Nuclear Waste Partnership LLC

An AECOM-led partnership with B&W and AREVA

CP:15:01151
UFC:5822.00

August 19, 2015

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

SUBJECT: Responses to Request for Additional Information Related to the TRUPACT-III Application for Exemption.

REFERENCE: (1) Docket No. 71-9305 & TAC No. L24885
(2) Application for Exemption for the Model No. TRUPACT-III –Request For Additional Information on Environmental Report dated June, 24, 2015, from B. H. White IV to T. Sellmer

Dear Mr. White:

Nuclear Waste Partnership LLC (NWP), on behalf of the U.S. Department of Energy, Carlsbad Field Office and Savannah River Operations Office, hereby submits the enclosed responses to the request for additional information on Environmental Report (ER) in response to reference 2 above.

The enclosure consists of the responses to the four questions identified in reference 2 above along with three attachments required in the response to question no. 4 identified in reference 2 above. These responses have been provided on the enclosed CD in electronic format. It should be noted that in the first bulleted item in Question No. 4 of reference 2 above that "AP-141, Revision 0" is dated actually December, 2008 as opposed to the date of "August 2008" identified in Question no. 4 of reference 2 above. Additionally, the document requested in the second bulleted item in Question No. 4 of reference 2 above, "*WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small Quantity Sites and Impacts from Using the TRUPACT-III* dated June 2006" is actually dated "July 2006" as opposed to "June 2006" identified in Question no. 4 of reference 2 above.

If you have any questions or require additional information regarding this request, please contact me at (575) 234-7396.

Sincerely,

T. E. Sellmer, Manager
Packaging & Information Systems

TES:lcg

Enclosure

cc: (without enclosure)
G. Hellstrom, CBFO
J. C. Rhoades, CBFO
J. R. Stroble, CBFO
H. M. Crapse, SRS
P. W. Noss, AFS
H. Akhavannik, USNRC

AREVA

AFS-15-0279

08-10-2015

Mr. Todd Sellmer
Packaging and Information Systems
National TRU Program
Nuclear Waste Partnership LLC
P.O. Box 2078
Carlsbad, NM 88221

Dear Mr. Sellmer:

RE: Responses to NRC RAI on the TRUPACT-III Environmental Report

The attachment to this letter constitutes the response to the first three of the Requests for Additional Information (RAI) issued by the NRC on June 24, 2015, on the subject Environmental Report. The fourth and final RAI concerned documents that will be provided by NWP. The electronic file of this letter and its attachment will be provided by email. Note that the last page requires an editorial addition by NWP.

If you have any questions, please don't hesitate to contact me.

Sincerely,

Phil Noss

Phil Noss
Licensing Manager

Cc:

Rich Smith
John Coody

AREVA

ATTACHMENT A

Docket No. 71-9305, Model No. TRUPACT-III Package

Responses to NRC Request for Additional Information Dated June 24, 2015

Question no. 1:

The transportation route listed on page 20 of the environmental report (ER) is slightly different than the route used in the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (SEIS-II). The rout differences begin in in Texas. Show how the route provided in the ER is bounded by the route used in SEIS-II (e.g., number of miles, rural vs suburban area, etc.).

This information is needed for the NRC staff to complete its environmental review of the application, for compliance with 10 CFR Part 51.

Response:

Specific routing varies over the years depending on new available roads, surrounding developments, and existing environmental conditions. On page 3-9, Section 3.1.2.2 of the SEIS-II, Volume 1, the following excerpt describes the ideology for revising future routes, "*The states through which the trucks would pass would designate shipment routes in consultation with DOE.... These routes, as well as any chosen in the future, would comply with DOT requirements, use the Interstate Highway System or other state-designated roads, and use the shortest routes to access the interstate highways. The routes also would bypass urban areas if this could be done safely and efficiently.*"

As commented, the current ER CBFO route deviates from the SEIS-II route beginning in Big Spring, Texas where a more direct route through Andrews, Texas runs to the south WIPP access road in New Mexico. TRAGIS was used to compare the node to node characteristics between the differing routes (see tabular results and figure illustration below). Starting at the Big Spring, Texas junction, the mileage in Texas and New Mexico following the current CBFO route is approximately 159 miles. Respectively, the total mileage in Texas and New Mexico following the SEIS-II route (SEIS-II, Appendix E, page E-10) is approximately 257 miles. In addition, the distance travelled through populated areas has decreased. This is due to removing the more populated cities of Midland and Odessa, Texas and Carlsbad, New Mexico from the SEIS-II route in preference to Andrews, Texas, and Eunice and Jal, New Mexico. This effectively reduces the population along route areas.

For this route comparison and given that the impacts from transportation are driven by distance and associated population density, the current route listed on page 20 of the ER is bounded by the SEIS-II.

AREVA Federal Services LLC

505 South 336th Street, Suite 400 · Federal Way, WA 98003
Tel: (253) 552-1300 · Fax: (253) 552-1398 · www.us.areva.com

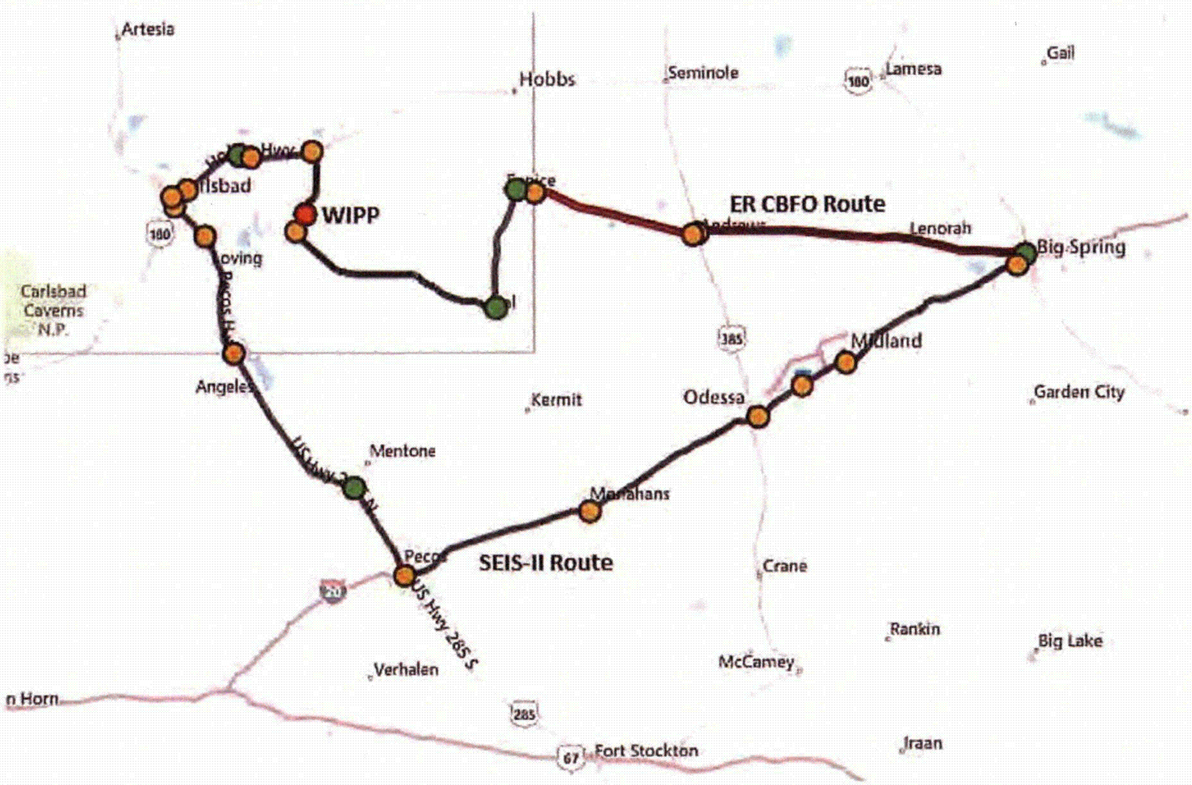
AREVA

TRAGIS Route Comparison Results:

ER			SEIS-II		
Route Nodes	Distance (mile)	Population (people within 800-meter)	Route Nodes	Distance (mile)	Population (people within 800-meter)
Big Spring, TX to Eunice, NM	92	23,136	Big Spring, TX to Pecos, TX	149	9,078
Eunice, NM to Jal, NM	23	12,780	Pecos, TX to Carlsbad, NM	82	269
Jal, NM to WIPP, south	45	9	Carlsbad, NM to WIPP, north	26	419
Sum	160	35,925	Sum	257	9,766

Table note: TRAGIS population data is from 2012 census.

TRAGIS Route Comparison Figure:



AREVA Federal Services LLC

505 South 336th Street, Suite 400 · Federal Way, WA 98003
Tel: (253) 552-1300 · Fax: (253) 552-1398 · www.us.areva.com

AREVA

Question no. 2:

Provide rationale for the transportation accidents conclusion on page 69 of the ER, "Not taking credit for the dampening effects of an accident under water versus in air, the subject TRUPACT-III radioactivity is conservatively bounded by the EIS bounding radioactivity. Therefore the dose impacts from an accident resulting from a greater than 15 meter (50 feet) underwater package breach is bounded by the EISs." If referencing analyses in other documents, provide citations to the page or table.

This information is needed for the NRC staff to complete its environmental review of the application, for compliance with 10 CFR Part 51.

Response:

An evaluation of the additional conservatism resulting from the damping effects of an accident under water versus air has concluded that any extra margin gained is unnecessary to the ER findings and therefore the qualitative statement may be ignored. The intent of the first sentence is to quantitatively state by comparison that the subject TRUPACT-III radioactivity is less than the EIS bounding radioactivity. The conservatism resulting from ambient conditions is unnecessary to the result. Therefore, the statement may be read as follows: "*The subject TRUPACT-III radioactivity is bounded by the EIS bounding radioactivity. Therefore the dose impacts from an accident resulting from a greater than 15 meter (50 feet) underwater package breach is bounded by the EISs.*"

Question no. 3:

Provide a citation (page number, table number, etc.) for the DOE 1997, DOE 2006, and/or SNL 2009 dose assessments referenced on page 83 in the ER. Show how the dose rates from the two SLB2 waste boxes are bounded by the dose assessments in DOE 1997, DOE 2006, and/or SNL 2009.

This information is needed for the NRC staff to complete its environmental review of the application, for compliance with 10 CFR Part 51.

Response:

Table 4.12-2 on page 83 in the ER (reproduced with corrections shown in bold font below) comes from surveys done on compliant shipments of the TRUPACT-III. Shipment SR3140011 (erroneously listed as Shipment SR31401**0** in Table 4.12-2) successfully shipped from the Savanah River Site on January 23, 2014, and shipment SR313026 shipped on April 11, 2013. Figures 1 and 2 are the source of the data used in Table 4.12-2, where "E" is contact and the other measurement is at 30cm.

Because the SLB2 containers in the proposed action have not been loaded into a TRUPACT-III at this time, a direct comparison of 1m dose rates on the transport container (the Transportation Index, or TI) as detailed in DOE 1997 or DOE 2006 is not presently possible. However, a comparison of the data from Table 4.12-1 (dose rates of the SLB2 containers in the proposed action) and Table 4.12-2 (dose rates on SLB2 containers in compliant shipments of the TRUPACT-III) provide evidence that the proposed action will not result in radiological consequences that exceed the EIR analysis of record.

AREVA Federal Services LLC

505 South 336th Street, Suite 400 · Federal Way, WA 98003
Tel: (253) 552-1300 · Fax: (253) 552-1398 · www.us.areva.com

AREVA

Table 4.12-2: Historical Measured Dose Rates for two SLB2s

	Contact Dose Rate(mrem/hr)		30cm Dose Rate(mrem/hr)		Large Area Wipe (dpm)		Smear (dpm/100 cm^2)	
Shipment-Package	γ + n	n	γ + n	N	α	βγ	α	βγ
SR314011-SLB2	5.3E+01	2.5E+01	4.6E+01	2.2E+01	ND		< 20	< 200
SR313026-SLB2	**1.5E+01**	7.0E+00	1.1E+01	5.0E+00	ND		< 20	< 200

Figure 1(Survey Data for SR313026)

VSDS Standard Map RSLS

Comments:

Performed dose rate and transferable contamination surveys on SLBII # WMAPSLB021 for Shipment # SR313026. Dose rate on container was 8 mrem/hr at contact with 7 mrem/hr neutrons, 5.5 mrem/hr at 30cms with 5 mrem/hr neutrons. All LAS surveys indicated ND dpm alpha, ND dpm beta-gamma. All disc smears indicated <20 dpm alpha/100 cm2 and <200 dpm beta gamma/100 cm2. See MAP for survey results.

All gamma dose rates are gamma plus neutrons unless otherwise noted.

VSDS Standard Map RSLS

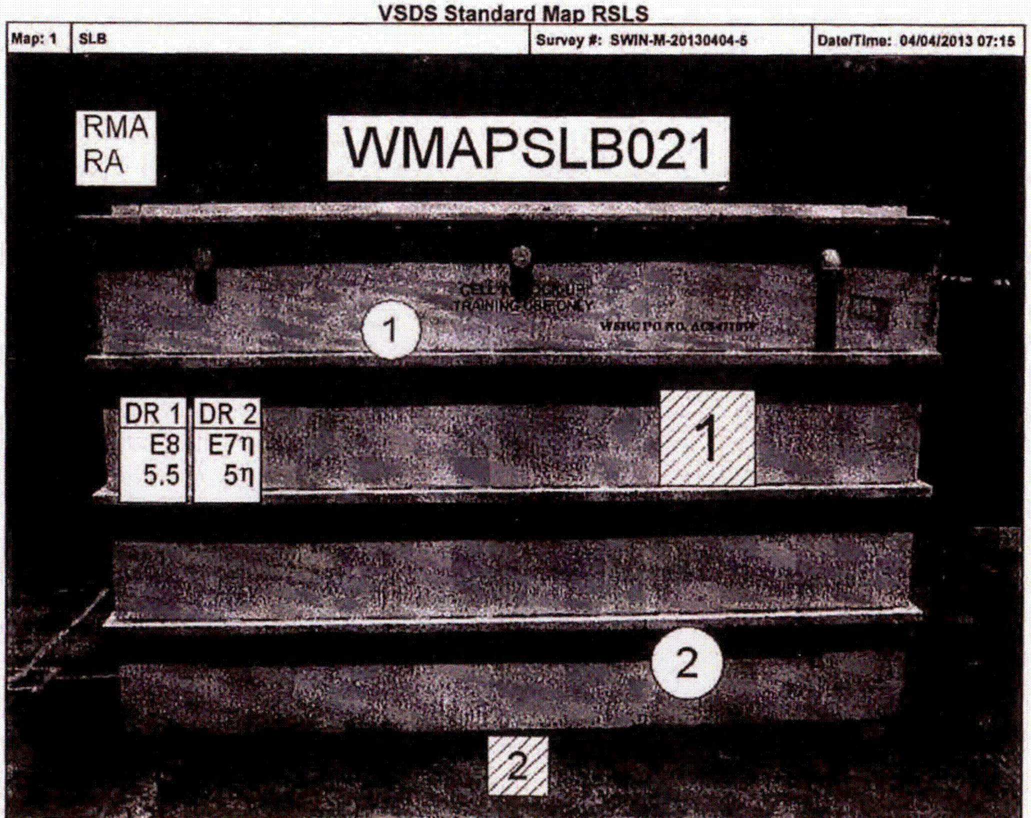


Figure 2 (Survey Data for SR314011)

VSDS

SLB
Date/Time: 01/20/2014 10:30

AREVA Federal Services LLC

505 South 336th Street, Suite 400 · Federal Way, WA 98003
Tel: (253) 552-1300 · Fax: (253) 552-1398 · www.us.areva.com

AREVA

Question no. 4:

Provide a copy of the following references on pages 97 and 98 of the ER:

- AP-141, Revision 1, *Summary Report for the Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant* dated June 2009, referenced in the ER. Also provide a copy of the August 2008, Revision 0.
- *WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small Quantity Sites and Impacts from Using the TRUPACT-III* dated June 2006.

All references in the NRC's environmental assessment must be publically available.

This information is needed for the NRC staff to complete its environmental review of the application, for compliance with 10 CFR Part 51.

Response:

Per the request stated above in "*Question no. 4*", the following electronic copies of the requested documents are attached. It should be noted that in the first bulleted item in Question No. 4 above that these documents are identified by Sandia National Laboratories Waste Isolation Pilot Plant as documents no. 551476 & 550601 respectively. "AP-141, Revision 0" is dated December, 2008 as opposed to the date of "August 2008" identified in Question no. 4 above. Additionally, the document requested in the second bulleted item in Question No. 4 above, "*WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small Quantity Sites and Impacts from Using the TRUPACT-III* dated June 2006" is actually dated "July 2006" as opposed to "June 2006" identified in Question no. 4 above. These documents are identified as follows;

- "Attachment 1" - AP-141, Revision 1, *Summary Report for the Update to Disposal Phase Supplemental Environment Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant* dated June 2009. Sandia National Laboratories Waste Isolation Pilot Plant document no. 551476.
- "Attachment 2" - AP-141, Revision 0, *Summary Report for the Update to Disposal Phase Supplemental Environment Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant* dated December 2008. Sandia National Laboratories Waste Isolation Pilot Plant document no. 550601.
- "Attachment 3" - *WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small Quantity Sites and Impacts from Using the TRUPACT-III* dated July 2006.

551476

Attachment 1

Sandia National Laboratories
Waste Isolation Pilot Plant

Summary Report for Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant

Revision 1.0

Author:	Ruth F. Weiner (6765) Print	[signature] for Signature	6/11/09 Date
Author:	Sean C. Dunagan (6711) Print	[signature] Signature	6/11/09 Date
Technical Review:	Lori J. Dotson (6712) Print	Mario Chavez for Signature	6/11/09 Date
QA Review:	Mario J. Chavez (6710) Print	Mario Chavez Signature	6/11/09 Date
Management Review:	David S. Kessel (6711) Print	[signature] Signature	6/11/09 Date

WIPP:1.6.4:PM:QA-L:549453

EXECUTIVE SUMMARY

This TA, an update to the SEIS-II (DOE 1997b), evaluated the impacts associated with the transportation of CH-TRU and RH-TRU waste from waste generator sites to the WIPP, using the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considered the impacts of transporting these wastes. Only transportation by truck was considered. This TA has been revised to include the state specific, incident-free collective dose results. Additionally, tables were updated, but the conclusions remain unchanged.

The TA used updated census data (U.S. Census Bureau 2006), changes in the number of shipments due to the use of different shipping containers, new TRU waste inventories, and WebTRAGIS to deterimine the routes instead of HIGHWAY. In addition, the analysis was conducted using an improved version of RADTRAN, Version 6 for the loss-of-lead shielding calculations and Version 5.6 for all other calculations. The improvements to RADTRAN, as well as the use of updated inventory (DOE 2008a) to calculate more realistic parameter values like a smaller TI, have resulted in smaller doses than those calculated in the SEIS-II for the same set of receptors. The number of shipments represents a more realistic value as it was determined using the most recent inventory (DOE 2008a) and the current and anticipated shipping containers. The use of WebTRAGIS resulted in more accurate routes and a more accurate simulation. The total population has increased with the new census data and has shifted from both urban and rural areas to suburbs. The net result is relatively larger doses to suburban than to urban populations. This TA also used a different methodology with respect to vehicle densities which played a significant role in the increase in the suburbs areas.

The analyses of radiological and non-radiological impacts incorporated different conservatisms and different degrees of conservatism, so that no conclusions can really be drawn by comparing them. The radiologic impacts are generally smaller than those in the SEIS-II, mostly because of the more precise analytical methods available. There are only a few instances (e.g., the rest stop employee, inspectors) where calculated doses are not insignificant, and these are largely due to conservative assumptions, in particular the simple addition of the number of shipments to which the receptor is exposed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acronyms

ALARA	As low as reasonably achievable (refers to occupational radiation exposure)
ANL	Argonne National Laboratory
ANL-E	Argonne National Laboratory – East
ANL-W	Argonne National Laboratory – West
AP	analysis plan
BAPL, BT	Bettis Atomic Power Laboratory
BCL, BL	Battelle Columbus Laboratories
BN	Brookhaven National Laboratory
BTS	(US Department of Transportation) Bureau of Transportation Statistics
BW	Babcock & Wilcox
CH	contact-handled
COTS	commercial off-the-shelf
DOE	(U.S.) Department of Energy
DOT	(U.S.) Department of Transportation
EIS	environmental impact statement
EPA	(U.S.) Environmental Protection Agency
ETEC	Energy Technology Engineering Center
FR	Federal Register
GE-VNC	General Electric - Vallecitos Nuclear Center
HRCQ	Highway Route Controlled Quantity
IDLH	immediately dangerous to life and health
INL, IN	Idaho National Laboratory
ISCORS	Interagency Steering Committee on Radiation Standards
KAPL, KA	Knolls Atomic Power Laboratory
K-NFS	Knolls Atomic Power Laboratory - Nuclear Fuel Services
LANL, LA	Los Alamos National Laboratory
LBNL, LB	Lawrence Berkeley National Laboratory
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LOS	Loss of (lead gamma) Shielding
MC	U.S. Army Materials Command
MEI	maximally exposed individual
MURR, MU	Missouri University Research Reactor
NAAQS	National Ambient Air Quality Standard.
NIOSH	National Institute of Occupational Safety and Health
NM	New Mexico
NRC	(U.S.) Nuclear Regulatory Commission
NRD	NRD L.L.C.
NTS, NT	Nevada Test Site
ORNL, OR	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PM_{10}	(respirable) particulate matter
R	Rural
RAM	radioactive material
RF	Rocky Flats Environmental Technology Site

RH	remote-handled
RITA	(DOT) Research and Innovative Technology Administration
RL	Richland (Hanford Works)
RMEI	reasonably maximally exposed individual
ROD	record of decision
S	Suburban
SA, SNL	Sandia National Laboratories
SEIS	supplemental environmental impact statement
SPRU	Separations Process Research Unit
SRS	Savannah River Site
SWB	Standard Waste Box
TA	transportation analysis
TDOP	Ten-Drum Overpack
TI	transportation index
TRAGIS	Transportation Geographic Information System
TRAMPAC	TRUPACT Authorized Methods for Payload Control
TRU	transuranic
TRUPACT	Transuranic Packaging Transporter
U	Urban
VOC	volatile organic compound
WAC	waste acceptance criteria
WID	Waste Isolation Division
WIPP	Waste Isolation Pilot Plant
WM PEIS	Waste Management Programmatic Environmental Impact Statement

1 INTRODUCTION AND OBJECTIVES

This Transportation Analysis (TA) is carried out in accordance with the Analysis Plan (AP) 141 "Analysis Plan for Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant". The scientific approach is described in detail in Weiner et al. (2006). Input data to the codes used (RADTRAN/RADCAT[1], WebTRAGIS, MICROSHIELD) are provided in the cited Analysis Plan AP-141. Input data to the post-processing calculations is provided in the attached CD. This TA has been revised to include the state specific, incident-free collective dose results. Additionally, tables were updated, but the conclusions remain unchanged.

The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, is the only facility licensed to dispose of transuranic (TRU) waste generated by U.S. Department of Energy (DOE) defense activities. TRU waste has been or is retrievably stored at 27 DOE sites across the United States.

This TA evaluates the impacts associated with the transportation of TRU waste from waste generator sites to the WIPP. The TA uses the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considers the impacts of transporting these wastes. The TA evaluates the impacts of remote-handled TRU (RH-TRU) waste being shipped in shielded containers, including the potential disposal of Uranium-233 (U-233) from Oak Ridge National Laboratory (OR). Only transportation by truck is considered in this analysis.

The impacts of transporting TRU waste to WIPP that have been analyzed are:

(1) number of traffic accidents, fatalities, and injuries likely to occur as a result of transporting the TRU waste round trip between WIPP and the generator sites.
(2) radiological impacts from routine, incident-free transportation that could be associated with the external radiation from a TRU waste transportation package. This radiation exposes the general public and transportation workers to very low levels of radiation both during transportation and while a shipment is stopped.
(3) health effects that could result from inhaling vehicle emissions (diesel exhaust) while the vehicle travels through urban areas.
(4) minor accidents and incidents that do not result in the release of any radioactive material (this is a deviation from AP-141).
(5) accidents that are severe enough to breach the TRU waste package, releasing some of the radioactive and hazardous material being shipped.
(6) accidents in which some of the lead gamma shield in RH waste packages slumps or is lost, resulting in the loss of gamma shielding.

These impacts have been analyzed for all of the transportation routes, as well as for impacts specific to the New Mexico (NM) residents along the transportation routes.

This TA presents information similar to the final *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (WIPP SEIS-II) (DOE 1997b), with the addition of impacts specific to NM, and results of the improved analytical techniques and codes currently available. This TA does not consider alternative actions as in the WIPP SEIS-II.

1 RADCAT generates input files for RADTRAN.

This TA contains new information produced since the WIPP SEIS-II, including 2000 U.S. Census data, which has been included in the routing code WebTRAGIS that is used together with RADTRAN (Johnson and Michelhaugh 2003), changes in the number of shipments due to the use of different transportation containers, changes in the TRU waste inventories, and improvements in the RADTRAN program and code (Weiner et al. 2006).

