Member of the Rustler Formation and the Culebra's role in radionuclide transport and WIPP performance under certain human-intrusion scenarios. Less has been said about modeling of the Salado Formation salt and the repository. In light of the existence of natural resources and the region's hydrocarbon extraction and potash-mining history, the probabilities of human intrusion used in calculations have been questioned as well, and several additional scenarios have been suggested for analysis. This section provides a summary of most of the major findings and conclusions presented by these past reviewers. The review comments are organized into two categories: (1) WIPP characteristics and conceptual models and (2) human impacts and intrusion.

H.9.1 WIPP Characteristics and Conceptual Models

This section presents an overview of alternative opinions regarding currently used WIPP site characteristics data, conceptual models, and calculation methods put forth by scientific and engineering review organizations. This overview is organized into the following major subject areas: repository characteristics, Salado Formation, Rustler/Salado Contact, Rustler Formation/Culebra Dolomite Member, and units above the Rustler Formation.

H.9.1.1 Repository Characteristics

Radionuclide Mobility - Partitioning of Actinides Into Oxidation States

Generic actinide solubilities are used in the CCA (DOE 1996f) calculations (i.e., solubilities of actinides of the same oxidation state are assumed to be equal). Actinides with multiple oxidation states are partitioned according to a set of simple formulae. According to Neill et al. (1996), this partitioning approach forces an actinide species to exist at several simultaneous oxidation states in certain proportions, which is not supported by experimental evidence. Also, a large uncertainty was associated with the assumed distribution of aqueous solubilities.

The Department has planned all along that experimentally determined actinide solubilities from its Actinide Solubility Program would be incorporated into calculations as they became available. Now, solubility values for several actinides have been experimentally determined and are being incorporated into WIPP performance assessment calculations. The SEIS-II analyses have incorporated the new actinide solubility values in source-term release calculations.

Radionuclide Mobility - Colloids

The EEG (Neill et al. 1996) point out that colloids are thought to travel no faster than the noncolloidal dissolved contaminants. This assumption negates the concern about colloids and allows calculations of unconservative (i.e., lower-than-expected) transport rates. Therefore, initial colloid concentration is assumed instead of being measured or calculated.

Currently, WIPP performance assessments methods and codes incorporate the concentrations of colloidal radionuclides into source-term release calculations. DOE has recognized the issues related to radionuclides in colloid form. In the CCA, Section 6.4.5.4 (DOE 1996f), the following discussion is presented: "Colloidal activities are subject to retardation by interaction between colloids and solid surfaces and by clogging of small pore throats (that is, sieving). It is expected that there would be some interaction of colloids with solid surfaces in the anhydrite interbeds. Because of the low permeability of intact interbeds, it is expected that pore apertures are small and some sieving will occur. However, colloidal particles, if not retarded, are transported more rapidly than the average velocity of the bulk liquid flow. Because the effects on transport of increased average pore velocity and retarding interactions with solid surfaces and sieving are offsetting, the DOE assumes residual effects of these opposing processes will be either small or beneficial and does not incorporate them in modeling of the transport of actinides in the Salado interbeds." Similarly, SEIS-II analyses include calculated colloid concentrations and do not include consideration of colloid transport processes.

Radionuclide Transport Within Repository

The assumed location(s) of the intrusion borehole(s) penetrating a Castile Formation brine reservoir within the repository would affect calculated release rates of radionuclides from the repository (EPA 1995). The effect of multiple intrusions on flow and transport was analyzed in the E1E2 scenario in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), but radionuclide transport within the repository and the effect on release rates were not modeled.

The EPA (1995) evaluated the sensitivity of radionuclide release rates to borehole locations for several different geometries. The results of the analysis varied widely with both the number and the locations of the boreholes. In one case, most of the brine flowed quickly up the borehole leaving the radionuclides far behind. Four boreholes located at the corners of the repository enabled greater quantities of radionuclides to flow up the borehole. Ten uniformly arranged boreholes maximize the flow rate and quantity of radionuclides from the repository.

Radionuclide transport within the repository was not explicitly modeled in the CCA (DOE 1996f) or in the SEIS-II analyses. After a single intrusion, the pressure in the repository would decline substantially. For a multiple-intrusion scenario, the maximum impact would be seen in the first intrusion; less material would be released at any one borehole following the first intrusion because gas pressure would likely dissipate after the first intrusion. Therefore, although it is recognized

that multiple-borehole intrusion scenarios could result in higher cumulative releases than those from a single-borehole intrusion, the intrusion scenario analyzed for SEIS-II would result in the highest releases from a single event.

Isothermal Calculations With BRAGFLO

Neill et al. (1996) state that BRAGFLO, according to the description and application presented in the CCA (DOE 1996f), is "apparently an isothermal code," and that the justification for isothermal treatment of two-phase flow should be given. Neill et al. (1996) also feel that an assessment of errors introduced by this sort of approximation should be provided.

In the SEIS-II analyses, isothermal conditions were assumed for all simulations. With the thermal power limits imposed by planning-basis WAC, it is not anticipated that thermal loading from TRU waste will be an important factor in source-term release and near-field transport from the repository. The small amount of heat that will be generated by RH-TRU waste will be dissipated by the repository salt.

H.9.1.2 Salado Formation

Salado Halite and Interbed Parameters

The permeability of halite, as modeled in BRAGFLO, is that of "impure" halite and was determined through testing. Neill et al. (1996), in their review of the CCA (DOE 1996f), maintained that it should be demonstrated that halite permeability bounds the overall permeability when interbeds, such as polyhalite and anhydrite, in the halite are considered. In addition, the effects of increased permeability of anhydrite interbeds from elevated gas pressures on the overall impure halite permeability should be incorporated.

Similarly, Neill et al. (1996) stated that if halite specific storage is used for the halite model, it should be demonstrated that the contribution of the interbeds to specific storage can be ignored. (The specific storage of a rock unit is a hydrologic term referring to the amount of water which would be squeezed from the unit's pores if the unit were compressed, as during creep closure, or the amount of water which the unit's pores would absorb if the unit were dilated, as may occur with elevated gas pressure in the repository. An anhydrite interbed would likely have a specific storage that is different from that of an impure halite layer, particularly when dilation of fractures in the interbeds due to elevated gas pressure is considered.)

In the April 30, 1996, draft of the *Final No-Migration Variance Petition*, Section 8.0 (DOE 1996d), which employs median and other appropriate values (not sampled parameter distributions), it is stated that parameter values for impure halite used in the modeling are "supported by four hydraulic tests in the underground repository [and are] believed to represent far-field conditions and stratigraphic variation in the Salado." Further, "except for the DRZ and anhydrite interbeds, under certain circumstances, this simulation [involving fluid flow, gas generation, and volume changes resulting from creep closure] assumes spatially constant properties for Salado rock types based on observations of compositional and structural regularity in layers exposed by the repository. The inference is that there is little variation in large-scale averages of rock or flow properties across the disposal system. Except for anhydrite interbeds, model parameters are also spatially invariant within each material region. At relatively low repository pressures, porosities of all Salado materials vary slightly; however, for interbeds, the model

implemented to simulate the effects of interbed fracturing causes large increases in both porosity and permeability above a designated fracture initiation pressure."

Regarding changes in interbed permeability and specific storage due to elevated gas pressures, it is stated in the April 30, 1996 draft of the *Final No-Migration Variance Petition* (DOE 1996d) that, "if high pressure develops in an interbed, its preexisting fractures may dilate, or new fractures may form, altering its porosity and permeability. Pressure-dependent changes in permeability are supported by experiments conducted in the underground repository and in the laboratory. Accordingly, the DOE has implemented in BRAGFLO a porous-media model of interbed dilation and fracturing that causes the porosity and permeability of a computational cell in an interbed to increase as its pore pressure rises above a designated value. There is a trade-off between the effects of permeability and porosity enhancements. Dilation or fracturing of interbeds is expected to increase the transmissivity of interbed intervals. Increased porosity will increase storage, which will retard outward flow." However, because of assumptions incorporated into the calculations, large increases in permeability are accompanied by modest increases in porosity. These concerns are accounted for in the performance assessment calculations.

In SEIS-II analyses, values of Salado Formation halite and interbed parameters were derived from DOE databases supporting the CCA (DOE 1996f). The analyses use both expected and conservative values based on existing distributions of these parameters.

Brine Inflow

The EEG (1994), in its review of the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), states that the "project position" on the preferred conceptual model for brine inflow should be "developed and justified." Furthermore, "the EEG does not agree with the strategy of treating various conceptual models to be of equal importance when overwhelming evidence exists that a particular model is far superior than others." The EEG's recommendation is to assume Darcy flow in the salt, impure salt permeabilities, and fractured anhydrite, using measured in situ permeabilities in the marker beds.

The conceptual model for brine inflow, as described in the CCA (DOE 1996f), includes two submodels to approximate far-field flow and redistribution mechanisms. A previously proposed mechanism, clay consolidation, was not considered important and was not included. A 1-degree stratigraphic dip was added to the model, Darcy flow was assumed, and permeability for impure halite was used. Permeability for anhydrite (presumably intact) was based on field and laboratory measurements, and the chosen maximum fractured anhydrite permeability values were "thought to be upper limits."

This approach used in the CCA (DOE 1996f) was adopted for the SEIS-II analyses. For the conservative case, the anhydrite permeability range included values for fractured anhydrite.

H.9.1.3 Rustler/Salado Contact

According to Neill et al. (1996), the contact zone between the Rustler and Salado Formations is characterized by residue left from dissolution of salt and has not been adequately considered as a potential pathway for migration of radionuclides. Several facts suggest that the Rustler/Salado contact merits further study. Chaturvedi and Channell (1985; cited in Neill et al. 1996) indicate that data from hydrologic testing at the WIPP site "shows that the 'brine aquifer' of the pre-WIPP

investigators extends east of Nash Draw to the WIPP site." Most boreholes have encountered brine in the Rustler/Salado contact zone, and water-level-recovery rates were more rapid in these wells than in a well in the Culebra Dolomite east of the WIPP site, suggesting that the contact zone exhibits relatively high permeability and transmissivity.

In DOE's responses to EPA comments (DOE 1996a), it is stated that dissolution at the top of the Salado is not expected to reach the edge of the controlled area within the regulatory period of analysis of 10,000 years. Thus, the Rustler/Salado contact was not explicitly considered as a region of enhanced flow in the CCA or SEIS-II analyses.

H.9.1.4 Rustler Formation/Culebra Dolomite Member

Discussion of alternative conceptual models and issues related to the Culebra Dolomite are presented below in three parts: (1) regional flow, (2) hydraulic properties and characteristics, and (3) contaminant transport and retardation characteristics.

Regional Flow

Two-Dimensional versus Three-Dimensional Flow

The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) treated flow in the Rustler Formation as occurring primarily in the Culebra Dolomite, which has been modeled as a confined, nonleaky, two-dimensional, horizontal, and heterogeneous water-bearing unit. It is, however, actually part of a three-dimensional flow system. SNL has modeled three-dimensional flow in the Rustler and interim results indicate that, while some flow occurs vertically between units of the Rustler, most flow occurs within the Culebra. Therefore, confining flow to the Culebra in the performance assessment calculations is a justifiable simplification. Konikow (1995) believes that the performance assessment effort has been "overly focused" on the two-dimensional analysis and that the ongoing three-dimensional analyses of the regional groundwater flow system are critical to the performance assessment effort.

Currently, DOE is retaining the concept of confined two-dimensional flow in the Culebra for compliance analysis. DOE is considering the development of a three-dimensional model for possible use in future performance assessment calculations, to evaluate the impact of regional groundwater flow on long-term WIPP performance. The SEIS-II analyses used the two-dimensional flow and transport model based on SECOFL2D and SECOTP2D to estimate the off-site impacts from releases to the Culebra Dolomite for the disturbed cases using 75th percentile parameter values. Releases to the Culebra were predicted to be too small to constitute a significant health risk.

Regional Flow and Anomalous Groundwater Geochemistry

It has been suggested by a number of investigators that the chemistry of the Culebra groundwater is inconsistent with the apparent direction of flow. Based on hydrologic well data, groundwater in the Culebra flows roughly from north to south. Groundwater chemistry along the flow direction is not what would be predicted, based on common flow-chemistry relationships. Total dissolved solids decrease downgradient, and the general chemical nature of the water changes as well (sodium and chloride at the WIPP site to magnesium, calcium, and sulfate south of the site).

According to Neill et al. (1996) and Konikow (1995), this inconsistency reflects an inadequate level of understanding of the entire hydrogeologic system. Axness et al. (1995) state that "the relationship between water chemistry and groundwater flow in the Culebra remains unresolved at this time."

In Neill et al. (1996), the EEG advocates a "full discussion [in the CCA] with respect to flow directions, vertical seepage, karst, present day recharge and paleo-recharge." The basis for determining the estimated age of Culebra groundwater as presented in the CCA (i.e., "tens of thousands of years") and as "a relict of a flow regime of a wetter climate" (Neill et al. 1996), has never been accepted by the EEG (Neill et al. 1996). According to the EEG, the arguments against the use of isotopic data from Carlsbad Caverns pools for Rustler groundwater (Neill et al. 1996) should be presented.

In a recent interpretation by Corbet (1997), the Department has suggested that changes in groundwater chemistry that would be expected for a confined aquifer system are complicated by contributions of vertical leakage and regional groundwater recharge that interact with distinctive rock types originating in different areas surrounding the WIPP site. Corbet (1997) concluded that the distributions of solute chemistry observed in the Culebra were consistent with inferred groundwater flow conditions and reflected a mixing of distinctly different groundwater originating from recharge areas surrounding the site. Additional information on this topic is provided in Section 4.1.3.2 and in Corbet (1997).

Recharge/Discharge

In Neill et al. (1996), the EEG points out that the recharge area for the Rustler has never been identified. At least two areas have been proposed on the basis of potentiometric surfaces, but "existing data are inadequate to determine recharge to the groundwater system in the vicinity of the WIPP site."

It is accepted that the Culebra probably discharges ultimately into the Pecos River and, perhaps, elsewhere (Neill et al. 1996). However, hydraulically separate water-bearing zones cannot be distinguished within the Rustler Formation at least 3 kilometers (2 miles) east of Livingston Ridge; therefore, water flowing into postulated areas of discharge may not be traced to a particular member of the Rustler Formation (Neill et al. 1996).

For the purpose of SEIS-II analyses, existing models that support the CCA analyses (DOE 1996f) are being used.

Unexplained Recent Changes in Water Levels

Neill et al. (1996) believe that the observed water-level rises in the Culebra are notable, in that they may be related to hydrocarbon and potash activity in the area. The CCA (DOE 1996f) used data through 1991 only in its related discussion, although there have been data collected up to the present. Konikow (1995) believes that the observations are important and maintains that the lack of a satisfactory interpretation is another element in the generally inadequate understanding of the site hydrogeology.

According to Neill et al. (1996), "water level rises in WIPP monitoring wells potentially correlate with brine disposal from the potash industry." Further, "in 1988, WIPP monitoring wells

experienced sharp water level rises which were strongly correlated with a nearby salt water disposal well operated by the oil and gas industry." These instances emphasize that WIPP is located in a resource-rich area, exploration and exploitation of the resources are likely to continue, and activities related to this may influence the regional hydrology apart from the modeled scenarios involving penetration of the repository. Therefore, Neill et al. (1996) maintain that more emphasis must be placed on interpreting the changes in Culebra water levels.

Analysis of water level changes in H-9 and in a number of other observation wells north and south of the WIPP site and near WIPP have suggested that the changes in wells to the south are the result of possible hydraulic impacts of water flooding (water injection to enhance secondary oil and gas recovery) activities south of the WIPP site. No specific evidence is currently available to conclude which specific water flooding operation or specific hydraulic condition is creating the specific water level changes observed near the WIPP site.

In response to these observations and other examples of the impacts of fluid injection, DOE has examined the potential impacts of fluid injection in the form of water flooding and salt water disposal in the CCA. The potential effects of water flooding and salt water disposal were modeled assuming two hypothetical injection wells located at the land withdrawal boundary operating over a 50-year period. The results of the modeling, given in Section SCR.3.3.1.3.1 of the CCA, indicate that fluid injection would not have a significant impact on repository performance. Specifically, even for the least favorable rock properties considered, the amount of brine reaching the repository over 10,000 years would be well within the range of volumes of brine expected to flow into the repository during normal undisturbed performance. On this basis, fluid injection was screened out of the performance assessment calculations in the CCA and SEIS-II analyses.

Hydraulic Properties and Characteristics

Independent Sampling of Parameters

In the probabilistic performance assessment calculations, many parameters are sampled. It has been pointed out (*cf.* EEG 1994; Konikow 1995; Neill et al. 1996) that certain model parameters in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) are being treated as independent random variables. This is a weakness (Konikow 1995) because, in reality, the variability of some sets of parameters indicates dependence on one another. For example, the values for fracture porosity and fracture spacing used in some flow and transport modeling calculations were sampled randomly from a selected range. This approach implies that there is no dependency between these two parameters. Single fractures could have very small apertures (resulting in low porosity) and multiple closely spaced fractures could have very large apertures (resulting in high porosity). These assumptions result in very large ranges in fracture hydraulic conductivity, which runs contrary to most hydrologists' understanding that fracture spacing and fracture aperture (porosity) generally increase or decrease together.

The EPA (1995) evaluated the relationship between and among fracture spacing, fracture porosity, and hydraulic conductivity. Based on the range of fracture spacings used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the EPA calculations indicated that corresponding fracture porosities are much lower than those used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992). The performance assessment calculations, therefore, indicate higher flow and transport rates and are very conservative.

In the SEIS-II analyses, expected and conservative parameter values (corresponding to median and 75th percentile, respectively) were used, rather than sampled values.

Fracture Properties

According to the EEG (1994), statements in the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994) regarding areal distribution and density of fractures in the Culebra are simplistic and ignore existing data, that the "pattern of fracture distribution and corresponding transmissivity values distribution is too complex to be explained away," and that its complexity has become more apparent as additional data are collected. In response, DOE stated that deduced fracture patterns were based on many observations in drill core, as well as outcrops and exposures in the air intake shaft.

Konikow (1995) states that fractures are a dominant control on transmissivity and they represent the highest-velocity channels for migration of contaminants. Further, a better definition of the nature, density, spacing, length, and interconnectedness of fractures and fracture networks is needed. He characterizes this uncertainty regarding Culebra fractures as "the most likely fatal flaw in site integrity."

Accordingly, Konikow (1995) believes that, given the fact that detailed local and regional mapping of fracture traces and lineaments were not completed during the early stages of site characterization, new approaches should be taken that may help clarify the possible existence and spacing of major through-going fracture zones. He indicates that techniques that could accomplish this include computer analysis of digital elevation data and high-resolution three-dimensional geophysical tomographic techniques. This issue remains open.

The EEG (1994) states that more than one conceptual model of the Culebra appears to fit the available data. Other possible interpretations include single-porosity flow (flow through the rock matrix), dual-porosity flow (flow through fractures in the rock, as well as the rock matrix), and channeling (flow through certain fractures only). Of equal importance is the role of matrix diffusion as a retardation process (diffusion of radionuclides through the fracture faces into the rock matrix; see below).

The EEG (1994) points out that the INTRAVAL committee (International Project to Study Validation of Geosphere Transport Models) believes that, while the current model incorporates dual-porosity flow, a model based entirely on channeling also fits the current field data. The channeling model does not incorporate matrix diffusion.

Since 1994, the model of the Culebra Dolomite regional hydrologic characteristics has not changed from those conceptualized in previous performance assessment calculations, although additional large-scale information from pumping at H-19 and small-scale information at Water Quality Sampling Program (WQSSP) wells has been incorporated into the calibration. Existing borehole transmissivity interpretations have been refined on the basis of analysis of new data from H-19 and H-11 and reanalysis of previous tests of H-3, H-11, and H-6.

The Culebra is now conceived of as a fractured porous medium with inherent local variability in the degree and scale of fracturing. Examination of core and shaft exposures has revealed that there are multiple scales of porosity within the Culebra including fractures from microscale to large, vuggy zones, and interparticle and intercrystalline porosity. This variability leads to both lateral

and vertical variations in permeability. Advection is believed to occur largely through fractures; however, in some areas it may also occur through vugs connected by small fractures and interparticle porosity. Performance assessment, rather than conceiving of transport in terms of fracture and matrix porosities, conceived the Culebra as being composed of advective and diffusive porosities. Matrix diffusion is still believed to be effective and significant. The effective transport thickness is thought to be less than the total stratigraphic thickness. The available data suggest that the permeability of the upper portion of the Culebra is relatively low. Therefore, the DOE has concluded that the Culebra is adequately represented by the double porosity continuum model on the scale of the performance assessment calculations, and it is not necessary to use the discrete-fracture model on this scale.

For compliance calculations and the purposes of SEIS-II, DOE is incorporating the assumption that flow in the Culebra is confined to a single fracture "in order not to overestimate the amount of diffusion [of radionuclides]" (Axness et al. 1995). Diffusion of radionuclides into fracture walls has the effect of slowing their transport and, thus, increasing retardation. Limiting the Culebra to a single fracture minimizes retardation and is a more conservative approach. In addition, in recognition of the importance of fracture characteristics of the Culebra, the DOE has conducted multiple-well tests and tracer tests to evaluate these characteristics and their influence on the regional groundwater flow field.

Karst Development

Anderson (1994), in his review of the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), disagreed that the absence of visible karstic surface features at WIPP implies that important karst processes are not occurring. According to Anderson, the "moderate thickness of halite and gypsum strata in the Rustler Formation precludes the development of large, visible collapse structures until late stages of dissolution." Sand cover at WIPP would tend to obscure smaller-scale features.

Anderson (1994) presents evidence that dissolution from karst processes is active at WIPP: (1) a dissolution front beginning along the Nash Draw axis has moved eastward approximately 16 kilometers (10 miles) to its present position within the WIPP site; (2) this dissolution front has moved in pulses in response to changes in climate; and (3) the northward extension, or finger, of the southeastern lobe of Nash Draw in the southern part of the WIPP site coincides with the main flow path in the Rustler aquifer and with the known localized area of increased transmissivity (Beauheim and Holt 1990; Anderson 1994).

Anderson (1994) cites several lines of evidence that suggest that karst processes at WIPP are at a relatively early stage: (1) the age of Nash Draw has been determined to be less than 600,000 years, which is considerably younger than has been believed (Beauheim and Holt 1990, cited in Anderson 1994); (2) the high-transmissivity zone is characterized by relatively fresh groundwater that is unsaturated with respect to gypsum, and by fractures from which gypsum has been dissolved; (3) fractures in soluble units below the Culebra, visible in one of the WIPP shafts, have been enlarged by dissolution to form flow channels; (4) hydraulic conductivity across the site varies by a factor of one million (specific Rustler lithologic units were not specified); and (5) vertical movements of fluids between units in the Rustler are characteristic.

For nearly 20 years, DOE has investigated the hydrology of important geologic units overlying the WIPP facility and the importance of karst features and related dissolution processes in defining the

surface features in the region surrounding the WIPP site. A description of the current understanding of the extent, timing, and features related to dissolution, including a brief history of past project studies related to karst in the area surrounding WIPP, is presented in Section 2.1.6.2.1 of the CCA. These studies have shown that there is considerable evidence of dissolution and karst features at shallow depths, although no evidence has been collected to date that would suggest that shallow dissolution processes are active within the deeper Salado Formation. Deep dissolution at the WIPP site was eliminated from the CCA and the SEIS-II performance assessment calculations on the basis of low probability of occurrence over the next 10,000 years. Additional information supporting this conclusion is provided in Section SCR.1.1.5.1 of Appendix SCR of the CCA (DOE 1996f).

DOE does not specifically address the karst issue in the long-term performance assessment. However, for SEIS-II, a potash mining scenario was analyzed which incorporated a three-order-of-magnitude increase in the hydraulic conductivities (which control permeabilities) in overlying hydrologic units. This analysis allowed the investigation of the potential effects of increased permeability from any cause, including karst development.

Contaminant Transport and Retardation Characteristics

Equilibrium Sorption

During transport of contaminants, several chemical processes may serve to slow down (i.e., retard) the contaminants. These processes include precipitation of the contaminants in a chemical compound, ion-exchange processes, or adsorption onto solid surfaces. These processes are collectively referred to as retardation. They may be temporary, as precipitation may stop in response to chemical conditions, or the solid surfaces may fill up with sorbed contaminants and lose their capacity to sorb further. For many contaminants, groundwater compositions, and rock/soil types, it is possible to estimate by calculation the distribution of contaminants sorbed on the rock and dissolved in the water by determining the distribution coefficient.

Distribution coefficients have been measured for application to WIPP but they do not represent anticipated conditions in the Culebra (Neill et al. 1996) for the following reasons: (1) experiments have used water that was chemically different from Culebra water; (2) the distribution coefficients were determined from single measurements on powdered samples, which have much greater surface area compared to their volume than the actual fractured Culebra rock and, therefore, would tend to show an artificially high degree of sorption; and (3) it was not well demonstrated that equilibrium was achieved in the experiments.

According to Konikow (1995), the use of a single retardation factor, as in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations (SNL 1992), has a “very weak scientific basis” because it cannot represent the sources of variation in the performance assessment model (chemical reactions, reaction rates, heterogeneous mineralogy, and changing aqueous geochemistry). In addition, Konikow (1995) states that the retardation factor model used does not place an upper limit on the amount of contaminant that can be sorbed. This means that the model does not account for the possibility of sorption sites filling up and precluding further sorption. He further states that sorbing tracer tests in the field are needed.

A multiwell tracer test is currently being conducted at the WIPP site and is designed to ascertain, among other things, distribution coefficients for sorbing contaminants but using a nonsorbing

tracer. Neill et al. (1996) compared residence times for sorbing and nonsorbing species in a system of porous and fractured rock. Their simple analysis indicates that a nonsorbing tracer test cannot be used to obtain a distribution coefficient for sorbing contaminants such as the radionuclides at WIPP.

In the CCA analysis, clay linings in Culebra fractures are not currently assumed to be present. In the SEIS-II analyses, transport calculations in the Culebra were performed using the CCA models to evaluate the predicted releases to the Culebra for selected disturbed performance cases. Evaluation of a release at a 3-kilometer (2-mile) stock well showed negligible risks.

Repository and Culebra not Coupled in Modeling

In the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the quantities of radionuclides calculated to leave the repository and flow up an intrusion borehole were incorporated into the simulation of flow and transport in the Culebra, but they were not introduced hydraulically into the flow regime of the Culebra (i.e., the influence of water flowing up the borehole on the ambient flow field of the Culebra was not calculated). Expressed another way, the processes in the repository were decoupled from processes in the Culebra.

The EPA (1995a) evaluated the effect on transport times of coupling repository and Culebra processes. It was found that travel times to the WIPP boundary decreased (i.e., transport rates increased) by approximately ten times (one order of magnitude). Similarly, radionuclide concentrations calculated at one kilometer (0.6 mile) from the repository after 10,000 years were approximately ten times higher in the coupled-process calculations.

The SEIS-II analyses follow the approach taken in the CCA (DOE 1996f) in which impacts of the borehole intrusion on the Culebra flow field are not considered. Reeves et al. (1991) performed a study that indicated that, for expected conditions and much of the range of brine reservoir and breach borehole parameters, the fluid disturbance created in the Culebra by the breach borehole would have minimal impact on the flow field. It was further stated that, under these conditions, transport calculations need not include the transient impact of locally increased hydraulic head near the breach borehole.

In the intrusion scenario analyzed in SEIS-II, the borehole was designed to reflect current oil field practices. Two concrete plugs are assumed to have a significant effect on long-term flow in the borehole: the lower plug is assumed to be located between the hypothetical Castile brine reservoir and the underlying formations, and a second plug is located within the lower portion of the Rustler and immediately above the Salado. Additional plugs that have little effect on long-term flow are also assumed to be present, both deeper in the hole and at the land surface. The brine reservoir and the repository are assumed to be in direct communication through an open-cased hole immediately following drilling. The plugs are represented in the borehole by material zone 29 of the BRAGFLO mesh in Figure H-4 (a surface plug and a plug in the Lower unnamed member). The plugs located below the brine reservoir are not modeled explicitly. Plugs are assigned initial permeabilities of 5×10^{-17} square meters (5.4×10^{-16} square feet), which is consistent with the expected properties of intact concrete, and the open segments of the borehole (between the plugs) are assigned an initial permeability of 10^{-9} square meters (1×10^{-8} square feet). Steel casing above the Salado Formation is assumed to begin to degrade within decades after abandonment and is assumed to have failed completely after 200 years. The concrete plugs above the Salado are also assumed to fail after 200 years, as a result of chemical degradation by contact with brine. The

plug below the Castile brine reservoir is in a less aggressive chemical environment, and its properties remain constant in performance assessment. After the upper plugs and casing have failed, the borehole is assumed to be filled by a silty, sand-like material containing degraded concrete, corrosion products, and material that sloughs into the hole from the walls. Thus, beginning 200 years after the time of intrusion, the entire borehole region in the BRAGFLO model, including the sections previously modeled as concrete plugs, is assigned a permeability corresponding to silty sand. This permeability is sampled from a log-uniform distribution from 10^{-11} square meters (1×10^{-10} square feet) to 10^{-14} square meters (1×10^{-13} square feet).

One thousand years after the plug at the base of the Rustler Formation has failed (1,200 years after the time of intrusion), the permeability of the borehole region below the waste-disposal panel in the BRAGFLO model used is decreased from its sampled value by one order of magnitude. For the remainder of the 10,000-year period, the borehole is modeled with its sampled permeability value above the repository and the adjusted value below. Conceptually, the decrease in permeability below the panel corresponds to compaction of the silty, sand-like material by partial creep closure of the lower portion of the borehole. As discussed in Appendix MASS (DOE 1996f), creep closure of boreholes is not expected to be significant above the repository horizon but will be effective at greater depths because of the greater lithostatic stress.

For these assumptions, releases were simulated only for the 75th percentile parameter cases. In these cases, the releases were quantitatively small enough to not pose a significant health risk (refer to Section H.8), and additional modeling of transport in the Culebra (which would further dilute the concentrations due to dispersion) was unwarranted.

Realism of Calculated Travel Times

In the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the Culebra was modeled by using various transmissivity fields, each of which was divided into regions of different hydraulic conductivity. For the purpose of travel time calculations, however, a mean Culebra hydraulic conductivity of 7 meters (23 feet) per year was used.

The EPA (1995) compared travel times calculated by using the mean, as in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), with those calculated by using the separate regions of hydraulic conductivity. Their results suggest that using separate hydraulic conductivities yields travel times “far shorter” (less conservative) than using the mean hydraulic conductivity for the entire Culebra.

In the SEIS-II analyses, transport calculations using the SECOTP2D model of the Culebra were performed for contaminant releases to the Culebra from disturbed conditions to a 3-kilometer (2-mile) stock well downgradient of the point of intrusion. Impacts at the stock well were found to be negligible.

Parallel Fracture Model Analysis for Culebra

Neill et al. (1996) state that the basis for the parallel fracture model in the SECO analyses for the Culebra in the CCA (DOE 1996f) is not presented nor is the justification for clay linings on the fracture walls, and that the influence of this assumption on the outcome of the calculations should be described. Channeling of groundwater flow should be considered, because it is recognized as a possibly important phenomenon in the Culebra.

In performance assessment calculations for compliance, a single fracture in the Culebra was assumed to limit the amount of fracture surface and calculated matrix diffusion. Porosity was assumed to be the approximate median of the distribution sampled in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), and tortuosity was given a "medium low" value. The fracture is assumed to be devoid of clay lining, and the distribution coefficient is taken to be zero.

In the SEIS-II analyses, transport calculations using the SECOTP2D model of the Culebra were performed to estimate the impacts of migration of contaminant releases to the Culebra from selected disturbed conditions to a 3-kilometer (2-mile) stock well downgradient from the point of intrusion. These impacts were found to be negligible.

Presence/Absence of Clay in Fractures

Neill et al. (1996) believe that there is insufficient evidence of clay linings in Culebra Dolomite fractures to assume their presence for purposes of estimation of retardation of radionuclide transport. The assumption of corrensite as the predominant clay mineral present in the fractures is also based on limited data.

According to the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations (SNL 1992), chemical sorption on clay fracture linings is assumed to occur and the clay mineral present is assumed to be corrensite. Neill et al. (1996) provide a discussion of the evidence on which these assumptions are based. SNL has been assuming in their performance assessment calculations that fractures in the Culebra are lined to some degree with clay and that the clay has been determined to be corrensite. The presence of corrensite is based on X-ray diffraction and electron microscopic analysis of core samples taken from clay-rich zones in the Rustler Formation (not necessarily in the Culebra Member), primarily from locations in Nash Draw, several miles west of the WIPP site.

