DEFENSE TRANSURANIC WASTE PROGRAM

**TRANSURANIC WASTE
TRANSPORTATION ASSESSMENT
AND GUIDANCE REPORT**

**DEPARTMENT OF ENERGY
ROCKWELL INTERNATIONAL
WESTINGHOUSE**

**JOINT INTEGRATION OFFICE
ALBUQUERQUE, N.M.**

AUGUST 1985

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DOE/JIO--002

DE86 005752

DEFENSE TRANSURANIC WASTE PROGRAM
TRANSPORTATION ASSESSMENT AND GUIDANCE REPORT

Joint Integration Office

August 1985

MASTER

MP

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CONTENTS

Acronyms.....	vii
Preface.....	ix
1. Introduction.....	1
1.1 Purpose.....	1
1.2 Scope.....	2
1.3 Existing NEPA Documentation for Transportation of TRU Wastes..	2
1.4 Cumulative Impact Analysis.....	3
2. NEPA Documentation Requirements.....	5
2.1 Introduction.....	5
2.2 NEPA Requirements and Procedures.....	6
2.3 Action Description Memorandum.....	7
2.4 Model Outline for a Typical Environmental Document.....	9
3. Defense TRU Waste Inventories and Transportation Data.....	13
3.1 TRU Waste Inventory Data.....	13
3.2 WIPP Waste Acceptance Criteria and Volumes.....	21
3.3 TRU Waste Transportation in New Mexico.....	27
3.3.1 Interstate Highways in New Mexico.....	27
3.3.2 Rail Transportation in New Mexico.....	27
3.3.3 Truck Transportation to WIPP.....	28
3.3.4 Rail Transportation to WIPP.....	30
3.4 TRU Waste Transportation Data.....	33
3.4.1 CH-TRU Waste Shipment Characteristics.....	33
3.4.2 RH-TRU Waste Shipment Characteristics.....	33
4. The Transportation of TRU Waste.....	39
4.1 Introduction.....	39
4.2 Agencies with Jurisdiction Over the Transportation of Radioactive Wastes.....	39
4.2.1 Federal Jurisdiction.....	39
4.2.2 State Role.....	40
4.3 Waste Packaging Systems.....	41
4.3.1 CH-TRU Waste Packages and Packaging Systems.....	41
4.3.1.1 The TRUPACT System.....	41
4.3.2 RH-TRU Waste Packages and Packaging Systems.....	43
4.3.3 HLW Packages and Packaging Systems.....	43
4.3.4 Spent Fuel Packages and Packaging Systems.....	44
4.4 Radiological Impacts of Transporting RAM Under Incident-Free Conditions.....	45
4.5 Radiological Impacts of Transporting RAM Under Accident Conditions.....	47
4.5.1 Accidents That Compromise Package Integrity.....	47
4.5.2 Unit Risk Factors.....	48

4.6	Nonradiological Impacts of Transporting RAM Materials Under Incident-Free Conditions.....	48
4.6.1	Nonradiological Impacts.....	48
4.6.2	Unit Consequence Factors.....	49
4.7	Nonradiological Impacts of Transporting RAM Under Accident Conditions.....	49
4.8	Insurance Coverage for Transportation Accidents.....	50
4.9	Emergency Response.....	51
4.9.1	The Role of the Federal Government in Responding to Transportation Accidents.....	51
4.9.2	The Role of State and Local Governments in Responding to Transportation Accidents.....	52
4.9.3	Carrier Transportation Responsibilities in Emergencies.....	52
4.10	Alternate Modes for the Transportation of TRU Wastes.....	53
4.10.1	Alternative 1: Transport of TRU Waste by Truck Via the Interstate Highway System or Via Routes Designated by Appropriate State Routing Agencies.....	53
4.10.2	Alternative 2: Transport of TRU Waste by Rail.....	53
4.10.3	Alternative 3: Transport of TRU Waste by Water or Air.....	54
5.	Transportation Risk Analysis.....	55
5.1	Introduction.....	55
5.2	Existing TRU Waste Shipment Risk Analysis.....	55
5.3	Risk Analysis of TRU Waste Shipments to WIPP.....	59
5.3.1	Analytical Approach for Cumulative Impacts.....	59
5.3.2	RADTRAN II Input Parameters.....	61
5.3.3	Maximum Radiological Exposure to an Individual.....	70
5.4	CH-TRU Waste Risk Analysis	71
5.5	RH-TRU Waste Analysis.....	83
5.5.1	RH-TRU Risk Analysis Results.....	83
6.	Glossary of Selected Radioactive Materials Transportation Terms....	93
7.	Cited References.....	95
8.	Appendix	
	Annotated Outline for Preparation of an Environmental Document.....	97

FIGURES

2-1	Diagram of TRU waste management activities.....	5
2-2	NEPA decision process.....	8
4-1	Packaging schematic of TRUPACT-1.....	42
4-2	Design concept for DHLW truck cask.....	43
4-3	Generic spent-fuel cask schematic.....	44
4-4	Accident dose pathways modeled in RADTRAN II.....	48

TABLES

2-1	List of Generic Information Requirements.....	11
3-1	Inventories and Characteristics of DOE/Defense Waste in TRU Retrievable Storage Through 1983.....	14
3-2	Physical Composition of TRU Waste at DOE/Defense Sites.....	15
3-3	Estimated Radionuclide Composition of Retrievable Stored, and Future Defense TRU Waste.....	17
3-4	Projected Generation of Contact-Handled TRU Waste from SFMP Activities at Several Sites.....	20
3-5	WIPP Acceptance Criteria--Waste Form Requirements.....	22
3-6	WIPP Acceptance Criteria--Container and Package Requirements.....	24
3-7	Expected Range in Representative Distance and Driving Times for Shipments to the WIPP using Interstate Highways.....	29
3-8	Expected Representative Range for Rail Shipments to the WIPP Using Alternative Routes.....	32
3-9	Projected CH-TRU Shipments from Generating and Storage Sites to the WIPP.....	35
3-10	CH-TRU Waste Characterization	36
3-11	Projected RH-TRU Waste Shipments from Generating and Storage Sites to the WIPP.....	37
3-12	RH-TRU Waste Characterization.....	38
4-1	Incident-Free Population Subgroups and Mode Combinations Used with RADTRAN II.....	47
4-2	Unit Consequence Factors.....	49
4-3	Unit Risk Factors for Accidents.....	50
4-4	Applicable Insurance or Indemnity Coverage for Public Liability Associated with Defense TRU Waste in the Course of Transportation in the US.....	51
5-1	Analysis of Radiological Impacts to WIPP Under Accident Conditions.....	57
5-2	WIPP EIS Analysis of Radiological Impacts of Transportation Under Accident Conditions.....	58
5-3	WIPP EIS Analysis of Nonradiological Impacts of Transportation Under Accident Conditions.....	59
5-4	RADTRAN II General Input Data.....	64
5-5	RADTRAN II Accident Input Data for CH and RH-TRU Waste Shipments....	67
5-6	Average Distance of Transportation and Percent of Travel in Various Population Zones.....	69
5-7	Nonradiological Risk per Shipment of CH-TRU Waste.....	74
5-8	Radiological Risk per Shipment of CH-TRU Waste.....	75
5-9	Cumulative Radiological Risk for Annual CH-TRU Waste Shipments.....	78
5-10	Cumulative Nonradiological Risk for Annual CH-TRU Waste Shipments...	81
5-11	Hypothetical Maximum Exposure to an Individual from Incident Free Transportation of CH-TRU Waste.....	82
5-12	Radiological Risk Per Shipment of RH-TRU Waste.....	86
5-13	Cumulative Radiological Risk for Annual RH-TRU Waste Shipments.....	88
5-14	Cumulative Nonradiological Risk for Annual RH-TRU Waste Shipments...	90
5-15	Hypothetical Maximum Exposure to An Individual from Incident-Free Transportation of RH-TRU Waste.....	91
A-1	Summary of Potential Environmental Impacts Associated with Hypothetical Action to Process Newly-Generated Wastes and Transport Off-site for Disposal.....	100
A-2	Summary Comparison of Potential Environmental Impacts of Hypothetical Action and Alternatives for Processing Newly-Generated Radioactive Wastes and Ship Off-Site for Disposal..	101

ACRONYMS

ADM Action description memorandum
CH Contact-handled
DHLW Defense high-level radioactive waste
DoD Department of Defense
DOE Department of Energy
DOT Department of Transportation
DTWP Defense Transuranic Waste Program
DWMP Defense Waste Management Plan
EA Environmental assessment
EIS Environmental Impact Statement
EPA Environmental Protection Agency
FEIS Final environmental impact statement
FEMA Federal Emergency Management Agency
HANF Hanford
HLW High-level radioactive waste
INEL Idaho National Engineering Laboratory
LANL Los Alamos National Laboratory
LLW Low-level radioactive waste
LRMP Long-Range Master Plan
LSA Low specific activity
NEPA National Environmental Policy Act
NRC Nuclear Regulatory Commission
NTS Nevada Test Site
ORNL Oak Ridge National Laboratory
RAM Radioactive material(s)
RFP Rocky Flats Plant
RH Remote-handled
ROD Record of Decision
SFMP Surplus Facilities Management Program
SRP Savannah River Plant
TAGR Transportation Assessment and Guidance Report
TI Transport Index
TRU Transuranic
UCF Unit consequence factor
URF Unit risk factors
WAC TRU Waste Acceptance Criteria
WIPP Waste Isolation Pilot Plant

PREFACE

In response to direction from the Congress,¹ the Department of Energy (DOE) prepared and issued the Defense Waste Management Plan² (DWMP) in June 1983. This plan, in part, describes the program to end interim storage of transuranic (TRU) waste generated in defense activities and to achieve permanent disposal in a safe and effective manner. The DWMP objectives provide overall guidance for managing site waste category inventories, for certifying wastes for disposal and waste treatment facilities, and for the safe movement of the waste to a permanent disposal site.

Addressing National Environmental Policy Act (NEPA) requirements for the demonstration of permanent disposal of defense TRU wastes, the DOE prepared an environmental impact statement (EIS) for the WIPP and in January 1981 issued the WIPP Record of Decision³ (ROD). In the ROD, the DOE announced its decision to proceed with the WIPP, located in southeastern New Mexico, as a "research and development facility to demonstrate the safe disposal of radioactive wastes resulting from defense activities and programs of the United States."

Consistent with the DWMP, a more detailed planning document, entitled the Long-Range Master Plan for Defense Transuranic Waste Management⁴ (LRMP), provides more extensive planning during the transition period from interim storage to permanent disposal of TRU wastes. The LRMP also includes planning for a relatively constant shipment rate of CH-TRU waste to optimize operations for both generation and storage sites and the WIPP during the WIPP's projected 25-year design life. CH-TRU waste shipments to WIPP will commence when the facility becomes operational in 1988.

At the end of 1984, the Defense Transuranic Waste Program (DTWP) issued the Defense Transuranic Waste Program NEPA Strategy and Planning Document⁵ to assess the status of existing environmental documentation for "retrieving, processing, certifying, transporting, and disposing" of transuranic waste materials. This Transportation Assessment and Guidance Report (TAGR) is written to support this program strategy and planning effort.

TRANSPORTATION ASSESSMENT AND GUIDANCE REPORT

1. Introduction

1.1 Purpose

The Transportation Assessment and Guidance Report (TAGR) is designed to provide DOE-managed defense sites with guidance and citable analyses addressing National Environmental Policy Act (NEPA) requirements for qualifying and transporting transuranic (TRU) wastes to the Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico. The need for this report is described in the Defense Transuranic Waste Program NEPA Strategy and Planning Document⁵ (p.4). This strategy directs TRU waste generating and storage sites to:

"...identify existing environmental documentation and determine if retrieving, processing, certifying, shipping, and emplacing of TRU wastes in the WIPP is adequately addressed. Where the level of required NEPA documentation is not otherwise apparent, the site will prepare an Action Description Memorandum (ADM) as a basis for determining what documentation may be necessary for preparing TRU waste for emplacement in the WIPP."

To meet this program objective, the strategy proposes a coordinated approach and schedule for individual TRU waste generation and storage sites to assess environmental documentation requirements. The strategy also identifies several system-wide issues requiring a comprehensive program approach, including the transportation of TRU wastes from sites not documented in the WIPP Final Environmental Impact Statement (WIPP/EIS) and the cumulative impact (See 40 CFR 1508.7) of transporting wastes to the WIPP from all sites. To meet these needs, the TAGR proposes guidance for individual sites to prepare integrated NEPA documentation consistent with DTWP goals and objectives. It also provides information and analysis on system-wide issues for individual sites to reference, append, or incorporate into site-specific NEPA documentation.

1.2 Scope

Specifically, the TAGR is intended to:

- o Provide defense TRU waste generating and storage sites with guidance for preparing integrated NEPA documentation addressing system-wide environmental concerns and integrating this information with the documentation for retrieving, processing, certifying, transporting and emplacing TRU wastes in the WIPP. Guidance for preparing an integrated environmental document is included in Chapter 2 and may be used to prepare an Action Description Memorandum (ADM) or other environmental documents.
- o Provide the sites with referenceable information and analyses assessing the system-wide cumulative impacts of the transporting of TRU wastes to the WIPP. This referenceable information and data, which may be incorporated by reference (See 40 CFR 1502.21) into site environmental documentation, is included in Chapters 3, 4, and 5.

1.3 Existing NEPA Documentation for Transportation of TRU Wastes

Environmental analyses addressing the transportation of radioactive wastes are included in several existing documents, namely the WIPP/EIS,⁶ and in an evaluation of NRC and DOT regulations governing transportation of radioactive materials entitled Final Environmental Statement on the Transportation of Radioactive Material By Air and Other Modes⁷ (NUREG-0170). In addition, an earlier related environmental analysis of the truck transport of radioactive wastes, entitled Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle. A Task Force Report⁸ (NUREG-0116), is consistent with analyses in NUREG-0170 and the WIPP/EIS and warrants mention. In all these analyses, the environmental impacts of incident-free (normal) transportation of radioactive wastes and the risks attendant to accidents involving the shipments were found to be small. The risk impacts of proposed TRU waste transportation in relation to existing transportation documentation is discussed in Chapter 5.

1.4 The Approach for Cumulative Impact Analysis

Although it is useful, where possible, to tier to existing documents (See 40 CFR 1502.20), either the generic or site-specific nature of these previous assessments prevents adopting them entirely in site-specific NEPA documentation addressing transportation of TRU wastes. Environmental analyses for transportation of radioactive wastes included in NUREG-0170 and NUREG-0116 had been considered in developing the analyses for this report. Where possible, information and analyses from these existing documents is cited and referenced in this report. However, it is possible now to trace the path of TRU wastes from generation and storage sites to the WIPP along potential transportation routes consistent with regulatory requirements (49 CFR 177.825), and more site-specific analysis is appropriate.

The strategy for meeting NEPA requirements for transporting TRU wastes to the WIPP provides that each site will prepare individual NEPA documentation considering their site-specific impacts for retrieving, preparing, certifying, transporting and emplacing wastes in the WIPP. At the same time, the sites will reference the analysis of system-wide cumulative impacts included in this document. The detailed analyses of transportation risks for TRU wastes, included in Chapter 5, have been developed using conservative estimates of transportation-related data, e.g. packing efficiencies, number of potential shipments from the sites to the WIPP, and other variables. This will allow for some variations to present planning as actual transportation conditions evolve.

Two additional system-wide issues of potential impacts addressed in this report include site TRU waste characteristics and volumes of TRU wastes expected to be emplaced in the WIPP. In both cases, environmental documentation for site-specific waste characteristics and volumes will be tiered to the WIPP/EIS. The logic of this analysis holds that since the characteristics and volumes of waste to be emplaced in the WIPP should meet the WIPP Waste Acceptance Criteria (WAC) and fall within the characteristics and volumes bound by this analysis of the WIPP, the environmental documentation addressing these impacts is included in the WIPP/EIS. Information and data about the WIPP Waste Acceptance Criteria and the capacity of the WIPP are included in Chapter 3.

2. NEPA Documentation Requirements

2.1 Introduction

The steps required to emplace TRU wastes from DOE-managed sites at the WIPP involves, in general, the operations shown in Figure 2-1, including:

(1) retrieve stored TRU wastes; (2) inspect/assay newly-generated and stored wastes; (3) treat and process the wastes to an acceptable form for WIPP disposal, if necessary; (4) certify that the wastes are acceptable in terms of the waste acceptance criteria for disposal at the WIPP site; (5) transport the wastes from the DOE facility to the WIPP; and (6) emplace the wastes at the WIPP site. The scope of this action requires that it be reviewed for compliance with NEPA, as outlined in the program strategy document.⁵

FLOW-CHART OF TRU WASTE MANAGEMENT ACTIVITIES

Figure 2-1. Diagram of TRU waste management activities

This chapter supports the implementation of an integrated NEPA-compliance strategy by describing specific stages of the NEPA decision process as they apply within DOE and presenting guidance for integrating site-specific NEPA documents with analysis of the system-wide cumulative impacts of shipping TRU wastes to WIPP. This guidance, in association with Chapters 3, 4, and 5 of the TAGR, identifies the issues that should be evaluated, types of appropriate analyses for environmental documents, and the types of information usually necessary to support these analyses.

2.2 NEPA Requirements and Procedures

The level of NEPA documentation (EA or EIS) required for decision-making and the attendant procedural requirements depends on the significance of the potential environmental impacts of implementing the actions in question. The chart in Figure 2-2 presents the flow of DOE's decision process for making this determination; it is structured by regulations set out by the Council on Environmental Quality⁹ and implemented under DOE guidelines¹⁰ and DOE Order 5440.1C.¹¹

Most sites will begin the process of determining the required level of NEPA documentation by preparing an Action Description Memorandum (ADM) addressing the potential environmental impact of the actions required to prepare and transport TRU wastes to WIPP. However, if it is immediately clear that a proposed action would have no significant impact, then a Memo-to-File should make a statement to that effect along with a brief rationale. The conditions in which a Memo-to-File is sufficient would include the categorical exclusions, which according to DOE's list of "Typical Classes of Action," are actions which are substantially the same as other actions that have been assessed in a NEPA document and determined by DOE to be clearly insignificant and where this assessment remains valid.¹² An assessment of the impact of small TRU generators continuing to transport waste to major sites for processing or shipment to the WIPP may be included in this category.

Preparation of an ADM can be viewed as a planning tool for early evaluation of the environmental significance of the proposed action. If an ADM reveals that the environmental impact is not significant, the NEPA decision process (Figure

2-2) could end with a Memo-to-File. If, based on the ADM, the impact is still undecided, then it would be necessary to prepare an Environmental Assessment (EA) to determine if an Environmental Impact Statement (EIS) is necessary. Guidance for preparation of an ADM, taken from the DOE NEPA Compliance Guide is included here.

2.3 Action Description Memorandum

Purpose

An action description memorandum serves as the basis for a determination of the required level of NEPA documentation and should be prepared for each proposed action not exempted by DOE Guidelines (45 FR 20694). It should be submitted to the Office of Environmental (now designated as the Office of Policy, Health and Environment) as early as possible in the planning process of an action. This will help ensure proper planning for NEPA compliance and allow integration of the NEPA process with the development process for an action and thereby help avoid delays. The action description memorandum should contain sufficient information to permit a reasonable determination of the NEPA documentation required.

