Supplemental Information Related to Risk Assessment for the Off-Site Transportation of Transuranic Waste for the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ANL-E	Argonne National Laboratory-East
CH-TRUW	contact-handled transuranic waste
DOE	U.S. Department of Energy
ETEC	Energy Technology Engineering Center
Hanford	Hanford Site
ICRP	International Commission on Radiological Protection
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley National Laboratory
LDR	land disposal restriction
LLNL	Lawrence Livermore National Laboratory
MEI	maximally exposed individual
Mound	Mound Plant
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
PEIS	Programmatic Environmental Impact Statement
PGDP	Paducah Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RH-TRUW	remote-handled transuranic waste
SFEIS	supplemental final environmental impact statement
SNL-NM	Sandia National Laboratories (New Mexico)
SRS	Savannah River Site
TRUW	transuranic waste
TSD	treatment, storage, and disposal
UofMO	University of Missouri at Columbia
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant
WM	Waste Management
WVDP	West Valley Demonstration Project

UNITS OF MEASURE

ft	foot (feet)
g	gram(s)
h	hour(s)

kg	kilogram(s)
km	kilometer(s)
lb	pound(s)
m	meter(s)
m ³	cubic meter(s)
mi	mile(s)
mph	mile(s) per hour
mrem	millirem(s)
nCi	nanocurie(s)
rem	roentgen-equivalent man
yd ³	cubic yard(s)
yr	year(s)

**SUPPLEMENTAL INFORMATION RELATED TO RISK ASSESSMENT FOR
THE OFF-SITE TRANSPORTATION OF TRANSURANIC WASTE FOR
THE U.S. DEPARTMENT OF ENERGY WASTE MANAGEMENT
PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT**

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ABSTRACT

This report presents supplemental information to support the human health risk assessment conducted for the transportation of transuranic waste (TRUW) in support of the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement (WM PEIS). Detailed descriptions of the transportation health risk assessment method and results of the assessment are presented in Appendix E of the WM PEIS and are not repeated in this report. This report presents additional information that is not presented in Appendix E but is necessary to conduct the transportation risk assessment for Waste Management (WM) contact- and remote-handled (CH and RH) TRUW. Included are definitions of the TRUW alternatives considered in the WM PEIS, data related to the inventory and to the physical and radiological characteristics of CH and RH TRUW, and detailed results of the assessment for each WM TRUW case considered.

1 INTRODUCTION

This report presents supplemental information to support the human health risk assessment conducted for the transportation of transuranic waste (TRUW) for the U.S. Department of Energy (DOE) Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE 1996a).

Detailed descriptions of the transportation health risk assessment methodology, major assumptions, and packaging and routing determinations, as well as a summary of the results of the transportation assessment, are presented in Appendix E of the WM PEIS and are not repeated in this report. This report presents additional information that is not presented in Appendix E but is necessary to conduct the transportation risk assessment. This report should be read in conjunction with Appendix E to provide a complete description of the transportation risk assessment conducted for TRUW. Similar supporting reports have been prepared for the transportation assessments

conducted for the WM PEIS alternatives for high-level waste, low-level waste, and low-level mixed waste (Monette et al. 1996a,b,c).

This report includes definitions of the TRUW alternatives considered in the WM PEIS and presents data related to the inventory and physical and radiological characteristics of TRUW that are used in the transportation assessment (Section 2). In addition, supplemental data for the calculations for risk assessment are provided (Section 3), and detailed results of the assessment are presented for each case considered (Section 4). Additional details of the DOE TRUW inventory, characteristics, and treatment options considered in the WM PEIS can be found in a technical supporting report by Hong et al. (1996).

2 TRANSURANIC WASTE ALTERNATIVES, INVENTORY, AND CHARACTERIZATION DATA

The risks of transporting TRUW have been assessed for five alternatives in the WM PEIS. The transportation risks for each alternative depend on the amount of waste transported, the physical waste form, and the quantity of radioactivity (curies) in each shipment. This section of the report describes the alternatives considered in the WM PEIS and presents important TRUW inventory and characterization data used in the transportation assessment.

2.1 DEFINITION OF TRANSURANIC WASTE

The DOE defines TRUW as, "without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years, and concentrations greater than 100 nCi/g [nanocuries per gram] at the time of assay" (DOE 1988). This lower limit is interpreted as being per gram of waste matrix; the limit does not include the weights of added external shielding or waste containers (including any rigid liners) (DOE 1991). By definition, TRUW includes isotopes of neptunium, plutonium, americium, curium, and californium. In addition, wastes containing uranium-233 and radium-226 may be managed as TRUW.

Transuranic waste is primarily generated by research and development activities, plutonium recovery, and manufacturing of weapons. In addition, TRUW is also often retrieved during environmental restoration and decontamination and decommissioning projects. Before 1970, all DOE-generated TRUW was disposed of on-site in shallow landfill-type configurations. In 1970, the Atomic Energy Commission, the DOE's predecessor, concluded that waste containing long-lived alpha-wave-emitting radionuclides should be more isolated from the environment. Thus, all TRUW generated since the early 1970s has been segregated from other types of waste and placed in temporary storage pending shipment and final disposal in a permanent geologic repository (Oak Ridge National Laboratory 1992). The TRUW generated since 1970 is described as retrievably stored and is the primary focus of the WM PEIS. The TRUW generated before 1970 is known as nonretrievably stored or buried TRUW, and it may ultimately be the focus of DOE environmental restoration activities.

Packaged TRUW is characterized by the external dose rate at the surface of the package. Packaged TRUW with a surface dose rate of 200 mrem/h or less is categorized as contact-handled TRUW (CH-TRUW). Packaged TRUW with a surface dose rate of more than 200 mrem/h is categorized as remote-handled TRUW (RH-TRUW). Contact-handled TRUW is typically contained in 0.21-m³ (55-gal) drums or in standard waste boxes. Remote-handled TRUW is typically contained in drums, canisters, or concrete casks. Compared with CH-TRUW, RH-TRUW generally requires additional shielding during handling and transportation to protect personnel. As such, RH-TRUW typically requires special equipment and facilities for handling, treatment, and transportation.

2.2 CHARACTERISTICS OF TRANSURANIC WASTE

To support the WM PEIS analysis of TRUW alternatives, a report has been prepared describing the TRUW inventory and characteristics at each DOE site (Hong et al. 1996). In addition, Hong et al. (1996) describe the current and projected capabilities for TRUW treatment, storage, and disposal (TSD) within the DOE complex and present the important assumptions associated with the analysis of TRUW alternatives. The information in Hong et al. (1996) was used as the primary source of information for the transportation assessment.

In Hong et al. (1996), the current inventories and annual generation rates of TRUW are reported for 16 sites in the DOE complex. Management activities involving TRUW generation and storage are performed at 10 major DOE sites: the Hanford Site (Hanford), Idaho National Engineering Laboratory (INEL), Los Alamos National Laboratory (LANL), the Oak Ridge Reservation (ORR), Rocky Flats Environmental Technology Site (RFETS), Savannah River Site (SRS), Argonne National Laboratory-East (ANL-E), Lawrence Livermore National Laboratory (LLNL), the Mound Plant (Mound), and the Nevada Test Site (NTS). Small generators include the Energy Technology Engineering Center (ETEC), the Paducah Gaseous Diffusion Plant (PGDP), Sandia National Laboratories (New Mexico) (SNL-NM), the West Valley Demonstration Project (WVDP), Lawrence Berkeley National Laboratory (LBL), and the University of Missouri at Columbia (UofMO).

For purposes of assessment, the WM PEIS considers current retrievably stored TRUW inventories plus 20 years of generation. For each site, information on inventory is presented by Hong et al. (1996) in terms of projected waste volumes and masses. In addition, the physical and radiological characteristics of the waste at each site are presented. Information from Hong et al. (1996) that is important for the transportation assessment is summarized subsequently.

2.2.1 Physical Waste Forms

The characteristics of TRUW, which originates from hundreds of waste streams, have been obtained through process knowledge supplemented by X-ray examination, radioassay, analysis of the gas in drum headspace, and sampling of a limited number of waste containers to verify the physical and chemical properties of their contents (Hong et al. 1996). Most TRUW is solid waste (e.g., contaminated protective clothing, paper trash, rags, glassware, tools, and machine parts); some, however, is in liquid or sludge form. Depending on their physical and chemical properties, TRUW inventories have been grouped by Hong et al. (1996) into waste stream categories that are a function of the potential options for treatment for various waste forms. Eight different TRUW treatability categories were developed for WM PEIS assessment purposes on the basis of physical waste characteristics. Treatability categories for TRUW are (1) aqueous liquids, (2) organic liquids, (3) solid process residues, (4) soils, (5) debris, (6) special (generally laboratory packs), (7) inherently hazardous, and (8) unknown (handled on a case-by-case basis).

2.2.2 Radiological Profiles

Hong et al. (1996) provide radionuclide concentrations in TRUW at the 10 major DOE TRUW sites. For purposes of evaluation, the radiological profiles for small generators, such as the ETEC, PGDP, SNL-NM, WVDP, LBL, and UofMO, are assumed to be the same as for LLNL (Hong et al. 1996). Radionuclide concentrations are given in terms of the radioactivity (curies) of each radioactive isotope in the waste at each site. The concentrations are developed independently for each generating or storage site. The updated TRUW volumes that are presented in Appendix I in the Final WM PEIS are not included in this analysis. The changes in these volumes are not expected to affect the comparison among alternatives.

2.3 TRANSURANIC WASTE ALTERNATIVES FOR THE WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

For the purposes of the WM PEIS, the DOE is considering a range of alternatives for the configuration of new or expanded waste management facilities and the potential consolidation of existing facilities. In general, the WM PEIS alternatives reflect decentralized, regionalized, and centralized approaches. For each type of waste, several options, referred to as cases, have been defined for each broad alternative. The individual cases differ in the number, location, and types of facilities for TSD that are being considered.

For TRUW, the WM PEIS cases range from decentralized to centralized approaches for treatment and storage before final geologic disposal. The Waste Isolation Pilot Plant (WIPP), a TRUW management facility operated by the DOE near Carlsbad, New Mexico, is currently identified as the permanent disposal site for DOE-generated TRUW. The mission of the WIPP, as established by the U.S. Congress under Public Law 96-164, is to serve as a research and development facility for the safe disposal of TRUW. Therefore, in the transportation assessment, all TRUW is assumed to be ultimately shipped to the WIPP for disposal.

The alternatives considered in the WM PEIS for TRUW analyze various options for treatment that may be necessary to prepare TRUW for disposal at the WIPP. Although the ultimate requirements for acceptable waste characteristics are uncertain at this time, the DOE has developed waste acceptance criteria (WAC) that waste generators and storage sites must meet before shipping waste to the WIPP. The WIPP WAC (DOE 1991) define waste forms, waste certification requirements, and transportation packaging requirements. More information about the requirements for disposal of TRUW at the WIPP is in Hong et al. (1996).

The final criteria necessary to achieve compliance with the standards for long-term performance for the WIPP will probably be more restrictive than the current criteria. For that reason, the WM PEIS analysis of TRUW management alternatives considers a range of potential treatment requirements. The treatment options considered are (1) treatment that meets the current WIPP WAC; (2) treatment to reduce gas generation by using shredding, grouting, and nonsteel containers,

resulting in waste that exceeds current WIPP WAC requirements but does not meet land disposal restrictions (LDRs) as defined under the Resource Conservation and Recovery Act (RCRA) (40 CFR Part 268); and, finally, (3) treatment to a level that meets or exceeds LDR requirements.

On the basis of the treatment options presented previously, 6 specific alternatives have been defined for detailed analysis in the WM PEIS. Because of different requirements for treatment and handling, the WM PEIS alternatives have separate CH-TRUW and RH-TRUW components. In general, sites that do not have any treatment capability ship to the nearest site that has such capability. The alternatives are defined as follows:

- No Action (CH-TRUW Case 1, RH-TRUW Case 10). Continue storing CH-TRUW at ANL-E, Hanford, INEL, LANL, LBL, LLNL, Mound, NTS, ORR, PGDP, RFETS, SNL-NM, SRS, and WVDP in accordance with current practices. Storage of RH-TRUW would continue at ANL-E, Hanford, INEL, LANL, and ORR in accordance with current practices. No transportation of waste is assumed.
- Decentralized (CH-TRUW Case 4, RH-TRUW Case 11). Ten sites (ANL-E, Hanford, INEL, LANL, LLNL, Mound, NTS, ORR, RFETS, and SRS) would treat CH-TRUW to meet the Waste Isolation Pilot Plant-Waste Acceptance Criteria (WIPP-WAC). Five sites (ANL-E, Hanford, INEL, LANL, and ORR) would treat RH-TRUW to WIPP-WAC. All treated TRUW would be disposed of at WIPP.
- Regionalized 1 (CH-TRUW Case 5, RH-TRUW Case 14). Five sites (Hanford, INEL, LANL, RFETS, and SRS) would treat CH-TRUW to reduce gas generation. Two sites (Hanford and ORR) would treat RH-TRUW to reduce gas generation. All treated TRUW would be disposed of at WIPP.
- Regionalized 2 (CH-TRUW Case 6, RH-TRUW Case 15). Five sites (Hanford, INEL, LANL, RFETS, and SRS) would treat CH-TRUW to LDR levels. Two sites (Hanford and ORR) would treat RH-TRUW to LDR levels. All treated TRUW would be disposed of at WIPP.
- Regionalized 3 (CH-TRUW Case 8, RH-TRUW Case 15). Three sites (Hanford, INEL, and SRS) would treat CH-TRUW to LDR levels. Two sites (Hanford and ORR) would treat RH-TRUW to LDR levels. All treated TRUW would be disposed of at WIPP.
- Centralized (CH-TRUW Case 9, RH-TRUW Case 15). One site (WIPP) would treat CH-TRUW to LDR levels. Two sites (Hanford and ORR) would treat RH-TRUW to LDR levels. All treated TRUW would be disposed of at WIPP.

2.4 QUANTITIES AND CHARACTERISTICS OF TRANSPORTED TRANSURANIC WASTE BY CASE

The TRUW inventory, characterization data, and alternatives described previously are used as the primary input to a computational model called WASTE_MGMT (Kotek et al. 1996). The WASTE_MGMT model has been developed at Argonne National Laboratory to support analyses of risks and costs for all alternatives for each type of waste considered in the WM PEIS (Kotek et al. 1996). Input to the model includes not only data on the waste inventory, characterization, and alternative definitions, but also data on operations for the TSD facilities used for the wastes. Specific modeling parameters for the TRUW assessment are discussed by Hong et al. (1996).

One output of the WASTE_MGMT model consists of the annual quantity, physical form, and radiological characteristics of the waste shipped between sites for each case. The model output consists of a set of origin-and-destination pairs that represent shipping linkages among TSD sites. For each origin-and-destination pair, the model computes the annual volume (cubic meter), weight (kilogram), and activity (curies) of the TRUW transported. In addition, the activity is computed for each individual radionuclide present in the TRUW from each site. The effects of the potential options for waste treatment are considered in the model and are reflected in changes in waste density and activity concentrations.

The WASTE_MGMT output files are used directly as input to the transportation risk assessment. As stated previously, these files summarize the volume and radiological characteristics of all TRUW shipped between sites for each alternative. The WASTE_MGMT transportation summary files generated for the TRUW transportation assessment are presented in Appendix A of this report.

The WASTE_MGMT files report the quantity of waste shipped on an *annual* basis (cubic meters per year or kilograms per year). As stated previously, the WM PEIS considers a 20-year time frame for TRUW generation; however, for purposes of assessment, it was assumed that shipments would occur uniformly over a 10-year period, which would allow an initial 10-year period to build treatment and storage facilities. Sites would essentially store their own waste for the first 10 years and ship all waste over the subsequent 10 years, including shipments to the WIPP for disposal. In practice, shipments to the WIPP would likely occur over a period of approximately 20 years. Therefore, because of the uncertainties in the actual timing of future waste shipments, the transportation impacts for the various TRUW alternatives are best compared by examining the total impacts of transporting the projected TRUW inventory ultimately to the WIPP, independent of the annual shipping rates. The total amount of TRUW transported for each alternative can be calculated by multiplying the annual shipment quantities (reported in the WASTE_MGMT files in Appendix A) by an assumed shipping duration of 10 years.

3 SUPPLEMENTAL RISK ASSESSMENT PARAMETERS

The majority of the parameters and assumptions necessary to conduct the TRUW transportation risk assessment are described in detail in Appendix E of the WM PEIS (DOE 1996a). Supplemental information is provided subsequently for a number of the most important assessment parameters.

3.1 ACCIDENT RATES

For the calculation of accident risks, vehicle accident and fatality rates are taken from data provided by Saricks and Kvitek (1994). For each mode of transportation, accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel by that mode in that same year. Therefore, the rate is a fractional value; accident-involvement count is the numerator of the fraction and vehicular activity (total travel distance) is its denominator. Accident rates are generally determined for a multiyear period. For purposes of assessment, the total number of expected accidents or fatalities is calculated by multiplying the total shipping distance for a specific alternative by the appropriate accident or fatality rate.

For truck transportation, the rates presented by Saricks and Kvitek (1994) are specifically for heavy combination trucks involved in interstate commerce. Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other. Heavy combination trucks are typically used for radioactive waste shipments. Saricks and Kvitek (1994) base their truck accident rates for each state on statistics compiled by the U.S. Department of Transportation Office of Motor Carriers for 1986–1988. Saricks and Kvitek (1994) present accident involvement and fatality counts; estimated kilometers of travel by state; and the corresponding average accident involvement, fatality, and injury rates for the three years investigated. Fatalities are deaths (including crew members) that are attributable to the accident and that occurred at any time within 30 days thereafter. The truck accident rates are summarized in Table 3.1.

Rail accident rates are computed and presented similarly to truck accident rates in Saricks and Kvitek (1994); however, the unit of haulage is considered to be the railcar. Saricks and Kvitek (1994) base their state-specific rates for rail accident involvement and for fatalities on statistics compiled by the Federal Railroad Administration for 1985–1988. Rail accident rates include both main-line accidents and those occurring in rail yards. The rail accident rates are summarized in Table 3.2.

TABLE 3.1 Highway Combination-Truck Accident, Fatality, and Injury Rates by Road Type^a Based on Reportable Interstate-Carrier Accidents, Reported Fatalities and Injuries, and Estimated Flows, 1986–1988 (10⁻⁷ accidents and injuries per shipment-kilometer, 10⁻⁸ fatalities per shipment-kilometer)

State ^b	Accident-Involvement Rates					Accident-Fatality Rates					Accident-Injury Rates				
	FAI-U	FAI-R	FAI	FAP	FAS	FAI-U	FAI-R	FAI	FAP	FAS	FAI-U	FAI-R	FAI	FAP	FAS
AL	4.68	1.26	1.85	5.16	3.96	3.29	1.84	2.09	6.34	7.84	4.66	1.24	1.83	5.62	4.22
AZ	2.71	1.60	1.76	2.12	1.45	3.56	2.13	2.33	4.97	1.20	2.89	1.65	1.82	2.20	2.77
AR	4.82	1.73	2.09	4.69	6.84	6.61	2.28	2.78	8.88	7.10	4.09	1.95	2.20	4.38	5.94
CA	1.92	1.64	1.76	1.15	2.22	1.39	2.56	2.06	1.98	3.81	1.82	1.68	1.74	1.12	2.67
CO	6.28	2.76	3.60	4.11	4.42	3.38	2.45	2.67	6.58	5.83	5.47	2.82	3.45	3.95	3.67
CT	2.67	4.60 ^c	3.23	2.56	9.09	1.01	5.11 ^c	2.20	1.17	9.09	1.71	4.61 ^c	2.55	1.89	7.09
DE	2.56	--	2.56	7.35	4.81	1.66	--	1.66	13.50 ^c	7.69	3.46	--	3.46	7.18	3.08
FL	2.25	1.21	1.50	3.73	6.33	1.74	2.62	2.38	5.92	6.12	2.36	1.28	1.58	4.12	7.92
GA	4.87	1.65	2.28	6.15	4.04	2.37	1.86	1.96	8.30	6.74	4.37	1.75	2.26	6.43	3.71
ID	1.73	2.30	2.22	4.93	2.29	0	2.06	1.78	7.46	2.54	1.18	2.12	1.99	3.54	1.69
IL	8.75 ^c	1.76	3.53	6.40	1.78	5.33	1.39	2.38	7.84	2.30	8.23 ^c	1.49	3.20	6.12	1.55
IN	4.58	1.92	2.43	4.72	2.80	3.51	1.22	1.66	7.66	4.02	4.36	1.81	2.30	4.42	2.32
IA	3.54	1.78	2.02	4.03	1.24	2.68	1.05	1.26	6.14	0.73	3.78	1.46	1.76	3.48	0.88
KS	4.48	2.04	2.56	5.11	1.38	5.52	1.88	2.66	9.35	1.72	3.66	1.91	2.28	4.09	1.12
KY	5.13	1.46	1.99	5.74	8.80	3.22	1.50	1.75	6.60	6.25	5.52	1.33	1.94	5.28	8.12
LA	3.54	1.30	1.88	3.53	2.39	4.90	1.77	2.59	5.73	3.28	4.57	1.32	2.16	4.46	2.85
ME	9.03 ^c	2.44	2.93	5.44	2.28	0	2.34	2.16	6.58	2.17	4.52	1.53	1.75	5.00	1.63
MD	3.08	3.95	3.46	3.56	12.40	1.62	4.03	2.69	3.66	8.99	3.41	3.98	3.66 ^c	4.32	13.40
MA	1.42	6.47 ^c	2.68	3.43	46.10 ^c	1.30	6.23 ^c	2.53	3.93	52.20 ^c	1.13	4.99 ^c	2.09	3.02	43.90 ^c
MI	3.16	1.59	2.12	2.68	0.81	1.52	1.23	1.33	3.96	1.22	3.04	1.29	1.87	2.61	1.38
MN	2.66	2.06	2.29	4.19	2.16	2.02	1.72	1.83	7.69	7.84	2.08	1.46	1.69	3.28	1.86
MS	2.01	1.19	1.35	4.48	0.65	2.46	1.81	1.93	9.26	1.62	1.85	1.10	1.25	4.55	0.50
MO	5.18	1.78	2.61	5.36	2.49	4.30	1.23	1.99	9.68	3.25	5.53	1.63	2.59	5.06	2.23
MT	10.00 ^c	2.52	2.89	5.38	1.02	3.12	1.44	1.52	7.97	2.04	4.69	1.79	1.93	3.95	0.20
NE	6.97	1.77	2.09	3.62	0.99	6.58	1.10	1.43	5.75	0	6.58	1.17	1.50	3.54	0.54
NV	6.33	1.57	1.97	4.35	3.17	8.89 ^c	1.14	1.79	10.50	7.94	5.67	1.58	1.93	3.72	2.54
NH	0.22	1.39	1.18	4.36	3.33	0	1.49	1.22	5.77	5.56	0	1.14	0.94	4.17	2.22
NJ	2.77	7.65 ^c	4.24 ^c	6.80	9.69	1.56	6.56 ^c	3.06	4.57	11.50	2.69	8.00 ^c	4.28 ^c	6.86	11.30
NM	9.64 ^c	1.92	2.35	4.77	12.20	9.01 ^c	1.93	2.32	6.99	5.56	8.92 ^c	1.86	2.25	4.62	10.60
NY	5.69	2.93	3.98 ^c	3.16	9.48	2.04	1.38	1.63	4.61	10.30	4.49	2.56	3.28	2.71	10.00
NC	5.92	2.28	2.97	5.17	6.37	5.08	2.92	3.33 ^c	6.71	11.00	6.37	2.19	2.99	5.53	6.22
OH	3.16	2.27	2.52	4.42	11.00	1.41	1.32	1.35	6.07	9.88	2.85	2.02	2.25	4.40	1070
OK	3.76	1.47	1.91	3.61	1.73	2.70	2.06	2.18	4.88	0.71	3.34	1.36	1.74	3.05	1.59
OR	3.99	2.20	2.48	4.17	1.63	2.47	1.12	1.33	5.85	4.07	3.82	1.69	2.02	2.94	0.57
PA	3.02	3.60	3.48	7.21	7.92	2.12	2.97	2.79	10.20	9.29	2.68	3.28	3.15	7.28	6.42
RI	2.27	1.98	2.16	1.37	16.70	0.71	3.70	1.80	1.71	66.70 ^c	3.12	2.35	2.84	0.86	23.30 ^c
SC	3.13	1.83	1.99	6.27	2.27	2.88	2.57	2.61	8.61	3.95	2.65	2.20	2.26	6.96	2.27
SD	8.57 ^c	2.09	2.18	3.94	1.49	14.30 ^c	0.42	0.62	5.38	2.13	5.71	1.38	1.95	2.94	0
TN	7.97	1.48	2.48	5.56	6.26	5.59	1.63	2.24	6.97	12.10	7.70 ^c	1.44	2.41	5.85	4.67

TABLE 3.1 (Cont.)