2 BACKGROUND

In the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997a), DOE analyzed the potential environmental impacts of the management (treatment and storage) of TRU waste at DOE sites. The *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* [63 FR 3629 (1998)] [TRU Waste Record of Decision (ROD)] (DOE 1998) documented DOE's decision that each DOE site that has generated or will generate TRU waste will prepare and store its TRU waste onsite, with one exception: Sandia National Laboratories (SNL) will transfer its TRU waste to the Los Alamos National Laboratory (LANL). In the ROD, DOE also stated that in the future, it may decide to ship TRU waste from sites where it may be impractical to prepare them for disposal to sites where DOE has or will have the necessary capability. The sites designated in the ROD to receive such shipments of TRU waste are the Idaho National Engineering and Environmental Laboratory (INEEL), [now the Idaho National Laboratory (INL)], the Oak Ridge Reservation (ORR), the Savannah River Site (SRS), and the Hanford Site. Since the issuance of the TRU Waste ROD, DOE decided to ship TRU waste from three other sites—the Mound Plant, Battelle Columbus Laboratories (BCL), and the Energy Technology Engineering Center (ETEC)—to the Hanford Site or the SRS.

In the Amended ROD (2008b), DOE decided to ship up to 8,764 cubic meters of contact-handled TRU (CH-TRU) waste and up to 255 cubic meters of RH-TRU waste as needed from Argonne National Laboratory (ANL), Bettis Atomic Power Laboratory (BAPL), Babcock & Wilcox (BW), General Electric - Vallecitos Nuclear Center (GE-VNC), Hanford, Knolls Atomic Power—Nuclear Fuel Services (K-NFS), Knolls Atomic Power Laboratory (KAPL), Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), NRD L.L.C. (NRD), Paducah Gaseous Diffusion Plant (PGDP), Nevada Test Site (NTS), Separations Process Research Unit (SPRU) and Sandia National Laboratories (SNL), to INL for treatment and characterization prior to shipment to WIPP for disposal. Table 1 indicates the CH-TRU and RH-TRU Waste Volumes to be shipped to INL (DOE 2008c).

Table 1 CH-TRU and RH-TRU Waste Volumes to be Shipped to INL (DOE 2008c)

Waste Generator Sites	TRU Waste Volume (m^3)	
	CH-TRU	RH-TRU
Argonne National Laboratory (ANL), IL	88	43
Bettis Atomic Power Laboratory (BAPL), PA	70	4
Babcock & Wilcox (BW), Lynchburg, VA	46	-
General Electric—Vallecitos Nuclear Center (GE-VNC), Sunol, CA	35	105
Hanford Reservation, WA	6,500	-
Knolls Atomic Power Laboratory (KAPL), Schenectady, NY	-	83
Knolls Atomic Power—Nuclear Fuel Services (K-NFS), TN	130	-
Lawrence Berkeley National Laboratory (LBNL), CA	1	-
Lawrence Livermore National Laboratory (LLNL), CA	1,125	-
Nevada Test Site (NTS), NV	670	-
NRD L.L.C., (NRD), Grand Island, NY	15	-
Paducah Gaseous Diffusion Plant	4	-
SNL, Albuquerque, NM	30	20
Separations Process Research Unit (SPRU), Schenectady, NY	50	-
Total	8,764	255

Source: Inventory data gathered for 2009 WIPP Compliance Recertification Application Update. Only the portion of the Hanford waste inventory that could be expected to move to INL is included for Hanford.

In its final WIPP SEIS-II, DOE analyzed the potential environmental impacts associated with disposing of TRU waste at WIPP. DOE's Proposed Action was to open WIPP and dispose of 175,600 cubic meters of post-1970 defense TRU waste. In addition, DOE analyzed several alternative actions, including an alternative that would dispose of a greater volume of TRU waste (336,000 cubic meters) than under the Proposed Action and that would consolidate waste from some DOE sites at ORR, SRS, and Hanford (Action Alternative 1).

Since the time the WIPP SEIS-II was issued, many decommissioning activities have taken place at sites across the DOE complex. In addition, some of the TRU wastes at sites with small quantities of such wastes have been consolidated at sites having greater capabilities to characterize the waste. These decommissioning activities have resulted in the identification of sites that were not thought to contain TRU wastes at the time the WIPP SEIS-II was prepared.

Another development that could not be assessed in the WIPP SEIS-II is the availability of shipping containers that are capable of carrying larger CH-TRU volumes (TRUPACT-III), heavier CH-TRU waste (HalfPACT), and RH-TRU waste stored in shielded containers and shipped in HalfPACTs. The impact of the TRUPACT-III was evaluated in DOE (2006b). An example of the potential reduction of shipments when HalfPACTs are used was displayed in the WIPP SEIS-II. The impact of using shielded containers has not been evaluated. For this reason, this report assesses the impacts of using these new containers to ship and store waste.

The OR building 3019 Complex is being considered for decommissioning. This TA considers the WIPP to be the ultimate disposal site for the U-233 TRU waste that may be generated as part of this decommissioning process. The environmental impact of transporting this U-233 waste to the WIPP is included in this analysis and TA.

3 APPROACH

This TA includes:

1. Inventory analysis and determination of shipment numbers,
2. Shielding calculations to determine a realistic TI (Transportation Index),
3. Calculation of impacts of routine, incident-free transportation, including analysis of uncertainty in external dose rate and transportation package inventory,
4. Calculation of the impacts of transportation accidents, including accidents involving a release of radioactive material (RAM), severe accidents, accidents involving loss of lead shielding, and minor accidents not affecting the radioactive cargo, and
5. Impact and consequence calculations included health effects.

Impacts were evaluated for CH-TRU and RH-TRU wastes. The results were compiled to identify the total impact from TRU waste shipments between generator sites and the WIPP site.

3.1 Inventory Analysis

The inventory documented in DOE (2008a) in combination with the information on the U-233 waste from OR and the most recent ROD (2008b) was used for the calculation in this TA. As identified in DOE (2008a), this inventory represents the waste as it was on December 31, 2006. The inventory was used to determine the number for shipments from the different sites to WIPP directly and to WIPP through an intermediate site.

3.1.1 Number of Shipments

The number of shipments have been determined based on the type of waste RH-TRU or CH-TRU, the volume of waste, the form of the waste (i.e., the type of container it is in), and the mass of the waste.

Restrictions on the number of packages per vehicle, identified in the CH-TRAMPAC (DOE 2005) and the RH-TRAMPAC (DOE 2006c), are shown in Table 2.

Table 2 Authorized CH-Waste Payload Containers

Payload Container Type	Number in Payload[1]	
	TRUPACT-II	HalfPACT
55-Gallon Drum	14	7
Standard Pipe Overpack[2]	14	7
S100 Pipe Overpack	14	7
S200 Pipe Overpack	14	7
S300 Pipe Overpack	14	7
85-Gallon Drum[3]	8	4
100-Gallon Drum	6	3
Standard Waste Box (SWB)	2	1
Ten-Drum Overpack (TDOP)	1	N/A

[1] Payloads shall be comprised of a single payload container type.
[2] Standard pipe overpacks must be assembled into seven packs of 6-inch standard pipe overpacks or 12-inch standard pipe overpacks only.
[3] The term "85-gallon drum" in this document includes 75- to 88- gallon drums.

Tables 3 and 4 show the weight limits for the various containers that may be used.

Table 3 CH Payload Containers

Payload Container Type	Maximum Gross Weight (lbs)	Empty Weight (lbs)
55-Gallon Drum	1,000	60
Standard Pipe Overpack (6-inch diameter)	328	153
Standard Pipe Overpack (12-inch diameter)	547	-407
S100 Pipe Overpack	550	153
S200 Pipe Overpack	547	407
S300 Pipe Overpack	547	407
85-Gallon Drum[1]	1,000	81
100-Gallon Drum	1,000	95
SWB	4,000	640
TDOP	6,700	1,700

[1] The term "85-gallon drum" in this document includes 75- to 88- gallon drums.

Table 4 CH Payload Assemblies Maximum Gross Weight Limits

Assembly	Maximum Gross Weight (lbs)
TRUPACT-II Payload (Contents)	7,265
HalfPACT Payload (Contents)	7,600

By using the HalfPACT, 21 heavy drums per shipment can be transported as opposed to 14 heavy drums using the TRUPACT-II. This is possible as a result of the low gross weight associated with the HalfPACTs. This was identified in the SEIS-II as a potential means of reducing the number of shipments.

In order to have a shipment of three TRUPACT-IIs, the content of the drums must average 142 kg (312 lbs) or less.

RH-TRU waste is transported in either a RH-72B or a 10-160B cask. A RH-72B is loaded with a RH-TRU waste canister that can transport up to 8,000 lbs by direct loading of the waste or packaging the waste in three 55-gallon drums. The empty weight of an RH-TRU waste canister ranges from 1,100 lbs to 1,762 lbs, depending upon the type of lid. For this analysis it is assumed that an empty canister weights 1,762 lbs.

10-160B casks can transport up to 14,500 lbs, with a ten 55-gallon drum capacity (DOE 2007).

The following restrictions were used to identify the number of shipments for cases where shielded containers are utilized (Crawford and Taggart 2007):

- Shielded containers will only be loaded with 30-gallon drums;
- Shielded containers will be shipped in packs of three, with one 3-pack shipped in one HalfPACT;
- The inventory used to estimate the number of shielded containers is found in Crawford and Taggart (2007). Crawford and Taggart (2007) used the 2004 inventory report (DOE 2006A) to estimate the number of shielded containers that could be used;
- Shielded containers maximum empty weight is 1,816 lbs (Moody 2008, Enclosure C); and
- Shielded containers can have a maximum of 405 lbs of waste, with total contents at a maximum of 444 lbs (Moody 2008, Enclosure C).

The inventory spreadsheet (DOE 2008a) provides the following data:

- The number of drums, standard waste boxes (SWBs) and 10-drum overpacks (TDOPs) in each waste stream, scaled to the WIPP capacity.
- The total weight of material, in kg, in each waste stream.
- The radioactive inventory of each waste stream.

Tables 3 and 4 show the weight limits and payload for vehicles transporting CH waste. The weight per 14-drum TRUPACT-II, two-SWB TRUPACT-II, and one-TDOP TRUPACT-II was calculated from the mass in kilograms per waste stream and the number of containers per waste stream. If the result exceeded the payload limit for the TRUPACT in Table 4, the number of TRUPACTs was recalculated so that the payload was not exceeded, always rounding up the number of containers and TRUPACTs to the next higher integer. The number of shipments from each site was then determined by considering three TRUPACTs per vehicle. Modifications using HalfPACTs were made where appropriate. A similar calculation was made for the RH waste streams, noting that there could be only one RH-72B cask per truck , and an RH-72B could hold three drums of waste.

Table 5 shows the number of shipments from each site, compared with the number of shipments from WIPP SEIS-II, Tables E-1 (Proposed Action) and E-2.

Table 5 Shipments from each site

NUMBERS OF CH SHIPMENTS							NUMBERS OF RH SHIPMENTS				
	DRUMS IN TRUPACTS	**SWB IN TRUPACTS**	**TDOP IN TRUPACTS**	**HALF PACKS**	**TOTAL**	**TABLE E-1***	**RH-72B**	**HALF PACKS**	**10-160B****	**TOTAL**	**TABLE E-2**
ANL-E	81	-	-	-	81	28	-	83	-	83	-
ANL-W	24	-	-	1	25	-	266	-	-	266	-
BL	1	-	-	-	1	-	-	-	-	-	-
BN	158	177	477	4	816	-	-	-	-	-	-
BT	1	-	-	-	1	-	4	-	-	4	-
IN	11096	1936	160	11	13203	5782	410	4	-	414	3136
KN	139	-	-	-	139	-	-	209	-	209	-
LA	1493	534	-	20	2047	5009	32	-	-	32	367
LB/LL	62	40	-	-	102	162	-	-	-	-	-
MC	-	-	-	1	1	-	-	-	-	-	-
MU	1	-	-	-	1	-	-	-	-	-	-
NT	50	254	10	1	314	86	-	-	-	-	-
OR	379	-	-	-	379	251	1516	494	-	2710	1276
OR (U-233)	-	-	-	-	0	-	700	-	-	700	-
RF	892	411	95	11	1409	2485	-	-	-	-	-
RL	888	412	100	9	1409	13666	1483	264		1747	3178
SA	7	-	-	-	7	-	66	-	-	66	-
SR	670	376	885	22	1953	2238	39	54	67	160	-
Total	**15942**	**4140**	**1727**	**80**	**21889**	**29707**	**4516**	**1107**	**67**	**6390**	**7957**

*Does not include 59 shipments from Mound Laboratories
** These packages may not be used, in which case this material would be in RH-72B casks

3.1.2 Radionuclides for TI and Other Input Parameters

The TI represents the radiation dose rate at 1 meter (3.3 feet) from the surface of the shipping package and is dependent on the waste density, distribution of radionuclides, quantity of radionuclides per shipment, mix of waste types, self-shielding provided by the waste and shielding provided by the package. The TI may, therefore, be sensitive to smaller quantities of gamma-emitting radionuclides such as cobalt-60 (Co-60) and cesium-137 (Cs-137). Different TIs were calculated for CH-TRU and for RH-TRU wastes.

The TIs were calculated using MICROSHIELD (Version 7.0) and the radionuclide inventory presented in DOE (2008a). These TI values are more realistic than the regulatory maximum (10 mrem/hr at 2 meters according to 10 CFR 71.47(b)(3), or 14 mrem/hour for a TRUPACT at one meter[2]) because they are calculated using the expected inventory to be received at the WIPP.

Results of the MICROSHIELD calculations are shown in Table 6. Uncertainty in the inventories was estimated to be +/- 10% for CH-TRU and +/- 30% for RH-TRU (DOE 1996). The value used in SEIS-II for the TI for CH-TRU was TI=4 mrem/hr.

2 The TI for cargo with a critical dimension of approximately 5 meters is calculated by RADTRAN to be 14 mrem/hr for the regulatory maximum dose rate of 10 mrem/hr at 2 m.

Table 6 Calculated TI for the TA. TI units are mrem/hr

Packaging	TI	+ Deviation	- Deviation	SEIS TI
TRUPACT	0.167	0.184	0.151	4
HalfPACT	0.104	0.144	0.0936	--
RH-72B	2.505	3.270	1.759	10

Risk and health effects calculations were performed using RADTRAN and WebTRAGIS (Johnson and Michelhaugh 2000). RADTRAN is the product of about 30 years of development and is a flexible analytical tool for assessing the risks and consequences of transporting radioactive material. RADTRAN 4 was used for the calculations performed in the WIPP SEIS-II. This TA uses the latest updated versions of RADTRAN: Version 6 for the loss-of-lead shielding calculation and Version 5.6 for all other calculations, which are the same in Versions 6 and 5.6. Both RADTRAN 6 and RADTRAN 5.6 are validated and verified (Dennis et al. 2008). Inputs and assumptions used in the RADTRAN calculations are shown in Table 7. A sample RADTRAN input and output file is in Appendix A and all files used are included on the attached CD.

WebTRAGIS is the updated version of the routing code HIGHWAY, which was used for the WIPP SEIS-II. WebTRAGIS is a much improved version of HIGHWAY, the routing code used in the SEIS-II. As implied, it incorporates a geographic information system which provides increased precision in route selection. The population densities shown in Table 7 along the different routes to be taken to the WIPP were determined by the code WebTRAGIS.

Table 7 RADTRAN Inputs and Assumptions for the TA

Parameter	CH-TRU Waste	RH-TRU Waste
Configuration		
Mode of Transportation	Truck	Truck
Package Type	TRUPACT-II, TRUPACT-III[a], HalfPACT	HalfPACT (for shielded containers), RH-72B cask
Packages per Shipment	3	1 (72 B cask, 10-160B) or 3 (HalfPACTs)
Package critical dimension (m)	8.4 (TRUPACT-II and HalfPACT), 6.1[a] (TRUPACT-III)	3.6 (72B cask), 3.3[a] (10-160B), 7.4 (HalfPACTs)
Shipment Speed (kilometer/hour)		
Urban[b]	88.6 non-rush hour; 44.3 rush hour	88.6 non-rush hour; 44.3 rush hour
Suburban (S)[b]	88.6 non-rush hour;	88.6
Rural (R)[b]	88.6	88.6
Stop model		
Truck stop time[c]	20 minutes/845 km	20 minutes/845 km
Maximum truck stop time[c]	50 minutes /845 km	50 minutes/845 km.
Inspection time	1 hour	1 hour
Walkaround inspection time	10 minutes/161 km	10 minutes/161 km
Average population exposed at the stop[c]	7	7
Public exposure distance[c]	1 meters to 15 meters	1 meters to 15 meters
Inspector exposure distance	1 meter	1 meter

Table 7 RADTRAN Inputs and Assumptions for the TA (continued)

Parameter	CH-TRU Waste	RH-TRU Waste
Crew exposure distance[d]	1 meter (each crew member for half of stop time)	1 meter (each crew member for half of stop time)
Resident public near stops	R or S population density as appropriate (route dependent)	R or S population density as appropriate (route dependent)
Distance of resident public from truck[d]	30 to 800 meters	30 to 800 meters
Normal Exposure Data		
Number of crew members	2	2
Effective distance from closest surface of source to crew	4 meters	4 meters
Number of people per public vehicle[e]	2	2
Accident Exposure Data		
Number of accident severity categories[d]	6	6
Accident severity category frequency[e] (Conditional probabilities)	(NUREG/CR 6672 values)	(NUREG/CR 6672 values)

Source: WIPP SEIS-II unless noted otherwise
[a] McCauslin (2008)
[b] 88.6 km/hr = 55 mph; rush hour speed = half of non-rush hour speed (DOE 2002)
[c] Griego et al. (1996) ; this is a deviation from the AP-141
[d] DOE (2002)
[e] Sprung et al. (2000)

3.2 Routing

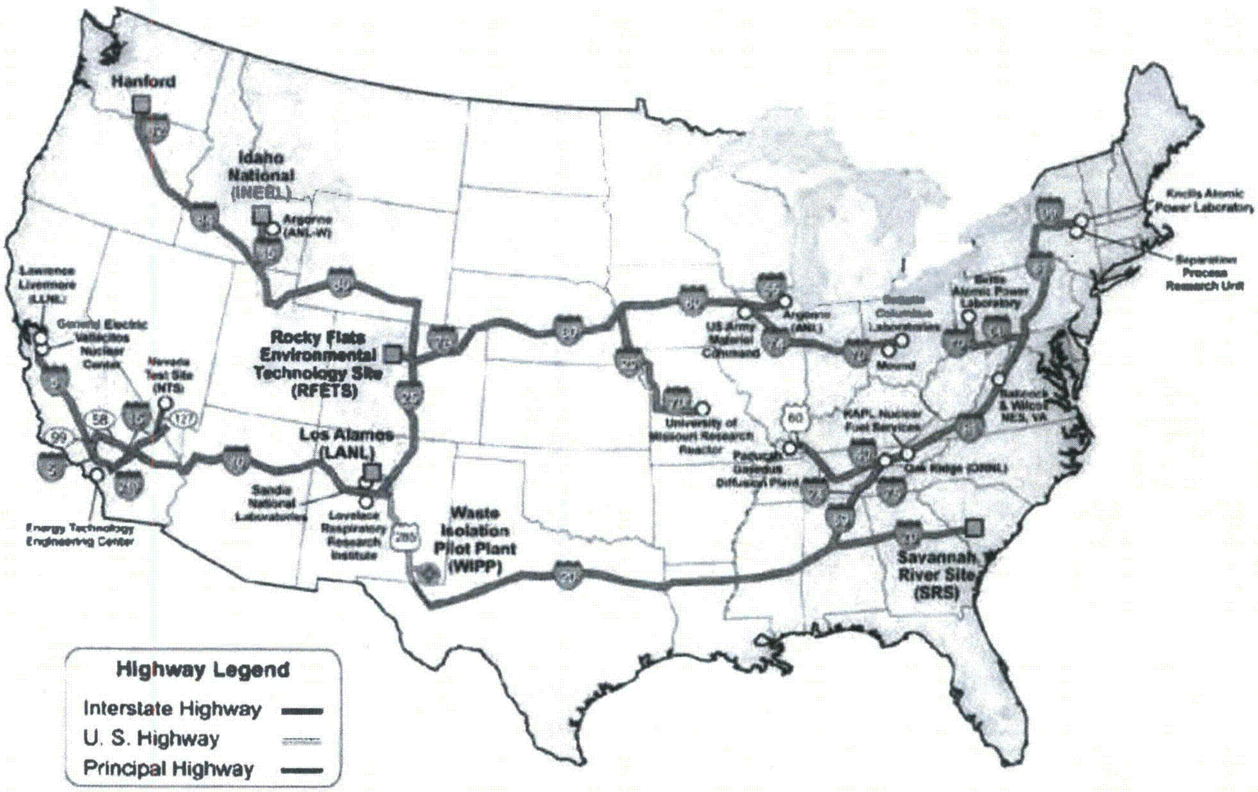


Figure 1 Highways Used for Transportation of Waste to the WIPP

Highway routes for exclusive-use Highway Route Controlled Quantity (HRCQ) vehicles are analyzed using WebTRAGIS, from the following origins to the WIPP. WebTRAGIS files are included on the attached CD:

- Argonne National Laboratory – East (IL)
- Battelle Memorial Institute (OH)
- Bettis Laboratory (Pittsburgh, PA)
- Brookhaven National Laboratory (NY)
- Idaho National Laboratory/ Argonne - West (ID)
- Knolls Atomic Power Laboratory (NY)
- Los Alamos National Laboratory (NM)
- Lawrence Berkeley National Laboratory (CA)
- Army Materials Command (VA)
- Missouri University Research Reactor (MO)
- Nevada Test Site (NV)
- Oak Ridge National Laboratory (TN)
- Rocky Flats Environmental Test Site (CO)
- Richland/Hanford Works (WA)
- Sandia National Laboratories (NM)
- Savannah River Site (SC)

WebTRAGIS includes the specific origin sites; HIGHWAY routing origins were in almost all cases the nearest city node. For example, routing from Argonne – East is from the laboratory location itself in WebTRAGIS, rather than from the node south of Chicago closest to the laboratory, as HIGHWAY required. The route lengths and population density distributions produced by WebTRAGIS are comparable to those produced by HIGHWAY. Table 8 shows the comparison for Argonne – East.

Table 8 Comparison of WebTRAGIS and HIGHWAY routes from Argonne—East to the WIPP

WEBTRAGIS						HIGHWAY
Miles	km	Route	Location	Intersection	State	(from SEIS II p. E-4)
1.8	2.9		DARIEN S	I55 X273	IL	Cass Avenue to I-55, north of ANL-E, 1.6 kilometers (1 mile)
109.8	176.6		NORMAL NW	I55 I74	IL	I-55 to I-294, southwest of Chicago, IL, 8 kilometers (5 miles)
6.8	10.9	I74	BLOOMINGTON SW	I55 I74	IL	I-294 to I-80, south of Chicago, IL, 29 kilometers (18 miles)
59.3	95.4		SPRINGFIELD E	I55 I72	IL	I-80 to I-57, near Tinley Park, 8 kilometers (5 miles)
5.1	8.2	I72	SPRINGFIELD S	I55 I72	IL	
73.5	118.2		EDWARDSVILLE SE	I270I55	IL	
9.5	15.3	I70	COLLINSVILLE W	I255I55	IL	
18.5	29.8		COLUMBIA NW	I255X6	IL	
2.9	4.7		crossing state border	r IL/MO	BD	I-57 to I-55, near Sikeston, MO, 592 kilometers (368 miles)
3.7	6.0		ST LOUIS S	I270I55	MO	I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
5.8	9.3		ST LOUIS SW	I270I44	MO	I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
274.9	442.2		JOPLIN SW	I44 X1	MO	I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
0.3	0.5		crossing state border	r MO/OK	BD	I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
15.7	25.3		MIAMI E	I44 X313	OK	
72.4	116.5	TWRT $	CATOOSA S	I44 X241	OK	
19.1	30.7		OAKHURST E	I44 X221	OK	
86.1	138.5	TTRT$	EDMOND SE	I35 I44	OK	
4.4	7.1	I44	OKLAHOMA CITY NE	I35 I44	OK	
11	17.7		OKLAHOMA CITY W	I40 I44	OK	
125.3	201.5		SAYRE S	I40 X20	OK	
20.7	33.3		crossing state border	r OK/TX	BD	I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
139.6	224.5		VEGA S	I40 X36	TX	
36.2	58.2		crossing state border	r NM/TX	BD	
97.7	157.1		SANTA ROSA	I40 X273	NM	
38.4	61.8		VAUGHN E	U54 U60	NM	US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
0.7	1.1	U60	VAUGHN SE	U285U54	NM	
90.1	144.9		ROSWELL N	U285U70	NM	
7.5	12.1	U70	ROSWELL W	U380U70	NM	
73.4	118.1		CARLSBAD NW	U285LCBR	NM	
8.7	14.0		CARLSBAD E	U62 LCBR	NM	
25.3	40.7	U180	TOWER HILL E	U62 LOCL	NM	US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
12.1	19.5		WIPP		NM	WIPP North Access Road to WIPP, 18 kilometers (11 miles)
TOTAL KM	2342.4					2337.6

WebTRAGIS provides rural, suburban, and urban distances and population densities, which are electronically imported into RADTRAN 5.6 and 6; this utility was not available for the SEIS II. The rural, suburban, and urban population bins in WebTRAGIS are, however, the same as in HIGHWAY. The total population has increased and has shifted from both urban and rural areas to suburbs, and more bypasses routed through suburban populations are available. The net result is relatively larger doses to suburban than to urban populations from routine radioactive materials (RAM) transportation. The population bins in WebTRAGIS are:

- rural: 0 to 139 persons/mi^2 (0 to 53.73 persons/km^2)
- suburban: 139 to 3326 persons/mi^2 (53.73 to 1286 persons/km^2)
- urban: more than 3326 persons/mi^2 (more than 1286 persons/km^2)

WebTRAGIS uses census data from the 2000 census. Updated population data to 2006 were provided in the 2008 Statistical Abstract (U.S. Census Bureau 2008). Table 13 of U.S. Census Bureau (2008) shows the percent increase in population for each of the 50 states of the United States, as well as for the U. S. as a whole, and Table 21 shows the percent increase in population for the 50 largest metropolitan areas in the U.S. Data from these two tables were combined to give population multipliers for states along WIPP routes for which the collective dose (including numbers of shipments) and the population increase were significant enough to make a correction.