Outline

An action description memorandum should contain, as appropriate, the following information:

1. Concise Description of Proposed Action

The proposed action should be briefly, but concisely, described. Included in this description is a statement as to the purpose and need for the proposed action; the type of action (program, policy, or project); the class of action (legislative or administrative); the type of energy technology; and an indication of the size of the action.

2. Location of the Action The proposed location of the action, if site specific; should be identified clearly by naming the closest city or metropolitan area, and the county and state in which the action is to take place. Other characteristics such as rural or urban qualities, environmental setting (forested, desert, outer continental shelf, grasslands, etc.) and economic conditions of the area may be included.
3. Potential Issues Any known or potential issues or problems, particularly environmental issues, should be briefly presented. These may include such issues as presence of endangered species, possible conflict with historical areas, conflict with Indian lands or religious sites, involvement of floodplains or wetlands, known air quality problems, water quality problems, etc.

NEPA DECISION CHART

Figure 2-2. NEPA decision process

2.4 Model Outline for a Typical Environmental Document

A brief outline of the contents of a more extensive typical environmental document (EA or EIS) is given below. This outline is not intended to supersede the guidance provided in the DOE Environmental Compliance Guide which should be consulted for further details in preparing environmental documentation. (For additional detail, an annotated outline for an environmental document is included in the Appendix.).

CONTENTS OF A TYPICAL ENVIRONMENTAL DOCUMENT

SUMMARY

- I. PURPOSE AND NEED FOR THE PROPOSED ACTION
 - I.1 Purpose
 - I.2 Need
 - I.3 Scope of Environmental Review
- II. ALTERNATIVES INCLUDED TO PROPOSED ACTION
 - II.1 Proposed Action
 - II.2 Alternatives
 - II.2.1 No Action
 - II.2.2 On-site Disposal
 - II.2.3 Other Alternatives
 - II.3 Comparison of Alternatives
- III. AFFECTED ENVIRONMENT
 - III.1 Site Location and Characteristics
 - III.2 Transportation Routes
- IV. ENVIRONMENTAL CONSEQUENCES
 - IV.1 Proposed Action
 - IV.1.1 On-site Impacts
 - IV.1.2 Transportation Issues
 - IV.1.3 Disposal Issues
 - IV.2 Alternatives
 - IV.2.1 Transportation Alternatives
 - IV.2.2 Alternatives to the Proposed Action
- V. LIST OF PREPARERS (Not Required for EA)

Because the basic approach and analysis of the EA and EIS are similar, these documents could be structured in this manner. The level of detail and depth of analysis will, however, depend on the specifics and implications of the action and the purpose of the document with respect to the NEPA decision process (Figure 2-2).

A list of generic information needs for the environmental analysis is included in Table 2-1. The information needs for various on-site operations and facilities (existing or to be constructed) are site-specific and, therefore, cannot be listed here. Chapter 3 of the TAGR provides the most current published information on the waste characteristics and quantities for each site; transportation information and data are also provided.

Table 2-1. List of Generic Information Requirements

Characterization of Waste to be Shipped

- o Physical
- o Chemical
- o Radionuclide composition
- o Curie content
- o Handling mode (CH-TRU or RH-TRU)
- o Containerization
- o Volume of stored waste
- o Projected rates for generating new wastes

Facilities

- o General description
- o Location of any new facility and size of construction workforce
- o Characterization of radioactivity
 - airborne emissions
 - effluents
 - solid waste
 - curies/year for each radionuclide and release point
- o Description of accident potential and consequences

(Above information does not need to be included when facilities are at off-site DOE sites.)

Transportation

- o Mode (Truck or Rail)
- o Shipment packaging
- o Shipment scheduling
- o Total number of shipments
- o Rate of shipments

3. Defense Transuranic Waste Inventories and Transportation Data

3.1 TRU Waste Inventory Data

A summary of TRU waste volumes and characteristics for major generator and storage sites is presented in Tables 3-1 through 3-4. Waste characterization information is drawn from defense program data and projections current to the end of 1983.

Table 3-1. Inventories and Characteristics of DOE/Defense Waste
In TRU Retrievable Storage Through 1983^a

Storage Site	Volume (m ³)	Mass of TRU Elements (kg)	Alpha Radioactivity (Ci)	Thermal Power ^b (W)
<u>Contact-Handled^c</u>				
HANF	12,808	340	27,680	800
INEL	50,958	524.4	171,157	5,500
LANL	6,294.8	247.5	138,017	4,000
NTS	319.7	7.775	1,318.7	100
ORNL	450	12.33	21,414	400
SRP	3,399	98.5	580,761	25,200
Subtotal	74,229.5	1230.5	940,348	36,000
<u>Remote-Handled^c</u>				
HANF ^d	21.8	5.4	750	100
INEL	50.69	0.319	24.1	100
LANL	26.6	1.27	78	100
ORNL	653	0.613	428	100
Subtotal	752.09	7.602	1,208.1	400
Total	74,981.6	1,238.1	941,628	36,400

Notes:

- a Data from Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics DOE/RW-0006, Sept. 1984¹³.
- b Values were calculated using estimated radionuclide compositions for the TRU nuclides.
- c Beginning with 1983, TRU waste inventories are estimated on the basis of DOE Order 5820.2. Prior inventories were estimated using the earlier definition of TRU waste (10nCi/g); a portion of the volume might be reclassified as non-TRU waste.
- d During 1983, Hanford reclassified Purex tunnel waste, designating the large equipment items as belonging to an operating facility. Consequently, the waste volume and radioactivity reported here are significantly less than reported previously.

Table 3-2. Physical Composition of TRU Waste at DOE/Defense Sites Through 1983^a

Waste Type	Waste Composition (vol %)	
	Contact-Handled	Remote-Handled
	<u>HANF</u>	
Absorbed liquids, sludges	5.8	
Combustibles	23.3	65.1
Concreted or cemented sludge	2.4	6.1
Filters or filter media	0.5	
Glass	3.6	
Metal	48.7	28.8
Other	15.7	
	<u>INEL</u>	
Absorbed liquids or sludges	14.13	
Alpha hot cell waste		80.09
Combustibles	20.67	4.333
Concreted or cemented sludges	3.034	
Dirt, gravel, or asphalt	1.802	
Filters or filter media	7.522	11.59
Glass	2.051	
Laboratory waste		3.513
Metal	28.02	
Solidified fuel		0.4684
Other	12.32	
Unknown	10.49	
	<u>LANL</u>	
Absorbed liquids or sludges	18.1	
Combustibles	16.6	
Concreted or cemented sludges	11.9	
Dirt, gravel, or asphalt	2.1	
Filters or filter media	2.6	
Glass	0.5	
Metal	39.3	
Other	8.9	100 ^b
	<u>NTS</u>	
Combustibles	45	
Metal	55	

Table 3-2. Physical Composition of TRU Waste at DOE/Defense Sites Through 1983^a
(Continued)

Waste Type	Waste Composition (vol %)	
	Contact-Handled	Remote-Handled
	<u>ORNL</u>	
Combustibles	56	39
Filters or filter media	0	2
Metal	16	40
Other	28	19
	<u>SRPC</u>	
Combustibles	70	
Noncombustible	30	

Notes:

- a. Data from Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics DOE/RW-0006, Sept. 1984¹³.
- b. Combustible and noncombustible waste in one- and two-gallon cans is randomly mixed in storage casks, and a meaningful waste composition cannot be determined.
- c. SRP records indicate only combustible and noncombustible classification.

Table 3-3. Estimated Radionuclide Composition of Retrievable Stored
Through 1983 and Future Defense TRU Waste

Radionuclide	Radionuclide Composition ^a (wt %)	
	Contact-Handled	Remote-Handled
<u>HANF</u>		
²³⁸ Pu	0.01	0.05
²³⁹ Pu	93.89	86.36
²⁴⁰ Pu	5.75	11.75
²⁴¹ Pu	0.34	1.63
²⁴² Pu	0.02	0.21
<u>INEL</u>		
²³³ U	18.22	
²³⁸ Pu	0.728	0.05417
²³⁹ Pu	72.36	92.86
²⁴⁰ Pu	4.552	7.001
²⁴² Pu	0.0238	0.0860
²⁴¹ Am	4.119	
<u>LANL</u>		
²³³ U	1.7	
²³⁶ Pu	2.8E-06	
²³⁸ Pu ^b	2.25	0.014
²³⁹ Pu ^c	87.92	93.55
²⁴⁰ Pu ^c	5.59	5.89
²⁴¹ Pu	0.518	0.536
²⁴² Pu	0.524	0.023
²⁴¹ Am	1.4	
²²⁶ Ra	0.1	
²³⁷ Np	0.1	
²⁴⁴ Cm	0.1	
<u>NTS</u>		
²³⁷ Np	9.96	
²³⁸ Pu	0.013	
²³⁹ Pu	83.54	
²⁴⁰ Pu	5.26	
²⁴¹ Pu	0.479	
²⁴² Pu	0.021	
²⁴¹ Am	0.631	
²⁴⁴ Cm	0.112	

Table 3-3. Estimated Radionuclide Composition of Retrievable Stored Waste Through 1983 and Future Defense TRU Waste (Continued)

Radionuclide	Radionuclide Composition ^a (wt %)	
	Contact-Handled	Remote-Handled
	<u>ORNL</u>	
²³³ U	63.5	38.6
²³⁷ Np	3.1	0
²³⁸ Pu	3.9	Trace
²³⁹ Pu	22.8	59.8
²⁴⁰ Pu	4.0	0
²⁴¹ Pu	0.3	0
²⁴² Pu	0.2	0
²⁴¹ Am	1.3	1.1
²⁴³ Am	0.4	Trace
²⁴² Cm	Trace	0
²⁴⁴ Cm	0.5	0.5
²⁴⁶ Cm	Trace	0
²⁵² Cf	Trace	Trace
²⁴⁹ Bk	Trace	Trace
	<u>SRPd (239Pu Operations)</u>	
²³⁸ Pu	0.02	
²³⁹ Pu	93-94	
²⁴⁰ Pu	6	
²⁴¹ Pu	0.5	
²⁴² Pu	0.07	
	<u>SRPd (238Pu Operations)</u>	
²³⁸ Pu	80-83	
²³⁹ Pu	17-20	
²⁴⁰ Pu	2	
²⁴¹ Pu	0.4	
²⁴² Pu	0.1	

Notes:

- a Data from Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics DOE/RW-0006, Sept. 1984¹³.
- b The ²³⁸Pu composition reported by LANL identified the material as heat-source plutonium, which is a mixture of several Pu isotopes. The above compositions were calculated using the following composition (wt %) for heat-source plutonium; ²³⁶Pu = 0.0001; ²³⁸Pu = 80; ²³⁹Pu = 16.3; ²⁴⁰Pu = 3.0; ²⁴¹Pu = 0.6; and ²⁴²Pu = 0.1.

Table 3-3. Estimated Radionuclide Composition of Retrievable Stored,
Through 1983 and Future Defense TRU Waste (Continued)

- c The ^{239}Pu - ^{240}Pu reported by LANL identified the material as weapons-grade plutonium, which is a mixture of several isotopes. The above composition was calculated using the following composition of (wt %) for weapons-grade plutonium: $^{238}\text{Pu} = 0.014$; $^{239}\text{Pu} = 93.55$; $^{240}\text{Pu} = 5.888$; $^{241}\text{Pu} = 0.536$; and $^{242}\text{Pu} = 0.023$.
- d SRP estimates that 50% of the CH-TRU waste is from ^{239}Pu operations and 50% from ^{238}Pu operations.

Table 3-4. Projected Generation of Contact-Handled TRU Waste
from SFMP Activities at Several Sites^{ab}

Year	Volume and Percent Certified ^c [m ³ (vol %)]			
	Mound	ORNL	RHOD ^d	TOTAL
1984	140 (25)	0.8 (100)	142	282.8
1985	210 (75)	3.2 (100)		213.2
1986	260 (100)	4.7 (100)		264.7
1987	160 (100)	2.0 (100)		162
1988	120 (100)	0.5 (100)		120.5
1989	90 (100)	2.0 (100)		92
1990	70 (100)	2.0 (100)		72
1991	5 (100)	2.0 (100)		7
1992	5 (100)	2.0 (100)		7
1993	5 (100)	2.0 (100)		7
Total Volume	1065	21.2	142	1228.2

Notes:

- a Data from Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006, Sept. 1984¹³.
- b SFMP = Surplus Facilities Management Program.
- c Certified as packaged.
- d Rockwell Hanford Operations reported a waste volume for 1984 only; the percent certifiable was not reported.

3.2 WIPP Waste Acceptance Criteria and Volumes

As part of the WIPP demonstration, TRU Waste Acceptance Criteria (WAC) were developed to provide guidelines and restrictions for the receipt of wastes. They are intended to assure proper performance of the WIPP facility and minimize public and occupational personnel exposure to hazards during shipping, handling, emplacement, and potential retrieval of the waste. Since the WAC establish limits for waste and packaging requirements for emplacement in the WIPP, they are summarized in Table 3-5 and 3-6. To facilitate review, the WAC are grouped into two categories: waste form requirements and package requirements. The sites are cautioned to refer to the WIPP/WAC¹⁴ for greater detail and to confirm that timely information is referenced in their environmental documentation.

The capacity of the WIPP is discussed in the WIPP/EIS (p. 1-5).

"Over its 25-year operating life, the WIPP could receive about 6.2 million cubic feet of contact-handled TRU waste and as much as 250,000 cubic feet of remotely handled TRU waste."

Although the total amount of defense TRU waste generated during the operating life of the WIPP depends on several factors including production activity, waste reclassification, and improvements in waste reduction technologies, current estimates of TRU waste available for possible emplacement in the WIPP would result in impacts within the range discussed in the WIPP/EIS.

Table 3-5. WIPP Acceptance Criteria -- Waste Form Requirements^a

WIPP Acceptance Category	Category Definition	WIPP Acceptance Criteria/Limit ^b	Primary Concern
Explosives and Compressed Gases	As defined by 49 CFR 173, Subpart C and G	None accepted	Public/personnel hazard during shipping, handling, and retrieval. Source of waste package failure.
Liquid Wastes	Liquid not absorbed into a host material with potential of spilling or draining from container.	Waste shall not be in free liquid form. Minor liquid residues in well drained bottles, cans, etc. are acceptable.	Personnel safety if handling accident occurs. Waste container integrity for retrieval (if required).
Immobilization	Materials that are fixed in a glass, ceramic, concrete, etc., matrix.	Wastes in each package with more than 1 wt% of particles below 10 microns or more than 15 wt% of particles below 200 microns shall be immobilized.	Personnel safety if handling accident occurs (minimize dispersability and inhalation).
Pyrophorics	Materials which may ignite spontaneously during shipping or storage condi- tions. A list of pyro- phoric is given in 49 CFR 173, Subpart D and E.	No more than 1 wt% of pyrophoric forms of radionuclide metals per waste package. Nonradionuclide pyrophoric materials to be mixed with chemical stable materials or processed to remove hazardous properties.	Fire hazard during shipping, handling, and retrieval.

Table 3-5. WIPP Acceptance Criteria -- Waste Form Requirements^a (Continued)

WIPP Acceptance Category	Category Definition	WIPP Acceptance Criteria/Limit ^b	Primary Concern
Radioactive Mixed Waste	Hazardous waste constituents such as poison A or B as defined by 49 CFR 261, Subpart C & D or corrosives as defined in Subpart F (Significant harm from single exposure).	None accepted unless co-contaminants with TRU material. Reactive materials shall be identified with appropriate DOT label. Corrosive materials shall be neutralized, rendered noncorrosive, or adequately packaged. Quantities to be reported are those defined in 49 CFR 261, Subparts C & D.	Public/personnel hazard during shipping, handling, and retrieval.
PU-239 Alpha Equivalent TRU Activity		Waste Packages not to exceed 1000 Ci of Pu-239 Alpha equivalent TRU activity (PE-Ci)	

Notes:

- ^a Based on TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, WIPP-DOE-069, Rev. 2.
- ^b Acceptance criterium for contact-handled (CH) and remote-handled (RH) transuranic waste are the same unless noted otherwise.

Table 3-6. WIPP Acceptance Criteria -- Container and Package Requirements^a

WIPP Acceptance Category	Category Definition	WIPP Acceptance Criteria/Limit ^b	Primary Concern
Gas Generation	Gas generation mechanisms include radiolytic, thermal corrosive, and bacterial degradation and dewatering processes.	<p>CH: Acceptable method of pressure relief; Each TRU waste shipper to provide data on:</p> <ul style="list-style-type: none"> Total activity (alpha Ci) Waste form description (from Certification Plan) Mass and volume percent of organic content No mixture of gases or vapors which could have spontaneous increases in heat or pressure, or explode and reduce effectiveness of the packaging. <p>RH: all canisters shall be vented</p>	Pressure induced fracture of geologic isolation medium resulting in increased fluid transmissivity.
Nuclear Criticality	Self-sustaining fission reaction of fissile isotopes.	<p>CH: Pu-239 fissile gram equivalent (ANSI/ANS-8.15-1981) limits:</p> <ul style="list-style-type: none"> 200g per 55-gallon drum 100g per 30-gallon drum 500g per DOT 6M container 5g per ft³ in boxes up to a maximum of 350g <p>RH: Fissile/fissionable isotope content shall not exceed 1.9g/liter. Otherwise, limited to 240 Pu-239 Pu-239 fissile gram equivalents except for canisters loaded with individual DOT 17 c drums:</p> <ul style="list-style-type: none"> 200g per 55-gallon drum 100g per 30-gallon drum. 	Criticality from water intrusion (increases reactivity), compaction from room closure (creep, rockfall), or compaction by treatment (incineration) which could cause thermally induced changes to geologic isolation medium.

Table 3-6. WIPP Acceptance Criteria - Container and Package Requirements^a (Continued)

WIPP Acceptance Category	Category Definition	WIPP Acceptance Criteria/Limit ^b	Primary Concern
Surface Contamination	Removable surface contamination on the waste package and is measured to identify the intensity (disintegrations) of radioactivity per unit area.	50 picocuries/100 cm ² of alpha emitting isotopes; 450 picocuries/100 cm ² of beta-gamma emitting isotopes.	Maintain WIPP facility in "clean" condition, minimize decommissioning and decontamination requirements, personnel safety and work efficiency.
Surface Dose Rate	Maximum dose rate at any point on the waste to identify the relative biological effect of the radiation.	CH: 200 mRem/hr Neutron contributions 50 mRem/hr to be reported separately in data package. RH: 100 Rem/hr. Neutron contributions limited to less than 270 mRem/hr Neutron contributions greater than 50mrem/hr to be reported in data package.	Minimize personnel radiation exposure using ALARA practices. Adequate personnel shielding and complies with rated capacity of waste hoist.
Thermal Power	Thermal power as generated by nuclear decay of the waste isotopes.	CH: Packages exceeding 3.5 watts/m ³ shall be recorded. RH: 300 watts/package.	Changes in geologic isolation medium. Package failure due to gas formation from waste decomposition resulting in handling.
Waste Container	Disposable containment vessel for waste including integral liner or shielding materials intended for emplacement at WIPP	Comply with Type A packaging requirements of 49 CFR 173.412 Noncombustible. 20-year life from date of certification, including labeling and color coding.	Suitability for shipping, handling, and retrieval.
Waste Package Handling	Not applicable	CH: Packages shall be provided with cleats, offsets, chines, or skids for handling by fork trucks or cranes. RH: Packages shall be equipped with an axial lifting pintle.	Compatibility with WIPP waste handling system.