State	Accident-Involvement Rates					Accident-Fatality Rates					Accident-Injury Rates				
	FAI-U	FAI-R	FAI	FAP	FAS	FAI-U	FAI-R	FAI	FAP	FAS	FAI-U	FAI-R	FAI	FAP	FAS
TX	2.74	1.56	2.00	2.78	1.09	1.93	1.97	1.95	4.77	1.84	2.53	1.42	1.83	2.53	0.92
VT	0	1.38	1.33	6.30	6.80	0	0.43	0.42	3.36	24.00	0	1.08	1.04	6.13	4.40
VA	2.63	2.54	2.56	4.67	5.03	1.91	1.76	1.80	7.28	7.73	2.49	2.46	2.47	5.39	4.81
WA	1.61	2.50	2.10	2.62	0.73	0.80	1.47	1.17	2.54	0	1.49	2.14	1.85	2.11	0.51
WV	2.95	3.10	3.07	11.70 ^c	7.87	1.28	1.67	1.60	17.80 ^c	1.70	2.78	2.80	2.79	9.91 ^c	7.13
WI	5.29	1.74	2.18	2.80	3.24	0.77	0.66	0.67	3.62	3.68	4.33	1.45	1.81	2.51	3.16
WY	2.98	3.42	3.40	3.41	3.70	0	2.08	2.01	6.22	3.70	0	2.84	2.74	1.86	2.35
USA	3.58	2.03	2.44	3.94	3.48	2.37	1.91	2.03	5.82	4.62	3.36	1.89	2.28	3.82	3.30
σ^d	2.36	1.25	0.69	1.77	6.98	2.70	1.27	0.63	3.01	11.74	1.99	1.22	0.69	1.79	7.10

^a FAI = federally aided interstate, U = urban, R = rural, FAP = federally aided primary, and FAS = federally aided secondary.

^b Includes only the 48 contiguous states, plus the totals for the United States.

^c Rates are two or more standard deviations greater than the national average rate for that highway category.

^d σ = standard deviation.

Source: Saricks and Kvitek (1994).

TABLE 3.2 Railroad-Freight-Car Accident Rates, by State, for 1986, 1987, 1988, and 1985-1988 Combined (10^{-8} accidents per railcar-kilometer^a)

State ^b	1986		1987		1988		1985-1988	
	Total	Main Only	Total	Main Only	Total	Main Only	Total	Main Only
AL	3.88	2.00	4.80	3.37	4.13	2.52	4.80	2.75
AZ	1.40	1.05	1.30	1.08	1.44	1.18	1.75	1.30
AR	5.05	2.59	4.27	2.32	8.34	3.94	6.78	3.54
CA	5.10	2.64	3.30	1.98	4.32	2.30	5.10	2.51
CO	1.44	1.01	0.86	0.40	2.55	1.51	1.73	1.02
CT	26.47	17.65	16.67	8.34	24.95	0	28.27 ^c	10.10
DE	27.44	9.15	25.23	16.82	18.04	18.04	17.71	11.07
DC	0	0	316	316	0	0	117.09 ^c	78.06 ^c
FL	2.86	2.12	3.90	1.90	4.16	2.38	4.02	2.21
GA	6.44	3.08	6.77	2.81	6.18	2.69	6.44	2.84
ID	5.90	5.25	6.74	4.10	9.03	3.99	7.01	4.14
IL	11.70	3.10	9.97	3.10	9.08	2.45	10.67	2.97
IN	4.18	1.85	3.71	1.48	3.80	1.44	4.64	1.93
IA	17.63	7.15	12.72	6.65	11.95	7.01	14.67	7.16
KS	3.01	1.62	2.97	1.55	4.09	1.98	3.61	1.75
KY	4.78	2.39	3.77	1.98	3.60	1.84	4.48	2.44
LA	12.67	5.98	7.07	2.02	11.94	3.92	12.37	4.28
ME	28.22	16.93	29.40	13.36	52.57	26.29	37.80 ^c	18.53 ^c
MD	6.07	3.54	5.55	2.44	4.55	1.24	5.62	2.58
MA	12.33	5.87	10.06	3.71	7.31	2.81	11.65	4.97
MI	18.34	8.18	15.10	4.42	15.52	7.45	16.47	7.19
MN	8.63	2.64	6.24	3.30	7.86	3.63	8.48	3.16
MS	15.16	11.20	12.93	9.84	8.47	7.14	11.52	8.51
MO	4.59	2.12	3.60	1.87	5.05	2.87	5.28	2.56
MT	1.35	1.01	1.24	0.81	2.11	1.17	1.73	1.10
NE	4.04	2.11	4.81	2.49	4.46	2.23	4.63	2.56
NV	3.27	1.87	1.29	0.86	3.97	2.65	3.23	2.19
NH	6.60	6.60	17.52	11.68	24.27	16.18	21.45	17.16 ^c
NJ	13.86	2.64	9.44	5.31	10.10	4.75	12.38	4.82
NM	0.90	0.52	0.93	0.75	0.86	0.65	0.94	0.66
NY	7.23	3.92	6.80	4.14	7.26	3.36	8.32	4.30
NC	5.40	2.70	5.48	1.62	6.29	2.95	5.70	2.27
ND	2.18	1.48	2.43	1.86	1.49	1.12	2.41	1.80
OH	5.35	2.50	3.55	1.58	4.04	1.92	4.73	2.12
OK	5.25	3.01	3.52	1.90	3.77	1.88	4.66	2.72
OR	11.74	4.96	12.23	6.12	13.64	6.04	12.48	5.77
PA	4.86	3.73	4.22	2.37	3.54	1.95	4.38	2.69
RI	0	0	0	0	0	0	105.33 ^c	0
SC	4.64	2.16	4.74	3.62	5.03	3.71	5.11	3.31
SD	8.16	6.27	14.98	14.49	7.27	6.36	10.19	9.09
TN	4.88	1.69	4.67	1.89	7.56	2.02	5.59	1.88
TX	7.03	3.36	5.29	2.50	5.92	2.45	7.12	3.16
UT	3.69	1.34	1.85	0.93	11.19	4.04	5.78	2.31
VT	5.98	2.99	7.86	5.24	24.32	18.24	15.22	11.59
VA	4.27	1.42	4.39	2.31	4.59	2.15	4.35	1.91

TABLE 3.2 (Cont.)

State ^b	1986		1987		1988		1985-1988	
	Total	Main Only	Total	Main Only	Total	Main Only	Total	Main Only
WA	3.65	1.38	2.69	1.50	3.57	1.12	3.49	1.44
WV	11.49	9.23	9.97	7.73	6.08	4.67	9.61	7.42
WI	18.79	7.52	16.75	7.75	12.57	7.21	16.53	7.66
WY	2.55	1.37	2.61	1.47	2.88	1.40	3.10	1.97
USA	5.51	2.63	4.70	2.36	5.14	2.43	5.57	2.66
σ^d	-	-	-	-	-	-	21.48	11.12

^a Nationwide average fatality rate, using count of fatalities consistent with combination-truck fatality counts, is 6.50×10^{-10} fatalities per railcar-kilometer. Nationwide average injury rate, using count of injuries consistent with combination-truck injury counts, is 7.83×10^{-8} injuries per railcar-kilometer.

^b Includes the 48 contiguous states, the District of Columbia, and the totals for the United States.

^c Rates are one or more standard deviations greater than the national average rate for that category (i.e., all accidents on carrier-owned track or accidents on main lines only).

^d σ = standard deviation.

Source: Saricks and Kvitek (1994).

3.2 CHARACTERISTICS OF PACKAGING OF TRANSURANIC WASTE AND ACCIDENT RELEASES

The radiological characteristics of TRUW require the use of Type B packaging as defined in 10 CFR Part 71. The DOE has agreed to have the U.S. Nuclear Regulatory Commission (NRC) certify the containers used for both CH-TRUW and RH-TRUW shipments as meeting Type B specifications (DOE 1990a). Shipments of TRUW will essentially consist of a number of Type A packages within reusable certified Type B packages. The Type B packages are assumed to be the TRUPACT-II for CH-TRUW and the RH-72B for RH-TRUW.

The TRUPACT-II was certified as meeting the NRC regulations for Type B packaging in August 1989 (DOE 1990a). The container is a cylinder with a flat bottom and domed top and is transported in an upright position. Each TRUPACT-II is approximately 2.4 m (8 ft) in diameter and 3.1 m (10 ft) in height. The TRUPACT-II was designed to maximize payload in both volume and weight. The usable volume of each TRUPACT-II is approximately 2.8 m^3 (3.7 yd^3). The payload capacity of each TRUPACT-II is 3,300 kg (7,275 lb). Three TRUPACT-IIs are assumed to be transported per truck and six per railcar. The total number of required shipments has been calculated on the basis of waste volume (8.4 m^3 [11 yd^3] and 16.8 m^3 [22 yd^3] for truck and rail shipments, respectively).

The RH-72B shipping cask is assumed to be used for all RH-TRUW shipments (WIPP SEIS II; DOE 1996b). The RH-72B is designed to meet Type B packaging specifications and is a scaled-down version of the certified NuPac 125B cask (DOE 1990a). (The NuPac 125B was used to transport core debris from the damaged Three Mile Island nuclear power station to the INEL.) The RH-72B cask is approximately 3.7 m (12 ft) long and has a diameter of 1.1 m (3.5 ft). The usable volume of each RH-72B is approximately 0.89 m^3 (1.2 yd^3). The payload capacity of each RH-72B is limited to 3,629 kg (8,000 lb). One RH-72B is assumed to be transported per truck and two per railcar. The total number of required shipments has been calculated on the basis of waste volume (0.89 m^3 [1.2 yd^3] and 1.8 m^3 [2.4 yd^3] for truck and rail shipments, respectively).

The transportation accident risk assessment depends on the fraction of material in a package that would be released or spilled to the environment during an accident, commonly referred to as the release fraction. The fraction of material released from a package is a function of the severity of the accident and the waste packaging. The release fractions used in the WM PEIS for both CH-TRUW and RH-TRUW packages are provided in Appendix E of the WM PEIS (DOE 1996a) and were based on information presented in the supplemental final environmental impact statement (SFEIS) for the WIPP (DOE 1990b).

3.3 EXTERNAL DOSE RATES FROM SHIPMENTS

The dose (and, correspondingly, the risk) to populations during routine transportation is directly proportional to the assumed external dose rate from the shipment. Representative shipment dose rates have been developed and used in the WM PEIS TRUW transportation analysis. The actual shipment dose rate is a complex function of the composition and configuration of shielding and containment materials used in the waste packaging, the geometry of the loaded shipments, and the characteristics of the waste material itself. In practice, external dose rates will vary not only from site to site, but also from shipment to shipment at a given site.

For TRUW shipments, representative external dose rates from packages have been derived from information provided in the SFEIS for the WIPP (DOE 1990b). In the WIPP SFEIS, site-specific external dose rates from packages were presented for both CH-TRUW and RH-TRUW packages. For the WM PEIS analyses, the average external dose rates were calculated by using the SFEIS site-specific values. The average external dose rates from packages were calculated to be 3 mrem/h and 7 mrem/h at 1 m (3.3 ft) for CH-TRUW and RH-TRUW packages, respectively. Average external dose rates were considered to be appropriate for the programmatic and comparative nature of the WM PEIS analyses.

The package dose rates given previously are for single loaded packages of either CH-TRUW or RH-TRUW. When transported, shipments will consist of multiple packages; the total number of packages per shipment will depend on the mode of transportation. For purposes of assessment, the external dose rates for loaded shipments were calculated on the basis of

single-package dose rates and geometric considerations. For CH-TRUW, the shipment dose rate (three TRUPACT-IIs per truck and six per railcar) was calculated to be approximately 5.7 mrem/h and 7.2 mrem/h at 1 m from a loaded shipment for truck and rail transportation, respectively. For RH-TRUW, the shipment dose rate (one RH-72B per truck and two per railcar) was calculated to be approximately 7 mrem/h and 14 mrem/h at 1 m from a loaded shipment for truck and rail transportation, respectively.

4 RISK ASSESSMENT RESULTS

Transportation risks have been calculated for five TRUW alternative cases summarized in Section 2.3. The alternatives range from decentralized to centralized approaches to treatment and storage before final geologic disposal. The No Action Alternative does not involve waste transportation. The other alternatives each have CH-TRUW and RH-TRUW components. The transportation assessment assumes that all TRUW will ultimately be shipped to WIPP for disposal. The WM PEIS (DOE 1996a) considers current inventories of TRUW plus 20 years of TRUW generation for all DOE sites. All impacts are calculated as totals for the entire waste inventory under consideration. The average annual risk can be estimated by dividing the summarized results by the duration of the shipping campaigns. For purposes of the PEIS, estimates of the sizes of potential facilities needed for treatment have been based on the assumption that waste would be shipped over a 10-year period. Previous assessments have assumed that TRUW would be shipped to WIPP over a 20-year period (DOE 1990b). Transportation of TRUW for TSD is also analyzed in the Draft WIPP Disposal Phase Supplemental Environmental Impact Statement (DOE 1996b).

The impacts of transportation are calculated in four areas: (1) collective population risks during routine conditions and accidents for each alternative, (2) risks to maximally exposed individuals (MEIs) during routine conditions for each alternative, (3) consequences to individuals and populations after the most severe accidents involving release of radioactive material, and (4) on-site transportation risks.

4.1 SHIPMENT SUMMARY

The total number of shipments and the mileage for loaded shipments for each TRUW alternative are summarized in Table 4.1 for truck and rail shipments. The total shipments were calculated using the inventory data presented in Appendix A and the assumptions concerning representative shipment sizes presented in Section 3.2 of this report and in Appendix E of the WM PEIS (DOE 1996a). The total number of truck shipments ranges from approximately 18,640 to 23,900. For rail transportation, the corresponding numbers range from 9,360 to 12,010 shipments. The total distance for loaded shipments ranges from 55 to 69 million km (34 to 43 million mi) for truck transportation and from 26 to 34 million km (16 to 21 million mi) for rail transportation. The average annual number of shipments and mileage can be estimated by dividing the total results by a shipping duration of either 10 or 20 years.

For comparison, within the United States for the years 1986 to 1988, the average annual reported mileage for interstate truck shipments of all commodities was approximately 45 billion km (28 billion mi), and for rail shipments approximately 48.8 billion railcar-km (30.3 billion railcar-mi) (Saricks and Kvitek 1994). The maximum estimated annual TRUW shipments would represent much less than 0.1% of the annual truck and rail transportation activity within the United States.

TABLE 4.1 Total Number of Shipments and Total One-Way Shipping Distances for the TRUW Alternatives^a

Alternative	No. of Shipments ^b		Total Mileage (mi)	
	Truck	Rail	Truck	Rail
Decentralized	23,900	12,010	4.24E+07	2.03E+07
Regionalized 1	21,680	10,890	3.83E+07	1.82E+07
Regionalized 2	18,640	9,360	3.40E+07	1.58E+07
Regionalized 3	20,600	10,340	3.72E+07	1.74E+07
Centralized	21,640	10,870	3.87E+07	1.84E+07

^a For each alternative, impacts were calculated and presented separately, assuming exclusive truck *or* exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

^b The number of shipments is calculated by assuming that truck and rail shipments consist of 8.4 m³ (11 yd³) and 16.8 m³ (22 yd³), respectively, for CH-TRUW and 0.89 m³ (1.2 yd³) and 1.8 m³ (2.4 yd³), respectively, for RH-TRUW.

4.2 COLLECTIVE POPULATION RISK RESULTS

The primary means of comparing the transportation risks of the various alternatives in the WM PEIS (DOE 1996a) is based on estimates of the total collective population risk. The collective population risk is a measure of the total risk posed to society as a whole by the case being considered. For the collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors.

In the WM PEIS (DOE 1996a), collective population risks are calculated from both vehicle- and cargo-related causes for both routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and include risks from vehicular exhaust emissions and traffic accidents (fatalities caused by physical trauma). Vehicle-related risks are presented in terms of estimated fatalities for each case.

For radioactive material, cargo-related risk refers to the risk posed by the radioactive nature of the material. The collective population risks are calculated for each case by using RADTRAN 4 (Neuhauser and Kanipe 1993). RADTRAN 4 is a computer code developed by SNL to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge. The code has been extensively reviewed, updated, and used for transportation risk assessments since it was issued in the late 1970s.

The RADTRAN 4 calculations for population risk take into account both the consequences and the probabilities of potential exposure-causing events (such as accidents). The accident risk values are referred to as "dose risk" because they incorporate the probabilities of a spectrum of accidents. The collective population risks are presented in terms of the total dose (person-rem) to workers and to members of the public for each case. The collective population risks are also presented in terms of estimated latent cancer fatalities, latent cancer cases, and genetic effects by using the health risk conversion factors from Publication 60 of the International Commission on Radiological Protection (ICRP 1991).

The results of the collective risk assessment are summarized subsequently. Detailed results for each individual case are presented in Appendix B. The detailed results include "per-shipment" risk factors for shipments between all origin and destination sites considered by an alternative.

The collective risk results for the TRUW alternatives are summarized subsequently in a series of tables. The collective risk results were calculated with the RADTRAN 4 computer code by using the WASTE_MGMT files provided in Appendix A as the primary input. The summarized results are presented for the total impacts from shipping current inventories plus 20 years of TRUW generation; no annual risk estimates have been included. The summarized results include all shipments for purposes of treatment, as well as all shipments to the WIPP for final disposal. As stated previously, the average annual risk can be estimated by dividing the summarized results by the duration of the shipping campaigns. For the WM PEIS analysis, it was assumed that shipments would occur uniformly over a 10-year period, assuming a 10-year period to build TSD facilities; however, in practice, shipments would likely be distributed over a period of approximately 20 years.

Total incident-free (routine) and accident doses for each alternative in terms of person-rem are presented in Tables 4.2 and 4.3, respectively. Cargo-related (radiological) and vehicle-related health effects are summarized in Tables 4.4 through 4.6. All impacts are presented in two columns; in the first, it is assumed that all shipments are via truck, and in the second, all shipments are via rail.

Examination of the results of the transportation risk assessment shows that differences in population risk among the various alternatives depend primarily on total shipping distances. The total shipping distance for each alternative is determined by the definition of the case (shipment origin and destination sites), site-specific waste inventories (specifically waste volume and mass, which directly determine the total number of shipments), packaging assumptions, and the route distances among all pairs of origin-and-destination sites.

The total estimated number of fatalities from radiological causes ranges from approximately 2.7 to 3.4 for truck shipments. For rail transportation, fatalities from radiological causes range from 0.67 to 0.90. In general, for TRUW shipments, the vehicle-related risks are comparable to the associated cargo-related risks.

TABLE 4.2 Total Incident-Free Dose for the TRUW Alternatives^a

Alternative	Total Dose (person-rem)			
	Truck		Rail	
	Crew ^b	Public ^c	Crew	Public
Decentralized	3.65E+03	3.87E+03	8.36E+02	1.13E+03
Regionalized 1	3.27E+03	3.36E+03	7.56E+02	9.78E+02
Regionalized 2	2.89E+03	2.94E+03	6.56E+02	8.21E+02
Regionalized 3	3.16E+03	3.31E+03	7.18E+02	9.07E+02
Centralized	3.31E+03	3.49E+03	7.59E+02	1.01E+03

^a Routine doses result from exposure to external radiation in the vicinity of a loaded shipment. The external dose rate for CH-TRUW is assumed to be 5.7 mrem/h and 7.2 mrem/h for truck and rail, respectively, at 1 m from a CH-TRUW shipment. The external dose rate for RH-TRUW is assumed to be 7.0 and 14.0 mrem/h for truck and rail, respectively, at 1 m from an RH-TRUW shipment. For each alternative, impacts were calculated and presented separately, assuming exclusive truck *or* exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

^b The crew includes truck drivers, rail crew members, and rail workers in marshaling or classification yards.

^c Members of the public include persons in vehicles sharing transportation routes, persons living along routes, and persons exposed at shipment stops.

TABLE 4.3 Total Accident Dose Risk for the TRUW Alternatives^{a,b}

Alternative	Total Dose Risk (person-rem)	
	Truck	Rail
Decentralized	9.80E+00	7.77E-01
Regionalized 1	8.98E+00	7.70E-01
Regionalized 2	8.98E+00	7.73E-01
Regionalized 3	1.18E+01	8.44E-01
Centralized	8.93E+00	7.68E-01

^a The calculation of accident dose risk takes into account the dose to the public following accidents involving the release of radioactive material to the environment, the probability of accident occurrences, and the distribution of accident severities.

^b For each alternative, impacts were calculated and presented separately, assuming exclusive truck *or* exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

TABLE 4.4 Total Estimated Fatalities for the WM LLW Alternatives^{a,b}

Alternative	Exposure Group	Estimated Fatalities	
		Truck	Rail
Decentralized	Radiological		
	Normal crew	1.5E+00	3.3E-01
	Normal public	1.9E+00	5.7E-01
	Accident public	4.9E-03	3.9E-04
	Vehicle-related		
	Emission	2.2E-01	1.0E-01
Regionalized 1	Accident	3.0E+00	4.3E-02
	Radiological		
	Normal crew	1.3E+00	3.0E-01
	Normal public	1.7E+00	4.9E-01
	Accident public	4.5E-03	3.9E-04
	Vehicle-related		
Regionalized 2	Emission	1.9E-01	9.1E-02
	Accident	2.7E+00	3.7E-02
	Radiological		
	Normal crew	1.2E+00	2.6E-01
	Normal public	1.5E+00	4.1E-01
	Accident public	4.5E-03	3.9E-04
Regionalized 3	Vehicle-related		
	Emission	1.8E-01	7.3E-02
	Accident	2.4E+00	3.3E-02
	Radiological		
	Normal crew	1.3E+00	2.8E-01
	Normal public	1.7E+00	4.6E-01
Centralized	Accident public	5.8E-03	4.2E-04
	Vehicle-related		
	Emission	1.9E-01	7.9E-02
	Accident	2.6E+00	3.6E-02
	Radiological		
	Normal crew	1.3E+00	3.0E-01
	Normal public	1.7E+00	5.1E-01
	Accident public	4.4E-03	3.9E-04
	Vehicle-related		
	Emission	2.0E-01	9.1E-02
	Accident	2.7E+00	3.9E-02

^a Latent cancer fatalities were calculated by multiplying the dose by ICRP Publication 60 (ICRP 1991) health risk conversion factors of 4.0E-04 fatal and 5.0E-04 cancer cases per person-rem for workers and for the public, respectively.

^b For each alternative, impacts were calculated and presented separately, assuming exclusive truck *or* exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

TABLE 4.5 Estimated Cancer Incidence for the TRUW Alternatives^{a,b}

Alternative	Exposure Group	Cancer Incidence	
		Truck	Rail
Decentralized	Radiological		
	Normal crew	5.1E+00	1.2E+00
	Normal public	6.5E+00	1.9E+00
	Accident public	1.7E-02	1.3E-03
	Vehicle-related		
	Emission	2.2E-01	1.0E-01
	Accident	NA ^c	NA
Regionalized 1	Radiological		
	Normal crew	4.6E+00	1.1E+00
	Normal public	5.7E+00	1.7E+00
	Accident public	1.5E-02	1.3E-03
	Vehicle-related		
	Emission	1.9E-01	9.1E-02
	Accident	NA	NA
Regionalized 2	Radiological		
	Normal crew	4.1E+00	9.2E-01
	Normal public	5.0E+00	1.4E+00
	Accident public	1.5E-02	1.3E-03
	Vehicle-related		
	Emission	1.8E-01	7.3E-02
	Accident	NA	NA
Regionalized 3	Radiological		
	Normal crew	4.4E+00	1.0E+00
	Normal public	5.6E+00	1.5E+00
	Accident public	2.0E-02	1.4E-03
	Vehicle-related		
	Emission	1.9E-01	7.9E-02
	Accident	NA	NA
Centralized	Radiological		
	Normal crew	4.7E+00	1.1E+00
	Normal public	5.9E+00	1.7E+00
	Accident public	1.5E-02	1.3E-03
	Vehicle-related		
	Emission	2.0E-01	9.1E-02
	Accident	NA	NA

^a Latent cancer incidences were calculated by multiplying the dose by ICRP Publication 60 (ICRP 1991) health risk conversion factors of 1.4E-03 fatal and 1.7E-03 cancer cases per person-rem for workers and for the public, respectively.