The population multipliers used are shown in Table 9. "Significant" was taken to mean either that the collective dose for all routes through a state exceeded 10^{-8} person-rem without the population multiplier, or that the multiplier was 1.01 or larger (e.g., multipliers of 1.005 or 0.96 were not considered significant). The state-specific multiplier was applied to rural and suburban routes through the state, and the multiplier for the largest metropolitan area in that state was applied to the urban routes. The U.S. multiplier was applied to ingestion doses. For computational efficiency, and because multiplication is commutative, the multipliers were applied to the collective doses calculated using RADTRAN rather than to the WebTRAGIS populations.

Table 9 Population multipliers

State	Rural, Suburban, Urban Designation	Population Multiplier
Arizona	R, S	1.202
	U	1.242
Arkansas	R, S	1.051
	U	1.051
California	R, S	1.076
	U	1.15
Colorado	R, S	1.105
	U	1.105
Georgia	R, S	1.144
	U	1.21
Idaho	R, S	1.133
	U	1.133
Illinois	R, S	1.033
	U	0.959
Maryland	R, S	1.037
	U	1.041
Missouri	R, S	1.044
	U	1.044
Nevada	R, S	1.249
	U	1.292
New Mexico	R,S	1.075
	U	1.075
Oklahoma	R, S	1.037
	U	1.07
Pennsylvania	R, S	1.013
	U	1.025
Oregon	R, S,	1.082
	U	1.109
Tennessee	R, S	1.061
	U	1.109
Texas	R,S	1.127
	U	1.175
Utah	R, S	1.142
	U	1.102
Virginia	R, S	1.08
	U	1.103

3.3 *Risk Calculations*

3.3.1 Calculations for Routine, Incident-free Transportation

Calculations for routine, incident-free transportation evaluated the same scenarios that are used in the WIPP SEIS-II. In the scenarios, some individuals will be exposed to a single shipment while others would be exposed to multiple shipments. Transportation crew members are monitored with radiation dosimeters to limit exposures. All of these exposure scenarios include a very large degree of conservatism by assuming that the effect of multiple shipments that take place over a period of time is cumulative, when in fact the effect is not cumulative (Mossman 2008). The scenarios for radiation dose assessment are:

- A person in a traffic jam next to a truck transporting TRU waste. For this assessment, the exposure distance is assumed to be 2 meter (6.6 feet) and the exposure time is assumed to be 30 minutes. The person is assumed to be exposed only once.
- An inspector of trucks ready for departure from a site. For this assessment, it is assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for an hour, although Weiner and Neuhauser (1992) clocked inspectors at Raton Pass at 45 minutes. The inspector would work at the same job for 10 years, and there would be two shifts working the same job. The number of shipments inspected by an individual would depend on the total number of shipments from a site and the rate at which they are shipped.
- A state safety inspector. For this assessment, it is assumed the inspector would be involved in 20 percent of the inspection over a 10-year period with an average exposure distance of approximately 1 meter (3.3 feet). Inspections could occur at the originating facility, upon arrival at WIPP, or in the corridor states at ports of entry for trucks. To allow for queues, a truck inspection time of 1 hour was be used. To bound the state inspector dose, the route on which the majority of waste enters NM was be used.
- A person residing along a shipment route. For this assessment, it is assumed that the individual would be exposed to every waste shipment for 70 years, at a distance of approximately 30 meters (98 feet).
- A rest stop employee. For this assessment, a stop duration of 50 minutes and an exposure distance of 1 to 15 meters (3 to 45 feet) is assumed. It was also assumed that the individual will be exposed to approximately 20 percent of all CH-TRU and RH-TRU waste shipments sent to WIPP over a 10-year period. This assumption is made on the basis that all trucks stop at the same location, an individual works for 10 years at the truck stop, and 3 shifts work at the truck stop.
- A driver of a truck hauling TRU waste. For this assessment, doses were assessed for both when the truck is moving and when it is stopped. An exposure distance of 4 meters (13 feet) is assumed. Doses received while the trucks are stopped are assumed to be due to walkaround inspections every 100 miles (160 km) and to rest stops for refueling, and food. The walkaround inspections are conservatively assumed to take 10 minutes (DOE 2002). Although the average rest stop time (Griego et al. 1996) is 20 minutes, the time used in this analysis is 50 minutes, which is the longest rest stop time reported in Griego et al. (1996). Semi-detached trailer trucks stop to refuel when the fuel tanks are half empty, and the distance calculated for this is 845 km (DOE 2002). A truck driver, rather than a service attendant, is assumed to refuel the truck. It should be noted that no matter what the estimated impacts are, current regulations state that any monitored crew member

who receives a radiation dose that approaches 2 rem (the administrative limit for occupational doses) in any given year is to be reassigned to other duties involving no further dose for the remainder of the year.

3.3.2 Results for Routine Incident-Free Transportation

3.3.2.1 Doses During Transit

Table 10 shows the per-shipment dose rates for CH shipments, compared to the analogous results reported in Table E-12 of the SEIS. Table 11 shows these collective doses converted to LCF(Latent Cancer Fatality) risk using the currently accepted risk factor of 6 x 10^{-4} LCF/rem (6 x 10^{-2} LCF/Sv) (ISCORS 2002). LCF risk should also be interpreted to include the risk of no LCF; a LCF risk of 1.87 x 10^{-7}, for example, implies a probability of no LCF of essentially 1 (i.e., a 100% probability that there will be no latent cancer fatality). Moreover, collective dose cannot be interpreted simply; the NRC advises that collective dose (e.g., person-rem) be used only in comparative analyses and should not be used as a risk assessment tool nor as a predictor of cancer risk (Ryan 2007). This TA reports collective dose and LCF risk, but cautions the reader to interpret these in light of the NRC position.

Table 10 Collective doses per CH shipment

	DOSE RATE = 0.5 mrem/hr*			SEIS DOSE RATE = 4 mrem/hr		
	DOSE FROM ROUTINE TRANSPORTATION -- PERSON-REM					
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	1.26E-02	3.20E-04	6.93E-03	3.00E-02	5.30E-03	9.70E-03
BATTELLE	1.40E-02	3.78E-04	7.68E-03	-	-	-
BETTIS	1.57E-02	5.95E-04	6.20E-03	-	-	-
BROOKHAVEN	1.95E-02	2.49E-03	1.19E-02	-	-	-
INL/ANL-W	8.59E-03	2.08E-04	2.35E-03	2.00E-02	2.7E-03	7.5E-03
KAPL	2.41E-02	2.46E-03	2.30E-02	-	-	-
LANL	3.28E-03	2.68E-05	4.80E-04	2.00E-02	2.50E-03	6.30E-03
LBL	1.26E-02	1.80E-04	8.84E-03	3.00E-02	4.80E-03	8.50E-03
MATERIALS COMMAND	1.35E-02	2.32E-03	7.87E-03	-	-	-
MURR	1.00E-02	1.87E-04	5.23E-03	-	-	-
NTS	1.01E-02	1.31E-04	2.98E-03	2.00E-02	1.90E-03	6.40E-03
ORNL	1.21E-02	3.85E-04	4.35E-03	3.00E-02	4.50E-03	8.20E-03
ROCKY FLATS	6.23E-03	1.28E-04	1.54E-03	1.00E-02	2.00E-03	4.00E-03
RICHLAND (HANFORD)	1.59E-02	2.81E-04	4.04E-03	3.00E-02	3.30E-03	7.50E-03
SANDIA	2.76E-03	8.05E-06	4.42E-04	-	-	-
SRS	1.32E-02	4.54E-04	5.11E-03	3.00E-02	5.40E-03	8.90E-03

*External dose rate from three TRUPACTs.

Table 11 Calculated per-shipment LCF risk from routine CH transportation

	LCF			LCF – SEIS		
	OCCUPA-TIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPA-TIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	7.59E-06	1.92E-07	4.16E-06	1.80E-05	3.18E-06	5.82E-06
BATTELLE	8.40E-06	2.27E-07	4.61E-06	-	-	-
BETTIS	9.41E-06	3.57E-07	3.72E-06	-	-	-
BROOKHAVEN	1.17E-05	1.50E-06	7.13E-06	-	-	-
INL/ANL-W	5.15E-06	1.25E-07	1.41 E-06	-	-	-
KAPL	1.45E-05	1.48E-06	1.38E-05	-	-	-
LANL	1.97E-06	1.61E-08	2.88E-07	1.20E-05	1.50E-06	3.78E-06
LBL	7.53E-06	1.08E-07	5.30E-06	1.80E-05	2.88E-06	5.10E-06
MATERIALS COMMAND	8.11E-06	1.39E-06	4.72E-06	-	-	-
MURR	6.01E-06	1.12E-07	3.14E-06	-	-	-
NTS	6.07E-06	7.86E-08	1.79E-06	1.20E-05	1.14E-06	3.84E-06
ORNL	7.25E-06	2.31E-07	2.61E-06	1.80E-05	2.70E-06	4.92E-06
ROCKY FLATS	3.74E-06	7.74E-08	9.24E-07	6.00E-06	1.20E-06	2.40E-06
RICHLAND (HANFORD)	9.53E-06	1.68E-07	2.42E-06	1.80E-05	1.98E-06	4.50E-06
SANDIA	1.66E-06	4.83E-09	2.65E-07	-	-	-
SRS	7.92E-06	2.72E-07	3.07E-06	1.80E-05	3.24E-06	5.34E-06

Parameter values that account for the difference between doses in the present study and those in the SEIS, in addition to increased population and changed population distribution, include smaller, more realistic TIs, route-specific population densities instead of the average values R=6 persons/km^2, S = 719 persons/km^2 and U=3861 persons/km^2 (SEIS p. E-5), the uniform speed of 88.6 km/hr on all freeways during non-rush hours instead of 88.6 km/hr in rural areas, 40.3 km/hr in suburban areas, and 24.2 km/hr in urban areas (SEIS Table E-10), and updated vehicle densities. The majority of these differences, like a smaller TI, decrease the dose, but a few would increase the doses. In general, the use of more realistic parameter values, supported by data or supplementary (e.g., MICROSHIELD) calculations, have resulted in lower doses than reported in SEIS-II.

Figure 2 is an example of the effect of TI on dose and shows that the dose is directly proportional to TI. Figure 2 also suggests that using the regulatory maximum TI or a "conservative" TI can greatly overestimate the collective dose from routine transportation.

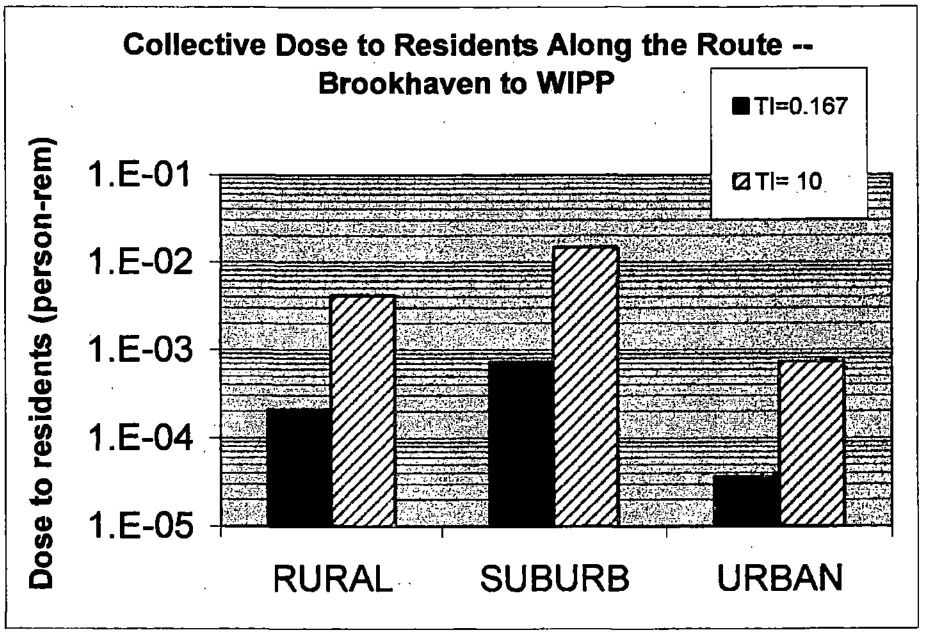


Figure 2. Effect of TI on collective dose along the route. Solid bars are values in this TA; striped bars are values in the SEIS Appendix E.

Overestimating the TI ensures that the risk will not be underestimated, but can overstate the dose or collective dose by an order of magnitude or more. RADTRAN 5.6 allows uncertainty in TI to be incorporated into the dose calculation and provides a more accurate statement of the probable dose and associated error in the dose estimate.

Tables 12 and 13 present the collective doses and LCF risks, respectively, for CH-TRU transportation when the TI is calculated from a +/- 10% uncertainty in the transported inventory (Table 6). The LCF risk is so small, as shown in Table 12, that the uncertainty does not make a significant difference in the case of routine CH-TRU transportation. It is nonetheless more accurate to express the TI as an average value and a range. Figures 3, 4, and 5 shows the uncertainties in in-transit crew dose, maximum individual in-transit dose, and collective in-transit dose, from routine transportation. The figures show the per-shipment doses. In distributing the input TI, calculated from the curie content, the assumption was that the curie content was equally likely to be overestimated as underestimated.

Table 12 Per-shipment CH-TRU doses accounting for 10% uncertainty in inventory

SITES	DOSE RATE = 0.167 mrem/hr per TRUPACT			DOSE RATE = 0.184 mrem/hr per TRUPACT			DOSE RATE = 0.151 mrem/hr per TRUPACT		
	DOSE FROM ROUTINE TRANSPORTATION -- PERSON-REM								
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	1.26E-02	3.06E-04	6.51E-03	1.45E-02	4.62E-04	5.17E-03	1.14E-02	2.77E-04	5.89E-03
BATTELLE	1.40E-02	3.65E-04	7.25E-03	1.54E-02	4.03E-04	7.99E-03	1.27E-02	3.30E-04	6.56E-03
BETTIS	1.57E-02	5.63E-04	5.92E-03	1.73E-02	6.20E-04	6.52E-03	1.42E-02	5.09E-04	5.35E-03
BROOKHAVEN	1.96E-02	9.74E-04	8.34E-03	2.15E-02	1.07E-03	9.19E-03	1.77E-02	8.80E-04	7.54E-03
INL/ANL-W	1.22E-02	1.96E-04	2.57E-03	1.34E-02	2.16E-04	2.83E-03	1.10E-02	1.77E-04	2.32E-03
KAPL	2.41E-02	8.95E-04	8.81E-03	2.65E-02	9.86E-04	9.71E-03	2.18E-02	8.09E-04	7.97E-03
LANL	3.28E-03	2.49E-05	4.47E-04	3.62E-03	2.75E-05	4.92E-04	2.97E-03	2.25E-05	4.04E-04
LBL	1.26E-02	1.62E-04	8.26E-03	1.38E-02	1.79E-04	9.10E-03	1.14E-02	1.47E-04	7.46E-03
MATERIALS COMMAND	1.35E-02	5.32E-04	5.76E-03	1.49E-02	5.86E-04	6.35E-03	1.22E-02	4.81E-04	5.21E-03
MURR	1.00E-02	1.79E-04	4.88E-03	1.10E-02	1.98E-04	5.38E-03	9.06E-03	1.62E-04	4.41E-03
NTS	1.01E-02	1.16E-04	2.62E-03	1.11E-02	1.28E-04	2.88E-03	9.15E-03	1.05E-04	2.37E-03
ORNL	1.21E-02	3.53E-04	3.99E-03	1.33E-02	3.88E-04	4.40E-03	1.09E-02	3.19E-04	3.61E-03
ROCKY FLATS	6.23E-03	1.17E-04	1.40E-03	6.87E-03	1.29E-04	1.55E-03	5.64E-03	1.06E-04	1.27E-03
RICHLAND (HANFORD)	1.58E-02	2.56E-04	3.72E-03	1.74E-02	2.82E-04	4.09E-03	1.43E-02	2.31E-04	3.36E-03
SRS	1.32E-02	4.19E-04	4.69E-03	1.45E-02	4.62E-04	5.17E-03	1.19E-02	3.79E-04	4.24E-03

Table 13 Per-shipment CH-TRU LCF risk accounting for 10% uncertainty in inventory

	DOSE RATE = 0.167 mrem/hr per TRUPACT			DOSE RATE = 0.184 mrem/hr per TRUPACT			DOSE RATE = 0.151 mrem/hr per TRUPACT		
	LCF RISK FROM ROUTINE TRANSPORTATION								
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	7.59E-06	1.84E-07	3.91E-06	8.73E-06	2.77E-07	3.10E-06	6.86E-06	1.66E-07	3.53E-06
BATTELLE	8.40E-06	2.19E-07	4.35E-06	9.25E-06	2.42E-07	4.79E-06	7.59E-06	1.98E-07	3.93E-06
BETTIS	9.41E-06	3.38E-07	3.55E-06	1.04E-05	3.72E-07	3.91E-06	8.51E-06	3.05E-07	3.21E-06
BROOKHAVEN	1.17E-05	5.84E-07	5.00E-06	1.29E-05	6.44E-07	5.51E-06	1.06E-05	5.28E-07	4.52E-06
INL/ANL-W	7.29E-06	1.18E-07	1.54E-06	8.03E-06	1.29E-07	1.70E-06	6.59E-06	1.06E-07	1.39E-06
KAPL	1.45E-05	5.37E-07	5.29E-06	1.59E-05	5.91E-07	5.83E-06	1.31E-05	4.85E-07	4.78E-06
LANL	1.97E-06	1.50E-08	2.68E-07	2.17E-06	1.65E-08	2.95E-07	1.78E-06	1.35E-08	2.42E-07
LBL	7.53E-06	9.75E-08	4.95E-06	8.30E-06	1.07E-07	5.46E-06	6.81E-06	8.82E-08	4.48E-06
MATERIALS COMMAND	8.11E-06	3.19E-07	3.46E-06	8.93E-06	3.52E-07	3.81E-06	7.33E-06	2.89E-07	3.13E-06
MURR	6.01E-06	1.08E-07	2.93E-06	6.63E-06	1.19E-07	3.23E-06	5.44E-06	9.73E-08	2.65E-06
NTS	6.07E-06	6.94E-08	1.57E-06	6.69E-06	7.65E-08	1.73E-06	5.49E-06	6.28E-08	1.42E-06
ORNL	7.25E-06	2.12E-07	2.40E-06	7.98E-06	2.33E-07	2.64E-06	6.55E-06	1.91E-07	2.17E-06
ROCKY FLATS	3.74E-06	7.03E-08	8.42E-07	4.12E-06	7.75E-08	9.28E-07	3.38E-06	6.36E-08	7.62E-07
RICHLAND (HANFORD)	9.49E-06	1.53E-07	2.23E-06	1.05E-05	1.69E-07	2.46E-06	8.58E-06	1.39E-07	2.02E-06
SRS	7.92E-06	2.52E-07	2.81E-06	8.73E-06	2.77E-07	3.10E-06	7.16E-06	2.27E-07	2.54E-06

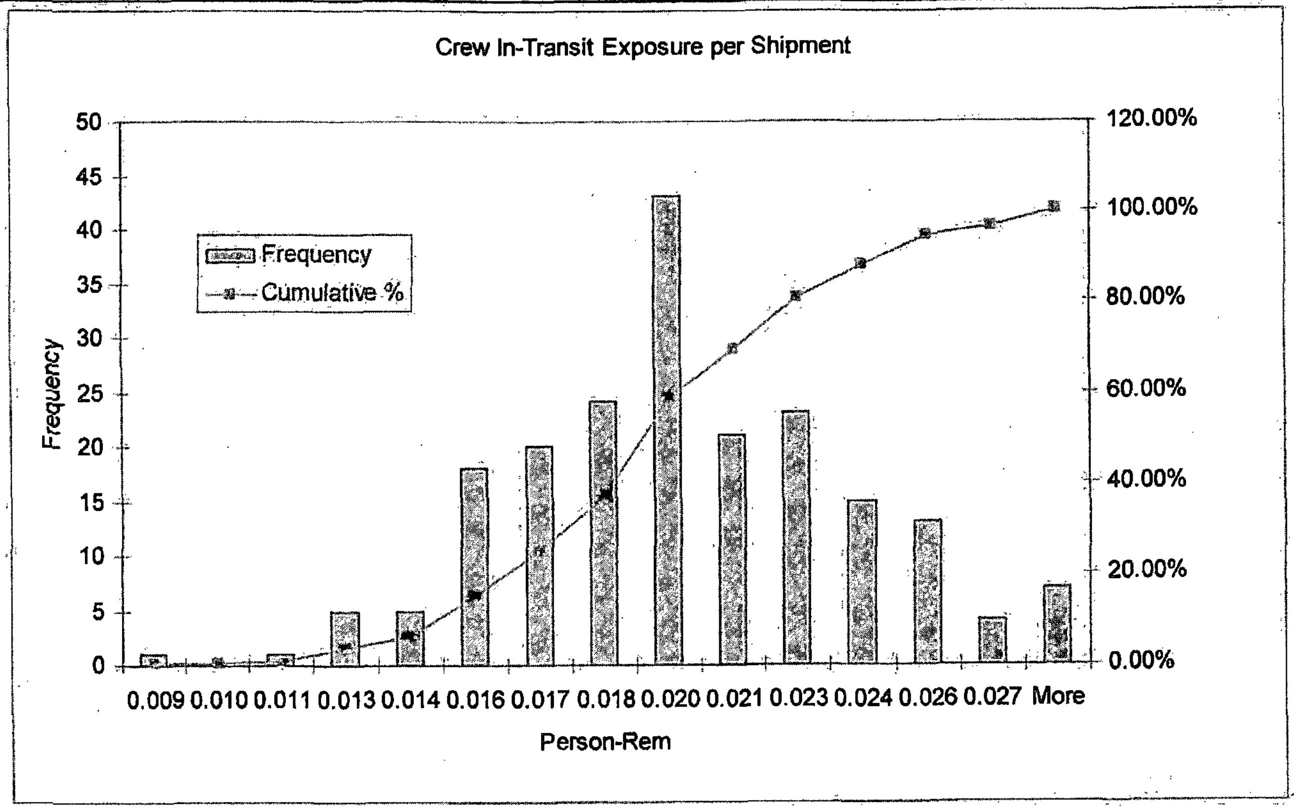


Figure 3 Crew in-transit dose per shipment.

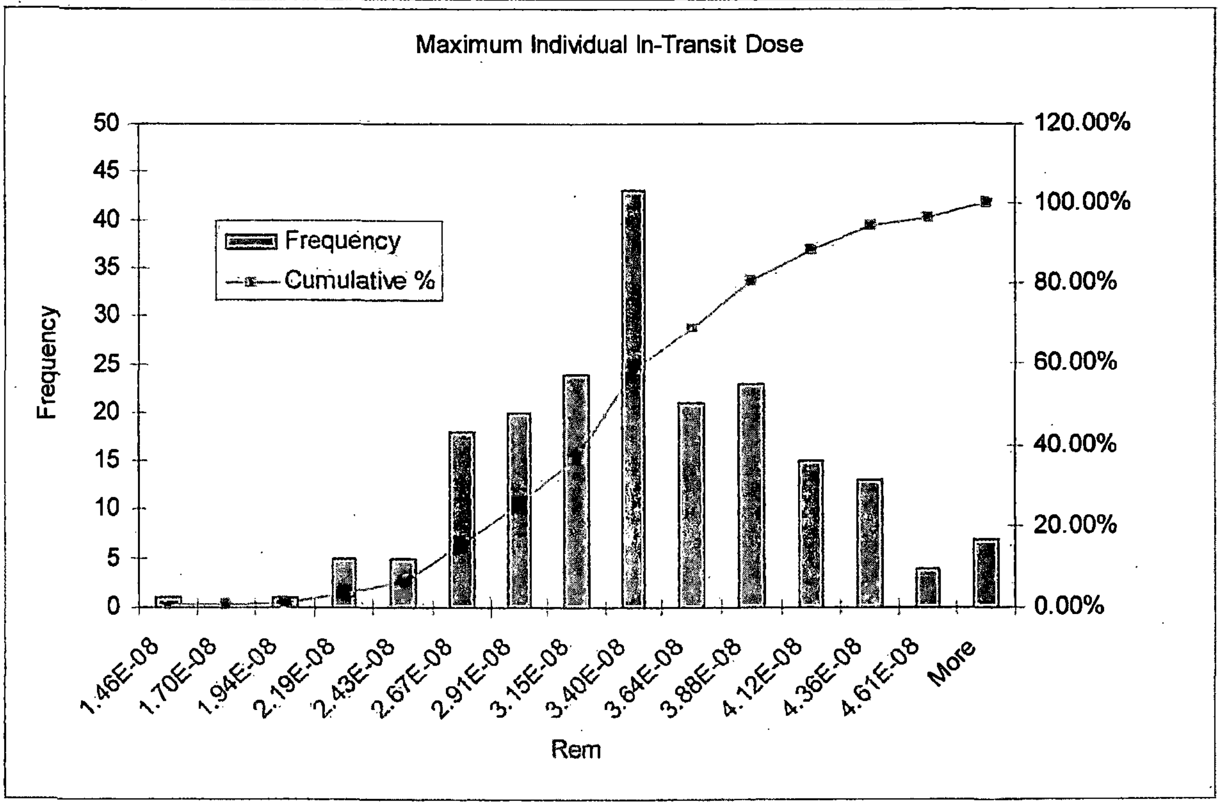


Figure 4 Maximum individual in-transit dose per shipment.