Table 3-6. WIPP Acceptance Criteria -- Container and Package Requirements^a (Continued)

WIPP Acceptance Category	Category Definition	WIPP Acceptance Criteria/Limit ^b	Primary Concern
Waste Package Weight	Not applicable	CH: Waste packages/assemblies shall not exceed 25,000 pounds. RH: Waste packages shall not exceed 8,000 pounds.	Compatibility with WIPP waste handling system.
Waste Package Size	Not applicable	CH: Waste packages/assemblies shall not exceed 12x8x8.5 (LxWxH) ft. RH: Waste packages shall not exceed 26 inches in diameter and 10 ft., 1 in. in length, including the pintle.	Compatibility with WIPP waste handling system.
Labeling	Not applicable	CH: Using 1 in. high characters, attach package I.D. number and weight (kg). RH: Using 2 in. high characters, attach package I.D. number.	Documentation and inventory control to assure safe operation within technical specifications.
Data Package	Not applicable	Waste package information will be transmitted to WIPP prior to and with waste shipment; a hard copy to accompany each shipment.	Documentation and inventory control to assure safe operation within technical specifications.

Notes:

^a Based on TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, WIPP-DOE-069, Rev. 2.

^b Acceptance criterium for contact-handled (CH) and remote-handled (RH) transuranic waste are the same unless noted otherwise.

3.3 TRU Waste Transportation in New Mexico

3.3.1 Interstate Highways in New Mexico¹⁵

The state of New Mexico has three interstate highways crossing its borders: Interstate 10 crosses the southern part of the State from the Arizona border to the Junction of I-25 near Las Cruces, and then heads southeast crossing the Texas border near Anthony. Interstate 25 heads in a northeasterly direction to Albuquerque, then northeast past Santa Fe, Las Vegas, and Raton and into Colorado. Interstate 40 is an east-west highway crossing the northern part of the state through Gallup, Albuquerque, and Tucumcari.

TRU waste shipments from outside the state, many of which will be "highway route controlled quantities", will cross the state border at only a few points. These entry points for the purpose of this study, with some exceptions, involve the interstate highway system. The State of New Mexico has not to date designated and qualified preferred routes, under DOT requirements, as alternatives to the interstate system. Even so, several studies^{16,17} indicate that no matter which route is approved and used, the radiological and nonradiological impact of transporting radioactive waste is small.

The WIPP facility is located in the southeastern part of the state near Carlsbad. The interstate highway closest to the WIPP Site is I-20 at Pecos, Texas which is 86 miles to the south. The approximate distance from the WIPP site to other interstate highways in New Mexico are as follows: 250 miles to I-10 and I-25 Junction near Las Cruces; and 254 miles to I-40 at Clines Corner.

3.3.2 Rail Transportation in New Mexico¹⁸

A selection of typical rail transportation patterns to the WIPP from each source of CH-TRU waste is shown in the WIPP/EIS⁶. The number of routes within 200 miles of WIPP is limited and would travel through Clovis, Roswell, Carlsbad, and Loving, New Mexico.

3.3.3 Truck Transportation to WIPP

The distances and driving times for shipments to the WIPP facility were estimated from the ORNL highway routing model (HIGHWAY).¹⁹ If and when additional preferred highways are defined by state routing agencies, there will be potential changes to the overall distance and driving times identified here. To date, only a few states have begun the process of identifying such preferred routes.

In order to quantify the potential impact of state-defined preferred routes and to provide a range of representative distances and driving times, two estimates of the distance and driving time to WIPP were made. The first estimate used the commercial HIGHWAY model routing criterion. While these routes generally follow the interstate highways, no restriction was placed on the model to remain only on interstate highways. The second estimate used an interstate bias option in the HIGHWAY routing model, preferentially selecting routes along interstate highways. The representative estimates of distance and driving time from the waste generator sites to the WIPP facility are identified in Table 3-7.

Table 3-7. Expected Range in Representative Distance and Driving Times for Shipments to the WIPP Using Interstate Highways^a

Source	Distance (mi)	Driving time (hr:min) ^b
Los Alamos, NM	343 ^c	8:20
Rocky Flats, CO	638 ^c	14:20
Nevada Test Site, NM	967-1235	21:00-26:00
INEL, ID	1339-1447	28:50-32:40
Argonne, IL	1324-1450	27:50-28:30
Oak Ridge, TN	1303-1389	27:30-33:50
Battelle, Columbus, OH	1452-1562	30:40-32:40
Mound Labs, OH	1421-1547	30:00-32:20
Savannah River, SC	1423-1720	30:30-36:10
Hanford, WA	1743-1851	37:30-41:20

Notes:

- a The range of mileage and driving times shown were developed by blocking the direct route and forcing the model to seek an alternative interstate highway route and does not restrict shipments to state-preferred routes.
- b All driving times based on a two-driver team.
- c Alternative routes were not calculated from these sites.

3.3.4 Rail Transportation to WIPP

Modeling Rail Routing The INTERLINE rail routing model²⁰ was designed to take cognizance of railroad characteristics in predicting likely routes, and was used to identify possible alternatives. INTERLINE uses a network representation of the U.S. rail system based on Federal Railroad Administration network assembled in the middle 1970's. It has subsequently been updated and corrected to reflect current operations. The data includes not only geographical location, but also characteristics of rail lines such as traffic levels, signal systems, and number of tracks. The model relies on a shortest path algorithm modified to minimize the use of low volume branch lines and the number of interlines in a route.

General Routing Practices. Because of its division into a large number of independent companies, each controlling separate parts of the entire network, the U.S. rail system is almost unique in the world. Except in rare cases where the point of origin and destination are served by a single company, shipments must be interlined, or transferred, from one railroad to another.

This gives shippers a large degree of freedom in specifying routes their shipment is to take, because shippers invariably are able to specify which railroads are to be used in a movement and the location of interline points. Typically, however, the shipper will not specify routes between interline points. That is an internal operating decision made by the railroad depending on transient operating conditions. The railroads will usually permit a shipper to specify a route, but at extra cost and time. In the following analysis, alternative paths for TRU-waste movement were constructed solely by varying interline points, allowing routes internal to each company to follow its typical routing practices without interference.

Common Elements of Routes Most of the origins and destinations of TRU-waste are relatively isolated, and are connected to the rail system by a branch line with very limited traffic. In all cases, switching operations will be required at both ends of the route to move cars from the site to the railroad's traffic collection yard.

The cars will generally travel a relatively short distance before reaching a high traffic volume mainline, and will travel the majority of their route on these mainlines. This implies that all routes will be travelling through major metropolitan areas, as mainlines are designated to serve these major traffic generators.

Another consequence of mainline operation is that delays due to disruptions of operations, from weather or accidents, are likely to be very limited. Mainlines are inspected very frequently, and the railroads will make major efforts to keep these lines open in inclement weather or to clear blockages from washouts or accidents. It would be unusual for any blockage to last for more than a day except in the face of severe mountain storms. Storms severe enough to stop operations may be expected one or two times each winter on all routes passing through the Rockies.

Any weather related problems are most likely to occur on those branch lines which are immediately adjacent to the origins and destinations, because less effort is devoted to maintaining branch lines. When weather conditions disrupt rail operations they will likely be severe enough to disrupt operations at the plants as well. The exceptions are washouts which will occur with rare frequency following severe rain storms and may block branch lines for days before work crews repair them.

Branch lines also have the most severe weight and dimensional limitations. However, cars carrying TRUPACTs and RH-TRU containers will be well within the limits of all lines on identified routes. Every line on every route can accommodate 240,000 lb gross weight cars; the dimensions of cars which would carry TRUPACTs are smaller than boxcars.

Table 3-8 presents a summary of the alternative routes for each site and destination pair. The table also includes an estimate of the time required for one-way shipment.

Table 3-8. Expected Representative Range for Rail Shipments
to the WIPP Using Alternative Routes

Origin and Destination	Alter- native ^a	Distance (miles) ^b	Number of RRs ^c	Transit time (days) ^b
INEL to WIPP	A	1426	2	10
	B	2032	2	12
Hanford to WIPP	A	2144	2	13
	B	1986	2	11.5
	C	2591	2	14.5
	D	2386	3	17
Savannah River to WIPP	A	1826	3	15
	B	1832	4	16
	C	1979	3	15
	D	2026	3	15
	E	2066	4	18
ORNL to WIPP	A	1635	3	14
	B	1656	3	14
	C	1532	3	16
Rocky Flats to WIPP	A	748	2	8.5
	B	980	2	9.5
	C	1572	3	12
Argonne to WIPP	A	1259	1	8.5
	B	1628	3	16
Mound Facility to WIPP	A	1492	2	14
	B	1467	3	15
	C	1699	4	16

Notes:

- a Alternative routes were generated to provide a range of times and distances.
- b One-way times and distances.
- c The number of separate railroad companies used in the route. The number of interlining operations is one less than this number.

3.4 TRU Waste Transportation Data

This section summarizes waste transportation data for the major generating and storage sites that will be shipping transuranic waste to the WIPP facility. Waste characterization data is presented on a site average basis and is not intended to represent specific shipments.

3.4.1 CH-TRU Waste Shipment Characterization

Shipment characterization data for the major waste generating/storage sites (LANL, LLNL, NTS, ORNL, and SRP) analyzed in this report are based upon data presented in Section 3.0 and projections in Tables 3.17 to 3.20 of Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006¹³, September, 1984. An average waste volume of 7.5 m³ per TRUPACT was estimated, resulting in a packing efficiency of 0.39. This is consistent with current program studies indicating that waste shipments will tend to be weight limited. Shipment calculations were based on one TRUPACT per truck shipment and two per rail-car shipment. Table 3-9 summarizes the total volume of CH-TRU waste projected to be shipped to the WIPP from each DOE-managed site as well as total and annual waste shipment frequencies. Waste shipments were assumed to occur at a constant rate over the projected 25-year operational life of the WIPP. Average curie content per TRUPACT and activity distributions by radionuclide are summarized in Table 3-10.

3.4.2 RH-TRU Waste Shipment Characterization

RH-TRU waste volumes to be shipped to the WIPP from Hanford, ORNL, INEL and LANL are based upon information provided in Section 3.0 and Tables 3.15, 3.17, and 3.19 of DOE/RW-0006; the volumes are summarized in Table 3-11. As with CH-TRU waste, RH-TRU waste shipments were assumed to occur at a uniform rate, but only over a 20-year workoff period beginning in 1994.

Currently, limited characterization data is available regarding fission product contamination and isotopic distributions for RH-TRU waste. In order to address this issue, the general approach has been to define a hypothetical "worst case" RH-TRU waste. For this analysis, the maximum expected activity

in an individual canister is based on the estimates provided in Table E-3 of the WIPP EIS⁶ and summarized in Table 3-12 of this report. TRU radionuclide content and distributions are based on site-specific characterization data presented in DOE/RW-0006. An assumed shipment volume of 1.0 m³ was used in the calculations, based on a nominal canister size of 26-inch diameter by 121-inches long as discussed in the Report of the RH-TRU Characteristics Interface Working Group, M. M. Warrant to distribution, Sandia National Laboratories, April 30, 1985.

Table 3-9. Projected CH-TRU Waste Shipments from
Generating and Storage Sites to the WIPP

	Total Volume (m ³)	^a Total Shipments		^b Average Annual Shipments	
		Truck	Rail	Truck	Rail
INEL	63,808 ^c	8,508	4,254	340	170
RFP	94,250 ^d	12,567	6,283	503	251
Hanford	27,339 ^c	3,645	1,823	146	73
LANL	16,495 ^c	2,199		88	
LLNL	5,905 ^c	787	394	32	16
NTS	987 ^c	132		5	
ORNL	1,283 ^c	171	86	7	3
SRP					
239 Pu Waste	8,022 ^c	1,070	535	43	21
238 Pu Waste	8,022 ^c	1,070	535	43	21
Mound	2,613 ^d	348	174	14	7

Notes:

- ^a Based on 7.5 m³/TRUPACT
- ^b Based on 25 years shipping campaign
- ^c Calculated from projections in DOE-RW-0006; Section 3.0; thru Oct, 2013
- ^d Calculated from DOE-TRU-8201, Table 1-3, (Rev 1). The total volume is based upon annual generation rates multiplied by 25 years.

Table 3-10. CH-TRU Waste Characterization^{a,b}

Shipment Origin Site	Average Ci Content/TRUPACT	Activity Fraction Per Radionuclide ^c											
		233U	236Pu	238Pu	239Pu	240Pu	241Pu	242Pu	237Np	241Am	243Am	244Cm	252Cf
RFP	5.05+1	2.65-3		1.91-1	6.87-2	1.59-2	5.05-1	1.44-6					
INEL	5.05+1	2.65-3		1.91-1	6.87-2	1.59-2	5.05-1	1.44-6		2.17-1			
Hanford	8.91+1			3.83-3	1.30-1	2.93-2	8.37-1	1.76-6					
LANL	3.41+2	1.40-4	1.29-3	3.34-1	4.74-2	1.11-2	4.94-1	1.79-5	6.12-7	4.17-2		7.03-2	
LLNL ^d	1.29+2			3.15-3	7.35-2	1.70-2	7.47-1	1.01-6	9.97-5	3.07-2		1.29-1	
NTS ^d	1.29+2			3.15-3	7.35-2	1.70-2	7.47-1	1.01-6	9.97-5	3.07-2		1.29-1	
ORNL	3.15+2	3.93-3		4.36-1	9.28-3	5.96-3	2.16-1	5.14-6	1.43-5	2.92-2	5.23-4	2.65-1	3.51-2
SRP													
238Pu Waste	3.09+3			2.99+3	2.30+0	9.90-1	9.56+1	8.53-4					
239Pu Waste	1.36+2			5.46-3	9.27-2	2.19-2	8.79-1	4.39-6		1.10-3			
Mound	1.87+2			9.51-1	6.84-4	4.78-4	4.88-2	3.54-7					

Notes:

^a Numbers are expressed in abbreviated scientific notation: $1.40 \times 10^{-4} = 1.40-4$.

^b Based on projected volumes and TRU mass of CH-TRU waste presented in Tables 3.17 to 3.20 of DOE/RW-0006 through October, 2013 and an average waste volume of 7.5 m³ per TRUPACT. The following specific activity values were used in the calculations:

Radionuclide	Specific Activity (Ci/g)	Radionuclide	Specific Activity (Ci/g)
233U	9.48-3	241Pu	1.10+2
236Pu	5.32+2	242Pu	3.93-3
237Np	7.06-4	241Am	3.44+0
238Pu	1.71+1	243Am	2.00-1
239Pu	6.21-2	244Cm	8.10+1
240Pu	2.28-1	252Cf	5.38+2

^c Radionuclide distributions are based on the data presented in Table 3-3. The distribution for SRP 239Pu operations waste was modified to include 241Am (0.0002 weight fraction), based upon typical weapons grade plutonium composition data provided in Characteristics of Transuranic Waste at Department of Energy Sites, RFP-3357, May, 1983.

^d LLNL ships CH-TRU waste to NTS for storage and constitutes the major source of retrievably stored CH-TRU waste at NTS. Consequently, CH-TRU waste characterization data is identical for both sites.

Table 3-11. Projected RH-TRU Waste Shipments from
Generating and Storage Sites to the WIPPa

	Total Volume(m ³)	Waste Shipments ^b	
		Total	Annual Average
Hanford	1635	1635	82
INEL	429	429	21
LANL	175	175	9
ORNL	1665	1665	83

Notes:

- a RH waste volumes shipped to the WIPP are based upon data presented in Tables 3-17 thru 3.20 of DOE/RW-0006.
- b Based upon a 20 year workoff period.

Table 3-12. RH-TRU Waste Characterization^{a,b,c}

Radionuclide	Activity Distribution per Shipment (Ci)			
	Hanford	INEL	LANL	ORNL
60Co	1.4+2	1.4+2	1.4+2	1.4+2
90Sr	1.1+4	1.1+4	1.1+4	1.1+4
106Ru	9.6+1	9.6+1	9.6+1	9.6+1
137Cs	5.5+1	5.5+1	5.5+1	5.5+1
152Eu	2.8+1	2.8+1	2.8+1	2.8+1
154Eu	1.1+1	1.1+1	1.1+1	1.1+1
233U				3.4-3
238Pu	4. 3	5.5-2	3.6-3	1.6-3
239Pu	2.8-2	3.6-1	8.8-2	3.5-2
240Pu	1.4-2	1.0-1	2.0-2	
241Pu	9.5-1		8.9-1	
242Pu	2.0-3			
241Am		2.1-5	1.4-6	3.6-2
243Am				1.9-5
244Cm				3.8-1
252Cf				5.0-2
Average Ci Content/Cask	1.2+4	1.1+4	1.1+4	1.1+4

Notes:

- a Data from Table E-3, Defense Remotely Handled TRU Waste WIPP FEIS was used to calculate the curie content of the waste package. 106Rh and 137m Ba were deleted from the list because they were very insignificant contributors.
- b Volume of waste cask was based on latest data (Approximately 1 m³).
- c Numbers are expressed in abbreviated scientific notation: 1.20 x 10⁴ = 1.20+4

4. The Transportation of TRU Waste

4.1 Introduction

This chapter presents basic information about the transportation of TRU waste materials. Much of the information contained herein is excerpted from a report by Wolff²¹ which should be read if more detailed information is needed regarding organizations responsible for regulating the transportation of radioactive materials (RAM), federal requirements and regulations, and definitions of selected transportation terms and other relevant information. This chapter may, if appropriate, be appended to environmental documents, or it may be excerpted to meet particular needs. The discussions throughout this chapter are specific to the defense TRU waste program.

4.2 Agencies with Jurisdiction over the Transportation of Radioactive Waste

4.2.1 Federal Jurisdiction

A large number of federal organizations are involved in the safe transport of radioactive waste; their responsibilities and authorities are interrelated. Responsibilities and authorities of these agencies are defined by several pieces of federal legislation and by memoranda of understanding between federal agencies. The functions of the Department of Transportation (DOT), and the Department of Energy (DOE) are discussed here because of their predominance in defense transuranic waste materials transport.

The DOT has regulatory responsibility for safety in the transportation of all hazardous materials, including radioactive materials. This responsibility extends to all modes and means of transportation that would be considered for shipping waste to a repository. Under its establishing legislation, the Department of Transportation Act of 1966, the DOT is responsible for encouraging cooperation among Federal, State, and local governments; carriers; shippers; laborers; and other interested parties to achieve national transportation objectives. The regulatory and enforcement authority of the DOT over the interstate commerce of hazardous materials was extended by the Hazardous Materials Transportation Act of 1974 to include packaging, handling, labeling, placarding, routing, and driver training.