In a study by Sewards et al. (1991; cited in EEG 1994 and Neill et al. 1996), X-ray diffraction determination of corrensite was not corroborated by the electron microscopy, yet they concluded that corrensite is the dominant clay phase in the Culebra (EEG 1994). Also, in Sewards et al. (1991; cited in EEG 1994 and Neill et al. 1996), it was stated that only small amounts of clay could be sampled from the Culebra fracture coatings. As a result, initial laboratory studies of adsorption on WIPP site clays were carried out with material from a black shale layer from the unnamed member of the Rustler Formation. The material was determined from a single sample to be mostly corrensite. Neill et al. (1996) state, in summary, that using a single sample from a shale located in a different part of the Rustler from the Culebra is not appropriate for performance assessment calculations that depend on the presence of sufficient corrensite clay in Culebra fractures to effect notable retardation of radionuclides. Therefore, either more evidence is needed for radionuclide sorption on clay linings or credit should not be taken for chemical retardation in fractures.

Clay can be a medium for sorption but it can also block radionuclides from diffusing into the rock matrix (see discussion below on physical retardation). The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) did not include the latter concept in its calculations (Neill et al. 1996). If the clay is not an effective sorber, it serves to inhibit migration of radionuclides into the matrix, thereby increasing the efficiency of channel flow.

For the purpose of performance assessment calculations in the CCA and SEIS-II analyses, clay linings in Culebra fractures are assumed not to be present. In the SEIS-II analyses, transport calculations using the SECOTP2D model of the Culebra were performed to estimate the impacts of migration of contaminant releases to the Culebra from selected disturbed conditions to a 3-kilometer (2-mile) stock well downgradient from the point of intrusion. These impacts were found to be negligible.

Physical Retardation (Matrix Diffusion)

Performance assessment calculations (SNL 1992) suggest that radionuclides will take from 100 to 1,000 years to travel from the repository to the WIPP boundary. This indicates that without matrix diffusion to slow up (retard) the radionuclides, cumulative releases would be greater over the 10,000-year regulatory period. It is believed by some (Neill et al. 1996; Konikow 1995) that there is insufficient evidence to assume that matrix diffusion plays an important role in retarding radionuclides in the Culebra. It is Konikow's (1995) opinion that field tests performed to date are ambiguous, that diffusion parameters have not been adequately characterized in laboratory tests, and that the nature of the fractures in the Culebra are not known sufficiently well to formulate a representative model.

Neill et al. (1996) state that, though performance assessment takes credit for matrix diffusion, there is “no direct experimental evidence for its extent.” The EEG (1994) points out that the INTRAVAL committee believes that existing field data support a channeling flow model (i.e., without matrix diffusion) as well as the dual-porosity model. The EPA (1995) performed simple calculations of travel times and distances with and without the retarding effects of matrix diffusion to obtain comparisons. For a set of simplifying conditions (fracture spacing 3.85 meters [12.6 feet], equivalent porous media hydraulic conductivity 7 meters [23 feet] per year, no chemical retardation), the calculation of distance traveled in 10,000 years yielded the following results: (1) with matrix diffusion, radionuclides traveled approximately 5 kilometers (3 miles) and (2) with no matrix diffusion, radionuclides traveled approximately 13,500 kilometers (8,383 miles), or 2,700 times farther.

In an attempt to limit the amount of fracture surface and ensure that matrix diffusion calculations are conservative, it was assumed in the CCA that fracturing in the Culebra is limited to one horizontal fracture. Fracture porosity was taken to be approximately the median of the range sampled in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), and tortuosity was given a “medium low value.”

In the SEIS-II analyses, transport calculations using the SECOTP2D model of the Culebra were performed to estimate the impacts of migration of contaminant releases to the Culebra from selected disturbed conditions to a 3-kilometer (2-mile) stock well downgradient from the point of intrusion. These impacts were found to be negligible.

H.9.1.5 Supra-Rustler Units

The water table in the region of the WIPP has not been defined. Konikow (1995) states that, in part, this reflects the degree of understanding of the site hydrology. He recommends that it either should be defined or a reasonable explanation regarding why it is not important or not technically feasible to define should be documented.

According to Neill et al. (1996), "without an understanding of the basic regional hydrologic parameters of an area, such as the water table and the recharge and discharge areas and amounts, the knowledge about the site is incomplete." They state that it is believed that the water table is in the Dewey Lake Formation, based on observations of water in several wells and one of the repository shafts at the WIPP site. Wells in the Dewey Lake have produced water at rates up to 106 liters (28 gallons) per minute (Neill et al. 1996; Axness et al. 1995).

In the *Final CCA* (DOE 1996f) simulation of the WIPP repository disposal system pressure gradient, it was assumed that the water table is located approximately 59 meters (194 feet) below the ground surface at an elevation of 980 meters (3,215 feet) within the Dewey Lake Formation. The Dewey Lake Formation contains a "productive zone of saturation, probably under water-table conditions" in the southwestern and south-central portion of the WIPP site as well as south of the site. This zone occurs approximately in the middle of the Dewey Lake and appears to derive much of its transmissivity from open fractures. North of the site, open fractures and/or moist (not saturated) conditions have been observed in the Dewey Lake at similar depths. Fractures below the productive zone tend to be filled with gypsum.

The role of the Dewey Lake Formation in repository performance is an issue as yet unresolved. Because the Culebra is assumed to be the principal pathway for contaminant transport above the Salado in the event of a repository breach as a result of human intrusion, the SEIS-II analyses do not specifically address off-site contaminant transport in the Dewey Lake.

H.9.2 Issues Related to Human Impacts and Intrusion

Scenarios analyzed in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) and assumptions regarding deterrents to human intrusion have come under review, and several scenarios not yet analyzed have been proposed. This section presents discussions on an analyzed scenario and the application of institutional controls.

Presence/Absence of Borehole Casing in Intrusion Borehole

Neill et al. (1996) identified an apparent inconsistency in intrusion scenarios analyzed to date. One set of scenarios, in which contaminated brine from the repository flows up the borehole and through the Culebra, implies that there is no casing in the vicinity of the Culebra. Another scenario analyzes the effect of CUTTINGS_S generated during drilling and brought to the land surface, bypassing the Culebra. This implies, according to Butcher et al. (1995; cited in Neill et al. 1996), that a well casing is present. Current drilling technology in the Delaware Basin calls for steel casing from the surface to within 100 to 200 meters (330-660 feet) of the "top of the salt section" (Butcher et al. 1995; cited in Neill et al. 1996).

According to Neill et al. (1996), two different scenarios should be analyzed: one with casing and the other without, with assignment of probabilities of occurrence to each. This issue was not directly addressed in SEIS-II. In the intrusion scenario analyzed in SEIS-II, the borehole was designed to reflect current oil field practices. No explicit credit is taken for the presence of casing. It was assumed that the intrusion borehole is plugged and thereafter maintains a relatively low permeability. In the scenario, the borehole penetrates the entire sequence of units in the modeled domain. The borehole permeability was set initially to 1×10^{-10} square meters (1×10^{-9} square feet) to represent a relatively high borehole permeability for 100 years after the intrusion. After

200 years, the borehole permeability was decreased to 1 x 10^{-14} square meters (1 x 10^{-13} square feet) to reflect a decrease in permeability consistent with plugging the borehole with concrete.

Credit for Passive Institutional Controls

Passive institutional controls (PICs) were considered to be a sufficiently effective deterrent to human intrusion in the CCA (DOE 1996f), to the extent that the possibility of human intrusion was not included in the cumulative complementary distribution function. Neill et al. (1996) believe that no credit should be taken in the Complementary Cumulative Distribution Function for a reduced future (beyond 100 years) drilling frequency based on PICs. The SEIS-II intrusion scenario was analyzed at 400 years after closure for cases using median parameter values and 300 years after closure for cases using 75th percentile parameter values.

H.10 REFERENCES CITED IN APPENDIX H

Anderson, R.Y., 1994, Letter to L.A. Lovejoy, (Assistant Attorney General, Office of the Attorney General of New Mexico), DOE/WIPP 94-019, July 14.

Axness, C., et al., 1995, *Systems Prioritization Method – Iteration 2 Baseline Position Paper: Non-Salado Flow and Transport*, March 27, Sandia National Laboratories, Albuquerque, New Mexico.

Barr, G.E., 1983, *Interim Report on the Modeling of the Regional Hydraulics of the Rustler Formation*, SAND83-0391, Sandia National Laboratories, Albuquerque, New Mexico.

Beauheim, R.L, 1986, *Hydraulic-Test Interpretations for Well DOE-2 at the Waste Isolation Pilot Plant (WIPP) Site*, SAND86-1364, Sandia National Laboratories, Albuquerque, New Mexico.

Beauheim, R.L., and R.M. Holt, 1990, "Hydrogeology of the WIPP Site, Geological and Hydrological Studies of Evaporites in the Northern Delaware Basin for the Waste Isolation Pilot Plant," *Field Trip #14 Guidebook*, SAND-90-2035J, October 29-November 1, Geological Society of America 1990 Annual Meeting, Dallas, Texas.

Beauheim, R.L., et al., 1991, *Interpretations of Single-Well Hydraulic Tests of the Rustler Formation Conducted in the Vicinity of the Waste Isolation Pilot Plant Site, 1988-1989*, SAND89-0869, Sandia National Laboratories, Albuquerque, New Mexico.

Butcher, B.M., et al., 1995, *Systems Prioritization Method - Iteration 2, Baseline Position Paper: Disposal Room and Cuttings Models, Volume I*, Sandia National Laboratories, Albuquerque, New Mexico.

Chaturvedi, L. and J. K. Channel, 1985, *The Rustler Formation as a Transport Medium for Contaminated Groundwater*, EEG-32, Environmental Evaluation Group, Albuquerque, New Mexico.

Cole, R.A., and W. Simmons, 1995, *WIPP Performance Assessment User's Manual for CUTTINGS_S, Version 4.00vv*, Sandia National Laboratories, Albuquerque, New Mexico.

Corbet, T. 1997. *Integration of Hydrogeology and Geochemistry of the Culebra Member of the Rustler Formation in Vicinity of the Waste Isolation Pilot Plant*. Sandia National Laboratories, Expedited CCA Activity, WPO#43215, Albuquerque, New Mexico.

DOE (U. S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1994, *Compliance Status Report for the Waste Isolation Pilot Plant*, DOE/WIPP 94-019, Revision 0, March, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP 95-2065, Revision 0, November, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Responses to [EPA] Comments, Draft 40 CFR 191 Compliance Certification Application*, January, Carlsbad, New Mexico.

DOE (U. S. Department of Energy), 1996b, *Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP-91-005, Revision 6.0, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996c, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996d, *Final No-Migration Variance Petition*, DOE/CAO-96-2160, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996e, *Transuranic Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996f, *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-2184, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997, *Disposal Phase Experimental Program Plan*, DOE/CAO 97-1223, Revision 0, Carlsbad, New Mexico.

EEG (Environmental Evaluation Group), 1994, *Comments on the Compliance Status Report for WIPP*, DOE/WIPP 94-019, Revision 0, Albuquerque, New Mexico.

EPA (U.S. Environmental Protection Agency), 1995, *Groundwater Flow and Contaminant Transport Modeling at WIPP (Draft)*, Contract No. 68D20155, November, Washington, D.C.

Konikow, L. F., 1995, "WIPP Site: Some Concerns About Non-Salado Hydrogeology (Processes, Parameters, Models)," presented at DOE/EPA Technical Exchange Meeting, December 5, 1995, Carlsbad, New Mexico.

Longsine, D.E., et al., 1987, *User's Manual for the NEFTRAN Computer Code*, NUREG/CR-4766, SAND86-2405, Sandia National Laboratories, Albuquerque, New Mexico.

Neill, R. H., et al., 1996, *Review of WIPP Draft Application to Show Compliance with EPA Transuranic Waste Disposal Standards*, EEG-61, March, Environmental Evaluation Group, Albuquerque, New Mexico.

Reeves, M., et al., 1991, *Regional Double-Porosity Solute Transport in the Culebra Dolomite Under Brine-Reservoir-Breach Conditions: An Analysis of Parameter Sensitivity and Importance*, SAND89-7069, Sandia National Laboratories, Albuquerque, New Mexico.

Sewards, T., et al., 1991, *Mineralogy of the Culebra Dolomite Member of the Rustler Formation*, SAND90-7008, Sandia National Laboratories, Albuquerque, New Mexico.

SNL (Sandia National Laboratories), 1992, *Preliminary Performance Assessment for the Waste Isolation Pilot Plant*, Volumes 1-5, SAND-92-0700, December, Albuquerque, New Mexico.

SNL (Sandia National Laboratories), 1995, *The Second Iteration of the Systems Prioritization Method: A Systems Prioritization and Decision-Aiding Tool for the Waste Isolation Pilot Plant: Final Report Revision 1*, April, Albuquerque, New Mexico.

SNL (Sandia National Laboratories), 1996, *Analysis Package for the Salado Flow Calculations of the Performance Assessment Analysis Supporting the Compliance Certification Application*, SNL/WIPP #40514, Albuquerque, New Mexico.

Thompson, T.W., et al., 1996, *Inadvertent Intrusion Borehole Permeability*, May, Final Draft Report to Sandia National Laboratories, Albuquerque, New Mexico.

This page intentionally left blank.

APPENDIX I
LONG-TERM CONSEQUENCE ANALYSIS FOR NO ACTION ALTERNATIVE 2

I.1 INTRODUCTION

This appendix provides detailed information related to the consequence analysis for No Action Alternative 2, including background information on the scenarios analyzed, descriptions of the conceptual models of releases used, and data input parameters cited. Also provided are the specific analytical methods, computer codes, and exposure calculations used. Methods described include summaries of models and codes used for waste source-term release, contaminant transport, radiation dose, and chemical exposures. The report also provides a summary of human health impacts for the sites considered in the analysis.

I.1.1 Background

Long-term environmental consequence analyses were not performed for the no action alternatives in either the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) or the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). The impact analyses described in those documents focused on expected site operations associated with treatment and storage, with the assumptions that transuranic (TRU) waste would be indefinitely stored at 10 major generator sites and that institutional control would be sufficient to preclude any site impacts. In general, it is estimated that if effective monitoring and maintenance of storage facilities were provided, adverse health effects to the general public would be quite small, and the principal adverse effects, also small, would be related to occupational activity at the facility. Health effects would continue indefinitely at such levels under the hypothesis of the U.S. Department of Energy (DOE or the Department) control.

However, if the DOE were to lose institutional control of the storage facilities, it is estimated that intruders could receive substantial radiation doses, a situation that could persist for the indefinite future. In addition, contaminants in TRU wastes stored in shallow burial trenches and surface storage facilities will eventually be released and would persist in the surrounding environments at the generator-storage sites, exposing on-site and off-site populations to chronic health risks.

In the FEIS (DOE 1980) and SEIS-I (DOE 1990) analyses, DOE referenced completed National Environmental Policy Act documents for some of the major retrievable storage facilities to describe the effects of continued retrievable storage. These sites included the Hanford Site (Hanford), Idaho National Engineering and Environmental Laboratory (INEEL), and the Savannah River Site (SRS).

The Record of Decision on the FEIS, which was published on January 28, 1981, determined, as part of the basis for decision, that the No Action Alternative was “unacceptable.” This determination was made at the time because of the potential impacts of natural, low-probability events and human intrusion at storage facilities after governmental control of the site is lost. In SEIS-I (DOE 1990), a summary of the FEIS analysis was provided and the conclusion was again reached in the Record of Decision, published in June 21, 1990, that the No Action Alternative was unacceptable.

I.1.2 Purpose and Scope

In this *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (SEIS-II), No Action Alternative 1 assumes that DOE would indefinitely maintain institutional control and, therefore, long-term impacts of post-closure intruders and environmental release were not assessed. No Action Alternative 2 assumes that TRU waste would not be emplaced at Waste Isolation Pilot Plant (WIPP) during the disposal phase, and, therefore, no radiological consequences to workers or the public would be realized in and around WIPP in this case. However, exposures would continue to occur at the major treatment facilities.

Under No Action Alternative 2, TRU waste is generated at all sites, including small-quantity sites, over the next 35 years. During this period, waste generated at the small-quantity sites would be consolidated and treated at the 10 major treatment sites, as described for this alternative in Chapter 3. Both consolidated and generated TRU waste will be put into retrievable storage consistent with current practices. Current storage configurations include soil-covered asphalt or concrete pads, shallow trenches, earthen berms, covered enclosures, storage buildings for contact-handled (CH) TRU waste, and buried caissons for remote-handled (RH) TRU waste. TRU waste would remain in these assumed storage configurations for an institutional control period of 100 years, beginning in 2033. During this period of institutional control, effective monitoring, surveillance, and maintenance would be expected to minimize the risk of contaminant release from the storage configurations.

At the end of the 100 years, following a TRU waste-generation period (i.e., 2133), institutional control is assumed to be lost. As facilities begin to degrade, TRU waste would be introduced into the accessible environment.

Calculations of the long-term consequences resulting from environmental releases from the storage facilities were performed for a 10,000-year period after the loss of institutional control. Environmental and human health impacts as a result of storage-facility releases were not evaluated for the period of institutional control.

Because 99 percent of the estimated TRU waste volume and inventory that would be generated can be accounted for at seven of the 10 major treatment sites (see Appendix A), environmental and human health impacts were estimated at these seven sites only: Hanford, INEEL, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Rocky Flats Environmental Technology Site (RFETS), and SRS. The three remaining sites not considered for this analysis were Argonne National Laboratory, the Mound Plant, and Nevada Test Site.

To the extent possible, this long-term consequence analysis for No Action Alternative 2 uses environmental data sets and models developed for low-level waste and low-level mixed waste consequence analyses conducted in the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997b). The data sets and models were modified for assumed TRU waste inventories, storage site locations, and related environmental transport parameters, as appropriate. Data sources for this analysis include site descriptions and data provided in the following:

- WM PEIS (DOE 1997b)
- referenced contractor reports supporting the WM PEIS analysis (Holdren et al. 1995, Bergenback et al. 1995, and Blaylock et al. 1995)
- key site-specific environmental references
- *Transuranic Waste Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996b)

I.2 RISK ANALYSIS METHODOLOGY

The human health impacts of TRU waste were estimated for two types of exposures: (1) inadvertent human intrusion into areas of TRU waste storage and (2) source-term releases to surface and subsurface environmental exposure points.

Consistent risk measures were used to facilitate the comparison with the disposal alternatives. For radioactive substances, doses were estimated for the maximally exposed individual (MEI) and exposed populations for a 70-year lifetime period of highest dose and then expressed in terms of latent cancer fatalities (LCFs). For hazardous carcinogens, excess cancer incidence was calculated to the MEI and to the exposed population for a 70-year lifetime of highest exposure. For noncarcinogenic substances, the hazard index for the MEI for the highest period of exposure was estimated.

The following section provides the approaches used for the inadvertent human intrusion and the long-term environmental releases used in this analysis.

I.2.1 Inadvertent Human Intrusion Impacts

Inadvertent human intrusion into waste remaining at the sites may result in human health impacts. Two human intrusion scenarios were considered for both buried waste and surface-stored waste configurations. RFETS and LLNL do not have waste stored in shallow burial configurations, so buried waste intrusion scenarios were not evaluated at these two sites.

Buried waste intrusion scenarios include the driller and gardener scenarios, described below.

- **Driller.** A hypothetical intruder drills a well directly through buried or soil-covered TRU waste to underlying groundwater. As a result of the drilling, contaminated soil is brought to the surface and mixes with the topsoil. The circular drill hole was assumed to be 30 centimeters (12 inches) in diameter and 4 meters (13 feet) in depth, with the volume of waste removed by drilling instantaneously combined with the clean soil in the top 15 centimeters (6 inches) of the soil column. The extent of the contamination was limited to an area of 10 meters by 10 meters (33 feet by 33 feet). The driller would be exposed at the drill site over a five-day work week via external ground radiation for 40 hours, via inhalation of resuspended soil for one hour at a rate of 20 cubic meters (706 cubic feet) per day, and via inadvertent ingestion of soil for five days at a rate of 100 milligrams (3.5×10^{-3} ounces) per day. The soil resuspension was based on an average mass loading factor of 1.0×10^{-4} gram of soil per cubic meter (6.3×10^{-9} pounds per cubic feet) of air.

- **Gardener.** An individual farms a garden on the land containing the contaminated soil (following the driller intrusion) over a period of 30 years. During this time, 25 percent of the individual's yearly vegetable and fruit intake was assumed to be produced from this garden. The area of contamination was limited to that of the drill cuttings, assumed to be 100 square meters (1,090 square feet). In addition to food crops, the individual would be further exposed via inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil. The gardener was assumed to spend 12 hours a day working outside, thus exposed to the soil 4,383 hours per year. The gardener's inhalation exposure is 8,766 hours per year (at 24 hours per day) and the soil ingestion rate is 100 milligrams (3.5×10^{-3} ounces) per day for 365.25 days per year. Also, the gardener would ingest 14 kilograms (30.8 pounds) per year of leafy vegetables, 55 kilograms (121 pounds) per year of root vegetables, 31 kilograms (68 pounds) per year of fruit, and 73 kilograms (161 pounds) per year of grain, all assumed to have been grown in the contaminated region of his or her yard.

Surface-stored waste intrusion scenarios include the scavenger and farm family scenarios, described below.

- **Scavenger.** A hypothetical scavenger intruder comes into direct contact with surface-stored TRU waste over a 24-hour period. The scavenger is exposed via inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil while at the site. The scavenger does not ingest any food but is exposed via inhalation of resuspended soil (waste) and via external radiation. It is also assumed that no clean soil covers the waste, so the dose factors per unit concentration are multiplied by the waste form concentration to get the total dose to the scavenger.

- **Farm Family.** In this scenario, a hypothetical farm family of two adults and two children lives and farms on the land immediately over the former surface-stored TRU waste disposal area. The MEI in the family is exposed via ingestion of contaminated food crops, inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil.

Estimates of radiation dose were made using unit dose factors (dose per unit concentration of each contaminant in soil) developed for each intruder scenario and site using the GENII computer code (see Appendix F). Unit dose factors were multiplied by calculated concentration of each contaminant in relocated waste in the top 15 centimeters (6 inches) of soil to produce dose per contaminant. The contaminant concentrations for waste were developed using volume information from Table A-14 and contaminant inventory information from Tables A-40, A-42, A-45, A-49, and A-50. Doses from all of the radionuclides of concern were summed to yield the total effective dose equivalent for the intruders in each scenario. Calculated doses were then converted to LCFs using methods described in Appendix F. All intrusions were assumed to occur at the time institutional control would be lost (i.e., 2133), minimizing reduction of radionuclide activity by radioactive decay.

Impacts from hazardous chemicals were determined by estimating the total intake of each chemical. This intake was then compared to the slope factor for carcinogens and to the permissible exposure limits for noncarcinogens. Methods and reference values used for calculating hazardous chemical impacts are presented in Appendix F and Appendix G.

I.2.2 Impacts of Long-Term Environmental Releases

Populations and individuals living near sites where TRU waste would remain under No Action Alternative 2 may be impacted by long-term environmental releases of contaminants. The following two scenarios were used to evaluate impacts to the MEI from chronic long-term environmental releases.

- Groundwater Exposure. The MEI from a farm family was assumed to live 300 meters (980 feet) downgradient based on average groundwater flow of a TRU waste storage area. The family grows and consumes their own crops and livestock and uses contaminated groundwater as a source of drinking water. Contaminated groundwater is used for watering the crops and animals. This receptor was considered for long-term releases from buried or soil-covered TRU waste and surface-stored TRU waste.

- Air Pathway Exposure. A hypothetical individual was assumed to be exposed to the maximum airborne contaminant concentration released from the stored TRU waste site. This receptor, located at least 100 meters (330 feet) from the site but within an 80-kilometer (50-mile) radius, was only considered for long-term releases from surface-stored TRU waste.

Impacts to the off-site populations within 80 kilometers (50 miles) of the sites were assumed to be exposed via atmospheric transport of contaminants and/or by contamination of surface water (used only for drinking water) from releases to the ground water pathway. Population exposure from the groundwater/surface water pathway is applicable only for Hanford, ORNL, and SRS. Current population distributions were used for all sites. Long-term releases from both buried or soil-covered TRU waste and surface-stored TRU waste were included.

The Modular Risk Analysis (MRA) methodology used in the WM PEIS (DOE 1997b) was used for these analyses. Evaluation of the multimedia transport of radionuclides and chemical contaminants in air, surface water, and groundwater pathways was done using the MEPAS® code. The source-term-release component of the MEPAS® code was used to generate a specified release rate for each assumed TRU waste form. This was done to simulate the release of radionuclides and hazardous chemicals from TRU waste from a storage facility. MEPAS® calculates the annual flux rate of each contaminant released from a storage facility. Output from the MEPAS® source-term-release module was used as input for the MEPAS® transport module calculations.

Output for the hazardous chemical concentrations calculated by the MEPAS® transport module was used by MEPAS® risk components to calculate a cancer incidence and hazard index profile of over 10,000 years for chronic releases of both carcinogenic and noncarcinogenic hazardous substances, respectively.

The MRA methodology was developed by Pacific Northwest National Laboratory and Advanced Sciences, Inc. to facilitate regional-scale risk analysis. This methodology is described in several documents (Strenge and Chamberlain 1995; Whelan et al. 1995) and presentations (Whelan et al. 1994). The MRA methodology was developed for regional- and site-wide risk computations involving a large number of release sites with different TRU waste forms for various environmental settings and transport and exposure pathways.

The MRA methodology is based on the assumptions of linearity between the release-site source, the environmental transport, and the impacts at the receptor. By assuming the linearity of the system, the methodology can be divided into compartments that can be implemented both independently and concurrently. The compartments of the MRA methodology are (1) contaminant mass at the source, (2) determination of contaminant release rate from the source, (3) transport modeling of the contaminant into the environment (environmental concentrations at the receptor location), (4) exposure assessment for dose to receptor (MEI or population), and (5) estimation of impacts at the receptor.

The MRA methodology is based on the following general description for health impact:

$$\text{Health Impact} = P \times RF \times URF \qquad \text{(Equation I-1)}$$

where Health Impact is the estimated probability of adverse effects (carcinogenic risk for radionuclides and chemical carcinogens, and hazard quotient for noncarcinogenic constituents) from a contaminant at a receptor; P is the probability of the release event (unitless); RF is the releasable fraction of the source (unitless); and URF is the health impact associated with a contaminant at a receptor based on a unit quantity at the source. The UTF and UFF require the convolution of time series and those products can combine with the UDF by straight multiplication. URF expresses health impact (cancer incidence for radionuclides and chemical carcinogens, and hazard quotient for chemical noncarcinogens) and is determined as follows:

$$URF = [\,(Q \times UFF) \bullet UTF\,] \times UDF \times UIF \qquad \text{(Equation I-2)}$$

where Q is the estimated quantity of contaminant at the source in grams or curies; UFF is a time series of contaminant release rate fluxes designated as contaminant mass per time divided by unit contaminant mass; and UTF is a time series of environmental concentrations at a receptor produced from the UFF for groundwater, air, surface water, and soil media (expressed as contaminant mass per volume of medium divided by unit contaminant mass per time).

UDF is the dose to an organism from a unit concentration for a given exposure pathway. For chemicals, UDF is expressed as contaminant mass per body mass per time divided by unit contaminant mass per volume of contaminant in the environment at the receptor point. For radionuclides, UDF is expressed as contaminant total dose (rem) divided by unit contaminant mass per volume of contaminant in the environment at the receptor point.

UIF is the unit health impact factor that provides the dose conversion factor for radionuclides, cancer potency factor for chemical carcinogens, or reference dose for noncarcinogenic contaminants. For radionuclides, UIF is expressed as cancer fatalities divided by unit contaminant total dose. For chemical carcinogens, UIF is expressed as cancer incidence divided by unit contaminant mass per body mass per time. For chemical noncarcinogens, UIF is expressed as hazard quotient divided by unit contaminant mass per body mass per time.

The UFF and UTF are time series at different locations. The UFF is the time series of contaminant release rate from the source, while the UTF is the time series of contaminant concentration at the receptor point. The UTF and UFF require the convolution of time series and those products can combine with the UDF by straight multiplication. Equation I-2 provides the convolution method used to combine the series (the convolution operation is represented by the symbol $\bullet$).

Whereas Equation I-2 provides a description of the link between the different unit factors involved in computing the URF, Equations I-3 through I-6 provide a description of each of the unit factors that were developed to compute URFs. Note that the UFF and UTF are time series that must be convoluted together. The source, UDF, and UIF are multipliers.

$$UFF = \frac{F_s}{S_u} \qquad \text{(Equation I-3)}$$

where S_u is the unit source mass (grams) or the unit source activity (curies) and F_s is the contaminant flux release rate from the TRU waste form expressed as mass per time. UFF includes the probability of release and the release factor fraction for a given scenario.

$$UTF = \frac{C_f}{F_u} \qquad \text{(Equation I-4)}$$

where F_u is the unit contaminant flux rate expressed as mass per time and C_f is the contaminant concentration at the receptor based on transport through the appropriate media expressed as mass per volume.

$$UDF = \frac{D_c}{C_u} \qquad \text{(Equation I-5)}$$

where C_u is the unit concentration at the receptor expressed as mass per volume and is based on contaminant transport through the appropriate media and D_c is the dose from the contaminant (for chemicals, D_c is expressed as mass of contaminant per body mass per time; for radionuclides, D_c is expressed as the total dose to a human receptor).

$$UIF = \frac{R_d}{D_u} \qquad \text{(Equation I-6)}$$

where D_u is the unit dose to a human (for chemicals, D_u is expressed as mass of contaminant per body mass per time; for radionuclides, D_u is expressed as total dose). R_d is the health impact associated with a unit dose (for chemical carcinogens, R_d is expressed as cancer incidence divided by mass of contaminant per body mass per time; for chemical noncarcinogens, R_d is expressed as hazard quotient divided by mass of contaminant per body mass per time; and for radionuclides, R_d is expressed as cancer fatalities divided by total dose).

Average environmental conditions that are dependent on the TRU waste storage site were selected. Separate URFs and associated factors were developed for the different environmental settings of the seven major generator sites. Environmental settings were assumed to have homogeneous climatological, hydrologic, and geologic characteristics. Therefore, the URF is representative of the risk from a release site within a region and not an actual risk. The local climatological, hydrologic, and geologic characteristics for this analysis were developed using Holdren et al. (1995). The regional climatology (joint frequency distributions) and population for regional air receptors for the seven major generator sites were based on the WM PEIS methods described in

detail in Bergenback et al. (1995). Details of the selection and application of these data and information for this analysis are described in Buck et al. (1997).

Conceptual site models were developed for each environmental setting associated with a storage site. These models defined the relationship between the source contaminant at the release sites and the health impacts at the receptors. The important components associated with these relationships were the constituents of interest, waste-source types, release mechanisms, exposure media, and receptor types. For this analysis, the probability of a release or exposure event was assumed to be 1.0. Likewise, it was assumed that sources were in a releasable form such that RF is equal to 1.0.

Once the waste configuration and TRU waste forms for each environmental setting were identified, the release mechanisms were identified. For this analysis, infiltration of contaminants to the vadose and groundwater system was considered to be the primary release mechanism. Volatilization, suspension, and overland flow release mechanisms were also considered. The resulting release rate (contaminant flux) for each release mechanism was also dependent on the TRU waste form. In addition, the solubility of each contaminant in the TRU waste form was an important factor in determining contaminant release rates. TRU waste forms listed in Appendix A were categorized to approximate the release of contaminants from the waste form into the environmental media. It was determined that all waste forms fell into one of two bounding waste form types, soil or cement. An analysis of the solubility limits for the primary TRU waste contaminants at each site was conducted. The results were incorporated into the computations of contaminant fluxes.

UFFs were generated using the MEPAS® model to simulate the release of contaminants from a source term. The model directly considers contaminated soil and solidified (cement) TRU waste forms. Contaminant is removed from the source by simultaneously evaluating degradation or decay, groundwater leaching, atmospheric volatilization, and soil erosion by wind suspension and overland runoff, as appropriate. To verify that contaminant release rates were not higher than the potential solubility associated with the TRU waste forms analyzed, Q (the estimated quantity of contaminant at the source) was included with the UFF to produce total flux factors. These were subsequently convoluted with the UTFs, thereby eliminating the contaminant release versus waste form solubility issue.

The UTF represented the environmental fate and transport component of the unit factor methodology. The UTF value was based on 1 gram or 1 curie of contaminant at the source which, after being transported through a specific environmental medium, ultimately arrives at the receptor exposure point. The receptor exposure point for groundwater analysis was a well 300 meters (984 feet) directly downgradient from the source, assumed centerline of the plume. The atmospheric receptor was located at the point of highest concentration that is at least 100 meters (328 feet) and within a radius of 80 kilometers (50 miles) from the release point. The UTF is media dependent. For example, UTF for air is expressed as milligrams per cubic meter per gram, or picocuries per cubic meter per curie; as milligrams per square meter per gram, or picocuries per square meter per curie for soil; and as grams per milliliter per gram, or curies per milliliter per curie for surface water and groundwater.

The UDF involves an average daily intake in milligrams per kilogram per day for chemicals or a lifetime radiation dose in rem for radionuclides. UIF relates the chemical intake or radiation dose

to a risk or hazard index, as appropriate, for each pollutant. Both UIF and UDF are defined for intake or exposure routes of inhalation, ingestion, and external radiation.