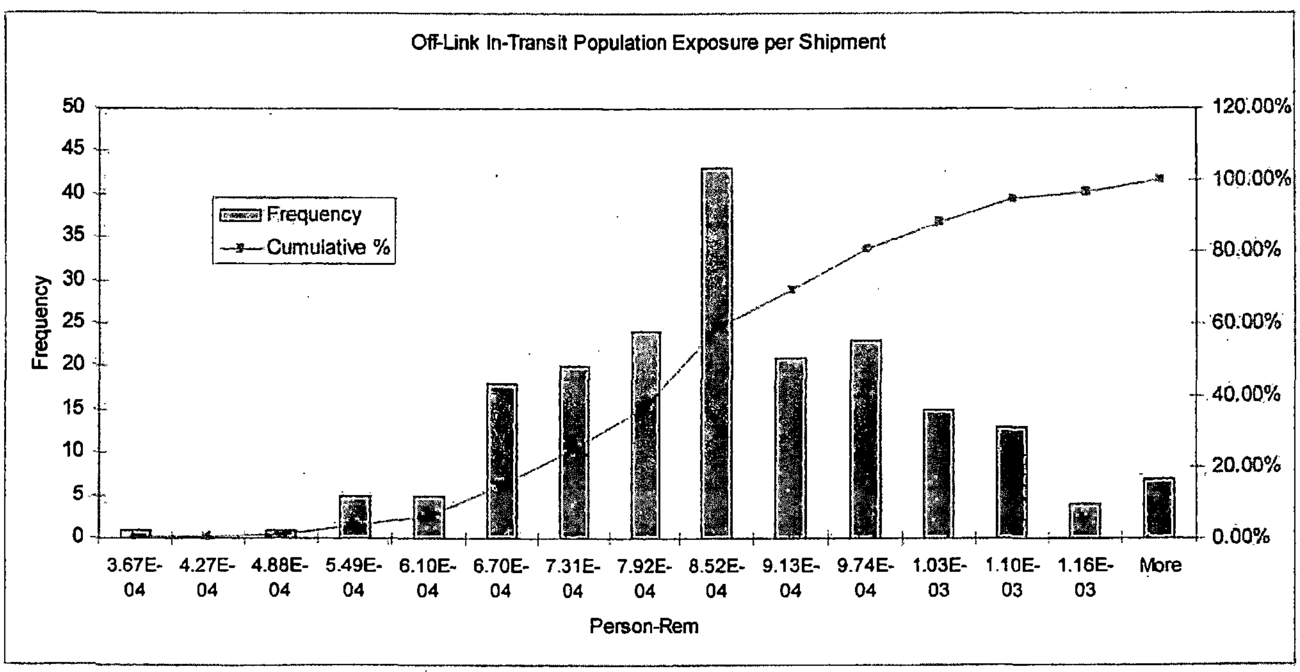


Figure 5 In-transit collective dose along the route, per shipment.

While the doses in routine transportation are directly proportional to TI, the relationship of these doses to other parameters is more complex. Figure 6 shows collective dose to occupants of vehicles that share the route with the radioactive cargo as a function of vehicle density (vehicles per hour) on the route. The SEIS used the traditional values: R=470, S= 760, U=2800 vehicles per hour, while the TA used for state or regional vehicle density data from state reports from the years 2000 to 2003 (Weiner et al. 2006, Appendix D). The TA values in Figure 6 were obtained by multiplying the vehicle density by the route segment to which it applied and adding the products for all the routes[3]. The SEIS values were obtained by multiplying the traditional vehicle densities by the total rural, suburban, and urban distances for all the routes. Using the traditional vehicle densities would underestimate doses, all other parameters being equal.

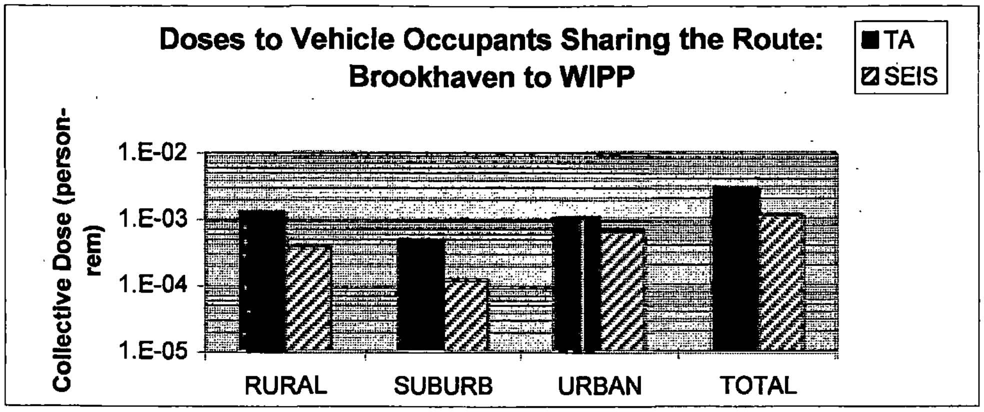


Figure 6 Comparison of the effect of vehicle densities on collective dose for vehicles sharing the route.

The in-transit dose to the maximally exposed individual along the route, per shipment; is 3.38×10^{-8} rem (3.38×10^{-5} mrem). For a truck passing at 24 km/hr (the conservative value used historically), that individual would be exposed for perhaps 0.4 minutes, and would have received 2.7×10^{-7} rem (2.7×10^{-4} mrem) of average background radiation. The dose per CH shipment is thus 12.5% of average U.S. background (360 mrem/year).

Appendix B tables show the collective doses from routine, incident free transportation for each state.

Tables 14 and 15 show the per-shipment doses and LCF for the public from RH-TRU transportation. The TI used in SEIS-II was 10 mrem/hr. Since the dose and the LCF risk are both proportional to the TI, comparison with SEIS-II values is provided only for people along the route.

3 Rush-hour vehicle densities and speeds were not included in the presentation. Their inclusion complicates the presentation without adding information or insight, or changing the result.

Table 14 Per-shipment doses from routine RH transportation.

DOSE FROM ROUTINE RH TRANSPORTATION – PERSON-REM				
	OCCUPATIONAL	ALONG ROUTE TI=2.5	SHARING ROUTE	ALONG ROUTE TI=10
ANL-E	1.88E-02	6.73E-03	5.05E-03	2.69E-02
BETTIS	2.33E-02	1.27E-02	3.50E-02	5.08E-02
INL/ANL-W	2.07E-02	9.79E-03	3.60E-03	3.92E-02
KAPL	1.20E-01	3.32E-02	1.97E-02	1.33E-01
LANL	4.87E-03	6.24E-05	1.12E-03	2.50 E-04
ORNL	1.79E-02	1.08E-02	5.62E-03	4.32E-02
SANDIA	4.10E-03	4.40E-03	1.87E-05	1.76E-02
RICHLAND (HANFORD)	2.35E-02	7.53E-03	1.67E-02	3.01E-02
SRS	9.18E-01	3.40E-02	3.40E-02	1.36E-01

Table 15 Per-shipment LCF risk from routine RH transportation

LCF RISK FROM ROUTINE RH TRANSPORTATION – PERSON-REM				
SITE	OCCUPATIONAL	ALONG ROUTE TI=2.5	SHARING ROUTE	ALONG ROUTE TI=10
ANL-E	1.13E-05	4.04E-06	3.03E-06	1.62E-05
BETTIS	1.40E-05	7.62E-06	2.10E-05	3.05E-05
INL/ANL-W	1.24E-05	5.87E-06	2.16E-06	2.35E-05
KAPL	7.20E-05	1.99E-05	1.18E-05	7.98E-05
LANL	2.92E-06	3.74E-08	6.72E-07	1.50E-07
ORNL	1.08E-05	6.48E-06	3.37E-06	2.59E-05
SANDIA	2.46E-06	2.64E-06	1.12E-08	1.06E-05
RICHLAND (HANFORD)	1.41E-05	4.52E-06	1.00E-05	1.81E-05
SRS	5.51E-04	2.04E-05	2.04E-05	8.16 E-05

In sum, doses calculated in this TA are smaller than those calculated in the SEIS-II for the same receptors as in SEIS-II.

3.3.2.2 Doses During Stops

Table 16 shows the doses at stops for transportation from each of the origin sites to the WIPP, and includes the most comparable data from Appendix E, Table E-12 of SEIS-II, and Table 17 shows the LCF risk. The modeling of stops was entirely different in this TA from that in the SEIS, so that the difference in results is not surprising. The improvements to RADTRAN have allowed for a more realistic representation of the transportation stops.

The model used in SEIS-II calculated only the collective dose to people who shared the stop with the truck carrying radioactive cargo, and assumed that 50 people at a fixed distance of 20 meters shared the stop. The SEIS II model also used stop times that were a uniform fraction of the distance traveled; e.g., that the truck stopped for one hour every 60 miles. These restrictions were a function of the computer capabilities for which RADTRAN 4 had been designed.

RADTRAN 5.6 and 6 allow structuring of any desired group of receptors located at different distances and for different lengths of time, with differing shielding. The groups of receptors analyzed in this TA are the people who share the stop with the radioactive cargo, residents who live around the stop, the truck crew, and rest stop employee, inspectors, and persons in a traffic jam next to the truck. Crew doses at rest stops are added to the doses accumulated at the mandated 100-mile (161-km) walkaround stops. Inspection stops have a different receptor and different exposure times; inspection doses can be calculated at the same time as for other stops, as can the receptor caught in a traffic jam.

Table 16 Per-CH shipment collective doses for 50-minute stops

SHIPMENT ORIGIN	DOSE (PERSON-REM): 50-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	1.80E-05	2.76E-04	2.00E-01
Battelle Columbus	7.11E-05	5.69E-03	-
Bettis Lab	2.63E-04	6.29E-03	-
Brookhaven NL	1.68E-04	1.02E-02	-
Idaho NL/Argonne West	4.18 E-05	6.61E-03	2.00E-01
Knolls Atomic Power Lab	9.37E-05	1.05E-02	-
Los Alamos NL	4.71E-06	1.80E-03	3.00E-02
Lawrence Berkeley NL	3.31E-05	6.74E-03	1.00E-01
Army Materials Command	1.13E-04	8.02E-03	-
Missouri U. Research Reactor	3.65E-05	5.41E-03	-
Nevada Test Site	1.90E-05	5.49E-03	1.00E-01
Oak Ridge NL	7.25E-05	8.59E-03	1.00E-01
Rocky Flats	2.54E-05	3.34E-03	7.00E-02
Richland (Hanford)	5.43E-05	3.34E-03	2.00E-01
Sandia NL	4.34E-06	1.51E-03	-
Savannah River NL	1.12E-04	7.56E-03	1.00E-01

Table 17 Per-CH shipment LCF for 50-minute stop

SHIPMENT ORIGIN	LCF: 50-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	1.08E-08	1.66E-07	1.20E-04
Battelle Columbus	4.27E-08	3.41E-06	-
Bettis Lab	1.58E-07	3.77E-06	-
Brookhaven NL	1.01E-07	6.10E-06	-
Idaho NL/Argonne West	2.51E-08	3.97E-06	1.20E-04
Knolls Atomic Power Lab	5.62E-08	6.27E-06	-
Los Alamos NL	2.83E-09	1.08E-06	1.80E-05
Lawrence Berkeley NL	1.99E-08	4.05E-06	6.00E-05
Army Materials Command	6.78E-08	4.81E-06	-
Missouri Univ. Research Reactor	2.19E-08	3.24E-06	-
Nevada Test Site	1.14E-08	3.30E-06	6.00E-05
Oak Ridge NL	4.35E-08	5.15E-06	6.00E-05
Rocky Flats	1.52E-08	2.01E-06	4.20E-05
Richland (Hanford)	3.26E-08	2.01E-06	1.20E-04
Sandia NL	2.60E-09	9.04E-07	-
Savannah River NL	6.69E-08	4.54E-06	6.00E-05

The data used in calculating doses to people sharing the stop were obtained from Griego et al. (1996), who visited truck stops in New Mexico and measured the time that large semi-detached trailer trucks were at the stop as well as the distance between the truck at a fuel tank and the nearest building. The latter was assumed to provide complete shielding from external radiation. The longest time observed by Griego et al. (1996) was 50 minutes, as reflected in the data in Tables 16 and 17. The average time observed was 20 minutes. Tables 18 and 19 show collective doses and LCF for 20-minute stops.

Table 18 Per-CH shipment doses for a 20- minute stop

DOSE(PERSON-REM): 20-MINUTE STOP			
SHIPMENT ORIGIN	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	7.19E-06	1.10E-04	2.00E-01
Battelle Columbus	2.84E-05	2.28E-03	-
Bettis Lab	1.05E-04	2.52E-03	-
Brookhaven NL	6.71E-05	4.07E-03	-
Idaho NL/Argonne West	1.67E-05	2.65E-03	2.00E-01
Knolls Atomic Power Lab	3.75E-05	4.18E-03	-
Los Alamos NL	1.88E-06	7.21E-04	3.00E-02
Lawrence Berkeley NL	1.33E-05	2.70E-03	1.00E-01
Army Materials Command	4.52E-05	3.21E-03	-

Table 18 Per-CH shipment doses for a 20- minute stop (continued)

DOSE(PERSON-REM): 20-MINUTE STOP			
SHIPMENT ORIGIN	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Missouri Univ. Research Reactor	1.46E-05	2.16E-03	-
Nevada Test Site	7.60E-06	2.20E-03	1.00E-01
Oak Ridge NL	2.90E-05	3.44E-03	1.00E-01
Rocky Flats	1.01E-05	1.34E-03	7.00E-02
Richland (Hanford)	2.17E-05	1.34E-03	2.00E-01
Sandia NL	1.74E-06	6.02E-04	-
Savannah River NL	4.46E-05	3.03E-03	1.00E-01

Table 19 Per-CH shipment LCF risk for a 20-minute stop.

SHIPMENT ORIGIN	LCF: 20-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	4.31E-09	6.62E-08	1.20E-04
Battelle Columbus	1.71E-08	1.37E-06	-
Bettis Lab	6.31E-08	1.51E-06	-
Brookhaven NL	4.02E-08	2.44E-06	-
Idaho NL/Argonne West	1.00E-08	1.59E-06	1.20E-04
Knolls Atomic Power Lab	2.25E-08	2.51E-06	-
Los Alamos NL	1.13E-09	4.33E-07	1.80E-05
Lawrence Berkeley NL	7.95E-09	1.62E-06	6.00E-05
Army Materials Command	2.71E-08	1.92E-06	-
Missouri Univ. Research Reactor	8.77E-09	1.30E-06	-
Nevada Test Site	4.56E-09	1.32E-06	6.00E-05
Oak Ridge NL	1.74E-08	2.06E-06	6.00E-05
Rocky Flats	6.09E-09	8.02E-07	4.20E-05
Richland (Hanford)	1.30E-08	8.02E-07	1.20E-04
Sandia NL	1.04E-09	3.61E-07	-
Savannah River NL	2.68E-08	1.82E-06	6.00E-05

Tables 20 and 21 show the doses and LCF risks for 50-minute RH-shipment stops.

Table 20 Per-shipment stop doses (person-rem) from routine RH transportation

SITE	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-13
ANL-E	5.97E-04	2.64E-02	-
BETTIS	1.52E-02	6.29E-03	-
INL/ANL-W	9.90E-05	6.61E-03	2.00E-01
KAPL	2.17E-04	1.05E-02	-
LANL	1.10E-05	1.80E-03	4.00E-02
ORNL	1.57E-04	8.59E-03	2.00E-01
RICHLAND (HANFORD)	1.29E-04	3.34E-03	2.00E-01
SANDIA	1.01E-05	3.51E-03	-
SRS	2.02E-04	7.56E-03	-

Table 21 Per-shipment stop LCF risk from routine RH transportation

SITE	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-13
ANL-E	3.58E-07	1.58E-05	-
BETTIS	9.11E-06	3.77E-06	-
INL/ANL-W	5.94E-08	3.97E-06	1.20E-04
KAPL	1.30E-07	6.27E-06	-
LANL	6.58E-09	1.08E-06	2.40E-05
ORNL	9.40E-08	5.15E-06	1.20E-04
RICHLAND (HANFORD)	7.73E-08	2.01E-06	1.20E-04
SANDIA	6.06E-09	2.11E-06	-
SRS	1.21E-07	4.54E-06	-

The in-transit dose to the (reasonably) maximally exposed individual (RMEI) for each shipment is calculated to be 3.33×10^{-8} rem (3.33×10^{-6} Sv; 3.33×10^{-5} mrem) for a CH shipment and 7.76×10^{-8} rem for a RH shipment. Table 22 shows the cumulative dose to this individual from routine transport of all shipments, CH and RH, even though the putative damage done by doses from these shipments is not cumulative (Tenforde 2008)[4]. The WIPP is currently projected to have an operating life of 35 years (1998 to 2033), and annual doses assume a uniform distribution of shipments over that time period. Table 23 shows doses and LCF risk to the rest stop employee.

4 Doses do not accumulate. The assumption in adding doses from shipments is that the damage done by these doses accumulates. However, since the shipments are not continuous – there is a sizable lapse of time between them – the receptor organism recovers between shipments in part from any damage done. The partial recovery is used routinely in therapeutic radiation treatment; therapeutic doses are fractionated and delivered in relatively small fractions with several days or weeks of recovery allowed between doses.

Table 22 Dose and LCF risk from all shipments to the RMEI

ORIGIN SITE	MAXIMUM DOSE (rem)	LCF	ANNUAL MAX DOSE (rem)	FRACTION OF AVERAGE ANNUAL BACKGROUND
ANL-E	9.19E-06	5.51E-09	2.62E-07	7.29E-07
ANL-W	2.15E-05	1.29E-08	6.14E-07	1.71E-06
BATTELLE	3.38E-08	2.03E-11	9.66E-10	2.68E-09
BNL	2.76E-05	1.66E-08	7.88E-07	2.19E-06
BETTIS	3.44E-07	2.07E-10	9.83E-09	2.73E-08
INL	4.78E-04	2.87E-07	1.37E-05	3.80E-05
KAPL	2.09E-05	1.25E-08	5.97E-07	1.66E-06
LANL	7.17E-05	4.30E-08	2.05E-06	5.69E-06
LBL	3.45E-06	2.07E-09	9.85E-08	2.74E-07
MAT. COMMAND	3.38E-08	2.03E-11	9.66E-10	2.68E-09
MURR	3.38E-08	2.03E-11	9.66E-10	2.68E-09
NTS	1.06E-05	6.37E-09	3.03E-07	8.43E-07
ORNL	2.23E-04	1.34E-07	6.37E-06	1.77E-05
RF	4.76E-05	2.86E-08	1.36E-06	3.78E-06
RL	1.83E-04	1.10E-07	5.23E-06	1.45E-05
SNL	5.35E-06	3.21E-09	1.53E-07	4.24E-07
SRS	7.84E-05	4.71E-08	2.24E-06	6.22E-06

Table 23 Doses and calculated LCF risks to the rest stop employee for all shipments

SHIPMENT ORIGIN	REST STOP EMPLOYEE					
	DOSE (rem)				LCF RISK	
	50-MINUTE STOP	20-MINUTE STOP	50-MIN. STOP ANNUAL DOSE	FRACTION OF BACKGROUND	50-MINUTE STOP	20-MINUTE STOP
Argonne NL East	6.06E-02	2.43E-02	1.73E-02	0.048	3.64E-05	1.46E-05
Battelle Columbus	1.26E-04	5.03E-05	3.59E-05	0.000	7.55E-08	3.02E-08
Bettis Lab	1.44E-03	5.74E-04	4.10E-04	0.001	8.61E-07	3.44E-07
Brookhaven NL	1.39E-01	5.55E-02	3.96E-02	0.110	8.32E-05	3.33E-05
Idaho NL/Argonne W	1.64E+00	6.54E-01	4.67E-01	1.30	9.81E-04	3.93E-04
Knolls Atomic Power	1.09E-01	4.36E-02	3.11E-02	0.086	6.54E-05	2.62E-05
Los Alamos NL	6.37E-02	2.55E-02	1.82E-02	0.051	3.82E-05	1.53E-05
Lawrence Berkeley NL	1.15E-02	4.59E-03	3.28E-03	0.009	6.89E-06	2.76E-06
Army Materials Com	1.34E-04	5.36E-05	3.83E-05	0.0001	8.04E-08	3.22E-08
Missouri Univ. Research Reactor	3.78E-05	1.51E-05	1.08E-05	0.0000	2.27E-08	9.07E-09
Nevada Test Site	3.61E-02	1.45E-02	1.03E-02	0.029	2.17E-05	8.67E-06
Oak Ridge NL	9.49E+00	3.80E+00	2.71E+00	7.53	5.69E-03	2.28E-03
Rocky Flats	7.86E-02	3.14E-02	2.25E-02	0.062	4.72E-05	1.89E-05
Richland (Hanford)	7.86E-01	3.14E-01	2.25E-01	0.62	4.72E-04	1.89E-04
Sandia NL	4.04E-03	1.61E-03	1.15E-03	0.003	2.42E-06	9.69E-07
Savannah River NL	2.35E+00	9.41E-01	6.72E-01	1.87	1. 41E-03	5.64E-04

The relatively significant doses for the routes from the Idaho, Oak Ridge, Richland (Hanford) and the Savannah River Site are artifacts of assuming that the effect of the shipments is cumulative. If these shipments are spaced uniformly throughout the 35 years of WIPP operation and the rest stop employee is exposed to 20% of them for 10 years, he or she will be exposed to about 175 shipments per year, or about one shipment every other day. The dose from each shipment is about 2.2 mrem, a small enough dose that the receptor would recover from its effects before being exposed to the next shipment. Multiplying the dose from a shipment by a number of shipments spaced a day or more apart is a significant conservatism. This consideration applies throughout this analysis.

The relatively significant collective doses for the routes from Brookhaven and the Knolls Atomic Power Laboratory result from the long distances that shipments from these sites travel, because the number of stops is directly proportional to the distance traveled.

Table 24 shows the dose and LCF to state inspectors. The assumption in calculating this table was that there would be one stop in each state. The dose to a state inspector at a one-hour stop was calculated to be 0.0022 rem (2.2 mrem) for an average CH shipment and 0.00723 rem (7.23 mrem) for an average RH shipment. A state inspector was assumed to be exposed to 20% of the shipments during a ten-year period.