DOT regulations recognize the authority of DOE to certify its own packaging under standards equivalent to those used by the NRC. The DOE standards are contained in DOE Order 5480.1. The DOE Order 5820.2 establishes policies and guidelines by which DOE manages its radioactive waste, waste byproducts, and radioactive contaminated facilities. Chapter II of this order establishes policies and guidelines for managing the Department's TRU waste. A DOE WIPP report¹⁴ specifies basic requirements for the disposal of CH-TRU and RH-TRU waste at the WIPP.

4.2.2 State Role

The States also have an important role in regulating the transportation of radioactive materials. DOT regulations as modified by Docket HM-164²² established, effective February 1, 1982, routing and driver training requirements for highway carriers of packages of RAM exceeding a quantity of material now called a "highway route controlled quantity".

A highway route controlled quantity is defined as an amount of RAM in a single package that exceeds either

- o 3000 times the A_1 quantity for special form material,
- o 3000 times the A_2 quantity for normal form material, or
- o 30,000 Ci, whichever is less.

For any particular radionuclide or mixture, these values correspond to 3000 times the contents permitted in a Type A package or, in the case of nuclides with an A_1 or A_2 value (as appropriate) of more than 10 Ci, a designation of 30,000 Ci as the value. Packages containing a highway route controlled quantity of RAM are subject to specific routing control applying to the highway carrier.

The objectives of Docket HM-164²² (now included in 49 CFR 177²³) were to reduce the impacts of transporting RAM and to identify the role of state and local governments in routing RAM. The rule advised state and local governments as to how they can exercise authority over motor carriers under their own laws in a manner that the DOT considers as consistent with the DOT

rules. The DOT rules make those routes designated by appropriate state agencies enforceable by the Federal Government, based on DOT's own determination that such routes, if derived from an adequate safety analysis, are likely to result in further reduction in radiological risk. A safety analysis must be performed to assess transportation risks. The designating state agency must also consult with affected local or neighboring state jurisdictions. In the absence of state action, carriers are required to use the interstate system highways subject to the specific conditions set forth in the DOT rules. The carrier must report to the shipper the route used in making the shipment. Within 90 days of acceptance by a carrier of package containing a highway route controlled quantity of RAM, the shipper is required to report the routing information to the DOT. Truck TRU waste shipments to the WIPP will be made in accordance with all applicable regulations.

4.3 Waste Packaging Systems

4.3.1 CH-TRU Waste Packages and Packaging Systems

The terms "packaging" and "package" are used throughout this section. Packaging refers to the assembly of components necessary to enclose the radioactive contents completely (i.e. the TRUPACT); the term package refers to the packaging with its radioactive contents, as presented for transport.

4.3.1.1 The TRUPACT System

Currently under development is the TRUPACT-I packaging that has been designed to move the wide assortment of containers in which the CH-TRU waste is stored.

Figure 4-1. Packaging schematic of TRUPACT-I

Figure 4-1 is an exploded isometric drawing of the TRUPACT-I. Generally, dimensions of its cavity were determined by the need to transport waste containers varying widely in size and shape, including the 55-gal drums banded into "six-packs." The packaging uses a double-box concept. The space between the inner and outer box is filled with rigid poured-in-place polyurethane foam. The TRUPACT will be certified to a maximum package weight of 50,000 lbs. and will be hauled on flatbed trailers or railcars. The packaging will be designed to protect the cargo against collision, puncture, and fire in case of accident.

The development of a packaging such as the TRUPACT-I proceeds in sequence through design, analysis, scale and prototype tests, and commercial fabrication. The conceptual design for the TRUPACT-I was formalized in 1979. Detailed design and scale-model tests were completed in 1983, and a safety-analysis report is being completed. A prototype of TRUPACT-I was completed in 1984. Prototype testing and licensing is expected to be completed during 1985. Production of additional TRUPACTs should begin in 1986. The packaging systems now being designed are intended to be in compliance with regulatory requirements. They are being subjected to a full range of engineering tests.

4.3.2 RH-TRU Waste Packages and Packaging Systems

Remote-handled TRU waste accounts for a small percentage of waste shipments and is commonly generated during the decontamination or decommissioning of equipment and facilities. Generally composed of piping, valves, machine tools, concrete rubble, etc, RH-TRU waste must be sealed in containers for shipment in shielded packagings. RH-TRU could be transported in HLW and spent fuel packages discussed below.

4.3.3 HLW Packages and Packaging Systems

No shipping casks designed specifically for transporting canisters of HLW have been manufactured, but within the next 10 years the DOE will be immobilizing defense high-level waste (DHLW) into borosilicate glass contained in sealed canisters. Because present-day packages for transporting canisters cannot be modified to be efficient, a new truck cask is being developed by the DOE (Figure 4-2) for shipping DHLW.

Figure 4-2. Design concept for DHLW truck cask

The cask is configured so that remote handling can be used for all normal operations required for canister loading and unloading. The purpose is to minimize the radiation dose to facility operating personnel.

A depleted uranium shield liner provides gamma radiation shielding; no shielding for neutrons is needed. This liner can be removed or replaced to allow transport of radioactive wastes other than DHLW. To absorb energy and to protect the closure end of the DHLW during accidents, a ring ("external impact limiter") extends beyond the closure. The external impact limiter is a separate part fitted to the cask body to limit distortion in the outer closure seal area. The canister is held securely in place by an internal impact limiter that fits against the closure lid.

4.3.4 Spent Fuel Packages and Packaging Systems

Irradiated or spent fuel, like HLW, is also moved in shielded packaging called casks. These casks are designed to satisfy the federal regulations and orders. Because of structural strength, shielding, and heat-removal requirements, these casks are massive, weighing from 20 to 100 tons or more.

A typical cask consists of a large cylindrical metal vessel with a solid bottom with a bolted and gasketed lid. The closure area is protected by an energy-absorbing structure. This cask body is designed to contain and shield the fuel. Figure 4-3 depicts a typical spent fuel cask.

Figure 4-3 Generic spent-fuel cask schematic

Surrounding the inner cask shell is a layer of heavy metal, such as lead or depleted uranium, that provides gamma shielding. The exterior of the heavy-metal shield is in turn encased in another stainless steel shell. Impact limiter systems further protect the cask in accidents. The cask inner cavities are usually designed to accept different fuel assemblies by using interchangeable fuel support baskets. Penetrations to the cavities are needed for draining, venting, sampling, and similar activity. These penetrations pass through the cask body, or through the closure, and terminate outside the shielding at a valve or plug. The termination point is protected by being either recessed or surrounded by an energy absorber. Factors that determine differences in transport casks include spent fuel characteristics, cask capacity required, and individual facilities limitations such as crane capacity and dimensional limitations. A source of information on packaging, including those for irradiated fuels, is the NRC Directory of Certificates of Compliance for Radioactive Materials Packages (NUREG-0383)²⁴.

4.4 Radiological Impacts of Transporting Radioactive Materials Under Incident-Free Conditions

In incident-free transport, RAM arrives at its planned destination on time without releasing its contents and without loss of any required shielding. Luna et al, 1982, p 269,²⁵ have described the steps that generally take place when HLW is shipped. Their scenario, however, applies to other shipments ranging from radiopharmaceuticals to spent fuel. From incident-free transport, the exposure of the public and workers to radiation arises only from the radiation allowed by the standards to penetrate the package. Even though radiation shields are incorporated into package designs where needed to protect the public, workers, and vehicle crew members, the population surrounding the route may be exposed to radiation at very low dose rates.

One analytical tool for calculating exposures to population groups is the computer code RADTRAN II.²⁶⁻²⁹ In RADTRAN II, the assessment of population dose during incident-free (normal) transport is based on the assumption that the source of radiation is either a point or line source of external penetrating radiation. The actual equations used to calculate exposures differ among population groups and transportation modes, but their basis in the point or line source assumption is the same.

A method of predicting consequence due to incident-free transport is the so-called "unit consequence factors" (UCFs) developed by using RADTRAN II or similar tools to give consequence per unit distance traveled for each type of shipment. Unit consequence factors are presented in terms of consequences per unit of distance traveled. The term "consequence" is used because the probability of exposure is equal to one. Once the unit factors are calculated, they can be applied by simply multiplying them by the total distance traveled: $UCF \times distance = consequence$.³⁰ Once generated for a given set of assumptions, the unit factors should give exactly the same answer as RADTRAN when the identical assumptions are used with the RADTRAN model (See Chapter 5).

Certain data are needed regardless of the analytical approach adopted. In general, these data include

- Shipment packaging type
- Transport Index (or some other measure of radiation level outside the package)
- Transport mode
- Transport mode characteristics (crew size, speeds, dimensions)
- Route characteristics (length, number of stops, roadway type, population zones, etc.)
- Number of shipments

Table 4-1, taken from Madsen et al, 1984,²⁷ lists this code's population subgroups and mode combinations. Currently, eight subgroups (crewmembers, passengers, cargo handlers, flight attendants, warehouse personnel, people in the vicinity of the transportation vehicle while it is stopped, people surrounding the transportation link on which the vehicle is moving, and people sharing the transportation link with the vehicle) are used with the RADTRAN II code to compute the total doses in person-rem.

Table 4-1. Incident-Free Population Subgroups and Mode Combinations Used With RADTRAN II

Incident-Free Population Modes

- Highway
- Rail
- Air
- Water
- Mode Independent

Incident-Free Population Subgroups

Highway	Rail	Air	Water	Mode Independent
Crew	Crew	Crew	Crew	Handlers
Persons at stops	Persons at stops	Persons at stops	Persons at stops	Warehouse storage
Persons off-link	Persons off-link	Passengers Flight	Persons off-link	
Persons on-link	Persons on-link	Attendants		

4.5 Radiological Impacts of Transporting Radioactive Materials Under Accident Conditions

The impacts that could result from transportation accidents can also be calculated with RADTRAN II.

4.5.1 Accidents That Compromise Package Integrity.

In RADTRAN II, accidents that compromise package integrity are divided into those involving shipments of nondispersible materials, and those involving shipments of dispersible materials. In the first case, only direct exposure from shielding loss is of interest. In the second case, five doses are evaluated--groundshine (external exposure from deposited material), cloudshine (external exposure from passing cloud), resuspension (inhalation of material deposited and then resuspended), inhalation (internal inhalation exposure from aerosolized material) and food ingestion. Figure 4-4 shows the accident dose pathways modeled in RADTRAN II. If radionuclides are released in accidents,

both health effects discussed above and economic consequences are evaluated. Risk is calculated by summing the products of the probabilities of accidents and their consequences.

4.5.2 Unit Risk Factors

A method of predicting accident risk is the unit risk factor approach. Unit risk factors (URFs) are presented in terms of risk per unit of distance traveled. In analyses where the same assumptions apply, unit risk factors can be applied by simply multiplying them by the total distance traveled: $URF \times \text{distance} = \text{risk}$.³⁰ Users should also consult the original documents to verify the applicability of these factors in new analyses.

4.6 Nonradiological Impacts of Transporting Radioactive Materials Under Incident-Free Conditions

4.6.1 Nonradiological Impacts

Nonradiological impacts of transporting nuclear materials are the same as those resulting from transporting non-nuclear materials. That is, the nonradiological impacts do not consider the characteristics of the cargo. For example, shipping RAM increases nonradiological hazards only to the extent

Figure 4-4. Accident dose pathways modeled in RADTRAN II

that shipping other cargo (from vegetables to steel girders) would increase them. Estimates of health effects that result from exposure to air pollutants generated during incident-free transport of RAM are provided by Rao et al, (1982).³¹ Their study presents results for both truck and rail modes.

4.6.2 Unit Consequence Factors

Unit consequence factors from transporting radioactive or nonradioactive materials were calculated by Rao et al, 1982³¹ for both truck and rail travel. These factors were calculated for a composite of pollutants and are provided in Table 4-2. Since important assumptions had to be made in calculating these health effects, the users of this document should consult the original work by Rao and co-authors to assure themselves of the applicability of these assumptions.

Table 4-2. Unit Consequence Factors^a

Source	Health Effects per Kilometer	
	Truck	Rail
Pollutants	1.0×10^{-7} (urban travel only)	1.3×10^{-7} (urban travel only)
	0.5×10^{-8} (urban travel assumed as 5% of total travel) ^b	0.65×10^{-8} (urban travel assumed as 5% of total travel) ^b

Notes:

- a Fatalities expected after some latency period, e.g., cancer death.
- b These factors may be used if urban travel distance is assumed as 5% of the total travel distance (90% rural and 5% suburban) as discussed in NRC⁷.

4.7 Nonradiological Impacts of Transporting Radioactive Materials Under Accident Conditions

Accidents may cause injury or death, regardless of type of cargo. Truck and rail accident statistics for general commerce compiled from DOT data are shown in Table 4-3. Thus, we can expect 5.1×10^{-7} injuries/km and 3×10^{-8} deaths/km by truck.

Table 4-3. Unit Risk Factors for Accidents

Mode	Injuries/Km	Fatalities/km
Truck	5.1×10^{-7a}	$3.0 \times 10^{-8} a,b$
Rail	4.6×10^{-7a}	$3.4 \times 10^{-8} a,b$

Notes:

- a Data from Tables 6 and 7 of Rao, et al (1982).³¹ Injuries were calculated by multiplying fatality factors by ratios of injuries to deaths.
- b Deaths at the scene of an accident or during initial hospital treatment.

About 0.094 and 0.15 occupational injuries and illnesses per man-year occur among railroad transportation workers and truck and warehousing employees, respectively.³² However, since transportation of RAM does not (and for the foreseeable future is not likely to) account for a significant fraction of the total amount of materials transported either by rail or truck, RAM transportation will not significantly contribute to these injury and illness incidence rates.

4.8 Insurance Coverage for Transportation Accidents

The system of insurance or indemnity coverage for liability associated with accidents in transporting radioactive materials provides a high level of protection to the public. The foundation of this system is the Price-Anderson Act, which provides coverage for liability associated with nuclear incidents. This includes incidents which occur at the sites of covered facilities (including commercial power reactors and DOE nuclear facilities) or in the course of transportation to or from such facilities. All transportation modes are covered. Liability even for a terrorist act that causes dispersal of nuclear material is covered as long as the act occurs in the course of transportation to or from a covered facility. Price-Anderson's coverage is "omnibus," i.e., it covers any person liable for personal injury or property damage under the applicable law with respect to a nuclear accident.

The Price-Anderson Act has been re-enacted twice since 1957 and amended several other times. The most recent re-enactment was at the end of 1975. Unless again extended, the Act's authority for new coverage will expire on August 1, 1987. Both DOE and NRC have submitted reports to Congress urging

extension of the Price-Anderson Act beyond 1987 with certain modifications. DOE has included in its report the recommendation that the DOE indemnification and limitation on liability be comparable to that afforded by commercial utilities.

Table 4-4 indicates the applicable coverage for public liability associated with TRU waste in the course of transportation from DOE-managed sites.

Table 4-4. Applicable Insurance or Indemnity Coverage for Public Liability Associated With Defense TRU Waste in the Course of Transportation in the US

Nuclear Material	Origin	Destination	Applicable Coverage for Liability
Defense TRU Waste	Storage facility or reprocessing plant	Storage or facility	Government indemnity ^a

Note:

- ^a Indemnity for public liability is provided by the Federal Government under agreements entered into pursuant to the Price-Anderson Act (Section 170d). These are entered into between the Federal Government and its contractors (for liability up to \$500 million) or nonprofit educational institutions (for liability between \$250 thousand and \$500 million). In the case of nonprofit educational institutions, the first \$250 thousand is usually covered under a separate Facility Form for that amount.

4.9 Emergency Response

4.9.1 The Role of the Federal Government in Responding to Transportation Accidents

State and local governments have the lead role in responding to transportation accidents. The Federal Government has a supporting role and usually does not become involved unless specifically requested to do so by State or local officials. Exceptions to this general rule include situations involving nuclear weapons or related materials. In such situations, either the DoD or the DOE has the lead role in responding to an accident.

The Federal Emergency Management Agency (FEMA) is currently coordinating development of the Federal Radiological Emergency Response Plan covering all types of radiological incidents. This plan will incorporate all the major radiological response functions of federal agencies. Examples of the federal response resources available to State and local governments are provided in Guidance for Developing State and Local Radiological Emergency Response Plans and Preparedness for Transportation Accidents.³³

4.9.2 The Role of State and Local Governments in Responding to Transportation Accidents

The shipper and carrier bear primary responsibility for ensuring safe packaging and transport of RAM. However, State and local police and emergency crews are normally those who take the necessary immediate action for protecting the health and safety of the public following any transportation accident. These officials have the authority to take such actions as clearing the immediate area of all unauthorized persons, controlling traffic, extinguishing fires, and rescuing persons trapped in wreckage; they may also carry out mitigating measures such as diking to prevent water dispersion or covering spilled material with sand, water, tarpaulins, or heavy plastic sheets to minimize airborne dispersion.

4.9.3 Carrier Transportation Responsibilities in Emergencies

DOT regulations require carriers to take immediate action in emergencies. The carrier is responsible for notifying law-enforcement officials, the DOT, and the carrier's own management at the earliest possible moment. The carrier is responsible for keeping people from reaching the packages and from contact with any spilled radioactive materials, and for ensuring that any vehicles, areas, and equipment that may have become contaminated are not placed in service again until they have been surveyed and decontaminated. The carrier has the basic responsibility to ensure complete cleanup.

4.10 Alternate Modes for the Transportation of TRU Wastes

In evaluating transportation alternatives, one particular impact must be balanced against all others. For example, an alternative that results in a lower annual population radiation dose would be desirable from a radiological point of view, but should be balanced against nonradiological impacts such as the cost of implementation, or increased mechanical injuries and deaths.

4.10.1 Alternative 1: Transport of TRU Waste by Truck Via the Interstate Highway System or Via Routes Designated by Appropriate State Routing Agencies.

Private, contract, or common carriers may be chosen to transport nuclear materials by means of the interstate highway system. The role of State routing agencies in designating highway routes for highway carriers of a highway route controlled quantity was discussed in Section 4.2.2 of this Chapter. DOT Docket HM-164 requires the carrier of any RAM other than those containing highway route controlled quantity packages to examine available highway routes and choose a route that minimizes radiological risk to the public. More than one route could qualify as an acceptable alternative; it is not incumbent on the carrier or driver to make detailed calculations in selecting the most appropriate route. In making this determination, the carrier must consider available information on the most important factors contributing to minimizing radiological risk. These factors are population, accident rates of available highways, transit time, and the time of day and day of week for the shipment.

4.10.2 Alternative 2: Transport of TRU Waste by Rail

49 CFR 174 applies to the carriage of RAM by rail. Rail carriers could move RAM, although most RAM is currently transported by other modes. Current planning calls for the transport of TRU waste to the WIPP by both truck and rail. Rail routes depend largely on the railroad originally offered the shipment and how that (and each successive) railroad handles interconnections to other companies until the line serving the final destination of the RAM is reached.

4.10.3 Alternative 3: Transport of TRU Waste by Water or Air

Some nuclear wastes -- such as irradiated fuel from nuclear power plants -- might be transported from its origin by barge to a repository or intermediate location.* Use of the water mode will generally require multimodal transfer, i.e., to or from rail or highway modes. This alternative is not reasonable for transporting defense TRU wastes from generating/storage sites to the WIPP, due to the lack of navigable waters at most sites and/or cost factors.