Three different human health impact types were estimated, including exposure to carcinogenic radionuclides, carcinogenic chemicals, and noncarcinogenic chemicals. These impacts are directly related to the three types of UIFs computed for this analysis.

MEI receptors influence UDF calculations by defining dose intake factors and UTF calculations by defining the exact location of the receptor; as a result, MEI impacts were calculated and then used in the determination of population impacts. Equation I-7 provides the convolution method used to combine the series (the convolution operation is represented by the symbol $\bullet$).

$$URF = [Q \times UFF] \bullet UTF(t) = \int_0^t [Q \times UFF(t)] \times UTF(t-t)dt \qquad \text{(Equation I-7)}$$

Once the convolution is completed, all the factors can be combined (based on Equation I-2) to provide health risk or hazard quotient impact values.

I.3 COMPUTER CODES

The potential health impacts from exposure to radioactive material and hazardous, nonradioactive material releases were evaluated with two computer codes. The MEPAS® code (described in Droppo et al. 1989 and 1991; Whelan et al. 1987; Strenge and Peterson 1989; and Buck et al. 1995) was used to assess contaminant transport and to calculate toxicological impacts and carcinogenic risks from hazardous constituents. GENII, described in Napier et al. (1988a, 1988b, 1988c), was used to calculate radiation dose from atmospheric releases and from radioactive material contamination trapped in soil. A brief discussion of the key components of the MEPAS® and GENII codes used in this analysis is presented in this section.

I.3.1 MEPAS® Code

The MEPAS® code integrates and evaluates transport and exposure pathways for chemicals and radioactive releases according to their potential human health impacts. MEPAS® is a physics-based approach that couples contaminant release, migration, and fate for environmental media with exposure routes and health consequences for radiological and nonradiological carcinogens and noncarcinogens.

Contaminant release from the waste zone was modeled with the source-term release component of MEPAS®. In general, the mass or activity of a contaminant in the source zone decreases over time because of contaminant removal by first-order degradation or radioactive decay, leaching to the groundwater, wind suspension, surface water erosion, and volatilization.

Radioactive and hazardous waterborne and airborne contaminant transport in multiple media were calculated using the transport components of the MEPAS® code. The MEPAS® waterborne transport code consists of: (1) groundwater, (2) surface water, and (3) overland transport models. These three transport models can either be run separately or linked to provide environmental concentrations at specified receptor points. For each waterborne transport pathway, contaminant retardation is described by an equilibrium coefficient, k_d. First-order degradation or decay is

assumed for all contaminants that do not result in toxic decay products. For radionuclides in the waterborne transport pathway, parent contaminants are conservatively treated (i.e., not decayed) during transport through intermediate pathways. On reaching the environmental receptor point, radiological decay is corrected using the Bateman equation, and the code subsequently computes the temporal distribution of each decay progeny.

The MEPAS® atmospheric transport code considers the input of suspension and volatilization release rates to compute transport and dilution, washout by cloud droplets and precipitation, and deposition on the underlying surface cover. The atmospheric model uses climatological information on wind speed and direction, precipitation, and atmospheric stability (joint frequency distribution data) to compute average air and surface contamination concentrations. The atmospheric model also accounts for plume depletion from decay and deposition to ensure mass balance for the system. Contaminant transport was assumed to occur quickly enough so that chemical transformation can be omitted.

Results from the different transport pathway models were used as input to the exposure to calculate the human health impacts for each hazardous chemical contaminant. The following exposure routes were considered to determine the potential exposure to the MEI and the surrounding population: (1) dermal contact, (2) external exposure, (3) inhalation, and (4) ingestion. Each exposure route is evaluated to obtain an estimated average daily human exposure from each contaminant. The daily exposure rates are then converted, using mathematical codes, to average individual impact factors for carcinogenic and noncarcinogenic chemicals. Detailed information on the exposure component of MEPAS® can be found in Appendix F.

I.3.2 GENII Code

Although GENII models the environmental transport, contaminant accumulation, and radiation dose to an individual or population, it was used to calculate radiation doses under human intrusion scenarios. Methods for calculating doses with GENII are found in Appendix F.

I.4 WASTE CHARACTERISTICS

To model the health effects associated with TRU waste at the various DOE sites, the waste must be characterized in terms of its volume, contaminant inventory, and waste form. Appendix A presents the site-specific volumes (Table A-14) and contaminant inventories (Tables A-40, A-42, A-45, A-49, and A-50) used for No Action Alternative 2 analyses. The following discussion presents descriptions of TRU waste forms and waste form categories, the quantity of each waste-form category, and the contaminant inventory distribution of each TRU waste-form category used in this analysis.

I.4.1 Description of TRU Waste Forms and TRU Waste-Form Categories

TRU waste form characteristics can have large effects on the rate at which contaminants are released from the waste zone. TRU waste-form characteristics vary widely at the treatment sites but can be classified into one of two general waste-form categories. These waste-form categories and the modeling parameters associated with each are discussed below.

The first general waste-form category is comprised of unconsolidated TRU wastes. Because this waste is unconsolidated, it is assumed to be permeable. Thus, water percolating through a zone

containing this category of waste would come into contact with all surfaces of the waste once waste contours are breached. This type of waste zone is also susceptible to wind suspension and water erosion processes. The release of contamination by leaching is regulated by the relative tendency of contaminants to exist in an aqueous phase or sorbed to solid surfaces. This partitioning between the aqueous and adsorbed phases is often expressed in terms of a surface-adsorption coefficient, k_d, and is dependent on the contaminant and the solid adsorbent material. If a contaminant is present in high-enough concentrations, the capacities of the aqueous and sorbed phases to contain the contaminant can be exceeded. Contaminant release, therefore, will be controlled by its solubility.

Unconsolidated TRU waste types in this first waste-form category can be further subdivided into those having either low or high surface-area-to-volume ratios. Examples of TRU waste with low surface-area-to-volume ratios and relatively low surface adsorption coefficients include waste containers, personal protective equipment (PPE), and metal process equipment. Contaminants from this type of TRU waste readily leach into the surrounding soil. Their release from the waste zone is controlled by the sorptive properties of the surrounding soil.

Unconsolidated TRU waste with high surface-area-to-volume ratios can have high surface adsorption coefficients. Contaminant release from these TRU waste types may be controlled by the sorptive properties of the TRU waste form itself. Examples of high surface area wastes include sludge, soil, and spent filters/adsorbents. Although the TRU waste form may control the release rate, physical data available for these waste types are limited, making it difficult to estimate sorption coefficients. For these types of TRU waste it is conservatively assumed, therefore, that the sorptive properties of the surrounding soil can also be used to determine the release characteristics of the high surface area TRU waste forms.

The second general waste-form category is comprised of solidified TRU waste whose permeability is much lower than that of the surrounding soil while sufficiently high to allow contaminant mobility within the TRU waste form. Percolating water tends to move around this category of waste and leach contaminants only from their exterior surface. The most common example of this TRU waste form is cemented waste. As contaminants are removed from the exterior surface, concentration gradients are established and contaminants tend to diffuse from the interior of the waste to the exterior surface. Therefore, the contaminant leaching release rate depends on the internal mobility of the contaminant, which is often expressed as an effective contaminant diffusion coefficient. Wind suspension and water erosion are assumed not to affect this solidified waste-form category until the TRU waste form fails.

In addition to contaminant-specific grout diffusion coefficients (Buck et al. 1997), the surface-area-to-volume ratio of the TRU waste form is required to model the release of contamination. It was assumed that waste will be disposed of in 55-gallon drums approximately 91 centimeters (36 inches) tall and 66 centimeters (26 inches) in diameter and that a cement slurry is poured directly into the drum, completely filling it. Using these assumptions, a surface-area-to-volume ratio of 0.082 cm^{-1} was calculated.

Another important parameter required for modeling contaminant release from this TRU waste-form category is the effective lifetime of the waste form. Cement degrades over time and will crack into small pieces such that the release of contamination is no longer limited to surface diffusion. At this point, contaminant release will be controlled more by surface adsorption and desorption than by diffusion. The effective lifetime of the TRU waste form depends on various properties of the

cement, including the type of solidification agent used, solidification agent-to-waste-to-water ratios, curing conditions, waste composition, and storage environment conditions, such as the number of wet/dry and freeze/thaw cycles. An effective lifetime of 500 years was used for cemented TRU waste forms in this analysis.

I.4.2 Quantity of Each TRU Waste-Form Category

The relative quantities of each TRU waste-form category at a site were determined using information available in Appendix A and BIR-3 (DOE 1996b). BIR-3 specifies a waste volume and waste density for each of 10 waste material types (Table I-1). These waste material types were categorized into one of the general TRU waste-form categories modeled in this analysis.

Table I-1
Categorization of BIR-3 TRU Waste Materials into General Waste-Form Categories [a]

TRU Waste Material Type	General TRU Waste-Form Category
Iron-based Metals/Alloys	Soil/Debris
Aluminum-Based Metal/Alloys	Soil/Debris
Other Metals	Soil/Debris
Other Inorganic Materials	Soil/Debris
Cellulosics	Soil/Debris
Rubber	Soil/Debris
Plastics	Soil/Debris
Solidified, Inorganic Matrix	Cement
Solidified, Organic Matrix	Cement
Soils	Soil/Debris

[a] BIR-3 (DOE 1996b)

The total mass of each TRU waste material type at each site was calculated by summing the product of the waste volume and the waste density for each waste stream. The total mass of all TRU waste material was used to determine the weight percent of each type of waste material at the various sites.

CH-TRU and RH-TRU waste masses for the different waste material types within a general category were combined to determine the relative weight percent for each general TRU waste-form category. Because of the lack of supporting data, the densities of the cement and soil TRU waste forms were assumed equal. In this way, weight percent analysis could be applied directly to the total waste volume. This assumption has minor impact on the resulting information.

Under No Action Alternative 2, TRU waste would be located in the 200-East and 200-West areas at Hanford. Because the distribution between the two Hanford areas is not currently known, it was assumed that 50 percent of the total volume would be disposed of at each Hanford location. The

final relative percentages for each general TRU waste-form category at each release site are shown in Table I-2. These relative quantities were multiplied by the total TRU waste volumes for the site (see Appendix A) to determine final site volumes for each TRU waste-form category. Volumes are also reported in Table I-2.

Table I-2
Relative Quantities and Volumes of Each TRU Waste-Form Category by Release Site

Release Site	Relative Quantities (percent)		Volumes (cubic meters)	
	Soil/Debris	Cement	Soil/Debris	Cement
Hanford Site - 200 East Area	100.0	0.0	43,500	0
Hanford Site - 200 West Area	100.0	0.0	43,500	0
Idaho National Engineering and Environmental Laboratory [a]	84.3	15.7	26,200	4,890
Lawrence Livermore National Laboratory	97.4	2.6	1,160	31
Los Alamos National Laboratory	63.8	36.2	13,600	7,700
Oak Ridge National Laboratory	76.1	23.9	3,610	1,140
Rocky Flats Environmental Technology Site	77.6	22.4	8,430	2,430
Savannah River Site	85.2	14.8	10,300	1,790

[a] INEEL values include waste volumes from ANL-W.

I.4.3 Contaminant Inventory Distribution of Each TRU Waste-Form Category

The radioactive and hazardous contaminant inventories used in the No Action Alternative 2 analysis, as discussed in Appendix A, are the total inventories present at each site for CH-TRU and RH-TRU waste. The inventories were not broken down by TRU waste material type. For the purpose of this analysis, the CH-TRU and RH-TRU waste inventories are added together and assumed to be distributed over the different TRU waste-form categories with the same relative ratios as the volume fractions. For example, if a site has 75 percent soil/debris and 25 percent cement TRU waste volume, the contaminant inventory was distributed 75 percent to soil/debris and 25 percent to cement.

I.5 WASTE CONFIGURATION AND CONTAMINANT RELEASE SCENARIOS

This section describes the basis for the source-term release analysis, which provided the contaminant flux factors in the MRA methodology described in Section I.2.2. Topics of this section include a general conceptual site storage model for buried or soil-covered TRU waste and surface-stored TRU waste, and assumptions governing the release of contaminants from the TRU waste-form categories.

The overall geometrical configuration of a waste storage zone, the assumed degradation of the waste storage zone, and the distribution of the TRU waste forms within the zone affect the magnitude and areal extent of the contaminant release fluxes from the zone. Each is discussed in this section.

I.5.1 Waste Storage Configuration

The following assumptions were made for the analysis of the buried or soil-covered TRU waste: (1) all TRU waste is contained in 55-gallon drums 91 centimeters (36 inches) tall and 66 centimeters (26 inches) in diameter that are stored together in one shallow burial zone, (2) four layers of drums are stacked on an asphalt or concrete pad with plywood sheets between the layers and on top, and (3) 1.2 meters (4 feet) of contaminant-free soil is used as backfill over the layers of drums. This overall configuration is illustrated in Figure I-1.

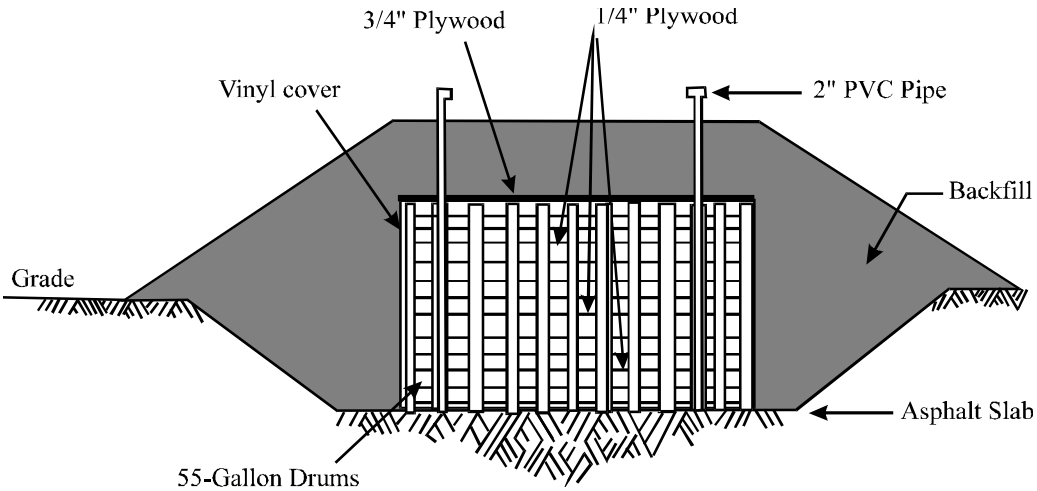


Figure I-1
Buried or Soil-Covered TRU Waste Storage Zone Configuration

For the analysis of surface-stored TRU waste, the initial waste zone configuration is similar to that for buried or soil-covered TRU waste. It is assumed that four layers of drums are stacked on an asphalt or concrete pad with plywood sheets between the layers and on top as illustrated in Figure I-2. However, instead of being placed in a buried or soil-covered configuration, the stacked drums are placed in metal storage buildings or covered storage areas.

The relative amount of material in a surface storage configuration versus a buried storage configuration was determined for each site using the following assumptions. First, the waste that is currently stored in either a surface configuration or buried waste configuration is not moved to a different configuration. Second, newly generated wastes are placed in a surface storage configuration. The relative amounts of waste in each configuration are shown in Table I-3.

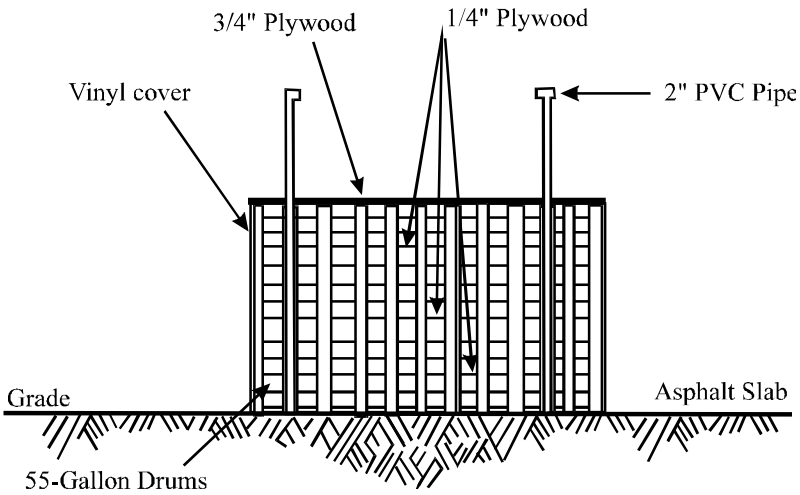


Figure I-2
Surface TRU Waste Storage Zone Configuration

Table I-3
Waste Zone Volumes, Horizontal Areas, and Configurations for Each Waste-Form Category by Release Site

	Waste Zone Volumes (cubic meters)		Waste Zone Horizontal Areas (square meters)		Waste Zone Configuration (Percent)	
Release Site	**Soil/Debris**	**Cement**	**Soil/Debris**	**Cement**	**Buried**	**Surface**
Hanford 200 East	55,300	0	15,200	0	13.6	86.4
Hanford 200 West	55,300	0	15,200	0	13.6	86.4
INEEL	33,400	6,230	9,150	1,710	49.9	50.1
LANL	17,300	9,800	4,740	2,690	37.9	62.1
LLNL	1,480	40	406	11	0	100
ORNL	5,350	1,680	1,470	460	15.2	84.8
RFETS	10,700	3,090	2,940	848	0	100
SRS	13,091	2,280	3,590	624	11.6	88.4

The vertical dimension of the waste zone for buried, soil-covered, and surface-stored configurations is approximately equal to 3.7 meters (12 feet). The drums are placed as close to one another as is possible in a rectangular grid arrangement. Because of this configuration, the volume of the waste zone will be larger than the volume of the TRU waste itself. The ratio of waste zone and waste drum volumes for a rectangular grid arrangement is:

$$\left[\frac{n \times (2r)^2 \times (4h)}{n\pi r^2 \times (4h)}\right] = \frac{4}{\pi} \qquad \text{(Equation I-8)}$$

where n is the number of drums, r is the drum radius, and h is the drum height. Waste zone volumes for each TRU waste-form category are calculated for each site by multiplying the corresponding volumes reported in Table I-2 by $4/\pi$. These overall waste zone volumes are reported in Table I-3. The horizontal cross-sectional areas of each TRU waste-form category for each site can be calculated by dividing the waste zone volumes by 3.7 meters (12 feet). These areas are also reported in Table I-3.

I.5.1.1 Facility and Waste Degradation

The ability of storage buildings, waste configuration components, waste containers, and TRU waste forms to contain contaminants needs to be considered when modeling the long-term release of contaminants. The following discussion provides an overview of each of these considerations in terms of their effect on the long-term release of contaminants from TRU wastes.

Facility Degradation

The surface storage scenario assumes that TRU waste is housed in metal storage buildings or a covered storage area. These buildings or covers will degrade relatively quickly as compared to the 10,000-year evaluation period, due chiefly to the lack of maintenance after the loss of institutional control. Therefore, metal storage buildings, enclosures, and covers are assumed to offer no protection and the surface storage scenario is modeled as if the stacked waste drums were not sheltered for the entire evaluation period. Facility degradation is not applicable to the buried or soil-covered TRU waste.

Waste Configuration Degradation

Components of the TRU waste form configuration are assumed to degrade quickly relative to the 10,000-year evaluation period. Degradation of the plywood or the storage building allows the spaces between the drums to fill with soil from the surface layer of the site. Likewise, once storage buildings degrade, the drums themselves will degrade at an accelerated rate, further altering the waste configuration.

It is also assumed that any asphalt or concrete pad at the base of the waste storage zone will be cracked or otherwise degraded for essentially the entire 10,000-year evaluation period. This allows infiltrating water to percolate through the waste zone, pass through the cracked or degraded pad, and move through the remainder of the vadose zone directly beneath the waste zone.

Waste Container Degradation

The integrity and longevity of the waste drums is also a factor in contaminant release from the waste zone. Both the surface-stored and buried or soil-covered scenarios assume that TRU waste will be contained in mild steel, U.S. Department of Transportation (DOT)-17C 55-gallon drums. Corrosion rates for mild steel drums are quite high even when buried in favorable, dry environments (i.e., drum lives of less than 100 years are expected). For surface storage facilities, once the storage enclosure or building degrades to the point where waste drums are directly exposed to the elements, stored TRU waste drums are expected to degrade more rapidly than TRU waste drums in a buried or soil-covered configuration. Because the expected life of the waste drums is relatively short compared to the 10,000-year evaluation period, no credit was given for the presence of containers during the evaluation period in the analysis.

Cemented TRU Waste Form Degradation

Initially, the cemented TRU waste form is assumed to be a solid block having the same size and shape as a 55-gallon drum. Cemented monoliths are known to crack and degrade into porous material over time. Unfortunately, the theory for modeling the transition from a solid block to porous material and its effect on contaminant release is not well developed. It is assumed, therefore, that the cemented waste blocks remain intact for the first 500 years and then catastrophically fail. After failure, the waste zone is assumed to act as a porous material.

I.5.1.2 Distribution of TRU Waste Forms

The horizontal cross-sectional area of the source zone is a required modeling input parameter. In reality, all drums of a given TRU waste-form category will not be emplaced in a single location within the waste zone. Rather, they will be interspersed with drums containing other TRU waste-form categories. To simplify the analysis, however, it is assumed that any specific area location contains drums of only one TRU waste-form category over the four vertical layers. It is also assumed that the waste zone is composed of a random distribution of “reasonably large” subareas of drums of only one TRU waste-form category. Each subarea is of sufficient size so that contaminant release is controlled by the physics and chemistry of that subarea’s TRU waste-form category alone. Therefore, contaminant release from the waste zone can be modeled in two parts (one for each waste-form category) using the conceptual mathematical models described and the appropriate fractional inventories and areas for each TRU waste-form category.

Contaminant mass flux is the output of source-term calculations for the subarea of each TRU waste-form category. Because the subareas are assumed to be uniformly dispersed throughout the waste zone, the mass flux of any contaminant from the two waste-form categories can be summed to determine the total mass flux of that contaminant over the cross-sectional area. Mass fluxes over the total waste zone area are required inputs for subsequent transport simulations.

I.5.2 Contaminant Release Scenarios

An overview of contaminant release scenarios from the different TRU waste forms for both the surface-stored and buried or soil-covered waste configurations is presented in this section. Geochemical controls that may limit the contaminant release from the overall waste zone are also discussed.

The overall rate of contaminant mass loss from the waste zone is the sum of the mass loss rates of five different loss processes. These processes are (1) decay, (2) leaching, (3) wind erosion, (4) water erosion, and (5) volatilization. The buried or soil-covered-waste scenario under No Action Alternative 2 assumes a 1.2-meter (4-foot) cover layer of soil that considerably reduces TRU waste interaction with surface erosion/dispersion mechanisms. By assuming that contaminant release to these mechanisms is zero, the contaminant inventories available for leaching increase, providing a maximized scenario for groundwater contamination. Leaching and decay, therefore, are the only two loss processes considered for the buried or soil-covered waste scenario.

A "multimedia" scenario was used for surface-stored releases. Water erosion, wind suspension, and volatilization were considered in addition to leaching and decay. This scenario assumes that there is no cover layer and contaminant transport by water erosion and wind suspension begins at the start of the analysis. Thus, the surface-stored scenario maximizes the potential air exposures. The effects of different TRU waste forms on each of the release mechanisms are discussed below.

I.5.2.1 Soil/Debris TRU Waste Form

When the waste zone is comprised of a soil/debris waste form, all five loss processes can occur. Degradation or decay is assumed to be a first-order process. Leaching is either solubility- or desorption-controlled. When there is no solubility-controlled solid phase, as with radionuclides and metals, or an organic liquid phase, as with organic chemicals, contaminant loss via leaching is assumed to occur by desorption-controlled transport. The velocity of the water percolating through the porous TRU waste form dominates this mode of transport. If the aqueous concentration of the contaminant is controlled by solubility, the mass flux is the product of the solubility of the contaminant and the volume of leachate passing through the waste zone. Water erosion and wind suspension are assumed to strip particles from the soil surface at a constant rate. These values were assumed to be zero for the buried or soil-covered waste scenarios to maximize leaching losses. Water erosion and wind suspension rates for the surface-stored scenario were calculated with MEPAS®.

Volatilization losses of organic contaminants were assumed to be zero in the buried or soil covered-waste scenario to establish a bounding case for groundwater contamination. In contrast, holes would develop in waste drums rather readily in the surface-stored scenario, causing most of the volatile organic inventory contaminants to be lost through volatilization. Therefore, the entire organic inventory is assumed to be released through volatilization during the first year, generating a maximized airborne scenario for volatile organic contaminants.

I.5.2.2 Cemented TRU Waste Form

The distribution of contaminants between different phases within the porous cement is not accounted for explicitly in the analysis. Decay and leaching are the only loss processes assumed to occur prior to failure. Decay of the overall contaminant mass is again assumed to be a first-order process. Infiltration water percolating through the waste zone is assumed to not penetrate the cemented TRU waste form. Rather, leaching loss results from percolating water flowing around the surface of the waste form and picking up contaminants as they diffuse through the water-filled pores of the cement. The cemented TRU waste form is assumed to fail after 500 years and, like the surface-stored scenario, it begins to act as a soil/debris TRU waste form and wind erosion, water erosion, and volatilization will begin.

I.5.3 Geochemical Controls on TRU Waste-Form Leaching

When the TRU waste form is cemented, leached contaminants do not immediately move out of the bottom of the waste zone. Under the assumed waste configuration, soil exists between each of the drum-shaped forms. Leached contaminants enter this soil zone before exiting the bottom of the waste zone with the percolating water. If the physical and chemical processes in this soil zone are such that contaminant leaching from the soil is slower than from the TRU waste form itself, this release process is the limiting step. The source-term release module, therefore, compares the leaching mass flux calculated from the cement TRU waste form with the leaching mass flux calculated under the assumption that the waste zone was composed of soil. The leaching mass flux used is the lower value of either the predicted desorption-controlled or the solubility-controlled soil release.

I.6 CONTAMINANTS OF CONCERN (CoC)

Initially, there were 141 radioactive, 47 organic, and 13 nonradioactive inorganic CoCs possible at the various treatment sites. To concentrate data collection efforts and analysis time on those CoCs that would contribute most to associated site hazards, a screening analysis was conducted. This analysis varied for radioactive, organic, and inorganic CoCs because of differing amounts of data available for each group. Data for the radioactive contaminants included site-specific radionuclide inventories. The screening analysis for this group of contaminants was divided into two possible transport pathways of concern: (1) airborne and (2) waterborne. A schematic of the screening process is shown in Figure I-3.

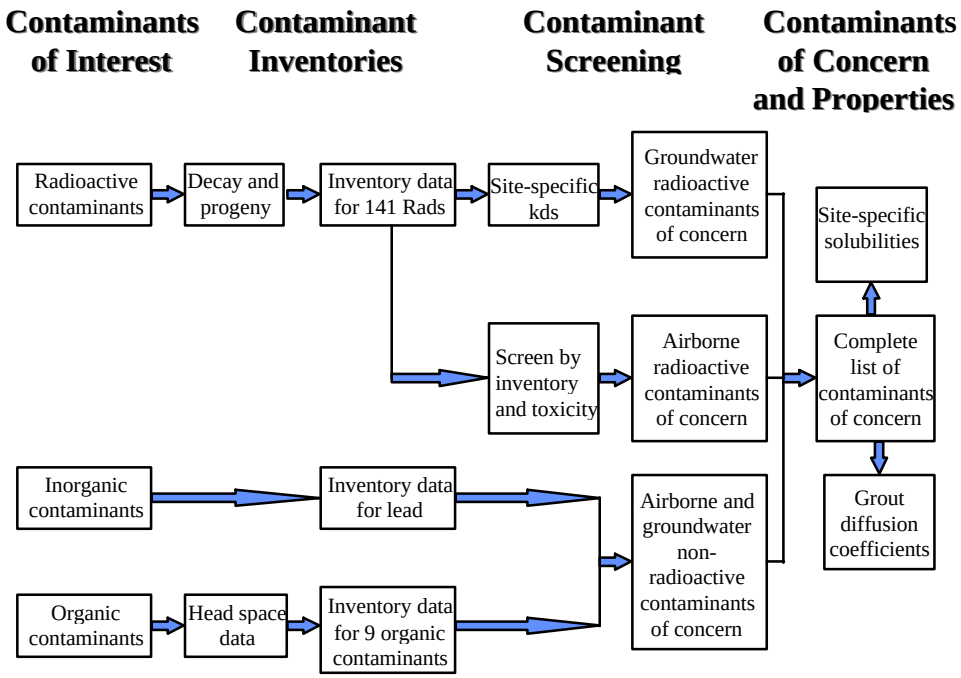


Figure I-3
Schematic of Screening Process for Contaminants of Concern

I.6.1 Radioactive Contaminant Screening Analysis

The first transport pathway to be considered was airborne contamination. It was assumed that unit amounts of waste, soil, or debris, with radioactive contaminant concentrations proportional to their inventories, were suspended by wind and transported through the air to a receptor. The human health impact resulting from this transport is, therefore, a function of the contaminant's inventory and inhalation dose factor. The relative impacts for each contaminant were compared and ranked according to their contribution to human health impact. The radionuclides with a combined risk equal to 90 percent of the total relative risk were designated as the airborne radioactive CoCs (Table I-4).

Table I-4
Contaminants of Concern for No Action Alternative 2

Contaminant	Type			
	Airborne Radioactive	Waterborne Radioactive	Inorganic	Organic
Am-241	x	---	---	---
Am-243	x	---	---	---
C-14	---	x	---	---
Cm-243	---	x	---	---
Cm-244	x	x	---	---
Cs-137	x	---	---	---
Eu-152	x	---	---	---
Np-237	---	x	---	---
Pa-233	x	---	---	---
Pu-238	x	x	---	---
Pu-239	x	x	---	---
Pu-240	x	x	---	---
Pu-241	x	---	---	---
Ra-226	x	---	---	---
Sr-90	x	---	---	---
U-233	---	x	---	---
U-234	---	x	---	---
U-235	---	x	---	---
Lead	---	---	x	---
Beryllium	---	---	x	---
Cadmium	---	---	x	---
Mercury	---	---	x	---
Carbon tetrachloride	---	---	---	x
Chloroform	---	---	---	x
Methylene chloride	---	---	---	x
1,1-Dichloroethylene	---	---	---	x
Methyl ethyl ketone	---	---	---	x
1,1,2,2-Tetrachloroethane	---	---	---	x
Toluene	---	---	---	x
Chlorobenzene	---	---	---	x
1,2-Dichloroethane	---	---	---	x
1,1,1-Trichloroethane	---	---	---	x

Leaching through the vadose zone to the groundwater was the second transport pathway to be considered. Contaminants must be present in sufficient quantities to result in health impacts through this pathway. Also, the site must have the necessary climatological and surface soil characteristics to percolate the amount of water needed to leach the contaminant from the waste zone and transport it through the vadose zone. The contaminant must then transport through the aquifer to a groundwater well, where it must be present in high enough concentrations and with sufficient toxicity to present consequential health impacts. Finally, radioactive contaminants must have long enough half-lives to sustain notable quantities of contaminant during the time required for transport.

To conduct this screening, slightly simplified MEPAS® runs were made. These runs utilized all of the release site data and assumed unit inventories for each contaminant. The release from the waste zone was assumed to be controlled by contaminant k_d values (i.e., the release was from a soil/debris TRU waste form and was not solubility limited). Transport through the environment was also controlled by the contaminant k_d values. Because of the importance of the assumed k_d values, all MEPAS®-generated radioactive contaminant k_d values were reviewed and modified with site-specific data, where available. These MEPAS® runs produced unit impact factors for each contaminant/site pair that was multiplied by the site-specific inventory to establish the estimated impact for each contaminant at each site. Relative impacts for each contaminant were again compared and ranked. The radioactive contaminants whose combined impact contributed 99 percent of the total relative impact were designated as waterborne CoCs (see Table I-4).

I.6.2 Inorganic Contaminant Screening Analysis

Reliable inventory data were generally not available for the inorganic contaminants. As a result, a qualitative screening method was employed.

Lead shielding is used to reduce surface dose rates to acceptable levels for RH-TRU waste containers; therefore, lead becomes a major part of the total waste mass and is included on the CoCs list. Lead from PPE is also a major contaminant in CH-TRU waste. The lead concentrations assumed in RH-TRU and CH-TRU waste are discussed in Appendix A.

Beryllium, cadmium, and mercury were also included on the list of CoCs, based on inventory estimates from the *Waste Isolation Pilot Plant Safety Analysis Report* fire scenario (DOE 1997a). Other inorganic contaminants, such as chromium, were not included on the CoCs list because of the lack of available inventory data. The assumed inorganic concentrations in RH-TRU and CH-TRU waste are discussed in Appendix A.