Table 24 Doses and calculated LCF risks to state inspectors

STATE	NUMBER OF SHIPMENTS		10-YEAR			
	CH	RH	DOSE TO INSPECTOR (rem)	LCF RISK	ANNUAL DOSE TO INSPECTOR (rem)	FRACTION OF BACK GROUND
AL	1953	160	1.09E+00	6.54E-04	0.312	0.87
AR	1336	2923	4.81E+00	2.89E-03	1.376	4
AZ	416	0	1.83E-01	1.10E-04	0.052	0.15
CA	416	0	1.83E-01	1.10E-04	0.052	0.15
CO	16046	3498	1.21E+01	7.27E-03	3.462	10
GA	1953	160	1.09E+00	6.54E-04	0.312	0.87
ID	14637	2427	9.95E+00	5.97E-03	2.843	8
IL	82	83	1.56E-01	9.37E-05	0.045	0.12
IN	13228	680	6.80E+00	4.08E-03	1.944	5
KS	1	4	6.22E-03	3.73E-06	0.002	0.00
KY	1	4	6.22E-03	3.73E-06	0.002	0.00
LA	1953	160	1.09E+00	6.54E-04	0.312	0.87
MD	955	209	7.22E-01	4.33E-04	0.206	0.57
MO	83	83	1.57E-01	9.39E-05	0.045	0.12
MS	1953	160	1.09E+00	6.54E-04	0.312	0.87
NJ	955	209	7.22E-01	4.33E-04	0.206	0.57
NM	22888	5691	1.83E+01	1.10E-02	5.229	15
NV	314		1.38E-01	8.29E-05	0.039	0.11
NY	955	209	7.22E-01	4.33E-04	0.206	0.57
OH	2	4	6.66E-03	4.00E-06	0.002	0.01
OK	83	83	1.57E-01	9.39E-05	0.045	0.12

Table 24 Doses and calculated LCF risks to state inspectors (continued)

STATE	NUMBER OF SHIPMENTS		10-YEAR			
	CH	RH	DOSE TO INSPECTOR (rem)	LCF RISK	ANNUAL DOSE TO INSPECTOR (rem)	FRACTION OF BACK GROUND
OR	1409	1747	3.15E+00	1.89E-03	0.899	2
PA	956	213	7.29E-01	4.37E-04	0.208	0.58
SC	1953	160	1.09E+00	6.54E-04	0.312	0.87
TN	1336	2923	4.81E+00	2.89E-03	1.376	4
TX	3372	3166	6.06E+00	3.64E-03	1.732	5
UT	14637	2416	9.93E+00	5.96E-03	2.838	8
VA	956	209	7.23E-01	4.34E-04	0.207	0.57
WA	1409	1747	3.15E+00	1.89E-03	0.899	2
WV	956	213	7.29E-01	4.37E-04	0.208	0.58
WY	14637	2416	9.93E+00	5.96E-03	2.838	8

Table 24 should be read with the same caution as Table 23. Nevertheless, inspectors would receive significant external doses. Under the suggested protocol, a New Mexico inspector would inspect about 163 shipments per year, or about one every other day (a Colorado inspector would inspect about 117 shipments per year). Weiner and Neuhauser (1992) proposed that, because of their somewhat extended proximity to the radioactive cargo, state inspectors should be considered radiation workers and should wear dosimeters in accordance with ALARA. This would almost certainly apply to New Mexico and inspectors in other states where the dose would exceed background. Inspection doses were projected in this study to exceed background in two-thirds of the states traversed. The projection is conservative in that it does not recognize that many of these states have different ports of entry, so that different inspectors would be involved. New Mexico, for example, has three interstate ports of entry (four, if the Big Spring, Texas cutoff is used).

The dose and risk to an inspector at each origin site are shown in Table 25. Each inspector was assumed to be exposed to half of the shipments, in accordance with the analysis plan. However, those sites shipping a large number of shipments (Idaho NL, Oak Ridge, Hanford, and probably Savannah River) would probably use more than two inspectors, if only because of the time required to inspect the number of shipments leaving those sites. All origin sites have ALARA practices in place in any case.

Table 25 Doses and calculated LCF risks to inspectors at shipment origins

	10-YR CH SHIPMENT DOSE (rem)	10-YR RH SHIPMENT DOSE (rem)	LCF RISK	ANNUAL DOSE	FRACTION OF BACK GROUND
Argonne NL East	1.26E-01	4.49E-01	3.46E-04	5.76E-02	0.1600
Battelle Columbus	1.56E-03	-	9.34E-07	1.56E-04	0.0004
Bettis Lab	1.56E-03	2.17E-02	1.39E-05	2.32E-03	0.0064
Brookhaven NL	1.27E+00	-	7.63E-04	1.27E-01	0.3532
Idaho NL/Argonne West	2.06E+01	3.68E+00	1.46E-02	2.43E+00	6.7438
Knolls Atomic Power Lab	2.16E-01	1.13E+00	8.08E-04	1.35E-01	0.3740
Los Alamos NL	3.19E+00	1.13E+00	2.59E-03	4.32E-01	1.1992
Lawrence Berkeley NL	1.59E-01	-	9.53E-05	1.59E-02	0.0441
Army Materials Command	1.56E-03	-	9.34E-07	1.56E-04	0.0004
Missouri Univ. Research Reactor	1.56E-03	-	9.34E-07	1.56E-04	0.0004
Nevada Test Site	4.89E-01	-	2.94E-04	4.89E-02	0.1359
Oak Ridge NL	5.90E-01	1.47E+01	9.16E-03	1.53E+00	4.2392
Rocky Flats	2.19E+00	-	1.32E-03	2.19E-01	0.6094
Richland (Hanford)	2.19E+00	9.46E+00	6.99E-03	1.17E+00	3.2372
Sandia NL	1.05E-02	3.57E-01	2.21E-04	3.68E-02	0.1022
Savannah River NL	3.04E+00	8.66E-01	2.34E-03	3.91E-01	1.0854

The final special receptor is an individual in a traffic jam, 2 meters laterally from a WIPP-bound truck, for 30 minutes, unshielded by the vehicle he or she is occupying. The doses that such an individual would receive are:

- 5.23×10^{-4} rem (0.523 mrem) from a CH-TRU vehicle[5].
- 1.19×10^{-3} rem (1.19 mrem) from a RH-TRU vehicle.

3.3.3 Accident Calculations

NRC-certified Type B packages used to ship CH-TRU and RH-TRU waste must undergo a series of performance tests which simulate accident conditions (10 CFR Part 71 Subpart E). The packages pass if no radioactive material is released as a result of the tests.

The WIPP SEIS-II assumed that 9 percent of truck accidents involving Type B containers or casks could result in radioactive material releases and could be more severe than test conditions. This was considered a conservative assumption (DOE 1997b). This assumption was not maintained for this TA. Instead, the more accurately calculated conditional probabilities of accidents (severity fractions) were used, as discussed further. The calculation of accident dose risk includes multiplication by the large semi-detached truck accident rate for each state (obtained from Bureau of Transportation Statistics data (BTS 2008).

Two analyses were conducted for radiological impacts due to transportation accidents. The first analysis assesses the radiological impact due to an accident occurring on each rural, suburban, and urban segment of each state traversed during transportation from each of the origin sites to the WIPP. The second analysis (severe accident analysis, Section 3.3.3.2) assessed four bounding accidents. For the WIPP SEIS-II, the radiological inventory assumed that every TRU waste package would be filled with waste containers to the maximum level of radionuclides and hazardous materials allowed by the planning-basis waste acceptance criteria (DOE 1996). This analysis used the maximum curie content for a TRUPACT and a RH-72B from the most recent WIPP inventory report (DOE 2008a); the curie content was from a Savannah River waste stream for CH waste and a Bettis Atomic Power Laboratory for RH waste. The compared inventories are shown in Table 26.

5 See the SRS_CH and SRS_RH RADTRAN outputs.

Table 26 Bounding Case Radionuclide Inventories for CH-TRU and RH-TRU Waste Accidents

	CH-TRU WASTE		RH-TRU WASTE	
Radionuclide	SEIS-II INVENTORY(CURIES PER TRUPACT-II)	NEW INVENTORY (CURIES PER TRUPACT-II)[1]	SEIS-II INVENTORY (CURIES PER RH-72B)	NEW INVENTORY (CURIES PER RH-72B)[1]
Co-60	6.40E-04	5.58E-03	2.5	13.4
Sr-90	0.01	0.087	49	263.6
Cs-137	0.01	0.087	49	263.6
U-233	Not found in inventory	Not found in inventory	0.03	0.161
U-235	Not found in inventory	Not found in inventory	1.10E-03	5.92E-03
U-238	Not found in inventory	Not found in inventory	7.10E-05	3.82E-04
Pu-238	990	8630.7	1,000	5379.5
Pu-239	16	139.5	20	107.6
Pu-240	4.2	36.6	10	53.8
Am-241	3.6	31.4	12	64.6
Pu-241	200	1743.6	10	53.8
Pu-242	6.80E-04	5.93E-03	Not found in inventory	Not found in inventory

[1] DOE (2008a)

Accident severity fractions (conditional probabilities) define the seriousness of an accident in terms of mechanical and thermal loads. The WIPP SEIS-II retained the severity classification scheme use by the NRC (1977) as shown in Table 27.

Table 27 Fractional Truck Accident Occurrences by Accident Severity Category and Population Density Zone used in the WIPP SEIS-II

Accident Severity Category	Fractional Occurrences	Rural	Suburban	Urban
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5E-5	0.8	0.1	0.1
VIII	1.5E-5	0.9	0.05	0.05

Source: NRC 1977.

The data presented in Table 27 were generated using the best engineering judgment available. Since publication of NRC (1977), two studies have developed these data further. The first of these studies (Fischer et al. 1987, NUREG/CR 4829) examined relevant truck and rail accident data from 1973 through 1986, constructed event trees to estimate the probabilities of each type of accident, and represented the accident severities as functions of thermal and mechanical stress on the transportation package. The

second study (Sprung et al. 2000, NUREG/CR-6672) refined and updated the event trees, and using both finite element analysis and data from cask tests, developed release fractions for 19 severity cases for truck accidents (and 21 severity cases for rail accidents) that encompass the universe of accidents, including the most probable (no release) accidents. The severity cases, related severity fractions (conditional probabilities), and release fractions from Sprung et al. (2000) are currently used for analysis of accidents involving Type B casks. In DOE (2002), the 19 severity cases and associated severity and release fractions were reduced to six by probability weighting. In addition, recognizing that no data supported the dependence of accident severity on population zone, the same severity fractions were used in all three population zones. The resulting accident scheme used in this TA is shown in Table 28.

Table 28 Fractional Truck Accident Occurrences by Accident Severity Category

Severity Category	Severity Fraction	Gas	Volatile	Particulates
1	0.99993	0.00000	0.00000	0.00000
2	6.06E-05	1.36E-01	4.09E-09	1.02E-07
3	5.86E-06	8.39E-01	1.68E-05	6.71E-08
4	4.95E-07	4.49E-01	1.35E-08	3.37E-07
5	7.49E-08	8.35E-01	3.60E-05	3.77E-06
6	3.00E-10	8.40E-01	2.40E-05	5.01E-06

Source: Sprung et al. (2000) (NUREG/CR-6672) ; DOE (2002).

3.3.3.1 Impact of Lead Loss or Slump

An accident can also cause the slumping or loss of lead gamma shielding (LOS), which would in turn results in an external dose to a receptor that exceeds the TI and can even exceed the regulatory maximum dose (10 mrem/hr at 2 meters). Sprung et al. (2000) developed a set of severity fractions for loss of lead gamma shielding, these were used in the analysis. In addition, Boyd et al. (2006) developed a factor by which to multiply the TI to reflect loss of shielding which was used in this analysis.

3.3.3.2 Severe Accident Calculations

For the severe accident calculations, two types of accidents were assumed to involve the breach of a CH-TRU shipping container and two types of accident were assumed to involve the breach of an RH-TRU shipping container. The accidents were assumed to occur under conditions which maximize the impacts to exposed populations (as used in the WIPP SEIS-II: urban area, stable meteorological conditions, breach containers engulfed in fire for two hours). The WIPP SEIS-II calculated an inhalation dose from resuspended material using a resuspension particle half-life of 365 days. However, Cederwall et al. (1987) and other studies measuring resuspended particles indicate that 100 days is already exceedingly conservative. Anspaugh (1990) suggests that a likely resuspension half life is 15 days. RADTRAN calculates the resuspension dose by assuming that released and aerosolized material is resuspended (and inhaled) for the entire time that the receptor is exposed, to fallout from the accident. This assumption is consonant with current transportation risk analysis practice (see e.g., DOE 2008d, Volume 2). The exposure time used in this analysis was 24 hours, with no change in the fraction resuspended. Accident

probability was calculated using current severity category data and joint frequency distributions of meteorological data (DOE 2002).

The following assumptions were made regarding the bounding-case transportation accident scenarios in the WIPP SEIS-II and were retained for this TA:

- Impacts were analyzed without regard to the likelihood of the accident occurring, and are thus consequences rather than risks. Risks are reported as well.
- The waste shipment would be three fully-loaded shipping containers (TRUPACT-II) or a fully loaded RH-72B. The inventory was chosen to maximally bound the impact by loading of the shipping containers up to the values shown in Table 26 for the current inventory. Since the doses in an accident are directly proportional to the activity of each radionuclide, the average (of each radionuclide, of waste streams, of containers) can be estimated from the bounding case.
- Accidents are the severity categories showing the largest releases (generally 5 and 6 in Table 25).
- Two percent (0.02) of the aerosolized, airborne radioactive waste material is released to the environment in a respirable form (less than 10 microns in diameter), consistent with recent analyses (Sprung et al. 2000; DOE 2002; DOE 2008d).
- Radioactive material is evenly distributed throughout the waste volume.
- One CH-TRU accident and one RH-TRU accident were assumed to occur in the urban portion of a nonspecific, large metropolitan area with the average population density of the most populous city in the U. S., of 2,570 persons per square kilometer (7,140 persons per square mile) (U.S. Census Bureau 2006).[6]
- Accidents occur during very stable meteorological conditions, limiting dispersion of the radioactive material plume and maximizing radiation doses.
- In the accident scenarios, one shipping container is breached and subsequently engulfed in fire for two hours.
- Receptors were exposed to the emitted material for 24 hours[7].

The bounding radionuclide inventories for CH-TRU and RH-TRU waste are shown in Table 26. These values were used for this TA.

3.3.4 Results of Accident Calculations

The per-shipment dose risks per CH shipment from accidents involving a release, are shown in Table 29. Dose risks include both the consequence and probability of accidents. Ingestion doses are listed separately because the receptors are the entire society, not the people along the routes. Table 30 shows the collective per shipment dose risks for all CH shipments. In the case of accidents, multiplying by the number of shipments is accurate because it increases the probability that a shipment will be involved in each type of accident. Another, more conservative, approximation is inherent in these dose risk results: the rural, suburban, and urban route segments are combined to form virtual rural, suburban, and urban route segments for each state. However, an accident will occur at only one place, so combining the populations (e.g., all rural populations) will overestimate the collective dose for that route segment. The

6 This is a deviation from the AP-141
7 This is a deviation from the AP-141

urban dose risks will be relatively accurately represented only in states that have only one urban population center. Collective dose risks for CH shipments are shown in Table 30. Tables 31 and 32 show the collective dose risks for a single RH shipment and for all RH shipments, respectively.

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX					
R	1.10E-10	1.66E-10	9.33E-11	1.65E-10	3.40E-11					
S	9.20E-10	1.47E-09	1.39E-10	1.27E-09	2.11E-10					
U	1.50E-09	1.51E-09	2.20E-10	2.79E-09	1.24E-10					
INGESTION	1.44E-09	1.85E-09	4.58E-09	2.69E-09	1.50E-09					
BATTELLE	IL	IN	MO	NM	OH	OK	TX			
R	6.05E-11	6.81E-11	1.66E-10	9.20E-11	3.40E-11	1.65E-10	3.36E-11			
S	5.18E-10	5.56E-10	1.47E-09	1.37E-10	4.52E-10	1.27E-09	2.08E-10			
U	3.44E-10	1.20E-09	1.51E-09	2.17E-10	7.94E-10	2.75E-09	2.32E-09			
INGESTION	8.80E-10	8.32E-10	1.85E-09	4.73E-09	3.85E-10	2.78E-09	1.55E-09			
BNL	AK	MC	NJ	NM	NY	PA	TN	TX	VA	WV
R	4.67E-10	6.54E-12	4.17E-11	5.41E-11	1.13E-11	2.20E-10	8.56E-10	7.30E-10	3.13E-10	3.95E-11
S	3.04E-09	2.85E-10	1.71E-09	3.18E-10	2.81E-09	2.92E-09	8.43E-09	7.26E-09	3.97E-09	1.05E-09
U	3.41E-09	5.21E-10	5.12E-09	7.41E-10	2.77E-08	4.88E-09	1.75E-08	1.33E-07	3.56E-09	4.28E-10
INGESTION	7.37E-09	7.64E-11	4.65E-10	2.83E-09	2.63E-10	2.14E-09	1.04E-08	8.85E-09	3.82E-09	2.94E-10
BETTIS	AK	KY	NM	OH	PA	TN	TX	WV		
R	1.78E-10	1.67E-10	1.82E-11	8.02E-11	1.15E-11	1.21E-10	2.47E-10	7.43E-12		
S	1.46E-06	1.65E-09	1.06E-10	9.67E-10	4.86E-10	1.43E-09	2.32E-09	1.46E-10		
U	1.43E-09	3.14E-09	2.19E-10	1.72E-09	2.26E-09	4.23E-09	5.75E-09	2.72E-10		
INGESTION	2.83E-09	1.78E-09	9.56E-09	9.79E-10	1.17E-10	1.77E-09	4.83E-09	6.85E-11		
INL/ANL-W	CO	ID	NM	UT	WY					
R	3.15E-10	1.86E-10	4.40E-11	1.32E-10	2.65E-10					
S	4.47E-09	9.06E-10	9.63E-10	9.65E-10	9.62E-10					
U	1.87E-08	1.23E-09	1.69E-09	6.40E-10	1.41E-09					
INGESTION	5.91E-09	4.11E-09	2.06E-09	2.31E-09	1.27E-08					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	4.67E-10	6.54E-12	4.17E-11	5.41E-11	8.75E-10	2.20E-10	8.56E-10	7.37E-10	3.13E-10	3.95E-11
S	3.04E-09	2.85E-10	1.71E-09	3.18E-10	2.34E-09	2.92E-09	8.43E-09	6.93E-09	3.97E-09	1.05E-09
U	3.41E-09	5.21E-10	5.12E-09	6.83E-10	3.13E-09	4.88E-09	1.75E-08	1.59E-08	3.56E-09	4.28E-10
INGESTION	7.37E-09	7.64E-11	4.65E-10	2.84E-09	1.14E-08	2.14E-09	1.04E-08	1.43E-08	3.82E-09	2.94E-10
LANL	NM									
R	3.82E-10									
S	9.85E-10									

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents (continued)

U	1.27E-08									
INGESTION	1.42E-08									
LBL	AZ	CA	NM							
R	3.92E-10	4.32E-10	5.66E-10							
S	1.47E-09	2.29E-09	2.47E-09							
U	2.54E-09	2.16E-08	1.14E-08							
INGESTION	1.23E-08	1.20E-08	1.72E-08							
MCA	AK	NM	TN	TX	VA					
R	5.32E-10	5.43E-11	5.35E-10	4.13E-10	3.53E-10					
S	3.47E-09	3.18E-10	8.04E-09	5.30E-09	5.01E-09					
U	4.17E-09	6.83E-10	2.01E-08	3.74E-09	1.11E-08					
INGESTION	8.40E-09	2.84E-09	1.04E-08	5.03E-09	4.38E-09					
MURR	KS	MO	NM	OK	TX					
R	2.84E-10	1.66E-10	2.75E-10	3.13E-10	1.00E-10					
S	2.16E-09	2.10E-09	4.10E-10	1.97E-09	6.21E-10					
U	1.03E-09	5.59E-09	7.08E-10	4.59E-09	3.33E-09					
INGESTION	5.24E-09	2.65E-09	1.40E-08	6.61E-09	4.58E-09					
NTS	AZ	CA	NV	NM						
R	3.92E-10	9.62E-11	1.00E-10	5.61E-10						
S	1.47E-09	4.23E-10	7.66E-10	2.46E-09						
U	2.54E-09	8.38E-10	6.16E-09	1.13E-08						
INGESTION	1.71E-08	1.23E-08	5.87E-09	1.54E-09						
OAK RIDGE	AK	NM	TN	TX						
R	5.32E-10	5.41E-11	6.30E-10	7.37E-10						
S	3.47E-09	3.18E-10	5.15E-09	6.87E-09						
U	4.17E-09	7.41E-10	1.57E-08	1.92E-08						
INGESTION	8.40E-09	2.83E-09	8.43E-09	1.43E-08						
ROCKY FLATS	CO	NM								
R	1.77E-10	3.95E-10								
S	3.78E-09	8.64E-10								
U	1.70E-08	1.51E-09								

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents (continued)

INGESTION	4.00E-09	1.27E-08								
RICHLAND	CO	ID	NM	OR	UT	WA	WY			
R	2.85E-10	3.74E-10	3.95E-10	1.66E-10	1.14E-10	3.03E-10	2.40E-10			
S	4.04E-09	2.05E-09	8.64E-10	6.79E-10	8.36E-10	2.39E-10	8.70E-10			
U	1.857E-08	8.35E-09	1.51E-09	8.891E-10	5.79E-10	2.66E-09	7.45E-10			
INGESTION	5.35E-09	5.00E-09	1.27E-08	4.45E-09	2.58E-09	1.27E-09	1.15E-08			
SNL	NM									
R	2.97E-10									
S	9.76E-11									
U	5.24E-09									
INGESTION	8.87E-09									
SRS	AL	GA	LA	MS	NM	SC	TX			
R	4.04E-10	2.6E-10	2.75E-10	3.41E-10	5.41E-11	2.55E-11	7.59E-10			
S	3.17E-09	3.99E-09	2.89E-09	2.61E-09	3.18E-10	2.62E-10	5.55E-09			
U	3.81E-09	1.19E-08	3.19E-09	2.72E-09	7.42E-10	2.63E-10	1.26E-08			
INGESTION	5.06E-09	3.17E-09	4.83E-09	4.90E-09	2.83E-09	3.50E-09	1.44E-08			

Table 30 Collective dose risks for CH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX				
R	2.95E-08	1.41E-08	8.15E-09	1.39E-08	3.11E-09				
S	2.47E-07	1.25E-07	1.21E-08	1.07E-07	1.93E-08				
U	5.48E-07	1.28E-07	1.92E-08	2.42E-07	1.19E-08				
INGESTION	1.24E-07	1.59E-07	3.94E-07	2.32E-07	1.29E-07				
BATTELLE	IL	IN	MO	NM	OH	OK	TX		
R	2.00E-10	6.81E-11	1.73E-10	9.89E-11	3.40E-11	1.71E-10	3.79E-11		
S	1.71E-09	5.56E-10	1.53E-09	1.47E-10	4.52E-10	1.32E-09	2.34E-10		
U	1.55E-09	1.20E-09	1.58E-09	2.33E-10	7.94E-10	2.94E-09	2.73E-09		
INGESTION	9.33E-10	8.82E-10	1.96E-09	5.01E-09	4.08E-10	2.95E-09	1.64E-09		
BROOKHAVEN	AK	MD	NJ	NM	NY	PA	TN	TX	VA
R	4.58E-07	5.54E-09	4.87E-04	4.75E-08	9.38E-09	1.82E-07	7.42E-07	6.72E-07	2.76E-07
S	2.98E-06	2.41E-07	4.84E-03	2.79E-07	2.33E-06	2.42E-06	7.30E-06	6.68E-06	3.50E-06
U	3.25E-03	4.43E-07	8.89E-02	6.50E-07	2.32E-05	4.08E-06	1.59E-05	1.28E-04	3.21E-06
INGESTION	6.38E-06	6.61E-08	4.02E-07	2.45E-06	2.28E-07	1.85E-06	9.00E-06	7.66E-06	3.31E-06
BETTIS	AK	KY	NM	OH	PA	TN	TX	WV	
R	2.14E-10	1.67E-10	1.96E-11	8.02E-11	1.16E-11	1.28E-10	2.78E-10	5.49E-09	
S	1.75E-06	1.65E-09	1.14E-10	9.67E-10	4.92E-10	1.52E-09	2.61E-09	1.46E-07	
U	4.23E-09	3.14E-09	2.35E-10	1.72E-09	2.32E-09	4.69E-09	6.76E-09	5.95E-08	
INGESTION	3.00E-09	1.89E-09	1.01E-08	1.04E-09	1.24E-10	1.88E-09	5.12E-09	7.26E-11	
INL/ANL-W	CO	ID	NM	UT	WY				
R	4.60E-06	2.79E-06	6.26E-07	1.99E-06	3.17E-06				
S	6.92E-07	1.44E-07	1.45E-07	1.54E-07	1.22E-07				
U	5.92E-05	3.99E-06	5.20E-06	2.02E-06	3.67E-06				
INGESTION	6.45E-07	4.49E-07	2.25E-07	2.52E-07	1.39E-06				
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA
R	7.80E-08	9.43E-10	1.42E-05	8.08E-09	1.24E-07	3.10E-08	1.26E-07	1.15E-07	4.70E-08
S	5.08E-07	4.11E-08	1.34E-04	4.75E-08	3.31E-07	4.11E-07	1.24E-06	1.09E-06	5.96E-07
U	9.43E-05	7.54E-08	3.07E-04	1.02E-07	4.47E-07	6.95E-07	2.70E-06	2.60E-06	5.46E-07
INGESTION	1.09E-06	1.13E-08	6.85E-08	4.18E-07	1.68E-06	3.15E-07	1.53E-06	2.11E-06	5.63E-07
LANL	NM								
R	8.41E-07								
S	2.17E-06								
U	2.79E-05								
INGESTION	3.08E-05								
LBL	AZ	CA	NM						
R	4.81E-08	4.74E-08	6.21E-08						
S	1.80E-07	2.51E-07	2.71E-07						
U	3.22E-07	2.53E-06	1.25E-06						
INGESTION	1.33E-06	1.30E-06	1.86E-06						
MCA	AK	NM	TN	TX	VA				
R	6.39E-10	5.84E-11	9.08E-10	4.65E-10	3.81E-10				
S	4.17E-09	3.42E-10	8.94E-09	5.97E-09	5.41E-09				
U	0.00E+0	7.34E-10	2.01E-08	4.40E-09	1.22E-08				