^b For each alternative, impacts were calculated and presented separately, assuming exclusive truck or exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

^c NA = not applicable.

TABLE 4.6 Estimated Genetic Effects for the TRUW Alternatives^{a,b}

Alternative	Exposure Group	Genetic Effects	
		Truck	Rail
Decentralized	Radiological		
	Normal crew	2.2E-01	5.0E-02
	Normal public	3.8E-01	1.1E-01
	Accident public	2.1E-04	1.7E-05
	Vehicle-related		
	Emission	NA ^c	NA
Regionalized 1	Accident	NA	NA
	Radiological		
	Normal crew	2.0E-01	4.6E-02
	Normal public	3.4E-01	9.8E-02
	Accident public	1.9E-04	1.7E-05
	Vehicle-related		
Regionalized 2	Emission	NA	NA
	Accident	NA	NA
	Radiological		
	Normal crew	1.7E-01	3.9E-02
	Normal public	2.9E-01	8.2E-02
	Accident public	1.9E-04	1.7E-05
Regionalized 3	Vehicle-related		
	Emission	NA	NA
	Accident	NA	NA
	Radiological		
	Normal crew	1.9E-01	4.3E-02
	Normal public	3.3E-01	9.0E-02
Centralized	Accident public	2.7E-04	1.9E-05
	Vehicle-related		
	Emission	NA	NA
	Accident	NA	NA
	Radiological		
	Normal crew	2.0E-01	4.5E-02
	Normal public	3.5E-01	1.0E-01
	Accident public	1.9E-04	1.7E-05
	Vehicle-related		
	Emission	NA	NA
	Accident	NA	NA

^a Genetic effects were calculated by multiplying the dose by ICRP Publication 60 (ICRP 1991) health risk conversion factors of 6.0E-05 fatal and 1.0E-04 adverse genetic effects per person-rem for workers and for the public, respectively.

^b For each alternative, impacts were calculated and presented separately, assuming exclusive truck or exclusive rail shipments. Therefore, the impacts for truck and rail modes should not be added together.

^c NA = not applicable.

4.3 MAXIMALLY EXPOSED INDIVIDUAL ASSESSMENT

The risk to MEIs has been estimated for a number of hypothetical exposure scenarios for off-site transportation. The receptors include crew members, departure inspectors, and members of the public exposed during traffic obstructions (traffic jams), while working at a service station, or by living near a TSD site. The dose and risk to MEIs were calculated for particular distances and durations of exposure with the RISKIND code (Yuan et al. 1993) as discussed further in Appendix E of the WM PEIS (DOE 1996a). The distances and durations of exposure for each receptor are similar to those used in previous transportation assessments (DOE 1987b, 1990b). The scenarios for exposure are not intended to be exhaustive but were selected to provide a range of potential exposure situations. The assumptions for exposure scenarios are as follows:

- **Crew Members.** Truck and rail crew members are assumed to be occupational radiation workers and would be monitored by a dosimetry program. Therefore, the maximum allowable dose would be 5 rem/yr. As an administrative procedure, DOE limits doses to its workers to 2 rem/yr (DOE 1992).
- **Inspectors (Truck and Rail).** Inspectors are assumed to be either federal or state vehicle inspectors. Inspectors are not assumed to be monitored by a dosimetry program. An average exposure distance of 3 m (9.8 ft) and an exposure duration of 30 minutes are assumed.
- **Rail-Yard Crew Member.** A rail-yard crew member is not assumed to be monitored by a dosimetry program. An average exposure distance of 10 m (32.8 ft) and an exposure duration of 2 hours are assumed.
- **Resident (Truck and Rail).** A resident is assumed to live 30 m (98 ft) from a site entrance route (truck or rail). Shipments pass at an average speed of 24 km/h (15 mph) and the resident is exposed unshielded. Cumulative doses are assessed for each site on the basis of the number of shipments entering or exiting the site, with the assumption that the resident is present for 100% of the shipments.
- **Person in Traffic Obstruction (Truck and Rail).** A person is assumed to be stopped next to a waste shipment (because of traffic or other obstructions). The person is assumed to be exposed unshielded at a distance of 1 m (3.3 ft) for 30 minutes.

- Person at Truck Service Station. A person is assumed to be exposed at an average distance of 20 m (65.6 ft) for 2 hours. This receptor could be a worker at a truck stop.
- Resident Near a Rail Stop. A resident is assumed to live near a rail classification yard. The resident is assumed to be exposed unshielded at a distance of 200 m (656 ft) for 20 hours.

The largest uncertainty in predicting the dose to MEIs during transportation involves determining the frequency of exposure occurrence. This difficulty arises from uncertainties in future shipment schedules and route selection and from the inherent uncertainty in predicting the frequency of random or chance events. For example, it is conceivable that an individual may be stopped in traffic next to a shipment of radioactive waste, but it is difficult to predict how often the same individual would experience this event. Therefore, doses are assessed on a per-event basis for most receptors considered. To account for possible multiple exposures, ranges of realistic total doses are discussed qualitatively. One exception is the dose calculation for hypothetical residents living near an entrance route to a TSD site. For these residents, total doses are calculated on the basis of the number of shipments entering or exiting each site for each PEIS alternative.

The estimated doses during routine transportation for each individual receptor considered (see Sections 3.2 and 3.3 for packaging assumptions and external dose rates) are presented in Table 4.7 for CH-TRUW and in Table 4.8 for RH-TRUW. The total dose for repeated exposures can be estimated by multiplying the per-event dose by the number of exposures.

Except for doses to crew members, all doses are presented for single exposures. The potential exists for significant individual exposures if multiple exposure-causing events occur. For example, the dose to a person stopped in traffic next to a truck shipment of CH-TRUW for 30 minutes is estimated to be 5 mrem; if the exposure duration were longer, the dose would rise proportionally. Therefore, it is conceivable that a person could receive a dose of approximately 10 to 20 mrem while stopped in traffic next to a TRUW shipment. In addition, a person working at a truck service station could receive an increased dose if trucks used the same stops repeatedly. If a truck stop worker were present for 100 CH-TRUW shipment stops (at the distance and duration given previously), the estimated dose would be approximately 20 mrem. Administrative controls could be instituted to control the location and duration of truck stops if multiple exposures were to happen routinely. The probability of multiple exposures increases as the amount of waste transportation increases.

TABLE 4.7 Estimated Routine Doses and Lifetime Risk of Fatal Cancer to MEIs From Shipments of CH-TRUW (per Exposure Event)^a

Receptor	Dose (rem)		Lifetime Risk ^b	
	Truck	Rail	Truck	Rail
Workers				
Crew member	c	c	c	c
Inspector	1.4E-03	1.4E-03	6E-07	6E-07
Rail-yard crew member	NA	1.5E-03	NA	6E-07
Public				
Resident	1.5E-07	3.0E-07	8E-11	2E-10
Person in traffic jam	4.7E-03	9.3E-03	2E-06	5E-06
Person at service station	1.9E-04	NA	1E-07	NA
Resident near rail stop	NA	2.1E-05	NA	1E-08

Note: NA = not applicable.

^a The dose rate is assumed to be 3 mrem/h at 1 m (3.3 ft) from each package.

^b Lifetime risk of fatal cancer based on ICRP Publication 60 (ICRP, 1991) health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers, and 5×10^{-4} for the public.

^c The DOE administrative control level limits doses to DOE workers to 2 rem/yr.

TABLE 4.8 Estimated Routine Doses and Lifetime Risk of Fatal Cancer to MEIs From Shipments of RH-TRUW (per Exposure Event)^a

Receptor	Dose (rem)		Lifetime Risk ^b	
	Truck	Rail	Truck	Rail
Workers				
Crew member	c	c	c	c
Inspector	1.0E-03	1.0E-03	4E-07	4E-07
Rail-yard crew member	NA	1.1E-03	NA	4E-07
Public				
Resident	1.1E-07	2.3E-07	6E-11	1E-10
Person in traffic jam	3.6E-03	7.1E-03	2E-06	4E-06
Person at service station	1.5E-04	NA	8E-08	NA
Resident near rail stop	NA	1.5E-05	NA	8E-09

Note: NA = not applicable.

^a Dose rate is assumed to be 7 mrem/h at 1 m (3.3 ft) from each package.

^b Lifetime risk of fatal cancer based on ICRP Publication 60 (ICRP, 1991) health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers, and 5×10^{-4} for the public.

^c The DOE administrative control level limits doses to DOE workers to 2 rem/yr.

Table 4.9 summarizes the cumulative dose to a resident living along a site entrance route. Each alternative involves both contact- and remote-handled shipments. The cumulative doses assume that an unshielded resident is present at a distance of 30 m (98 ft) from the roadway for every shipment entering or exiting a site. In almost all cases, the maximum cumulative dose would occur near the WIPP disposal site. If all CH-TRUW and RH-TRUW were shipped to WIPP, the maximum dose to a resident would be less than 4 mrem for both truck and rail cases. The truck and rail doses are similar because the same number of packages would be shipped for each mode. The annual dose can be estimated by assuming that shipments would occur over either a 10- or 20-year period. The annual dose to a resident would be well below the annual limit of 100 mrem specified for members of the public through DOE orders (DOE 1990a), as well as comparable NRC limits (10 CFR 20).

4.4 ACCIDENT CONSEQUENCE ASSESSMENT

The RISKIND code (Yuan et al. 1993) was used to provide a detailed assessment of the consequences of the most severe transportation-related accidents for each type of TRUW. The RADTRAN 4 collective accident risk assessment considers the entire range of accident severities and their related probabilities, whereas the RISKIND accident consequence assessment assumes that an accident of the highest severity category (Category VIII) has occurred. The consequences, in terms of committed dose (rem) and latent cancer fatalities, are calculated for exposed populations and individuals near an accident. The accident consequence assessment is intended to provide an estimate of the maximum potential impacts posed by a severe transportation-related accident.

For the accident consequence assessment, the characteristics of contact- and remote-handled waste for each site were screened to determine the waste with the highest potential radiological consequences if a release were to occur during an accident. For CH-TRUW, waste shipments from LANL were found to result in the highest potential transportation accident doses. For RH-TRUW, shipments from the Hanford site were found to result in the highest potential accident doses. The accident consequence results are presented in Table 4.10 for contact-handled shipments and Table 4.11 for remote-handled shipments. The population doses are for a uniform population density within an 80-km (50-mi) radius of accidents occurring in rural, suburban, and urban population density zones. For most TRUW shipments, the consequences of severe accidents would be less severe than those presented here.

The location of the MEI after an accident is determined on the basis of atmospheric conditions and buoyant characteristics of the released plume. The locations of maximum exposure are 160 m (525 ft) from the accident site for neutral conditions and 400 m (1,312 ft) from the accident site for stable conditions. The dose to the MEI is independent of the accident location. The maximum dose to an individual (approximately 34 rem for a RH-TRUW rail accident under unfavorable weather conditions) corresponds to a potential lifetime fatal cancer risk of 2×10^{-2} .

TABLE 4.9 Cumulative Dose and Lifetime Risk to an MEI Living Along a Site Entrance Route for Shipments of TRUW (Current Inventories Plus 20 Years of Generation)^a

Alternative/Site	All Truck			All Rail		
	Total Shipments	Dose (rem)	Lifetime Risk ^b	Total Shipments	Dose (rem)	Lifetime Risk ^b
Decentralized						
WIPP	23,860	3.1E-03	2E-06	11,970	3.1E-03	2E-06
Hanford	10,260	1.2E-03	6E-07	5,140	1.2E-03	6E-07
INEL	5,970	8.7E-04	4E-07	2,990	8.7E-04	4E-07
SRS	2,370	3.6E-04	2E-07	1,190	3.6E-04	2E-07
ORR	1,910	2.1E-04	1E-07	970	2.2E-04	1E-07
LANL	1,590	2.3E-04	1E-07	800	2.4E-04	1E-07
RFETS	830	1.2E-04	6E-08	420	1.3E-04	6E-08
ANL-E	590	7.1E-05	4E-08	300	7.4E-05	4E-08
LLNL	260	3.9E-05	2E-08	130	3.9E-05	2E-08
NTS	90	1.4E-05	7E-09	50	1.5E-05	8E-09
Mound	30	4.5E-06	2E-09	20	6.0E-06	3E-09
LBL	10	1.5E-06	8E-10	10	3.0E-06	2E-09
PGDP	10	1.5E-06	8E-10	10	3.0E-06	2E-09
SNL-NM	10	1.5E-06	8E-10	10	3.0E-06	2E-09
UofMO	10	1.5E-06	8E-10	10	3.0E-06	2E-09
Regionalized 1						
WIPP	20,080	2.5E-03	1E-06	10,060	2.6E-03	1E-06
Hanford	11,920	1.4E-03	7E-07	5,970	1.4E-03	7E-07
INEL	4,900	7.1E-04	4E-07	2,460	7.1E-04	4E-07
ORR	2,440	2.7E-04	1E-07	1,230	2.8E-04	1E-07
LANL	1,320	1.9E-04	1E-07	670	2.0E-04	1E-07
SRS	1,240	1.9E-04	9E-08	630	1.9E-04	9E-08
RFETS	610	9.2E-05	5E-08	310	9.3E-05	5E-08
ANL-E	510	6.1E-05	3E-08	260	6.3E-05	3E-08
LLNL	200	3.0E-05	2E-08	100	3.0E-05	2E-08
NTS	80	1.2E-05	6E-09	40	1.2E-05	6E-09
Mound	20	3.0E-06	2E-09	10	3.0E-06	2E-09
LBL	10	1.5E-06	8E-10	10	3.0E-06	2E-09
PGDP	10	1.5E-06	8E-10	10	3.0E-06	2E-09
SNL-NM	10	1.5E-06	8E-10	10	3.0E-06	2E-09
UofMO	10	1.5E-06	8E-10	10	3.0E-06	2E-09

TABLE 4.9 (Cont.)

Alternative/Site	All Truck			All Rail		
	Total Shipments	Dose (rem)	Lifetime Risk ^b	Total Shipments	Dose (rem)	Lifetime Risk ^b
Regionalized 2						
WIPP	17,040	2.1E-03	1E-06	8,530	2.2E-03	1E-06
Hanford	11,830	1.3E-03	7E-07	5,930	1.4E-03	7E-07
INEL	4,250	6.1E-04	3E-07	2,130	6.1E-04	3E-07
LANL	1,030	1.5E-04	8E-08	520	1.5E-04	8E-08
ORR	990	1.1E-04	5E-08	500	1.1E-04	6E-08
SRS	820	1.2E-04	6E-08	420	1.3E-04	6E-08
ANL-E	510	6.1E-05	3E-08	260	6.3E-05	3E-08
RFETS	470	7.1E-05	4E-08	240	7.2E-05	4E-08
LLNL	200	3.0E-05	2E-08	100	3.0E-05	2E-08
NTS	80	1.2E-05	6E-09	40	1.2E-05	6E-09
Mound	20	3.0E-06	2E-09	10	3.0E-06	2E-09
LBL	10	1.5E-06	8E-10	10	3.0E-06	2E-09
PGDP	10	1.5E-06	8E-10	10	3.0E-06	2E-09
SNL-NM	10	1.5E-06	8E-10	10	3.0E-06	2E-09
UofMO	10	1.5E-06	8E-10	10	3.0E-06	2E-09
Regionalized 3						
WIPP	17,030	2.1E-03	1E-06	8,520	2.2E-03	1E-06
Hanford	11,830	1.3E-03	7E-07	5,930	1.4E-03	7E-07
INEL	7,610	1.1E-03	6E-07	3,820	1.1E-03	6E-07
LANL	1,350	2.0E-04	1E-07	680	2.0E-04	1E-07
ORR	990	1.1E-04	5E-08	500	1.1E-04	6E-08
SRS	820	1.2E-04	6E-08	420	1.3E-04	6E-08
RFETS	720	1.1E-04	5E-08	360	1.1E-04	5E-08
ANL-E	510	6.1E-05	3E-08	260	6.3E-05	3E-08
LLNL	200	3.0E-05	2E-08	100	3.0E-05	2E-08
NTS	80	1.2E-05	6E-09	40	1.2E-05	6E-09
Mound	20	3.0E-06	2E-09	10	3.0E-06	2E-09
LBL	10	1.5E-06	8E-10	10	3.0E-06	2E-09
PGDP	10	1.5E-06	8E-10	10	3.0E-06	2E-09
SNL-NM	10	1.5E-06	8E-10	10	3.0E-06	2E-09
UofMO	10	1.5E-06	8E-10	10	3.0E-06	2E-09

TABLE 4.9 (Cont.)

Alternative/Site	All Truck			All Rail		
	Total Shipments	Dose (rem)	Lifetime Risk ^b	Total Shipments	Dose (rem)	Lifetime Risk ^b
Centralized						
WIPP	20,500	2.6E-03	1E-06	10,290	2.7E-03	1E-06
Hanford	11,610	1.3E-03	7E-07	5,820	1.4E-03	7E-07
INEL	5,180	7.5E-04	4E-07	2,600	7.6E-04	4E-07
SRS	2,080	3.1E-04	2E-07	1,040	3.1E-04	2E-07
LANL	1,350	2.0E-04	1E-07	680	2.0E-04	1E-07
ORR	990	1.1E-04	5E-08	500	1.1E-04	6E-08
RFETS	720	1.1E-04	5E-08	360	1.1E-04	5E-08
ANL-E	510	6.1E-05	3E-08	260	6.3E-05	3E-08
LLNL	200	3.0E-05	2E-08	100	3.0E-05	2E-08
NTS	80	1.2E-05	6E-09	40	1.2E-05	6E-09
Mound	20	3.0E-06	2E-09	10	3.0E-06	2E-09
LBL	10	1.5E-06	8E-10	10	3.0E-06	2E-09
PGDP	10	1.5E-06	8E-10	10	3.0E-06	2E-09
SNL-NM	10	1.5E-06	8E-10	10	3.0E-06	2E-09
UofMO	10	1.5E-06	8E-10	10	3.0E-06	2E-09

^a The external dose rates are assumed to be 3 mrem/h at 1 m (3.3 ft) for CH-TRUW, and 7 mrem/h for RH-TRUW shipments. The resident is assumed to be present for all shipments that enter or exit the site. Shipments are assumed to pass at a distance of 30 m (98 ft) and an average speed of 24 km/h (15 mph).

^b Lifetime risk of fatal cancer based on ICRP Publication 60 (ICRP, 1991) health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public.

TABLE 4.10 Estimated Consequences for the Most Severe Accidents Involving Shipments of CH-TRUW^{a,b}

Mode and Accident Location	Neutral Conditions ^c				Stable Conditions ^d			
	Population ^e		MEI ^f		Population ^e		MEI ^f	
	Dose (person- rem)	Risk (cancer fatalities)	Dose (rem)	Risk (cancer fatality)	Dose (person- rem)	Risk (cancer fatality)	Dose (rem)	Risk (cancer fatality)
Truck								
Urban	4.0E+03	2.0E+00	3.5E+00	1.8E-03	3.2E+04	1.6E+01	1.2E+01	6.0E-03
Suburban	7.4E+02	3.7E-01	3.5E+00	1.8E-03	5.9E+03	3.0E+00	1.2E+01	6.0E-03
Rural	6.5E+00	3.0E-03	3.5E+00	1.8E-03	5.2E+01	3.0E-02	1.2E+01	6.0E-03
Rail								
Urban	7.9E+02	4.0E+00	7.1E+00	3.6E-03	6.3E+04	3.2E+01	2.4E+01	1.2E-02
Suburban	1.5E+02	7.5E-01	7.1E+00	3.6E-03	1.2E+04	6.0E+00	2.4E+01	1.2E-02
Rural	1.3E+01	7.0E-03	7.1E+00	3.6E-03	1.0E+02	5.0E-02	2.4E+01	1.2E-02

^a The most severe accidents correspond to the highest NUREG-0170 accident severity category (Category VIII) (NRC, 1977a). Results are reported for CH-TRUW from LANL.

^b Buoyant plume rise resulting from fire for a severe accident was included in the exposure model. Three TRUPACT-IIIs are assumed to be breached in a truck accident; six TRUPACT-IIIs are assumed to be equally breached in a rail accident.

^c Neutral weather conditions result in moderate dispersion and dilution of the released plume. Neutral conditions were taken to be Pasquill Stability Class D with a windspeed of 4 m/s (9 mph). Neutral conditions occur approximately 50% of the time in the United States.

^d Stable weather conditions result in minimal dispersion and dilution of the released plume and are thus unfavorable. Stable conditions were taken to be Pasquill Stability Class F with a windspeed of 1 m/s (2.2 mph). Stable conditions occur approximately one-third of the time in the United States.

^e Populations extend at a uniform population density to a radius of 80 km (50 mi) from the accident site. Population exposure pathways include acute inhalation; acute cloudshine; groundshine; resuspended inhalation; resuspended cloudshine; and ingestion of food, including initially contaminated food (rural only). No decontamination or mitigative actions are taken.

^f The MEI is assumed to be at the location of maximum exposure. The locations of maximum exposure would be 160 m (525 ft) from the accident site under neutral atmospheric conditions, and 400 m (1,312 ft) for stable atmospheric conditions. Individual exposure pathways include acute inhalation, acute cloudshine, and groundshine during passage of the plume. No ingested dose is considered.

TABLE 4.11 Estimated Consequences for the Most Severe Accidents Involving Shipments of RH-TRUW^{a,b}

Mode and Accident Location	Neutral Conditions ^c				Stable Conditions ^d			
	Population ^e		MEI ^f		Population ^e		MEI ^f	
	Dose (person- rem)	Risk (cancer fatality)	Dose (rem)	Risk (cancer fatality)	Dose (person- rem)	Risk (cancer fatality)	Dose (rem)	Risk (cancer fatality)
Truck								
Urban	6.0E+01	3.0E-02	5.1E-02	2.6E-05	4.8E+02	2.4E-01	1.7E+01	8.5E-03
Suburban	1.1E+01	5.5E-03	5.1E-02	2.6E-05	8.9E+01	4.5E-02	1.7E+01	8.5E-03
Rural	1.0E-01	5.0E-03	5.1E-02	2.6E-05	8.3E+01	4.2E-04	1.7E+01	8.5E-03
Rail								
Urban	1.2E+02	6.0E-02	1.0E-01	5.0E-05	9.5E+02	4.8E-01	3.4E+01	1.7E-02
Suburban	2.2E+01	1.1E-02	1.0E-01	5.0E-05	1.8E+02	9.0E-02	3.4E+01	1.7E-02
Rural	2.1E-01	1.1E-04	1.0E-01	5.0E-05	1.7E+00	8.5E-04	3.4E+01	1.7E-02

^a The most severe accidents correspond to the highest NUREG-0170 accident severity category (Category VIII) (NRC, 1977a). Results are reported for RH-TRUW from the Hanford site.

^b Buoyant plume rise resulting from fire for a severe accident was included in the exposure model. One RH-72B is assumed to be breached in a truck accident; two RH-72Bs are assumed to be equally breached in a rail accident.

^c Neutral weather conditions result in moderate dispersion and dilution of the released plume. Neutral conditions were taken to be Pasquill Stability Class D with a windspeed of 4 m/s (9 mph). Neutral conditions occur approximately 50% of the time in the United States.

^d Stable weather conditions result in minimal dispersion and dilution of the released plume and are thus unfavorable. Stable conditions were taken to be Pasquill Stability Class F with a windspeed of 1 m/s (2.2 mph). Stable conditions occur approximately one-third of the time in the United States.

^e Populations extend at a uniform population density to a radius of 80 km (50 mi) from the accident site. Population exposure pathways include acute inhalation; acute cloudshine; groundshine; resuspended inhalation; resuspended cloudshine; and ingestion of food, including initially contaminated food (rural only). No decontamination or mitigative actions are taken.

^f The MEI is assumed to be at the location of maximum exposure. The locations of maximum exposure would be 160 m (525 ft) and from the accident site under neutral atmospheric conditions, and 400 m (1,312 ft) for stable atmospheric conditions. Individual exposure pathways include acute inhalation, acute cloudshine, and groundshine during passage of the plume. No ingested dose is considered.

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APPENDIX A:
TRANSPORTED MATERIAL SUMMARY FILES GENERATED
BY THE WASTE_MGMT MODEL

APPENDIX A:

**TRANSPORTED MATERIAL SUMMARY FILES GENERATED
BY THE WASTE_MGMT MODEL**

The WASTE_MGMT model has been developed at Argonne National Laboratory to support analyses of risks and costs for all alternatives for each type of waste considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE 1996).¹ One output of the WASTE_MGMT model consists of the annual quantity, physical form, and radiological characteristics of the waste shipped between sites for each case. The WASTE_MGMT output files are used directly as input to the transportation risk assessment.