I.6.3 Organic Contaminant Screening Analysis

As with inorganic contaminants, little reliable inventory data were available for the organic contaminants. Some data reported in the *Final No-Migration Variance Petition* (DOE 1996a), however, could be used as an indirect indication of the volatile organic concentrations. The *No-Migration Variance Petition* summarized the results of a headspace sampling and analysis study conducted on TRU waste from the INEEL and RFETS. This study sampled 930 drums of varying waste types to determine a weighted-average headspace-gas composition that could be used for all TRU waste. The weighted values were screened using the concentration toxicity screening technique presented by the U.S. Environmental Protection Agency in the *Risk Assessment*

Guidance to Superfund, Volume 1, Human Health Evaluation Manual (Part A), (EPA 1989). This screening provided a list of carcinogenic and noncarcinogenic contaminants that account for over 99 percent of the human health impacts resulting from airborne contamination.

I.6.4 Key Contaminants Evaluated in No Action Alternative 2

The complete list of CoCs for No Action Alternative 2 is the combination of the waterborne radioactive, airborne radioactive, inorganic, and organic contaminants shown in Table I-4. The screening analyses resulted in a combined total of 32 CoCs. Once this list of CoCs was developed, an effort was made to obtain improved values for certain contaminant properties at specific sites. The contaminant diffusion coefficient in porous cement (required to model contaminant release from cement TRU waste forms) and contaminant solubility (required to model the solubility bounding case) were evaluated (Buck et al. 1997). Once the updated set of contaminant parameters was developed, actual waste zone contaminant release calculations were performed and flux factors for No Action Alternative 2 were generated.

I.6.5 Flux Factors

Source-term contaminant release calculations were run for all 32 CoCs for each site and for each waste-form category for a 10,000-year time period. The resulting contaminant flux factors were used to compute modular risk, which is represented as the flux factor term in Equation I-6. If a contaminant on the CoCs list was not present at a particular site, an inventory of zero was used for that calculation. Furthermore, if a particular TRU waste-form category was not present at a site, it was not considered in the flux-factor analysis. Table I-5 shows the number of nonzero flux factors produced by site and TRU waste-form category.

Table I-5
Nonzero Contaminant Flux Factors by Site and TRU Waste-Form Category

Release Site	Number of Nonzero Flux Factors	
	Soil/Debris	Cement
Hanford Site 200 East Area	30	---
Hanford Site 200 West Area	30	---
Idaho National Engineering and Environmental Laboratory	32	32
Lawrence Livermore National Laboratory	28	28
Los Alamos National Laboratory	31	31
Oak Ridge National Laboratory	32	32
Rocky Flats Environmental Technology Site	25	25
Savannah River Site	29	29

I.7 WATERBORNE AND AIRBORNE TRANSPORT

The transport portion of the impact analysis required specific information related to waterborne transport, airborne transport, and receptor locations. Each area is discussed below.

I.7.1 Waterborne Transport Parameters

Parameters related to the hydrologic and geologic characteristics of each site analyzed were selected from site-specific environmental settings developed for the WM PEIS (DOE 1997b) and Holdren et al. (1995). The environmental settings assumed for each of major treatment site analyzed are summarized in Buck et al. (1997). The references listed above contained the number of vadose zone layers at each site, the thicknesses and hydraulic conductivity properties of the vadose zone and aquifer layers, and a suite of physicochemical properties for all layers.

I.7.2 Calculated Waste Infiltration Rates

Flux factor calculations required additional site-specific parameters, in order to determine the waste infiltration rates needed for contaminant release calculations. Table I-6 shows MEPAS®-calculated water infiltration and soil erosion rate values for each site. The calculated rates are based on local climatology (i.e., precipitation, cloudiness, wind speed, and humidity), surface soil properties, and vegetation cover.

Table I-6
MEPAS®-Calculated Water Infiltration and Soil Erosion Rates for Each Site

Category	Hanford		INEEL	LANL	LLNL	ORNL	RFETS	SRS
	200E	200W						
Water Infiltration (centimeters/year)	1.49	1.49	1.43	0.663	9.28	42.2	0.156	24
Annual Precipitation (centimeters)	16	16	22	45	37	139	39	110
Percent Precipitation to Infiltration	9	9	6	1.4	25	32	0.4	22
Wind Suspension Erosion Rate (centimeters/year)	5.8E-04	5.8E-04	0.045	1.3E-03	6.1E-03	3.5E-05	7.7E-03	2.0E-03
Soil Eroded by Wind in 10,000 Years (feet)	0.19	0.19	1.48	0.44	2.00	0.01	2.53	6.59
Overland Flow Erosion Rate (centimeters/year)	1.9E-04	1.9E-04	3.4E-03	5.2E-03	0.014	0.012	6.5E-04	1.1E-02
Soil Eroded by Water in 10,000 Years (feet)	0.06	0.06	1.11	1.70	4.06	3.79	0.21	3.45
Total Soil Erosion in 10,000 Years (feet)	0.25	0.25	1.59	2.14	6.06	3.81	2.74	4.10

I.7.3 Airborne Transport Parameters

Parameters related to atmospheric release, transport, and deposition analyses required surface soil characteristics and regional climatological information. The surface soil and regional climatological information required to estimate soil suspension rates were obtained from Holdren et al. (1995). The regional meteorological data and atmospheric dispersion data, in the form of a joint frequency distribution of wind direction, wind speed, and atmospheric stability, were obtained from the WM PEIS (DOE 1997b).

I.7.4 Calculated Soil Erosion Rates

Flux factor calculations required additional site-specific parameters in order to determine the soil erosion rates needed for contaminant release calculations. Table I-6 showed MEPAS®-calculated water infiltration and soil erosion rates for each site. Wind suspension and overland waterflow soil erosion rates were computed using site-specific surface soil and local climatological information. Table I-6 also provided an estimate of the amount of surface soil removed over the 10,000-year modeling period to determine whether the 1.2-meter (4-foot) overburden could be removed to expose waste to the surface.

I.7.5 Air and Water Receptor Locations

Population impacts from atmospheric releases were calculated for all No Action Alternative 2 sites using site-specific joint frequency and population data. Population impacts from domestic and agricultural surface water uses were calculated for some of the sites. The atmospheric population distributions were obtained for all the sites from the WM PEIS (DOE 1997b). Results of a review of the annual site reports and specific recommendations regarding population exposure for each site are summarized in Buck et al. (1997).

I.8 CALCULATION OF UNIT EXPOSURE AND UNIT IMPACT FACTORS

The human health impact analysis for SEIS-II requires definition of the unit dose factor (UDF) and the unit impact factor (UIF). The UDF relates average daily intake (milligrams per kilogram per day) for chemicals and lifetime radiation dose (rem) for radionuclides. The UIF relates intake or dose to impact or hazard index for each pollutant, as appropriate. The UIF and UDF are defined for contaminant inhalation and ingestion and for external radiation exposure. The following sections describe the calculation of UDF and UIF from the health impact endpoint values provided in the MEPAS® output files for both individual and population exposures. Parameter arrays can also be calculated from information in the MEPAS® output files. Background information and the scope of the analysis are summarized first.

I.8.1 Background Information and Scope of Analysis

SEIS-II project analysis requires calculation of population health impacts as well as individual health impacts. The UIF values for individual and population exposures are the same and provide conversion from intake or dose to impact. These values are based on slope factors, reference doses, and radiation dose conversion factors. The UDF values differ from UIF values, in that the population UDF is evaluated using average parameter values instead of 90th percentile values. The number of people exposed is not included in UDF or UIF values; however, the population exposed must be included in the final analysis of impact, because populations are defined for each release site and receptor location. The UDF and UIF values are independent of release site and receptor location.

Many combinations of variables must be used to generate the UDF and UIF. These variables are described below.

I.8.1.1 Exposure Scenario

Analyses are performed for an MEI and for local populations. Both scenarios involve the potential exposure to air, soil, and waterborne contamination.

I.8.1.2 Receptor Type

Like the exposure scenario, MEI and local population receptor types are evaluated for No Action Alternative 2. Each receptor type requires the generation of specific UIF/UDF files; they cannot be combined into one calculation.

I.8.1.3 Exposure Media

Each analysis is performed with the appropriate exposure media for the MEI and local population scenarios. Types of exposure media include soil per unit mass, soil per unit area, air, and groundwater.

I.8.1.4 Pollutant Type

Specific output files are generated for each type of pollutant: noncarcinogenic chemicals, carcinogenic chemicals, and radionuclides. As with previous analyses, the list of chemicals in the two chemical file types is identical. All chemicals are analyzed for carcinogenic risk and noncarcinogenic hazard quotient. Chemical types that are not appropriate for a specific chemical will result in a zero health impact result.

I.8.2 Individual UDF and UIF Calculations

The results from individual UDF and UIF calculations provide the cancer incidence risk and hazard index values for the following parameters: each exposure pathway, each pollutant, one scenario, one pollutant type, and one set of up to 20 pollutants. These parameters are referred to as unit exposure factors. The file also contains the slope factors and reference doses used for chemicals in the analysis. MEPAS® assimilates the data and a postprocessor program extracts the UDF and UIF from each output file, as necessary, for subsequent calculations. For each set of results, the UDF values are summed over the specific values for each exposure pathway within an exposure route. The calculation output is a set of UDF values for each pollutant, calculated from the risk/hazard quotient values that are described in more detail in Buck et al. (1997). For total cancer fatalities, the UIF is set to 5×10^{-4} LCFs per rem.

I.8.3 Population UDF and UIF Calculations

Population UDF and UIF values are calculated according to the equations for individual UDF and UIF values (Equation I-5 and I-6). Population UDF, risk and hazard quotient values in the output files, however, must be taken from files generated specifically for population exposures. The population UIF value should be numerically equal to the individual UIF value.

I.9 HUMAN HEALTH IMPACTS OF NO ACTION ALTERNATIVE 2

This section provides estimates of human health impacts from stored TRU waste at the major generator-storage sites following loss of institutional control under No Action Alternative 2.

Impacts are presented for scenarios of human intrusion into the waste, and for scenarios of long-term environmental release from the waste via the atmosphere and groundwater/surface water. These scenarios are described in Sections I.2.1 and I.2.2.

The impacts to human health from waste intrusion and long-term environmental release were estimated using methods outlined in this appendix and described in more detail in Buck et al. (1997). This analysis focused on the impacts of waste at the seven major treatment sites, because the majority (99 percent) of the wastes generated would be stored at these sites under No Action Alternative 2. Estimates of impacts from RH-TRU waste were made only for those sites storing RH-TRU waste (i.e., Hanford, INEEL, LANL, and ORNL).

I.9.1 Impacts from Intrusion into Wastes

Human health impacts from waste intrusion were evaluated under scenarios for buried waste storage and surface-stored waste. Buried waste storage scenarios include those for a driller and gardener, while surface-stored waste scenarios include those for a scavenger and a farm family. The following sections present radiological and hazardous chemical impacts to hypothetical intruders from buried and surface-stored wastes.

I.9.1.1 Intrusion into Buried Waste

With the loss of institutional control, an inadvertent intruder could become directly exposed to waste stored in shallow burial facilities. The driller scenario postulates that an individual would drill into the waste and become exposed to waste material brought to the land surface by the drilling process. The gardener scenario assumes that an individual would farm in soil contaminated by the waste materials brought to the surface from the driller scenario and would ingest contaminated materials and eat produce from the garden. The results of analyses performed for these scenarios for both CH-TRU and RH-TRU wastes are presented below.

The estimated maximum dose to a hypothetical driller from exposure to CH-TRU WASTE ranged from about 2.2×10^{-3} to 0.01 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 1.1×10^{-6} to 5.4×10^{-6} for the five sites with buried wastes (Table I-7). The estimated maximum dose to a hypothetical driller from RH-TRU wastes ranged from 2.2×10^{-3} to 0.058 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 1.1×10^{-6} to 2.9×10^{-5} for the four sites that store RH-TRU wastes (Table I-8).

The estimated maximum 30-year dose for the gardener exposed to CH-TRU waste ranged from 19 to 126 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 9.6×10^{-3} to 0.063 LCFs (Table I-7). The estimated maximum 30-year dose to the gardener from RH-TRU wastes ranged from 6.1 to 89 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 3.6×10^{-3} to 0.045 (Table I-8). The highest estimated dose for CH-TRU wastes was calculated for INEEL for the driller scenario and for SRS for the gardener scenario. The highest estimated dose for RH-TRU wastes was calculated for Hanford for both scenarios.

Table I-7
Radiation Dose and Hazardous Chemical Impacts from Buried CH-TRU Waste Intrusion Scenarios

Radiological Impacts					
Radionuclide	**Hanford**	**INEEL**	**LANL**	**ORNL**	**SRS**
Driller Impacts (rem)					
Sr-90	6.1E-7	1.3E-8	4.9E-8	1.1E-5	1.3E-8
Y-90	8.5E-7	1.7E-8	6.1E-8	1.5E-5	1.7E-8
Cs-137	8.2E-5	5.3E-06	6.4E-6	2.4E-3	1.8E-6
Pu-238	2.9E-4	1.1E-4	4.6E-4	1.6E-4	4.1E-3
Pu-239	2.2E-4	1.5E-4	7.5E-4	2.2E-4	1.6E-4
Pu-240	5.2E-5	3.6E-5	9.8E-7	7.2E-5	4.0E-5
Am-241	1.5E-3	0.010	3.3E-3	7.6E-3	3.0E-3
Cm-244	2.4E-7	7.9E-7	6.1E-7	3.2E-5	8.3E-6
Total Dose (rem)	2.2E-3	0.011	4.5E-3	0.010	7.3E-3
LCF Probability	1.1E-6	5.4E-6	2.3E-6	5.2E-6	3.2E-6
Gardener Impacts (rem) - 30 years					
Sr-90	0.022	4.5E-4	1.6E-3	0.40	9.5E-4
Y-90	2.2E-3	4.3E-5	1.6E-4	0.048	4.5E-5
Cs-137	0.094	6.1E-3	7.4E-3	2.7	2.1E-3
Pu-238	8.3	3.1	13	4.4	115
Pu-239	6.7	4.6	23	6.6	4.9
Pu-240	1.6	1.1	30	2.2	1.2
Am-241	2.5	17.2	5.5	12	5.0
Cm-244	2.9E-4	9.8E-4	7.5E-4	0.039	0.010
Total Dose (rem)	19	26	41	29	126
LCF Probability	9.6E-3	0.013	0.021	0.015	0.063

Hazardous Chemical Impacts		
Driller Impacts		
Hazardous Chemical	**PEL**	**Cancer Incidence**
Cadmium	9.8E-2	1.4E-9
Beryllium	17	1.3E-7
Lead	27	
Mercury	12	
Gardener Impacts – 30 years		
Hazardous Chemical	**Hazard Quotient**	**Cancer Incidence**
Cadmium	0.01	2E-5
Beryllium	0.08	1E-4
Lead	CH: 36	
Mercury	77	

LCF = Latent Cancer Fatality

Table I-8
Radiation Dose and Hazardous Chemical Impacts from Buried RH-TRU Waste Intrusion Scenarios

Radiological Impacts				
Radionuclide	**Hanford**	**INEEL**	**LANL**	**ORNL**
Dose to Driller (rem)				
Sr-90	3.5E-04	1.4E-04	1.4E-05	1.5E-04
Y-90	4.8E-04	1.9E-04	2.0E-05	2.1E-04
Cs-137	0.051	8.9E-03	2.1E-03	6.2E-03
Pu-238	1.0E-05	3.4E-06	1.9E-06	8.0E-07
Pu-239	1.7E-04	1.7E-05	1.0E-4	6.3E-06
Pu-240	8.5E-05	6.7E-06	0	1.1E-06
Am-241	5.5E-03	6.2E-04	0	3.6E-04
Cm-244	0	1.3E-05	0	1.6E-05
Total Dose (rem)	0.058	9.9E-03	2.2E-03	7.0E-03
LCF Probability	2.9E-05	4.9E-06	1.1E-06	3.5E-06
Dose to Gardener (rem)				
Sr-90	12	4.9	0.51	5.5
Y-90	1.2	0.49	0.051	0.55
Cs-137	59	10	2.4	7.1
Pu-238	0.29	0.097	0.052	0.023
Pu-239	5.2	0.52	3.1	0.19
Pu-240	2.6	0.20	0	0.033
Am-241	9.0	1.0	0	0.59
Cm-244	0	0.016	0	0.020
Total Dose (rem)	89	17	6.1	14
LCF Probability	0.045	8.7E-03	3.6E-03	7.0E-03

Hazardous Chemical Impacts		
Driller Impacts		
Hazardous Chemical	**PEL**	**Cancer Incidence**
Cadmium	9.8E-02	1.4E-09
Beryllium	17	1.3E-07
Lead	3,000	
Mercury	12	
Gardener Impacts		
Hazardous Chemical	**Hazard Quotient**	**Cancer Incidence**
Cadmium	0.01	2.0E-05
Beryllium	0.08	1.0E-04
Lead	3,900	
Mercury	77	

LCF = Latent Cancer Fatality

Carcinogenic health impacts from hazardous chemicals, including volatile organic compounds (VOC), were found to be negligible compared to radiological impacts (see Tables I-7 and I-8). The air concentration for the driller was 12, 17, and 27 times the permissible exposure limit (PEL) for mercury, beryllium, and lead, respectively, for CH-TRU waste; for RH-TRU waste, lead concentration in the air was 3,000 times the PEL. The 30-year gardener impacts ranged from 0.01 to 77 for CH-TRU waste and from 0.01 to 3,900 for RH-TRU waste. The hazard index for mercury was 77 for both CH-TRU and RH-TRU waste, while the hazard index for lead was 3,900 for RH-TRU waste and 36 for CH-TRU waste.

I.9.1.2 Intrusion into Surface-Stored Wastes

With the loss of institutional control, inadvertent intruders would be more likely to come into direct contact with waste in surface storage facilities than with buried waste. To estimate this impact, exposure calculations were performed for a hypothetical scavenger intruder in contact with surface-stored wastes during a 24-hour period at loss of institutional control. The scavenger was assumed to be exposed via inhalation of resuspended contamination and external and inadvertent ingestion of contaminated soil while at the site.

The estimated maximum dose to a hypothetical scavenger exposed to surface-stored CH-TRU wastes ranged from about 1.3 to 37.6 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 6.4×10^{-4} to 0.02 (Table I-9). The estimated maximum dose to the scavenger from surface-stored RH-TRU wastes ranged from about 1.4 to 24.5 rem, corresponding to a maximum probability of an LCF occurring in the intruder of 6.9×10^{-4} to 1×10^{-2} (Table I-9). For CH-TRU wastes, the highest doses were estimated at RFETS. The highest doses for RH-TRU wastes were estimated for Hanford and INEEL.

Another potential intruder scenario involves a hypothetical family (2 adults and 2 children) that lives and farms on a plot of land immediately over the surface-stored waste, where the waste has degraded and become indistinguishable from the surrounding land. For these conditions, the maximally exposed intruder in the family could be exposed via ingestion of contaminated food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil. If this scenario occurred, the four-member family would receive high annual radiation dose equivalents over the 30-year exposure period (i.e., in excess of 400 rem per year). For the first year of farming the calculated maximum probability of an LCF occurring for this scenario ranges from 0.24 to greater than 1 (6.9) for CH-TRU waste and from 0.27 to greater than 1 (5.1) for RH-TRU waste. Table I-10 presents estimated radiation doses and resulting LCFs for all sites.

Health impacts due to hazardous chemicals would be significant following the loss of institutional control for surface-stored waste. For VOCs, the cancer incidence would be less than 1.0 for both the scavenger and 30-year farming scenarios. During the 24 hours the scavenger is on the site, the air concentration of heavy metals could be as much as 5 to 91 times the PEL for cadmium, mercury, and beryllium for CH-TRU waste and RH-TRU waste and 1,400 and 160,000 times the PEL for lead for CH-TRU waste and RH-TRU waste, respectively. Cancer incidence for the scavenger would be negligible.

Table I-9
Radiation Dose and Hazardous Chemical Impacts from Scavenger Intrusion into Surface-Stored Wastes

Radionuclide	Hanford	INEEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Dose (rem)							
Sr-90	4.9E-05	1.0E-06	0	3.5E-06	8.9E-04	0	1.0E-06
Y-90	3.3E-04	6.8E-06	0	2.4E-05	6.0E-03	0	6.8E-06
Cs-137	0.03	2.2E-03	4.5E-09	2.7E-03	1.00	0	7.7E-04
Pu-238	1.37	0.51	0.07	2.16	0.73	0.22	19.01
Pu-239	1.05	0.71	0.35	3.52	1.03	12.04	0.76
Pu-240	0.24	0.17	0.14	0.00	0.34	4.83	0.19
Am-241	0.42	2.81	0.73	0.89	2.05	20.51	0.81
Cm-244	6.4E-05	2.1E-04	3.3E-03	1.6E-04	0.01	0	2.2E-03
Total Dose (rem)	3.11	4.22	1.29	6.58	5.19	37.60	21
LCF Probability	1.6E-03	2.1E-03	6.4E-04	3.3E-03	2.6E-03	0.02	0.01
RH-TRU Waste Dose (rem)							
Sr-90	0.03	0.01	N/A	1.1E-03	0.01	N/A	N/A
Y-90	0.19	0.07	N/A	7.7E-03	0.08	N/A	N/A
Cs-137	21.51	3.74	N/A	0.89	2.63	N/A	N/A
Pu-238	0.05	0.02	N/A	8.6E-03	3.7E-03	N/A	N/A
Pu-239	0.81	0.08	N/A	4.8E-01	0.03	N/A	N/A
Pu-240	0.40	0.03	N/A	0	0.01	N/A	N/A
Am-241	1.47	0.17	N/A	0	0.10	N/A	N/A
Cm-244	0	3.4E-03	N/A	0	4.3E-03	N/A	N/A
Total Dose (rem)	24.46	4.13	N/A	1.39	2.86	N/A	N/A
LCF Probability	0.01	2.1E-03	N/A	6.9E-04	1.4E-03	N/A	N/A

Hazardous Chemical Impacts

CH-TRU Hazardous Chemical	PEL	Cancer Incidence
Cadmium	5.2	2E-6
Beryllium	91	2E-4
Lead	CH: 1400/RH: 160,000	
Mercury	6.2	

LCF = Latent Cancer Fatality
N/A = Not Applicable

Table I-10
Radiation Dose and Hazardous Chemical Impacts
for First Year of Farmer Intrusion into Surface-Stored Wastes

Radionuclide	Hanford	INEEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Impacts Dose (rem)							
Sr-90	7.5	0.16	N/A	0.56	140	0	0.18
Y-90	0.50	0.01	N/A	0.036	9.0	0	0.01
Cs-137	7.2	0.50	9.4E-7	0.57	210	0	0.17
Pu-238	500	190	26	800	270	80.92	7.0E + 03
Pu-239	360	250	120	1.2E + 03	360	4.2E + 03	260
Pu-240	84	59	47	1.60	120	1.7E + 03	64
Am-241	160	1.1E + 03	280	340	780	7.9 + 03	310
Cm-244	0.02	0.08	1.23	0.06	3.2	0	0.84
U-233	0.54	2.6	7.6E-8	0.34	10	0.94	0.052
Total Dose (rem)	1.1E + 03	1.6E + 03	475	2.4E + 03	1.9E + 3	1.4e + 04	7.7E + 03
LCF Probability[a]	0.56	0.79	0.24	1 (1.2)	0.95	1 (6.9)	1 (3.8)
RH-TRU Waste Impacts Dose (rem)							
Sr-90	4.4	1.7E + 03	N/A	180	1.9E + 03	N/A	N/A
Y-90	280	110	N/A	12	120	N/A	N/A
Cs-137	4.5	780	N/A	190	550	N/A	N/A
Pu-238	18	5.91	N/A	3.18	1.37	N/A	N/A
Pu-239	281	28.00	N/A	167.01	10	N/A	N/A
Pu-240	139	11	N/A	0	1.80	N/A	N/A
Am-241	564	64	N/A	0	37	N/A	N/A
Cm-244	0	1.29	N/A	0	1.62	N/A	N/A
U-233	0.53	0.04	N/A	6.8E-4	6.2E-3	N/A	N/A
Total Dose (rem)	1.0E + 4	2.7E + 03	N/A	550	2.7E + 03	N/A	N/A
LCF Probability[a]	1 (5.1)	1 (1.4)	N/A	0.27	1 (1.3)	N/A	N/A

Hazardous Chemical Impacts		
	Hazardous Index	**Cancer Incidence**
Cadmium	15	0.02
Beryllium	10	1.9
Lead	CH: 50,000/RH: 5.2E + 6	
Mercury	100,000	

[a] Numbers in parentheses represent the actual calculated probability of an LCF.

LCF = Latent Cancer Fatality
N/A = Not Applicable

The hazard index to the MEI farmer would range from 10 to 5,200,000. The greatest indices would be for lead with 5,200,000 and 48,000 for RH-TRU waste and CH-TRU waste, respectively, and for mercury with 100,000 for both waste types.

Repeated farm family intrusion over a long period of time such as the 10,000-year impact period evaluated in Section I.9.2 could result in a large aggregate number of intrusion fatalities. As shown in Table I-10, the probability of a latent cancer fatality is very high at all sites, with some calculated values being 1.0 during the first lifetime after loss of institutional control. In the event of population pressure that resulted in individuals occupying the sites of former waste storage facilities, the number of LCFs from exposure to TRU waste could reach several thousand, assuming continuous occupation of the sites and four LCFs every 50 years, while the calculated probability of an LCF to an individual remained 1 or higher.

I.9.2 Impacts of Long-Term Environmental Release

Contaminants in TRU wastes stored in shallow burial trenches and surface storage facilities within site-specific environmental settings would eventually be released to the surrounding environments at the generator-storage sites. Contaminants within the buried or surface-stored wastes would be leached and released to underlying soils and aquifer systems at depth. Eventually, at most sites, contaminants would reach groundwater and migrate laterally to downgradient receptor locations. Contaminants may also eventually be discharged into nearby surface-water bodies, particularly at the Hanford, ORNL, and SRS sites. Once in these surface-water systems, dilute concentrations of the contaminants would become available to the public in nearby communities.

Wastes stored in surface facilities would also degrade and become available in the environment as a result of cyclic and ongoing processes, such as direct water and air erosion, deposition onto soils surrounding the site, and resuspension of contaminated soils in air. The general surrounding on-site and off-site populations would be exposed to contaminants redistributed into the environment by these processes.

For this analysis, the impacts to the hypothetical farm family living 300 meters (980 feet) downgradient of the waste storage area were estimated. It was assumed that the family would engage in farming activities such as growing and consuming their own crops and livestock. The family would use contaminated groundwater as a source of drinking water for themselves and the animals and for watering the crops. The MEI would be exposed via ingestion of food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil. This analysis also considered the off-site population that could potentially be exposed to environmental releases to the surface water and air. For analyses of buried waste releases, all CH-TRU and RH-TRU waste was combined into a single waste disposal unit, and only the groundwater pathway was considered. For analyses of surface-stored waste releases, all CH-TRU and RH-TRU wastes were combined into a single waste storage unit and were allowed to be released to all pathways.

The population impacts from exposure to radiation and hazardous chemicals were estimated based on current storage-site population distributions. At present, most sites are remote from large population centers. While it is unknown how populations at the sites will change over the next 10,000 years, populations may increase substantially over present day levels and encroach onto sites and locate near storage facilities. The latter point is certainly implied for the inadvertent human intrusion scenarios discussed above in Section I.9.1. Thus, the potential for additional

impacts may increase and potential long-term radiological and hazardous chemical impacts could be considerably higher (i.e., an order of magnitude or more) than those estimated in this analysis.

I.9.2.1 Radiological Impacts

The estimated lifetime (70 years) radiological impacts over 10,000 years, as a result of environmental contaminant releases from buried and surface-stored wastes at the seven generator-storage sites, are presented in Table I-11. The MEI maximum lifetime radiation dose for all sites ranged from 5.2 x 10^{-3} to 7.8 rem per 70-year lifetime. Resultant maximum probability of an LCF ranged from 2.6 x 10^{-6} to 3.9 x 10^{-3}. The highest estimated probability of an LCF occurred at INEEL. The dose to the MEI at each site for each 70-year lifetime over 10,000 years is shown in Figure I-4.

Table I-11
Maximum Lifetime MEI and Population Impacts at Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2

Site	Radiological Impacts			Chemical Carcinogenic Impacts	
	Lifetime Dose (rem/70 years)	Lifetime LCF [a]	Dominant Pathway	Lifetime Cancer Incidence	Dominant Pathway
MEI Impacts					
Hanford	0.3	1.2E-4	Inhalation	2.3E-6	Groundwater Ingestion
INEEL	7.8	3.9E-3	Groundwater Ingestion	5.4E-3	Groundwater Ingestion
LANL	0.09	4.5E-5	Inhalation	2.4E-4	Resuspended Soil Ingestion
LLNL	0.01	6.9E-6	Inhalation	1.1E-7	Groundwater Ingestion
ORNL	5.0E-3	2.6E-6	Groundwater Ingestion	5.9E-7	Groundwater Ingestion
RFETS	4.9	2.5E-3	Inhalation	3.1E-7	Groundwater Ingestion
SRS	1.4	6.5E-4	Groundwater Ingestion	3.7E-4	Groundwater Ingestion
Population Impacts					
Hanford	1.4	6.8E-4	Resuspended Soil Ingestion	1.5E-6	Surface Water Ingestion
INEEL	149	0.07	Inhalation	2.9E-6	Resuspended Soil Ingestion
LANL	162	8.1E-2	Inhalation	2.4E-4	Resuspended Soil Ingestion
LLNL	30	1.5E-2	Inhalation	1.1E-7	Resuspended Soil Ingestion
ORNL	0.07	3.6E-5	Inhalation	2.7E-7	Surface Water Ingestion
RFETS	14,200	7.1	Inhalation	2.8E-4	Resuspended Soil Ingestion
SRS	175	8.8E-2	Inhalation	5.6E-5	Surface Water Ingestion

[a] Lifetime LCF is the probability of an LCF for an MEI and the number of LCFs in a population.

The radiological impacts to populations over 70-year lifetimes were estimated from the air and surface water exposure pathways for all sites. The groundwater pathway was determined to not be a notable source of off-site drinking water, so it was not considered in the estimation of off-site population impacts. The estimated maximum lifetime population dose for all sites (see Table I-11) ranged from 0.07 to 14,200 person-rem. The resultant LCFs ranged from 3.6 x 10^{-5} to 7.1. The highest impact was estimated to occur in the population around RFETS, where the calculated number of LCFs was over an order of magnitude higher than any other site. The dose to the population around each site for each 70-year lifetime over 10,000 years is shown in Figure I-5.