	0								
INGESTION	8.90E-09	3.01E-09	1.10E-08	5.33E-09	4.64E-09				
MURR	KS	MO	NM	OK	TX				
R	2.10E-10	1.28E-10	2.18E-10	2.40E-10	8.34E-11				
S	1.60E-09	1.62E-09	3.25E-10	1.51E-09	5.16E-10				
U	5.47E-09	4.30E-09	5.61E-10	3.63E-09	2.88E-09				
INGESTION	4.17E-09	2. 10E-09	1.11E-08	5.25E-09	3.65E-09				
NTS	AZ	CA	NV	NM					
R	1.48E-07	3.25E-08	3.92E-08	1.89E-07					
S	5.55E-07	1.43E-07	3.01E-07	8.31E-07					
U	9.93E-07	3.03E-07	2.50E-06	3.83E-06					
INGESTION	5.70E-06	4.10E-06	1.95E-06	5.13E-07					
OAK RIDGE	AK	NM	TN	TX					
R	2.42E-07	2.20E-08	2.53E-07	3.15E-07					
S	1.58E-06	1.30E-07	2.07E-06	2.93E-06					
U	0.00E+0 0	3.02E-07	6.59E-06	8.55E-06					
INGESTION	3.37E-06	1.14E-06	3.39E-06	5.74E-06					
ROCKY FLATS	CO	NM							
R	2.76E-07	5.98E-07							
S	5.89E-06	1.31E-06							
U	2.65E-05	2.29E-06							
INGESTION	5.97E-06	1.90E-05							
RICHLAND	CO	ID	NM	OR	UT	WA	WY		
R	4.44E-07	5.97E-07	5.98E-07	2.53E-07	1.83E-07	4.27E-07	3.17E-06		
S	6.29E-06	3.27E-06	1.31E-06	1.04E-06	1.35E-06	3.37E-07	1.22E-07		
U	2.89E-05	1.33E-05	2.29E-06	1.39E-06	8.99E-07	3.74E-06	3.67E-06		
INGESTION	5.67E-09	7.70E-09	1.95E-08	4.72E-09	2.73E-09	1.35E-09	1.22E-08		
SNL	NM								
R	2.14E-09								
S	7.04E-10								
U	3.78E-08								
INGESTION	6.31E-08								
SRS	AL	GA	LA	MS	NM	SC	TX		
R	9.73E-05	5.81E-07	5.37E-07	6.66E-07	1.14E-07	4.98E-08	1.67E-06		
S	9.99E-04	8.91E-06	5.64E-06	5.10E-06	6.68E-07	5.12E-07	1.22E-05		
U	1.00E-03	2.81E-05	6.24E-06	5.32E-06	1.56E-06	5.14E-07	2.88E-05		
INGESTION	1.05E-05	6.56E-06	1.00E-05	1.01E-05	5.86E-06	7.25E-06	2.98E-05		

Table 31 Per-shipment dose risks for RH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX					
R	5.15E-10	7.86E-10	4.33E-10	7.81E-10	1.59E-10					
S	4.30E-09	6.98E-09	6.46E-10	6.03E-09	9.74E-10					
U	7.01E-09	1.36E-08	1.02E-09	1.18E-08	5.81E-09					
INGESTION	2.55E-09	3.17E-09	8.04E-09	4.76E-09	2.65E-09					
BETTIS	AR	KY	NM	OH	PA	TN	TX	WV		
R	7.02E-11	6.57E-11	7.16E-12	3.16E-11	4.52E-12	4.79E-11	9.73E-11	2.93E-12		
S	4.58E-10	6.51E-10	4.19E-11	3.81E-10	1.92E-10	5.64E-10	9.15E-10	5.77E-11		
U	1.79E-09	1.13E-09	4.47E-10	8.63E-10	1.05E-09	1.50E-09	2.99E-09	1.07E-10		
INGESTION	1.12E-09	7.05E-10	3.79E-10	3.88E-10	4.62E-11	7.00E-10	1.91E-09	2.71E-11		
INL/ANL-W	CO	ID	NM	UT	WY					
R	4.53E-10	2.66E-10	5.65E-10	1.89E-10	3.81E-10					
S	6.42E-09	1.30E-09	1.79E-09	1.39E-09	1.38E-09					
U	5.09E-08	1.77E-09	2.67E-09	9.19E-10	2.02E-09					
INGESTION	3.09E-09	2.15E-09	1.07E-08	1.21E-09	6.62E-09					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	7.42E-10	1.04E-11	6.63E-11	8.59E-11	1.39E-09	3.49E-10	1.36E-09	1.17E-09	4.97E-10	6.28E-11
S	4.83E-09	4.53E-10	2.71E-09	5.05E-10	3.72E-09	4.64E-09	1.34E-08	1.10E-08	6.31E-09	1.66E-09
U	5.41E-09	6.50E-10	8.12E-09	2.38E-08	4.98E-09	7.75E-09	2.79E-08	2.52E-08	5.65E-09	2.30E-11
INGESTION	4.26E-09	4.41E-11	2.69E-10	1.63E-09	6.61E-09	1.23E-09	6.00E-09	8.27E-09	2.21E-09	1.70E-10
LANL	NM									
R	8.05E-10									
S	2.07E-09									
U	2.66E-08									
INGESTION	1.53E-08									
OAK RIDGE	AR	NM	TN	TX						
R	8.45E-10	8.59E-11	1.00E-09	8.59E-11						
S	5.50E-09	5.05E-10	8.18E-09	5.05E-10						
U	6.62E-09	1.17E-09	2.50E-08	3.05E-08						
INGESTION	4.85E-09	1.63E-09	4.87E-09	8.27E-09						
RICHLAND	CO	ID	NM	OR	UT	WA	WY			

Table 31 Per-shipment dose risks for RH-TRU shipment potential accidents (continued)

R	4.53E-10	5.93E-10	6.27E-10	1.08E-09	1.81E-10	4.42E-11	3.81E-10			
S	6.42E-09	3.25E-09	1.37E-09	1.27E-09	1.33E-09	4.81E-10	1.38E-09			
U	2.95E-08	7.02E-09	2.40E-09	1.41E-09	9.19E-10	4.21E-09	1.18E-09			
INGESTION	3.09E-09	4.19E-09	1.07E-08	2.57E-09	1.49E-09	7.36E-10	6.62E-09			
SNL	NM									
R	4.71E-10									
S	1.55E-10									
U	8.31E-09									
INGESTION	6.84E-09									
SRS	AL	GA	LA	MS	NM	SC	TX			
R	6.41E-10	4.13E-10	5.59E-10	5.42E-10	8.59E-11	2.97E-11	1.17E-09			
S	5.03E-09	6.33E-09	4.58E-09	4.15E-09	5.05E-10	3.05E-10	1.09E-08			
U	6.06E-09	1.88E-08	4.97E-09	1.68E-18	1.59E-09	3.07E-10	3.84E-08			
INGESTION	2.93E-09	1.83E-09	3.57E-09	2.62E-09	1.63E-09	1.48E-10	8.27E-09			

Table 32 Collective dose risks for RH-TRU shipment potential accidents for all shipments

ANL-EAST	IL	MO	NM	OK	TX					
R	4.27E-08	6.52E-08	3.59E-08	6.48E-08	1.32E-08					
S	3.57E-07	5.79E-07	5.36E-08	5.00E-07	8.08E-08					
U	5.82E-07	1.13E-06	8.47E-08	9.81E-07	4.82E-07					
INGESTION	2.12E-07	2.63E-07	6.67E-07	3.95E-07	2.20E-07					
BETTIS	AR	KY	NM	OH	PA	TN	TX	WV		
R	2.81E-10	2.63E-10	2.86E-11	1.26E-10	1.81E-11	1.92E-10	3.89E-10	1.17E-11		
S	1.83E-09	2.60E-09	1.68E-10	1.52E-09	7.68E-10	2.26E-09	3.66E-09	2.31E-10		
U	7.14E-09	4.52E-09	1.79E-09	3.45E-09	4.19E-09	6.00E-09	1.20E-08	4.28E-10		
INGESTION	4.48E-09	2.82E-09	1.52E-09	1.55E-09	1.85E-10	2.80E-09	7.64E-09	1.08E-10		
INL/ANL-W	CO	ID	NM	UT	WY					
R	3.08E-07	1.81E-07	3.84E-07	1.28E-07	2.59E-07					
S	4.36E-06	8.84E-07	1.22E-06	9.45E-07	9.38E-07					
U	3.46E-05	1.20E-06	1.82E-06	6.24E-07	1.37E-06					
INGESTION	2.10E-06	1.46E-06	7.27E-06	8.22E-07	4.50E-06					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	1.55E-07	2.17E-09	1.38E-08	1.79E-08	2.90E-07	7.28E-08	2.84E-07	2.44E-07	1.04E-07	1.31E-08
S	1.01E-06	9.45E-08	5.65E-07	1.05E-07	7.76E-07	9.68E-07	2.80E-06	2.30E-06	1.32E-06	3.46E-07
U	1.13E-06	1.36E-07	1.69E-06	4.96E-06	1.04E-06	1.62E-06	5.83E-06	5.26E-06	1.18E-06	4.80E-09
INGESTION	8.89E-07	9.20E-09	5.61E-08	3.40E-07	1.38E-06	2.57E-07	1.25E-06	1.73E-06	4.61E-07	3.55E-08
LANL	NM									
R	2.60E-08									
S	6.70E-08									
U	8.61E-07									
INGESTION	4.95E-07									
OAK RIDGE	AR	NM	TN	TX						
R	2.29E-06	2.33E-07	2.71E-06	2.33E-07						
S	1.49E-05	1.37E-06	2.22E-05	1.37E-06						
U	1.79E-05	3.18E-06	6.77E-05	8.27E-05						

Table 32 Collective dose risks for RH-TRU shipment potential accidents for all shipments (continued)

INGESTION	1.31E-05	4.42E-06	1.32E-05	2.24E-05						
RICHLAND	CO	ID	NM	OR	UT	WA	WY			
R	7.91E-07	1.04E-06	1.10E-06	1.89E-06	3.16E-07	7.72E-08	6.66E-07			
S	1.12E-05	5.68E-06	2.39E-06	2.22E-06	2.32E-06	8.40E-07	2.41E-06			
U	5.15E-05	1.23E-05	4.19E-06	2.47E-06	1.61E-06	7.36E-06	2.07E-06			
INGESTION	5.40E-06	7.32E-06	1.87E-05	4.49E-06	2.60E-06	1.29E-06	1.16E-05			
SNL	NM									
R	3.11E-08									
S	1.02E-08									
U	5.48E-07									
INGESTION	4.51E-07									
SRS	AL	GA	LA	MS	NM	SC	TX			
R	1.03E-07	6.61E-08	8.94E-08	8.67E-08	1.37E-08	4.75E-09	1.87E-07			
S	8.05E-07	1.01E-06	7.33E-07	6.64E-07	8.08E-08	4.88E-08	1.74E-06			
U	9.70E-07	3.01E-06	7.95E-07	2.69E-16	2.54E-07	4.91E-08	6.14E-06			
INGESTION	4.69E-07	2.93E-07	5.71E-07	4.19E-07	2.61E-07	2.37E-08	1.32E-06			

3.3.4.1 Severe Accident

Figures 7 and 8 show the dose from the severe no-fire accident involving an RH72-B cask carrying the bounding inventory of RH-TRU waste. The accident is postulated to occur in an urban area with a population of 2570 persons per km^2, the largest population density of any U.S metropolitan area in 2005, the most recent year for which validated metropolitan population data are available (U.S. Census Bureau 2006). The semi-logarithmic plot (Figure 7) shows the dramatic decrease of dose with distance; the log-log plot of Figure 8 shows the dose values more precisely. Table 33 is a tabulation of the data reflected in Figures 7 and 8.

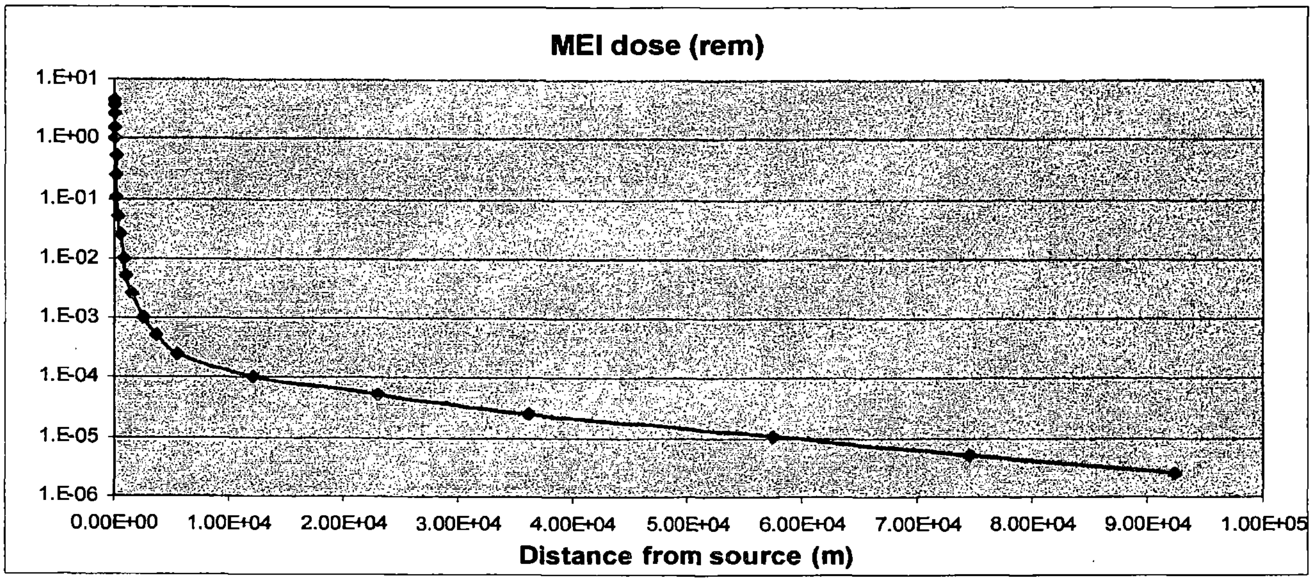


Figure 7 Dose to the MEI from a severe accident in an urban area.

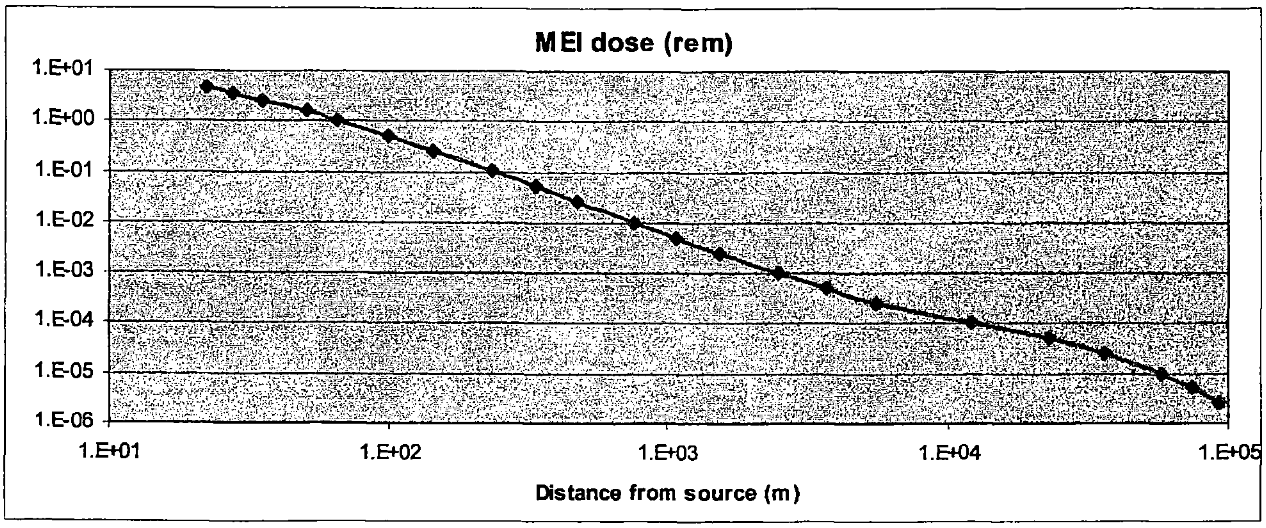


Figure 8 Dose to the MEI from a severe accident in an urban area (log-log).

Table 33 Variation of MEI dose with downwind distance from the source

Distance from source (m)	MEI dose (rem)	Distance from source (m)	MEI dose (rem)
2.23E+01	4.59E+00	1.08E+03	5.10E-03
2.74E+01	3.56E+00	1.54E+03	2.54E-03
3.54E+01	2.54E+00	2.52E+03	1.02E-03
5.04E+01	1.53E+00	3.72E+03	5.10E-04
6.53E+01	1.02E+00	5.54E+03	2.54E-04
9.85E+01	5.10E-01	1.22E+04	1.02E-04
1.45E+02	2.54E-01	2.29E+04	5.10E-05
2.35E+02	1.02E-01	3.61E+04	2.54E-05
3.35E+02	5.10E-02	5.76E+04	1.02E-05
4.76E+02	2.54E-02	7.46E+04	5.10E-06
7.56E+02	1.02E-02	9.23E+04	2.54E-06

Figure 9 shows the maximum MEI dose as a function of distance from the source for the case where the accident involves a car fire (release elevation: 100 m; emitted heat: 1000 calories). Data from the no-fire accident depicted in Figure 7 is shown on the graph for comparison. Conditions in the two cases were the same except for the fire, and the same model was used for both. As the graph shows, an elevated release results in moving the maximum dose to the MEI downwind; the maximum occurs at

$$x = H/\sqrt{2}$$

where x is the downwind distance in meters and H is the release height in meters (Wark et al. 1998). The dose to the RMEI from the fire accident, as modeled, is also much less than the dose from the no-fire accident at distances less than a kilometer from the accident. The doses from the two accidents are the same, and are about 100 mrem, about 7 km from the source.

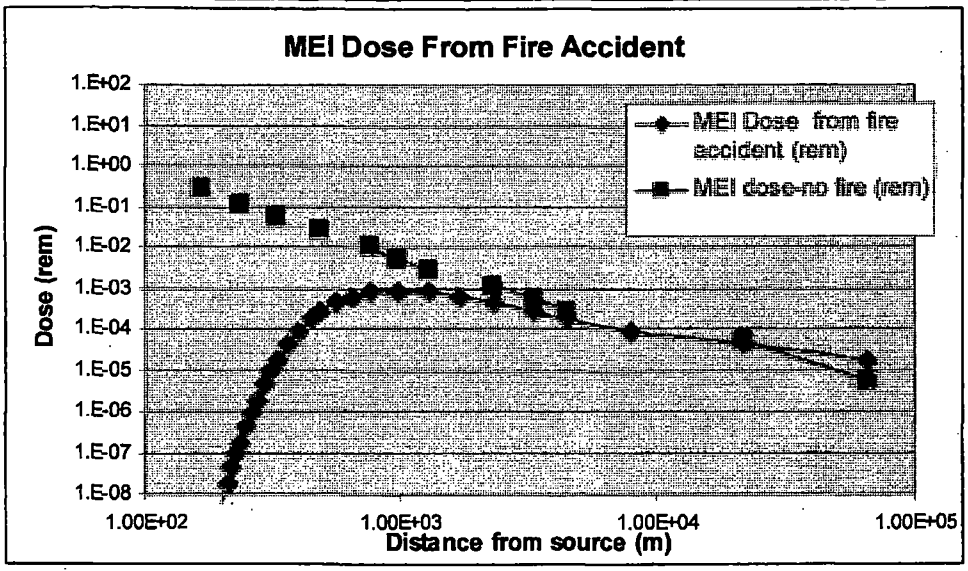


Figure 9 MEI doses from an accident that involved a fire and one that did not involve a fire.

Figure 10 compares the dose risks from a ground-level release with those from an elevated release. The data shown are from an accident involving a TRUPACT, but the differences between ground-level and elevated releases are about the same for an accident with a RH-72B. The elevated release accident includes both fire and impact; the ground-level release is from an impact-only accident.

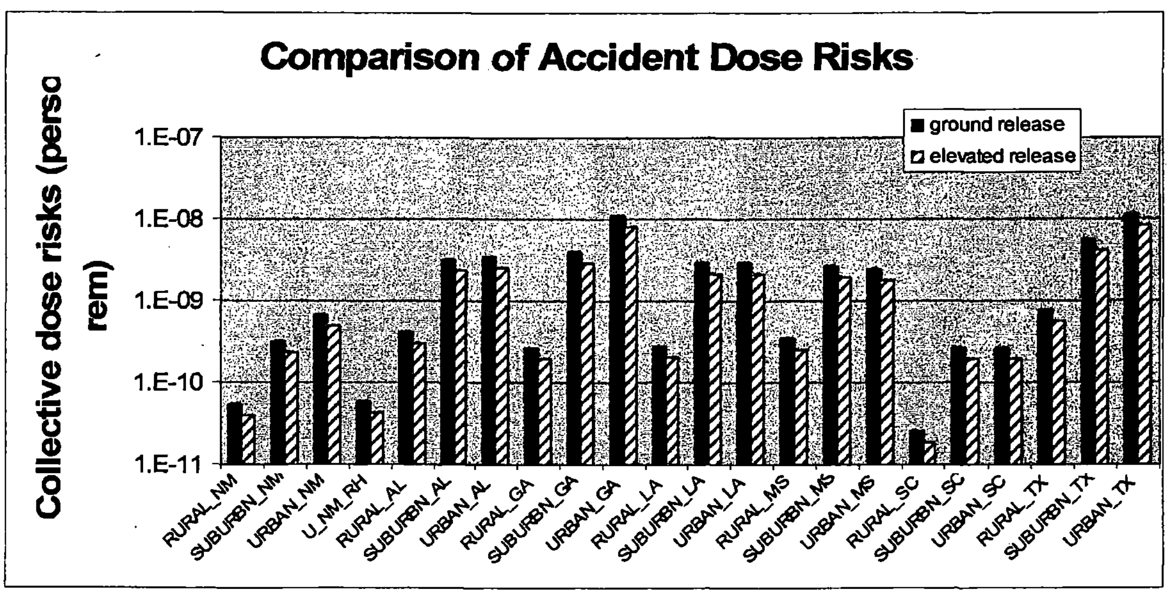


Figure 10 Comparison of accident dose risks from a ground level and an elevated release.

Table 34 compares the consequences of the severe accident in the most heavily populated urban area for the RH-72B and one TRUPACT. This table reflects the results shown in Table 33 and Figure 7: the consequences of an accident that involves a fire are less than those of a no-fire accident because of the

dilution created by an elevated release. Also, the worst case of those shown in Table 34, the no-fire RH-72B accident, results in a radiation dose to the MEI smaller than the maximum annual occupational dose recommended in 10 CFR Part 20 (5 rem).

Table 34 Consequences of the postulated severe accident in an urban area. Shipments contain the bounding radionuclide inventory.

	RH-72B	TRUPACT	RH-72B LCF RISK	TRUPACT LCF RISK
No Fire				
total dose (person-rem)	92.8	2.89	5.57E-02	1.73E-03
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	0.12	0.12	-	-
total persons	330	330	-	-
average dose (rem)	0.28	0.009	-	-
MEI dose (rem)	3.14	0.168	1.88E-03	1.01E-04
Fire				
total dose(p-rem)	97.2	83.8	5.83E-02	5.03E-02
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	0.12	0.12	-	-
total persons	330	330	-	-
average dose (rem)	0.29	0.25	-	-
MEI dose (rem)	3.62E-04	1.94E-05	2.17E-07	1.16E-08

Table 35 shows the consequences of an accident involving a TRUPACT and a RH72-B carrying an average inventory, which was calculated by dividing the average activity of the bounding case radionuclides for CH-TRU and RH-TRU (from DOE 2008a) and dividing by the average number of CH-TRU and RH-TRU shipments, respectively.

Table 35 Consequences of the postulated severe accident in an urban area. Shipments contain the average radionuclide inventory.

	RH-72B	TRUPACT	RH-72B LCF RISK	TRUPACT LCF RISK
No Fire				
total dose(p-rem)	9.28E+01	6.70E-02	5.57E-02	4.02E-05
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	1.20E-01	1.20E-01	-	-
total persons	3.30E+02	3.30E+02	-	-
Average dose (rem)	2.81E-01	2.03E-04	-	-
MEI dose (rem)	3.14E+00	3.20E-03	1.88E-03	1.92E-06
Fire				
total dose(p-rem)	9.72E+01	5.70E-02	5.83E-02	3.42E-05
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	1.20E-01	1.20E-01	-	-
total persons	3.30E+02	3.30E+02	-	-
average dose (rem)	2.95E-01	1.73E-04	-	-
MEI dose (rem)	3.62E-04	4.03E-07	2.17E-07	2.42E-10

3.3.4.2 "No-release" Accidents

More than 99.99% of the traffic accidents that involve a Type B container[8] are postulated to result in no impact at all on the radioactive cargo or its packaging (Sprung et al. 2000). However, a truck involved in such an accident will sit in or near the spot where the accident occurred, often for many hours, and will continue to emit ionizing radiation externally. Table 36 shows the doses sustained by members of the public if such an accident were to happen in a very densely populated area.