The WASTE_MGMT transportation summary files generated for the transuranic waste (TRUW) transportation assessment are presented in this appendix. The WASTE_MGMT files report the quantity of waste shipped on an *annual* basis (cubic meters per year or kilograms per year). As stated in the main body of this report, the WM PEIS considers a 20-year time frame for TRUW generation and treatment. For purposes of assessment, it was assumed that shipments would occur uniformly over a 10-year period, which would allow an initial 10-year period to build treatment, storage, and disposal facilities. Sites would essentially store their own waste for the first 10 years and ship all waste over the subsequent 10 years.

Because of the uncertainties in the actual timing of future waste shipments, the transportation impacts for the various cases are best compared by examining the total impacts of transporting a specific inventory of waste, independent of the annual shipping rates. The total amount of TRUW transported for each case can be calculated by multiplying the annual shipment quantities by 10 years. In practice, shipments to the Waste Isolation Pilot Plant (WIPP) would likely occur over a period of approximately 20 years (if shipments occur over a 20-year period, the annual amount of transportation would be roughly one-half of that reported in this appendix).

¹ U.S. Department of Energy, 1996, *Office of Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, Washington, D.C.

A.1 TRUW CASE 4

Transported Material with Radionuclide Profile

Alternative: 4 Regionalized 10 Sites - WIPP WAC Compliance

Waste Stream: TRUW

Waste Type: CH Waste

Destination: HANF

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LBL	1.14E-01	6.62E+01

Radionuclide	Activity (Ci/yr)
Pu-238	8.30E-03
Pu-239	1.70E-01
Pu-240	5.00E-02
Pu-241	1.20E+00
Pu-242	5.30E-06
Am-241	5.50E-02

Destination: LANL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: SNLA	1.08E-01	1.76E+02

Radionuclide	Activity (Ci/yr)
Pu-238	1.14E-02
Pu-239	2.35E-01
Pu-240	6.91E-02
Pu-241	1.66E+00
Pu-242	7.33E-06
Am-241	7.60E-02

Destination: ORNL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: PADUCAH	1.70E+00	3.37E+03

Radionuclide	Activity (Ci/yr)
Pu-238	1.12E-01
Pu-239	2.29E+00
Pu-240	6.75E-01
Pu-241	1.62E+01
Pu-242	7.15E-05
Am-241	7.42E-01

	Total Volume	Total Mass
Shipping Site: UMC	(m3/yr) 4.57E+00	(kg/yr) 2.65E+03

Radionuclide	Activity (Ci/yr)
Pu-238	3.32E-01
Pu-239	6.81E+00
Pu-240	2.00E+00
Pu-241	4.81E+01
Pu-242	2.12E-04
Am-241	2.20E+00

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: ANL-E	(m3/yr) 1.25E+02	(kg/yr) 2.67E+05

Radionuclide	Activity (Ci/yr)
U-235	2.29E-04
U-238	6.49E-05
Pu-239	6.97E+01
Pu-240	1.52E+01
Pu-241	4.20E+02

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 7.76E+02	(kg/yr) 1.23E+06

Radionuclide	Activity (Ci/yr)
Sr-90	5.19E+03
Y-90	5.19E+03
Ru-106	6.26E+01
Rh-106	6.26E+01
Cs-137	4.01E+03
Ba-137m	3.52E+03
Ce-144	6.26E+02
Pr-144	6.26E+02
Pm-147	4.70E+03
Th-232	1.56E-03
U-235	1.76E-02
U-238	1.37E-01
Pu-238	2.15E+03
Pu-239	6.27E+02
Pu-240	1.56E+02
Pu-241	4.31E+03
Pu-242	5.30E-06
Am-241	5.50E-02

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 4.37E+03	(kg/yr) 7.08E+06

Radionuclide	Activity (Ci/yr)
Sr-90	7.27E+01
Ru-106	9.35E-02
Cs-137	9.35E+01
Ce-144	6.75E-01
Pm-147	3.01E+02
Th-232	3.95E-02
U-233	1.09E+02
U-235	1.97E-02
U-238	1.66E-02
Np-237	7.79E-02
Pu-238	7.79E+03
Pu-239	4.83E+03
Pu-240	1.19E+03
Pu-241	3.48E+04
Pu-242	1.24E-01
Am-241	1.03E+04
Cm-244	1.35E+02
Cf-252	7.79E-03

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 1.22E+03	(kg/yr) 2.02E+06

Radionuclide	Activity (Ci/yr)
Sr-90	4.02E+01
Y-90	4.02E+01
Cs-137	4.02E+01
Ba-137m	2.63E+01
Pm-147	3.05E+01
U-235	6.80E-03
U-238	3.75E-02
Pu-238	2.22E+04
Pu-239	8.47E+03
Pu-240	2.77E+03
Pu-241	1.18E+05
Pu-242	3.47E-01
Am-241	2.50E+04

	Total Volume	Total Mass
Shipping Site: LLNL	(m3/yr) 2.17E+02	(kg/yr) 3.73E+05

	Activity
Radionuclide	(Ci/yr)
Pu-238	1.39E+01
Pu-239	2.85E+02
Pu-240	8.40E+01
Pu-241	2.01E+03
Pu-242	8.90E-03
Am-241	9.24E+01

	Total Volume	Total Mass
Shipping Site: MOUND	(m3/yr) 1.95E+01	(kg/yr) 2.87E+04

	Activity
Radionuclide	(Ci/yr)
Pu-238	1.39E+02
Pu-239	1.03E-01
Pu-240	7.23E-02

	Total Volume	Total Mass
Shipping Site: NTS	(m3/yr) 6.98E+01	(kg/yr) 1.13E+05

	Activity
Radionuclide	(Ci/yr)
Pu-238	4.72E-01
Pu-239	1.15E+01
Pu-240	2.58E+00
Pu-241	1.06E+02
Pu-242	1.78E-04

	Total Volume	Total Mass
Shipping Site: ORNL	(m3/yr) 6.28E+00	(kg/yr) 6.03E+03

	Activity
Radionuclide	(Ci/yr)
Pu-238	4.44E-01
Pu-239	9.11E+00
Pu-240	2.68E+00
Pu-241	6.43E+01
Pu-242	2.84E-04
Am-241	2.94E+00

	Total Volume	Total Mass
Shipping Site: RFP	(m3/yr) 6.95E+02	(kg/yr) 9.82E+05

Radionuclide	Activity (Ci/yr)
U-235	9.64E-05
Pu-238	3.67E+01
Pu-239	1.02E+03
Pu-240	2.47E+02
Pu-241	6.63E+03
Pu-242	7.23E-03
Am-241	1.08E+03

	Total Volume	Total Mass
Shipping Site: SRS	(m3/yr) 1.99E+03	(kg/yr) 1.15E+06

Radionuclide	Activity (Ci/yr)
Th-232	2.09E-05
U-233	1.15E-03
U-235	1.46E-03
U-238	9.94E-04
Np-237	4.36E-01
Pu-238	9.94E+04
Pu-239	2.26E+03
Pu-240	6.45E+02
Pu-241	2.26E+04
Pu-242	5.40E-01
Am-241	3.31E+02
Cm-244	2.61E+02
Cf-252	3.31E+00

A.2 TRUW CASE 5

Transported Material with Radionuclide Profile

Alternative: 5 Regionalized 5 Sites - Stabilization Option

Waste Stream: TRUW

Waste Type: CH Waste

Destination: HANF

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LBL	1.00E-01	4.00E+01

Radionuclide	Activity (Ci/yr)
Pu-238	8.30E-03
Pu-239	1.70E-01
Pu-240	5.00E-02
Pu-241	1.20E+00
Pu-242	5.30E-06
Am-241	5.50E-02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LLNL	1.68E+02	1.85E+05

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+01
Pu-239	2.85E+02
Pu-240	8.40E+01
Pu-241	2.01E+03
Pu-242	8.90E-03
Am-241	9.24E+01

Destination: INEL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: NTS	6.12E+01	9.18E+04

Radionuclide	Activity (Ci/yr)
Pu-238	3.24E-01
Pu-239	7.95E+00
Pu-240	1.77E+00
Pu-241	7.34E+01
Pu-242	1.22E-04

Destination: LANL

	Total Volume	Total Mass
Shipping Site: SNLA	(m3/yr) 9.50E-02	(kg/yr) 1.42E+02

Radionuclide	Activity (Ci/yr)
Pu-238	7.88E-03
Pu-239	1.61E-01
Pu-240	4.75E-02
Pu-241	1.14E+00
Pu-242	5.03E-06
Am-241	5.22E-02

Destination: SRS

	Total Volume	Total Mass
Shipping Site: ANL-E	(m3/yr) 9.54E+01	(kg/yr) 1.03E+05

Radionuclide	Activity (Ci/yr)
U-235	2.29E-04
U-238	6.49E-05
Pu-239	6.97E+01
Pu-240	1.52E+01
Pu-241	4.20E+02

	Total Volume	Total Mass
Shipping Site: MOUND	(m3/yr) 1.64E+01	(kg/yr) 1.97E+04

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+02
Pu-239	1.03E-01
Pu-240	7.23E-02

	Total Volume	Total Mass
Shipping Site: PADUCAH	(m3/yr) 1.35E+00	(kg/yr) 1.68E+03

Radionuclide	Activity (Ci/yr)
Pu-238	1.12E-01
Pu-239	2.29E+00
Pu-240	6.75E-01
Pu-241	1.62E+01
Pu-242	7.15E-05
Am-241	7.42E-01

	Total Volume	Total Mass
Shipping Site: UMC	(m3/yr) 4.01E+00	(kg/yr) 1.60E+03

Radionuclide	Activity (Ci/yr)
Pu-238	3.32E-01
Pu-239	6.81E+00
Pu-240	2.00E+00
Pu-241	4.81E+01
Pu-242	2.12E-04
Am-241	2.20E+00

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 7.51E+02	(kg/yr) 3.27E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.60E+03
Y-90	3.60E+03
Ru-106	4.35E+01
Rh-106	4.35E+01
Cs-137	2.78E+03
Ba-137m	2.44E+03
Ce-144	4.35E+02
Pr-144	4.35E+02
Pm-147	3.26E+03
Th-232	1.08E-03
U-235	1.22E-02
U-238	9.51E-02
Pu-238	1.50E+03
Pu-239	7.20E+02
Pu-240	1.92E+02
Pu-241	5.00E+03
Pu-242	8.90E-03
Am-241	9.24E+01

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 3.50E+03	(kg/yr) 1.44E+07

Radionuclide	Activity (Ci/yr)
Sr-90	5.33E+01
Ru-106	6.85E-02
Cs-137	6.85E+01
Ce-144	4.95E-01
Pm-147	2.20E+02
Th-232	2.89E-02
U-233	7.99E+01
U-235	1.44E-02
U-238	1.21E-02
Np-237	5.71E-02
Pu-238	5.71E+03
Pu-239	3.55E+03
Pu-240	8.77E+02
Pu-241	2.55E+04
Pu-242	9.15E-02
Am-241	7.61E+03
Cm-244	9.90E+01
Cf-252	5.71E-03

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 1.01E+03	(kg/yr) 3.68E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.06E+01
Y-90	3.06E+01
Cs-137	3.06E+01
Ba-137m	2.01E+01
Pm-147	2.32E+01
U-235	5.18E-03
U-238	2.85E-02
Pu-238	1.69E+04
Pu-239	6.45E+03
Pu-240	2.11E+03
Pu-241	8.99E+04
Pu-242	2.64E-01
Am-241	1.90E+04

	Total Volume	Total Mass
Shipping Site: RFP	(m3/yr) 5.12E+02	(kg/yr) 1.77E+06

Radionuclide	Activity (Ci/yr)
U-235	9.64E-05
Pu-238	3.67E+01
Pu-239	1.02E+03
Pu-240	2.47E+02
Pu-241	6.63E+03
Pu-242	7.23E-03
Am-241	1.08E+03

	Total Volume	Total Mass
Shipping Site: SRS	(m3/yr) 9.02E+02	(kg/yr) 2.25E+06

Radionuclide	Activity (Ci/yr)
Th-232	2.09E-05
U-233	1.15E-03
U-235	1.69E-03
U-238	1.05E-03
Np-237	4.36E-01
Pu-238	9.96E+04
Pu-239	2.34E+03
Pu-240	6.63E+02
Pu-241	2.31E+04
Pu-242	5.41E-01
Am-241	3.34E+02
Cm-244	2.61E+02
Cf-252	3.31E+00

A.3 TRUW CASE 6

Transported Material with Radionuclide Profile

Alternative: 6 Regionalized 5 Sites - RCRA Compliance

Waste Stream: TRUW

Waste Type: CH Waste

Destination: HANF

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LBL	1.00E-01	4.00E+01

Radionuclide	Activity (Ci/yr)
Pu-238	8.30E-03
Pu-239	1.70E-01
Pu-240	5.00E-02
Pu-241	1.20E+00
Pu-242	5.30E-06
Am-241	5.50E-02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LLNL	1.68E+02	1.85E+05

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+01
Pu-239	2.85E+02
Pu-240	8.40E+01
Pu-241	2.01E+03
Pu-242	8.90E-03
Am-241	9.24E+01

Destination: INEL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: NTS	6.12E+01	9.18E+04

Radionuclide	Activity (Ci/yr)
Pu-238	3.24E-01
Pu-239	7.95E+00
Pu-240	1.77E+00
Pu-241	7.34E+01
Pu-242	1.22E-04

Destination: LANL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: SNLA	9.50E-02	1.42E+02

Radionuclide	Activity (Ci/yr)
Pu-238	7.88E-03
Pu-239	1.61E-01
Pu-240	4.75E-02
Pu-241	1.14E+00
Pu-242	5.03E-06
Am-241	5.22E-02

Destination: SRS

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: ANL-E	9.54E+01	1.03E+05

Radionuclide	Activity (Ci/yr)
U-235	2.29E-04
U-238	6.49E-05
Pu-239	6.97E+01
Pu-240	1.52E+01
Pu-241	4.20E+02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: MOUND	1.64E+01	1.97E+04

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+02
Pu-239	1.03E-01
Pu-240	7.23E-02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: PADUCAH	1.35E+00	1.68E+03

Radionuclide	Activity (Ci/yr)
Pu-238	1.12E-01
Pu-239	2.29E+00
Pu-240	6.75E-01
Pu-241	1.62E+01
Pu-242	7.15E-05
Am-241	7.42E-01

	Total Volume	Total Mass
Shipping Site: UMC	(m3/yr) 4.01E+00	(kg/yr) 1.60E+03

Radionuclide	Activity (Ci/yr)
Pu-238	3.32E-01
Pu-239	6.81E+00
Pu-240	2.00E+00
Pu-241	4.81E+01
Pu-242	2.12E-04
Am-241	2.20E+00

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 6.88E+02	(kg/yr) 3.18E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.60E+03
Y-90	3.60E+03
Ru-106	4.35E+01
Rh-106	4.35E+01
Cs-137	2.78E+03
Ba-137m	2.44E+03
Ce-144	4.35E+02
Pr-144	4.35E+02
Pm-147	3.26E+03
Th-232	1.08E-03
U-235	1.22E-02
U-238	9.51E-02
Pu-238	1.50E+03
Pu-239	7.20E+02
Pu-240	1.92E+02
Pu-241	5.00E+03
Pu-242	8.90E-03
Am-241	9.24E+01

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 2.95E+03	(kg/yr) 1.44E+07

Radionuclide	Activity (Ci/yr)
Sr-90	5.33E+01
Ru-106	6.85E-02
Cs-137	6.85E+01
Ce-144	4.95E-01
Pm-147	2.20E+02
Th-232	2.89E-02
U-233	7.99E+01
U-235	1.44E-02

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 2.95E+03	(kg/yr) 1.44E+07

Radionuclide	Activity (Ci/yr)
U-238	1.21E-02
Np-237	5.71E-02
Pu-238	5.71E+03
Pu-239	3.55E+03
Pu-240	8.77E+02
Pu-241	2.55E+04
Pu-242	9.15E-02
Am-241	7.61E+03
Cm-244	9.90E+01
Cf-252	5.71E-03

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 7.69E+02	(kg/yr) 3.72E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.06E+01
Y-90	3.06E+01
Cs-137	3.06E+01
Ba-137m	2.01E+01
Pm-147	2.32E+01
U-235	5.18E-03
U-238	2.85E-02
Pu-238	1.69E+04
Pu-239	6.45E+03
Pu-240	2.11E+03
Pu-241	8.99E+04
Pu-242	2.64E-01
Am-241	1.90E+04

	Total Volume	Total Mass
Shipping Site: RFP	(m3/yr) 3.94E+02	(kg/yr) 1.78E+06

Radionuclide	Activity (Ci/yr)
U-235	9.64E-05
Pu-238	3.67E+01
Pu-239	1.02E+03
Pu-240	2.47E+02
Pu-241	6.63E+03
Pu-242	7.23E-03
Am-241	1.08E+03

	Total Volume	Total Mass
	(m3/yr)	(kg/yr)
Shipping Site: SRS	5.47E+02	1.25E+06

Radionuclide	Activity (Ci/yr)
Th-232	2.09E-05
U-233	1.15E-03
U-235	1.69E-03
U-238	1.05E-03
Np-237	4.36E-01
Pu-238	9.96E+04
Pu-239	2.34E+03
Pu-240	6.63E+02
Pu-241	2.31E+04
Pu-242	5.41E-01
Am-241	3.34E+02
Cm-244	2.61E+02
Cf-252	3.31E+00

A.4 TRUW CASE 8

Transported Material with Radionuclide Profile

Alternative: 8 Regionalized 3 Sites - RCRA Compliance

Waste Stream: TRUW

Waste Type: CH Waste

Destination: HANF

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LBL	1.00E-01	4.00E+01

Radionuclide	Activity (Ci/yr)
Pu-238	8.30E-03
Pu-239	1.70E-01
Pu-240	5.00E-02
Pu-241	1.20E+00
Pu-242	5.30E-06
Am-241	5.50E-02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LLNL	1.68E+02	1.85E+05

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+01
Pu-239	2.85E+02
Pu-240	8.40E+01
Pu-241	2.01E+03
Pu-242	8.90E-03
Am-241	9.24E+01

Destination: INEL

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: LANL	1.05E+03	1.58E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.06E+01
Y-90	3.06E+01
Cs-137	3.06E+01
Ba-137m	2.01E+01
Pm-147	2.32E+01
U-235	5.18E-03
U-238	2.85E-02
Pu-238	1.69E+04
Pu-239	6.45E+03

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 1.05E+03	(kg/yr) 1.58E+06

	Activity
Radionuclide	(Ci/yr)
Pu-240	2.11E+03
Pu-241	8.99E+04
Pu-242	2.64E-01
Am-241	1.90E+04

	Total Volume	Total Mass
Shipping Site: NTS	(m3/yr) 6.12E+01	(kg/yr) 9.18E+04

	Activity
Radionuclide	(Ci/yr)
Pu-238	3.24E-01
Pu-239	7.95E+00
Pu-240	1.77E+00
Pu-241	7.34E+01
Pu-242	1.22E-04

	Total Volume	Total Mass
Shipping Site: RFP	(m3/yr) 6.02E+02	(kg/yr) 7.41E+05

	Activity
Radionuclide	(Ci/yr)
U-235	9.64E-05
Pu-238	3.67E+01
Pu-239	1.02E+03
Pu-240	2.47E+02
Pu-241	6.63E+03
Pu-242	7.23E-03
Am-241	1.08E+03

	Total Volume	Total Mass
Shipping Site: SNLA	(m3/yr) 9.50E-02	(kg/yr) 1.42E+02

	Activity
Radionuclide	(Ci/yr)
Pu-238	7.88E-03
Pu-239	1.61E-01
Pu-240	4.75E-02
Pu-241	1.14E+00
Pu-242	5.03E-06
Am-241	5.22E-02

Destination: SRS

	Total Volume	Total Mass
Shipping Site: ANL-E	(m3/yr) 9.54E+01	(kg/yr) 1.03E+05

Radionuclide	Activity (Ci/yr)
U-235	2.29E-04
U-238	6.49E-05
Pu-239	6.97E+01
Pu-240	1.52E+01
Pu-241	4.20E+02

	Total Volume	Total Mass
Shipping Site: MOUND	(m3/yr) 1.64E+01	(kg/yr) 1.97E+04

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+02
Pu-239	1.03E-01
Pu-240	7.23E-02

	Total Volume	Total Mass
Shipping Site: PADUCAH	(m3/yr) 1.35E+00	(kg/yr) 1.68E+03

Radionuclide	Activity (Ci/yr)
Pu-238	1.12E-01
Pu-239	2.29E+00
Pu-240	6.75E-01
Pu-241	1.62E+01
Pu-242	7.15E-05
Am-241	7.42E-01

	Total Volume	Total Mass
Shipping Site: UMC	(m3/yr) 4.01E+00	(kg/yr) 1.60E+03

Radionuclide	Activity (Ci/yr)
Pu-238	3.32E-01
Pu-239	6.81E+00
Pu-240	2.00E+00
Pu-241	4.81E+01
Pu-242	2.12E-04
Am-241	2.20E+00

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 6.88E+02	(kg/yr) 3.18E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.60E+03
Y-90	3.60E+03
Ru-106	4.35E+01
Rh-106	4.35E+01
Cs-137	2.78E+03
Ba-137m	2.44E+03
Ce-144	4.35E+02
Pr-144	4.35E+02
Pm-147	3.26E+03
Th-232	1.08E-03
U-235	1.22E-02
U-238	9.51E-02
Pu-238	1.50E+03
Pu-239	7.20E+02
Pu-240	1.92E+02
Pu-241	5.00E+03
Pu-242	8.90E-03
Am-241	9.24E+01

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 4.11E+03	(kg/yr) 1.99E+07

Radionuclide	Activity (Ci/yr)
Sr-90	8.40E+01
Y-90	3.06E+01
Ru-106	6.85E-02
Cs-137	9.92E+01
Ba-137m	2.01E+01
Ce-144	4.95E-01
Pm-147	2.44E+02
Th-232	2.89E-02
U-233	7.99E+01
U-235	1.97E-02
U-238	4.07E-02
Np-237	5.71E-02
Pu-238	2.26E+04
Pu-239	1.10E+04
Pu-240	3.24E+03
Pu-241	1.22E+05
Pu-242	3.63E-01
Am-241	2.77E+04
Cm-244	9.90E+01
Cf-252	5.71E-03

	Total Volume	Total Mass
Shipping Site: SRS	(m3/yr) 5.47E+02	(kg/yr) 1.25E+06

Radionuclide	Activity (Ci/yr)
Th-232	2.09E-05
U-233	1.15E-03
U-235	1.69E-03
U-238	1.05E-03
Np-237	4.36E-01
Pu-238	9.96E+04
Pu-239	2.34E+03
Pu-240	6.63E+02
Pu-241	2.31E+04
Pu-242	5.41E-01
Am-241	3.34E+02
Cm-244	2.61E+02
Cf-252	3.31E+00

A.5 TRUW CASE 9

Transported Material with Radionuclide Profile

Alternative: 9 Centralized 1 Site - RCRA Compliance

Waste Stream: TRUW

Waste Type: CH Waste

Destination: WIPP

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: ANL-E	9.54E+01	1.03E+05

Radionuclide	Activity (Ci/yr)
U-235	2.29E-04
U-238	6.49E-05
Pu-239	6.97E+01
Pu-240	1.52E+01
Pu-241	4.20E+02

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: HANF	6.79E+02	9.94E+05

Radionuclide	Activity (Ci/yr)
Sr-90	3.60E+03
Y-90	3.60E+03
Ru-106	4.35E+01
Rh-106	4.35E+01
Cs-137	2.78E+03
Ba-137m	2.44E+03
Ce-144	4.35E+02
Pr-144	4.35E+02
Pm-147	3.26E+03
Th-232	1.08E-03
U-235	1.22E-02
U-238	9.51E-02
Pu-238	1.49E+03
Pu-239	4.35E+02
Pu-240	1.08E+02
Pu-241	2.99E+03

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 3.80E+03	(kg/yr) 5.59E+06

Radionuclide	Activity (Ci/yr)
Sr-90	5.33E+01
Ru-106	6.85E-02
Cs-137	6.85E+01
Ce-144	4.95E-01
Pm-147	2.20E+02
Th-232	2.89E-02
U-233	7.99E+01
U-235	1.44E-02
U-238	1.21E-02
Np-237	5.71E-02
Pu-238	5.71E+03
Pu-239	3.54E+03
Pu-240	8.76E+02
Pu-241	2.55E+04
Pu-242	9.14E-02
Am-241	7.61E+03
Cm-244	9.90E+01
Cf-252	5.71E-03