Air transport is used for speed (where half-life is short and use is critical) and perhaps as a more secure, secondary transport mode. Since these advantages are not required for TRU waste, massive shipments by air are highly unlikely and would not be cost effective.

5. Transportation Risk Analysis

5.1 Introduction

This chapter reviews individual site and cumulative risk assessments for transporting defense TRU wastes from generating and storage sites to the WIPP and compares the risk assessments to similar existing analyses in NUREG-0170⁷ and in the WIPP/EIS⁶. More specifically, analyses presented here estimate the transportation impacts associated with TRU waste shipments from Hanford, INEL, LANL, LLNL, Mound, NTS, ORNL, and SRP to derive a system-wide (cumulative) transportation risk assessment.

This risk assessment incorporates the best available characterization data of TRU wastes and proposed transportation system information. However, because of the evolving nature of the DTWP, both information and data on the transportation of TRU wastes may be revised. To accommodate this uncertainty, the analyses included in this report represent conservative, or a range of conservative, estimates where specific planning information is not available at this time.

5.2 Existing TRU Waste Shipment Risk Analysis

NUREG-0170 Analyses. Risk analyses in NUREG-0170⁷ concluded that the risk of transporting radioactive material, including radioactive waste, over the nation's highways and rails is small. This generic risk assessment evaluated transportation of radioactive material for the level of shipment activity identified in 1975 and projected for 1985. Specific conclusions of the evaluation listed in the report's summary section (Pages vii and viii) include:

- o The average radiation dose to the population at risk from normal transportation of radioactive material is a small fraction of the limits recommended for members of the general public from all sources of radiation other than natural and medical sources and is a small fraction of natural background dose (110 mRem/yr $\pm$ 10 depending on altitude location, etc.).
- o Maximum radiation exposure of individuals from normal transportation is within allowable limits for members of the general public.

- o The radiological risk from accidents in transportation is small, amounting to about one-half of the normal (incident-free) transportation risk on an annual basis.
- o The NRC staff has determined that the environmental impacts of normal transportation of radioactive material and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes. Because transportation conducted under present regulations provides adequate safety to the public, the staff concludes that no immediate changes to the (NRC and DOT) regulations are needed at this time.

WIPP/EIS Analyses. Additional analyses in the WIPP/EIS⁶ address specific risks associated with the transportation of transuranic waste and high-level waste (for repository experiments) to WIPP. This assessment considered both the radiological and nonradiological impacts of CH-TRU waste shipments from INEL and RFP, RH-TRU waste shipments from INEL, an experimental high-level waste from Hanford (Pacific Northwest Lab). The WIPP/EIS did not address all waste generating and storage sites which could transport TRU wastes to the WIPP, though typical routes and estimated transportation distances from various origin sites to WIPP were identified.

Additionally, in the WIPP/EIS, it was assumed that 25 percent of the total CH-TRU volume would be shipped by truck and 75 percent by rail. All experimental high-level waste shipments were assumed to be by rail. Using a dose rate value of 2 mRem/hr at the outside surface of the TRUPACT, the WIPP/EIS analysis concluded that the radiological impact of incident-free transportation to the public is many times smaller than the effects from natural background radiation. The analysis further concluded that the probability of accidents involving TRU waste shipments which would result in radiological consequences is also small -- between 1 in 40,000 years and 1 in 4 million years. Even if such an event should occur in a small or large urban area, its impact would be less than the 50 year dose commitment (10 years to lungs) from natural background radiation. The WIPP/EIS analysis results are summarized in Tables 5-1, 5-2, and 5-3.

Table 5-1. WIPP/EIS Analysis of Radiological Impacts of Transportation
Under Incident-Free Conditions^a

Scenario ^b	Total Annual Dose (person-rem)	
	<u>Nonoccupational</u>	<u>Occupational^c</u>
Contact-Handled Waste		
INEL	4.69	17.39
RFP	.71	2.41
Remote-Handled Waste		
INEL	1.19	2.41
High-Level Waste		
Hanford	.14	0.006
Maximum Exposure Cases		
Individual exposed to all waste shipments at distance of 25 feet	.00015	
Individual detained 2 hours behind stalled truck trans- porting waste	.0016 ^d	

Notes:

- a Adapted from WIPP/EIS⁶ analysis (Table 6-6, 6-7, 6-8)
- b Based on fixed transportation mode-mix scenarios (CH: 75 percent rail, 25 percent truck; RH: 3 percent rail, 97 percent truck; DHLW: 100 percent rail)
- c Transportation crew only
- d Single occurrence

Table 5-2. WIPP/EIS Analysis of Radiological Impacts Of Transportation
Under Accident Conditions^{a, b, c, d}

Scenario	50 Year Dose Commitment (rem)		
	Bone	Lung	Whole Body
Contact-Handled Waste (INEL & RFP)			
Truck - small urban area	2,560	130	62
- large urban area	4,410	220	110
- maximum individual ^e	5.8	0.29	0.14
Rail - small urban area	7,680	390	190
- large urban area	13,200	660	330
- maximum individual ^e	17.4	0.87	0.42
Remote-Handled Waste (INEL)			
Truck - small urban area	0.6	0.2	0.7
- large urban area	1.2	0.3	1.1
- maximum individual ^e	0.0016	0.0004	0.0014
Rail - small urban area	3.6	0.9	3.2
- large urban area	6.2	1.5	5.4
- maximum individual ^e	.008	.002	0.007
Defense High-Level Waste (Hanford)			
Rail - small urban area	16,600	4,050	14,800
- large urban area	28,500	6,960	25,400
- maximum individual ^b	37	9.1	33

Notes:

^a Adapted from WIPP/EIS⁶ analysis (Tables 6-11, 6-12, 6-13)

^b Accident scenario probabilities:

Truck accident	- CH-TRU waste	.00000222
	- RH-TRU	.00000025
Rail accident	- CH-TRU waste	.000025
	- RH-TRU	.00000222
	- DHLW	.000001

^c The impact of radioactive material while in the body (inhaled at time of accident) was determined by integrating over a 50 year period.

^d For a small urban area, approximately 6000 people would be affected. The doses received by this population from natural background radiation are 30,000 person-rem to the bone and to the whole body during 50 years and 11,000 person-rem to the lung during 10 years.

^e For a large urban area, approximately 105,000 people are affected. The doses received at this population from natural background radiation are 525,000 person-rem to the bone and to the whole body during 50 years and 189,000 person-rem to the lung during 10 years.

Table 5-3. WIPP/EIS Analysis of Nonradiological Impacts of Transportation Under Accident Conditions

<u>Transport Mode</u>	<u>Expected Annual Consequences</u>	
	<u>Injuries</u>	<u>Deaths</u>
Truck	0.40	0.04
Rail	0.44	0.04
Total	0.84	0.08

Notes:

- a Adapted from WIPP/EIS analysis (Table 6-15)
- b Accidents include vehicular accidents, derailments, etc.

5.3 Risk Analysis of TRU Waste Shipments to WIPP

5.3.1 Analytical Approach for Cumulative Impacts

The cumulative risk analysis of TRU waste transport to WIPP evaluates both radiological and nonradiological impacts. In addition, risk contributions from both normal transportation (incident-free) and accident cases are considered.

Radiological impacts are further categorized by the population groups affected and are divided into occupational and nonoccupational groups. Individuals who receive occupational exposure would include truck drivers and crew members of trains. Rail occupational exposures include the dose received while performing inspections at interchanges in accordance with Department of Transportation regulations for railcars carrying hazardous materials. The inspection dose was calculated on the basis that one crew member performs the inspection, that the exposure rate equals the Transport Index Value, and that the exposure duration of all inspections along the route is one percent of the total stop-over time per shipment. The general public comprises the nonoccupationally-exposed group receiving only random exposure from radioactive waste transportation. To assess the impact to that segment of the population which may receive more exposure from living near a DOE-managed facility or along one of the transportation routes, the hypothetical maximum individual dose was calculated. Details of this calculation are presented in Section 5.3.3.

This cumulative risk assessment evaluates TRU waste shipments as discussed in the Defense Waste Management Plan² and as detailed in the Long Range Master Plan⁴ for TRU.

Accordingly, the analysis addresses only retrievably-stored and newly-generated TRU wastes. A definitive program for the processing and disposal of buried wastes and contaminated soils is being planned. Consequently, while various management options are being explored, these waste categories are not included in this transportation analysis. The analysis does include the impact of shipping both 238 Pu and 239 Pu operations waste from SRP to the WIPP, should this program option be selected. An artificial distinction of 50% 238 Pu and 239 Pu is made regarding transportation risk contributions from both TRU waste types in the analysis. Actual SRP shipments would not necessarily be segregated by TRU waste type and would have a risk estimate equal to the combined values for both 238 Pu and 239 Pu operations waste.

In all cases, the analysis in this report addresses TRU waste shipments from the sites to WIPP. While the possibility of intra-site shipments for centralized waste processing exists, none are currently planned and consequently are not included in the analysis. It is further noted that RH-TRU retrieval, processing, certification, and transportation programs are generally less advanced than similar programs for CH-TRU. This is because WIPP will not begin emplacement of RH waste until after routine emplacement of CH waste begins. Consequently, the analysis for RH-TRU waste transportation is based on conservative, or a range of conservative, estimates of information about transporting RH-TRU waste, consistent with WIPP/EIS assumptions for transporting RH-TRU waste.

At the present time, no definitive estimates of transportation mode mix ratios have been established. Therefore, to allow for the dynamics of transportation costs and the Defense TRU Waste Program, two cumulative transportation analyses were performed: a 100 percent truck case and a "maximum rail" case. The maximum rail case acknowledges that not all sites have rail access and in those instances waste shipments will be limited to the truck transport mode. This is the case for LANL and NTS. Rail lines are located near LLNL and ORNL,

but not on site. Consequently, the rail transportation option at LLNL and ORNL would also involve truck shipments from the site to the rail head. Since it is judged to be a low probability that inter-modal waste shipments will be employed, the analysis in this report assumes that any rail shipments will originate from the site. This simplification permits quantification of the impact of rail shipments, allows preliminary examination of alternative actions as encouraged by the NEPA process, and avoids incorporating uncertainties in the analysis associated with truck transport from the site to the rail head. However, if either LLNL or ORNL elect to transport TRU wastes by rail, the site will have to assess whether the combined transportation risk for both modes differs significantly from the risk assessment included in this report.

The RADTRAN II computer code was used to calculate the radiological impacts of TRU waste shipments to WIPP. A general discussion of RADTRAN II modeling capabilities is presented in Sections 4.4 and 4.5 of this report. Nonradiological impacts are calculated using methodology discussed in Sections 4.6 and 4.7.

5.3.2 RADTRAN II Input Parameters

Significant input data are required to run the RADTRAN II model. Major input parameters are summarized in this section. Several data sets have default values which are contained within the computer code and are used whenever they represent the best available information. For this analysis, general input data for CH- and RH-TRU waste shipments are listed in Table 5.4. Accident input data are presented in Table 5-5.

In the absence of historical data for package response to accidents of varying severity, certain assumptions were required. The general approach was to estimate an average release fraction for each severity category and assume that all containers in the Type B packaging respond the same way regardless of actual waste contents or form. It is assumed that there is no release for accidents falling within the limits of severity class one or two for which Type B packaging is qualified. For CH-TRU waste shipments using the TRUPACT, a release fraction of 10^{-6} was estimated for severity class 3 and represents

a loss of package integrity for an accident that slightly exceeds the regulatory limits for Type B packaging. Subsequent release fractions were increased by an order of magnitude for each succeeding accident severity class. Based upon impact test results summarized in Section 5.2.3 of NUREG-0170⁷ and release fraction Model II of this generic transportation risk analysis, it is believed that the foregoing assumptions are conservative. For RH-TRU waste shipments using a cask, release fractions for the various accident severity categories were estimated using the Model II values for 1975 Type B packages listed in Table 5-8 of NUREG-0170⁷.

The average distance from each origin site to WIPP, including the percent of travel in the rural, suburban, and urban populations zones, is presented in Table 5.6.

Determination of the Transport Index (TI), defined by transportation regulations as the dose in millirems per hour at one meter from the package, is dependent on several factors. Among these are the waste characteristics and curie loading per drum, the mix of waste types within the package, the number of drums per package, the self-shielding benefits of the package itself, and the shielding available from the TRUPACT-I or other transportation system. Due to the variability of CH-TRU and RH-TRU waste types at the individual sites, on-going waste characterization efforts, and an evolving TRUPACT-I and cask design, it was elected to perform the analysis using a range of average TI values. For CH-TRU wastes, TI values of 0.1 and 2.0 mRem/hr were selected. Based upon measured dose rates for actual shipments of TRU waste, this range of TI values is believed to conservatively bound expected dose rates. The upper bounding value is consistent with the dose rate assumption of 2 mRem/hr at the package surface in the WIPP/EIS. RH-TRU waste calculations were performed using TI values of 5.0, 10.0, and 20.0 mRem/hr, where the two larger values represent the regulatory maximum (49 CFR 173.441) for common and exclusive use shipments, respectively. It was assumed that RH-TRU rail shipments are by common carrier and RH-TRU truck shipments are made by exclusive use vehicles.

The average mass of TRU elements per cubic meter of waste and the average waste isotopic distribution for each site was calculated based upon the

projections for the year 2013 as listed in inventory data (Tables 3.17, 3.18, 3.19, 3.20 of Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics -- September 1984)¹³ and from information included in Table 3-3 of the TAGR. LLNL currently ships its TRU waste to NTS for interim storage. Consequently, for lack of more definitive information, NTS TRU waste characterization data are assumed to be representative of LLNL waste. Relevant radionuclide parameters are as noted in Table 5-4.

Table 5-4. RADTRAN II General Input Data

Parameter ^a	CH-TRU Waste		RH-TRU Waste	
	Truck	Rail	Truck	Rail
Package Type	TRUPACT		Cask	
Package Waste Volume, m ³	7.5		1.0	
Packages/Shipment	1	2	1	
Transport Index (TI), mrem/hr ^b	0.1/2.0		5.0/20.0	5.0/10.0
Package Length Dimension, m	4.69		4.12	
Number of Crewmen	2	5	2	5
Distance from Source to Crew, m	5	152	5	152
Speed, km/hr				
Urban Population Zone	24		24	
Suburban Population Zone	40		40	
Rural Population Zone	88	64	88	64
Stop Time per Kilometer, hr/km	.011	.086	.011	.086
No. of People Exposed while Stopped	50	100	50	100
No. of People per Vehicle	2	3	2	3
Population Density, People/km ²				
Urban Population Zone	3861		3861	
Suburban Population Zone	719		719	
Rural Population Zone	6		6	
Dispersability Category ^c	5		5	
Velocity of Deposition, m/sec	.01		.01	

Table 5-4. RADTRAN II General Input Data
(Continued)

Parameter ^a	CH-TRU Waste	RH-TRU Waste
Curie Content/Package ^{d,e}		
Average Curies/Package ^{d,e}		
RFP	5.05+1 ^f	
INEL	5.05+1	1.14+4
Hanford	8.91+1	1.19+4
LANL	3.41+2 ^g	1.15+4
SRP		
238Pu Waste	3.09+3	
239Pu Waste	1.36+2	
LLNL	1.29+2	
ORNL	3.15+2	1.14+4
NTS	1.29+2	
Mound	1.87+2	

Radionuclide	Photon Energy (MeV) ^{e,h}	Half-Life (Days) ^{e,h}	Cloudshine Dose Factor (rem-m ³ /ci-s) ^{e,i}
60Co	2.50+0	1.93+3	3.88-1
90Sr	0.00+0	1.06+4	0.00+0
106Ru	0.00+0	3.68+2	0.00+0
137Cs	0.00+0	1.10+4	0.00+0
152Eu	1.14+0	4.87+3	1.75-1
154Eu	1.22+0	3.21+3	1.94-1
233U	1.31-3	5.79+7	3.34-5
236Pu	2.09-3	1.04+3	1.69-5
237Np	3.43-2	7.82+8	3.22-3
238Pu	1.81-3	3.20+4	1.26-5
239Pu	7.96-4	8.79+6	1.16-5
240Pu	1.73-3	2.39+6	1.23-5
241Pu	2.54-6	5.26+3	0.00+0
241Am	3.24-2	1.58+5	2.66-3
242Pu	1.44-3	1.37+8	1.04-5
243Am	5.59-2	2.70+6	7.14-3
244Cm	1.70-3	6.61+3	1.21-5
252Cf	1.20-3	9.64+2	1.10-5

Table 5-4. RADTRAN II General Input Data
(Continued)

Notes:

- a Parameters are as defined in the RADTRAN II guide²⁶
- b A range of TI values were used for both the truck and rail cases. For the RH-TRU analysis, upper TI values were based upon regulatory radiation level limitations for exclusive use (truck) and common carrier (rail) shipments per 49 CFR 173.441.
- c Dispersibility categories were specified for CH and RH-TRU waste in order to model potential accidents resulting in the release of waste material. The dispersibility category determines the assumed fraction of waste which escapes in aerosol form and the fraction of aerosol less than 10 microns in aerodynamic diameter, which is potentially respirable. CH and RH-TRU wastes were conservatively modeled as a fine loose powder (Category 5).
- d Curie content per package for CH-TRU waste is based on average site specific characterization data presented in DOE/RW-0006¹³ and summarized in Section 3.4 of this document. For RH-TRU waste, the curie content of TRU isotopes is also based on average site-specific information presented in DOE/RW-0006. However, due to the limited nature of data for fission product co-contaminants (which dominate RH-TRU waste activity), curie distributions were based on expected maximum conditions provided in Table E-3 of the WIPP-EIS⁶. They are summarized in Section 3.4. This analytical approach is consistent with the WIPP/EIS and the level of detail afforded by current characterization data. It is noted that while the variability of waste types and loading of shipping packages will result in deviations from average values, the analytical approach is to utilize average site wastes characteristics. This makes it possible to develop a representative and composite estimate of transportation impacts over the operational life of the WIPP, but not for specific waste types, shipments, or years.
- e Numbers are presented in abbreviated scientific notation: $3.41 \times 10^3 = 3.41+3$.
- f Based upon INEL TRU waste characterization data.
- g Based upon NTS TRU waste characterization data.
- h From ICRP-38, Radionuclide Transformation, Energy and Intensity of Emissions, 1983.
- i From Dose-Rate Conversion Factors for External Exposure to Photons and Electrons, NUREG/CR-1918, July 1981.