Table 36 Doses from a "no-release" accident

	Dose	LCF RISK	Population/sq. km	Distance from accident (m)	Exposure time (hrs)
TRUPACT (person-rem)	4.95E-03	2.97E-06	2750	30 - 800	10
TRUPACT-MEI (rem)	9.69E-05	5.81E-08	-	30	10
RH-72B (person-rem)	1.15E-02	6.90E-06	2750	30-800	10
RH-72B-MEI (rem)	2.26E-04	1.36E-07	-	30	10

3.3.4.3 Impact of Lead Loss or Slump

An accident involving a lead-shielded container like the RH-72B can also cause the slumping or loss of lead gamma shielding (LOS), which would in turn results in an external dose that exceeds the TI and can even exceed the regulatory maximum dose (10 mrem/hr at 2 meters). Boyd et al. (2006) have developed a factor by which to multiply the TI to reflect loss of lead gamma shielding; this model has been incorporated into RADTRAN. The model relies on conditional probabilities and severity fractions for loss of lead gamma shielding (Sprung et al. 2000). These conditional probabilities are shown in Table 37.

Table 37 Description of LOS Cases

LOS case	LOS accident condition	Fraction of shield lost	Conditional Probability
1	End impact	0.052	1.71E-06
2	End impact	0.158	4.63E-07
3	End impact	0.264	3.21E-08
4	End impact	0.368	2.53E-10
5	Corner impact	0.033	2.20E-05
6	Corner impact	0.096	5.97E-06
7	Corner impact	0.158	4.14E-07
8	Corner impact	0.255	3.27E-09
9	Lead melt (T > 350°C)	0.029	4.90E-05
10	Lead melt with puncture (T > 350°C)	0.5	1.66E-09

8 All packaging used to ship TRU waste is shipped in Type B containers.

The RADTRAN LOS model was used to determine dose estimates to the public during an extreme spent nuclear fuel transportation accident. Results varied according to the following: type of accident condition, percent of lead slump, distance to shipment, time spent in the area. The RADTRAN input file was setup using data obtained from and two LOS stops were modeled, one each for rural/suburban and urban routes with the same shipment vehicle. Data shown in Table 37 was used to construct the conditional probability and slump fraction portion of the input. Table 38 provides stop related data used to setup the example problem.

Table 38. LOS Stop Input Parameters

Name	Vehicle	People	Inner Distance (m)	Outer Distance (m)	Shielding Factor	Exposure Time (hr)
LOSR/S	RH72b	1	1	100	1	0.67
LOSU	RH72b	1	1	100	1	0.46

The LOS stops with exposure durations of 0.46 and 0.67 hours are intended to mimic the resident population dose prior to arrival of first-responders and ultimate evacuation. These times are based on the average emergency response times per population zone. Therefore, it is assumed that the public will remain exposed to the accident for up to 0.67 hours in a rural or suburban setting and 0.46 hours in an urban setting until emergency crews arrive and evacuate members of the nearby public. The LOS model provides results for average dose, maximum dose at two meters, and LOS dose-risk. The results presented below were calculated for one representative shipment from Los Alamos National Laboratory to the WIPP.

Figures 11 and 12 present how the average dose is affected by slump fraction and distance from the accident. All results were normalized to one person. The dose received can be significant with increasing slump and proximity to the accident. Since the LOS model, when determining average or maximum dose, makes no automatic account for population zone, the only differentiating factor between the rural and urban results is the emergency response time.

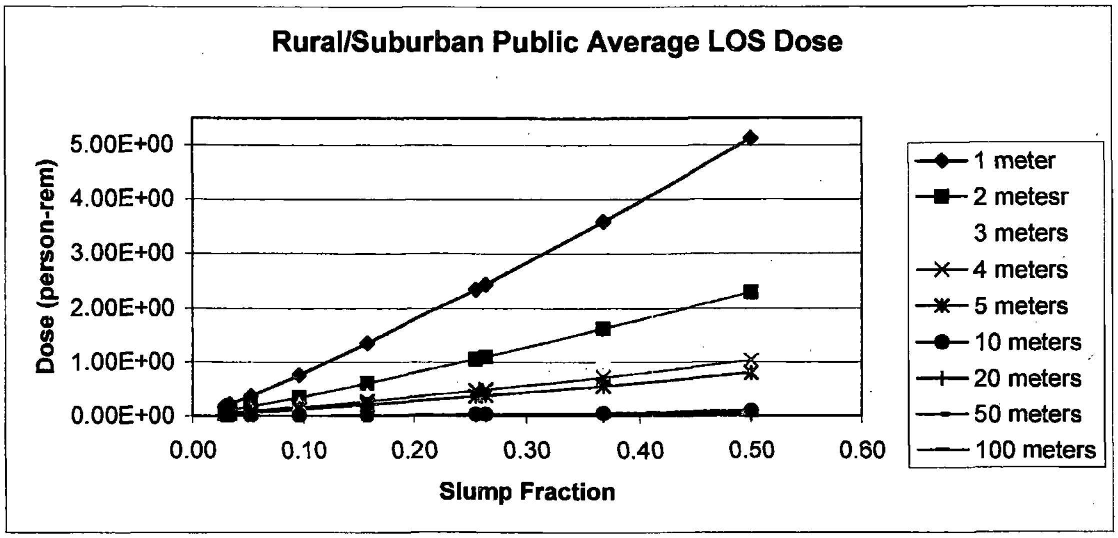


Figure 11 Rural and Suburban Public Average LOS Dose

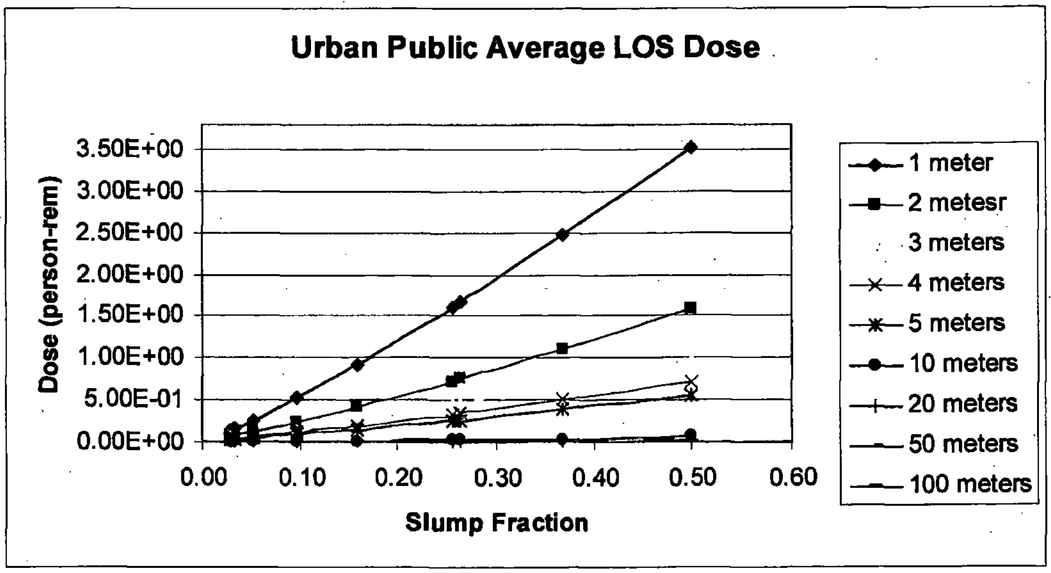


Figure 12 Urban Public Average LOS Dose

Finally, Figure 13 shows the maximum LOS dose at 2 meters. It is unlikely that in an accident scenario anyone would ever approach the cask at such proximity, but this value serves as a comparison to how the LOS maximum deviates from the regulatory maximum.

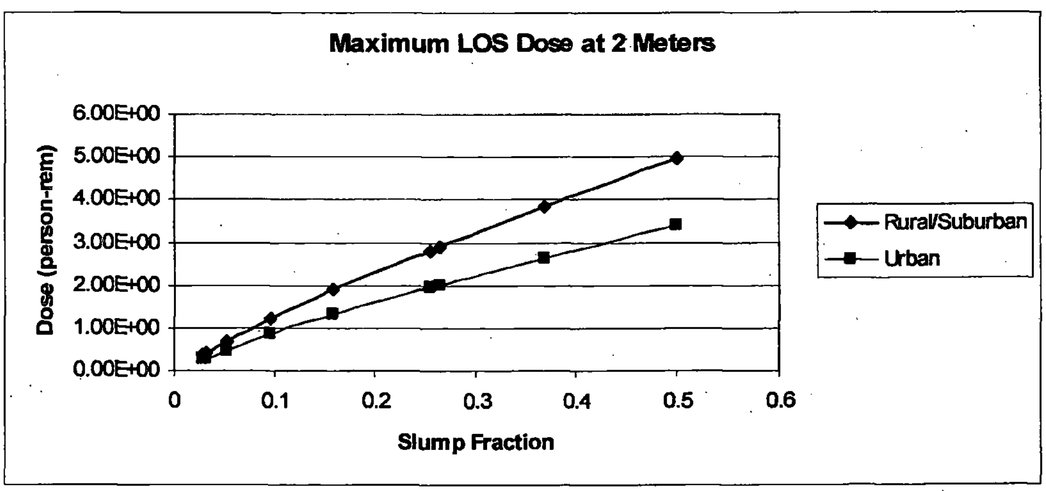


Figure 13 Maximum LOS Dose at 2 meters for rural/suburban and urban population zones

3.3.5 Other Impact Calculations

3.3.5.1 Nonradiological Impacts

The nonradiological impacts associated with the transportation of TRU waste to WIPP were calculated using the number of shipments from Table 5. No assumption was made that the carrier drivers of TRU waste would be more careful than other truck drivers on the nation's roads.

The WebTRAGIS code was used to estimate the distances from the various sites to WIPP and to estimate the corresponding population density fractions. The rural, suburban, and urban population route mileages along a given route were multiplied by state-specific accident and fatality rates to obtain route-specific impacts. For states, the most reliable data are the state-specific Department of Transportation (DOT) validated data from the DOT Research and Innovative Technology Administration (RITA) web site of the Bureau of Transportation Statistics: http://www.bts.gov/, (USDOT 2008) which was used.

Route-specific data per shipment accident, injury, and fatality rates were multiplied by the appropriate number of route shipments to obtain the aggregate number of accidents, injuries, and fatalities. Because this analysis is not dependent on whether a truck is transporting full or empty TRU waste containers, twice the one-way mileage was used. The impacts, including the total impact, are shown in Table 39.

Table 39 Non-radiological (traffic) accidents and fatalities

	ACCIDENTS/ SHIPMENT	FATALITIES/ SHIPMENT	SHIPMENTS	ACCIDENTS	FATALITIES	ACCIDENTS/ YEAR
Argonne NL East	6.97E-03	2.39E-06	164	2.29	7.84E-04	0.005
Battelle Columbus	7.50E-03	2.66E-05	1	0.02	5.32E-05	5.7E-04
Bettis Lab	8.82E-03	3.12E-05	5	0.09	3.12E-04	0.003
Brookhaven NL	1.00E-05	3.54E-08	816	0.02	5.78E-05	5.7E-04
Idaho NL/Argonne West	7.10E-03	2.50E-05	13908	197.49	6.95E-01	5.65
Knolls Atomic Power Lab	1.16E-02	4.09E-05	348	8.07	2.85E-02	0.23
Los Alamos NL	2.32E-03	8.20E-06	2079	9.65	3.41E-02	0.28
Lawrence Berkeley NL	7.14E-03	2.52E-05	102	1.46	5.14E-03	0.041
Army Materials Command	7.47E-03	3.19E-02	1	0.01	6.38E-02	2.9E-04
Missouri U. Research Reactor	5.84E-03	2.06E-05	1	0.01	4.12E-05	2.9E-04
Nevada Test Site	6.03E-03	2.13E-05	314	3.79	1.34E-02	0.10
Oak Ridge NL	7.03E-03	2.48E-05	3089	43.43	1.53E-01	1.24
Rocky Flats	3.91E-03	1.37E-05	1409	11.02	3.86E-02	0.31
Richland (Hanford)	8.88E-03	3.48E-05	3156	56.05	2.20E-01	1.60
Sandia NL	1.96E-03	6.92E-06	73	0.29	1.01E-03	0.008
Savannah River NL	7.58E-03	2.68E-05	2113	32.03	1.13E-01	0.92
TOTAL	-	-	27579	365.71	1.37	10.39

The distance traveled in an urban population zone and the impact factor truck emissions (EPA 1991; Biwer and Butler 1999) were used to estimate additional urban-area pollution health effects due to TRU waste shipments. The impact factor, 5 x 10^{-8} per km (8 x 10^{-8} per mile) (Biwer and Butler 1999) estimates the latent cancer fatality (LCF) risk per urban mile traveled. The volume of exhaust emissions in an urban area by a single truck shipment should be quite small. The WIPP SEIS-II showed that LCFs attributed to diesel exhaust exposure in an urban area are very small relative to the impact of accidents, fatalities, or injuries.

Table 40 shows the LCF risk calculated using the Biwer and Butler (1999) risk factor. Comparison with the results shown in Table 38 indicates that the LCF risk from exhaust emissions is comparable to (about 2/3 of) the calculated number of traffic fatalities. Both analyses are dominated by shipments from Idaho NL and Hanford.

Table 40 Calculated LCF risk from vehicle pollution.

ORIGIN SITE	URBAN (km)	2XURBAN (km)	SHIPMENTS	SHIPMENT-(km)	LCF RISK
Argonne NL East	41.9	83.8	164	1.4E+04	6.9E-04
Battelle Columbus	49	98.0	1	9.8E+01	4.9E-06
Bettis Lab	101.9	203.8	5	1.0E+03	5.1E-05
Brookhaven NL	162.8	325.6	816	2.7E+05	1.3E-02
Idaho NL/Argonne West	627.5	1255.0	13908	1.7E+07	8.7E-01
Knolls Atomic Power Lab	109.9	219.8	348	7.6E+04	3.8E-03
Los Alamos NL	2.1	4.2	2079	8.7E+03	4.4E-04
Lawrence Berkeley NL	56.4	112.8	102	1.2E+04	5.8E-04
Army Materials Command	47.3	94.6	1	9.5E+01	4.7E-06
Missouri U. Research Reactor	40.3	80.6	1	8.1E+01	4.0E-06
Nevada Test Site	26.8	53.6	314	1.7E+04	8.4E-04
Oak Ridge NL	61.3	122.6	3089	3.8E+05	1.9E-02
Rocky Flats	33.9	67.8	1409	9.6E+04	4.8E-03
Richland (Hanford)	51.9	103.8	3156	3.3E+05	1.6E-02
Sandia NL	6.5	13.0	73	9.5E+02	4.7E-05
Savannah River NL	64.7	129.4	2113	2.7E+05	1.4E-02
TOTAL	1484.2		27579	1.85E+07	0.943

SEIS-II cites 0.1 LCF risk from vehicle pollution (Table E-9) – almost an order of magnitude less than the TA calculation. This difference does not appear to have an obvious explanation: the total mileage is about the same for SEIS-II and this TA, the fraction of miles that are urban miles is about the same for this TA (0.042) as for the normal array of RADTRAN 4 (0.05), and the number of shipments is less in this TA. The only difference is that for this TA, the accidents and fatalities were calculated in RADTRAN, which uses the same input data throughout, and whose calculations have been verified (Dennis et al. 2008). RADTRAN 4 did not have this capability.

3.3.5.2 Hazardous Chemical Impacts

Hazardous chemicals in TRU mixed waste occur as volatile organic compounds (VOCs) and metals. Accidents involving hazardous chemicals and metals were evaluated as acute-release events with respect to potential exposures and associated impacts. During routine, incident-free transportation, exposure to hazardous non-radioactive constituents of the transported waste would not occur because the hazardous components in the waste are completely contained in the transportation container/cask. Thus, no impacts to human health are posed by the hazardous, non-radioactive waste components under routine, incident-free transportation.

An accident in which the shipping container is breached constitutes a source of hazardous chemical exposures. The hazardous chemical assessment was conservatively based on a very severe transportation accident involving one shipping container. In the WIPP-SEIS II, it was assumed that a fire would engulf all three shipping containers; this is not assumed for this TA as a fire would reduce the potential VOC emissions. As in the WIPP SEIS-II, this bounding-case accident scenario was based on the assumption that the entire releasable fraction of each chemical considered is used. The assumptions used in the radiological accident assessment provide the basis for the impacts of accidents involving the chemical components of the waste. The hazardous chemical impact compared to the maximum airborne chemical concentrations allowed by regulation and the immediately dangerous to life or health (IDLH) values. IDLH values, originally developed by the National Institute of Occupational Safety and Health (NIOSH) for emergency response purposes, are based on a 30-minute exposure period for an individual who inhales 10 cubic meters (353 cubic feet) of contaminated air. They were used in the WIPP SEIS-II, and are used in this TA, because no ambient concentration values exist to which chemically hazardous emissions can be compared. The hazardous constituents analyzed for these accident scenarios and the IDLH values and IDLH-equivalent intake values are shown in Table 41.

Table 41 Chemical Constituents Analyzed in CH-TRU Waste

Chemical Name	IDLH (Parts per million)	IDLH (milligrams per cubic meter)
Carbon Tetrachloride	200	1278
Chloroform	500	2480
Methylene Chloride	2300	8119
1.1,2,2-Tetrachloroethane	100	700
Chlorobenzene	1000	4680
Methyl Ethyl Ketone	3000	9000
Toluene	500	1915
1,2 Dichloroethane	50	206
Beryllium	N/A	4
Cadmium	N/A	9
Lead	N/A	100
Mercury	N/A	10

Source: WIPP SEIS-II

The following assumptions were used to maximize the hazardous chemical concentrations within the breached shipping container:

- Nonflammable VOCs with planning-basis WAC (Waste Acceptance Criteria)-prescribed limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be at those limits.
- Flammable VOCs were assumed to have a maximum concentration of 500 parts per million because they are limited to that in planning-basis WAC.
- VOCs without planning-basis WAC limits are assumed to be present at the maximum concentrations identified to date during sampling of CH-TRU waste.
- Heavy metals (lead, mercury, beryllium, and cadmium) are assumed to be uniformly mixed in the waste container and found in the containers in average amounts. Metals would be released as particulates; therefore, the calculations used to determine the radioactive material particulate releases are applied to these as well.
- VOC emissions were assumed to exhibit ideal gas behavior.
- Plastics and organic materials and matrices were considered sources of VOCs. Other constituents were considered sources of particulate matter (this assumption is a deviation from AP-141).

Carbon tetrachloride, trichloroethylene, and methylene chloride are considered potential carcinogens by the EPA, and 1,1,1-trichloroethane may produce adverse somatic effects.

Respirable particulate matter (PM_{10}) is also considered a health hazard by EPA, which has set a National Ambient Air Quality Standard (NAAQS) for PM_{10} of 150 $\mu g/m^3$ (40 CFR Part 50).

The air concentrations of each hazardous chemical for the maximally exposed member of the public at the scene of the accident were determined using the Gaussian dispersion model in RADTRAN (Wark et al. 1998). Ground-level concentrations were calculated along the centerline of the plume. Emitted gases were treated like ideal gases, and emitted aerosols were treated as fine particulate matter. Emitted particulate matter was considered to be aerosolized.

Plume depletion effects from particulate settlement (by gravitational or chemical effects) were considered for particulate matter only. Each accident was postulated to occur during a period of very stable meteorological conditions (Pasquill Stability Class F, wind speed of 0.5 meter per second) to introduce additional conservatism into the analyses.

The effective height of the plume from the accident was estimated to be approximately 100 meters (about 300 feet), which will account for the buoyancy rise associated with the thermal effects from the accident. The maximum airborne chemical concentration inhaled by a member of the public was calculated by calculating the air concentration along the plume centerline using the Gaussian dispersion equation:

$$CHI = \frac{Q}{\pi u \sigma_y \sigma_z} \exp(-\frac{H^2}{2\sigma_z^2})$$

where:

- CHI = concentration at ground level
- Q = source emission rate (leak rate)
- u = wind speed
- σ_y, σ_z are meteorological constants that are a function of downwind distance and stability class[9]
- H = effective plume height

The inhaled concentration is then calculated by assuming a breathing rate of 3.3×10^{-4} m^3/sec.

The plume is depleted of particulates by assuming deposition velocity of 1 cm/sec (0.01 m/sec). This equation and its solutions are modeled in RADTRAN.

The concentration of airborne particulate matter may be compared to the national ambient air quality standard for 10-micron particulate matter (PM_{10}): 0.150 mg/m^3 24-hour average not to be exceeded more than once per year (40 CFR Part 50). No analogous standard exists for VOCs; EPA regulated VOCs from stationary sources on the basis of prevention of significant deterioration (40 CFR 51.166) in a particular air basin.

The inventory of non-radioactive, potentially hazardous waste constituents in DOE 2008a provided the basis for calculation of impacts. This inventory is more detailed and specific as to material composition than the inventory of SEIS-II. DOE 2008a provides a list of the non-radioactive constituents of TRU waste: Table 42 shows these together with the most likely physical/chemical group for them. Beryllium, cadmium, and lead were considered particulate matter, and no data were found

Table 42 Non-radioactive constituents of CH-TRU wastes

NON-RADIOACTIVE WASTE CONSTITUENTS	PHYSICAL/ CHEMICAL GROUP	RELEASE FRACTION, NO FIRE	RELEASE FRACTION, FIRE	CH Total (kg)	RH Total (kg)	CH (kg/TRUPACT)	RH (kg/TRUPACT)
Aluminum-based metals and alloys	particulate	7.339E-07	4.57E-06	2.25E+06	4.06E+04	3.08E+02	7.14E+00
Cellulosics	particulate	7.339E-07	4.57E-06	1.12E+07	1.11E+05	1.54E+03	1.95E+01
Cements	particulate	7.339E-07	4.57E-06	1.27E+07	5.53E+04	1.73E+03	9.72E+00
Inorganic Matrix	particulate	7.339E-07	4.57E-06	1.71E+07	3.59E+06	2.34E+03	6.30E+02
Iron-based metals and alloys	no release	-	-	-	-	-	-
Organic matrix	volatile	2.40E-05	7.68E-05	6.82E+06	5.12E+03	9.34E+02	9.00E-01
Other inorganic materials	particulate	7.339E-07	4.57E-06	5.26E+06	1.59E+05	7.21E+02	2.79E+01

[9] The meteorological constants σ_y and σ_z may be interpreted as the standard deviation of the emission distribution in the crosswind and vertical directions, respectively. However, there have been several empirical measurements of these constants, resulting in several empirical formulas for calculating them, so they are generally considered empirical functions of the downwind distance and Fickian diffusion, rather than being identified by a somewhat idealized mathematical formulation.

Table 42 Non-radioactive constituents of CH-TRU wastes (continued)

NON-RADIOACTIVE WASTE CONSTITUENTS	PHYSICAL/ CHEMICAL GROUP	RELEASE FRACTION, NO FIRE	RELEASE FRACTION, FIRE	CH Total (kg)	RH Total (kg)	CH (kg/TRUPACT)	RH (kg/TRUPACT)
Other metals	no release	-	-	-	-	-	-
Plastics	volatile	2.40E-05	7.68E-05	1.27E+07	1.40E+05	1.74E+03	2.46E+01
Rubber	particulate	7.339E-07	4.57E-06	1.07E+06	2.42E+04	1.47E+02	4.25E+00
Soils and gravel	particulate	7.339E-07	4.57E-06	1.53E+06	1.33E+06	2.10E+02	2.34E+02
Vitrified	particulate	7.339E-07	4.57E-06		1.48E+03		2.60E-01
Packaging material, plastic	volatile	2.40E-05	7.68E-05	3.27E+06	7.29E+04	4.48E+02	1.28E+01
Packaging Material, steel	no release	-	-	-	-	-	-
Packaging Material, cellulosics	volatile	7.339E-07	4.57E-06	6.98E+05		9.57E+01	
Packaging Material, lead	particulate	7.339E-07	4.57E-06		7.33E+04		1.29E+01

Release fractions for each physical/chemical group are those in Table 28; severity categories 3 and 5 of Table 28 included fire, so the release fractions associated with these severity categories were included only in the "accident with fire" analysis.

3.3.5.3 Results

Figure 14 shows the decrease in VOC emissions as a function of downwind distance from the source for the no-fire accident involving CH-TRU waste, and Figure 15 shows this decrease for an accident involving fire.