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 1.05E+03	(kg/yr) 1.58E+06

Radionuclide	Activity (Ci/yr)
Sr-90	3.06E+01
Y-90	3.06E+01
Cs-137	3.06E+01
Ba-137m	2.01E+01
Pm-147	2.32E+01
U-235	5.18E-03
U-238	2.85E-02
Pu-238	1.69E+04
Pu-239	6.45E+03
Pu-240	2.11E+03
Pu-241	8.99E+04
Pu-242	2.64E-01
Am-241	1.90E+04

	Total Volume	Total Mass
Shipping Site: LBL	(m3/yr) 1.00E-01	(kg/yr) 4.00E+01

Radionuclide	Activity (Ci/yr)
Pu-238	8.30E-03
Pu-239	1.70E-01
Pu-240	5.00E-02
Pu-241	1.20E+00
Pu-242	5.30E-06
Am-241	5.50E-02

	Total Volume	Total Mass
Shipping Site: LLNL	(m3/yr) 1.68E+02	(kg/yr) 1.85E+05

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+01
Pu-239	2.85E+02
Pu-240	8.40E+01
Pu-241	2.01E+03
Pu-242	8.90E-03
Am-241	9.24E+01

	Total Volume	Total Mass
Shipping Site: MOUND	(m3/yr) 1.64E+01	(kg/yr) 1.97E+04

Radionuclide	Activity (Ci/yr)
Pu-238	1.39E+02
Pu-239	1.03E-01
Pu-240	7.23E-02

	Total Volume	Total Mass
Shipping Site: NTS	(m3/yr) 6.12E+01	(kg/yr) 9.18E+04

Radionuclide	Activity (Ci/yr)
Pu-238	3.24E-01
Pu-239	7.95E+00
Pu-240	1.77E+00
Pu-241	7.34E+01
Pu-242	1.22E-04

	Total Volume	Total Mass
Shipping Site: PADUCAH	(m3/yr) 1.35E+00	(kg/yr) 1.68E+03

Radionuclide	Activity (Ci/yr)
Pu-238	1.12E-01
Pu-239	2.29E+00
Pu-240	6.75E-01
Pu-241	1.62E+01
Pu-242	7.15E-05
Am-241	7.42E-01

	Total Volume	Total Mass
Shipping Site: RFP	(m3/yr) 6.02E+02	(kg/yr) 7.41E+05

Radionuclide	Activity (Ci/yr)
U-235	9.64E-05
Pu-238	3.67E+01
Pu-239	1.02E+03
Pu-240	2.47E+02
Pu-241	6.63E+03
Pu-242	7.23E-03
Am-241	1.08E+03

	Total Volume	Total Mass
Shipping Site: SNLA	(m3/yr) 9.50E-02	(kg/yr) 1.42E+02

Radionuclide	Activity (Ci/yr)
Pu-238	7.88E-03
Pu-239	1.61E-01
Pu-240	4.75E-02
Pu-241	1.14E+00
Pu-242	5.03E-06
Am-241	5.22E-02

	Total Volume	Total Mass
Shipping Site: SRS	(m3/yr) 1.74E+03	(kg/yr) 6.98E+05

Radionuclide	Activity (Ci/yr)
Th-232	2.09E-05
U-233	1.15E-03
U-235	1.46E-03
U-238	9.94E-04
Np-237	4.36E-01
Pu-238	9.94E+04

	Total Volume	Total Mass
Shipping Site: SRS	(m3/yr)	(kg/yr)
	1.74E+03	6.98E+05

Radionuclide	Activity (Ci/yr)
Pu-239	2.26E+03
Pu-240	6.45E+02
Pu-241	2.26E+04
Pu-242	5.40E-01
Am-241	3.31E+02
Cm-244	2.61E+02
Cf-252	3.31E+00

	Total Volume	Total Mass
Shipping Site: UMC	(m3/yr)	(kg/yr)
	4.01E+00	1.60E+03

Radionuclide	Activity (Ci/yr)
Pu-238	3.32E-01
Pu-239	6.81E+00
Pu-240	2.00E+00
Pu-241	4.81E+01
Pu-242	2.12E-04
Am-241	2.20E+00

A.6 TRUW CASE 11

Transported Material with Radionuclide Profile

Alternative: 11 RH - Decentralized 5 Sites - WIPP WAC Compliance

Waste Stream: TRUW

Waste Type: RH Waste

Destination: WIPP

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: ANL-E	3.88E+01	2.25E+04

Radionuclide	Activity (Ci/yr)
Cs-137	3.12E+02
U-238	3.74E+00
Pu-239	5.10E+00
Pu-240	3.74E+00
Pu-241	4.76E+01

	Total Volume (m3/yr)	Total Mass (kg/yr)
Shipping Site: HANF	8.29E+02	1.80E+06

Radionuclide	Activity (Ci/yr)
Co-60	2.82E+02
Ni-63	1.94E+00
Sr-90	4.46E+04
Y-90	4.46E+04
Nb-95	2.51E+02
Tc-99	3.51E+01
Ru-106	1.19E+04
Rh-106	1.19E+04
Sb-125	2.07E+03
Cs-134	1.38E+03
Cs-137	5.46E+04
Ba-137m	5.15E+04
Ce-144	4.02E+04
Pr-144	4.02E+04
Pm-147	5.59E+04
Eu-152	1.75E+00
Eu-154	2.51E+02
Eu-155	4.58E+02
Th-232	3.07E-03
U-235	3.26E-02
U-236	3.26E-04
U-238	2.63E-01
Np-237	1.06E-01
Pu-238	3.83E+03
Pu-239	1.19E+03
Pu-240	3.26E+02
Pu-241	9.42E+03

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 8.29E+02	(kg/yr) 1.80E+06

Radionuclide	Activity (Ci/yr)
Pu-242	2.51E-04
Am-241	1.44E+02
Cm-244	3.39E-01

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 6.68E+01	(kg/yr) 1.07E+05

Radionuclide	Activity (Ci/yr)
Cr-51	9.79E-01
Mn-54	6.33E+04
Fe-59	9.79E-01
Co-58	1.61E+01
Co-60	6.33E+00
Ni-63	5.76E+01
Sr-90	9.21E+03
Y-90	2.99E+01
Nb-95	1.03E-01
Tc-99	2.18E-02
Ru-106	2.36E+03
Rh-106	1.84E-01
Sb-125	8.64E-01
Cs-134	1.32E+02
Cs-137	2.59E+03
Ba-137m	2.36E+01
Ce-144	5.58E+02
Pr-144	2.18E+00
Pm-147	2.99E+04
Eu-154	2.18E-01
Eu-155	1.09E-01
Th-232	9.79E-06
U-233	3.39E-02
U-235	7.49E-02
U-236	6.91E-04
U-238	8.06E-03
Np-237	7.49E-04
Pu-238	1.09E+01
Pu-239	4.37E+00
Pu-240	1.95E+01
Pu-241	1.09E+04

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 1.01E+01	(kg/yr) 1.65E+04

Radionuclide	Activity (Ci/yr)
Sr-90	3.11E+02
Y-90	3.11E+02
Cs-137	2.33E+02
Ba-137m	2.07E+02
Pm-147	2.33E+02
U-235	1.68E-03
U-238	1.55E-04
Pu-238	1.19E+00
Pu-239	1.42E+01
Pu-240	4.53E+00
Pu-241	1.94E+02
Pu-242	8.81E-04

	Total Volume	Total Mass
Shipping Site: ORNL	(m3/yr) 1.67E+02	(kg/yr) 1.91E+05

Radionuclide	Activity (Ci/yr)
Co-60	3.25E+02
Sr-90	1.13E+04
Cs-137	1.20E+04
Eu-152	1.55E+03
Eu-154	9.33E+02
Th-232	3.67E-01
U-233	1.32E+01
U-235	3.39E-05
U-238	6.64E-05
Np-237	1.27E-02
Pu-238	5.37E+01
Pu-239	2.26E+01
Pu-240	2.96E-02
Pu-241	7.35E-04
Am-241	4.38E+00
Cm-244	2.82E+02
Cf-252	5.79E+00

A.7 TRUW CASE 14

Transported Material with Radionuclide Profile

Alternative: 14 RH - Regionalized 2 Sites - Stabilization Option

Waste Stream: TRUW

Waste Type: RH Waste

Destination: HANF

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 5.71E+01	(kg/yr) 7.99E+04

Radionuclide	Activity (Ci/yr)
Cr-51	9.70E-01
Mn-54	6.28E+04
Fe-59	9.70E-01
Co-58	1.59E+01
Co-60	6.28E+00
Ni-63	5.71E+01
Sr-90	9.13E+03
Y-90	2.96E+01
Nb-95	1.02E-01
Tc-99	2.17E-02
Ru-106	2.34E+03
Rh-106	1.82E-01
Sb-125	8.56E-01
Cs-134	1.31E+02
Cs-137	2.57E+03
Ba-137m	2.34E+01
Ce-144	5.54E+02
Pr-144	2.17E+00
Pm-147	2.96E+04
Eu-154	2.17E-01
Eu-155	1.08E-01
Th-232	9.70E-06
U-233	3.36E-02
U-235	7.42E-02
U-236	6.85E-04
U-238	7.99E-03
Np-237	7.42E-04
Pu-238	1.08E+01
Pu-239	4.34E+00
Pu-240	1.94E+01
Pu-241	1.08E+04

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 8.90E+00	(kg/yr) 1.33E+04

Radionuclide	Activity (Ci/yr)
Sr-90	2.13E+02
Y-90	2.13E+02
Cs-137	1.60E+02
Ba-137m	1.42E+02
Pm-147	1.60E+02
U-235	1.15E-03
U-238	1.06E-04
Pu-238	8.18E-01
Pu-239	9.79E+00
Pu-240	3.11E+00
Pu-241	1.33E+02
Pu-242	6.05E-04

Destination: ORNL

	Total Volume	Total Mass
Shipping Site: ANL-E	(m3/yr) 3.40E+01	(kg/yr) 1.36E+04

Radionuclide	Activity (Ci/yr)
Cs-137	3.12E+02
U-238	3.74E+00
Pu-239	5.10E+00
Pu-240	3.74E+00
Pu-241	4.76E+01

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 8.95E+02	(kg/yr) 1.98E+06

Radionuclide	Activity (Ci/yr)
Cr-51	9.70E-01
Mn-54	6.28E+04
Fe-59	9.70E-01
Co-58	1.59E+01
Co-60	2.89E+02
Ni-63	5.90E+01
Sr-90	5.39E+04
Y-90	4.48E+04
Nb-95	2.51E+02
Tc-99	3.52E+01
Ru-106	1.42E+04
Rh-106	1.19E+04
Sb-125	2.07E+03
Cs-134	1.51E+03
Cs-137	5.74E+04

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 8.95E+02	(kg/yr) 1.98E+06

Radionuclide	Activity (Ci/yr)
Ba-137m	5.17E+04
Ce-144	4.07E+04
Pr-144	4.02E+04
Pm-147	8.58E+04
Eu-152	1.75E+00
Eu-154	2.51E+02
Eu-155	4.58E+02
Th-232	3.08E-03
U-233	3.36E-02
U-235	1.08E-01
U-236	1.01E-03
U-238	2.72E-01
Np-237	1.07E-01
Pu-238	3.84E+03
Pu-239	1.20E+03
Pu-240	3.49E+02
Pu-241	2.04E+04
Pu-242	8.56E-04
Am-241	1.44E+02
Cm-244	3.39E-01

	Total Volume	Total Mass
Shipping Site: ORNL	(m3/yr) 1.82E+02	(kg/yr) 2.28E+05

Radionuclide	Activity (Ci/yr)
Co-60	3.25E+02
Sr-90	1.13E+04
Cs-137	1.23E+04
Eu-152	1.55E+03
Eu-154	9.33E+02
Th-232	3.67E-01
U-233	1.32E+01
U-235	3.39E-05
U-238	3.74E+00
Np-237	1.27E-02
Pu-238	5.37E+01
Pu-239	2.77E+01
Pu-240	3.76E+00
Pu-241	4.76E+01
Am-241	4.38E+00
Cm-244	2.82E+02
Cf-252	5.79E+00

A.8 TRUW CASE 15

Transported Material with Radionuclide Profile

Alternative: 15 RH - Regionalized 2 Sites - RCRA Compliance

Waste Stream: TRUW

Waste Type: RH Waste

Destination: HANF

	Total Volume	Total Mass
Shipping Site: INEL	(m3/yr) 5.71E+01	(kg/yr) 7.99E+04

Radionuclide	Activity (Ci/yr)
Cr-51	9.70E-01
Mn-54	6.28E+04
Fe-59	9.70E-01
Co-58	1.59E+01
Co-60	6.28E+00
Ni-63	5.71E+01
Sr-90	9.13E+03
Y-90	2.96E+01
Nb-95	1.02E-01
Tc-99	2.17E-02
Ru-106	2.34E+03
Rh-106	1.82E-01
Sb-125	8.56E-01
Cs-134	1.31E+02
Cs-137	2.57E+03
Ba-137m	2.34E+01
Ce-144	5.54E+02
Pr-144	2.17E+00
Pm-147	2.96E+04
Eu-154	2.17E-01
Eu-155	1.08E-01
Th-232	9.70E-06
U-233	3.36E-02
U-235	7.42E-02
U-236	6.85E-04
U-238	7.99E-03
Np-237	7.42E-04
Pu-238	1.08E+01
Pu-239	4.34E+00
Pu-240	1.94E+01
Pu-241	1.08E+04

	Total Volume	Total Mass
Shipping Site: LANL	(m3/yr) 8.90E+00	(kg/yr) 1.33E+04

Radionuclide	Activity (Ci/yr)
Sr-90	2.13E+02
Y-90	2.13E+02
Cs-137	1.60E+02
Ba-137m	1.42E+02
Pm-147	1.60E+02
U-235	1.15E-03
U-238	1.06E-04
Pu-238	8.18E-01
Pu-239	9.79E+00
Pu-240	3.11E+00
Pu-241	1.33E+02
Pu-242	6.05E-04

Destination: ORNL

	Total Volume	Total Mass
Shipping Site: ANL-E	(m3/yr) 3.40E+01	(kg/yr) 1.36E+04

Radionuclide	Activity (Ci/yr)
Cs-137	3.12E+02
U-238	3.74E+00
Pu-239	5.10E+00
Pu-240	3.74E+00
Pu-241	4.76E+01

Destination: WIPP

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 8.94E+02	(kg/yr) 2.03E+06

Radionuclide	Activity (Ci/yr)
Cr-51	9.70E-01
Mn-54	6.28E+04
Fe-59	9.70E-01
Co-58	1.59E+01
Co-60	2.88E+02
Ni-63	5.90E+01
Sr-90	5.39E+04
Y-90	4.48E+04
Nb-95	2.51E+02
Tc-99	3.52E+01
Ru-106	1.42E+04
Rh-106	1.19E+04
Sb-125	2.07E+03
Cs-134	1.51E+03
Cs-137	5.73E+04

	Total Volume	Total Mass
Shipping Site: HANF	(m3/yr) 8.94E+02	(kg/yr) 2.03E+06

Radionuclide	Activity (Ci/yr)
Ba-137m	5.16E+04
Ce-144	4.07E+04
Pr-144	4.02E+04
Pm-147	8.57E+04
Eu-152	1.75E+00
Eu-154	2.51E+02
Eu-155	4.58E+02
Th-232	3.08E-03
U-233	3.36E-02
U-235	1.08E-01
U-236	1.01E-03
U-238	2.71E-01
Np-237	1.07E-01
Pu-238	3.84E+03
Pu-239	1.20E+03
Pu-240	3.49E+02
Pu-241	2.04E+04
Pu-242	8.56E-04
Am-241	1.44E+02
Cm-244	3.39E-01

	Total Volume	Total Mass
Shipping Site: ORNL	(m3/yr) 5.28E+01	(kg/yr) 1.78E+05

Radionuclide	Activity (Ci/yr)
Co-60	3.25E+02
Sr-90	1.13E+04
Cs-137	1.23E+04
Eu-152	1.55E+03
Eu-154	9.33E+02
Th-232	3.67E-01
U-233	1.32E+01
U-235	3.39E-05
U-238	3.73E+00
Np-237	1.27E-02
Pu-238	5.37E+01
Pu-239	2.77E+01
Pu-240	3.76E+00
Pu-241	4.75E+01
Am-241	4.38E+00
Cm-244	2.82E+02
Cf-252	5.79E+00

APPENDIX B:
TRANSPORTATION RISK ASSESSMENT RESULTS

APPENDIX B:

TRANSPORTATION RISK ASSESSMENT RESULTS

Detailed results of the collective population risk assessment for transportation of transuranic waste (TRUW) are presented in this appendix. The collective risk results are presented on an *annual* basis. As stated previously, the U.S. Department of Energy (DOE) Waste Management Programmatic Environmental Impact Statement (DOE 1996)¹ considers a 20-year time frame for TRUW generation and treatment; however, for purposes of assessment, it was assumed that shipments would occur uniformly over a 10-year period, which would allow an initial 10-year period to build treatment, storage, and disposal facilities. Sites would essentially store their own waste for the first 10 years and ship all waste over the subsequent 10 years.

Because of the uncertainties in the actual timing of future waste shipments, the transportation impacts for the various cases are best compared by examining the total impacts of transporting a specific inventory of waste, independent of the annual shipping rates. The total impacts of TRUW transportation for each case can be calculated by multiplying the annual shipment impacts by a 10-year shipping duration. The total impacts are provided in Section 4 of the main body of this report. In practice, shipments to the Waste Isolation Pilot Plant (WIPP) would likely occur over a period of approximately 20 years (if shipments occur over a 20-year period, the annual impacts would be roughly one-half of those reported in this appendix).

¹ U.S. Department of Energy, 1996, *Office of Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, Washington, D.C.

B.1 TRANSPORTATION RISK ASSESSMENT RESULTS FOR CH-TRUW

B.1.1 TRUW Case 4

Table 1. Summary of Route Information

		Distance (miles)	Percentage in Zone		
Route			Rural	Suburban	Urban
Truck					
Argonne - East	to WIPP	1505	81.4	17.8	0.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to WIPP	693	86.8	11.1	2.2
Lawrence Berkeley	to Hanford Site	875	78.1	17.8	4.1
Lawrence Livermore	to WIPP	1468	85.5	10.0	4.5
Mound Plant	to WIPP	1561	78.4	20.2	1.3
Nevada Test Site	to WIPP	1365	87.5	9.6	2.8
Oak Ridge Reserv.	to WIPP	1381	82.6	16.0	1.4
Paducah GDP	to Oak Ridge Reserv.	304	81.3	18.5	0.2
Rocky Flats Plant	to WIPP	1067	85.8	11.8	2.4
SNL - Albuquerque	to Los Alamos NL	102	75.8	20.1	4.1
Savannah River	to WIPP	1524	77.8	20.9	1.3
U of MO - Columbia	to Oak Ridge Reserv.	594	79.0	19.5	1.5
Rail					
Argonne - East	to WIPP	1279	89.9	9.2	0.9
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to WIPP	581	90.6	8.0	1.4
Lawrence Berkeley	to Hanford Site	986	78.5	15.8	5.7
Lawrence Livermore	to WIPP	1633	90.3	8.0	1.7
Mound Plant	to WIPP	1703	82.8	15.1	2.1
Nevada Test Site	to WIPP	1475	95.1	4.1	0.8
Oak Ridge Reserv.	to WIPP	1678	87.1	10.9	1.9
Paducah GDP	to Oak Ridge Reserv.	527	89.3	9.0	1.7
Rocky Flats Plant	to WIPP	769	86.3	11.5	2.3
SNL - Albuquerque	to Los Alamos NL	104	74.3	20.0	5.7
Savannah River	to WIPP	2243	79.0	18.8	2.2
U of MO - Columbia	to Oak Ridge Reserv.	695	82.5	14.2	3.3

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East to WIPP		15	8	2.26E+04	1.02E+04
Hanford Site to WIPP		93	47	2.02E+05	9.37E+04
INEL to WIPP		521	261	9.16E+05	3.78E+05
Los Alamos NL to WIPP		146	73	1.01E+05	4.24E+04
Lawrence Berkeley to Hanford Site		1	1	8.75E+02	9.86E+02
Lawrence Livermore to WIPP		26	13	3.82E+04	2.12E+04
Mound Plant to WIPP		3	2	4.68E+03	3.41E+03
Nevada Test Site to WIPP		9	5	1.23E+04	7.38E+03
Oak Ridge Reserv. to WIPP		1	1	1.38E+03	1.68E+03
Paducah GDP to Oak Ridge Reserv.		1	1	3.04E+02	5.27E+02
Rocky Flats Plant to WIPP		83	42	8.86E+04	3.23E+04
SNL - Albuquerque to Los Alamos NL		1	1	1.02E+02	1.04E+02
Savannah River to WIPP		237	119	3.61E+05	2.67E+05
U of MO - Columbia to Oak Ridge Reserv.		1	1	5.94E+02	6.95E+02
Totals		1138	575	1.75E+06	8.59E+05

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)		Crew	General Public			
			Off-Link	On-Link	Stops	Total
TRUW(CH) AN to WI						
Argonne - East	to WIPP					
	Truck	1.36E-01	9.46E-03	1.92E-02	1.44E-01	1.73E-01
	Rail	5.47E-02	3.09E-02	8.50E-04	4.82E-02	7.99E-02
TRUW(CH) HS to WI						
Hanford Site	to WIPP					
	Truck	1.83E-01	1.12E-02	2.81E-02	2.08E-01	2.48E-01
	Rail	7.45E-02	4.35E-02	1.21E-03	6.25E-02	1.07E-01
TRUW(CH) IN to WI						
INEL	to WIPP					
	Truck	1.49E-01	9.68E-03	2.33E-02	1.69E-01	2.02E-01
	Rail	5.94E-02	3.31E-02	9.09E-04	5.15E-02	8.56E-02
TRUW(CH) LA to WI						
Los Alamos NL	to WIPP					
	Truck	6.04E-02	4.67E-03	1.02E-02	6.64E-02	8.12E-02
	Rail	3.53E-02	1.66E-02	3.90E-04	3.42E-02	5.12E-02
TRUW(CH) LB to HS						
Lawrence Berkeley	to Hanford Site					
	Truck	8.48E-02	1.03E-02	1.77E-02	8.39E-02	1.12E-01
	Rail	4.66E-02	8.97E-02	1.32E-03	4.23E-02	1.33E-01
TRUW(CH) LL to WI						
Lawrence Livermore	to WIPP					
	Truck	1.33E-01	1.53E-02	2.92E-02	1.41E-01	1.85E-01
	Rail	6.45E-02	5.33E-02	1.15E-03	5.52E-02	1.10E-01
TRUW(CH) MP to WI						
Mound Plant	to WIPP					
	Truck	1.46E-01	1.20E-02	2.21E-02	1.50E-01	1.84E-01
	Rail	6.65E-02	8.06E-02	1.66E-03	5.67E-02	1.39E-01
TRUW(CH) NT to WI						
Nevada Test Site	to WIPP					
	Truck	1.19E-01	1.03E-02	2.19E-02	1.31E-01	1.63E-01
	Rail	6.02E-02	2.32E-02	7.18E-04	5.21E-02	7.60E-02
TRUW(CH) OR to WI						
Oak Ridge Reserv.	to WIPP					
	Truck	1.24E-01	9.30E-03	1.89E-02	1.32E-01	1.61E-01
	Rail	6.58E-02	6.54E-02	1.37E-03	5.62E-02	1.23E-01
TRUW(CH) PA to OR						
Paducah GDP	to Oak Ridge Reserv.					
	Truck	2.73E-02	1.61E-03	3.42E-03	2.91E-02	3.41E-02
	Rail	3.38E-02	1.79E-02	3.88E-04	3.31E-02	5.14E-02
TRUW(CH) RF to WI						
Rocky Flats Plant	to WIPP					
	Truck	9.42E-02	7.85E-03	1.64E-02	1.02E-01	1.26E-01
	Rail	4.05E-02	3.39E-02	6.70E-04	3.80E-02	7.26E-02
TRUW(CH) SA to LA						
SNL - Albuquerque	to Los Alamos NL					
	Truck	1.01E-02	1.27E-03	2.10E-03	9.77E-03	1.31E-02
	Rail	2.21E-02	1.01E-02	1.53E-04	2.47E-02	3.49E-02
TRUW(CH) SR to WI						
Savannah River	to WIPP					
	Truck	1.43E-01	1.18E-02	2.15E-02	1.46E-01	1.79E-01
	Rail	8.15E-02	1.20E-01	2.48E-03	6.75E-02	1.90E-01
TRUW(CH) MC to OR						
U of MO - Columbia	to Oak Ridge Reserv.					
	Truck	5.54E-02	4.60E-03	8.53E-03	5.69E-02	7.00E-02
	Rail	3.85E-02	4.17E-02	7.35E-04	3.65E-02	7.89E-02

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(CH) AN to WI		
Argonne - East to WIPP	4.95E-05	3.33E-06
TRUW(CH) HS to WI		
Hanford Site to WIPP	1.91E-04	1.09E-05
TRUW(CH) IN to WI		
INEL to WIPP	2.69E-04	9.69E-06
TRUW(CH) LA to WI		
Los Alamos NL to WIPP	1.29E-03	9.40E-06
TRUW(CH) LB to HS		
Lawrence Berkeley to Hanford Site	8.65E-07	1.13E-07
TRUW(CH) LL to WI		
Lawrence Livermore to WIPP	5.76E-05	5.45E-06
TRUW(CH) MP to WI		
Mound Plant to WIPP	3.12E-04	2.86E-05
TRUW(CH) NT to WI		
Nevada Test Site to WIPP	5.34E-06	1.41E-07
TRUW(CH) OR to WI		
Oak Ridge Reserv. to WIPP	9.24E-05	5.78E-06
TRUW(CH) PA to OR		
Paducah GDP to Oak Ridge Reserv.	8.38E-06	2.75E-07
TRUW(CH) RF to WI		
Rocky Flats Plant to WIPP	1.49E-04	4.09E-06
TRUW(CH) SA to LA		
SNL - Albuquerque to Los Alamos NL	4.46E-07	2.14E-09
TRUW(CH) SR to WI		
Savannah River to WIPP	2.41E-03	6.06E-04
TRUW(CH) MC to OR		
U of MO - Columbia to Oak Ridge Reserv.	5.60E-05	2.95E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to WIPP	4.31E-06	1.01E-04
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to WIPP	4.80E-06	5.71E-05
Lawrence Berkeley	to Hanford Site	1.16E-05	4.91E-05
Lawrence Livermore	to WIPP	2.11E-05	1.08E-04
Mound Plant	to WIPP	6.69E-06	1.11E-04
Nevada Test Site	to WIPP	1.25E-05	1.00E-04
Oak Ridge Reserv.	to WIPP	6.28E-06	1.01E-04
Paducah GDP	to Oak Ridge Reserv.	1.93E-07	2.14E-05
Rocky Flats Plant	to WIPP	8.27E-06	8.52E-05
SNL - Albuquerque	to Los Alamos NL	1.35E-06	1.20E-05
Savannah River	to WIPP	6.31E-06	1.02E-04
U of MO - Columbia	to Oak Ridge Reserv.	2.83E-06	4.12E-05
Rail			
Argonne - East	to WIPP	4.81E-06	2.68E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to WIPP	3.39E-06	1.22E-06
Lawrence Berkeley	to Hanford Site	2.33E-05	2.06E-06
Lawrence Livermore	to WIPP	1.18E-05	3.42E-06
Mound Plant	to WIPP	1.53E-05	3.56E-06
Nevada Test Site	to WIPP	4.77E-06	3.09E-06
Oak Ridge Reserv.	to WIPP	1.35E-05	3.51E-06
Paducah GDP	to Oak Ridge Reserv.	3.81E-06	1.10E-06
Rocky Flats Plant	to WIPP	7.36E-06	1.61E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)
(Cont.)