Table 5-5. RADTRAN II Accident Input Data for CH and RH-TRU Waste Shipments ^a

Transport Mode ^b	Accidents Rates							
	Urban	Suburban	Rural					
Truck (Accidents/km) ^b	1.60-5	2.68-6	1.40-7					
Rail (Accidents/Railcar-km) ^b	1.30-5	2.97-6	1.45-7					
Accident Severity Categories								
	1	2	3	4	5	6	7	8
Severity Fraction ^b								
Truck								
Urban	5.83-1	3.82-1	2.78-2	6.36-3	7.42-4	1.46-4	1.13-5	9.94-7
Suburban	4.35-1	2.85-1	2.21-1	5.06-2	6.64-3	1.74-3	6.72-5	5.93-6
Rural	4.62-1	3.02-1	1.76-1	4.03-2	1.18-2	6.47-3	5.71-4	1.13-4
Rail								
Urban	5.72-1	3.43-1	7.72-2	7.72-2	5.14-4	1.86-5	8.57-6	7.15-7
Suburban	3.13-1	1.88-1	4.51-1	4.51-2	3.38-3	1.63-4	3.76-5	3.13-6
Rural	3.56-1	2.14-1	3.85-1	3.85-2	6.41-3	6.48-4	3.42-4	6.41-5
Release Fraction ^c								
CH-TkU	0.00	0.00	1.00-6	1.00-5	1.00-4	1.00-3	1.00-2	1.00-1
RH-TRU	0.00	0.00	0.00	0.00	0.00	1.00-2	5.00-2	1.00-1
Aerosol Fraction ^d								
	0.00	0.00	1.00-1	1.00-1	1.00-1	1.00-1	1.00-1	1.00-1
Respirable Aerosol ^d Fraction								
	0.00	0.00	5.00-2	5.00-2	5.00-2	5.00-2	5.00-2	5.00-2

Table 5-5. RADTRAN II Accident Input Data for CH and RH-TRU Waste Shipments ^a (Continued)

Notes:

- a Numbers are expressed in abbreviated scientific notation: $1.60 \times 10^{-5} = 1.60-5$
- b Accident frequency factors and the distribution of accident severity categories by population zone are RADTRAN II default values and represent the best available data.
- c Fraction of material released is based on discussion presented in text.
- d Aerosol and respirable fractions are RADTRAN II default values for fine, loose powder waste forms used to model all waste shipments.

Table 5-6. Average Distance to WIPP and Percent of Travel
in Various Population Zones^a

	Average Distance		Population Zone		
	Miles	(km)	Rural	Suburban	Urban
<u>Truck</u>					
RFP	700	(1126)	90.0	5.0	5.0
INEL	1200	(1931)	90.0	5.0	5.0
Hanford	1796	(2891)	81.9	16.5	1.6
LANL	343	(552)	90.2	9.1	.7
SRP	1605	(2583)	72.3	26.3	1.4
LLNL	1494	(2404)	84.0	13.3	2.7
ORNL	1345	(2164)	70.6	27.9	1.5
NTS	1101	(1772)	88.7	10.4	.9
Mound	1485	(2390)	90.0	5.0	5.0
<u>Rail</u>					
RFP	750	(1207)	79.7	18.9	1.4
INEL	1750	(2816)	79.7	18.9	1.4
Hanford	2277	(3664)	79.7	18.9	1.4
SRP	1946	(3131)	79.7	18.9	1.4
LLNL	1969	(3168)	79.7	18.9	1.4
ORNL	1607	(2587)	79.7	18.9	1.4
Mound	1553	(2500)	79.7	18.9	1.4

Notes:

^a RADTRAN II default mean population densities are utilized and correspond to:

Rural	-	6 persons/km ²
Suburban	-	719 persons/km ²
Urban	-	3861 persons/km ²

5.3.3 Maximum Radiological Exposure to an Individual

Calculations were made to determine the hypothetical maximum exposure to an individual from incident-free transportation of waste from each of the storage and generator sites. The cumulative value of all site shipments represents the maximum radiological exposure to an individual living near the WIPP facility. The analysis includes the following conservative assumptions:

- o The maximumly-exposed individual lives 30 m from a rail line or highway.
- o The individual is exposed to every waste shipment leaving a specific site or arriving at the WIPP.
- o Every shipment passes by traveling at 24 Km/hr.

The calculational procedure to estimate the maximum Dose Rate (DR) is summarized below²² (page 28 of reference 22):

$$DR(x) = \frac{2.0 \times 10^{-6} \cdot I(x) \cdot PPS \cdot SPY \cdot K}{V}$$

where,

$$I(x) = \int_x^{\infty} \frac{e^{-ur} B(r) dr}{r(r^2 - x^2)^{1/2}}$$

and

- PPS = Number of packages/shipment
- SPY = Total number of shipments
- K = Dose rate factor (mrem-m²/hr) = (TI)(1+d/2)²
where TI = Transportation Index
- x = Perpendicular distance of the individual from the shipment path (m)
- V = Average velocity (km/hr) of the shipment passing the point
- r = Distance of the individual from the passing vehicle (m)
- B(r) = Berger buildup factor for exposure increase. As a photon beam travels toward a target, some of the energy is attenuated by collisions with air molecules. This is expressed by the exponential decay function, e^{-ur}. Some of the scattered energy will be rescattered back toward the target. The Berger buildup factor accounts for this and is written as:
B(r) = (0.0006 r) + 1.
- u = The absorption coefficient for air (3.87 x 10⁻³ m⁻¹)

When the expression for B(r) is substituted into the integral I(x), the resulting equation can be written in terms of the zeroth order modified Bessel function and its first integral:

$$I(x) = 0.00006 \int_0^{ux} K_0(w) dw + \frac{1}{x} \int_{ux}^{\infty} K_1(w) dw$$

5.4 CH-TRU Risk Analysis Results

Nonradiological and radiological risks per CH-TRU waste shipment are presented in Tables 5-7 and 5-8, respectively. Nonradiological risks, as noted previously, include the impact of the return trip from WIPP to the individual sites. Risk contributions from both incident free transportation and potential vehicular accidents are tabulated for truck and rail cases (where rail access exists). To be consistent with existing analyses, this report presents radiological risks in units of person-rem. This measure also presents a basis for comparison with natural background radiation.

Cumulative radiological and nonradiological impacts from annual CH-TRU waste shipments are summarized in Tables 5-9 and 5-10, respectively. The average number of waste shipments per year from each site to the WIPP was calculated based upon the transportation projections listed in Table 3-9.

Radiological risks were computed as a function of both the transportation mode mix and Transport Index (TI) value. Nonoccupational risks from annual CH-TRU waste shipments range from approximately 3.5 to 1220.0 person-rem, while occupational risks vary from approximately 0.2 to 56.0 person-rem. The nonoccupational risk contribution from potential accidents which may result in the release of radioactive waste is very small and ranges from 0.100% to 0.035% of the radiological impact from normal transportation. For the stated conditions and assumptions in the analysis, nonoccupational exposures are highest for the maximum rail scenario (by a factor of approximately 16), with occupational exposures greatest for the 100% truck scenario (by factor of approximately 15). In this latter case, rail occupational exposures are insignificant due to the large source-to-crew distances involved and are primarily the result of DOT inspection activities. Estimated nonoccupational impacts for both the 100% truck and maximum rail scenarios are dominated by radiation exposure to the public during stop-over time, i.e. the period when the waste package is stationary for an extended period of time. As noted in Table 5-4, the stop-over time is specified as a function of the distance traveled from each waste generator/storage site to the WIPP. A value of $0.011 \text{ hrs/km}^{16}$ is used for truck shipments and $.086 \text{ hrs/km}^{16}$ for rail shipments. These stop times per km are based on estimated industry averages

for transcontinental trips. The truck value is relatively conservative considering that it factors in overnight stop-over time for transcontinental trips while proposed plans are to have two-person crews and no overnight stop-overs for shipments to the WIPP.

It should be recognized that the length of time spent at stops, the number of people present, and the distance between them and the shipment package are important factors in the estimation of transportation risk. These parameters have a high degree of variability with moderately large uncertainties associated with them. Values have been selected in an attempt to give an upper estimate of transportation impacts.

Sandia National Laboratory has recently made further refinements to the RADTRAN II code with an updated rail model. Preliminary computer runs using the new rail model and downwardly revised rail stop times, which Sandia believes to more realistically reflect actual industry averages, resulted in a significantly lower nonoccupational exposure (by a factor of 140). Occupational impacts increased by a factor of three, but remained very small. Due to time constraints and limited peer review of the revised model, this analysis did not incorporate the updated rail model. With the longer stop times utilized, however, this analysis provides a conservative estimate of the radiological risk to the public.

In addition, this analysis does not calculate dose commitments received by the public via the ingestion pathway should an accident occur involving a release of radionuclides to the environment. It is assumed that federal, state, and local agencies intervene by impounding property and using decontamination procedures to effectively eliminate this mode as a credible exposure pathway. This assumption is consistent with the WIPP EIS⁶. In response to questions regarding this assumption, Sandia Laboratory recently revised the RADTRAN code to include an ingestion pathway model. Preliminary computer runs using this revised model indicate that the ingestion dose commitment ranges from approximately 0.0002 to 0.001 of the total accident impact, which is already negligible when compared with the risk from normal transportation. Thus, due to the apparent insignificant impact of ingestion pathways and for the same reasons cited above for the revised rail model, this analysis did not incorporate the ingestion model.

The significance of the population doses can be determined by comparing the impact with doses received by the same population from natural background radiation. Estimating the affected population size as that segment of the public living within a half mile of the shipping routes, a total of approximately 7.0 million persons will be affected by Defense Waste Management Program CH-TRU waste shipments. If each person along the routes receives an average of 0.1 rem annually from natural background radiation sources, as discussed in the WIPP/EIS⁶ (Appendix O), the population dose resulting from natural radioactivity is 700,000 person-rem. Thus, in comparison, the upper limit of incremental risk to the same population exposed to CH-TRU waste shipments is approximately 0.17 percent of the dose that population would receive from natural sources.

Nonradiological health impacts per shipment (including return trip) are listed in Table 5-8, with cumulative annual risks quantified in Table 5-10.

The cumulative maximum radiological exposure resulting from incident-free transportation of waste from the various origin sites is presented in Table 5-11.

Table 5-7. Nonradiological Risk Per Shipment Of TRU Waste^{a,b,c}

Shipment Origin Site	Truck			Rail		
	Normal Transportation		Accident Case	Normal Transportation		Accident Case
	LCF's ^d	Fatalities		LCF's ^d	Fatalities	
RFP	1.13-5	6.76-5	1.15-3	4.39-6	8.21-5	1.11-3
INEL	1.93-5	1.16-4	1.97-3	1.03-5	1.92-4	2.59-3
Hanford	9.25-6	1.73-4	2.95-3	1.33-5	2.49-4	3.37-3
LANL ^e	7.18-7	3.31-5	5.63-4			
SRP	7.34-6	1.55-4	2.63-3	1.14-5	2.13-4	2.88-3
LLNL	1.28-5	1.44-4	2.45-3	1.15-5	2.15-4	2.91-3
ORNL	6.62-6	1.30-4	2.21-3	9.42-6	1.76-4	2.38-3
NTS ^e	3.15-6	1.06-4	1.81-3			
Mound	2.39-5	1.43-4	2.44-3	9.10-6	1.70-4	2.30-3

Notes:

- ^a Numbers are expressed in abbreviated scientific notation: $1.13 \times 10^{-5} = 1.13-5$.
- ^b Calculated risks include the impact of the return trip from WIPP to the generator/storage site.
- ^c The nonradiological risk per shipment is calculated using the average distance and fraction of travel information presented in Table 5-6, the incident-free (pollution) consequence factor is from Table 4-2 and the accident risk factors are listed in Table 4-3.
- ^d LCF's represent latent cancer fatalities from incremental vehicle pollution in urban areas.
- ^e Waste transportation to WIPP from LANL and NTS is limited to the truck mode.

Table 5-8. RADIOLOGICAL RISK PER SHIPMENT OF CH-TRU WASTE
TRUCK
(person-rem/shipment)^{a,b,c,d}

Shipment Origin Site	TI =	Normal Transportation Contribution				Accident Contribution
		Occupational		Nonoccupational		Nonoccupational
		2.0	0.1	2.0	0.1	2.0/0.1
RFP		2.70-2	1.43-2	3.83-2	1.86-3	1.48-6
INEL		4.70-2	2.30-3	6.45-2	3.28-3	2.54-6
Hanford		7.30-2	3.60-3	9.94-2	4.91-3	7.22-6
LANL ^e		1.30-2	6.30-4	1.82-2	9.10-4	7.61-6
SRP ^f						
238 Pu waste		7.10-2	3.60-3	9.19-2	4.65-3	1.78-3
239 Pu waste		7.10-2	3.60-3	9.19-2	4.65-3	5.55-5
LLNL		6.00-2	3.00-3	8.23-2	4.11-3	8.41-6
ORNL		6.10-2	3.00-3	7.84-2	3.87-3	1.11-4
NTS ^e		4.10-2	2.10-3	5.83-2	2.92-3	4.86-6
Mound		5.80-2	2.90-3	8.00-2	4.04-3	1.97-5
TI =		2.0		0.1		
Hypothetical Maximum ^g Exposed Individual From Normal Transportation		7.65-8		3.82-9		

Table 5-8. RADIOLOGICAL RISK PER SHIPMENT OF CH-TRU WASTE (Continued)
RAIL
(person-rem/shipment)^{a,b,c,d}

Shipment Origin Site	TI =	Normal Transportation Contribution				Accident Contribution
		Occupational ^h		Nonoccupational		Nonoccupational
		2.0	0.1	2.0	0.1	2.0/0.1
RFP		2.24-3	1.12-4	1.20+0	5.82-2	5.92-6
INEL		5.22-3	2.61-4	2.71+0	1.40-1	1.38-5
Hanford		6.79-3	3.39-4	3.51+0	1.81-1	1.11-5
SRP ^f						
238 Pu waste		5.80-3	2.90-4	3.01+0	1.51-1	1.64-3
239 Pu waste		5.80-3	2.90-4	3.01+0	1.51-1	5.14-5
LLNL		5.86-3	2.93-4	3.01+0	1.51-1	1.65-5
ORNL		4.79-3	2.39-4	2.51+0	3.88-4	9.56-5
Mound		4.63-3*	2.32-4*	2.41+0	1.20-1	7.81-5
TI =				2.0	0.1	
Hypothetical Maximum ^g Exposed Individual From Normal Transportation				1.53-7	7.65-9	

* Tabulated occup risks did not include DOT rail inspection activities. They were included in Table 5-9.

Table 5-8. RADIOLOGICAL RISK PER SHIPMENT OF CH-TRU WASTE (Continued)
RAIL
(person-rem/shipment)^{a,b,c,d}

Notes:

- a Numbers are expressed in abbreviated scientific notation: $2.70 \times 10^{-2} = 2.70-2$.
- b Risks per waste shipment are expressed in equivalent whole body dose and are tabulated in units of person-rem.
- c Values for rail are expressed per railcar shipment.
- d Risks per waste shipment are presented as a function of the Transport Index (TI) which is defined as the dose rate in mrem/hr at 1 meter from the waste package. Calculations are based on one TRUPACT-1 waste package per truck and two per railcar shipment.
- e LANL and NTS waste shipments are limited to the truck mode.
- f Several options exist for processing and disposing of SRP ^{238}Pu waste. This analysis incorporates the impact of shipping ^{238}Pu operations waste to the WIPP in the event that the defense TRU Program makes the decision to do so; however, its impact is separated from ^{239}Pu waste transportation risks to allow for alternative program actions.
- g The hypothetical maximum exposure to an individual was calculated assuming he is exposed to every waste shipment and lives 30 meters from a rail line or highway.
- h Rail occupational risks resulting from normal transportation include the impact of DOT inspection activities.

Table 5-9. Cumulative Radiological Risk for Annual^{a,b,c}
CH-TRU Waste Shipments (person-rem)

TI = 2.0 mrem/hr				
Shipment Origin Site	100% Truck		Maximum Rail	
	Nonoccupational	Occupational	Nonoccupational	Occupational
RFPd				
Normal	1.93+1	1.36+1	3.02+2	5.63-1
Accident	7.44-4		1.49-3	
INEL				
Normal	2.20+1	1.60+1	4.61+2	8.88-1
Accident	8.64-4		2.35-3	
Hanford				
Normal	1.45+1	1.06+1	2.56+2	4.95-1
Accident	1.05-3		8.09-4	
LANL ^e				
Normal	1.60+0	1.14+0	1.60+0	1.14+0
Accident	6.69-4		6.69-4	
SRP				
238 Pu Waste				
Normal	3.93+0	3.04+0	6.44+1	1.24-1
Accident	7.62-2		3.51-2	
239 Pu Waste				
Normal	3.93+0	3.04+0	6.44+1	1.24-1
Accident	2.38-3		1.10-3	
LLNL ^f				
Normal	2.59+0	1.89+0	4.74+1	9.24-2
Accident	2.65-4		2.60-4	
ORNL				
Normal	5.36-1	5.22+0	8.63+0	1.65-2
Accident	7.59-4		3.29-4	
NTS				
Normal	3.08-1	2.16-1	3.08-1	2.16-1
Accident	2.59-5		2.57-5	
Mound				
Normal	1.55+1	8.07-1	1.68+1	3.22-2
Accident	2.74-4		5.44-4	
Cumulative Risk	8.42+1	5.56+1	1.22+3	3.69

Table 5-9. Cumulative Radiological Risk for Annual^{a,b,c}
CH-TRU Waste Shipments (person-rem)
(Continued)

Shipment Origin Site	TI = 0.1 mrem/hr			
	100% Truck		Maximum Rail	
	Nonoccupational	Occupational	Nonoccupational	Occupational
RFPd				
Normal	9.35-1	7.19-1	1.46+1	2.82-2
Accident	7.44-4		1.49-3	
INEL				
Normal	1.12+0	7.83-1	2.38+1	4.44-2
Accident	8.64-4		2.35-3	
Hanford				
Normal	7.16-1	5.25-1	1.32+1	2.47-2
Accident	1.05-3		8.09-4	
LANL ^e				
Normal	8.00-2	5.54-2	8.00-2	5.54-2
Accident	6.69-4		6.69-4	
SRP				
238 Pu Waste				
Normal	1.99-1	1.54-1	3.23+0	6.21-3
Accident	7.62-2		3.51-2	
239 Pu Waste				
Normal	1.99-1	1.54-1	3.23+0	6.21-3
Accident	2.38-3		1.10-3	
LLNL ^f				
Normal	1.29-1	9.44-2	2.38+0	4.62-3
Accident	2.65-4		2.60-4	
ORNL				
Normal	2.65-2	2.05-2	1.33-3	8.22-4
Accident	7.59-4		3.29-4	
NTS ^e				
Normal	1.54-2	1.11-2	1.57-2	1.11-2
Accident	2.57-5		2.57-5	
Mound				
Normal	5.62-2	4.04-2	8.35-1	1.61-3
Accident	2.74-4		5.44-4	
Cumulative Risk	3.48+0	2.56+0	6.13+1	1.83-1

Table 5-9. Cumulative Radiological Risk for Annual
CH-TRU Waste Shipments (person-rem)^a
(Continued)

Notes:

- a Cumulative radiological risks are presented in terms of person-rem for normal transportation and accident conditions. Equivalent whole-body doses are calculated for accident case dose commitments to individual organs following the recommendations of the International Commission on Radiological Protection, Publication 26, January 1977. The number of latent cancer fatalities (LCF) may be estimated by multiplying by the dose conversion factor of 2.10^{-4} LCFs/person-rem.
- b Occupational impacts quantify the doses received by the transportation crews.
- c Annual population group risks are calculated by multiplying the risk/shipment identified in Table 5-8 by the average number of shipments to WIPP per year by truck or rail as determined from the projections in Table 3-9 and 3-10 respectively. Rail occupational risks resulting from normal transportation include the impact of inspection activities.
- d RFP risks are estimated assuming waste characteristics, including radionuclide distribution and content, are comparable to INEL.
- e LANL and NTS waste shipments are limited to the truck mode.
- f LLNL risks are estimated assuming waste characteristics, including radionuclide composition, are comparable to NTS.