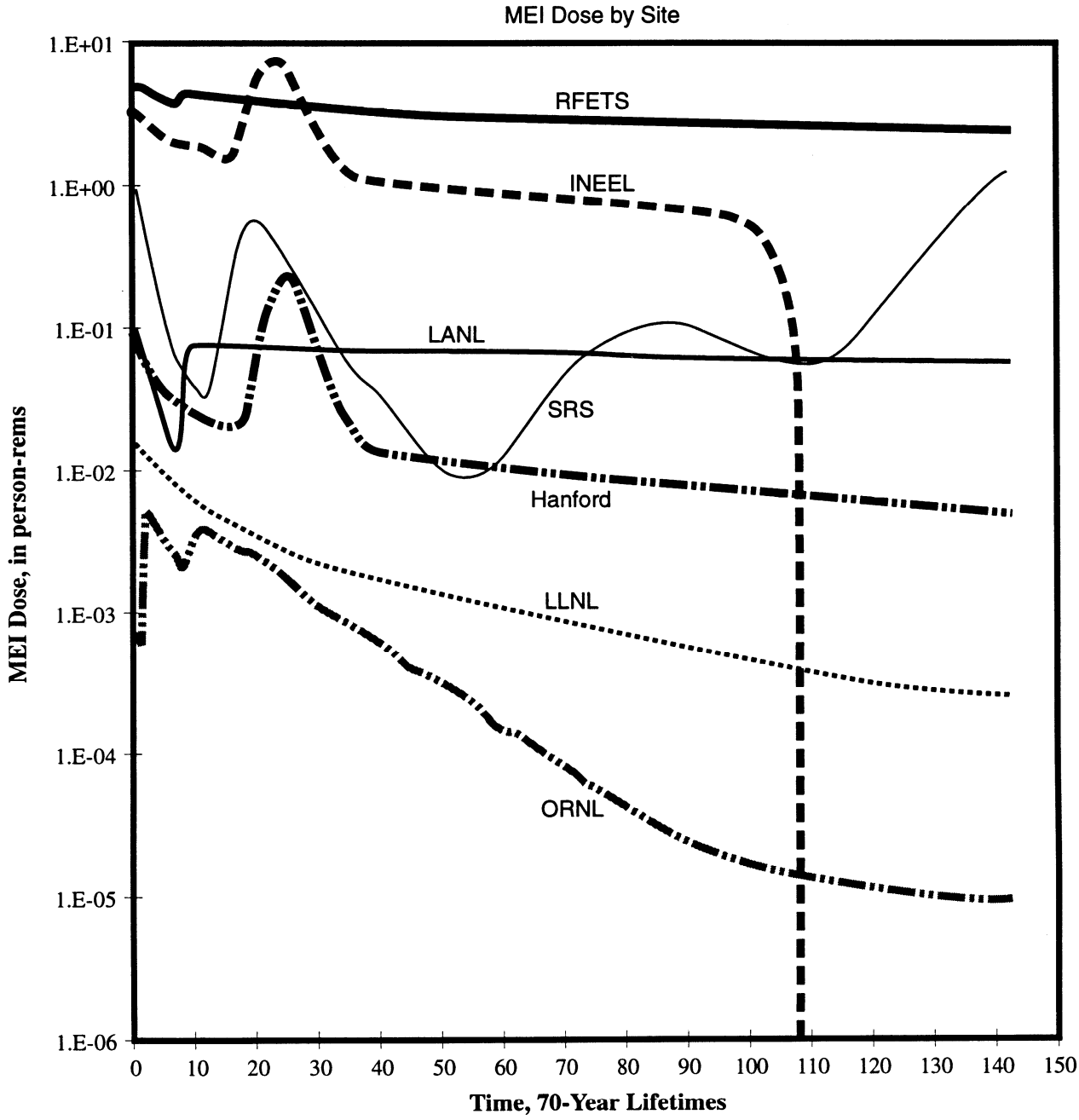


Figure I-4
Lifetime Doses to the MEIs at Seven Major Generator-Storage Sites over 10,000 Years Following Loss of Institutional Control Under No Action Alternative 2

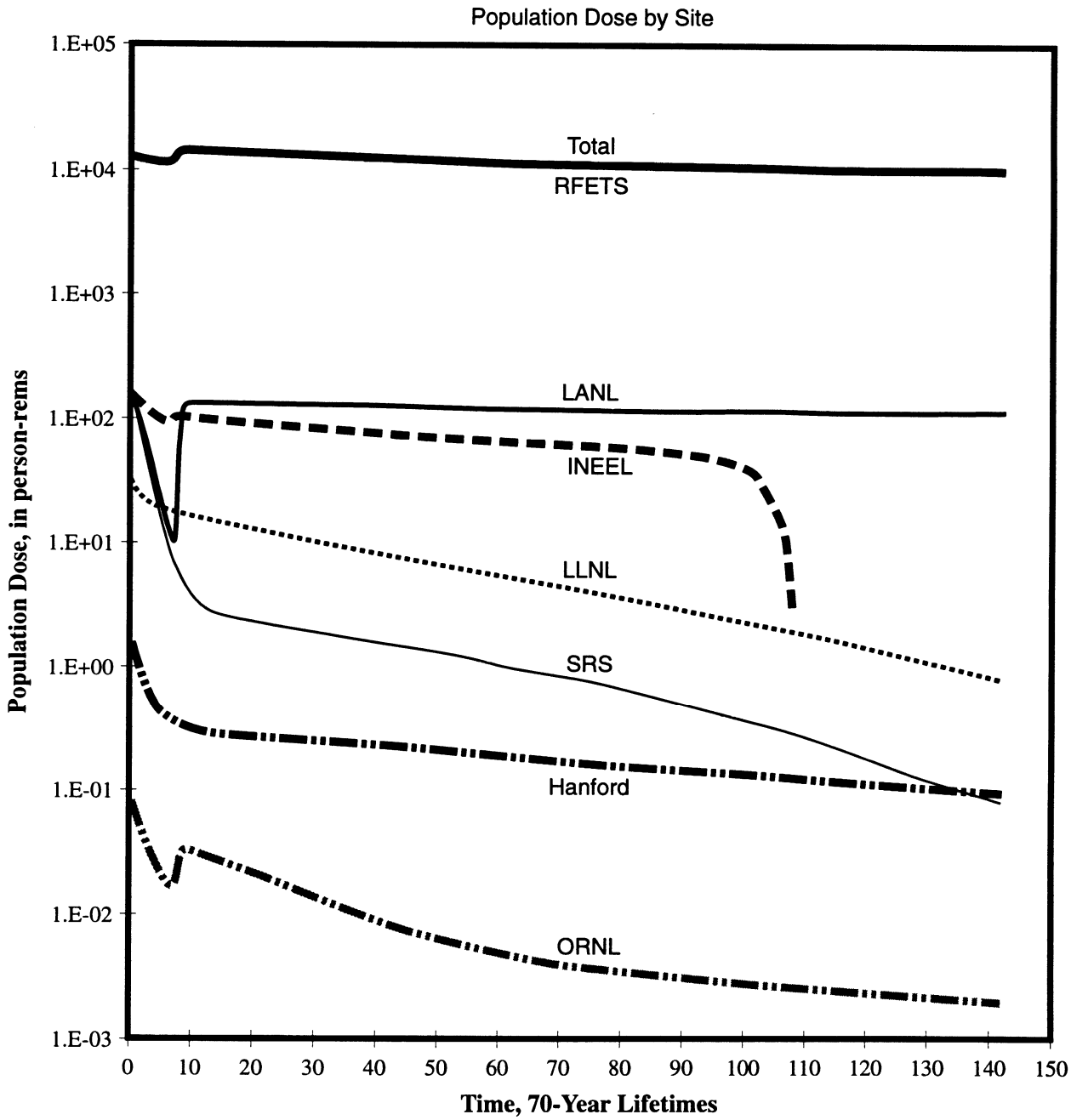


Figure I-5
Lifetime Population Doses for Seven Major Generator-Storage Sites over 10,000 Years Following Loss of Institutional Control Under No Action Alternative 2

The aggregate number of LCFs that could occur in off-site populations around the seven sites over 10,000 years (~ 142 70-year lifetimes) from release of the No Action 2 inventory was estimated by summing for each site the estimated LCFs for each lifetime, then summing the aggregate 10,000-year LCFs for the seven sites to provide the total estimated LCFs over 10,000 years. The aggregate number of LCFs was estimated to be 794 LCFs, with 98 percent of the estimated LCFs (781) occurring in the population around RFETS. In addition to the impact from release of the No Action Alternative 2 inventory, the number of aggregate LCFs at the seven sites was estimated for the Additional Inventory of Action Alternative 1 (see Tables 3-2 and 3-3) which would also remain in place at the sites under the No Action 2 Alternative. An additional 13 aggregate LCFs were estimated to occur from release of the Additional Inventory. Release of the combined inventories would result in about 800 LCFs. Estimates of site-specific and total aggregate LCFs are presented in Table I-12. As noted above these impacts were estimated based on current population distributions. These distributions may change substantially, creating the potential for significant increases over these estimates of aggregate LCFs.

Table I-12
Aggregate LCFs over 10,000 Years for Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2

Site	Aggregate LCFs from Basic Inventory	Aggregate LCFs from Additional Inventory	Aggregate LCFs from Combined Inventory
Hanford	1.4E-02	1.0E-02	2.4E-02
INEEL	3.8E + 00	7.7E + 00	1.14E + 01
LANL	8.5E + 00	5.6E + 00	1.41E + 01
LLNL	4.5E-01	0	4.5E-01
ORNL	6.3E-04	3.0E-04	9.3E-04
RFETS	7.81E + 02	0	7.81E + 02
SRS	2.8E-01	1.1E-01	4.0E-01
Total	794	13	807

I.9.2.2 Chemical Carcinogen Impacts

The estimated maximum lifetime cancer incidence from chemical carcinogens to a MEI (see Table I-11) ranged from 1.3×10^{-7} to 5.4×10^{-3} for the seven sites. The highest cancer incidence was estimated for INEEL. The predominant impacts at nearly all sites, except LANL, resulted from ingestion of groundwater containing 1,1,2,2-tetrachloroethane.

The estimated maximum lifetime cancer incidence for exposed populations (see Table I-11) was estimated to range from 1.1×10^{-7} to 2.8×10^{-4} for the seven sites. The aggregate cancer incidence for the seven sites over 10,000 years was estimated to be 0.002.

I.9.2.3 Noncarcinogenic Impacts

The noncarcinogenic impact from chemicals was very low compared to the radiological impact. Maximum hazard indices for an MEI from exposure to noncarcinogenic chemicals for the seven sites ranged from 6.4×10^{-5} to 1.5 (see Table I-13). The highest hazard index was estimated for the SRS. The predominant impacts at all sites resulted from ingestion of either mercury or carbon tetrachloride except for RFETS where the impact was from inhalation of lead.

Table I-13
Noncarcinogenic Impacts to a Maximally Exposed Individual at Seven Major Generator-Storage Sites after Loss of Institutional Control for No Action Alternative 2 [a]

Site	Maximum Hazard Index	Key Chemical	Dominant Pathway
Hanford	0.2	Mercury	Groundwater Ingestion
INEEL	0.3	Carbon Tetrachloride	Groundwater Ingestion
LANL	1.7E-3	Mercury	Resuspended Soil Ingestion
LLNL	5.3E-4	Mercury	Resuspended Soil Ingestion
ORNL	2.8E-4	Mercury	Groundwater Ingestion
RFETS	6.4E-5	Lead	Inhalation
SRS	1.5	Mercury	Groundwater Ingestion

[a] The best available data was used to calculate concentrations of VOCs and mercury, but DOE recognizes that the data may not reflect actual usage of hazardous chemicals at all sites. Conservative assumptions, such as that all waste is mixed waste, were used to ensure the impacts stated in this document reflect a reasonable upper limit of likely impacts.

I.10 REFERENCES CITED IN APPENDIX I

Bergenback, B., et al., 1995, *Waste Management Programmatic Environmental Impact Statement Methodology for Estimating Human Health Risks*, ORR-6864, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Blaylock, B., et al., 1995, *U. S. Department of Energy Public and On-Site Population Health Risk Evaluation Methodology for Assessing Risks Associated with Environmental Restoration and Waste Management*, ORR-6832, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Buck, J. W., et al., 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS®) Application Guidance: Guidance for Evaluating MEPAS® Input Parameters for Version 3.1*, PNL-10395, Pacific Northwest National Laboratory, Richland, Washington.

Buck, J., et al., 1997, *Analysis of the Long-Term Impacts of TRU Waste Remaining at Generator/Storage Sites for No Action Alternative 2 - Support Information for the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, PNNL-11251, Pacific Northwest National Laboratory, Richland, Washington.

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U. S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Albuquerque, New Mexico.

DOE (U. S. Department of Energy), 1996a, *Final No-Migration Variance Petition*, DOE/CAO-96-2160, June, Carlsbad, New Mexico.

DOE (U. S. Department of Energy), 1996b, *Transuranic Waste Baseline Inventory Report, Revision 3*, DOE/CAO-95-1121, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997a, *Waste Isolation Pilot Plant Safety Analysis Report*, DOE/WIPP-95-2065, Revision 1, March, Carlsbad, New Mexico.

DOE (U. S. Department of Energy), 1997b, *Final Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-F, May, Washington, D.C.

Droppo, J. G., Jr. et al., 1989, *Supplemental Mathematical Formulations: The Multimedia Environmental Pollutant Assessment System (MEPAS®)*, PNL-7201, Pacific Northwest National Laboratory, Richland, Washington.

Droppo, J. G., Jr. et al., 1991, *Multimedia Environmental Pollutant Assessment System (MEPAS®) Application Guidance Volume 1 - User's Guide*, PNL-7216, Pacific Northwest National Laboratory, Richland, Washington.

EPA (U. S. Environmental Protection Agency), 1989, *Risk Assessment Guidance to Superfund Volume 1, Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, Washington, D. C.

Holdren, G. R., et al., 1995, *Environmental Settings for Selected U. S. Department of Energy Installations - Support Information for the Programmatic Environmental Impact Statement and the Baseline Environmental Management Report*, PNL-10550, Pacific Northwest National Laboratory, Richland, Washington.

Napier, B. A., et al., 1988a, *GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 1*, December, Pacific Northwest National Laboratory, Richland, Washington.

Napier, B. A., et al., 1988b, *GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 2*, November, Pacific Northwest National Laboratory, Richland, Washington.

Napier, B. A., et al., 1988c, *GENII - The Hanford Environmental Radiation Dosimetry Software System, Volume 3*, September, Pacific Northwest National Laboratory, Richland, Washington.

Strenge, D. L., and P. J. Chamberlain, 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS®): Exposure Pathways and Human Health Impact Assessment Models*, PNL-10523, Pacific Northwest National Laboratory, Richland, Washington.

Strenge, D.L., and S.R. Peterson, 1989, *Chemical Databases for the Multimedia Environmental Pollutant Assessment System (MEPAS®); Version 1*, PNL-7145, December, Pacific Northwest National Laboratory, Richland, Washington.

Whelan, G., et al., 1987, *The Remedial Action Priority System (RAPS): Mathematical Formulations*, PNL-6200, Pacific Northwest National Laboratory, Richland, Washington.

Whelan, G., et al., 1994, *Modular Risk Analysis for Assessing Multiple Waste Sites*, PNL-SA-24239, Pacific Northwest National Laboratory, Richland, Washington.

Whelan, G., et al., 1995, *Unit Environmental Transport Assessment of Contaminants from Hanford's Past-Practice Wastes Sites*, PNL-10233, Pacific Northwest National Laboratory, Richland, Washington.

APPENDIX J
UPDATED ESTIMATES OF THE DEPARTMENT OF ENERGY'S TRANSURANIC WASTE VOLUMES

The analyses presented in Chapter 5 of this second supplemental environmental impact statement (SEIS-II) are based on the transuranic (TRU) waste volume estimates published in 1996 in the *Transuranic Waste Baseline Inventory Report, Revision 3* (BIR-3) (DOE 1996a). The same waste volume estimates were used for the *Waste Isolation Pilot Plant Supplemental Draft Environmental Impact Statement* (Draft SEIS-II).

Since the completion of the Draft SEIS-II, though, the U.S. Department of Energy (DOE or the Department) has published *The National Transuranic Waste Management Plan* (DOE 1996b), which includes updated estimates of the stored and projected volumes of defense TRU waste at the generator and storage sites.[1] These more recent estimates include a 4 percent increase in the total volume of contact-handled (CH) TRU waste and an 86 percent decrease in the total volume of remote-handled (RH) TRU waste. The differences in the waste volumes presented in the BIR-3 and *The National Transuranic Waste Management Plan* are largely due to changes throughout the DOE Complex in the schedules for those remediation and decontamination and decommissioning (D&D) activities that may generate TRU waste during the next 35 years. Overall, the volumes in BIR-3 result in a more conservative estimate of the impacts of disposal at the Waste Isolation Pilot Plant (WIPP) and were chosen for the analyses in Chapter 5. This appendix has been prepared to allow a comparison of impacts had the volumes presented in *The National Transuranic Waste Management Plan* been the basis for the analyses presented in Chapter 5.

Table J-1 provides a comparison of the CH-TRU waste volumes in *The National Transuranic Waste Management Plan* and in the Basic Inventory (which is based on BIR-3). There are a number of differences in the site-specific volumes, as noted in the "percent difference" columns of Table J-1. Under the *National Transuranic Waste Management Plan*, there are major increases in waste volumes at Idaho National Engineering and Environmental Laboratory (INEEL) and Rocky Flats Environmental Technology Site (RFETS), while large decreases are reported for the Hanford Site (Hanford) and Los Alamos National Laboratory (LANL). Because the differences between TRU waste volumes at some sites differ significantly, a particular site's impacts could vary to a greater extent than indicated by the differences in the total volumes.

A comparison of RH-TRU waste volumes is provided in Table J-2. *The National Transuranic Waste Management Plan* reports more than 30,000 cubic meters (1,059,000 cubic feet) less of RH-TRU waste than the Basic Inventory. A major decrease in RH-TRU waste was reported at Hanford, where TRU waste from environmental restoration activities is now expected to be generated after the 35-year waste generation period that was evaluated.

A comparison of the total waste volumes that would be disposed of at WIPP under each of the action alternatives is shown in Table J-3. CH-TRU waste volumes using *The National Transuranic Waste Management Plan* increase slightly (2 to 5 percent), while RH-TRU waste volumes decrease dramatically (82 to 90 percent).

[1] *The National Transuranic Waste Management Plan* does not include estimates of radionuclide or hazardous chemical inventories.

Table J-1
Comparison of CH-TRU Waste Volumes in Basic Inventory and *The National Transuranic Waste Management Plan*

Site	NTRUWM Plan [a]			Basic Inventory [b]			NTRUWM Plan, Volume Difference and Percent Difference from Basic Inventory					
							Stored		To Be Generated		Total Inventory	
	Stored	Projected	(Total)	Stored	Projected	Total	Volume	Percent	Volume	Percent	Volume	Percent
Hanford Reservation (Hanford)	16,407	9,251	25,658	12,300	45,190	57,490	4,107	133%	-35,939	20%	-31,832	45%
Los Alamos National Laboratory (LANL)	7,770	9,259	17,029	11,050	9,980	21,030	-3,280	70%	-721	93%	-4,001	81%
Idaho National Engineering and Environmental Laboratory (INEEL)	65,102 [c]	81	65,183 [c]	28,150	0	28,150	36,945	231%	-924	8%	36,021	224%
Argonne National Laboratory - West (ANL-W)				7	1,005	1,012	in INEEL		in INEEL		in INEEL	
Savannah River Site (SRS)	9,165	3,773	12,938	2,880	9,180	12,060	6,285	318%	-5,407	41%	878	107%
Rocky Flats Environmental Technology Site (RFETS)	1,043	14,741	15,784	4,890	5,970	10,860	-3,847	21%	8,771	247%	4,924	145%
Oak Ridge National Laboratory (ORNL)	1,303	256	1,559	1,320	350	1,670	-17	99%	-94	73%	-111	93%
Lawrence Livermore National Laboratory (LLNL)	249	905	1,154	230	960	1,190	19	108%	-55	94%	-36	97%
Nevada Test Site (NTS) [d]	623	12	635	620	10	630	3	100%	2	120%	5	101%
Mound Plant (Mound)	239	12	251	300	0	300	-61	80%	12		-49	84%
Argonne National Laboratory – East (ANL-E)	83	12	95	25	180	205	58	332%	-168	7%	-110	46%
Bettis Atomic Power Laboratory (BAPL)	0	123	123	0	170	170	-		-47	72%	-47	72%
Sandia National Laboratories (SNL-NM)	7	6	13	7	10	17	-	100%	-4		-4	
Paducah Gaseous Diffusion Plant (PGDP)	2	0	2	0	8	8	2		-8		-6	
U.S. Army Material Command (USAMC)	3	0	3	3	0	3	-	100%	-		-	
Energy Technology Engineering Center (ETEC)	2	0	2	2	0	2	-	100%	-		-	
University of Missouri Research Reactor (U of Mo)	1	1	2	1	0	1	1	100%	1		-	
Pantex Plant (Pantex)	1	0	1	1	0	1	1	100%	-		-	
Ames Laboratory (Ames)	0	1	1	0	1	1	-		1		-	
Teledyne Brown Engineering (TBE)	1	0	1	1	0	1	1	100%	-		-	
Battelle Columbus Laboratories (Battelle)	0	0	0	0	0	0	-		-		-	
ARCO Medical Products Company (ARCO)	1	0	1				1		-		1	
Knolls Atomic Power Laboratory (Knolls)	0	0	0				-		-		-	
Lawrence Berkeley Laboratory (LBL)	1	1	2				1		1		2	
General Electric-Vallecitos Nuclear Center (GE-VNC) [e]	5	4	9				5		4		9	
Babcock & Wilcox (B&W) [e]	18	0	18				18		-		18	
West Valley Demonstration Project (WVDP) [f]												
Totals	102,025	38,437	140,462	61,787	73,014	134,801	40,242		-34,575		5,662	104%

[a] *National TRU Waste Management Plan* (DOE 1996b). Values <1 are shown here as 1.
[b] Unrounded Basic Inventory values.
[c] Includes 27,000 cubic meters of alpha low-level waste. INEEL may also have 2,500 cubic-meters of commercial TRU waste.
[d] NTS may have an additional waste volume of approximately 120 cubic meters, composed of classified TRU waste and previously disposed of TRU waste not reported in BIR-3.
[e] GE-VNC and B&W are included only in the *National TRU Waste Management Plan*.
[f] WVDP is not included in either the *National TRU Waste Management Plan* or the Basic Inventory. WVDP has waste in the Additional Inventory.

Table J-2
Comparison of RH-TRU Waste Volumes in Basic Inventory and *The National Transuranic Waste Management Plan*

Site	NTRUWM Plan [a]			Basic Inventory [b]			NTRUWM Plan, Volume Difference and Percent Difference from Basic Inventory					
							Stored		To Be Generated		Total Inventory	
	Stored	Projected	Total	Stored	Newly Generated	Total	Volume	Percent	Volume	Percent	Volume	Percent
Hanford	200	2,420	2,620	200	29,200	29,400	-	0%	-26,780	-92%	-26,780	-91%
LANL	94	136	230	90	130	220	4	+4%	6	+5%	10	+5%
INEEL	86	53	139	-	-	-	66	+330%	-1,667	-97%	-1,601	-92%
ANL-W				20	1,720	1,740	in INEEL		in INEEL		in INEEL	
SRS	-	-	-									
RFETS	-	-	-									
ORNL	962	193	1,155	2,470	600	3,070	-1,508	-61%	-407	-68%	-1,915	-68%
LLNL	-	-	-									
NTS [c]	-	-	-									
Mound	-	-	-									
ANL-E	-	-	-									
Bettis	-	2	2	-	9	9	-		-7	-78%	-7	-78%
SNL-AL	1	2	3									
PGDP	-	-	-									
USAMC	-	-	-									
ETEC	6	1	7	6	1	7	-	0%	-		-	0%
U of M	-	-	-									
Pantex	-	-	-									
Ames	-	-	-									
TBE	-	-	-									
Battelle	581	-	581	580	-	580	1	0%	-		1	0%
ARCO	-	-	-									
Knolls	6	1	7									
LBL	-	-	-									
GE-VNC [d]	5	8	13									
B&W [d]	-	-	-									
WVDP [e]												
Totals	1,941	2,816	4,757	3,366	31,660	35,026	-1,437	-42%	-28,855	-91%	-30,292	-86%

[a] *The National TRU Waste Management Plan* (DOE 1996b).
[b] Unrounded Basic Inventory values.
[c] Includes approximately 1 cubic meter of RH-TRU waste.
[d] GE-VNC and B&W are included only in *The National TRU Waste Management Plan*.
[e] WVDP is not included in either *The National TRU Waste Management Plan* or the SEIS-II Basic Inventory. WVDP has waste in the SEIS-II Additional Inventory.

Table J-3
Comparison of Waste Volumes Among Alternatives Using
***The National Transuranic Waste Management Plan* and Basic Inventory Volumes**

	Proposed Action [a]		Action Alternative 1		Action Alternative 2		Action Alternative 3	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Post-Treatment Disposal Volumes (cubic meters) for the Total Inventory								
NTRUWM Plan [b]	168,500	7,080	291,000	7,180	109,200	2,510	343,100	8,620
BIR-3 Based	168,500	7,080	281,000	55,000	107,000	19,000	334,000	66,000
Difference, cubic meters:	0	0	10,000	-47,820	2,200	-16,490	9,100	-57,380
NTRU percent difference	0%	0%	+4%	-87%	+2%	-87%	+3%	-87%
Pre-Treatment Consolidated Volumes (cubic meters) for the Total Inventory								
NTRUWM Plan [b]	168,500	7,080	279,700	7,180	280,400	7,180	279,700	7,180
BIR-3 Based	168,500	7,080	273,000	39,000	274,000	39,000	273,000	39,000
Difference, cubic meters:	0	0	6,700	-31,820	6,400	-31,820	6,700	-31,820
NTRU percent difference	0%	0%	+2%	-82%	+2%	-82%	+2%	-82%

[a] All volumes for the Proposed Action were adjusted to 168,500 cubic meters for CH-TRU waste and 7,080 cubic meters for RH-TRU waste.
[b] Alternative waste volumes in *The National TRU Waste Management Plan* waste inventory were substituted for the Basic Inventory.

Potential Changes in Estimated Impacts

The Proposed Action (Preferred Alternative) presents impacts adjusted to the treatment and disposal of 168,500 cubic meters (5,950,000 cubic feet) of CH-TRU waste (the maximum allowed under the Land Withdrawal Act [LWA]) and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste (the maximum allowed under the Agreement for Consultation and Cooperation [C & C] with the State of New Mexico). Using *The National Transuranic Waste Management Plan* in the same manner, no change would occur in the impacts for the Proposed Action except for the elimination of impacts related to storage of excess RH-TRU waste.

Under Action Alternatives 1, 2, and 3 and for the individual sites, the following changes would be expected:

- Negligible changes to the impacts would be anticipated in areas of land use and management, biological resources, cultural resources, noise, water resources and infrastructure, long-term performance, or consequences of lag storage accidents. No change would be expected in consequences from treatment accidents or WIPP disposal accidents.

- Changes in the estimated impacts for human health, life-cycle costs (except transportation costs), air quality, industrial safety, and economics would be directly related to changes in CH-TRU and RH-TRU waste volumes. Site impacts would change, as presented in the "percent difference" columns of Table J-1 for CH-TRU waste and Table J-2 for RH-TRU waste. Unlike most other impact areas, CH-TRU waste is a much higher contributor to impacts for involved workers than is RH-TRU waste; therefore, large decreases in RH-TRU waste volumes would have little impact for involved workers. However, at WIPP, large decreases in the amount of RH-TRU waste volumes would reduce the operations time needed for excavation and emplacement, reducing industrial safety and economics impacts.

- Changes in transportation impacts, including costs, are directly related to the number of shipments, which is dependent upon the type of waste treatment. Tables J-4 and J-5 present detailed CH-TRU and RH-TRU waste shipment information for all sites under all alternatives using *The National Transuranic Waste Management Plan* volumes. Table J-6 summarizes the differences in shipments and the percentages of the total inventories between *The National Transuranic Waste Management Plan* and the Basic Inventory.

Overall, impacts would be slightly lower using data from *The National Transuranic Waste Management Plan* because, although CH-TRU waste volumes are slightly higher, the RH-TRU waste volumes are markedly lower (except for the impacts to the involved workers, as noted above). The difference is quite marked for transportation impacts because of the reduction of nearly 61,000 shipments of RH-TRU waste under Action Alternative 3 (see Table J-6).

Changes in volume-dependent impacts would be expected at some sites. The changes in impacts would be greatest at INEEL, a major generator, treatment and potential consolidation site under all alternatives, where volume-dependent impacts could increase by about 124 percent. Impacts at RFETS would increase by about 50 percent and at Savannah River Site (SRS) by less than 10 percent. Impacts at Hanford would decrease dramatically: approximately 50 percent from CH-TRU waste and 90 percent from RH-TRU waste. Oak Ridge National Laboratory (ORNL) impacts, mainly from RH-TRU waste, would be about 60 percent lower. Impacts at LANL, the other key generator site, would also decrease by about 15 to 20 percent.

Table J-4
Number of CH-TRU Waste Shipments from Each Potential Consolidation Site to WIPP by Alternative Using *The National Transuranic Waste Management Plan* Volumes

Sites	Proposed Action	Alternative 1			Alternative 2A			Alternative 2B			Alternative 2C			Alternative 3		
	Basic	Basic	Additional	Total	Basic	Additional	Total	Basic	Additional	Total	Basic	Additional	Total	Basic	Additional	Total
ANL-E	12	11	0	11	0	0	0	0	0	0	11	0	11	0	0	0
Hanford	5,817	5,162	7,197	12,359	3,761	8,850	12,611	3,762	8,850	12,612	5,160	12,691	17,851	11,036	8,636	19,672
INEEL	12,466	11,046	6,758	17,804	9,230	12,469	21,699	13,834	14,408	28,242	11,061	9,738	20,799	22,947	8,049	30,996
LLNL	150	133	0	133	0	0	0	0	0	0	133	0	133	0	0	0
LANL	3,867	3,431	1,606	5,037	2,390	1,940	4,330	0	0	0	3,430	2,786	6,216	6,177	1,901	8,078
Mound	47	42	76	118	0	0	0	0	0	0	42	4	46	0	0	0
NTS	83	73	0	73	0	0	0	0	0	0	73	0	73	0	0	0
ORNL	221	196	13	209	0	0	0	0	0	0	179	13	192	0	0	0
RFETS	3,037	2,695	0	2,695	2,214	0	2,214	0	0	0	3,054	0	3,054	3,419	0	3,419
SRS	2,288	2,030	558	2,588	2,101	794	2,895	2,102	794	2,896	2,030	765	2,795	2,981	776	3,757
Ames	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
ARCO	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0
B&W [a]	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0
Battelle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bettis	0	0	0	0	0	0	0	0	0	0	15	0	15	0	0	0
ETEC	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
GE-VNC [a]	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0
Knolls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LBL	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0
PGDP	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Pantex	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
SNL-AL	0	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0
TBE	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
USAMC	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
U of M	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
WVDP	0	0	0	0	0	0	0	0	0	0	0	76	76	0	0	0
Totals	27,988 (29,766)[b]	24,819	16,208	41,027	19,696	24,053	43,749	19,698	24,052	43,750	25,204	26,076	51,280	46,560	19,362	65,922

[a] GE-VNC and B&W are included only in *The National TRU Waste Management Plan.*
[b] Total shipments when adjusted to the 168,500 cubic meters of CH-TRU waste allowed to be disposed of at WIPP under the LWA.

Table J-5
Number of RH-TRU Waste Shipments from Each Potential Consolidation Site to WIPP by Alternative Using *The National Transuranic Waste Management Plan* Volumes

Alternatives	Number of Shipments to WIPP for the Total Inventory				
	Hanford	INEEL	LANL	ORNL	Totals
Proposed Action	4,232	223	374	2,797	7,626 (7,957)[a]
Action Alternative 1					
Basic	4,210	223	395	2,797	7,625
Additional	1,229	121	269	2,265	3,884
Total	5,439	344	664	5,062	11,509
Action Alternative 2A					
Basic	1,690	0	0	979	2,669
Additional	566	0	0	793	1,359
Total	2,256	0	0	1,772	4,028
Action Alternative 2B					
Basic	1,690	0	0	979	2,669
Additional	566	0	0	793	1,359
Total	2,256	0	0	1,772	4,028
Action Alternative 2C					
Basic	4,828	0	0	2,797	7,625
Additional	1,617	0	0	2,265	3,882
Total	6,455	0	0	5,062	11,507
Action Alternative 3					
Basic	5,793	0	0	3,356	9,149
Additional	1,941	0	0	2,718	4,659
Total	7,737	0	0	6,074	13,808

[a] Total shipments when adjusted to the 7,080 cubic meters of RH-TRU waste allowed to be disposed of at WIPP under the C&C Agreement.

Table J-6
Comparison of Shipments Between Alternatives Using *The National Transuranic Waste Management Plan* and Basic Inventory

Alternatives	Number of Shipments to WIPP for the Total Inventory			
	NTRUWM Plan	Basic Inventory	Difference (Cubic Meters)	NTRUWM Plan Percent Difference
Proposed Action				
CH-TRU Waste	29,766[a]	29,766[a]	0	0%
RH-TRU Waste	7,957[b]	7,957[b]	0	0%
Action Alternative 1				
CH-TRU Waste	41,027	41,003	24	0%
RH-TRU Waste	11,509	62,162	-50,653	-81%
Action Alternative 2A				
CH-TRU Waste	43,749	42,775	974	+2%
RH-TRU Waste	4,028	21,895	-17,867	-82%
Action Alternative 2B				
CH-TRU Waste	43,750	42,774	976	+2%
RH-TRU Waste	4,028	21,895	-17,867	-82%
Action Alternative 2C				
CH-TRU Waste	43,431	41,206	2,225	+5%
RH-TRU Waste	11,507	62,160	-50,653	-81%
Action Alternative 3				
CH-TRU Waste	65,922	67,309	-1,387	-2%
RH-TRU Waste	13,808	74,606	-60,798	-81%

[a] Adjusted to the 168,500 cubic meters of CH-TRU waste allowed to be disposed of at WIPP under the LWA.
[b] Adjusted to the 7,080 cubic meters of RH-TRU waste allowed to be disposed of at WIPP under the C&C Agreement.

REFERENCES CITED IN APPENDIX J

DOE (U.S. Department of Energy), 1996a, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 3, June, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *The National Transuranic Waste Management Plan*, DOE/NTP-96-1204, Revision 0, September, Carlsbad, New Mexico.

APPENDIX K
LIST OF PREPARERS AND CONTRIBUTORS

This list identifies individuals who were principal preparers and contributors to this supplemental environmental impact statement (SEIS-II). Harold Johnson of the Department of Energy's Carlsbad Area Office directed the preparation of SEIS-II. Randy F. Reddick and Lucinda Low Swartz co-managed the project and provided technical and document preparation support. Tracy A. Ikenberry provided management of the technical staff at DOE's Pacific Northwest National Laboratory (managed and operated by Battelle).

Name: STEPHEN R. ALCORN

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Geology (Geochemistry), University of Georgia, 1981
- M.S., Geology, University of South Carolina, 1975
- A.B., Geology, Lafayette College, 1969

Technical Experience: Seventeen years of experience as an environmental scientist, expert consultant, and manager of hazardous and radioactive waste projects, in the areas of geology and geochemistry, site modeling and contaminant transport analysis, site assessment and remediation, performance assessment, and environmental compliance.