Mode	Route	Emission	Accident
SNL - Albuquerque	to Los Alamos NL	2.47E-06	2.18E-07
Savannah River	to WIPP	2.09E-05	4.69E-06
U of MO - Columbia	to Oak Ridge Reserv.	9.54E-06	1.45E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to WIPP	2.04E+00	2.59E+00	4.38E-01	6.39E-01
Hanford Site	to WIPP	1.70E+01	2.30E+01	3.50E+00	5.04E+00
INEL	to WIPP	7.79E+01	1.05E+02	1.55E+01	2.23E+01
Los Alamos NL	to WIPP	8.82E+00	1.19E+01	2.58E+00	3.74E+00
Lawrence Berkeley	to Hanford Site	8.48E-02	1.12E-01	4.66E-02	1.33E-01
Lawrence Livermore	to WIPP	3.46E+00	4.81E+00	8.39E-01	1.43E+00
Mound Plant	to WIPP	4.38E-01	5.51E-01	1.33E-01	2.78E-01
Nevada Test Site	to WIPP	1.07E+00	1.47E+00	3.01E-01	3.80E-01
Oak Ridge Reserv.	to WIPP	1.24E-01	1.61E-01	6.58E-02	1.23E-01
Paducah GDP	to Oak Ridge Reserv.	2.73E-02	3.41E-02	3.38E-02	5.14E-02
Rocky Flats Plant	to WIPP	7.82E+00	1.05E+01	1.70E+00	3.05E+00
SNL - Albuquerque	to Los Alamos NL	1.01E-02	1.31E-02	2.21E-02	3.49E-02
Savannah River	to WIPP	3.40E+01	4.25E+01	9.70E+00	2.26E+01
U of MO - Columbia	to Oak Ridge Reserv.	5.54E-02	7.00E-02	3.85E-02	7.89E-02
Totals		1.53E+02	2.03E+02	3.49E+01	5.99E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign
(person-rem/yr)

Route		Truck	Rail
Argonne - East	to WIPP	7.42E-04	2.67E-05
Hanford Site	to WIPP	1.78E-02	5.13E-04
INEL	to WIPP	1.40E-01	2.53E-03
Los Alamos NL	to WIPP	1.88E-01	6.86E-04
Lawrence Berkeley	to Hanford Site	8.65E-07	1.13E-07
Lawrence Livermore	to WIPP	1.50E-03	7.08E-05
Mound Plant	to WIPP	9.36E-04	5.72E-05
Nevada Test Site	to WIPP	4.81E-05	7.06E-07
Oak Ridge Reserv.	to WIPP	9.24E-05	5.78E-06
Paducah GDP	to Oak Ridge Reserv.	8.38E-06	2.75E-07
Rocky Flats Plant	to WIPP	1.24E-02	1.72E-04
SNL - Albuquerque	to Los Alamos NL	4.46E-07	2.14E-09
Savannah River	to WIPP	5.71E-01	7.21E-02
U of MO - Columbia	to Oak Ridge Reserv.	5.60E-05	2.95E-06
Totals		9.33E-01	7.62E-02

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	6.1E-02	1.4E-02
Normal Public	1.0E-01	3.0E-02
Accident Public	4.7E-04	3.8E-05
Nonradiological		
Emission	9.5E-03	5.2E-03
Accident	1.3E-01	1.8E-03

Table 9. Expected Annual Cancer Incidence for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	2.1E-01	4.9E-02
Normal Public	3.4E-01	1.0E-01
Accident Public	1.6E-03	1.3E-04
Nonradiological		
Emission	9.5E-03	5.2E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	9.2E-03	2.1E-03
Normal Public	2.0E-02	6.0E-03
Accident Public	2.0E-05	1.7E-06
Nonradiological		
Emission	NA	NA
Accident	NA	NA

B.1.2 TRUW Case 5

Table 1. Summary of Route Information

Route		Distance (miles)	Percentage in Zone		
			Rural	Suburban	Urban
Truck					
Argonne - East	to Savannah River	892	68.8	29.3	1.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to WIPP	693	86.8	11.1	2.2
Lawrence Berkeley	to Hanford Site	875	78.1	17.8	4.1
Lawrence Livermore	to Hanford Site	894	77.2	19.3	3.4
Mound Plant	to Savannah River	656	66.5	32.7	0.8
Nevada Test Site	to INEL	712	82.8	13.7	3.5
Paducah GDP	to Savannah River	568	67.6	30.4	2.1
Rocky Flats Plant	to WIPP	1067	85.8	11.8	2.4
SNL - Albuquerque	to Los Alamos NL	102	75.8	20.1	4.1
Savannah River	to WIPP	1524	77.8	20.9	1.3
U of MO - Columbia	to Savannah River	858	70.6	27.0	2.3
Rail					
Argonne - East	to Savannah River	976	64.3	31.6	4.0
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to WIPP	581	90.6	8.0	1.4
Lawrence Berkeley	to Hanford Site	986	78.5	15.8	5.7
Lawrence Livermore	to Hanford Site	973	78.9	15.3	5.8
Mound Plant	to Savannah River	744	67.4	29.2	3.3
Nevada Test Site	to INEL	756	92.8	5.9	1.3
Paducah GDP	to Savannah River	714	65.2	31.4	3.4
Rocky Flats Plant	to WIPP	769	86.3	11.5	2.3
SNL - Albuquerque	to Los Alamos NL	104	74.3	20.0	5.7
Savannah River	to WIPP	2243	79.0	18.8	2.2
U of MO - Columbia	to Savannah River	1011	66.6	29.5	4.0

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to Savannah River	12	6	1.07E+04	5.86E+03
Hanford Site	to WIPP	90	45	1.96E+05	8.97E+04
INEL	to WIPP	417	209	7.33E+05	3.03E+05
Los Alamos NL	to WIPP	121	61	8.39E+04	3.55E+04
Lawrence Berkeley	to Hanford Site	1	1	8.75E+02	9.86E+02
Lawrence Livermore	to Hanford Site	20	10	1.79E+04	9.73E+03
Mound Plant	to Savannah River	2	1	1.31E+03	7.44E+02
Nevada Test Site	to INEL	8	4	5.70E+03	3.02E+03
Paducah GDP	to Savannah River	1	1	5.68E+02	7.14E+02
Rocky Flats Plant	to WIPP	61	31	6.51E+04	2.38E+04
SNL - Albuquerque	to Los Alamos NL	1	1	1.02E+02	1.04E+02
Savannah River	to WIPP	108	54	1.65E+05	1.21E+05
U of MO - Columbia	to Savannah River	1	1	8.58E+02	1.01E+03
Totals		843	425	1.28E+06	5.95E+05

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)	Crew	General Public			
		Off-Link	On-Link	Stops	Total
TRUW(CH) AN to SR Argonne - East	to Savannah River				
	Truck	9.16E-02	9.78E-03	1.50E-02	8.55E-02 1.10E-01
	Rail	4.63E-02	9.05E-02	1.66E-03	4.21E-02 1.34E-01
TRUW(CH) HS to WI Hanford Site	to WIPP				
	Truck	1.83E-01	1.12E-02	2.81E-02	2.08E-01 2.48E-01
	Rail	7.45E-02	4.35E-02	1.21E-03	6.25E-02 1.07E-01
TRUW(CH) IN to WI INEL	to WIPP				
	Truck	1.49E-01	9.68E-03	2.33E-02	1.69E-01 2.02E-01
	Rail	5.94E-02	3.31E-02	9.09E-04	5.15E-02 8.56E-02
TRUW(CH) LA to WI Los Alamos NL	to WIPP				
	Truck	6.04E-02	4.67E-03	1.02E-02	6.64E-02 8.12E-02
	Rail	3.53E-02	1.66E-02	3.90E-04	3.42E-02 5.12E-02
TRUW(CH) LB to HS Lawrence Berkeley	to Hanford Site				
	Truck	8.48E-02	1.03E-02	1.77E-02	8.39E-02 1.12E-01
	Rail	4.66E-02	8.97E-02	1.32E-03	4.23E-02 1.33E-01
TRUW(CH) LL to HS Lawrence Livermore	to Hanford Site				
	Truck	8.66E-02	9.87E-03	1.69E-02	8.57E-02 1.12E-01
	Rail	4.62E-02	8.97E-02	1.30E-03	4.21E-02 1.33E-01
TRUW(CH) MP to SR Mound Plant	to Savannah River				
	Truck	6.79E-02	6.53E-03	9.67E-03	6.28E-02 7.90E-02
	Rail	3.98E-02	6.01E-02	1.15E-03	3.75E-02 9.87E-02
TRUW(CH) NT to IN Nevada Test Site	to INEL				
	Truck	6.56E-02	6.94E-03	1.30E-02	6.82E-02 8.82E-02
	Rail	4.02E-02	1.82E-02	4.47E-04	3.77E-02 5.63E-02
TRUW(CH) PA to SR Paducah GDP	to Savannah River				
	Truck	5.90E-02	6.55E-03	9.85E-03	5.44E-02 7.08E-02
	Rail	3.90E-02	6.04E-02	1.16E-03	3.69E-02 9.84E-02
TRUW(CH) RF to WI Rocky Flats Plant	to WIPP				
	Truck	9.42E-02	7.85E-03	1.64E-02	1.02E-01 1.26E-01
	Rail	4.05E-02	3.39E-02	6.70E-04	3.80E-02 7.26E-02
TRUW(CH) SA to LA SNL - Albuquerque	to Los Alamos NL				
	Truck	1.01E-02	1.27E-03	2.10E-03	9.77E-03 1.31E-02
	Rail	2.21E-02	1.01E-02	1.53E-04	2.47E-02 3.49E-02
TRUW(CH) SR to WI Savannah River	to WIPP				
	Truck	1.43E-01	1.18E-02	2.15E-02	1.46E-01 1.79E-01
	Rail	8.15E-02	1.20E-01	2.48E-03	6.75E-02 1.90E-01
TRUW(CH) MC to SR U of MO - Columbia	to Savannah River				
	Truck	8.70E-02	9.54E-03	1.50E-02	8.22E-02 1.07E-01
	Rail	4.73E-02	9.02E-02	1.64E-03	4.28E-02 1.35E-01

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(CH) AN to SR		
Argonne - East to Savannah River	5.77E-05	7.90E-06
TRUW(CH) HS to WI		
Hanford Site to WIPP	1.73E-04	9.95E-06
TRUW(CH) IN to WI		
INEL to WIPP	2.47E-04	8.91E-06
TRUW(CH) LA to WI		
Los Alamos NL to WIPP	1.19E-03	8.56E-06
TRUW(CH) LB to HS		
Lawrence Berkeley to Hanford Site	8.65E-07	1.13E-07
TRUW(CH) LL to HS		
Lawrence Livermore to Hanford Site	7.61E-05	1.86E-05
TRUW(CH) MP to SR		
Mound Plant to Savannah River	3.26E-04	3.50E-05
TRUW(CH) NT to IN		
Nevada Test Site to INEL	2.40E-06	2.15E-07
TRUW(CH) PA to SR		
Paducah GDP to Savannah River	2.05E-05	1.24E-06
TRUW(CH) RF to WI		
Rocky Flats Plant to WIPP	2.03E-04	5.53E-06
TRUW(CH) SA to LA		
SNL - Albuquerque to Los Alamos NL	3.06E-07	1.47E-09
TRUW(CH) SR to WI		
Savannah River to WIPP	5.31E-03	1.34E-03
TRUW(CH) MC to SR		
U of MO - Columbia to Savannah River	9.21E-05	6.00E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to Savannah River	5.41E-06	7.04E-05
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to WIPP	4.80E-06	5.71E-05
Lawrence Berkeley	to Hanford Site	1.16E-05	4.91E-05
Lawrence Livermore	to Hanford Site	9.85E-06	5.03E-05
Mound Plant	to Savannah River	1.67E-06	5.26E-05
Nevada Test Site	to INEL	8.08E-06	4.36E-05
Paducah GDP	to Savannah River	3.77E-06	4.10E-05
Rocky Flats Plant	to WIPP	8.27E-06	8.52E-05
SNL - Albuquerque	to Los Alamos NL	1.35E-06	1.20E-05
Savannah River	to WIPP	6.31E-06	1.02E-04
U of MO - Columbia	to Savannah River	6.41E-06	6.09E-05
Rail			
Argonne - East	to Savannah River	1.65E-05	2.04E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to WIPP	3.39E-06	1.22E-06
Lawrence Berkeley	to Hanford Site	2.33E-05	2.06E-06
Lawrence Livermore	to Hanford Site	2.36E-05	2.04E-06
Mound Plant	to Savannah River	1.03E-05	1.56E-06
Nevada Test Site	to INEL	3.98E-06	1.58E-06
Paducah GDP	to Savannah River	1.01E-05	1.49E-06
Rocky Flats Plant	to WIPP	7.36E-06	1.61E-06
SNL - Albuquerque	to Los Alamos NL	2.47E-06	2.18E-07
Savannah River	to WIPP	2.09E-05	4.69E-06
U of MO - Columbia	to Savannah River	1.69E-05	2.12E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to Savannah River	1.10E+00	1.32E+00	2.78E-01	8.06E-01
Hanford Site	to WIPP	1.65E+01	2.23E+01	3.35E+00	4.82E+00
INEL	to WIPP	6.23E+01	8.40E+01	1.24E+01	1.79E+01
Los Alamos NL	to WIPP	7.31E+00	9.83E+00	2.15E+00	3.12E+00
Lawrence Berkeley	to Hanford Site	8.48E-02	1.12E-01	4.66E-02	1.33E-01
Lawrence Livermore	to Hanford Site	1.73E+00	2.25E+00	4.62E-01	1.33E+00
Mound Plant	to Savannah River	1.36E-01	1.58E-01	3.98E-02	9.87E-02
Nevada Test Site	to INEL	5.25E-01	7.05E-01	1.61E-01	2.25E-01
Paducah GDP	to Savannah River	5.90E-02	7.08E-02	3.90E-02	9.84E-02
Rocky Flats Plant	to WIPP	5.75E+00	7.72E+00	1.26E+00	2.25E+00
SNL - Albuquerque	to Los Alamos NL	1.01E-02	1.31E-02	2.21E-02	3.49E-02
Savannah River	to WIPP	1.55E+01	1.94E+01	4.40E+00	1.02E+01
U of MO - Columbia	to Savannah River	8.70E-02	1.07E-01	4.73E-02	1.35E-01
Totals		1.11E+02	1.48E+02	2.47E+01	4.12E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to Savannah River	6.92E-04	4.74E-05
Hanford Site	to WIPP	1.55E-02	4.48E-04
INEL	to WIPP	1.03E-01	1.86E-03
Los Alamos NL	to WIPP	1.43E-01	5.22E-04
Lawrence Berkeley	to Hanford Site	8.65E-07	1.13E-07
Lawrence Livermore	to Hanford Site	1.52E-03	1.86E-04
Mound Plant	to Savannah River	6.53E-04	3.50E-05
Nevada Test Site	to INEL	1.92E-05	8.58E-07
Paducah GDP	to Savannah River	2.05E-05	1.24E-06
Rocky Flats Plant	to WIPP	1.24E-02	1.71E-04
SNL - Albuquerque	to Los Alamos NL	3.06E-07	1.47E-09
Savannah River	to WIPP	5.73E-01	7.22E-02
U of MO - Columbia	to Savannah River	9.21E-05	6.00E-06
Totals		8.51E-01	7.54E-02

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	4.4E-02	9.9E-03
Normal Public	7.4E-02	2.1E-02
Accident Public	4.3E-04	3.8E-05
Nonradiological		
Emission	6.9E-03	3.5E-03
Accident	9.3E-02	1.2E-03

Table 9. Expected Annual Cancer Incidence
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.6E-01	3.5E-02
Normal Public	2.5E-01	7.0E-02
Accident Public	1.4E-03	1.3E-04
Nonradiological		
Emission	6.9E-03	3.5E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	6.7E-03	1.5E-03
Normal Public	1.5E-02	4.1E-03
Accident Public	1.8E-05	1.7E-06
Nonradiological		
Emission	NA	NA
Accident	NA	NA

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Table 1. Summary of Route Information

Route		Distance (miles)	Percentage in Zone		
			Rural	Suburban	Urban
Truck					
Argonne - East	to Savannah River	892	68.8	29.3	1.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to WIPP	693	86.8	11.1	2.2
Lawrence Berkeley	to Hanford Site	875	78.1	17.8	4.1
Lawrence Livermore	to Hanford Site	894	77.2	19.3	3.4
Mound Plant	to Savannah River	656	66.5	32.7	0.8
Nevada Test Site	to INEL	712	82.8	13.7	3.5
Paducah GDP	to Savannah River	568	67.6	30.4	2.1
Rocky Flats Plant	to WIPP	1067	85.8	11.8	2.4
SNL - Albuquerque	to Los Alamos NL	102	75.8	20.1	4.1
Savannah River	to WIPP	1524	77.8	20.9	1.3
U of MO - Columbia	to Savannah River	858	70.6	27.0	2.3
Rail					
Argonne - East	to Savannah River	976	64.3	31.6	4.0
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to WIPP	581	90.6	8.0	1.4
Lawrence Berkeley	to Hanford Site	986	78.5	15.8	5.7
Lawrence Livermore	to Hanford Site	973	78.9	15.3	5.8
Mound Plant	to Savannah River	744	67.4	29.2	3.3
Nevada Test Site	to INEL	756	92.8	5.9	1.3
Paducah GDP	to Savannah River	714	65.2	31.4	3.4
Rocky Flats Plant	to WIPP	769	86.3	11.5	2.3
SNL - Albuquerque	to Los Alamos NL	104	74.3	20.0	5.7
Savannah River	to WIPP	2243	79.0	18.8	2.2
U of MO - Columbia	to Savannah River	1011	66.6	29.5	4.0

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to Savannah River	12	6	1.07E+04	5.86E+03
Hanford Site	to WIPP	82	41	1.78E+05	8.17E+04
INEL	to WIPP	352	176	6.19E+05	2.55E+05
Los Alamos NL	to WIPP	92	46	6.38E+04	2.67E+04
Lawrence Berkeley	to Hanford Site	1	1	8.75E+02	9.86E+02
Lawrence Livermore	to Hanford Site	20	10	1.79E+04	9.73E+03
Mound Plant	to Savannah River	2	1	1.31E+03	7.44E+02
Nevada Test Site	to INEL	8	4	5.70E+03	3.02E+03
Paducah GDP	to Savannah River	1	1	5.68E+02	7.14E+02
Rocky Flats Plant	to WIPP	47	24	5.01E+04	1.85E+04
SNL - Albuquerque	to Los Alamos NL	1	1	1.02E+02	1.04E+02
Savannah River	to WIPP	66	33	1.01E+05	7.40E+04
U of MO - Columbia	to Savannah River	1	1	8.58E+02	1.01E+03
Totals		685	345	1.05E+06	4.78E+05

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)	Crew	General Public			
		Off-Link	On-Link	Stops	Total
TRUW(CH) AN to SR Argonne - East	to Savannah River				
	Truck	9.16E-02	9.78E-03	1.50E-02	8.55E-02 1.10E-01
	Rail	4.63E-02	9.05E-02	1.66E-03	4.21E-02 1.34E-01
TRUW(CH) HS to WI Hanford Site	to WIPP				
	Truck	1.83E-01	1.12E-02	2.81E-02	2.08E-01 2.48E-01
	Rail	7.45E-02	4.35E-02	1.21E-03	6.25E-02 1.07E-01
TRUW(CH) IN to WI INEL	to WIPP				
	Truck	1.49E-01	9.68E-03	2.33E-02	1.69E-01 2.02E-01
	Rail	5.94E-02	3.31E-02	9.09E-04	5.15E-02 8.56E-02
TRUW(CH) LA to WI Los Alamos NL	to WIPP				
	Truck	6.04E-02	4.67E-03	1.02E-02	6.64E-02 8.12E-02
	Rail	3.53E-02	1.66E-02	3.90E-04	3.42E-02 5.12E-02
TRUW(CH) LB to HS Lawrence Berkeley	to Hanford Site				
	Truck	8.48E-02	1.03E-02	1.77E-02	8.39E-02 1.12E-01
	Rail	4.66E-02	8.97E-02	1.32E-03	4.23E-02 1.33E-01
TRUW(CH) LL to HS Lawrence Livermore	to Hanford Site				
	Truck	8.66E-02	9.87E-03	1.69E-02	8.57E-02 1.12E-01
	Rail	4.62E-02	8.97E-02	1.30E-03	4.21E-02 1.33E-01
TRUW(CH) MP to SR Mound Plant	to Savannah River				
	Truck	6.79E-02	6.53E-03	9.67E-03	6.28E-02 7.90E-02
	Rail	3.98E-02	6.01E-02	1.15E-03	3.75E-02 9.87E-02
TRUW(CH) NT to IN Nevada Test Site	to INEL				
	Truck	6.56E-02	6.94E-03	1.30E-02	6.82E-02 8.82E-02
	Rail	4.02E-02	1.82E-02	4.47E-04	3.77E-02 5.63E-02
TRUW(CH) PA to SR Paducah GDP	to Savannah River				
	Truck	5.90E-02	6.55E-03	9.85E-03	5.44E-02 7.08E-02
	Rail	3.90E-02	6.04E-02	1.16E-03	3.69E-02 9.84E-02
TRUW(CH) RF to WI Rocky Flats Plant	to WIPP				
	Truck	9.42E-02	7.85E-03	1.64E-02	1.02E-01 1.26E-01
	Rail	4.05E-02	3.39E-02	6.70E-04	3.80E-02 7.26E-02
TRUW(CH) SA to LA SNL - Albuquerque	to Los Alamos NL				
	Truck	1.01E-02	1.27E-03	2.10E-03	9.77E-03 1.31E-02
	Rail	2.21E-02	1.01E-02	1.53E-04	2.47E-02 3.49E-02
TRUW(CH) SR to WI Savannah River	to WIPP				
	Truck	1.43E-01	1.18E-02	2.15E-02	1.46E-01 1.79E-01
	Rail	8.15E-02	1.20E-01	2.48E-03	6.75E-02 1.90E-01
TRUW(CH) MC to SR U of MO - Columbia	to Savannah River				
	Truck	8.70E-02	9.54E-03	1.50E-02	8.22E-02 1.07E-01
	Rail	4.73E-02	9.02E-02	1.64E-03	4.28E-02 1.35E-01