Table 5-10. Cumulative Nonradiological Risk for
Annual CH-TRU Waste Shipments^{a,b,c}

Shipment Origin Site	100% Truck			Maximum Rail		
	LCFs ^d	Fatalities	Injuries	LCFs ^d	Fatalities	Injuries
RFP	5.68-3	3.40-2	5.78-1	1.10-3	2.06-3	2.79-1
INEL	6.57-3	3.95-2	6.70-1	1.75-3	3.27-2	4.41-1
Hanford	1.35-3	2.52-2	4.30-1	9.70-4	1.82-2	2.46-1
LANL ^e	6.32-5	2.91-3	4.95-2	6.32-5	2.91-3	4.95-2
SRP						
238 Pu Waste	3.14-4	6.63-3	1.13-1	2.44-4	4.56-3	6.16-2
239 Pu Waste	3.14-4	6.63-3	1.13-1	2.44-4	4.56-3	6.16-2
LLNL	4.03-4	4.53-3	7.71-2	1.81-4	3.39-3	4.59-2
ORNL	4.53-5	8.89-4	1.51-2	3.24-5	6.05-4	8.19-3
NTS ^e	1.66-5	5.60-4	9.56-3	1.66-5	5.60-4	9.56-3
Mound	3.33-4	1.99-3	3.40-2	6.33-5	1.18-3	1.60-2
Cumulative Risk	1.51-2	1.23-1	2.09+0	4.66-3	7.07-2	1.22+0

Notes:

- a Numbers are expressed in abbreviated scientific notation: $5.68 \times 10^{-3} = 5.68-3$.
- b Calculated risks include the impact of the return trip from WIPP to the generator/storage site.
- c Annual individual site risks are calculated by multiplying the risk per shipment identified in Table 5.8 by the average projected number of shipments to WIPP per year by truck or rail as determined from Table 3.9 and 3.10 respectively.
- d LCFs represent latent cancer fatalities.
- e LANL and NTS waste shipments are limited to the truck mode.

Table 5-11. Hypothetical Maximum Exposure to an Individual
From Incident-Free Transportation of CH-TRU Waste^{a,b}

Shipment Origin Site	Annual Maximum Exposure (person-rem)			
	^d		^d	
	100% Truck		Maximum Rail	
	TI = 2.0	0.1	2.0	0.1
RFP	3.85-5	1.92-6	3.85-5	1.92-6
INEL	2.60-5	1.30-6	2.60-5	1.30-6
Hanford	1.12-5	5.57-7	1.12-5	5.57-7
LANL ^c	6.73-6	3.36-7	6.73-6	3.36-7
SRP				
238 Pu Waste	3.27-6	1.64-7	3.27-6	1.64-7
239 Pu Waste	3.27-6	1.64-7	3.27-6	1.64-7
LLNL	2.41-6	1.20-7	2.41-6	1.20-7
ORNL	5.23-7	2.61-8	5.23-7	2.61-8
NTSC	4.04-7	2.02-8	4.04-7	2.02-8
Mound	1.06-6	5.32-8	1.06-6	5.32-8
Cumulative Exposure (WIPP) ^d	9.34-5	4.66-6	9.35-5	4.66-6

Notes:

- ^a Numbers are expressed in abbreviated scientific notation: $3.85 \times 10^{-5} = 3.85-5$.
- ^b Annual values are calculated by multiplying the hypothetical maximum exposure per shipment identified in Table 5-7 by the average number of shipments to WIPP per year by truck or rail as determined from the projections in Table 3-9.
- ^c Transportation is limited to the truck mode.
- ^d The cumulative hypothetical maximum exposure represents the potential dose received by an individual living near WIPP exposed to every waste shipment emplaced at the facility.

5.5 RH-TRU Waste Analysis

Remote-handled (RH) Transuranic (TRU) waste materials are contaminated with beta or gamma emitting nuclides. RH-TRU waste containers have a waste container surface radiation level that exceeds 200 mrem/hr. The radiation level of most RH-TRU waste is less than 100 rem/hr.

To place RH-TRU wastes in perspective with CH-TRU wastes, a comparison of the overall volumes of retrievably TRU wastes is useful. The volume of CH-TRU waste is a large percentage (99 percent) of all retrievable stored TRU waste. The stored RH-TRU waste (753 m^3) is geographically distributed among the storage sites at Hanford, INEL, LANL, and ORNL³⁴. The majority of RH-TRU waste (653 m^3) is stored at ORNL³⁴.

Over the next decade, it is projected that approximately 88 m^3 of RH TRU waste will be generated annually, primarily at ORNL ($34 \text{ m}^3/\text{yr}$) and Hanford ($33 \text{ m}^3/\text{yr}$)³⁴. Other significant contributors of RH TRU waste include the Idaho Chemical Processing Plant ($7 \text{ m}^3/\text{yr}$); Argonne-East ($5 \text{ m}^3/\text{yr}$); LANL ($5 \text{ m}^3/\text{yr}$); Argonne-West ($2 \text{ m}^3/\text{yr}$); and Battelle Columbus ($1 \text{ m}^3/\text{yr}$)³⁴.

Shipment of RH-TRU waste to WIPP will begin after CH-TRU waste shipments to WIPP become routine. It is currently planned that RH-TRU waste be directly shipped to WIPP from the waste generator. The following risk analysis is based on the current volumes in storage and the projected volumes presented above. The analysis presents only worst scenarios based on the best available data to date.

5.5.1 RH-TRU Risk Analysis Results

Radiological risks per RH-TRU waste shipment are presented in Table 5-12. Nonradiological risks, as noted previously, include the impact of the return trip from WIPP to the individual sites and are quantified in Table 5-8. Risk contributions from both incident free transportation and potential vehicular accidents are tabulated for truck and rail (where access exists) cases. As noted previously, this report presents radiological risks in units of person-rem.

Cumulative radiological and nonradiological impacts from annual RH-TRU waste shipments are summarized in Tables 5-13 and 5-14, respectively. From Table 3-11, a total of 195 shipments of RH-TRU waste will be shipped to WIPP annually. For purpose of this study, 250 shipments (the maximum receiving rate for WIPP) were assumed. This provides a conservative estimate of RH-TRU waste transportation impacts. Accordingly, the analysis assumed annual individual site shipments to WIPP that are 30% (250 vs. 195) higher than the values presented in Table 3-11.

Radiological risks were computed as a function of both the transportation mode mix and Transport Index (TI) value. Nonoccupational risks from annual RH-TRU waste shipments range from approximately 27.5 to 927.0 person-rem, while occupational risks vary from 3.5 to 35.0 person-rem. The risk contribution from potential accidents which may result in the release of radioactive waste is very small. Estimated nonoccupational impacts are dominated by radiation exposure to the public during stop-over time, i.e. the period when the waste package is stationary for an extended period of time. As noted in Table 5-4, the stop-over time is specified as a function of the distance traveled from each waste generator/storage site to the WIPP. A value of 0.011 hrs/km¹⁷ is used for truck shipments and .086 hrs/km¹⁷ for rail shipments. These stop times per kilometer are based on estimated industry averages for transcontinental trips. The truck value is relatively conservative considering that it factors in overnight stop-over time for transcontinental trips while proposed plans are to have two-person crews and no overnight stop-overs for shipments to the WIPP.

The reader is referred to the discussion in Section 5.4 regarding exclusion from consideration of dose commitments received from ingestion pathways for accidents involving a release of radionuclides to the environment

The significance of the population doses can be determined by comparing the impact with doses received by the same population from natural background radiation. Estimating the affected population size as that segment of the public living within a half mile of the shipping routes, a total of approximately 4.40 million persons will be affected by Defense Waste Management Program RH-TRU waste shipments. If each person along the routes

receives an average of 0.1 rem annually from natural background radiation sources, as discussed in the WIPP/EIS⁶ (Appendix O), the population dose resulting from natural radioactivity is 440,000 person-rem. Thus, in comparison, the upper limit of incremental risk to the same population exposed to RH-TRU waste shipments is approximately 0.2 percent of the dose that the population would receive from natural sources.

Nonradiological health impacts per shipment (including return trip) are listed in Table 5-7, with cumulative annual risks quantified in Table 5-14.

The cumulative maximum radiological exposure resulting from incident-free transportation of waste from the various origin sites is presented in Table 5-15. For the case where the TI equals the regulatory maximum value, the annual hypothetical maximum exposure to an individual who sees every waste shipment emplaced at the WIPP ranges from 5.18×10^{-5} to 9.98×10^{-5} person-rem, depending on the transportation mode.

Table 5-12. Radiological Risk Per Shipment of RH-TRU Waste^{a,b,c,d}
(person-rem/shipment)

Shipment Origin Site	Normal Transportation Contribution				Accident Contribution	
	Occupational		Nonoccupational		Nonoccupational	
Truck	TI =	20.0	5.0	20.0	5.0	20.0/5.0
HANFORD		1.60-1	9.50-2	3.68-1	1.34-1	4.12-4
ORNL		1.40-1	7.90-2	2.92-1	1.02-1	4.17-4
INEL		1.00-1	6.10-2	2.41-1	8.43-2	1.46-4
LANL ^e		2.80-2	1.70-2	6.74-2	2.36-2	3.70-5
Rail	TI =	10.0	5.0	10.0	5.0	10.0/5.0
HANFORD		3.24-2	1.62-2	4.61+0	2.31+0	1.16-4
ORNL		2.28-2	1.14-2	3.21+0	1.61+0	6.89-5
INEL		2.49-2	1.24-2	3.51+0	1.81+0	7.51-5
TI =		20.0		10.0		5.0
Hypothetical Maximum ^f Exposed Individual From Normal Transportation						
Truck		3.99-7				9.97-8
Rail				1.99-7		9.97-8

Table 5-12. Radiological Risk per Shipment of RH-TRU waste^{a,b,c,d} (Continued)
(person-rem/shipment)

Notes:

- a Numbers are expressed in abbreviated scientific notation: $1.60 \times 10^1 = 1.60-1$.
- b Values for rail are expressed per railcar shipment.
- c Risks per waste shipment are tabulated in units of person-rem. The equivalent whole body dose was calculated based upon the recommendations of the International Commission on Radiological Protection, Publication 26, January 1977.
- d Risks per waste shipment are presented as a function of the Transport Index (TI) which is defined as the dose rate in mrem/hr at 1 meter from the waste package. Calculations are based on one RH canister per cask and one cask per truck or railcar shipment.
- e LANL RH-TRU waste shipments are limited to the truck mode.
- f The hypothetical maximum exposure to an individual from normal transportation of TRU waste was calculated assuming he lives 30 meters from a rail line or highway. The hypothetical maximum exposure value per shipment is dependent on the Transport Index (TI) and independent of waste origin site.
- g Rail occupational risks resulting from normal transportation include the impact of DOT inspection activities.

Table 5-13. Cumulative Radiological Risk
for Annual RH-TRU Waste Shipments^{a,b,c,d,e}
(person-rem)

Shipment Origin Site	TI = 5.0 mRem/hr			
	100% Truck		Maximum Rail	
	Nonoccupational	Occupational	Nonoccupational	Occupational
HANFORD				
Normal	1.40+1	9.98+0	2.42+2	1.71+0
Accident	4.33-2		1.22-2	
ORNL				
Normal	1.09+1	8.45+0	1.72+2	1.22+0
Accident	4.46-2		7.37-3	
INEL				
Normal	2.36+0	1.71+0	5.05+1	3.48-1
Accident	4.09-3		2.10-3	
LANL ^f				
Normal	2.36-1	1.70-1	2.36-1	1.70-1
Accident	3.70-4		3.70-4	
Cumulative Risk	2.75+1	2.03+1	4.65+2	3.45+0
TI = Regulatory Maximum ^g				
HANFORD				
Normal	3.86+1	1.68+1	4.84+2	3.40+0
Accident	4.33-2		1.22-2	
ORNL				
Normal	3.12+1	1.50+1	3.44+2	2.44+0
Accident	4.46-2		7.37-3	
INEL				
Normal	6.75+0	2.80+0	9.83+1	6.97-1
Accident	3.70-4		3.70-4	
LANL ^f				
Normal	6.74-1	2.80-1	6.74-1	2.80-1
Accident	3.70-4		3.70-4	
Cumulative Risk	7.73+1	3.49+1	9.27+2	6.82+0

Table 5-13. Cumulative Radiological Risk
for Annual RH-TRU Waste Shipments^{a,b,c,d,e}
(person-rem) (Continued)

Notes:

- a Numbers are expressed in abbreviated scientific notation: $1.40 \times 10^1 = 1.40+1$.
- b Cumulative radiological risks are presented in terms of person-rem for normal transportation and accident conditions. The number of latent cancer fatalities (LCF) may be estimated by multiplying by the dose conversion factor of 2.10^{-4} LCFs/person-rem.
- c Occupational impacts quantify the doses received by the transportation crews. For rail transportation cases, this includes the dose received during inspection activities.
- d Nonoccupational impacts quantify the doses received by the general public.
- e Annual population group risks are calculated by multiplying the risk/shipment identified in Table 5-12 by upper estimates for the average number of site shipments to WIPP per year as noted below (see Chapter 5 discussion):

HANFORD	105 shipments/year
ORNL	107 shipments/year
INEL	28 shipments/year
LANL	10 shipments/year
- f LANL waste shipments are limited to the truck mode.
- g 49 CFR 173.441 specifies transportation radiation level limitations, with a maximum transport index of 10 for common carriers and a maximum of 10 millirem per hour at 2 meters from the transport vehicle for exclusive use shipments. Assuming a line source, this latter requirement results in a maximum transport index of 20. This analysis assumes that rail shipments are by common carrier and truck shipments are made as exclusive use.

Table 5-14. Cumulative Nonradiological Risk for
Annual RH-TRU Waste Shipments^{a,b,c}

Shipment Origin Site	100% Truck			Maximum Rail		
	LCFs ^d	Fatalities	Injuries	LCFs ^d	Fatalities	Injuries
Hanford	9.71-4	1.82-2	3.10-1	1.40-3	2.61-2	3.54-1
ORNL	7.08-4	1.39-2	2.36-1	1.01-3	1.88-2	2.55-1
INEL	5.40-4	3.25-3	5.52-2	2.88-4	5.38-3	7.25-2
LANL ^e	7.18-6	3.31-4	5.63-3	7.18-6	3.31-4	5.63-3
Cumulative Risk	2.23-3	3.57-2	6.07-1	2.71-3	5.06-2	6.87-1

Notes:

- a Numbers are expressed in abbreviated scientific notation: $9.71 \times 10^{-4} = 9.71-4$.
- b Calculated risks include the impact of the return trip from WIPP to the generator/storage site.
- c Annual individual site risks are calculated by multiplying the risk per shipment identified in Table 5.7 by upper estimates for the average number of site shipments to WIPP per year as summarized below:

Hanford	105 Shipments/Year
ORNL	107 Shipments/Year
INEL	28 Shipments/Year
LANL	10 Shipments/Year

- d LCFs represent latent cancer fatalities.
- e LANL waste shipments are limited to the truck mode.

Table 5-15. Hypothetical Maximum Exposure to an Individual
From Incident-Free Transportation of RH-TRU Waste^{a,b}

Shipment Origin Site	Annual Maximum Exposure (person-rem)			
	100% Truck		Maximum Rail	
	TI = 5.0	20.0	5.0	10.0
Hanford	1.05-5	4.19-5	1.05-5	2.09-5
ORNL	1.07-5	4.27-5	1.07-5	2.13-5
INEL	2.79-6	1.12-5	2.79-6	5.57-6
LANLC	9.97-7	3.99-6	9.97-7	3.99-6 ^e
Cumulative Risk ^d (WIPP)	2.50-5	9.98-5	2.50-5	5.18-5

Notes:

- a Numbers are expressed in abbreviated scientific notation $1.05 \times 10^{-5} = 1.05-5$.
- b Annual values are calculated by multiplying the hypothetical maximum exposure per shipment identified in Table 5-12 by the average number of shipments to WIPP per year by truck or rail.
- c Transportation is limited to the truck mode.
- d The cumulative hypothetical maximum exposure represents the potential dose received by an individual living near WIPP exposed to every waste shipment emplaced at the facility.
- e Based on TI value of 20.0.

6. Glossary of Selected Radioactive Materials and Transportation Terms

Certified Waste. Waste that has been confirmed to comply with disposal site waste acceptance criteria.^a

Contact-Handled TRU Waste. TRU waste with external dose rates low enough (less than 200/hr mrem at container's surface) such that shielding beyond the primary containment packaging is not necessary. Containers of Contact-Handled TRU waste may be handled directly without the need for remote handling equipment.^b

Defense Waste. Radioactive waste from any activity performed in whole or in part in support of DOE atomic energy defense activities. The term excludes radioactive waste under purview of the Nuclear Regulatory Commission or generated by the commercial nuclear power industry.^a

Department of Energy Radioactive Waste. Radioactive waste generated directly by activities of the Department (or its predecessors) and its contractors or subcontractors or other radioactive waste for which the Department is responsible. Such waste may be referred to as DOE Waste.^a

High-Level Waste (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of TRU waste and fission products in concentrations as to require permanent isolation.^a

Newly-Generated TRU Wastes. TRU wastes that are being produced by ongoing operations. They are considered newly-generated until placed into interim storage.^b

Radioactive Waste. Solid, liquid, or gaseous material of negligible economic value that contains radionuclides in excess of threshold quantities except for radioactive material from post weapons test activities.^a

Remotely Handled TRU Waste. TRU waste that requires shielding in addition to that provided by its container. In general, this includes wastes with a beta-gamma radiation dose rate of more than 200 mrem/hr at the surface. When surface radiation dose levels exceed these limits, packages are handled by remote techniques and/or require additional shielding.^b

Transuranium Radionuclide. Any radionuclide having an atomic number greater than 92.^b

Transuranic Package Transporter. (TRUPACT-I) - A transportation system under development for truck or train transportation of TRU wastes.^b

TRU Waste. Without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g. Regarding the Waste Isolation Pilot Plant, high-level waste and spent nuclear fuel as defined by this Order are specifically excluded by this definition.^a

TRU WASTE ACCEPTANCE CRITERIA FOR WIPP (WIPP-WAC) - General requirements established to qualify TRU wastes for emplacement in the WIPP.^b

TRU WASTE COMPLIANCE REQUIREMENTS - The detailed and specific requirements for waste containers, waste forms and waste packages to certify that TRU wastes meet the Waste Acceptance Criteria. TRU waste generating and storage sites must develop their own site-specific certification procedures from these compliance requirements.^b

Notes:

a DOE Order 5820.2

b DOE-TRU-8302, Defense Transuranic Waste Program Strategy Document, 1984.