EIS Responsibility: Technical reviewer. Contributed to the geology and hydrology sections of Chapter 4 and Appendix H, and to the Comment Response Document.

Name: DAVID M. ANDERSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Forest Economics, Oregon State University, 1991
- B.S., Forest Resources, Oregon State University, 1989

Technical Experience: Six years of experience with regional economic and socioeconomic analysis modeling.

EIS Responsibility: Contributed to the socioeconomics sections of Chapters 4 and 5 and Appendix D, and to the Comment Response Document.

Name: LARRY M. BAGAASEN

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Ceramic Engineering, University of Illinois, 1983
- B.S., Ceramic Engineering, University of Illinois, 1981

Technical Experience: Twelve years of experience in ceramic fabrication, cement waste form development, and systems modeling of remediation technologies.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: JAMES M. BECKER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Range and Wildlife Resources, Brigham Young University, 1987

Technical Experience: Five years of experience in planning and conducting field surveys of terrestrial wildlife and plant taxa.

EIS Responsibility: Prepared the biology section of Chapter 5 and assisted with the Comment Response Document.

Name: MARCEL P. BERGERON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.A., Geology, Indiana University, 1979
- B.A., Geology, University of Vermont, 1975

Technical Experience: Seventeen years of experience in a variety of hydrologic studies at hazardous waste and contaminated ground water sites.

EIS Responsibility: Deputy Project Manager, PNNL activities. Lead preparer for assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I. Contributed to the Comment Response Document.

Name: SUSAN L. BLANTON

Affiliation: Battelle – Pacific Northwest National Laboratory

Education:
- B.S., Zoology, Miami University, 1992

Technical Experience: Six years of experience in ecological monitoring, biological research, and over three years of experience in NEPA compliance.

EIS Responsibility: Assisted with the Comment Response Document.

Name: JOHN W. BUCK

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Meteorology, University of Wisconsin, 1980
- B.S., Meteorology, University of Wisconsin, 1978

Technical Experience: Fifteen years of experience in energy research, multi-media transport and exposure assessment, and risk assessment.

EIS Responsibility: Technical lead, assessment of the post-institutional control period for No Action Alternatives 1 and 2 in Chapter 5 and Appendix I.

Name: KARL CASTLETON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Computer Science and Applied Mathematics, Mesa State College, 1992

Technical Experience: Four years of experience in environmental assessment modeling.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: PHILIP M. DALING

Affiliation: Battelle – Pacific Northwest National Laboratory

Education:
- B.S., Physical Metallurgy, Washington State University, 1981

Technical Experience: Fifteen years of experience as a risk and safety analyst and project manager in areas of radioactive and hazardous chemical material transportation risk analyses, transuranic solid waste management risks, and risk-based decision-making.

EIS Responsibility: Technical reviewer and contributor to the transportation impact analysis.

Name: JUDY DANKO

Affiliation: Battelle – Pacific Northwest National Laboratory

Education:
- B.A., Liberal Arts: History/English/Biology, 1981

Technical Experience: Sixteen years of experience as a technical editor, concentrating on technology management, energy, economics, and waste management.

EIS Responsibility: Assisted in the technical editing of the document.

Name: SALVATORE DIMARIA

Affiliation: Battelle - Albuquerque

Education:
- M.A., Geography, University of New Mexico, 1988
- B.S., Biology, University of New Mexico, 1972

Technical Experience: Eight years of experience with geographical, biological, and quantitative research methods.

EIS Responsibility: Technical lead for Chapter 4. Prepared the biotic resources, land use, and generator site sections of Chapter 4. Prepared the list of agencies and persons consulted. Contributed to the Comment Response Document.

Name: JAMES F. DONAGHUE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- J.D., Law, Golden Gate University, 1990
- B.S., Civil Engineering, University of Arkansas, 1985

Technical Experience: Seven years of experience in environmental management and regulatory compliance.

EIS Responsibility: Contributed to Appendix A.

Name: FRANCIS C. DOUGLAS

Affiliation: Battelle - Albuquerque

Education:
- M.A., English, Kansas State University, 1994
- B.S., Journalism, Ohio University, 1982

Technical Experience: Eighteen years of experience as a writer and editor, including three years serving the environmental industry.

EIS Responsibility: Deputy Project Manager, Battelle Albuquerque activities. Contributor to Chapters 1, 2, 3 and 5 and comment response document. Conducted editorial reviews and provided technical document support. Lead for document production.

Name: AMY S. DUDA

Affiliation: Battelle - Albuquerque

Education:
- B.A., English, University of New Mexico, 1996

Technical Experience: Five years of experience in editing.

EIS Responsibility: Assisted in the technical editing of the document.

Name: LANCE W. ERRICKSON

Affiliation: Battelle – Albuquerque

Education:
- B.A., Geology, University of New Mexico, 1990

Technical Experience: Two years of experience working on WIPP technical data at Sandia National Laboratories.

EIS Responsibility: Assisted with document production.

Name: PAUL W. ESLINGER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Statistics, Southern Methodist University, 1983
- M.S., Mathematics, Washington State University, 1978
- B.S., Mathematics, George Fox College, 1976

Technical Experience: Seventeen years of experience in risk assessment, dose reconstruction, and performance assessment modeling.

EIS Responsibility: Lead preparer, Appendix A and the performance assessment sections of Chapter 5 and Appendix H. Contributed to the Comment Response Document.

Name: CHRISTIAN J. FOSMIRE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Meteorology, Pennsylvania State University, 1993
- B.S., Meteorology, Pennsylvania State University, 1990

Technical Experience: Two years of experience in atmospheric diffusion modeling and risk assessment.

EIS Responsibility: Prepared the air quality sections of Chapter 5 and Appendix C. Assisted with the Comment Response Document.

Name: GARIANN GELSTON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Applied Mathematics, Mesa State College, 1991

Technical Experience: One year of experience in environmental assessment modeling.

EIS Responsibility: Modeled nonradiological impacts for the human health and facility accidents sections of Chapter 5 and Appendices F and G, and contributed to assessment of post-institutional control period for the No Action Alternative 2 in Chapter 5 and Appendix I.

Name: DONNA D. HAMMOND

Affiliation: Battelle – Albuquerque

Education:
- B.S., Education, New Mexico State University, 1995

Experience: Five years of experience in document production and database management.

EIS Responsibility: Contributed to text processing and the production of the document.

Name: GLEN T. HANSON

Affiliation: Battelle - Albuquerque

Education:
- M.A., Anthropology/Archaeology, Arizona State University, 1976
- B.S., Anthropology/Archaeology, Grand Valley State College, 1971

Technical Experience: Twenty-four years of experience in environmental and resource management, regulatory compliance, environmental assessment and impact analyses for NEPA documentation, facility siting, site characterization, cultural resource assessment and management, and environmental program management.

EIS Responsibility: Draft SEIS-II Project Manager, Battelle Albuquerque.

Name: PAUL L. HENDRICKSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- J.D., Law, University of Washington, 1971
- M.S., Industrial Management, Purdue University, 1972
- B.S., Chemical Engineering, University of Washington, 1968

Technical Experience: Twenty-three years of experience in energy and environmental studies with special emphasis on regulatory issues.

EIS Responsibility: Prepared the sections on land use impacts in Chapter 5.

Name: JAMES A. HILEMAN

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Seismology, California Institute of Technology, 1977
- M.S., Seismology, California Institute of Technology, 1971
- Geophysical Engineer, Colorado School of Mines, 1960

Technical Experience: Thirty years of experience in exploration, research, management, and review, particularly in siting critical facilities and assessing geologic hazards.

EIS Responsibility: Contributed to sections of Chapter 3.

Name: TRACY A. IKENBERRY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Radiology & Radiation Biology, Colorado State University, 1982
- B.A., Biology, McPherson College, 1979

Technical Experience: Fifteen years of experience in radiological assessment, operational and environmental health physics. Diplomate, American Board of Health Physics, 1988.

EIS Responsibility: Project Manager, PNNL activities. Lead preparer, Appendices B and J. Technical and management reviewer. Contributed to Chapter 3 and the Comment Response Document.

Name: TERRY D. JAMES

Affiliation: Battelle – Columbus

Education:
- B.A., International Studies and English, Bradley University, 1969
- A.S., Life Sciences, Parkland College, 1986

Technical Experience: Twenty-seven years of experience in publications, including writing, editing, and proposal management.

EIS Responsibility: Contributed to the production of the draft final document.

Name: HAROLD JOHNSON

Affiliation: U.S. Department of Energy

Education:
- J.D., Law, Mercer University, 1976
- B.S., Math and Physics, Mercer University, 1971

Technical Experience: Nine years of experience in writing, reviewing, and approving NEPA documents.

EIS Responsibility: DOE Document Manager.

Name: CHRISTINE D. LADD

Affiliation: Battelle - Albuquerque

Education
- Certified in the beginning, intermediate, and advanced levels of Adobe Illustrator, University of New Mexico, 1995

Technical Experience: Two years of experience in document production and graphics design.

EIS Responsibility: Lead text processor and production coordinator. Contributed to the design of the graphics and production of the document.

Name: DAVID LECHEL

Affiliation: Lechel, Inc.

Education:
- M.S., Fisheries Biology, Michigan State University, 1974
- B.S., Fisheries Biology, Michigan State University, 1972

Technical Experience: Twenty-two years of experience in project management, regulatory compliance and permitting, NEPA planning and implementation for hazardous and radioactive waste disposal facilities.

EIS Responsibility: Technical reviewer. Lead preparer of Chapter 2, assisted in the development of alternatives, and contributed to the Comment Response Document.

Name: LEIGH LECHEL

Affiliation: Lechel, Inc.

Education:
- B.S., Speech Pathology, James Madison University, 1976

Technical Experience: Twenty years of experience in document production and administrative support.

EIS Responsibility: Contributed to the production of the document.

Name: ROBERT A. LECHEL

Affiliation: Battelle - Albuquerque

Education:
- B.S., Environmental Studies and Planning: Hazardous Materials Management, California State University - Sonoma, 1995

Technical Experience: One year of experience in performance assessment modeling.

EIS Responsibility: Contributed to the transportation sections of Chapter 5 and Appendix E. Assisted with the Comment Response Document.

Name: MARCUS K. LESTER

Affiliation: Battelle - Seattle Research Center

Education:
- M.A., Geography, University of Washington, 1991
- B.A., Geography, University of Washington, 1989

Technical Experience: Six years of experience in cartography, geographic information systems (GIS), and spatial analysis of environmental and socioeconomic data.

EIS Responsibility: Prepared the environmental justice section of Chapter 4.

Name: GEORGE A. MARINO

Affiliation: Battelle - Albuquerque

Education:
- M.E., Civil/Environmental Engineering, University of South Florida, 1994
- B.S., Mechanical Engineering, University of Pittsburgh, 1983

Technical Experience: Six years of experience in quality assurance, production engineering, and industrial hygiene and safety, and seven years of experience in environmental remediation.

EIS Responsibility: Technical Reviewer and assisted with the Comment Response Document.

Name: MACHELE McKINLEY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Environmental Engineering, Humboldt State University, 1992

Technical Experience: Three years of experience in computer modeling of saturated and unsaturated hydrology.

EIS Responsibility: Contributed to assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: THOMAS McSWEENEY

Affiliation: Battelle - Columbus

Education:
- Ph.D., Chemical Engineering, University of Michigan, 1967
- M.A., Math, University of Michigan, 1964
- M.S., Chemical Engineering, University of Michigan, 1961
- B.S., Chemical Engineering, University of Notre Dame, 1960

Technical Experience: Twenty-eight years of experience in risk and safety analysis and ten years of experience in transportation risk analysis.

EIS Responsibility: Contributed to the transportation sections of Chapter 5 and Appendix E.

Name: TERRI B. MILEY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Mathematics, University of South Carolina, 1986
- B.S., Mathematics, University of South Carolina, 1982

Technical Experience: Eight years of experience in performance assessment and groundwater risk assessments.

EIS Responsibility: Contributed to the performance assessment sections of Chapter 5 and Appendix H.

Name: TOM MONROE

Affiliation: Battelle – Columbus

Education:
- B.S., Journalism, Ohio University, 1995

Technical Experience: Two years of experience in technical writing/editing, proposal development, desktop publishing, and database development.

EIS Responsibility: Assisted in editing of the document.

Name: MARK T. MURPHY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Geology, Johns Hopkins University, 1989
- M.S., Geology, University of New Mexico, 1985
- B.S., Earth Science, University of California at Santa Cruz, 1977

Technical Experience: Eighteen years of experience in environmental geology and geological engineering.

EIS Responsibility: Contributed to the geology section of Chapter 4.

Name: ELIZABETH A. NAÑEZ

Affiliation: Battelle - Albuquerque

Education:
- B.S., Industrial Engineering, Texas Tech University, 1990

Technical Experience: Three years of experience in environmental engineering including one year of experience in NEPA document preparation.

EIS Responsibility: Comment Response Document Manager. Contributed to sections of Chapters 1, 3, 4, and 5, and compiled the list of preparers and contributors.

Name: IRAL C. NELSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.A., Physics, University of Oregon, 1955
- B.S., Mathematics, University of Oregon, 1951

Technical Experience: Forty years of experience in various aspects of health physics (radiation protection) and twenty-four years of experience in conducting NEPA reviews and preparing NEPA documentation. Diplomate, American Board of Health Physics, 1962.

EIS Responsibility: Co-preparer of Appendix B.

Name: WILLIAM E. NICHOLS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Civil Engineering, Oregon State University, 1990
- B.S., Agricultural Engineering, Oregon State University, 1987

Technical Experience: Five years of experience in hydrologic and hydrothermal vadose zone modeling for performance assessment of waste isolation and disposal issues.

EIS Responsibility: Performed ground water transport modeling for the performance assessment sections of Chapter 5 and Appendix H.

Name: PAUL R. NICKENS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Anthropology, University of Colorado, 1977
- M.A., Anthropology, University of Colorado, 1974
- B.A., Anthropology, University of Colorado, 1969

Technical Experience: Twenty-one years of experience in southwestern archaeology and cultural resource management, site protection and preservation.

EIS Responsibility: Prepared the cultural resources sections of Chapters 4 and 5.

Name: TINA PAYNE

Affiliation: Battelle – Columbus

Education:
- B.A., Journalism, Otterbein College, 1994

Technical Experience: Three years of experience in technical editing and writing. Over fifteen years of experience in document production.

EIS Responsibility: Assisted in the technical editing of the document.

Name: TED M. POSTON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Fisheries, Central Washington University, 1978
- B.S., Fisheries, Central Washington University, 1973

Technical Experience: Twenty years of experience in research, environmental assessment, and noise analysis.

EIS Responsibility: Performed the noise impact analyses for Chapter 5.

Name: MICHELLE R. POTTER

Affiliation: Battelle - Albuquerque

Education:
- M.S., Radiological Sciences and Control, University of Lowell, 1991
- B.H.S., Medical Technology, University of Missouri - Columbia, 1984

Technical Experience: Five years of health physics and technical writing experience.

EIS Responsibility: Quality Assurance Manager for Draft SEIS-II. Assisted in the technical reviews and editing of the draft document.

Name: RANDY F. REDDICK

Affiliation: Battelle - Albuquerque

Education:
- M.S., Environmental Health Engineering, University of Kansas, 1983
- B.S., Civil Engineering, University of Kansas, 1982

Technical Experience: Twelve years of experience with NEPA compliance, NEPA document preparation, and safety studies.

EIS Responsibility: Final SEIS-II Co-Project Manager, Battelle Albuquerque, technical support. Major contributor to Chapter 3. Conducted technical and management reviews of the document and contributed to the Comment Response Document.

Name: ROBERT A. ROOT

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Botany, Miami University, 1971
- M.S., Botany, University of Montana, 1968
- B.S., Botany, University of Maine, 1963

Technical Experience: Over twenty years of experience as an environmental scientist and project manager.

EIS Responsibility: Lead preparer of Chapter 3. Assisted with the Comment Response Document.

Name: STEVEN B. ROSS

Affiliation: Battelle - Albuquerque

Education:
- M.S., Nuclear Engineering, University of New Mexico, 1987
- B.S., Nuclear Engineering, University of New Mexico, 1985

Technical Experience: Ten years of experience in safety analysis, risk assessment, transportation, regulatory analysis, and fire risk assessment.

EIS Responsibility: Lead preparer of the transportation sections of Chapters 4, 5, and Appendix E. Contributed to the Comment Response Document.

Name: KEITH D. SHIELDS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Environmental Science, Washington State University - Tri-Cities, 1995
- B.S., Physics, Whitman College, 1989

Technical Experience: Six years of experience in environmental assessments and modeling.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: SANDRA F. SNYDER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S.P.H., Radiological Hygiene, University of North Carolina-Chapel Hill, 1991
- B.S., Environmental Resource Management, Pennsylvania State University, 1986

Technical Experience: Seven years of experience in environmental health physics risk assessment.

EIS Responsibility: Lead preparer, human health and facility accidents sections of Chapter 5 and Appendices F and G. Contributed to the Comment Response Document.

Name: LISSA H. STAVEN

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Health Physics, Colorado State University, 1990
- B.S., Environmental Conservation, University of New Hampshire, 1984

Technical Experience: Six years of experience in environmental health physics.

EIS Responsibility: Contributed to the human health and facility accidents sections of Chapter 5, Appendices F and G, and assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: GARY STREILE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Soil Science (Soil Physics), University of California Riverside, 1984
- B.S., Physics, University of California Riverside, 1975

Technical Experience: Twenty years of experience in contaminant transport modeling and research into reactive contaminant transport processes.

EIS Responsibility: Contributed to the assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: DENNIS L. STRENGE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Chemical Engineering, University of Minnesota, 1968
- B.S., Chemical Engineering, University of Washington, 1966

Technical Experience: Twenty-seven years of experience in the fields of environmental health physics and risk assessment.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: LUCINDA L. SWARTZ

Affiliation: Battelle – Albuquerque

Education:
- J.D. (Law), Washington College of Law, The American University, 1979
- B.A., Political Science and Administrative Studies, University of California, Riverside, 1976

Technical Experience: Seventeen years of experience in environmental law and regulation, most recently specializing in National Environmental Policy Act compliance.

EIS Responsibility: Final SEIS-II Co-Project Manager, Battelle Albuquerque. Technical reviewer of Comment Response Document and Final SEIS-II for conformity to NEPA and CEQ and DOE regulations and guidance.

Name: DESIREE THALLEY

Affiliation: Battelle – Albuquerque

Education:
- B.A., Journalism, University of New Mexico, 1983

Technical Experience: Thirteen years of experience in technical editing of Department of Energy and Department of Defense documentation.

EIS Responsibility: Assisted in the technical editing of the document.

Name: CARLOS A. ULIBARRÍ

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Economics, University of New Mexico, 1992
- B.A., Economics and Spanish Literature, University of New Mexico, 1984

Technical Experience: Six years of experience in natural resource and environmental economics.

EIS Responsibility: Lead preparer of the socioeconomic sections of Chapters 4 and 5 and Appendix D.

Name: LANCE W. VAIL

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Civil Engineering, Montana State University, 1981
- B.S., Environmental Resources Engineering, Humboldt State University, 1980

Technical Experience: Fifteen years of experience in surface and subsurface hydrology.

EIS Responsibility: Contributed to the hydrology section of Chapter 4.

Name: SANDRA K. WALTERS

Affiliation: Battelle - Albuquerque

Education:
- B.S., Environmental Health, Colorado State University, 1995

Technical Experience: Eight years of experience in data management, quality assurance and one year of experience in NEPA compliance.

EIS Responsibility: Prepared portions of Chapter 3, contributed to the preparation of the transportation sections of Chapter 5, and assisted with the Comment Response Document.

Name: TOMMYE S. WRIGHT

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Health Physics, Oklahoma State University, 1978

Technical Experience: Seventeen years of experience in occupational safety and health physics. Certified Safety Professional (CSP) and member of the National Registry of Radiation Protection Technologists (NRRPT).

EIS Responsibility: Prepared the industrial health and safety sections of Chapter 5.

APPENDIX L
DISTRIBUTION LIST

L.1 FULL SEIS-II

Albuquerque Technical Vocational Institute
U.S. Department of Energy
Albuquerque Operations Office Library
Albuquerque, NM

Board on Radioactive Waste Management
National Research Council
National Academy of Sciences
Washington, DC

Carlsbad Public Library
Carlsbad, NM

Chair
Environmental Quality Advisory Board
City of Oak Ridge
Oak Ridge, TN

Citizens Advisory Board
Westminster, CO

City of Laramie
Laramie, WY

DOE Oak Ridge Public Reading Room
U.S. Department of Energy
Oakridge, TN

Env. Review Section
Washington State Department of Ecology
Olympia, WA

FOI Publication/Document Room
U.S. Department of Energy
Gregg-Graniteville Library
Aiken, SC

Government Information Department
Zimmerman Library
University of New Mexico
Albuquerque, NM

Information Center
Colorado Dept. of Public Health and Environment
Denver, CO

Lockheed Martin/INEEL
Boise Operations
Boise, ID

Martin Speare Memorial Library
New Mexico Institute of Mining & Technology
Socorro, NM

New Mexico State Library
Santa Fe, NM

New Mexico State University Library
Las Cruces, NM

Pannell Library
New Mexico Junior College
Hobbs, NM

Public Library Reading Room
U.S. Department of Energy
Washington, DC

Public Reading Room
U. S. Department of Energy
Hanford Science Center
Richland, WA

Public Reading Room
U.S. Department of Energy
Idaho Falls, ID

Public Reading Room
Technical Laboratory
Idaho National Engineering and
Environmental Laboratory
Idaho Falls, ID

Raton Public Library
Raton, NM

Shoshone-Bannock Library
Human Resources Center
Bannock and Pims
Fort Hall, ID

Standley Lake Library
Arvada, CO

Shoshone-Bannock Tribes
Fort Hall, ID

Texas State Library
Information Services Division
Austin, TX

Thomas Brannigan Memorial Library
Las Cruces, NM

U.S. Department of Energy
CERCLA Public Reading Room
Miamisburg, OH

U.S. Department of Energy
Front Range Community College, B1103
Rocky Flats Public Reading Room
Westminster, CO

U.S. Department of Energy
Public Reading Room
Argonne, IL

U.S. Department of Energy
Public Reading Room
North Las Vegas, NV

U.S. Department of Energy
Public Reading Room
Oakland, CA

Thomas C. Adams
Texas Governor's Office of Budget and
Planning
Austin, TX

Anthony Adduci
U.S. Department of Energy
Oakland, CA

Howard Adler
Oxyrase, Incorporated
Knoxville, TN

James Alders
Northern States Power Company
Minneapolis, MN

Peter Allan
Short Hills, NJ

Richard Allen
Illinois Department of Nuclear Safety
Springfield, IL

Phil Altomare
U.S. Department of Energy
Germantown, MD

Tom Altrento
Boulder, CO

Navroze Amara
Raytheon Engineers and Constructors
Englewood, CO

Robert Anderson
Kalamazoo, MI

Sandy Anderson
Nuclear Fuel Services Inc.
Richland, WA

Dr. Joseph A. Angelo, Jr.
Radiation Protection/Nuclear Waste Management
Florida Institute of Technology
Melbourne, FL

Steve P. Aozniak
Boulder, CO

John Applegate
University of Cincinnati
College of Law
Cincinnati, OH

Joni Arends
South Royalton, VT

Lois Arnold
Denver, CO

Richard Arnold
Consolidated Group of Tribes and Organizations
Pahrump, NV

Tim Augustine
Gibsonia, PA

Honorable E. Shirley Baca
Las Cruces, NM

Pat Baca
Albuquerque, NM

Tom Baillieul
U.S. Department of Energy
Dublin, OH

Patricia A. Barclay
Idaho Council on Industry & the Environment
Boise, ID

Bruce and Clo Barnaby
Albuquerque, NM

Tim Barney
Envirocare of Utah
Salt Lake City, UT

John R. Barry
Denver, CO

Dr. William Bartlett
Environmental Evaluation Group
Albuquerque, NM

Jim Bartosch
Albuquerque, NM

Honorable Phil Batt
Governor of Idaho
State of Idaho
Boise, ID

Penny Bauder
Kalamazoo, MI

Honorable David Beasley
Governor of South Carolina
State of South Carolina
State House
Columbia, SC

George Becker
WSRC
Aiken, SC

Lira Behrens
Associate Editor
Inside Energy
Washington, DC

Mavis Belisle
Panhandle, TX

Lynne M. Bell
Boulder, CO

Nancy Bennett
DOE FOIA Reading Room
Albuquerque, NM

Leevon Benally
Navajo EPA Reading Room
Window Rock, AZ

Roy Bernal
Chairman
All Indian Pueblo Council
Albuquerque, NM

W.M. Berryman
Morrison, CO

Kevin Betz
Deputy Commissioner
Indiana Department of Environmental Management
Indiana Govt. Center North
Indianapolis, IN

Walt Beyler
SAIC
Albuquerque, NM

James E. Bickford
KY Cabinet for Natural Resources & Environmental Protection
Frankfort, KY

Honorable Jeff Bingaman
Senator of New Mexico
United States Senate
Washington, DC

R.S. Bird
Carlsbad, NM

Bruce M. Biwer
Lemont, IL

Donald R. Blair
Member
Eunice City Council
Eunice, NM

Robert S. Blair
Boulder, CO

Honorable John A. Boehner
Representative of Ohio
U.S. House of Representatives
Washington, DC

Jerry Boese
Environmental Consultant
Ross and Associates
Seattle, WA

John Bohacheft
Sandia National Laboratory
Albuquerque, NM

Dr. L. Hall Bohlinger
Deputy Secretary
Office of the Secretary
Louisiana Dept. of Environmental Quality
Baton Rouge, LA

Richard Boren
El Paso, TX

Lou Borghi
Science Applications International Corporation
Germantown, MD

Carol Borgstrom
Office of NEPA Policy & Assistance,
Washington, DC

Janet Boulter
Denver, CO

Honorable Barbara Boxer
Senator of California
United States Senate
Washington, DC

Barbara Bradley
Boulder, CO

Beatrice Brailsford
Snake River Alliance
Pocatello, ID

Nancy C. Brantley
Member
Eddy County Commission
Carlsbad, NM

Vernon Brechen
Mountain View, CA

Ron Bridgeman
Oak Ridge, TN

Claudeo Broncho
Fort Hall Business Council
Shoshone-Bannock Tribes
Fort Hall, ID

Honorable Hank Brown
Senator of Colorado
United States Senate
Washington, DC

Dr. Norman Brown
Albuquerque, NM

Honorable Richard H. Bryan
Senator of Nevada
United States Senate
Washington, DC

Harry A. Bryson
Knoxville, TN

Daniel B. Bullen
Associate Professor
Nuclear Engineering Program
Iowa State University
Ames, IA

Ken Bulmahn
Idaho Falls, ID

Dorie Bunting
Albuquerque, NM

Frank Burchardt
Carlsbad, NM

Omeagia Burgess
Grant Services
Office of the Governor
Columbia, SC

Scott W. Burngardner
Boulder, CO

Rob Burnside
Captain - Fire Department
Confederates Tribes of the Umatilla
Pendleton, OR

Thomas Burton
Executive Director
Nevada Indian Environmental Coalition
Reno, NV

Genald Bush
Bureau Manager
Information Services Bureau
New Mexico Environment Department
Santa Fe, NM

Honorable George W. Bush
Governor of Texas
State of Texas
Austin, TX

Julie Butler
Coordinator
Department of Administration
Nevada State Clearinghouse
Carson City, NV

Bruce Buvinger
U.S. Department of Energy
Albuquerque Operations Office
Albuquerque, NM

Barbara Byron
California Energy Commission
Sacramento, CA

Jacqueline Cabasso
Director
Western States Legal Foundation
Oakland, CA

Chris Caldwell
Knoxville, TN

Connie Callan
National Environmental Technology Network
University of New Mexico
Albuquerque, NM

Carol Campbell
U.S. Environmental Protection Agency
Denver, CO

Donna Campbell
Librarian
Foster Wheeler Environmental Corporation
Oak Ridge, TN

K. Perry Campbell
West Richland, WA

Melissa Campbell
Albuquerque, NM

Honorable Tom Campbell
Senator
State of California
Washington, DC

Don Capone
BPF Inc.
Duncanville, TX

Marcia Caregeorges
Albuquerque, NM

Honorable Mel Carnahan
Governor of Missouri
State of Missouri
Jefferson City, MO

Tom Carpenter
Government Accountability Project
Seattle, WA

Chris Carter
Legislative Director
Representative Bill Baker
Washington, DC

Joel Case
Program Manager
Waste Management Program Office
U.S. Department of Energy
Idaho Falls, ID

Lois Chalmers
IEER
Tacoma Park, MD

Ellyn F. Chantos
Boulder, CO

Everett Chavez
Acting Director, EP
All Indian Pueblo Council
Albuquerque, NM

Bernadelfe Chavira-Morriman
Los Alamos, NM

Honorable Helen Chenoworth
Representative of Idaho
U.S. House of Representatives
Washington, DC

Dr. Sue B. Clark
National Academy of Sciences
WIPP Committee
Washington State University Chemistry Department
Pullman, WA

Honorable William Clyburn
Representative
State of South Carolina
Washington, DC

Jay Coghlan
Program Director
Concerned Citizens for Nuclear Safety
Santa Fe, NM

Honorable William S. Cohen
United States Senate
Washington, DC

Lawrence Coldren
Denver, CO

Eleanor Cole
Oak Ridge Reservation Oversight Committee
Oak Ridge, TN

Sam Cole
Executive Director
Colorado Chapter
Physicians for Social Responsibility
Denver, CO

Lizbeth Cone
Thornton, CO

Jose Conto
Washington, DC

John T. Conway
Chairman
Defense Nuclear Facility Safety Board
Washington, DC

Jim Cool
Placitas, NM

Dr. Susan C. Cooper
Vice President
Sisneros-Cooper Environmental Corp.
Albuquerque, NM

Tracy Copeland
Manager
Department of Finance and Administration
Arkansas State Clearinghouse
Office of Intergovernment Service
Little Rock, AR

Brian Costner
Director
Energy Research Foundation
Columbia, SC

Bill Craig
Division of Radiation Control
Utah Department of Environmental Quality
Salt Lake City, UT

Honorable Michael Crapo
Representative of Idaho
U.S. House of Representatives
Washington, DC

Carol Crawford
Nuclear Waste Management Library
Albuquerque, NM

David L. Crawford
Boulder, CO

Dr. Kevin C. Crawley
National Academy of Sciences
Washington, DC

Maureen Crocker
Associate Director
The State of Illinois Office
Washington, DC

David Crose
Director of Technological Hazards
Indiana State Emergency Management Agency
Indianapolis, IN

Martha Crosland
Environmental Management
Forrestal Building, EM-75
Washington, DC

Honorable Barbara Cubin
Representative of Wyoming
U.S. House of Representatives
Washington, DC

Steven Dapra
Albuquerque, NM

Honorable Miranda Darcy
Mayor
Village of Loving
Loving, NM

Honorable Walter Dasheno
Governor
Pueblo of Santa Clara
Espanola, NM

Ellen Daugherty
Lockheed Martin-Idaho
Idaho Falls, ID

Pete Davis
Banner, WY

Ed S. Debolt
Boulder, CO

Robert Deegan
Nuclear Waste Task Force
Sierra Club
Virginia Beach, VA

Honorable Diana DeGette
Representative of Colorado
U.S. House of Representatives
Washington, DC

Antonio Delgado, Ph.D.
Ranchos de Taos, NM

Honorable Ronald V. Dellums
Representative of California
U.S. House of Representatives
Washington, DC

Mike Dempsey
White Rock, NM

Lorraine Dennis Allen
Executive Director
Carlsbad Department of Development
Carlsbad, NM

Lata Desai
WIPP Site Library
Carlsbad, NM

Honorable Michael DeWine
Senator of Ohio
United States Senate
Washington, DC

Sylviana Diaz-d-Ouville
CO-18 AFSCME
Albuquerque, NM

Russell DiBartolo
Clark County Nuclear Waste Division
Las Vegas, NV

Greta Dicus
Division of Radiation Control &
Emergency Management
Arkansas Department of Health
Little Rock, AR

Michael Dillaplain
DOE/Yucca Mountain Science Center
Las Vegas, NV

John Dimarzio
Damascus, MD

Gary Dintsch
Oak Ridge, TN

Robert Disney
North Dakota Department of Health
Bismark, ND

Katherine A. Dobson
Boulder, CO

Ann Dold
Manager
INEEL Oversight Program
Idaho Falls, ID

Honorable A. W. Dolman
Mayor
Village of Encino
Encino, NM

Honorable Pete V. Domenici
Senator of New Mexico
United States Senate
Washington, DC

Jesse Dompreh
Albuquerque, NM

Jeff Donahue
Denver, CO

Michael Dooley
Albuquerque, NM

Honorable John T. Doolittle
Representative of California
U.S. House of Representatives
Washington, DC