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(CH) AN to SR		
Argonne - East to Savannah River	5.77E-05	7.90E-06
TRUW(CH) HS to WI		
Hanford Site to WIPP	1.89E-04	1.09E-05
TRUW(CH) IN to WI		
INEL to WIPP	2.93E-04	1.06E-05
TRUW(CH) LA to WI		
Los Alamos NL to WIPP	1.56E-03	1.13E-05
TRUW(CH) LB to HS		
Lawrence Berkeley to Hanford Site	8.65E-07	1.13E-07
TRUW(CH) LL to HS		
Lawrence Livermore to Hanford Site	7.61E-05	1.86E-05
TRUW(CH) MP to SR		
Mound Plant to Savannah River	3.26E-04	3.50E-05
TRUW(CH) NT to IN		
Nevada Test Site to INEL	2.40E-06	2.15E-07
TRUW(CH) PA to SR		
Paducah GDP to Savannah River	2.05E-05	1.24E-06
TRUW(CH) RF to WI		
Rocky Flats Plant to WIPP	2.63E-04	7.15E-06
TRUW(CH) SA to LA		
SNL - Albuquerque to Los Alamos NL	3.06E-07	1.47E-09
TRUW(CH) SR to WI		
Savannah River to WIPP	8.69E-03	2.19E-03
TRUW(CH) MC to SR		
U of MO - Columbia to Savannah River	9.21E-05	6.00E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to Savannah River	5.41E-06	7.04E-05
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to WIPP	4.80E-06	5.71E-05
Lawrence Berkeley	to Hanford Site	1.16E-05	4.91E-05
Lawrence Livermore	to Hanford Site	9.85E-06	5.03E-05
Mound Plant	to Savannah River	1.67E-06	5.26E-05
Nevada Test Site	to INEL	8.08E-06	4.36E-05
Paducah GDP	to Savannah River	3.77E-06	4.10E-05
Rocky Flats Plant	to WIPP	8.27E-06	8.52E-05
SNL - Albuquerque	to Los Alamos NL	1.35E-06	1.20E-05
Savannah River	to WIPP	6.31E-06	1.02E-04
U of MO - Columbia	to Savannah River	6.41E-06	6.09E-05
Rail			
Argonne - East	to Savannah River	1.65E-05	2.04E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to WIPP	3.39E-06	1.22E-06
Lawrence Berkeley	to Hanford Site	2.33E-05	2.06E-06
Lawrence Livermore	to Hanford Site	2.36E-05	2.04E-06
Mound Plant	to Savannah River	1.03E-05	1.56E-06
Nevada Test Site	to INEL	3.98E-06	1.58E-06
Paducah GDP	to Savannah River	1.01E-05	1.49E-06
Rocky Flats Plant	to WIPP	7.36E-06	1.61E-06
SNL - Albuquerque	to Los Alamos NL	2.47E-06	2.18E-07
Savannah River	to WIPP	2.09E-05	4.69E-06
U of MO - Columbia	to Savannah River	1.69E-05	2.12E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to Savannah River	1.10E+00	1.32E+00	2.78E-01	8.06E-01
Hanford Site	to WIPP	1.50E+01	2.03E+01	3.06E+00	4.39E+00
INEL	to WIPP	5.26E+01	7.09E+01	1.05E+01	1.51E+01
Los Alamos NL	to WIPP	5.56E+00	7.47E+00	1.62E+00	2.35E+00
Lawrence Berkeley	to Hanford Site	8.48E-02	1.12E-01	4.66E-02	1.33E-01
Lawrence Livermore	to Hanford Site	1.73E+00	2.25E+00	4.62E-01	1.33E+00
Mound Plant	to Savannah River	1.36E-01	1.58E-01	3.98E-02	9.87E-02
Nevada Test Site	to INEL	5.25E-01	7.05E-01	1.61E-01	2.25E-01
Paducah GDP	to Savannah River	5.90E-02	7.08E-02	3.90E-02	9.84E-02
Rocky Flats Plant	to WIPP	4.43E+00	5.95E+00	9.73E-01	1.74E+00
SNL - Albuquerque	to Los Alamos NL	1.01E-02	1.31E-02	2.21E-02	3.49E-02
Savannah River	to WIPP	9.46E+00	1.18E+01	2.69E+00	6.25E+00
U of MO - Columbia	to Savannah River	8.70E-02	1.07E-01	4.73E-02	1.35E-01
Totals		9.08E+01	1.21E+02	1.99E+01	3.27E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to Savannah River	6.92E-04	4.74E-05
Hanford Site	to WIPP	1.55E-02	4.49E-04
INEL	to WIPP	1.03E-01	1.86E-03
Los Alamos NL	to WIPP	1.44E-01	5.22E-04
Lawrence Berkeley	to Hanford Site	8.65E-07	1.13E-07
Lawrence Livermore	to Hanford Site	1.52E-03	1.86E-04
Mound Plant	to Savannah River	6.53E-04	3.50E-05
Nevada Test Site	to INEL	1.92E-05	8.58E-07
Paducah GDP	to Savannah River	2.05E-05	1.24E-06
Rocky Flats Plant	to WIPP	1.24E-02	1.72E-04
SNL - Albuquerque	to Los Alamos NL	3.06E-07	1.47E-09
Savannah River	to WIPP	5.74E-01	7.24E-02
U of MO - Columbia	to Savannah River	9.21E-05	6.00E-06
Totals		8.51E-01	7.57E-02

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	3.6E-02	8.0E-03
Normal Public	6.1E-02	1.6E-02
Accident Public	4.3E-04	3.8E-05
Nonradiological		
Emission	5.7E-03	2.7E-03
Accident	7.6E-02	1.0E-03

Table 9. Expected Annual Cancer Incidence
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.3E-01	2.8E-02
Normal Public	2.1E-01	5.6E-02
Accident Public	1.4E-03	1.3E-04
Nonradiological		
Emission	5.7E-03	2.7E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	5.4E-03	1.2E-03
Normal Public	1.2E-02	3.3E-03
Accident Public	1.8E-05	1.7E-06
Nonradiological		
Emission	NA	NA
Accident	NA	NA

B.1.4 TRUW Case 8

Table 1. Summary of Route Information

Route		Distance (miles)	Percentage in Zone		
			Rural	Suburban	Urban
Truck					
Argonne - East	to Savannah River	892	68.8	29.3	1.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to INEL	1144	88.7	9.8	1.4
Lawrence Berkeley	to Hanford Site	875	78.1	17.8	4.1
Lawrence Livermore	to Hanford Site	894	77.2	19.3	3.4
Mound Plant	to Savannah River	656	66.5	32.7	0.8
Nevada Test Site	to INEL	712	82.8	13.7	3.5
Paducah GDP	to Savannah River	568	67.6	30.4	2.1
Rocky Flats Plant	to INEL	716	91.3	8.1	0.6
SNL - Albuquerque	to INEL	1168	88.6	9.8	1.6
Savannah River	to WIPP	1524	77.8	20.9	1.3
U of MO - Columbia	to Savannah River	858	70.6	27.0	2.3
Rail					
Argonne - East	to Savannah River	976	64.3	31.6	4.0
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to INEL	1179	92.2	6.8	1.0
Lawrence Berkeley	to Hanford Site	986	78.5	15.8	5.7
Lawrence Livermore	to Hanford Site	973	78.9	15.3	5.8
Mound Plant	to Savannah River	744	67.4	29.2	3.3
Nevada Test Site	to INEL	756	92.8	5.9	1.3
Paducah GDP	to Savannah River	714	65.2	31.4	3.4
Rocky Flats Plant	to INEL	738	93.0	5.2	1.8
SNL - Albuquerque	to INEL	1247	91.0	7.6	1.4
Savannah River	to WIPP	2243	79.0	18.8	2.2
U of MO - Columbia	to Savannah River	1011	66.6	29.5	4.0

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to Savannah River	12	6	1.07E+04	5.86E+03
Hanford Site	to WIPP	82	41	1.78E+05	8.17E+04
INEL	to WIPP	490	245	8.62E+05	3.55E+05
Los Alamos NL	to INEL	125	63	1.43E+05	7.43E+04
Lawrence Berkeley	to Hanford Site	1	1	8.75E+02	9.86E+02
Lawrence Livermore	to Hanford Site	20	10	1.79E+04	9.73E+03
Mound Plant	to Savannah River	2	1	1.31E+03	7.44E+02
Nevada Test Site	to INEL	8	4	5.70E+03	3.02E+03
Paducah GDP	to Savannah River	1	1	5.68E+02	7.14E+02
Rocky Flats Plant	to INEL	72	36	5.15E+04	2.66E+04
SNL - Albuquerque	to INEL	1	1	1.17E+03	1.25E+03
Savannah River	to WIPP	66	33	1.01E+05	7.40E+04
U of MO - Columbia	to Savannah River	1	1	8.58E+02	1.01E+03
Totals		881	443	1.37E+06	6.35E+05

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

		General Public				
Source/Route(s)		Crew	Off-Link	On-Link	Stops	Total
TRUW(CH) AN to SR						
Argonne - East	to Savannah River					
	Truck	9.16E-02	9.78E-03	1.50E-02	8.55E-02	1.10E-01
	Rail	4.63E-02	9.05E-02	1.66E-03	4.21E-02	1.34E-01
TRUW(CH) HS to WI						
Hanford Site	to WIPP					
	Truck	1.83E-01	1.12E-02	2.81E-02	2.08E-01	2.48E-01
	Rail	7.45E-02	4.35E-02	1.21E-03	6.25E-02	1.07E-01
TRUW(CH) IN to WI						
INEL	to WIPP					
	Truck	1.49E-01	9.68E-03	2.33E-02	1.69E-01	2.02E-01
	Rail	5.94E-02	3.31E-02	9.09E-04	5.15E-02	8.56E-02
TRUW(CH) LA to IN						
Los Alamos NL	to INEL					
	Truck	9.68E-02	5.91E-03	1.46E-02	1.10E-01	1.30E-01
	Rail	5.19E-02	2.60E-02	7.02E-04	4.62E-02	7.29E-02
TRUW(CH) LB to HS						
Lawrence Berkeley	to Hanford Site					
	Truck	8.48E-02	1.03E-02	1.77E-02	8.39E-02	1.12E-01
	Rail	4.66E-02	8.97E-02	1.32E-03	4.23E-02	1.33E-01
TRUW(CH) LL to HS						
Lawrence Livermore	to Hanford Site					
	Truck	8.66E-02	9.87E-03	1.69E-02	8.57E-02	1.12E-01
	Rail	4.62E-02	8.97E-02	1.30E-03	4.21E-02	1.33E-01
TRUW(CH) MP to SR						
Mound Plant	to Savannah River					
	Truck	6.79E-02	6.53E-03	9.67E-03	6.28E-02	7.90E-02
	Rail	3.98E-02	6.01E-02	1.15E-03	3.75E-02	9.87E-02
TRUW(CH) NT to IN						
Nevada Test Site	to INEL					
	Truck	6.56E-02	6.94E-03	1.30E-02	6.82E-02	8.82E-02
	Rail	4.02E-02	1.82E-02	4.47E-04	3.77E-02	5.63E-02
TRUW(CH) PA to SR						
Paducah GDP	to Savannah River					
	Truck	5.90E-02	6.55E-03	9.85E-03	5.44E-02	7.08E-02
	Rail	3.90E-02	6.04E-02	1.16E-03	3.69E-02	9.84E-02
TRUW(CH) RF to IN						
Rocky Flats Plant	to INEL					
	Truck	5.83E-02	2.38E-03	7.61E-03	6.86E-02	7.86E-02
	Rail	3.97E-02	2.16E-02	4.55E-04	3.74E-02	5.94E-02
TRUW(CH) SA to IN						
SNL - Albuquerque	to INEL					
	Truck	9.91E-02	6.28E-03	1.53E-02	1.12E-01	1.33E-01
	Rail	5.38E-02	3.44E-02	8.19E-04	4.75E-02	8.28E-02
TRUW(CH) SR to WI						
Savannah River	to WIPP					
	Truck	1.43E-01	1.18E-02	2.15E-02	1.46E-01	1.79E-01
	Rail	8.15E-02	1.20E-01	2.48E-03	6.75E-02	1.90E-01
TRUW(CH) MC to SR						
U of MO - Columbia	to Savannah River					
	Truck	8.70E-02	9.54E-03	1.50E-02	8.22E-02	1.07E-01
	Rail	4.73E-02	9.02E-02	1.64E-03	4.28E-02	1.35E-01

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(CH) AN to SR		
Argonne - East to Savannah River	5.77E-05	7.90E-06
TRUW(CH) HS to WI		
Hanford Site to WIPP	1.89E-04	1.09E-05
TRUW(CH) IN to WI		
INEL to WIPP	7.67E-04	2.77E-05
TRUW(CH) LA to IN		
Los Alamos NL to INEL	1.25E-03	4.37E-05
TRUW(CH) LB to HS		
Lawrence Berkeley to Hanford Site	8.65E-07	1.13E-07
TRUW(CH) LL to HS		
Lawrence Livermore to Hanford Site	7.61E-05	1.86E-05
TRUW(CH) MP to SR		
Mound Plant to Savannah River	3.26E-04	3.50E-05
TRUW(CH) NT to IN		
Nevada Test Site to INEL	2.40E-06	2.15E-07
TRUW(CH) PA to SR		
Paducah GDP to Savannah River	2.05E-05	1.24E-06
TRUW(CH) RF to IN		
Rocky Flats Plant to INEL	4.52E-05	3.21E-06
TRUW(CH) SA to IN		
SNL - Albuquerque to INEL	1.05E-06	1.89E-08
TRUW(CH) SR to WI		
Savannah River to WIPP	8.69E-03	2.19E-03
TRUW(CH) MC to SR		
U of MO - Columbia to Savannah River	9.21E-05	6.00E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to Savannah River	5.41E-06	7.04E-05
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to INEL	5.25E-06	8.21E-05
Lawrence Berkeley	to Hanford Site	1.16E-05	4.91E-05
Lawrence Livermore	to Hanford Site	9.85E-06	5.03E-05
Mound Plant	to Savannah River	1.67E-06	5.26E-05
Nevada Test Site	to INEL	8.08E-06	4.36E-05
Paducah GDP	to Savannah River	3.77E-06	4.10E-05
Rocky Flats Plant	to INEL	1.42E-06	4.68E-05
SNL - Albuquerque	to INEL	5.83E-06	8.45E-05
Savannah River	to WIPP	6.31E-06	1.02E-04
U of MO - Columbia	to Savannah River	6.41E-06	6.09E-05
Rail			
Argonne - East	to Savannah River	1.65E-05	2.04E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to INEL	4.90E-06	2.47E-06
Lawrence Berkeley	to Hanford Site	2.33E-05	2.06E-06
Lawrence Livermore	to Hanford Site	2.36E-05	2.04E-06
Mound Plant	to Savannah River	1.03E-05	1.56E-06
Nevada Test Site	to INEL	3.98E-06	1.58E-06
Paducah GDP	to Savannah River	1.01E-05	1.49E-06
Rocky Flats Plant	to INEL	5.44E-06	1.54E-06
SNL - Albuquerque	to INEL	7.11E-06	2.61E-06
Savannah River	to WIPP	2.09E-05	4.69E-06
U of MO - Columbia	to Savannah River	1.69E-05	2.12E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to Savannah River	1.10E+00	1.32E+00	2.78E-01	8.06E-01
Hanford Site	to WIPP	1.50E+01	2.03E+01	3.06E+00	4.39E+00
INEL	to WIPP	7.32E+01	9.88E+01	1.45E+01	2.10E+01
Los Alamos NL	to INEL	1.21E+01	1.63E+01	3.27E+00	4.59E+00
Lawrence Berkeley	to Hanford Site	8.48E-02	1.12E-01	4.66E-02	1.33E-01
Lawrence Livermore	to Hanford Site	1.73E+00	2.25E+00	4.62E-01	1.33E+00
Mound Plant	to Savannah River	1.36E-01	1.58E-01	3.98E-02	9.87E-02
Nevada Test Site	to INEL	5.25E-01	7.05E-01	1.61E-01	2.25E-01
Paducah GDP	to Savannah River	5.90E-02	7.08E-02	3.90E-02	9.84E-02
Rocky Flats Plant	to INEL	4.20E+00	5.66E+00	1.43E+00	2.14E+00
SNL - Albuquerque	to INEL	9.91E-02	1.33E-01	5.38E-02	8.28E-02
Savannah River	to WIPP	9.46E+00	1.18E+01	2.69E+00	6.25E+00
U of MO - Columbia	to Savannah River	8.70E-02	1.07E-01	4.73E-02	1.35E-01
Totals		1.18E+02	1.58E+02	2.61E+01	4.13E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to Savannah River	6.92E-04	4.74E-05
Hanford Site	to WIPP	1.55E-02	4.49E-04
INEL	to WIPP	3.76E-01	6.78E-03
Los Alamos NL	to INEL	1.56E-01	2.75E-03
Lawrence Berkeley	to Hanford Site	8.65E-07	1.13E-07
Lawrence Livermore	to Hanford Site	1.52E-03	1.86E-04
Mound Plant	to Savannah River	6.53E-04	3.50E-05
Nevada Test Site	to INEL	1.92E-05	8.58E-07
Paducah GDP	to Savannah River	2.05E-05	1.24E-06
Rocky Flats Plant	to INEL	3.25E-03	1.16E-04
SNL - Albuquerque	to INEL	1.05E-06	1.89E-08
Savannah River	to WIPP	5.74E-01	7.24E-02
U of MO - Columbia	to Savannah River	9.21E-05	6.00E-06
Totals		1.13E+00	8.28E-02

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	4.7E-02	1.0E-02
Normal Public	7.9E-02	2.1E-02
Accident Public	5.6E-04	4.1E-05
Nonradiological		
Emission	6.9E-03	3.3E-03
Accident	9.9E-02	1.3E-03

Table 9. Expected Annual Cancer Incidence
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.6E-01	3.7E-02
Normal Public	2.7E-01	7.0E-02
Accident Public	1.9E-03	1.4E-04
Nonradiological		
Emission	6.9E-03	3.3E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	7.1E-03	1.6E-03
Normal Public	1.6E-02	4.1E-03
Accident Public	2.6E-05	1.9E-06
Nonradiological		
Emission	NA	NA
Accident	NA	NA

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Table 1. Summary of Route Information

Route		Distance (miles)	Percentage in Zone		
			Rural	Suburban	Urban
Truck					
Argonne - East	to WIPP	1505	81.4	17.8	0.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to WIPP	693	86.8	11.1	2.2
Lawrence Berkeley	to WIPP	1509	84.2	10.7	5.2
Lawrence Livermore	to WIPP	1468	85.5	10.0	4.5
Mound Plant	to WIPP	1561	78.4	20.2	1.3
Nevada Test Site	to WIPP	1365	87.5	9.6	2.8
Paducah GDP	to WIPP	1258	85.8	13.4	0.8
Rocky Flats Plant	to WIPP	1067	85.8	11.8	2.4
SNL - Albuquerque	to WIPP	605	86.8	10.4	2.8
Savannah River	to WIPP	1524	77.8	20.9	1.3
U of MO - Columbia	to WIPP	1203	84.5	13.8	1.6
Rail					
Argonne - East	to WIPP	1279	89.9	9.2	0.9
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to WIPP	581	90.6	8.0	1.4
Lawrence Berkeley	to WIPP	1660	88.1	8.9	3.0
Lawrence Livermore	to WIPP	1633	90.3	8.0	1.7
Mound Plant	to WIPP	1703	82.8	15.1	2.1
Nevada Test Site	to WIPP	1475	95.1	4.1	0.8
Paducah GDP	to WIPP	1410	88.8	10.1	1.1
Rocky Flats Plant	to WIPP	769	86.3	11.5	2.3
SNL - Albuquerque	to WIPP	477	94.2	5.4	0.5
Savannah River	to WIPP	2243	79.0	18.8	2.2
U of MO - Columbia	to WIPP	1024	89.9	9.1	0.9

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to WIPP	12	6	1.81E+04	7.67E+03
Hanford Site	to WIPP	81	41	1.76E+05	8.17E+04
INEL	to WIPP	453	227	7.97E+05	3.29E+05
Los Alamos NL	to WIPP	125	63	8.66E+04	3.66E+04
Lawrence Berkeley	to WIPP	1	1	1.51E+03	1.66E+03
Lawrence Livermore	to WIPP	20	10	2.94E+04	1.63E+04
Mound Plant	to WIPP	2	1	3.12E+03	1.70E+03
Nevada Test Site	to WIPP	8	4	1.09E+04	5.90E+03
Paducah GDP	to WIPP	1	1	1.26E+03	1.41E+03
Rocky Flats Plant	to WIPP	72	36	7.68E+04	2.77E+04
SNL - Albuquerque	to WIPP	1	1	6.05E+02	4.77E+02
Savannah River	to WIPP	208	104	3.17E+05	2.33E+05
U of MO - Columbia	to WIPP	1	1	1.20E+03	1.02E+03
Totals		985	496	1.52E+06	7.44E+05

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)		Crew	General Public			
			Off-Link	On-Link	Stops	Total
TRUW(CH) AN to WI Argonne - East	to WIPP					
	Truck	1.36E-01	9.46E-03	1.92E-02	1.44E-01	1.73E-01
	Rail	5.47E-02	3.09E-02	8.50E-04	4.82E-02	7.99E-02
TRUW(CH) HS to WI Hanford Site	to WIPP					
	Truck	1.83E-01	1.12E-02	2.81E-02	2.08E-01	2.48E-01
	Rail	7.45E-02	4.35E-02	1.21E-03	6.25E-02	1.07E-01
TRUW(CH) IN to WI INEL	to WIPP					
	Truck	1.49E-01	9.68E-03	2.33E-02	1.69E-01	2.02E-01
	Rail	5.94E-02	3.31E-02	9.09E-04	5.15E-02	8.56E-02
TRUW(CH) LA to WI Los Alamos NL	to WIPP					
	Truck	6.04E-02	4.67E-03	1.02E-02	6.64E-02	8.12E-02
	Rail	3.53E-02	1.66E-02	3.90E-04	3.42E-02	5.12E-02
TRUW(CH) LB to WI Lawrence Berkeley	to WIPP					
	Truck	1.40E-01	1.78E-02	3.26E-02	1.45E-01	1.95E-01
	Rail	6.53E-02	8.15E-02	1.42E-03	5.58E-02	1.39E-01
TRUW(CH) LL to WI Lawrence Livermore	to WIPP					
	Truck	1.33E-01	1.53E-02	2.92E-02	1.41E-01	1.85E-01
	Rail	6.45E-02	5.33E-02	1.15E-03	5.52E-02	1.10E-01
TRUW(CH) MP to WI Mound Plant	to WIPP					
	Truck	1.46E-01	1.20E-02	2.21E-02	1.50E-01	1.84E-01
	Rail	6.65E-02	8.06E-02	1.66E-03	5.67E-02	1.39E-01
TRUW(CH) NT to WI Nevada Test Site	to WIPP					
	Truck	1.19E-01	1.03E-02	2.19E-02	1.31E-01	1.63E-01
	Rail	6.02E-02	2.32E-02	7.18E-04	5.21E-02	7.60E-02
TRUW(CH) PA to WI Paducah GDP	to WIPP					
	Truck	1.09E-01	6.31E-03	1.49E-02	1.21E-01	1.42E-01
	Rail	5.83E-02	3.93E-02	1.01E-03	5.08E-02	9.11E-02
TRUW(CH) RF to WI Rocky Flats Plant	to WIPP					
	Truck	9.42E-02	7.85E-03	1.64E-02	1.02E-01	1.26E-01
	Rail	4.05E-02	3.39E-02	6.70E-04	3.80E-02	7.26E-02
TRUW(CH) SA to WI SNL - Albuquerque	to WIPP					
	Truck	5.31E-02	4.61E-03	9.67E-03	5.80E-02	7.22E-02
	Rail	3.24E-02	6.50E-03	2.37E-04	3.21E-02	3.89E-02
TRUW(CH) SR to WI Savannah River	to WIPP					
	Truck	1.43E-01	1.18E-02	2.15E-02	1.46E-01	1.79E-01
	Rail	8.15E-02	1.20E-01	2.48E-03	6.75E-02	1.90E-01
TRUW(CH) MC to WI U of MO - Columbia	to WIPP					
	Truck	1.07E-01	7.90E-03	1.67E-02	1.15E-01	1.40E-01
	Rail	4.76E-02	2.50E-02	6.81E-04	4.31E-02	6.88E-02