7. CITED REFERENCES

1. Public Law 97-90, Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1982.
2. US Department of Energy, 1983. The Defense Waste Management Plan, DOE/DP-0015.
3. Waste Isolation Pilot Plant (WIPP); Record of Decision 48 FR 9162, January 28, 1981.
4. US Department of Energy, 1984. Long-Range Master Plan for Defense Transuranic Waste Management, DOE-TRU-8201 (Rev 1).
5. US Department of Energy, 1984. Defense Transuranic Waste Program NEPA Strategy and Planning Document, TLO-85/7.
6. US Department of Energy, 1980. Final Environmental Impact Statement, Waste Isolation Pilot Plant, DOE/EIS-0026 Washington, DC.
7. US Nuclear Regulatory Commission, 1977. Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0170, Vols 1 and 2, Office of Standards Development, Washington, DC.
8. US Nuclear Regulatory Commission, 1976. Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle. A Task Force Report. NUREG-0116 (Supp 1 to WASH-1248) PB-258 316 US Department of Commerce, National Technical Information Service.
9. 40 CFR 1500-1508 as reported in FR 43 55978-56007, November 29, 1978.
10. US Department of Energy. Compliance with the National Environmental Policy Act; Final Guidelines. 45 FR:20694-20701; March 28, 1980, and any subsequent amendments.
11. DOE Order 5440.1B.
12. 48 FR 7977, February 23, 1982.
13. US Department of Energy, 1984. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006.
14. US Department of Energy, 1981. TRU Waste Acceptance Criteria for the Waste Isolation Plant, WIPP-DOE-069.
15. Personal Communication.
16. Neuhauser, K. S., J. W. Cashwell, P. C. Reardon, and G. W. McNair, 1984. A Preliminary Cost and Risk Analysis for Transporting Spent Fuel and High-Level Wastes to Candidate Repository Sites, SAND84-1795, TTC-0506, Albuquerque, NM: Sandia National Laboratories.
17. Wilmot, E. L., M. M. Madsen, J. W. Cashwell, and D. S. Joy, 1983. A Preliminary Analysis of the Cost and Risk of Transporting Nuclear Waste to Potential Candidate Repository Sites, SAND83-0867, TTC-0434, Albuquerque, N.M.: Sandia National Laboratories.
18. Personal Communication.
19. Joy, D. S. and P. E. Johnson, 1983. Highway Transportation Routing Model: Program Description and Revised Users Manual, ORNL/TM-8759, Oak Ridge, TN: Oak Ridge National Laboratory.
20. Peterson, B. E., 1984. Interline: A Railroad Routing Model. Oak Ridge National Laboratory, ORNL/TM-8944.
21. Wolff, T.A., 1984. The Transportation of Nuclear Materials, SAND 84-0062, TTC 0471, Albuquerque, NM: Sandia National Laboratories.
22. DOT Docket Number HM-164, 46 FR 5298, January 19, 1981.
23. 49 CFR 177.825.
24. US Nuclear Regulatory Commission, Directory of Certificates of Compliance for Radioactive Materials Packages, NUREG-0383.
25. Luna, R. E., R. M. Jefferson, R. B. Pope, and G. C. Allen, 1982. "Nuclear Waste Transportation," Underground Space, Vol 6, pp 264-271.

26. Madsen, M. M., E. L. Wilmot, and J. M. Taylor, 1983. RADTRAN II User Guide, SAND82-2681, TTC-0399, Albuquerque, NM: Sandia National Laboratories.
27. Madsen, M. M., J. M. Taylor, and P. C. Reardon, 1984. RADTRAN II, UPDATED, SAND84-0036, TTC-0470, Albuquerque, NM: Sandia National Laboratories.
28. Taylor, J. M. and S. L. Daniel, 1977. RADTRAN II: A Computer Code to Analyze Transportation of Radioactive Material, SAND76-0243, Albuquerque, NM: Sandia National Laboratories.
29. Taylor, J. M. and S. L. Daniel, 1982. RADTRAN II: Revised Computer Code to Analyze Transportation of Radioactive Material, SAND80-1943, TTC-0239, Albuquerque, NM: Sandia National Laboratories.
30. Finley, N. C., R. E. Luna, M. M. Madsen, J. D. McClure, T. A. Wheeler, E. L. Wheeler, E. L. Wilmot, 1983. The Transportation of Radioactive Material (RAM) To and From US Nuclear Power Plants,, Draft Environmental Assessment, SAND81-0118, NUREG/CR-2325.
31. Rao, R. K., E. L. Wilmot, and R. E. Luna, 1982. Non-Radiological Impacts of Transporting Radioactive Material, SAND81-1703, TTC-0236, Albuquerque, NM: Sandia National Laboratories.
32. US Bureau of the Census, 1982. Statistical Abstract of the United States: 1982-1983, (103d ed) Washington, DC.
33. FEMA (Federal Emergency Management Agency), 1983. Guidance for Developing State and Local Radiological Emergency Response Plans and Preparedness for Transportation Accidents, FEMA-REP-5, Washington, DC
34. U. S. Department of Energy, 1985. Remote-Handled TRU Waste Strategy Document.

Appendix

Annotated Outline for Preparation of an Environmental Document

This section provides annotated comments on the typical environmental document outline included in section 2.4. This information is presented to provide guidance in developing integrated site-specific NEPA documentation. It should help ensure consistency with other NEPA documents assessing the potential impact of transporting TRU wastes to WIPP. The annotation describes typical issues and inputs that would be relevant for integrated site documentation. It should be emphasized that many potential issues may already have been addressed in existing individual site environmental impact statements and should, therefore, be incorporated in any additional documentation by reference.¹⁴

I. PURPOSE AND NEED FOR THE PROPOSED ACTION

I.1 Purpose

This section should briefly describe the purpose of the proposed action and what it entails.

I.2 Need

Information for this section should be taken from program planning documents which outline the goals and objectives of ending interim storage and emplacing wastes in the WIPP.

I.3 Scope of the Review

This section should state why the document is being prepared and what alternatives are examined. Potentially significant issues should be noted, as well as issues already analyzed in other NEPA documents and incorporated by reference in this one.

II. ALTERNATIVES INCLUDING THE PROPOSED ACTION

II.1 Proposed Action

Here the proposed action should be described in terms of what is intended to be accomplished. This will include a description of the processes involved in the action. In general, the action consists of those operations portrayed in Figure 2-1, which

includes retrieving, processing, certifying, shipping, and emplacing TRU waste in the WIPP. These actions should be described for the site-specific action to the extent necessary for assessing environmental consequences in section IV of this outline.

II.2 Alternatives

This section should describe the alternatives examined in the environmental document. These alternatives should include no action, on-site disposal, transportation modes, and packaging. Other alternatives may also be included depending on the specific on-site operations and facilities required to prepare wastes for shipment.

The no-action alternative is a "business as usual" assessment, a continuation of the present operation. The implications and reasonableness of this alternative should be discussed. For instance, it may require construction of additional storage facilities. Depending on the level of detail necessary, the environmental consequences of the alternative may be briefly described here. If a detailed description is necessary it may be appropriate to defer this discussion to section IV of this outline.

On-site disposal would be a major alternative to the proposed action. A scenario for developing an on-site disposal facility should be described if it is deemed feasible. This description might consist of a general consideration of available locations, scheduling, on-site transportation, and costs of an on-site disposal facility. Other considerations may be discussed, such as local and state requirements and perceptions of developing an on-site facility. This description will be largely determined by site-specific considerations.

Information needed for describing alternative modes of transportation, waste packaging, and transportation routes is included in Chapters 3, 4, and 5 of the TAGR. These alternatives should be described only to the extent needed for the environmental analysis in section IV of this outline.

II.3 Comparison of Alternatives

This section should present the environmental impacts of the proposed action and alternatives in comparative form. This approach is necessary to provide the reviewers and decision-makers with a basis for evaluating the relative

environmental consequences of options. One convenient and effective way of providing this comparison is through tables that provide a matrix summarizing environmental consequences of the various alternatives and comparing them to the proposed action. This can be accomplished by developing two tables. A hypothetical example of what these tables might look like is provided in Tables A-1 and A-2. Table A-1 presents the activities involved in the proposed action with a summary of their impact on various environmental categories. Table A-1 then summarizes the aggregate impacts for each category of the proposed action as a base level of impact and uses this as the reference for comparing the impacts of alternatives to those of the proposed action. It should be noted that the information used in these tables should be developed from results of analysis in Section IV of this document. In other words, this is a type of executive summary that has been extracted from the detailed analysis of environmental consequences.

III. THE AFFECTED ENVIRONMENT

The section on the affected environment provides the reader with an orientation through a description of the relevant aspects of the existing environment. The relevant description will be determined by what analysis is necessary to assess the environmental consequences of the proposed action. For instance: if new construction should take place, it might be necessary to describe the physical environment of the proposed site; analysis of emissions may require a description of prevailing weather patterns; analysis of effluents would imply describing relevant aspects of the existing streams in the area. For a NEPA document, some brief general description of traditional aspects of the environment such as wildlife, ecology, endangered species, wetlands, and terrain may be necessary even though there may be little or no environmental consequences associated with the proposed action related to these aspects of the environment. Sections III.1 and III.2 below suggest some general areas where description may be relevant to the proposed action.

III.1 Site Location and Characteristics

There should be a general description of the DOE site where the waste is stored and/or generated. This should include the location of the DOE site in terms of generally known landmarks such as major cities and the nearest incorporations. There should be a more specific description of the area(s) where the waste proposed for shipment is located within the DOE facility. Other specific subsections will probably be required. These might include: site topography, land use, meteorology, geology, hydrology, surface water, groundwater, and ambient radiological

Table A-1. Summary of Potential Environmental Impacts Associated with Hypothetical Action to Process Newly-Generated Radioactive Wastes and Transport Off-Site for Disposal

Activities	Land Use/Water Use	Ecology	Air Quality/ Water Quality	Work Force	Surrounding Population
<u>Site</u>					
Construction	Minimal land use for new structures	Negligible	Short-term fugitive dust emissions and suspended solids in storm sewer	Small work crew	Minimal socioeconomic impacts
Operation	Negligible increase in current water usage; discontinue use of waste storage pits	Negligible	1% increase in radioactive emissions to atmosphere. Negligible changes in liquid effluents	No significant change from existing operations	Incremental radiation dose commitments less than 1% of EPA standards of 25 millirem/year (40 CFR Part 61)
<u>Transportation</u>					
Normal transport	None	None	None	Radiation dose commitment of less than 11.5 person-rem/year to truck drivers	Total radiation dose commitment of about 168 person-rem/year for waste transportation
Accidents	None	None	Potential release of small quantity of radioactive materials to atmosphere	Estimated radiation dose to lungs of 180 mrem for persons in accident area who inhale radioactive dust for 1 hour	Potential exposure to dispersed radioactive materials. Dose commitment would be small (few millirems)
<u>Disposal</u>	Few acres of land each year Negligible water	Minimal	Negligible change in air quality. Potential for groundwater contamination in long term	Small exposure to radioactivity	Potential exposure to radioactivity in long term

Table A-2. Summary Comparison of Potential Environmental Impacts of Hypothetical Action and Alternatives for Processing Newly-Generated Radioactive Wastes and Ship Off-Site for Disposal

Alternatives	Land Use/Water Use	Ecology	Air Quality/ Water Quality	Work Force ^a	Surrounding Population
Proposed Action	Reference ^c	Reference	Reference	Reference	Reference
No Action	More land for on-site storage (disposal) pits	Same	Continued fugitive dust emissions from waste pits. Potential ground-water contamination from on-site storage pits	Continued exposure to radioactivity from on-site storage pits	Potential exposure to radioactivity in air and groundwater from on-site storage pits
On-site Storage of Processed Waste	More land for storage facilities	Same	Same	No exposure to radioactivity from transportation of waste	No exposure to radioactivity from transportation of waste
Rail Shipment of Processed Wastes	Same	Possibly greater since trans. accidents would likely occur in undisturbed areas	Same	Less exposure to radioactivity from transportation of waste	Less exposure to radioactivity from transportation of waste
Alternative Disposal Sites ^b	Same	Same	Same	Slight difference: exposures vary with transportation distances	Slight difference: exposures vary with transportation distances
Improved Waste Form	Possibly more land for a waste-cement mixing plant	Same	Same	Slightly greater exposures to radioactivity due to increased shipment volumes	Potential exposures much less for transportation accidents

Notes:

^a Includes transportation personnel

^b Includes only acceptable alternative sites

^c Potential impacts in Table 1; all other impacts are compared to reference case for each impact area.

characteristics. Many of these descriptions may be quite brief. In general, relatively more detailed descriptions would be appropriate for those aspects of the affected environment where potential environmental consequences were closely scrutinized. For instance, description of existing radiological conditions and monitoring at the storage site(s) would tend to be more detailed than descriptions of land use.

Most of the descriptions required for this section can probably be found in other site NEPA documents. If so, the information should be briefly summarized and the document incorporated by reference.

III.2 Transportation Routes

The process of transporting the waste to WIPP defines another general category for describing the affected environment. This would include a description of the likely route to WIPP, traffic, and population patterns along the route, and any general or specific components of the transportation environment that would be relevant to the proposed shipments to WIPP. Description may include the states and localities traveled through, the types of road (interstate, state, local), mileage, time required, percentage of rural and urban transport, accident rates for sections of the route, etc. This information specific for each site is included in Chapters 3 and 4 of this report. Any on-site transportation should also be described. On-site transportation may be relatively insignificant in terms of mileage covered; however, it could be potentially significant for analysis since it may result in additional handling, a different container for shipping, or some other factor that make it different from cross-country shipment.

IV. ENVIRONMENTAL CONSEQUENCES

This section assesses the potential environmental consequences of implementing the proposed action described in section II.1 of the outline. The environment in which the action is taken is described in section III. Analysis required for assessing the potential environmental consequences of alternatives described in section II should also be included here.

A crucial question is: What are the potentially significant consequences that should be evaluated? This is not a question that can be answered from a strictly objective viewpoint. It is important to consider public and reviewer perceptions in determining what potential impacts should be addressed. For instance, analysis may show that the potential radioactive impacts are much less significant than potential impacts from nonradiological components of the action. Yet, it may be obvious that the potential radiological impacts are perceived as the important issue. This implies that the focus of the assessment will be predominately on potential radiological impacts even though they are less significant.

An important aspect of this section is using reference points for determining the significance of the potential impact which are consistent with other site analyses. Therefore, the sites should reference the analyses included in Chapter 5 of this report. The health effects are assessed in terms of the regulatory limits for exposure to radiation. The significance impacts may be stated in terms of their relative importance compared to other types of risk. For example, the risk of exposure to radiation from transport may be compared to other occupational and nonoccupational risks of transportation such as vehicle accidents and pollution.

IV.1 Proposed Action

The potentially significant impacts of the proposed action can be divided into potential impacts resulting from on-site activities, potential impacts from transportation to WIPP, and potential incremental impacts from disposal at the WIPP site.

IV.1.1 On-site Impacts

The scope of on-site operations necessary to process the TRU wastes for shipment should be reviewed to set the stage for analyzing the on-site impacts. This review may be brief, but it should be sufficiently thorough to indicate that the necessary operations relative to the proposed action have been considered.

Most on-site issues will be related to occupational exposures to radiation. However, potential nonradiation impacts from activities, such as construction of processing facilities, might be briefly considered for completeness even if the potential impacts would generally be considered insignificant and noncontroversial. Occupational radiation exposures are associated with the handling and processing of TRU wastes as it is readied for shipment. Exposures may result from direct radiation, airborne emissions, and effluents. For the most part, potential exposures would probably affect the on-site workforce. However, the possibility of off-site radiation exposures from nontransportation activities should be addressed in each site's NEPA documentation.

The agenda for analysis of potential on-site impact will be determined by the site-specific activities that have been defined by the scope of on-site operations. The essential elements for consideration are the potential ways in which exposure could occur, the number of persons who are likely to receive increased exposure because of the activity, followed by quantifying the exposure. Quantifying the potential exposure involves estimating the expected dose and effects under the planned scenario as well as considering potential accidental exposures.

It is important to consider both the aggregate increase in radiation exposure and the incidence and magnitude of exposure to the individuals with the highest risk. In other words, the summation of all incremental exposures should be considered as a potential impact. This measurement will reflect the potential impact relative to existing levels. The potential impact will depend on on-site activities required to process and package the TRU wastes for shipment. Potential processing steps include any volume reduction such as shredding, incineration, or compaction; assaying in order to certify that the site's wastes meet WIPP/WAC; treatment processes that assure the waste conforms to WIPP/WAC and DOT requirements, including such treatments as grouting wastes into solid matrix or reducing moisture content to an acceptable level.

Assessing the potential on-site impacts will require mapping out the various steps of the on-site processes. Information to assess potential impacts may come from the site's previous experience with monitoring radiation activity including occupational exposures. This information may be applied to various types of analyses including dispersion models for estimating potential radiation releases through airborne emissions and water effluents. The sophistication of the analysis should depend on the available information and the probability of potential radiation exposures.

IV.1.2 Transportation Issues

Issues related to transporting TRU wastes to the WIPP include: the potential radiological impact to the drivers and associated workforce involved in transporting the wastes; and potential impacts to population along the route under incident-free and accident conditions. Both maximum individual exposures and population doses should be considered.

Potential radiation exposure and health effects from transportation of wastes is an especially crucial area for NEPA documentation because of public perceptions. Therefore, even if potential impacts from transporting wastes can be shown to be insignificant in general, this assessment needs to be carefully documented.

TRU waste generation/storage facilities should be incorporated with the results of the transportation risk analysis presented in Chapter 5 of the TAGR to comply with their site-specific NEPA documentation requirements to quantify their individual transportation risks and the cumulative impact of all site waste shipments.

IV.1.3 Disposal Issues

Final disposal at WIPP involves issues associated with the incremental impact on WIPP's planned operation. This involves both planned capacity at WIPP and the ability of WIPP to process the peak flows given shipment schedules. The site-specific analysis should answer what the incremental impact of that site's projected shipment of waste would have on the WIPP operation. Because the operations at WIPP have already been the subject of a NEPA review, here the quantities of waste from the site in question should be compared to the capacity considered in the WIPP/EIS. In most (if not all) cases, the relative quantities will be small and the environmental consequences of disposal can be incorporated into the site's documentation by reference to the WIPP/EIS (See Chapter 3 of this report for relevant data).

IV.2 Alternatives

Alternatives to the proposed action include options within the proposed action and alternatives to the proposed action (See section II of the outline). Alternatives within the proposed action may include such options as alternative modes of transport to WIPP, or perhaps alternatives to processing and packaging wastes.

IV.2.1 Transportation Alternatives

Transportation alternatives may include alternative modes of shipment, and alternative transport packaging and routes within each mode. The most obvious alternative transport modes are rail and truck (alternative packaging options and modes are described in Chapter 4 of this document). The assessment of these options should focus

on the advantages and disadvantages relative to the proposed action. Issues might include the differences in environmental and health risk, availability of the option, cost of the option, and the option's conformity to federal and state regulations. For instance, an assessment of a packaging option may estimate whether the alternative will be available in the time frame when the proposed action is scheduled; or how the health and environmental risk would differ.

Analysis of other alternatives to the proposed action should be placed in a context appropriate for making comparisons to the proposed action. For instance, the analysis could abstract aspects from an alternative similar to the proposed action. This would not be the focus of analysis since consequences would also be similar. Rather the focus of analysis would be on the aspects of the alternatives.

V. List of Preparers

This section should list the individuals who prepared the environmental document, including their affiliations and qualifications.