David J. Dossett
U. S. Department of Energy
Tulsa, OK

Jerry Downs
State of Idaho
INEEL Oversight Program
Idaho Falls, ID

Paul Drez
Albuquerque, NM

Lorrie Dunaway
Carlsbad, NM

Mike Duncan
Risk Manager
BDC/Falcon Special Waste Services
Sierra Madre, CA

Fred Dunhous
ASI
Idaho Falls, ID

Paul F.X. Dunigan, Jr.
Environmental Assurance, Policy and Permits
U.S. Department of Energy
Richland, WA

Don Dustin
Boulder, CO

John Dykes
Executive Assistant
Governor's Office of Business Advocacy
Baton Rouge, LA

Joel Eacker
Lakewood, CO

Honorable Jim Edgar
Governor of Illinois
State of Illinois
Springfield, IL

Don A. Edling
President
Edling & Associates, Inc.
Russell Springs, KY

Dr. A.J. Eggenberger
Vice Chairman
Defense Nuclear Facility Safety Board
Washington, DC

Nadine L. Eichelberger
Longmont, CO

Lois Mae Eike
Golden, CO

Maureen Eldredge
Military Protection Network
Washington, DC

Arthur Eldridge
Boulder, CO

Dr. Donald Elle
Office of Assistant Manager for National Security
U.S. Department of Energy
Las Vegas, NV

Jeoff Elliot
AmbioCom Strategies
Grand Lake, CO

Paula Elofson-Gardine
Environmental Information Network
Arvada, CO

Honorable John Ensign
Representative of Nevada
U.S. House of Representatives
Washington, DC

Janie Enter
Los Alamos National Laboratory
Los Alamos, NM

David Envicto
Neway, SC

Fred M. Ernsberger
National Academy of Sciences
Gainesville, FL

Jerry Erpenbach
Oak Ridge, TN

Honorable Anna G. Eshoo
Representative of California
U.S. House of Representatives
Washington, DC

Borik Esmailzadeh
Battelle
Columbus, OH

Daniel Evans
Halliburton NUS Corporation
Aiken, SC

Honorable J. James Exon
United States Senate
Washington, DC

Dr. Charles Fairhurst
NAS WIPP Panel
University of Minnesota
Civil Engineering Dept.
Minneapolis, MN

Honorable Harris W. Fawell
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Vic Fazio
Representative of California
U.S. House of Representatives
Washington, DC

Dan Fehringer
Senior Professional Staff
Nuclear Waste Technical Review Board
Arlington, VA

Honorable Dianne Feinstein
Senator of California
United States Senate
Washington, DC

Robert N. Ferguson
Administrator
Department of Health and Welfare
State of Idaho
INEEL Oversight Program
Idaho Falls, ID

Dr. Donald J. Fingleton
Director
Carlsbad Environmental Monitoring & Research Ctr
Carlsbad, NM

Judy Fissel
BNFL, Inc.
Oak Ridge, TN

Donald A. Flater
Chief
Iowa Department of Public Health
Lucas State Office Building
Des Moines, IA

Bonney Fogdall
Las Vegas, NV

Steve Folga
Argonne National Laboratory
Argonne, IL

Connie Follett
Chamber of Commerce
Idaho Falls, ID

Jerry L. Folsom
Pueblo of Pojoaque
Santa Fe, NM

Jane Foreman
Kennewick, WA

Betty Forster
Boulder, CO

Honorable M.J. “Mike” Foster
Governor of Louisiana
State of Louisiana
Baton Rouge, LA

Charles Fraley
Radiation Maintenance & Cal. Facility
Wyoming Emergency Management Agency
Cheyenne, WY

Jack Frankel
Santa Fe, NM

Caroline Fraser
Santa Fe, NM

David Frederick
State of Idaho
INEEL Oversight Program
Idaho Falls, ID

George Freund
Coalition 21
Idaho Falls, ID

Paul H. Friesma
Center for Urban Affairs & Policy Research
Northwestern University
Evanston, IL

Honorable Bill Frist
Senator of Tennessee
United States Senate
Washington, DC

Benjamin P. Fuchs
Boulder, CO

Beth Fulmer
Senior Policy Analyst
Southern States Energy Board
Norcross, GA

Dodd Galbreath
Don Dills, Commissioner
Tennessee Department of Environment and Conservation
Nashville, TN

Sandra Garber
Aiken, SC

Dale Garcia
Merrick & Co.
Denver, CO

B. John Garrick
PLG, Incorporated
Newport Beach, CA

Henry Garson
Defense Programs
U.S. Department of Energy
Germantown, MD

Bob Gaston
Carlsbad, NM

Beverly Gattis
Serious Texans Against Nuclear Dumping
of Amarillo, Inc.
Amarillo, TX

Dr. Susan Gawarecki
Oak Ridge Local Oversight Committee
Oak Ridge, TN

Richard L. Geddes
North Augusta, SC

John Geddie
Albuquerque, NM

Rick Geinitz
Arvada, CO

Denise Gelston
S.M. Stoller
Boulder, CO

Critz George
Ogden Environmental
Albuquerque, NM

Don George
S.M. Stoller Corporation
Carlsbad, NM

Tom Gerard
Alexandria, VA

Carl Gertz
U.S. Department of Energy
Mercury, NV

Joe Ginanni
U.S. Department of Energy
Nevada Operations Office
Las Vegas, NV

Dena Gitterman
Boulder, CO

Honorable John Glenn
Senator of Ohio
United States Senate
Washington, DC

Mike Glora
SAIC
Albuquerque, NM

Denise Glore
Office of Chief Counsel
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, ID

Rick Gochal
Greenpeace
Boulder, CO

Joseph Goldfield
Denver, CO

Honorable David Gomez
Governor
Pueblo of Taos
Taos, NM

Davis Gonzales
Chairman
Inter-Tribal Council of Nevada
Elko, NV

Manny Gonzales
The New Mexican
Santa Fe, NM

Cavan B. Gonzalez
San Ildefonso Pueblo
Santa Fe, NM

Michael Goodis
Manager
Experimental Programs
U.S. Department of Energy
Washington, DC

Susan Gordon
Director
Military Production Network
Seattle, WA

Honorable Slade Gorton
Senator of Washington
United States Senate
Washington, DC

Honorable Lindsey Graham
Representative of South Carolina
U.S. House of Representatives
Washington, DC

Drew Grainger
Engineering & Analysis Division
U.S. Department of Energy
Aiken, SC

Dave Granquist
Golden, CO

Johnny Grant
Gathersburg, MD

Janet Greenwald
Citizens for Alternatives to Radioactive Dumping
Albuquerque, NM

John Griess
Knoxville, TN

Mike Griffin
Bechtel Nevada
Las Vegas, NV

Rudy Guercia
Program Manager
Solid Waste and Transportation
U.S. Department of Energy
Richland, WA

Steve Gunderson
Director
Emergency Management Unit
Colorado Department of Health
Denver, CO

Bob Guzowski
SAIC
Albuquerque, NM

Bern Haggerty
Laramie, WY

Regina Haines
Librarian
SAIC
Germantown, MD

Albert Hale
President
Navajo Nation
Window Rock, AZ

Beth Hale
Albuquerque, NM

April Hall
H&R Technical Associates, Inc.
Oak Ridge, TN

Honorable Tony P. Hall
Representative of Ohio
U.S. House of Representatives
Washington, DC

Don Hancock
Southwest Research and Information Center
Albuquerque, NM

Tom Haney
Firth, ID

Honorable James V. Hansen
Representative of Utah
U.S. House of Representatives
Washington, DC

Chris Harbin
Louisville, KY

James C. Hardeman, Jr.
Manager
Environmental Radiation Program
Georgia Department of Natural Resources
Atlanta, GA

Rick Hardy
Morrison Knutson Inc.
Boise, ID

R.M. Harmel
U.S. Bureau of Mines
Lakewood, CO

Timothy Harms
TRU Waste Steering Committee
U.S. Department of Energy
Washington, DC

Melinda Harriman
Denver, CO

John Hart
Albuquerque, NM

William Hasselkus
Springfield, VA

Honorable Richard Hastings
Representative of Washington
U.S. House of Representatives
Washington, DC

Honorable Orrin G. Hatch
Senator of Utah
United States Senate
Washington, DC

Earl Hatley
Oklahoma Toxics Campaign
Guthrie, OK

Joel Haugen
Director
Waste Management & Technology
Development Division
U.S. Department of Energy
Argonne, IL

Delbert Havatone
Chairman
Hualapai Tribal Council
Peach Springs, AZ

Matthew Hawkins
Boulder, CO

Robert Hazovsky
Lakewood, CO

John Heaton
Carlsbad, NM

Honorable Joel Hefley
Representative of Colorado
U.S. House of Representatives
Washington, DC

Richard Heiderstadt
Environmentac Co.
Charlottesville, VA

Kathy Helms
Nashville, TN

Mike Henderson
TransCore - JHK
Albuquerque, NM

Honorable Wally Herger
Representative of California
U.S. House of Representatives
Washington, DC

Steve Herman
SAHCI, Inc.
New Lenox, IL

Dan Hester
Attorney-at-Law
Confederated Tribes of the Umatilla
Pendleton, OR

Phil Hill
Director
Waste Management Division
U.S. Department of Energy
Oakland, CA

David Hoel
U.S. Department of Energy
Washington, DC

Darleane C. Hoffman
Lawrence Berkeley Laboratory
Berkeley, CA

Robert Holden
Nuclear Waste Program Director
National Congress of American Indians
Washington, DC

Richard Holder
Jason Technologies
Las Vegas, NM

Honorable Ernest F. (Fritz) Hollings
Senator of South Carolina
United States Senate
Washington, DC

Delbert Holmes
Fort Mojave Tribe
Needles, CA

Sarah Horton
Santa Fe Reporter
Santa Fe, NM

Benny Houdan
Carlsbad, NM

Paul Hoversten
Reporter
USA Today
Arlington, VA

John L. Howard
Governor's Policy Office
Austin, TX

Stan A. Huber
Stan A. Huber Consultants, Inc.
New Lenox, IL

Honorable Michael D. Huckabee
Governor of Arkansas
State of Arkansas
Little Rock, AR

Honorable Duncan L. Hunter
Representative of California
U.S. House of Representatives
Washington, DC

Vernon Hunter
Chairman
Caddo Tribal Council
Binger, OK

Ralph Hutchinson
Coordinator
Oak Ridge Environmental Peace Alliance
Oak Ridge, TN

Honorable Kay Bailey Hutchison
Senator of Texas
United States Senate
Washington, DC

Raymond Isaason
Richland, WA

Renee Iverson
Department of Law Enforcement
Idaho State Police Division
Meridian, ID

Jake The Dog
Critters
Longmont, CO

Kai Olof Jakobsson
02940 ESPOO Finland

Michael P. Jansky
Environmental Engineer
Office of Planning and Coordination
U.S. Environmental Protection Agency
Dallas, TX

Javier S. Jasso
Carlsbad, NM

Hank Jenkins-Smith
Director
UNM Institute of Public Policy
Dept of Political Science
Albuquerque, NM

Honorable Gary Johnson
Governor of New Mexico
Santa Fe, NM

Jay Johnson
Woodstock, GA

Honorable Roland E. Johnson
Governor
Pueblo of Laguna
Laguna, NM

Joe Johnston
Bechtel of Nevada
Las Vegas, NV

Paulette Johnston
NM Attorney General's Office
Santa Fe, NM

Mike Jolley
Pocatello, ID

Michael Jones
Parsons Brinkerhoff
Denver, CO

Robert Monsavi Jones
Los Alamos, NM

Ted Joy
Southern States Energy Board
Norcross, GA

Mark Kansas
Littleton, CO

Honorable Lela Kaskalla
Governor
Pueblo of Nambe
Nambe Pueblo, NM

Honorable Frank Keating
Governor of Oklahoma
State of Oklahoma
Oklahoma City, OK

Dr. Thomas E. Keiss
Board on Radioactive Waste Management
National Academy of Sciences
Washington, DC

Dr. Ed Kelley
Director
Water and Waste Management Division
New Mexico Environment Department
Santa Fe, NM

Marylia Kelley
President
Tri-Valley Citizens Against The
Radioactive Environment
Livermore, CA

Matthew Kelsch
Boulder, CO

Honorable Dirk Kempthorne
Senator of Idaho
United States Senate
Washington, DC

John Kennedy
ETEC
Los Lunas, NM

Jim Kenney
Environmental Scientist/Supervisor
Environmental Evaluation Group
Carlsbad, NM

Dr. Dan Kerlinsky
Physicians for Social Responsibility
Albuquerque, NM

Jeff Kerridge
Environmental Assessment Division
U.S. Department of Energy
Golden, CO

Hank Khan
University of California—Lawrence Livermore
Livermore, CA

Dr. Thomas Kiess
National Academy of Sciences
Washington, DC

Bill King
Clinton, TN

M.C. Kirkland
Aiken, SC

Honorable John Kitzhaber
Governor of Oregon
Salem, OR

Steve Kline
Gram Inc.
Los Alamos, NM

George Kniazewycz
Kim Technologies
Walnut Creek, CA

Leonard Konikow
U.S. Geological Survey
Reston, VA

Stan Kosiewicz
LANL
Los Alamos, NM

Dr. Herbert C. Kouts
Defense Nuclear Facility Safety Board
Washington, DC

Betsy Kraus
EEG
Albuquerque, NM

Andree Krause
Office of Congressman Dan Schaefer
Englewood, CO

Tom Krause
Benchmark Environmental Corporation
Albuquerque, NM

Konrad B. Krauskopf
Department of Geology
Stanford University
Stanford, CA

Charles Krick
Blairseville, GA

Gene Krupp
Golden, CO

Ron Kucera
Director
Intergovernmental Cooperation
Missouri Department of Natural Resources
Jefferson City, MO

Larry Kutnik
Power Reactor Nuclear Fuel Division
Washington, DC

Susan Lacy
U.S. Department of Energy
Kirtland Area Office
Albuquerque, NM

Dan J. Lajcunesse
Boulder, CO

Joe Lane
Policy Advisor
Office of the Governor
Phoenix, AZ

Thomas Lang
Office of the Director
Missouri Department of Natural Resources
Jefferson City, MO

Honorable Tom Lantos
Representative of California
U.S. House of Representatives
Washington, DC

Jon Lawritson
Policy Analyst
Western Governors' Association
Denver, CO

Honorable Michael Leavitt
Governor of Utah
State of Utah
Salt Lake City, UT

Kyounghee Lee
Boulder, CO

Mike Lee
U. S. Nuclear Regulatory Commission
Rockville, MD

Nancy Lee
Boulder, CO 80303

Earl Leming
DOE Oversight
Tennessee Department of Environment and Conservation
Oak Ridge, TN

Alan Lester
Department of Geological Sciences
University of Colorado
Boulder, CO

Honorable Carl Levin
United States Senate
Washington, DC

Kenneth Lickliter
Albuquerque, NM

Honorable Robert S. Light
Carlsbad, NM

Patrick Lipford
Knoxville, TN

Jason Litwiller
Lockheed Martin Utility Services
Piketon, OH

Honorable Gary Locke
Governor of Washington
State of Washington
Olympia, WA

Bruce Lorenz
Richland, WA

Honorable Trent Lott
Senator of Mississippi
United States Senate
Washington, DC

Robert Loux
Executive Director
Agency for Nuclear Projects
Carson City, NV

Lindsay Lovejoy
Assistant Attorney General
Santa Fe, NM

Perry K. Lovell
Boise, ID

Scott Ludwig
Oak Ridge National Laboratory
Oak Ridge, TN

Mark Lusk
Waste Policy Institute
Idaho Falls, ID

Peter Luthiger
Grants, NM

Beverly L. Lyne
Rocky Flats Citizens Advisory Board
Westminster, CO

Lee Lysne
Executive Director
Concerned Citizens for Nuclear Safety
Santa Fe, NM

Fenggang Ma
Washington State
Kennewick, WA

Michael MacMullen
U.S. Environmental Protection Agency, Region 5
Chicago, IL

Patricia Madueno
Chairperson
Fort Mojave Indian Tribe
Needles, CA

Donovan Mager
Carlsbad, NM

James E. Maher
Director
Mississippi Emergency Management Agency
Jackson, MS

Steve Maheras
Columbus, OH

Richard Malcolm
Ruidoso, NM

Lawry Mann
Vice Chairman
Los Alamos County Council
Los Alamos, NM

Bart Marcy
Westinghouse Savannah River
Aiken, SC

Maribel Marin
Los Angeles Office
Natural Resources Defense Council Inc.
Los Angeles, CA

Sue Marit
Sierra Club
Denver, CO

James E. Markham
Boulder, CO

Ann Marshall
Seatac
Carlsbad, NM

Dr. Terry Marshall
Carlsbad, NM

Tom Marshall
Chair
Rocky Flats Citizens Advisory Board
Denver, CO

Kathy Martin
U.S. Department of Energy
Washington, DC

Theo Martin
U.S. Department of Energy
Richland, WA

Timothy Martinez
San Ildefonso Pueblo
Santa Fe, NM

Valerie Martinez
Albuquerque, NM

Honorable Robert T. Matsui
Representative of California
U.S. House of Representatives
Washington, DC

Joel Maxwell
Tri-State Transportation
Joplin, MO

Roger Mayer
LATA
Idaho Falls, ID

Cheryl Maynard
Associate
Governmental Dynamics, Inc.
Arlington, VA

Pat McCasland
New Mexico Environment Department
Carlsbad, NM

Gary McCaslin
District Manager
District IV
New Mexico Environment Department
Roswell, NM

Dr. Mildred McClain
President
Citizens for Environmental Justice
Savannah, GA

Scott McComb
Andersonville, TN

Jim McGuire
Carlsbad, NM

Dale McHard
Environmental Health Consultant
Department of Environmental Quality
Oklahoma City, OK

Honorable Scott McInnis
Representative of Colorado
U.S. House of Representatives
Washington, DC

Keith E. McKamey
DOE Oversight Bureau
New Mexico Environment Department
Carlsbad, NM

Nancy McKinnie
Lakewood, CO

Don McReynolds
Lubbock, TX

Bob Meccia
Foster Wheeler Environmental
Oak Ridge, TN

Timothy A. Melberg
Division Director
Safety and Health Division
U.S. Department of Energy
Golden, CO

Greg Mello
Los Alamos Study Group
Santa Fe, NM

Om Mendicatta
West Valley, NY

Jack Mento
Greenpeace
Boulder, CO

Samaya K. Meraine
Boulder, CO

Ann Mesnikoff
Associate Representative
Global Warming and Energy Programs
Sierra Club
Washington, DC

Kathy Middleton
Idaho Falls, ID

Honorable George Miller
Representative of California
U.S. House of Representatives
Washington, DC

George L. Miller
Appleton, MN

Honorable Robert J. Miller
Governor of Nevada
State of Nevada
Executive Chambers
Carson City, NV

George Minot
Hilton Head Island, SC

Dave Mitchell
Belen, NM

Alfreda Mitre
Chairperson
Las Vegas Tribal Council
Las Vegas, NV

Camille Mittelholtz
U.S. Department of Transportation
Washington, DC

Steve Moeller
Nebraska Governor's Policy Office
Lincoln, NE

Stephanie Montano
Benchmark Environmental
Albuquerque, NM

Juan Montes
Rural Alliance for Military Accountability
Questa, NM

James Montoya
Albuquerque, NM

Amy Moon
Laramie, WY

Betty Moore
Livermore, CA

Ken Moore
Idaho Falls, ID

LeRoy Moore
Rocky Mountain Peace Center
Boulder, CO

Rick Moore
Consultant
State of Wyoming
Cheyenne, WY

Susan Moore
Radiological HazMat Officer
Office of Emergency Management
Carson City, NV

Chuck Moran
Yates Petroleum Corporation
Artesia, NM

David Moran
Dept. of Environment and Conservation
State of Tennessee
Nashville, TN

Thomas A. Morgan
Los Alamos, NM

Kevin J. Morris
Wild Oats Market
Boulder, CO

Honorable Carol Moseley-Braun
Senator of Illinois
United States Senate
Washington, DC

Gerry Motl
Science Applications International Corp.
Cincinnati, OH

Heinz Mueller
U.S. Environmental Protection Agency,
Region 4
Atlanta, GA

Roger Mulder
Director, Pantex
State Energy Conservation Office
Austin, TX

Harriet Mulvany
Arvada, CO

Linda Murakami
Rocky Flats Citizens Advisory Board
Denver, CO

Honorable Patty Murray
Senator of Washington
United States Senate
Washington, DC

Stephanie Myers
Jason and Associates
Idaho Falls, ID

Joe Nagel
Boise, ID

Honorable Gerald Nailor
Governor
Pueblo of Picuris
Penasco, NM

Aurelia Najar
Coordinator
New Mexico Alliance
Albuquerque, NM

John Nash
Falls Church, VA

Karen Navarro
Albuquerque, NM

Jeff C. Neal
General Manager
Best Western Stevens Inn
Carlsbad, NM

Robert H. Neill
Director
Environmental Evaluation Group
Albuquerque, NM

Honorable E. Benjamin Nelson
Governor of Nebraska
Lincoln, NE

Joe Nelson
Golden, CO 80401

Ken Nemith
Executive Director
Southern States Energy Board
Norcross, GA

Steve Nesta
Broomfield, CO

Richard E. Nicholson
Boulder, CO

Rick Nielsen
Director
Citizen Alert
Las Vegas, NV

Honorable Ben Nighthorse-Campbell
Senator of Colorado
United States Senate
Washington, DC

Ken Niles
Oregon Department of Energy
Salem, OR

Steve Nisley
TDEC - DOE Oversight Division
Oak Ridge, TN

Suzanne Noga
Santa Fe, NM

Nils Nokkentved
Times News
Twin Falls, ID

Bill Noll
Director
Solid Waste Division
U.S. Department of Energy
Savannah River Field Office
Aiken, SC

Douglas Novak
Coulmbia, SC

Honorable Larry Nuckolls
Governor
Absentee Shawnee Executive Committee
Shawnee, OK

Jack M. Nugent, Jr.
Vice President
Advocacy Group
Washington, DC

Walter Odening
San Diego, CA

Susan Offerdahl
U.S. Environmental Protection Agency
Washington, DC

Becky O'Guin
Colorado Daily Newspaper
Boulder, CO

Colleen T. O'Laughlin
U.S. Department of Energy
Las Vegas, NV

Tim O'Neil
Managing Editor
Mining Engineering Magazine
Littleton, CO

Kathryn E. Olmsted
Boulder, CO

R.G. Olsen
Arvada, CO

Collin K. Olson
Boulder, CO

Dale A. Ormond
General Engineer
U.S. Department of Energy
Aiken, SC

Richard Orthen
Brown and Root Environmental
Aiken, SC

Thomas W. Orticiger
Director
Illinois Department of Nuclear Safety
Springfield, IL

Honorable Bill Orton
Representative of Utah
U.S. House of Representatives
Washington, DC

Paul Ortstadt
Knoxville, TN

Dan Osetek
Manager
Risk and Safety Engineering
Los Alamos Technical Associates
Albuquerque, NM

Connie Ostrove
Bureau of Radiation Protection
Ohio Department of Health
Columbus, OH

John Otter
Santa Fe, NM

Tammy Ottmer
WIPP Coordinator
Emergency Management Program
Colorado Dept. of Public Health and Environment
Denver, CO

Lt. Gail Otto
Washington State Patrol
General Administration Building
Olympia, WA

Robert E. Owen
Manager, Technical Services
Bureau of Radiation Protection
Ohio Department of Health
Columbus, OH

Christopher Paine
Washington Office
Natural Resources Defense Council
Washington, DC

Gary Palmer
U.S. Department of Energy
Headquarters
Washington, DC

Jimmy Palmer
Executive Director
Mississippi Department of Environmental Quality
Jackson, MS

Carl J. Paperiello
Director
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC

Karen Papouchado
Aiken City Council
Aiken, SC

Doug Parker
Arvada, CO

John Parker
New Mexico Environment Department
Santa Fe, NM

Rick Parkin
U.S. Environmental Protection Agency, Region 10
Seattle, WA

Honorable Don Parsons
Mayor
City of Northglenn
Northglenn, CO

Janice Parthree
Richland, WA

Jeffrey Pecka
Englewood, CO

Gaffney F. Peglar
Boulder, CO

Lucy B. Peglar
Boulder, CO

Honorable Nancy Pelosi
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Gary Perkowski
Mayor
City of Carlsbad
Carlsbad, NM

Walter N. Perry
Community Relations Manager
Public Affairs Office
U.S. Department of Energy
Oak Ridge Operations
Oak Ridge, TN

Allison Peters
Director
Office of Environmental Affairs
City of Boulder
Boulder, CO

Franklin G. Peters
Acting Associate Deputy Secretary for Field Management
U.S. Department of Energy
Headquarters
Washington, DC

Jeff Petraglia
Manassas, VA

John Petring
Ogden Environmental Services
Fairfax, VA

Buddy Petsonk
KBIM Radio
Roswell, NM

Patricia Phillips
U.S. Department of Energy
Oak Ridge, TN

Susan Pickering
Sandia National Laboratories
Carlsbad, NM

K. Pillay
Los Alamos National Laboratory
Los Alamos, NM

Sam Pillay
Los Alamos National Laboratory
Los Alamos, NM

Lee Plansky
INEEL
Idaho Falls, ID

Lois Pohl
Office of Administration
Division of General Services
Missouri Federal Assistance Clearinghouse
Jefferson City, MO

Gerald Pollet
Heart of America Northwest
Seattle, WA

Honorable Richard W. Pombo
Representative of California
U.S. House of Representatives
Washington, DC

Tammy Pomeroy
ES&H
Rocky Flats
Golden, CO

David Pope
PAI Corp/JEG
Oak Ridge, TN

Richard Powell
Olean, NY

Dana Prince
Denver, CO

Larry Radcliffe
Director
Waste Management & Technology
Development Division
U.S. Department of Energy
Oak Ridge, TN

Jean Ramirez
Jacksboro, TN

Tom Rauch
American Friends Service Committee
Denver, CO

Andre V. Reaume
Boulder, CO

Deborah Reed
Santa Fe, NM

Merilyn Reeves
Amity, OR

Honorable Harry Reid
Senator of Nevada
United States Senate
Washington, DC

Norbert Rempe
Carlsbad, NM

Lilly Rendt
Albuquerque, NM

Nick Rexroth
Las Cruces, NM

David C. Rich
Captain
Idaho State Police
Meridian, ID

Betty Richards
Carlsbad, NM

Honorable Bill Richardson
Representative of New Mexico
U.S. House of Representatives
Washington, DC

John Richards
U.S. Environmental Protection Agency,
Region 4
Atlanta, GA

Steve Richardson
Tri-State Motor Transit Co.
Joplin, MO

Peter Rickards
INEEL
Twin Falls, ID

Honorable Thomas J. Ridge
Governor of Pennsylvania
State of Pennsylvania
Harrisburg, PA

Honorable Frank Riggs
Representative of California
U.S. House of Representatives
Washington, DC

Gary Riner
U.S. Department of Energy
Oak Ridge, TN

Barbara Ritchie
NEPA Coordinator
Environmental Review Section
Washington State Department of Ecology
Olympia, WA

Terry Rivasplata
State Clearing House
Governor's Office of Planning and Research
Sacramento, CA

Mike Rivera
Boulder, CO

Pete Ro
Office of Congressman George Miller
Washington, DC

John Roach
Los Alamos Technical Associates
Albuquerque, NM

Jeff Robbins
EPD, NEPA Compliance Officer
U.S. Department of Energy
Albuquerque Operations Office
Albuquerque, NM

Jack Robinson
Snohomish, WA

Mac Roddye
Project Manager
Waste Management
U.S. Department of Energy
Knoxville, TN

Terri Rodefer
Department of Administration
Nevada State Clearinghouse
Carson City, NV

Charlie Rodman
Delaware, OH

Ann Roe
WSRC
Savannah River Site
Aiken, SC

Dan Roe
Arizona DEM
Phoenix, AZ

Janna Rolland
Physicians for Social Responsibility
Albuquerque, NM

Gene Rollins
Aiken, SC

Honorable Roy Romer
Governor of Colorado
State of Colorado
Denver, CO

Ronald Ross
Program Manager
Western Governors' Association
Denver, CO

Rob Rothman
Team Leader
Waste Management
U.S. Department of Energy
Miamisburg, OH

Della Martin Roy
Professor
Materials Research Laboratory
Pennsylvania State University
University Park, PA

Paula Rozzi
Stone & Webster Engineering
Washington, DC

Honorable Steve Ruddick
Senator
State of Colorado - District 2
Aurora, CO

Amy Russell
Research Assistant
NMSU WERC Student
Las Cruces, NM

Duane Ryan
Broadcast Director
KENW-FM/TV
ENMU
Portales, NM

W. R. Ryhne
Oak Ridge, TN

Honorable Earl Salazar
Governor
Pueblo of San Juan
San Juan Pueblo, NM

Jennifer A. Salisbury
Secretary
New Mexico Energy, Minerals and
Natural Resources Department
Santa Fe, NM

Donald Sampson
Chairman
Umatilla Board of Trustees
The Confederated Tribes of the Umatilla
Indian Reservation
Pendleton, OR

Mary Ellen Sampson
Division of the Budget
New York State Clearinghouse
Albany, NY

Honorable Mark Sanford
Representative
U.S. House of Representatives
Washington, DC

Marvin P. Sarracino
Reclamation Project Technician I
Pueblo of Laguna
Laguna, NM

Marvin Sassacina
Laguna, NM

Lisa Sattler
Midwestern Office
Council of State Governments
Lombard, IL

Honorable Daniel Schaefer
Representative of Colorado
U.S. House of Representatives
Washington, DC

Marcia Schafer
Arvada, CO

William Schaefer
Nampa, ID

Jerome A. Schalz
Boulder, CO

Walt Schattinger
CAST
Denver, CO

Honorable Paul D. Schauer
Representative
State of Colorado - District 39
Littleton, CO

Velma Schear
Englewood, OH

Honorable Steven H. Schiff
Representative of New Mexico
U.S. House of Representatives
Washington, DC

Bob Schlegel
SAIC
Germantown, MD

Frank Schmaltz
Environmental Engineer
DOE-MB
Miamisburg Area Office
Miamisburg, OH

Jeff Schrade
Senior Special Assistant
U.S. Department of Energy Affairs
Office of the Governor
Boise, ID

George Schroeder
Albuquerque, NM

Cathy Schuster
Colorado Peace Council
Westminster, CO

Gregg Sckscienski
Albuquerque, NM

Glenn Scott
Westminster, CO

Kathy Scott
Librarian
NUS Corporation
Clearwater, FL

Steve Semken
Navajo Community College
Shiprock, NM

Dan Shain
Ashburn, VA

T.C. Shapard
USTB
New Mexico Environment Department
Roswell, NM

Al Shapolia
Santa Fe, NM

Randy Sharron
Maintenance Supervisor
Las Vegas, NV

Christine Shaver
Senior Attorney
Rocky Mountain Office
Environmental Defense Fund, Inc.
Boulder, CO

Deb Shaw
Rocky Flats Program
Colorado Department of Public Safety
Denver, CO

Zach Shelley
Germantown, MD

Jay Shelton
Santa Fe Prep School
Santa Fe, NM

Herman Shorty
Director
Navajo Nation
Window Rock, AZ

Honorable Ronald D. Shutiva
Governor
Acoma Pueblo
Acomita, NM

Fred Sica
President/CEO
Chamber of Commerce
Idaho Falls, ID

Jason Simmons
Keyser, WV

Honorable Paul Simon
Senator of Illinois
United States Senate
Washington, DC

Kathleen Sisneros
Sisneros-Cooper Environmental Corp.
Santa Fe, NM

Honorable David E. Skaggs
Representative of Colorado
U.S. House of Representatives
Washington, DC

Honorable Joe Skeen
Representative of New Mexico
U.S. House of Representatives
Washington, DC

Charles Slade
Vancouver BC Canada,

Susan Smillie
Labat-Anderson Inc.
McLean, VA

Ellen Smith
ORNL
Oak Ridge, TN

Karl D. Smith
Arvada, CO

Reuel Smith
Idaho Falls, ID

Honorable Robert C. Smith
United States Senate
Washington, DC

Jim Snyder
U.S. Department of Energy
Albuquerque, NM

Cheryl Sobert
Energy Community Alliance
Arlington, VA

Chad C. Soliz
Thornton, CO

Honorable Floyd Spence
Representative of South Carolina
U.S. House of Representatives
Washington, DC

Bob Spooner
MCT Industries Inc
Albuquerque, NM

Alan Stahler
KVM Radio
Nevada City, CA

Debbie Stalsic
KBCI-TV
Boise, ID

Honorable Fortney H. (Pete) Stark
Representative of California
U.S. House of Representatives
Washington, DC

Wayne Starke
Oak Ridge, TN

Nick Stas
Billings, MT

Ralph Stein
Golden Federal Services
Tucson, AZ

Lynne Stembridge
Hanford Education Action League
Spokane, WA

Ronald Stewart
Boulder County
Boulder, CO

Jim Stone
Technical Advisor
Rocky Flats Cleanup Commission
Lakewood, CO

John P. Stone
County Commissioner
Jefferson County
Golden, CO

Hank Stovall
Mayor Pro-Tem
City of Broomfield
Broomfield, CO

Gilbert Suazo
Tribal Relations
Pueblo of Taos
Los Alamos National Lab
Los Alamos, NM