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(CH) AN to WI		
Argonne - East to WIPP	6.19E-05	4.44E-06
TRUW(CH) HS to WI		
Hanford Site to WIPP	1.52E-04	8.67E-06
TRUW(CH) IN to WI		
INEL to WIPP	2.27E-04	8.20E-06
TRUW(CH) LA to WI		
Los Alamos NL to WIPP	1.15E-03	8.29E-06
TRUW(CH) LB to WI		
Lawrence Berkeley to WIPP	9.45E-07	5.31E-08
TRUW(CH) LL to WI		
Lawrence Livermore to WIPP	7.46E-05	7.09E-06
TRUW(CH) MP to WI		
Mound Plant to WIPP	4.68E-04	5.72E-05
TRUW(CH) NT to WI		
Nevada Test Site to WIPP	4.14E-06	1.22E-07
TRUW(CH) PA to WI		
Paducah GDP to WIPP	1.46E-05	1.20E-06
TRUW(CH) RF to WI		
Rocky Flats Plant to WIPP	1.72E-04	4.76E-06
TRUW(CH) SA to WI		
SNL - Albuquerque to WIPP	7.44E-07	1.92E-09
TRUW(CH) SR to WI		
Savannah River to WIPP	2.75E-03	6.94E-04
TRUW(CH) MC to WI		
U of MO - Columbia to WIPP	4.54E-05	1.51E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to WIPP	4.31E-06	1.01E-04
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to WIPP	4.80E-06	5.71E-05
Lawrence Berkeley	to WIPP	2.51E-05	1.10E-04
Lawrence Livermore	to WIPP	2.11E-05	1.08E-04
Mound Plant	to WIPP	6.69E-06	1.11E-04
Nevada Test Site	to WIPP	1.25E-05	1.00E-04
Paducah GDP	to WIPP	3.22E-06	8.53E-05
Rocky Flats Plant	to WIPP	8.27E-06	8.52E-05
SNL - Albuquerque	to WIPP	5.38E-06	4.89E-05
Savannah River	to WIPP	6.31E-06	1.02E-04
U of MO - Columbia	to WIPP	6.37E-06	8.11E-05
Rail			
Argonne - East	to WIPP	4.81E-06	2.68E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to WIPP	3.39E-06	1.22E-06
Lawrence Berkeley	to WIPP	2.08E-05	3.47E-06
Lawrence Livermore	to WIPP	1.18E-05	3.42E-06
Mound Plant	to WIPP	1.53E-05	3.56E-06
Nevada Test Site	to WIPP	4.77E-06	3.09E-06
Paducah GDP	to WIPP	6.53E-06	2.95E-06
Rocky Flats Plant	to WIPP	7.36E-06	1.61E-06
SNL - Albuquerque	to WIPP	9.21E-07	9.99E-07
Savannah River	to WIPP	2.09E-05	4.69E-06
U of MO - Columbia	to WIPP	3.98E-06	2.14E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to WIPP	1.64E+00	2.07E+00	3.28E-01	4.79E-01
Hanford Site	to WIPP	1.48E+01	2.01E+01	3.06E+00	4.39E+00
INEL	to WIPP	6.77E+01	9.13E+01	1.35E+01	1.94E+01
Los Alamos NL	to WIPP	7.55E+00	1.02E+01	2.23E+00	3.22E+00
Lawrence Berkeley	to WIPP	1.40E-01	1.95E-01	6.53E-02	1.39E-01
Lawrence Livermore	to WIPP	2.66E+00	3.70E+00	6.45E-01	1.10E+00
Mound Plant	to WIPP	2.92E-01	3.67E-01	6.65E-02	1.39E-01
Nevada Test Site	to WIPP	9.53E-01	1.30E+00	2.41E-01	3.04E-01
Paducah GDP	to WIPP	1.09E-01	1.42E-01	5.83E-02	9.11E-02
Rocky Flats Plant	to WIPP	6.78E+00	9.11E+00	1.46E+00	2.61E+00
SNL - Albuquerque	to WIPP	5.31E-02	7.22E-02	3.24E-02	3.89E-02
Savannah River	to WIPP	2.98E+01	3.73E+01	8.47E+00	1.97E+01
U of MO - Columbia	to WIPP	1.07E-01	1.40E-01	4.76E-02	6.88E-02
Totals		1.33E+02	1.76E+02	3.02E+01	5.17E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to WIPP	7.43E-04	2.66E-05
Hanford Site	to WIPP	1.23E-02	3.56E-04
INEL	to WIPP	1.03E-01	1.86E-03
Los Alamos NL	to WIPP	1.43E-01	5.22E-04
Lawrence Berkeley	to WIPP	9.45E-07	5.31E-08
Lawrence Livermore	to WIPP	1.49E-03	7.09E-05
Mound Plant	to WIPP	9.37E-04	5.72E-05
Nevada Test Site	to WIPP	3.31E-05	4.88E-07
Paducah GDP	to WIPP	1.46E-05	1.20E-06
Rocky Flats Plant	to WIPP	1.24E-02	1.71E-04
SNL - Albuquerque	to WIPP	7.44E-07	1.92E-09
Savannah River	to WIPP	5.72E-01	7.21E-02
U of MO - Columbia	to WIPP	4.54E-05	1.51E-06
Totals		8.46E-01	7.52E-02

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	5.3E-02	1.2E-02
Normal Public	8.8E-02	2.6E-02
Accident Public	4.2E-04	3.8E-05
Nonradiological		
Emission	8.2E-03	4.5E-03
Accident	1.1E-01	1.6E-03

Table 9. Expected Annual Cancer Incidence
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.9E-01	4.2E-02
Normal Public	3.0E-01	8.8E-02
Accident Public	1.4E-03	1.3E-04
Nonradiological		
Emission	8.2E-03	4.5E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	8.0E-03	1.8E-03
Normal Public	1.8E-02	5.2E-03
Accident Public	1.8E-05	1.7E-06
Nonradiological		
Emission	NA	NA
Accident	NA	NA

B.2 TRANSPORTATION RISK ASSESSMENT RESULTS FOR RH-TRUW

B.2.1 TRUW Case 11

Table 1. Summary of Route Information

		Distance (miles)	Percentage in Zone		
			Rural	Suburban	Urban
Truck					
Argonne - East	to WIPP	1505	81.4	17.8	0.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to WIPP	1759	88.6	9.7	1.6
Los Alamos NL	to WIPP	693	86.8	11.1	2.2
Oak Ridge Reserv.	to WIPP	1381	82.6	16.0	1.4
Rail					
Argonne - East	to WIPP	1279	89.9	9.2	0.9
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to WIPP	1447	91.1	8.0	0.9
Los Alamos NL	to WIPP	581	90.6	8.0	1.4
Oak Ridge Reserv.	to WIPP	1678	87.1	10.9	1.9

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to WIPP	44	22	6.62E+04	2.81E+04
Hanford Site	to WIPP	932	466	2.03E+06	9.29E+05
INEL	to WIPP	76	38	1.34E+05	5.50E+04
Los Alamos NL	to WIPP	12	6	8.32E+03	3.49E+03
Oak Ridge Reserv.	to WIPP	188	94	2.60E+05	1.58E+05
Totals		1252	626	2.49E+06	1.17E+06

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)		Crew	General Public			
			Off-Link	On-Link	Stops	Total
TRUW(RH) AN to WI						
Argonne - East	to WIPP					
	Truck	1.36E-01	6.11E-03	1.24E-02	9.31E-02	1.12E-01
	Rail	5.98E-02	2.47E-02	6.81E-04	3.86E-02	6.40E-02
TRUW(RH) HS to WI						
Hanford Site	to WIPP					
	Truck	1.83E-01	7.21E-03	1.81E-02	1.35E-01	1.60E-01
	Rail	8.15E-02	3.48E-02	9.68E-04	5.00E-02	8.58E-02
TRUW(RH) IN to WI						
INEL	to WIPP					
	Truck	1.49E-01	6.25E-03	1.51E-02	1.09E-01	1.30E-01
	Rail	6.49E-02	2.65E-02	7.28E-04	4.13E-02	6.85E-02
TRUW(RH) LA to WI						
Los Alamos NL	to WIPP					
	Truck	6.04E-02	3.01E-03	6.56E-03	4.29E-02	5.24E-02
	Rail	3.86E-02	1.33E-02	3.13E-04	2.74E-02	4.10E-02
TRUW(RH) OR to WI						
Oak Ridge Reserv.	to WIPP					
	Truck	1.24E-01	6.00E-03	1.22E-02	8.54E-02	1.04E-01
	Rail	7.19E-02	5.24E-02	1.10E-03	4.50E-02	9.84E-02

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route	Truck	Rail
TRUW(RH) AN to WI Argonne - East	to WIPP	2.63E-06 2.05E-07
TRUW(RH) HS to WI Hanford Site	to WIPP	4.49E-05 2.73E-06
TRUW(RH) IN to WI INEL	to WIPP	2.86E-05 1.16E-06
TRUW(RH) LA to WI Los Alamos NL	to WIPP	7.88E-06 5.90E-08
TRUW(RH) OR to WI Oak Ridge Reserv.	to WIPP	1.23E-05 2.13E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to WIPP	4.31E-06	1.01E-04
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to WIPP	9.27E-06	1.30E-04
Los Alamos NL	to WIPP	4.80E-06	5.71E-05
Oak Ridge Reserv.	to WIPP	6.28E-06	1.01E-04
Rail			
Argonne - East	to WIPP	4.81E-06	2.68E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to WIPP	5.65E-06	3.03E-06
Los Alamos NL	to WIPP	3.39E-06	1.22E-06
Oak Ridge Reserv.	to WIPP	1.35E-05	3.51E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to WIPP	6.00E+00	4.91E+00	1.32E+00	1.41E+00
Hanford Site	to WIPP	1.71E+02	1.49E+02	3.80E+01	4.00E+01
INEL	to WIPP	1.14E+01	9.89E+00	2.47E+00	2.60E+00
Los Alamos NL	to WIPP	7.25E-01	6.29E-01	2.32E-01	2.46E-01
Oak Ridge Reserv.	to WIPP	2.34E+01	1.95E+01	6.76E+00	9.25E+00
Totals		2.12E+02	1.84E+02	4.87E+01	5.35E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to WIPP	1.16E-04	4.52E-06
Hanford Site	to WIPP	4.19E-02	1.27E-03
INEL	to WIPP	2.17E-03	4.40E-05
Los Alamos NL	to WIPP	9.45E-05	3.54E-07
Oak Ridge Reserv.	to WIPP	2.31E-03	2.00E-04
Totals		4.66E-02	1.52E-03

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	8.5E-02	1.9E-02
Normal Public	9.2E-02	2.7E-02
Accident Public	2.3E-05	7.6E-07
Nonradiological		
Emission	1.2E-02	5.1E-03
Accident	1.7E-01	2.5E-03

Table 9. Expected Annual Cancer Incidence
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	3.0E-01	6.8E-02
Normal Public	3.1E-01	9.1E-02
Accident Public	7.9E-05	2.6E-06
Nonradiological		
Emission	1.2E-02	5.1E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects
for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.3E-02	2.9E-03
Normal Public	1.8E-02	5.3E-03
Accident Public	1.3E-06	4.3E-08
Nonradiological		
Emission	NA	NA
Accident	NA	NA

B.2.2 TRUW Case 14

Table 1. Summary of Route Information

			Percentage in Zone		
			Rural	Suburban	Urban
	Route	Distance (miles)			
Truck					
Argonne - East	to Oak Ridge Reserv.	584	67.0	30.1	2.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to Hanford Site	599	91.3	7.6	1.1
Los Alamos NL	to Hanford Site	1560	89.8	8.8	1.3
Oak Ridge Reserv.	to WIPP	1381	82.6	16.0	1.4
Rail					
Argonne - East	to Oak Ridge Reserv.	648	70.7	25.3	4.0
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to Hanford Site	658	91.4	7.1	1.4
Los Alamos NL	to Hanford Site	1725	92.5	6.5	0.9
Oak Ridge Reserv.	to WIPP	1678	87.1	10.9	1.9

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to Oak Ridge Reserv.	39	20	2.28E+04	1.30E+04
Hanford Site	to WIPP	1006	503	2.19E+06	1.00E+06
INEL	to Hanford Site	65	33	3.89E+04	2.17E+04
Los Alamos NL	to Hanford Site	10	5	1.56E+04	8.62E+03
Oak Ridge Reserv.	to WIPP	205	103	2.83E+05	1.73E+05
Totals		1325	664	2.55E+06	1.22E+06

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)		Crew	General Public			
			Off-Link	On-Link	Stops	Total
TRUW(RH) AN to OR						
Argonne - East						
	to Oak Ridge Reserv.					
	Truck	6.14E-02	4.84E-03	7.22E-03	3.61E-02	4.82E-02
	Rail	4.06E-02	4.34E-02	7.71E-04	2.85E-02	7.27E-02
TRUW(RH) HS to WI						
Hanford Site						
	to WIPP					
	Truck	1.83E-01	7.21E-03	1.81E-02	1.35E-01	1.60E-01
	Rail	8.15E-02	3.48E-02	9.68E-04	5.00E-02	8.58E-02
TRUW(RH) IN to HS						
INEL						
	to Hanford Site					
	Truck	4.92E-02	1.59E-03	4.55E-03	3.70E-02	4.32E-02
	Rail	4.09E-02	1.47E-02	3.42E-04	2.86E-02	4.37E-02
TRUW(RH) LA to HS						
Los Alamos NL						
	to Hanford Site					
	Truck	1.30E-01	4.77E-03	1.25E-02	9.65E-02	1.14E-01
	Rail	7.33E-02	2.91E-02	8.03E-04	4.57E-02	7.56E-02
TRUW(RH) OR to WI						
Oak Ridge Reserv.						
	to WIPP					
	Truck	1.24E-01	6.00E-03	1.22E-02	8.54E-02	1.04E-01
	Rail	7.19E-02	5.24E-02	1.10E-03	4.50E-02	9.84E-02

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route		Truck	Rail
TRUW(RH) AN to OR			
Argonne - East	to Oak Ridge Reserv.	2.08E-06	1.83E-07
TRUW(RH) HS to WI			
Hanford Site	to WIPP	4.40E-05	2.68E-06
TRUW(RH) IN to HS			
INEL	to Hanford Site	4.80E-06	1.30E-06
TRUW(RH) LA to HS			
Los Alamos NL	to Hanford Site	8.19E-06	5.96E-07
TRUW(RH) OR to WI			
Oak Ridge Reserv.	to WIPP	1.17E-05	2.00E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to Oak Ridge Reserv.	5.38E-06	4.21E-05
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to Hanford Site	2.19E-06	3.07E-05
Los Alamos NL	to Hanford Site	6.66E-06	1.02E-04
Oak Ridge Reserv.	to WIPP	6.28E-06	1.01E-04
Rail			
Argonne - East	to Oak Ridge Reserv.	1.08E-05	1.36E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to Hanford Site	3.98E-06	1.38E-06
Los Alamos NL	to Hanford Site	6.82E-06	3.61E-06
Oak Ridge Reserv.	to WIPP	1.35E-05	3.51E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to Oak Ridge Reserv.	2.40E+00	1.88E+00	8.13E-01	1.45E+00
Hanford Site	to WIPP	1.84E+02	1.61E+02	4.10E+01	4.32E+01
INEL	to Hanford Site	3.20E+00	2.81E+00	1.35E+00	1.44E+00
Los Alamos NL	to Hanford Site	1.30E+00	1.14E+00	3.67E-01	3.78E-01
Oak Ridge Reserv.	to WIPP	2.55E+01	2.12E+01	7.40E+00	1.01E+01
Totals		2.16E+02	1.88E+02	5.09E+01	5.66E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to Oak Ridge Reserv.	8.13E-05	3.66E-06
Hanford Site	to WIPP	4.43E-02	1.35E-03
INEL	to Hanford Site	3.12E-04	4.30E-05
Los Alamos NL	to Hanford Site	8.19E-05	2.98E-06
Oak Ridge Reserv.	to WIPP	2.40E-03	2.06E-04
Totals		4.72E-02	1.61E-03

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	8.7E-02	2.0E-02
Normal Public	9.4E-02	2.8E-02
Accident Public	2.4E-05	8.0E-07
Nonradiological		
Emission	1.2E-02	5.6E-03
Accident	1.8E-01	2.5E-03

Table 9. Expected Annual Cancer Incidence for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	3.0E-01	7.1E-02
Normal Public	3.2E-01	9.6E-02
Accident Public	8.0E-05	2.7E-06
Nonradiological		
Emission	1.2E-02	5.6E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.3E-02	3.1E-03
Normal Public	1.9E-02	5.7E-03
Accident Public	1.3E-06	4.6E-08
Nonradiological		
Emission	NA	NA
Accident	NA	NA

B.2.3 TRUW Case 15

Table 1. Summary of Route Information

			Percentage in Zone		
			Rural	Suburban	Urban
Route		Distance (miles)			
Truck					
Argonne - East	to Oak Ridge Reserv.	584	67.0	30.1	2.9
Hanford Site	to WIPP	2175	89.4	9.0	1.5
INEL	to Hanford Site	599	91.3	7.6	1.1
Los Alamos NL	to Hanford Site	1560	89.8	8.8	1.3
Oak Ridge Reserv.	to WIPP	1381	82.6	16.0	1.4
Rail					
Argonne - East	to Oak Ridge Reserv.	648	70.7	25.3	4.0
Hanford Site	to WIPP	1993	91.7	7.4	0.9
INEL	to Hanford Site	658	91.4	7.1	1.4
Los Alamos NL	to Hanford Site	1725	92.5	6.5	0.9
Oak Ridge Reserv.	to WIPP	1678	87.1	10.9	1.9

Table 2. Annual Number of Shipments and One-Way Shipment Distances

Route		# of Shipments		Total Mileage(mi)	
		Truck	Rail	Truck	Rail
Argonne - East	to Oak Ridge Reserv.	39	20	2.28E+04	1.30E+04
Hanford Site	to WIPP	1005	503	2.19E+06	1.00E+06
INEL	to Hanford Site	65	33	3.89E+04	2.17E+04
Los Alamos NL	to Hanford Site	10	5	1.56E+04	8.62E+03
Oak Ridge Reserv.	to WIPP	60	30	8.28E+04	5.03E+04
Totals		1179	591	2.35E+06	1.10E+06

Table 3. Incident-Free Dose per Shipment (person-rem/shipment)

Source/Route(s)		General Public				
		Crew	Off-Link	On-Link	Stops	Total
TRUW(RH) AN to OR						
Argonne - East	to Oak Ridge Reserv.					
	Truck	6.14E-02	4.84E-03	7.22E-03	3.61E-02	4.82E-02
	Rail	4.06E-02	4.34E-02	7.71E-04	2.85E-02	7.27E-02
TRUW(RH) HS to WI						
Hanford Site	to WIPP					
	Truck	1.83E-01	7.21E-03	1.81E-02	1.35E-01	1.60E-01
	Rail	8.15E-02	3.48E-02	9.68E-04	5.00E-02	8.58E-02
TRUW(RH) IN to HS						
INEL	to Hanford Site					
	Truck	4.92E-02	1.59E-03	4.55E-03	3.70E-02	4.32E-02
	Rail	4.09E-02	1.47E-02	3.42E-04	2.86E-02	4.37E-02
TRUW(RH) LA to HS						
Los Alamos NL	to Hanford Site					
	Truck	1.30E-01	4.77E-03	1.25E-02	9.65E-02	1.14E-01
	Rail	7.33E-02	2.91E-02	8.03E-04	4.57E-02	7.56E-02
TRUW(RH) OR to WI						
Oak Ridge Reserv.	to WIPP					
	Truck	1.24E-01	6.00E-03	1.22E-02	8.54E-02	1.04E-01
	Rail	7.19E-02	5.24E-02	1.10E-03	4.50E-02	9.84E-02

Table 4. Accident Dose Risk per Shipment (person-rem/shipment)

Source/Route		Truck	Rail
TRUW(RH) AN to OR			
Argonne - East	to Oak Ridge Reserv.	2.08E-06	1.83E-07
TRUW(RH) HS to WI			
Hanford Site	to WIPP	4.40E-05	2.68E-06
TRUW(RH) IN to HS			
INEL	to Hanford Site	4.80E-06	1.30E-06
TRUW(RH) LA to HS			
Los Alamos NL	to Hanford Site	8.19E-06	5.96E-07
TRUW(RH) OR to WI			
Oak Ridge Reserv.	to WIPP	3.99E-05	6.86E-06

Table 5. Nonradiological Risk Factors per Shipment (fatalities/shipment)

Mode	Route	Emission	Accident
Truck			
Argonne - East	to Oak Ridge Reserv.	5.38E-06	4.21E-05
Hanford Site	to WIPP	1.07E-05	1.50E-04
INEL	to Hanford Site	2.19E-06	3.07E-05
Los Alamos NL	to Hanford Site	6.66E-06	1.02E-04
Oak Ridge Reserv.	to WIPP	6.28E-06	1.01E-04
Rail			
Argonne - East	to Oak Ridge Reserv.	1.08E-05	1.36E-06
Hanford Site	to WIPP	7.57E-06	4.17E-06
INEL	to Hanford Site	3.98E-06	1.38E-06
Los Alamos NL	to Hanford Site	6.82E-06	3.61E-06
Oak Ridge Reserv.	to WIPP	1.35E-05	3.51E-06

Table 6. Annual Incident-Free Dose for the Shipping Campaign (person-rem/yr)

Route		Truck		Rail	
		Crew	Public	Crew	Public
Argonne - East	to Oak Ridge Reserv.	2.40E+00	1.88E+00	8.13E-01	1.45E+00
Hanford Site	to WIPP	1.84E+02	1.61E+02	4.10E+01	4.32E+01
INEL	to Hanford Site	3.20E+00	2.81E+00	1.35E+00	1.44E+00
Los Alamos NL	to Hanford Site	1.30E+00	1.14E+00	3.67E-01	3.78E-01
Oak Ridge Reserv.	to WIPP	7.46E+00	6.22E+00	2.16E+00	2.95E+00
Totals		1.98E+02	1.73E+02	4.57E+01	4.94E+01

Table 7. Annual Accident Dose Risk for the Shipping Campaign (person-rem/yr)

Route		Truck	Rail
Argonne - East	to Oak Ridge Reserv.	8.13E-05	3.66E-06
Hanford Site	to WIPP	4.43E-02	1.35E-03
INEL	to Hanford Site	3.12E-04	4.30E-05
Los Alamos NL	to Hanford Site	8.19E-05	2.98E-06
Oak Ridge Reserv.	to WIPP	2.39E-03	2.06E-04
Totals		4.71E-02	1.61E-03

Table 8. Expected Annual Fatalities for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	7.9E-02	1.8E-02
Normal Public	8.6E-02	2.5E-02
Accident Public	2.4E-05	8.0E-07
Nonradiological		
Emission	1.2E-02	4.6E-03
Accident	1.6E-01	2.3E-03

Table 9. Expected Annual Cancer Incidence for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	2.8E-01	6.4E-02
Normal Public	2.9E-01	8.4E-02
Accident Public	8.0E-05	2.7E-06
Nonradiological		
Emission	1.2E-02	4.6E-03
Accident	NA	NA

Table 10. Expected Annual Genetic Effects for the Shipping Campaign

Exposure Group	Truck	Rail
Radiological		
Normal Crew	1.2E-02	2.7E-03
Normal Public	1.7E-02	4.9E-03
Accident Public	1.3E-06	4.6E-08
Nonradiological		
Emission	NA	NA
Accident	NA	NA