Honorable Don Sundquist
Governor of Tennessee
State of Tennessee
Nashville, TN

Rich Swedberg
Office of Motor Carriers
U.S. Department of Transportation
Lakewood, CO

Honorable Fife Symington
Governor of Arizona
State of Arizona
Phoenix, AZ

Steve Tarlton
Rocky Flats Department
Colorado Department of Public Health & Environment
Denver, CO

Paul Tarrant
Oak Ridge, TN

Mike Taugher
Environment Reporter
Albuquerque Journal
Albuquerque, NM

Angela Taylor
National Academy of Sciences
Washington, DC

Ellen Taylor
Lawrence Livermore National Laboratory
Germantown, MD

Kathleen Taylor
Golden, CO

Steven Taylor
Lake City, TN

Willie R. Taylor
Office of Environmental Policy and Compliance
U.S. Department of the Interior
Washington, DC

Joe Teal
West Richland, WA

Charlotte Textor
Battelle
Oak Ridge, TN

Andrew Thibadeau
Supervisory Information Management Specialist
Reading Room
Defense Nuclear Facilities Safety Board
Washington, DC

John A. Thies
Informatics Corporation
Albuquerque, NM

Robert J. Thomas
Boulder, CO

John Thomas
U.S. Nuclear Regulatory Commission
Washington, DC

Honorable Fred D. Thompson
Senator of Tennessee
United States Senate
Washington, DC

Julie Thompson
Sen. Jeff Bingaman's Office
Roswell, NM

Reginald Thorpe
Department of Public Safety
The Shoshone-Bannock Tribe
Fort Hall, ID

Sandra Threatt
Manager, Nuclear Emergency Planning
Bureau of Solid and Hazardous Waste
Department of Health and Environmental Control
Columbia, SC

Honorable J. Strom Thurmond
Senator of South Carolina
United States Senate
Washington, DC

Keith Tinno
Chairman
The Shoshone-Bannock Tribes of the Fort Hall Reservation
Fort Hall, ID

David Tomsovic
U.S. Environmental Protection Agency, Region 9
San Francisco, CA

Honorable Elmer Torres
Governor
Pueblo of San Ildefonso
Santa Fe, NM 87501

Dean Triebal
Los Alamos, NM

Allen Tsao
Oak Ridge, TN

Honorable Shirleen Tucker
Representative
State of Colorado - District 2
Denver, CO

Doug W. Turner
Oak Ridge National Laboratory
Oak Ridge, TN

Kyle Turner
McCallum-Turner
Evergreen, CO

Roger Twitchell
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, ID

Reginal Tyler
RFETS
Golden, CO

Elgan Usrey
Assistant Director
Tennessee Emergency Management Agency
Nashville, TN

David Ussery
MEVATECH Corp.
White Sands Missile Range, NM

Raymond L. VanVleet
County Sheriff
County of Caribou
Soda Springs, ID

Peter Van Wyck
Vancouver, BC

William L. Vasconi
Las Vegas, NV

Howard Vasquez
WID-Santa Fe
Santa Fe, NM

Bruce Verhaaren
Argonne National Laboratory
Woodridge, IL

Honorable Jacob Viarrial
Governor
Pueblo of Pojoaque
Santa Fe, NM

Michelle Vicars
Pajarito Scientific Co.
Los Alamos, NM

Honorable Frederick Vigil
Governor
Pueblo of Tesuque
Santa Fe, NM

Oba L. Vincent
Associate Director
Office of Environmental Management
U.S. Department of Energy
Miamisburg, OH

Doug Vogt
Jason Technologies Corporation
Las Vegas, NV

Honorable George V. Voinovich
Governor of Ohio
State of Ohio
Columbus, OH

Dr. John A. Volpe
Manager
Radiation Control Branch
Division of Community Safety
Frankfort, KY

Joseph Vozella
Assistant Area Manager, Environment &
Pr
U.S. Department of Energy
Los Alamos, NM

Melvin Vuk
Carlsbad, NM

Marty Wade
Snake River Alliance
Pocatello, ID

David A. Waite
CH2 M Hill
Bellevue, WA

Randy Wald
KTVB-TV
Boise, ID

John Walker
Nevada Agency for Nuclear Projects
Capitol Complex
Carson City, NV

Toni Walker Chiri
Current Argus
Carlsbad, NM

A. Brian Wallace
President
Nevada Indian Environmental Coalition
Reno, NV

Mark Wallace
Fire Chief
Emergency Preparedness Coordinator
City of Golden
Golden, CO 80401

Barbara Walton
Oak Ridge, TN

Rafaela Ware
Gram, Inc.
Los Alamos, NM

Honorable John W. Warner
United States Senate
Washington, DC

Sharon Warren-Briggs
Carlsbad, NM

Jamie Warrick
Taylor University OH243
Upland, IN

Wendell Weart
Sandia National Laboratories/BDM
Albuquerque, NM

Robert Weiberg
UNM General Library
Albuquerque, NM

Mark E. Weidler
Secretary
New Mexico Environment Department
Santa Fe, NM

Duane Weigel
U.S. General Accounting Office
Washington, DC

Jenny Weil
Editor
Exchange Monitor Publications
Washington, DC

Peter Weiss
Valley Times
Pleasanton, CA

Honorable Paul Weissmann
Senator
State of Colorado
Louisville, CO

Deborah Welles
Denver, CO

Jerry Wells
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, ID

Chris Wentz
Coordinator
New Mexico Radioactive Waste Task Force
Santa Fe, NM

Bill Weston
Westinghouse
Carlsbad, NM

Kirk Whatley
Director
Division of Radiation Control
Alabama Department of Health
Montgomery, AL

Chris G. Whipple
ICF Kaiser Engineers
Environment Group, 7th Floor
Oakland, CA

Kathleen Whitaker
DOE-Idaho-P.A.
Idaho Falls, ID

Charlie White
Idaho Falls, ID

Dan K. Wiencek
Colorado Springs, CO

Debbie Wilcox
Las Vegas, NV

Honorable Gayle Wilde
Representative
State of Idaho
McCall, ID

Diane Willett
Chamber of Commerce
Golden, CO

Carol Williams
Beverly, MA

Curtis Williams
Emergency Response
Mescalero Apache Tribe
Mescalero, NM

James R. Williams
Chief of Staff
Ohio Emergency Management Agency
Columbus, OH

Jim Williams
Planning Information Corporation
Denver, CO

Honorable Pete Wilson
Governor of California
State of California
Sacramento, CA

Dr. Suzanne Winters
State Science Advisor
State of Utah
Salt Lake City, UT

Lavonne Wise
Golden, CO 80401

Elizabeth Withers
U.S. Department of Energy
Los Alamos, NM

Kara Wittstock
Colorado State University
Ft. Collins, CO

Buffi Wolfe
Golden, CO

Maggie Wood
Parsons Brinckerhoff
Denver, CO

Randolph Wood
Director
Nebraska Department of Environmental Quality
Lincoln, NE

Honorable Lynn C. Woolsey
Representative of California
U.S. House of Representatives
Washington, DC

Carolyn Wright
Governor's Office of Planning and Budget
Salt Lake City, UT

Suzanne Wshe
CAST
Denver, CO

Bill Wyatt
San Ildefonso Pueblo
Santa Fe, NM

Doug Young
Governor's Office of Policy
Denver, CO

Karen Young
Carlsbad Environmental Monitoring and Research Center
Carlsbad, NM

Steve Zappe
Hazardous and Radioactive Materials Bureau
New Mexico Environment Department
Santa Fe, NM

Ken Zahn
Livermore, CA

Carl W. Zeh
North Augusta, SC

Abe Zeitoun
Science Applications International Corporation
Germantown, MD

Barbara Ziegler
Western Mineral Corporation
Golden, CO

John J. Zodrow
Zodrow et al. P.C.
Denver, CO

Thomas A. Zordan
Jordan Associates, Inc.
Murrysville, PA

Eric M. Zsebenyi
Naropa Institute
Boulder, CO

L.2 SUMMARY

City of Laramie
Laramie, WY

Shoshone-Bannock Tribes
Fort Hall, ID

Susie Ackerman
City of Northglenn
Northglenn, CO

Diane Albert
Los Alamos, NM

James Alders
Northern States Power Company
Minneapolis, MN

Manuel Alvarado
Cleveland, NM

Sandy Anderson
Nuclear Fuel Services Inc.
Richland , WA

Eddie Anico-Garcia
Kickapoo Tribe of Oklahoma
McLoud, OK

Honorable Bill Anoatubby
Governor
The Chickasaw Nation
Ada, OK

Honorable Bill Archer
Representative of Texas
U.S. House of Representatives
Washington, DC

Joni Arends
South Royalton, VT

Honorable Dick Armey
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable John D. Ashcroft
Senator of Missouri
United States Senate
Washington, DC

Tim Augustine
Gibsonia, PA

Paula Austin
SAIC
Gaithersburg, MD

Honorable Richard Baker
Representative of Louisiana
U.S. House of Representatives
Washington, DC

John Ballard
Administrator
Modoc Tribe of Oklahoma
Miami, OK

Honorable Bob Barr
Representative of Georgia
U.S. House of Representatives
Washington, DC

John A. Barrett
Chairman
Citizen Band Potawatomi Business
Committee
Shawnee, OK

Honorable Joe Barton
Representative of Texas
U.S. House of Representatives
Washington, DC

Jim Bartosch
Albuquerque, NM

Sheryle Bass
Director
Eight Tribes Inter-Tribal Council
Miami, OK

Leaford Bearskin
Chief
Wyandotte Tribe of Oklahoma
Wyandotte, OK

R. Perry Beaver
Principal Chief
Muscogee Creek Nation of Oklahoma
Okmulgee, OK

Honorable Xavier Becerra
Representative of California
U.S. House of Representatives
Washington, DC

Kristi Beguin
Los Alamos, NM

Honorable Anthony C. Beilenson
Representative of California
U.S. House of Representatives
Washington, DC

Mavis Belisle
Panhandle, TX

Nancy Bennett
DOE FOIA Reading Room
Albuquerque, NM

Honorable Robert F. Bennett
Senator of Utah
United States Senate
Washington, DC

Honorable Ken Bentsen
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Howard L. Berman
Representative of California
U.S. House of Representatives
Washington, DC

Ron Bhada
Director
Waste-management Education and
Research Consortium
Las Cruces, NM

Honorable Brian P. Bilbray
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Sanford D. Bishop
Representative of Georgia
U.S. House of Representatives
Washington, DC

Honorable John A. Boehner
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Christopher Bond
Senator of Missouri
United States Senate
Washington, DC

Honorable Henry Bonilla
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Sonny Bono
Representative of California
U.S. House of Representatives
Washington, DC

Dr. Bobby BraBoy
Lumbee Tribe
Pembroke, NC

Honorable John B. Breaux
Senator of Louisiana
United States Senate
Washington, DC

Honorable George E. Brown
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Sherrod Brown
Representative of Ohio
U.S. House of Representatives
Washington, DC

Richard Brusuelas
Director
Bernalillo County Environmental Health Department
Albuquerque, NM

Honorable Ed Bryant
Representative of Tennessee
U.S. House of Representatives
Washington, DC

Honorable John Bryant
Representative of Texas
U.S. House of Representatives
Washington, DC

Captain Bruce Bugg
Hazardous Materials Specialist
Georgia Public Service Commission
Hapeville, GA

Honorable Dale Bumpers
Senator of Arkansas
United States Senate
Washington, DC

Honorable Jim Bunn
Representative of Oregon
U.S. House of Representatives
Washington, DC

Grace Bunner
Mekko Chief
Thlopthlocco Tribal Town
Okemah, OK

Frank Burchardt
Carlsbad, NM

Honorable Dan Burton
Representative of Indiana
U.S. House of Representatives
Washington, DC

Honorable Steve Buyer
Representative of Indiana
U.S. House of Representatives
Washington, DC

Joe Byrd
Principal Chief
Cherokee Nation of Oklahoma
Tahlequah, OK

Honorable Sonny Callahan
Representative of Alabama
U.S. House of Representatives
Washington, DC

Honorable Ken Calvert
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Tom Campbell
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Nelis S. Captain
Chief
Eastern Shawnee Tribe of Oklahoma
Seneca, MO

Honorable Steve Chabot
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Saxby Chambliss
Representative of Georgia
U.S. House of Representatives
Washington, DC

Greg Champlin
Denver, CO

Honorable Jim Chapman
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable William Clay
Representative of Missouri
U.S. House of Representatives
Washington, DC

Honorable Bob Clement
Representative of Tennessee
U.S. House of Representatives
Washington, DC

Honorable William Clyburn
Representative
State of South Carolina
Washington, DC

Honorable Dan Coats
Senator of Indiana
United States Senate
Washington, DC20510-1403

Honorable Thad Cochran
Senator of Mississippi
United States Senate
Washington, DC

Honorable Ronald D. Coleman
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Larry Combest
Representative of Texas
U.S. House of Representatives
Washington, DC

Barbara Conroy
Santa Fe, NM

Jose Conto
Washington, DC

Honorable Wes Cooley
Representative of Oregon
U.S. House of Representatives
Washington, DC

Erica Cooper
Gram Inc.
Los Alamos, NM

Benjamin Corbett
Boulder, CO

Honorable Jerry F. Costello
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Paul Coverdell
Senator of Georgia
United States Senate
Washington, DC

Jill Cowley
Santa Fe, NM

Honorable Chris Cox
Representative of California
U.S. House of Representatives
Washington, DC

Grady Cox
Kennewick, WA

Honorable Bud Cramer
Representative of Alabama
U.S. House of Representatives
Washington, DC

Honorable Philip M. Crane
Representative of Illinois
U.S. House of Representatives
Washington, DC

Carol Crawford
Nuclear Waste Management Library
Albuquerque, NM

Honorable Frank Cremeans
Representative of Ohio
U.S. House of Representatives
Washington, DC

W.T. Crenshaw
Southwestern Public Service Company
Amarillo, TX

Honorable Randy Cunningham
Representative of California
U.S. House of Representatives
Washington, DC

Ed Dallago
Energy and Environment
Idaho Falls, ID

Honorable Pat Danner
Representative of Missouri
U.S. House of Representatives
Washington, DC

Louise Dano
NM Tech Library
Socorro, NM

Ellen Daugherty
Lockheed Martin-Idaho
Idaho Falls, ID

Charles Dawes
Chief
Ottawa Tribe of Oklahoma
Miami, OK

Honorable E. (Kika) de la Garza
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Nathan Deal
Representative of Georgia
U.S. House of Representatives
Washington, DC

Honorable Peter A. DeFazio
Representative of Oregon
U.S. House of Representatives
Washington, DC

Honorable Tom Delay
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Ronald V. Dellums
Representative of California
U.S. House of Representatives
Washington, DC

Lata Desai
WIPP Site Library
Carlsbad, NM

Honorable Michael DeWine
Senator of Ohio
United States Senate
Washington, DC

Russell DiBartolo
Clark County Nuclear Waste Division
Las Vegas, NV

Honorable Jay W. Dickey
Representative of Arkansas
U.S. House of Representatives
Washington, DC

Honorable Norman D. Dicks
Representative of Washington
U.S. House of Representatives
Washington, DC

Honorable Lloyd Doggett
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Calvin Dooley
Representative of California
U.S. House of Representatives
Washington, DC

Honorable John T. Doolittle
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Robert K. Dornan
Representative of California
U.S. House of Representatives
Washington, DC

Honorable David Dreier
Representative of California
U.S. House of Representatives
Washington, DC

Sid Dumont
Oak Ridge, TN

Honorable John J. Duncan
Representative of Tennessee
U.S. House of Representatives
Washington, DC

Honorable Jennifer Dunn
Representative of Washington
U.S. House of Representatives
Washington, DC

Honorable Richard Durbin
Representative of Illinois
U.S. House of Representatives
Washington, DC

Joel Eacker
Lakewood, CO

Brian Eddlemon
Environmental Coordinator
Citizen Potawatomi Nation
Shawnee, OK

Honorable Chet Edwards
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Anna G. Eshoo
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Lane Evans
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable R. Terry Everett
Representative of Alabama
U.S. House of Representatives
Washington, DC

Honorable Thomas Ewing
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Sam Farr
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Harris W. Fawell
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Vic Fazio
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Cleo Fields
U.S. House of Representatives
Washington, DC

Honorable Jack Fields
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Bob Filner
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Michael Patrick Flanagan
Representative of Illinois
U.S. House of Representatives
Washington, DC

Bonney Fogdall
Las Vegas, NV

Honorable Bill G. Follis
Chief
Modoc Tribe of Oklahoma
Miami, OK

Honorable Kirk Fordice
Governor of Mississippi
State of Mississippi
Jackson, MS

Jane Foreman
Kennewick, WA

Honorable Martin Frost
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Elizabeth Furse
Representative of Oregon
U.S. House of Representatives
Washington, DC

Honorable Elton Gallegly
Representative of California
U.S. House of Representatives
Washington, DC

Sandra Garber
Aiken, SC

Honorable Richard A. Gephardt
Representative of Missouri
U.S. House of Representatives
Washington, DC

Donald E. Giles
Chief
Peoria Indian Tribe of Oklahoma
Miami, OK

Honorable Paul E. Gillmor
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Newt Gingrich
Representative of Georgia
U.S. House of Representatives
Washington, DC

Honorable John Glenn
Senator of Ohio
United States Senate
Washington, DC

Mike Glora
SAIC
Albuquerque, NM

Grace Goodeagle
Chairman
Quapaw Tribal Business Committee
Quapaw, OK

Honorable Lindsey Graham
Representative of South Carolina
U.S. House of Representatives
Washington, DC

Honorable Gene Green
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Luis V. Gutierrez
Representative of Illinois
U.S. House of Representatives
Washington, DC

Bob Guzowski
SAIC
Albuquerque, NM

Blaine Hadden
Mobile Characterization Services
Los Alamos, NM

April Hall
H&R Technical Associates, Inc.
Oak Ridge, TN

Honorable Ralph Hall
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Lee H. Hamilton
Representative of Indiana
U.S. House of Representatives
Washington, DC

W.L.Hampson
Boise, ID

Honorable Mel Hancock
Representative of Missouri
U.S. House of Representatives
Washington, DC

Rick Hardy
Morrison Knutson Inc.
Boise, ID

Honorable Jane Harman
Representative of California
U.S. House of Representatives
Washington, DC

Honorable J. Dennis Hastert
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Richard Hastings
Representative of Washington
U.S. House of Representatives
Washington, DC

Lightfoot Hawkins
Chairman
Cheyenne-Arapaho Business Council
Concho, OK

Honorable Howell T. Heflin
Senator of Alabama
United States Senate
Washington, DC

Richard Heiderstadt
Environmentac Co.
Charlottesville, VA

Kathy Helms
Nashville, TN

Mike Henderson
TransCore – JHK
Albuquerque, NM

Honorable Wally Herger
Representative of California
U.S. House of Representatives
Washington, DC

Steve Herman
SAHCI, Inc.
New Lenox, IL

Hobby Hevewah
Ft. Hall, ID

Elissa Higgins
Albuquerque, NM

Honorable Van Hilleary
Representative of Tennessee
U.S. House of Representatives
Washington, DC

Honorable Earl Hilliard
Representative of Alabama
U.S. House of Representatives
Washington, DC

Honorable David L. Hobson
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Martin R. Hoke
Representative of Ohio
U.S. House of Representatives
Washington, DC

Richard Holder
Jason Technologies
Las Vegas, NM

Patricia Holloway
County Commissioner
Jefferson County
Golden, CO

Honorable Steve Horn
Representative of California
U.S. House of Representatives
Washington, DC

Honorable John Hostettler
Representative of Indiana
U.S. House of Representatives
Washington, DC

Paul Hoversten
Reporter
USA Today
Arlington, VA

Honorable Duncan L. Hunter
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Tim Hutchinson
Representative of Arkansas
U.S. House of Representatives
Washington, DC

Honorable Sheila Jackson-Lee
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable William J. Jefferson
Representative of Louisiana
U.S. House of Representatives
Washington, DC

Kai Olof Jakobsson
02940 ESPOO Finland

Bob Jenson
Pendleton, OR

Honorable Eddie Bernice Johnson
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Sam Johnson
Representative of Texas
U.S. House of Representatives
Washington, DC

Paulette Johnston
NM Attorney General's Office
Santa Fe, NM

Mike Jolley
Pocatello, ID

Honorable Marcy Kaptur
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable John R. Kasich
Representative of Ohio
U.S. House of Representatives
Washington, DC

Stan Ketchum
Office of Environmental Health
Hugo, OK

Honorable Jay C. Kim
Representative of California
U.S. House of Representatives
Washington, DC

M.C. Kirkland
Aiken, SC

Honorable Jim Kolbe
Representative of Arizona
U.S. House of Representatives
Washington, DC

Stan Kosiewicz
LANL
Los Alamos, NM

Betsy Kraus
EEG
Albuquerque, NM

Charles Krick
Blairseville, GA

Gene Krupp
Golden, CO

Honorable Jon L. Kyl
Senator of Arizona
United States Senate
Washington, DC

Honorable Ray LaHood
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Tom Lantos
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Steven C. LaTourette
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Greg Laughlin
Representative of Texas
U.S. House of Representatives
Washington, DC

Lisa Ledwidge
Physicians for Social Responsibility
Washington, DC

Mike Lee
U. S. Nuclear Regulatory Commission
Rockville, MD

Honorable Floyd Leonard
Chief
Miami Tribe of Oklahoma
Miami, OK

Honorable Jerry Lewis
Representative of California
U.S. House of Representatives
Washington, DC

Honorable John Lewis
Representative of Georgia
U.S. House of Representatives
Washington, DC

Marvin Lewis
Philadelphia, PA

Honorable John Linder
Representative of Georgia
U.S. House of Representatives
Washington, DC

Honorable William O. Lipinski
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Bob Livingston
Representative of Louisiana
U.S. House of Representatives
Washington, DC

Honorable Zoe Lofgren
Representative of California
U.S. House of Representatives
Washington, DC

Bruce Lorenz
Richland, WA

Donovan Mager
Carlsbad, NM

John Magyar
WEIR International Consultants
Des Plains, IL

Travis Majenty
Hualapai Tribe
Peach Springs, AZ

Elizabeth Manning
High Country News
Paonia, CO

Honorable Donald Manzullo
Representative of Illinois
U.S. House of Representatives
Washington, DC

Phillip Martin
Chief
Mississippi Band of Choctaw Indians
Choctaw Branch
Philadelphia, MS

Honorable Matthew G. Martinez
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Robert T. Matsui
Representative of California
U.S. House of Representatives
Washington, DC

Roger Mayes
Los Alamos Technical Associates, Inc.
Idaho Falls, ID

Gary McAdams
President
Wichita & Affiliated Tribal Executive Committee
Anadarko, OK

Honorable John McCain
Senator of Arizona
United States Senate
Washington, DC

Honorable Karen McCarthy
Representative of Missouri
U.S. House of Representatives
Washington, DC

Honorable Jim McCrery
Representative of Louisiana
U.S. House of Representatives
Washington, DC

Honorable Jim McDermott
Representative of Washington
U.S. House of Representatives
Washington, DC

William McDonell
Abilene, SC

Dr. William R. McDonell
Aiken, SC

Guy McElroy
Minister of Domestic & Foreign Affairs
Chickasaw Nation
Ada, OK

Honorable Scott McInnis
Representative of Colorado
U.S. House of Representatives
Washington, DC

Honorable David M. McIntosh
Representative of Indiana
U.S. House of Representatives
Washington, DC

Stacy McIntosh
Natural Resources Manager
Muscogee (Creek) Nation
Okmulgee, OK

Honorable Howard P. McKeon
Representative of California
U.S. House of Representatives
Washington, DC

Bob Meccia
Foster Wheeler Environmental
Oak Ridge, TN

Mrs. June Fikiko Mekko
Kialegee Tribal Town
Wetumka, OK

Honorable Jack Metcalf
Representative of Washington
U.S. House of Representatives
Washington, DC

Kathy Middleton
Idaho Falls, ID

George Minot
Hilton Head Island, SC

Honorable G.V. Montgomery
Representative of Mississippi
U.S. House of Representatives
Washington, DC

Bill Moore
Fort Hall, ID

Honorable Carlos J. Moorhead
Representative of California
U.S. House of Representatives
Washington, DC

Eugene Mosqueda
Business Committee
Cheyenne-Arapaho Tribes
Concho, OK

Lawrence Murray
Chairman
Iowa Tribe of Oklahoma
Perkins, OK

Calvin Myers
Moapa Band of Paiute
Moapa, NV

Stephanie Myers
Jason and Associates
Idaho Falls, ID

Honorable George Nethercutt
Representative of Washington
U.S. House of Representatives
Washington, DC

Honorable Bob Ney
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Charlie Norwood
Representative of Georgia
U.S. House of Representatives
Washington, DC

Honorable Sam Nunn
Senator of Georgia
United States Senator
Washington, DC

Cynthia Oceguera
Consultant
Te-Moak Tribe
Reno, NV

Martina Oltman
FEMA Representative
Natural Resources
New Town, ND

Honorable Solomon P. Ortiz
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Michael G. Oxley
Representative of Ohio
U.S. House of Representatives
Washington, DC

Tommy Pacheco
Acting Chairman
Northwestern Band of Shoshoni Nation
Brigham City, UT

Honorable Ron Packard
Representative of California
U.S. House of Representatives
Washington, DC

Karen Papouchado
Aiken City Council
Aiken, SC

Janice Parthree
Richland, WA

Honorable Ed Pastor
Representative of Arizona
U.S. House of Representatives
Washington, DC

Jeffrey Pecka
Englewood, CO

Robert Peelle
Oak Ridge, TN

Honorable Nancy Pelosi
Representative of California
U.S. House of Representatives
Washington, DC

Cynthia Peterson
Littleton, CO

John Petring
Ogden Environmental Services
Fairfax, VA

Kenneth Phillips
Oneida Indian Nation of NY
Vernon, NY

Honorable Richard W. Pombo
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Rob Portman
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Glen Poshard
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Deborah Pryce
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable David Pryor
Senator of Arkansas
United States Senate
Washington, DC

Tina Punchard
Public Affairs
Nuclear Waste Project Office
Fallon, NV

Honorable George P. Radanovich
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Ralph Regula
Representative of Ohio
U.S. House of Representatives
Washington, DC

Norbert Rempe
Carlsbad, NM

Jon Richards
Office of Radiation
U.S. Environmental Protection Agency,
Region 4
Atlanta, GA

Dixie Richardson
Staff Assistant
Office of U.S. Senator Dirk Kempthorne
Idaho Falls, ID

Peter Rickards
INEEL
Twin Falls, ID

Honorable Frank Riggs
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Bob Riley
Representative of Alabama
U.S. House of Representatives
Washington, DC

Rebecca Robertson
Chattanooga, TN

Mary Beth Rodgers
Governor's Office
Austin, TX

Anne Roe
Savannah River Site
Aiken, SC

Honorable Timothy J. Roemer
Representative of Indiana
U.S. House of Representatives
Washington, DC

Honorable Dana Rohrabacher
Representative of California
U.S. House of Representatives
Washington, DC

Gene Rollins
Aiken, SC

John Ross
Chief
United Keetoowah Band of Cherokee Indians
Tahlequah, OK

Honorable Lucille Roybal-Allard
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Ed Royce
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Bobby L. Rush
Representative of Illinois
U.S. House of Representatives
Washington, DC

Honorable Matt Salmon
Representative of Arizona
U.S. House of Representatives
Washington, DC

Randy Salyer
Albuquerque, NM

Karin Salzmann
Santa Fe, NM

Honorable Marshall (Mark) Sanford, Jr.
Representative of South Carolina
U.S. House of Representatives
Washington, DC

Velma Schear
Englewood, OH

George Schroeder
Albuquerque, NM

Kendall Scott
Chairman
Kickapoo of Oklahoma Business Council
McLoud, OK

Honorable John Shadegg
Representative of Arizona
U.S. House of Representatives
Washington, DC

Dr. Velma M. Shearer
Director
Neighbors in Need
Englewood, OH

Honorable Richard C. Shelby
Senator of Alabama
United States Senate
Washington, DC

Jay Shelton
Santa Fe Prep School
Santa Fe, NM

Lorene Sigal
Oak Ridge, TN

Jason Simmons
Keyser, WV

Honorable Alan K. Simpson
Senator of Wyoming
United States Senate
Washington, DC

Honorable Ike Skelton
Representative of Missouri
U.S. House of Representatives
Washington, DC

Sherisse Smelser
Albuquerque, NM

Donnie Smith
Absentee-Shawnee Tribe
Shawnee, OK

Honorable Lamar Smith
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Linda Smith
Representative of Washington
U.S. House of Representatives
Washington, DC

Lawrence F. Snake
President
Delaware Executive Committee
Anadarko, OK

Honorable Mark Edward Souder
Representative of Indiana
U.S. House of Representatives
Washington, DC

Honorable Floyd Spence
Representative of South Carolina
U.S. House of Representatives
Washington, DC

Bob Spooner
MCT Industries Inc
Albuquerque, NM

John St. Ledger
LANL
Albuquerque, NM

Honorable Fortney H. (Pete) Stark
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Charles W. Stenholm
Representative of Texas
U.S. House of Representatives
Washington, DC

Jan Stevens
Environmental Coordinator
Sac and fox Nation of Oklahoma
Stroud, OK

Honorable Steve Stockman
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Louis Stokes
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Bob Stump
Representative of Arizona
U.S. House of Representatives
Washington, DC

Kathleen Sullivan
Boulder, CO

Honorable John Tanner
Representative of Tennessee
U.S. House of Representatives
Washington, DC

Paul Tarrant
Oak Ridge, TN

Honorable Randy Tate
Representative of Washington
U.S. House of Representatives
Washington, DC

Honorable W.J. (Billy) Tauzin
Representative of Louisiana
U.S. House of Representatives
Washington, DC

Honorable Gene Taylor
Representative of Mississippi
U.S. House of Representatives
Washington, DC

Kathleen Taylor
Golden, CO

Honorable Frank Tejeda
Representative of Texas
U.S. House of Representatives
Washington, DC

Charlotte Textor
Battelle
Oak Ridge, TN

Honorable Craig Thomas
Senator of Wyoming
United States Senate
Washington, DC

Honorable William Thomas
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Bennie Thompson
Representative of Mississippi
U.S. House of Representatives
Washington, DC

Honorable William M. Thornberry
Representative of Texas
U.S. House of Representatives
Washington, DC

Honorable Ray Thornton
Representative of Arkansas
U.S. House of Representatives
Washington, DC

Honorable Esteban Torres
Representative of California
U.S. House of Representatives
Washington, DC

Honorable James A. Traficant
Representative of Ohio
U.S. House of Representatives
Washington, DC

Honorable Jim Turner
Representative of Texas
U.S. House of Representatives
Washington, DC

David Ussery
MEVATECH Corp.
White Sands Missile Range, NM

Peter Van Wyck
Vancouver, BC

Howard Vasquez
WID-Santa Fe
Santa Fe, NM

Michelle Vicars
Pajarito Scientific Co.
Los Alamos, NM

Honorable Peter J. Visclosky
Representative of Indiana
U.S. House of Representatives
Washington, DC

Doug Vogt
Jason Technologies Corporation
Las Vegas, NV

Honorable Harold L. Volkmer
Representative of Missouri
U.S. House of Representatives
Washington, DC

Stan Waligora
President/Health Physicist
Environmental Dimensions
Albuquerque, NM

Honorable Maxine Waters
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Henry A. Waxman
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Jerry Weller
Representative of Illinois
U.S.. House of Representatives
Washington, DC

Bill Weston
Westinghouse
Carlsbad, NM

Honorable Rick White
Representative of Washington
U.S. House of Representatives
Washington, DC

Terry Whitetree
Chief
Seneca-Cayuga Tribe of Oklahoma
Miami, OK

Honorable Roger Wicker
Representative of Mississippi
U.S. House of Representatives
Washington, DC

Debby Wilcox
Las Vegas, NV

Deborah Wiley
Murray, UT

James R. Wilkinson
Umatilla Board of Trustees
Pendleton, OR

Jennifer E. Williams
Staff Attorney
Cherokee Nation of Oklahoma
Tahlequah, OK

Charles Wilson
Technological Hazards
Indiana Emergency Management Agency
Indianapolis, IN

Kara Wittstock
Colorado State University
Ft. Collins, CO

Honorable Lynn C. Woolsey
Representative of California
U.S. House of Representatives
Washington, DC

Honorable Ron Wyden
Senator
State of Oregon
Washington, DC

Tarpie Yargee
Acting Chief
Alabama-Quassarte Tribel Town
Henryetta, OK

Honorable Sidney R. Yates
Representative of Illinois
U.S. House of Representatives
Washington, DC

Jim York
Arlington, VA

Dora S. Young
Principal Chief
Sac & Fox Tribe of Oklahoma
Stroud, OK

Roy Young
Nederland, CO

This page intentionally left blank.