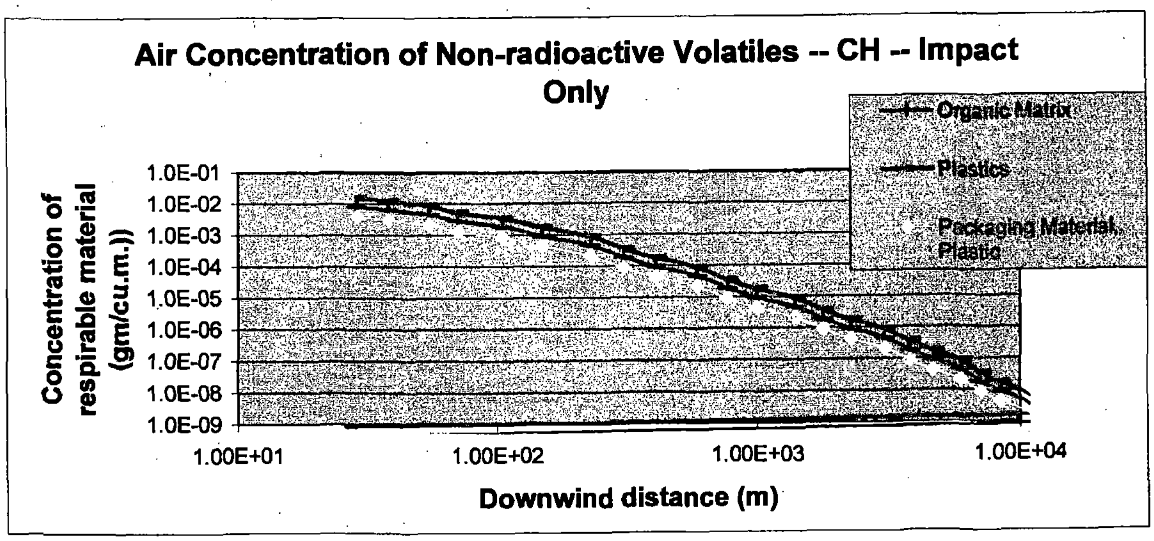


Figure 14 Air concentration of non-radioactive volatile substances, for an impact-only accident.

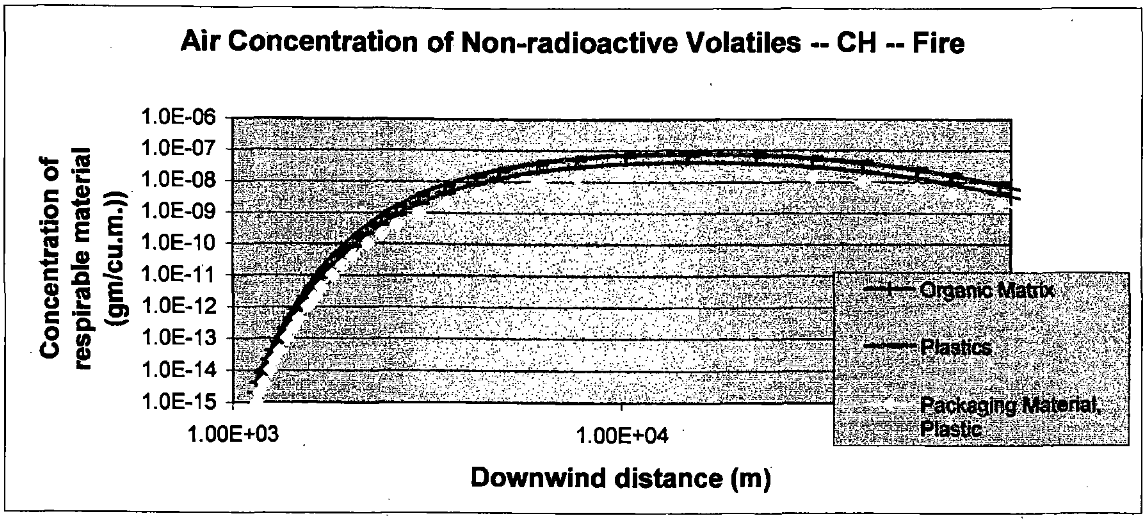


Figure 15 Air concentration of non-radioactive volatile substances, for an accident involving impact and fire.

The shapes of these curves, and the displacement of the maximum ground-level concentration to about 7 km. downwind, is about the same for particulate releases and for volatile releases from an RH-72B package, because the release height and fire temperature are the same in all cases.

Table 43 shows the air concentration for releases of non-radioactive materials for both a TRUPACT and a RH-72B for both impact-only accidents and accidents involving a fire. The concentrations were compared to the total IDLH values for volatile releases and to the National Ambient Air Quality Standard (NAAQS; 40 CFR Part 50) for 10-micron particulate matter (PM_{10}).

Table 43 Air concentrations of non-radioactive releases

	VOLATILE	PARTICULATE
CH- No Fire (gm/m^3)	0.0493	9.69E-04
Percent of IDLH or NAAQS	0.17%	6456%
CH-Fire (gm/ m^3)	5.42E-07	1.38E-05
Percent of IDLH or NAAQS	1.90E-6%	92.0%
RH-No Fire (gm/ m^3)	0.00173	4.13E-04
Percent of IDLH or NAAQS	0.006%	2750%
RH-Fire (gm/ m^3)	8.34E-07	4.31E-07
Percent of IDLH or NAAQS	2.92E-6%	0.288%

All but three of the eleven non-volatile components were assumed to release aerosolized particulate matter (Table 41). This assumption is exceedingly conservative, since aerosolized releases in impact-only traffic accidents are unlikely. The particulate release fractions are based on Type B casks carrying spent fuel, which would release material only through the seals, so that only aerosolized material would be released from the cask (Sprung 2000). The particulate release fraction is thus more applicable to the RH-72B cask than to the TRUPACT. Since the material in the TRUPACT is in sealed drums or standard waste boxes, soils and gravel, and possibly some of the inorganic matrices, are the only non-volatile constituents that would be released in particles 10 microns or less in diameter in an impact-only accident. Any releases of other non-volatile materials would be in larger particle sizes.

The lead (Pb) fraction of particulate emissions is 0.0111 (1.11%). This equates to an amount of lead emitted of (.0111)*(0.413) = 4.60E-3 mg/m^3, as compared to 0.22 mg/m^3 in the SEIS-II (Table 5-10, DOE, 1997b). The difference is due to a number of assumptions that differ between the SEIS-II and the current TA:

- SEIS-II states (p.5-24) "It was assumed that CH-TRU accidents waste hazardous chemical accident scenarios would bound any impacts from RH-TRU...[s] no hazardous chemical accidents were analyzed for RH-TRU shipments. The current inventory, on the other hand, lists Pb as a component only of RH-TRU shipments, not of CH-TRU shipments.
- SEIS-II used the release fractions and severity categories from NUREG-0170 (1977) (SEIS-II Appendix E Table E-10) and assumed a severity category VIII accident with a release fraction of 2E-4 (SEIS-II, Appendix E Table E-20). The current analysis used an aerosolized release fraction of 4.57E-6 (Sprung, et al. 2000).
- SEIS-II used RADTRAN 4 (Neuhauser and Kanipe 1992) which assumed that a fraction of solid material released would be aerosolized. The current analysis (using RADTRAN 6 accident analysis) assumes that anything released from a Type B package is released through the seals and therefore is an aerosol.

This TA used an updated version of the code, made slightly different assumptions, and estimated release fractions based on more recent data and test values than those used for SEIS-II which resulted in a decrease in the amount of lead emissions.

4 SUMMARY

This TA, an update to the SEIS-II (DOE 1997b), evaluated the impacts associated with the transportation of CH-TRU and RH-TRU waste from waste generator sites to the WIPP, using the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considered the impacts of transporting these wastes. Only transportation by truck was considered.

The TA used updated census data (U.S. Census Bureau 2006), changes in the number of shipments due to the use of different shipping containers, new TRU waste inventories, and WebTRAGIS to deterimine the routes instead of HIGHWAY. In addition, the analysis was conducted using an improved version of RADTRAN, Version 6 for the loss-of-lead shielding calculations and Version 5.6 for all other calculations. The improvements to RADTRAN, as well as the use of updated inventory (DOE 2008a) to calculate more realistic parameter values like a smaller TI, have resulted in smaller doses than those calculated in the SEIS-II for the same set of receptors. The number of shipments represents a more realistic value as it was determined using the most recent inventory (DOE 2008a) and the current and anticipated shipping containers. The use of WebTRAGIS resulted in more accurate routes and a more accurate simulation. The total population has increased with the new census data and has shifted from both urban and rural areas to suburbs. The net result is relatively larger doses to suburban than to urban populations. This TA also used a different methodology with respect to vehicle densities which played a significant role in the increase in the suburbs areas.

The analyses of radiological and non-radiological impacts incorporated different conservatisms and different degrees of conservatism, so that no conclusions can really be drawn by comparing them. The radiologic impacts are generally smaller than those in the SEIS-II, mostly because of the more precise analytical methods available. There are only a few instances (e.g., the rest stop employee, inspectors)

where calculated doses are not insignificant, and these are largely due to conservative assumptions, in particular the simple addition of the number of shipments to which the receptor is exposed.

5 REFERENCES

10 CFR Part 71 Subpart E; US Code of Federal Regulations, Volume 10 (Energy), Part 71, Washington, DC 2008

40 CFR Part 50, US Code of Federal Regulations, Volume 40 (Environmental Protection), Part 50 (National Ambient Air Quality Standards), Washington, DC 2008

Anspaugh, L. R. 1990 "Environmental Behavior of Plutonium," Health Phys. 58, S5 (1990).

Biwer, B.M., and J.P. Butler, 1999. "Vehicle Emission Unit Risk Factors for Transportation Risk Assessments." *Risk Analysis,* 19(6):1157-1171.

Boyd, A.M., Worthy, D.K., Weiner, R.F. Osborn, D.M. "Benchmarking RADTRAN Loss of Shielding Model for a Spent Fuel Cask" International High-Level Radioactive Waste Conference, Las Vegas, NV, May, 2006

BTS (US Department of Transportation, Bureau of Transportation Statistics, Research and Innovative Technology Administration), 2008. "National Transportation Statistics 2008", Washington, DC 2008. http://www.bts.gov/ (retrieved 11/2008)..

Cederwall, R.T., Ricker,Y.E., Cederwall,P.L., Homan, D.N., and Anspaugh, L.R., "Measurements of Airborne Radionuclide Concentrations Near the Nevada Test Site from Atmospheric Testing," Health Phys. 52, S75-S76 (1987)

Crawford, B, and Taggart, D. 2007. Analysis of RH TRU wastes for Containment in Lead Shielded Containers. Los Alamos National Laboratory Carlsbad Operations, Simple Analysis Report INV-SAR-08, Rev 0.

Dennis, M.L., Osborn, D. O., Weiner, R. F., Heames, T.J. 2008. *Verification and Validation of RADTRAN 6.0* SAND2008-4556, Sandia National Laboratories, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1995. *Engineered Alternatives Cost/Benefit Study Final Report,* WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996. *Waste Acceptance Criteria for the Waste Isolation Pilot Plant,* DOE/WIPP 94-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997a. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (Volumes 1 through 5), DOE/EIS-0200-F, Washington, DC, May.

DOE (U.S. Department of Energy), 1997b. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement.* DOE/EIS-0026-S-2, Washington, DC, September. (WIPP SEIS-II).

DOE (U.S. Department of Energy), 1998. *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* (TRU Waste ROD). 63 FR 3629. January 23, 1998.

DOE (U.S. Department of Energy), 2002. Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250F. Summary, Volumes I and II. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

DOE (U.S. Department of Energy), 2005. Contact Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC), Rev. 2. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2006a. Transuranic Baseline Inventory Report – 2004, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/TRU-2006-3344.

DOE (U.S. Department of Energy), 2006b. WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small-Quantity Sites and Impacts from Using the TRUPACT-III. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2006c. Remote Handled Transuranic Waste Authorized Methods for Payload Control (RH-TRAMPAC), Rev. 0. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2007. CNS 10-160B RH Cask Program Guidance, Revision 1. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/WIPP-06-3336

DOE (U.S. Department of Energy), 2008a. Annual Transuranic Baseline Inventory Report – 2007, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/TRU-2008-3379.

DOE (U.S. Department of Energy), 2008b. Amendment to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste. March 7, 2008.

DOE (U.S. Department of Energy), 2008c. Supplement Analysis for the Treatment of Transuranic Waste at the Idaho National Laboratory. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. February 2008. DOE/EIS-0200-SA03.

DOE (U.S. Department of Energy), 2008d. Supplemental Environmental Impact Statement for. a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250F–S1. Summary, Volumes I and II. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

EPA (U.S. Environmental Protection Agency) 1991. Mobile Sources. Volume II of Supplement A to Compilation of Air Pollutant Emission Factors. AP-42. [Washington, D.C.]: U.S. Environmental Protection Agency.

Fischer, L.E.; Chou, C.K.; Gerhard, M.A.; Kimura, C.Y.; Martin, R.W.; Mensing, R.W.; Mount, M.E.; and Witte, M.C. 1987. Shipping Container Response to Severe Highway and Railway Accident

Conditions. NUREG/CR-4829. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Griego, N.R.; Smith, J.D.; and Neuhauser, K.S. 1996. Investigation of RADTRAN Stop Model Input Parameters for Truck Stops. [SAND96-0714C]. Albuquerque, New Mexico: Sandia National Laboratories

ISCORS (Interagency Steering Committee on Radiation Standards). 2002. *A Method for Estimating Radiation Risk from TEDE.* ISCORS Technical Report No. 1, Washington, DC

Johnson, P.E. and Michelhaugh, R.D. 2000. Transportation Routing Analysis Geographic Information System (WebTRAGIS) User's Manual. ORNL/TM-2000/86. Oak Ridge, Tennessee: Oak Ridge National Laboratory.

McCauslin, S. 2008. Input Used as References. U.S. Department of Energy, Carlsbad, NM. ERMS# 549454.

Moody, D.C. 2008. Shielded container Planned Change Request Letter to Juan Reyes, U.S. Department of Energy, Carlsbad, NM. ERMS# 549327.

Mossman, K. 2008. 188th Meeting of the NRC Advisory Committee on Nuclear Waste and Materials. Meeting Transcript pp 207-208, April 8, 2008, US Nuclear Regulatory Commission, Rockville, MD. http://www.nrc.gov/reading-rm/doc-collections/acnw/tr/2008/188-4-8.pdf

Neuhauser, K.S., and F.L. Kanipe, 1992, RADTRAN IV- Volume 3: User Guide. SAND89-2370, TTC-0943, January, Albuquerque, New Mexico.

NRC (U.S. Nuclear Regulatory Commission), 1977. *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170, Washington, D.C.

Ryan, M.T. 2007, Letter to Chairman Dale Klein "Report of the French Academy of Sciences 'the Dose-Effect Relationship and Estimating the Carcinogenic Effect of Low Doses of Ionizing Radiation'" January 7, 2007, Rockville, MD.

Sprung, J.L.; Ammerman, D.J.; Breivik, N.L.; Dukart, R.J.; Kanipe, F.L.; Koski, J.A.; Mills, G.S.; Neuhauser, K.S.; Radloff, H.D.; Weiner, R.F.; and Yoshimura, H.R. 2000. Reexamination of Spent Fuel Shipment Risk Estimates. NUREG/CR-6672. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Tenforde, Thomas, 2008. U.S. Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, 188th Meeting, April 8, 2008, P. 207 et seq, USNRC, Washington, DC.

U. S. Census Bureau. 2006. State and Metropolitan Area Data Book : 2006, Bureau of the Census, Washington, DC. http://www.census.gov/prod/www/abs/smadb.htm.

U. S. Census Bureau. 2008. *The 2008 Statistical Abstract of the United States*, Bureau of the Census, Washington, DC. http://www.census.gov/compendia/statab

DOT (U.S. Department of Transportation). 2008. National Transportation Statistics 2008, Bureau of Transportation Statistics, Research and Innovative Technology Administration, Washington, DC. http://www.rita.dot.gov/

Wark, K., Warner, C.F., Davis, W.T. *Air Pollution, Its Origin and Control, 1998.* Addison-Wesley-Longman, Menlo Park, CA Section 4-4.

Weiner, R. F. and Neuhauser, K. S., 1992. "Near-Field Radiation Doses From Spent Fuel Transportation". International High-Level Waste Management Conference, Las Vegas, NV.

Weiner, R.F D.M. Osborn, D. Hinojosa, B.M. O'Donnell, D.J. Orcutt, T.J. Heames. 2006 *RADCAT2.3 User Guide,* Sandia National Laboratories, June 2006

APPENDIX A: RADTRAN AND WEBTRAGIS FILES

Sample RADTRAN and WebTRAGIS files are included in this Appendix. the complete set of these files is on an accompanying CD.

```
RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE   1


 RRRR  AAA  DDDD  TTTTT RRRR  AAA  N  N 55555      6
 R  R A  A D  D   T   R  R A  A NN N 5          6
 R  R A  A D  D   T   R  R A  A NNNN 5          6
 RRRR A  A D  D   T   RRRR A  A N NN 5555     6666
 RR  AAAAA D  D   T   RR  AAAAA N  N    5     6  6
 R R A  A D  D   T   R R A  A N  N 5  5      6  6
 R  R A  A DDDD   T   R  R A  A N  N 5555  *  666

                 RADTRAN 5.6  FEBRUARY 20, 2006

                      INPUT ECHO
                      ----------



 && MAX SRS CH CURIE CONTENT
 && NO URBAN STOPS_ADD U+S TIMES
 && STOP TIME IS AVERAGE; CALCULATE MAX OFF-LINE
 && ADD VEHCILE DESNITIES!!!!! ADD VEHICLE DENSITIES
 TITLE RF_CH
 INPUT STANDARD
STD: 0 10 18                    && DIMEN=NSEV NRAD NAREAS
STD: 1 3 3 0                    && PARM=IRNKC IANA ISEN IPSQSB
STD: .TRUE. .FALSE.             && FORM = UNIT, SI-UNITS?
STD: 2.3E12                     && NEVAL FOR CF252
STD: 9.25E5 5.77E6 1.27E6       && RPCTHY FOR I125, I129, I131
STD: 0.0 0.0 0.0 0.0 0.0        && TRANSFER GAMMA
STD: 7.42E-3 2.02E-2 6.17E-5 3.17E-8 0.0  && TRANSFER NEUTRON
STD: 30  24                     && MITDDIST  MITDVEL
STD: 1  2  .0018                && ITRAIN FMINCL DDRWEF
STD:   33   68   105  244  369          && CENTER LINE
STD:  561  1018  1628 2308 4269         && DISTANCES
STD:  5468 11136  13097 21334 40502     && FOR AVERAGE
STD: 69986 89860 120878 0 0 0 0 0 0 0 0 0 0 0 0  && US CLOUD
STD: 4.59E+02 1.53E+03 3.94E+03 1.25E+04 3.04E+04 6.85E+04 1.76E+05 4.45E+05
STD: 8.59E+05 2.55E+06 4.45E+06 1.03E+07 2.16E+07 5.52E+07 1.77E+08 4.89E+08
STD: 8.12E+08 1.35E+09 0 0 0 0 0 0 0 0 0 0 0 0   && AREADA
STD: 3.42E-03 1.72E-03 8.58E-04 3.42E-04 1.72E-04 8.58E-05 3.42E-05 1.72E-05
STD:  8.58E-06 3.42E-06 1.72E-06 8.58E-07 3.42E-07 1.72E-07 8.58E-08 5.42E-08
STD:  4.30E-08 3.42E-08 0 0 0 0 0 0 0 0 0 0 0 0   && DFLEV
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0 && RADIST
STD: 0.5                  && SMLPKG
STD: 1.0  0.87  0.018          && SHIELDING FACTORS RR  RS  RU
STD:  30  30  800              && OFFLINK {FREEWAY}
STD:  27  30  800              && OFFLINK {NON-FREEWAY}
STD:   5   8  800              && OFFLINK {CITY STREETS}
STD:  30  30  800              && OFFLINK {RAILWAY}
STD: 200 200 1000              && OFFLINK {WATERWAY}
```

```
STD: 15 3 3 3 4              && ONLINK {FWAY NONFWY STREET RAIL ADJ}
STD: 6.0 4 40.0              && RPD FNOATT INTERDICT
STD: 0.05 0.2 3.3E-4         && BDF CULVL BRATE
STD: 0.9 0.1                 && UBF USWF
STD: 1.0 10.0 1.0            && EVACUATION SURVEY CAMPAIGN

          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE   2

                    RF_CH

STD: 0.0 0.0   1.5E-8 5.3E-8     && HIGHWAY - RURAL - NONRAD
STD: 0.0 0.0   3.7E-9 1.3E-8     && HIGHWAY - SUBURBAN - NONRAD
STD: 0.0 0.0   2.1E-9 7.5E-9     && HIGHWAY - URBAN - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - R - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - S - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - U - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - R - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - S - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - U - NONRAD
STD: 0.0 0.0 0.0 0.0 0.0 0.0     && PSPROB
STD: 0.67 0.67 0.42              && TIMENDE NON-DISPERSAL EVAC TIME (LCF&EARLY)
STD: 2 2 1                       && FLAGS=IUOPT IACC REGCHECK
STD: 5E-4, 4E-4, 1.0E-4          && LCFCON(1), LCFCON(2), GECON
STD: R5INGEST.BIN                && INGESTION FILE
 OUTPUT CI_REM
 FORM UNIT
 DIMEN 6 10 18
 PARM 1 3 3 2
 SEVERITY
   NPOP=1
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

   NPOP=2
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

   NPOP=3
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

 RELEASE
   GROUP=VOL
     RFRAC
       0.0
  4.09E-9 1.68E-5 1.35E-8 3.6E-5 2.4E-5

     AERSOL
       0.0
  1.0 1.0 1.0 1.0 1.0

     RESP
       0.0

```

```
              RUN DATE: [ 07-OCT-08 AT 16:21:24 ]         PAGE   3

                         RF_CH

0.02 0.02 0.02 0.02 0.02

   LOS
     0.0
0.0 0.0 0.0 0.0 0.0

   DEPVEL 0.01
  GROUP=PART
   RFRAC
     0.0
1.02E-7 6.71E-8 3.37E-7 3.77E-6 5.01E-6

   AERSOL
     0.0
1.0 1.0 1.0 1.0 1.0

   RESP
     0.0
0.02 0.02 0.02 0.02 0.02

   LOS
     0.0
0.0 0.0 0.0 0.0 0.0

   DEPVEL 0.01
RISKIND
  0 0.0 0.0 4.5 8.4 0.5 10.0 293.0 500.0 0.0 2 6 2
PACKAGE TRUPACT 0.1674 1.0 0.0 3.5
  CS137 0.0872 VOL
  CO60 0.00558 PART
  SR90 0.0872 PART
  PU238 8630.0 PART
  PU239 1390.0 PART
  PU240 366.0 PART
  AM241 3.14 PART
  PU241 1740.0 PART
  PU242 0.00593 PART
END
VEHICLE -1 TRUPACT_II 5.02E-01 1.0 0.0 8.4 1.0 2.0 4.0 1.0 3.5
    TRUPACT 3.0
FLAGS
  IACC 2
  IUOPT 2
  REGCHECK 0
MODSTD
  DISTOFF FREEWAY 3.00E01 3.00E01 8.00E02
  DISTOFF SECONDARY 2.70E01 3.00E01 8.00E02
  DISTOFF STREET 5.00E00 8.00E00 8.00E02
  DISTON
        FREEWAY 1.50E01
        SECONDARY 3.00E00
        STREET 3.00E00
        ADJACENT 4.00E00
```

172

```
            RUN DATE: [ 07-OCT-08 AT 16:21:24 ]          PAGE   4

                          RF_CH

  BDF 5.00E-02
  BRATE 3.30E-04
  CULVL 2.00E-01
  EVACUATION 1.00E02
  GECON 1.00E-04
  INTERDICT 4.00E01
  LCFCON 5.75E00 5.75E-04
  SURVEY 1.00E02
  UBF 5.20E-01
  USWF 4.80E-01
  CAMPAIGN 8.33E-02
  MITDDIST 3.00E01
  MITDVEL 2.40E01
  RPD 6.00E00
  RR 1.00E00
  RU 1.80E-02
  RS 8.70E-01
  SMALLPKG 5.00E-01
  RPCTHYROID
        I131      1.27E06
EOF
LINK RURAL_NM TRUPACT_II 736.8 88.6 2.0 4.7 654.0 3.83E-6 0.00353 R 1 0.5
LINK SUBURBN_NM TRUPACT_II 23.8 88.6 2.0 318.1 1208.0 3.83E-6 0.00353 S 1 0.0
LINK URBAN_NM TRUPACT_II 2.25 88.6 2.0 1823.2 3347.0 3.83E-6 0.00353 U 1 0.0
LINK URBAN_NM_RH TRUPACT_II 0.25 44.3 2.0 1820.0 6700.0 3.83E-6 0.00353 U 1 0.0
LINK RURAL_CO TRUPACT_II 239.7 88.6 2.0 9.7 1248.0 2.55E-6 0.00353 R 1 0.5
LINK SUBURBN_CO TRUPACT_II 117.5 88.6 2.0 423.8 2342.0 2.55E-6 0.0033 S 1 0.0
LINK URBAN_CO TRUPACT_II 28.26 88.6 2.0 2451.0 4051.0 2.55E-6 0.00353 U 1 0.0
LINK URBAN_CO_RH TRUPACT_II 3.14 44.3 2.0 2450.0 8102.0 2.55E-6 0.00353 U 1 0.0

STOP RURAL_NM TRUPACT_II 4.7 30.0 800.0 1.0 1.489
STOP SUBURB_NM TRUPACT_II 318.1 30.0 800.0 1.0 0.048
STOP RURAL_CO TRUPACT_II 9.7 30.0 800.0 1.0 0.485
STOP SUBSURBAN_CO TRUPACT_II 423.8 30.0 800.0 1.0 0.238
STOP TRUCKCREW TRUPACT_II 1.0 1.0 1.0 1.0 2.26
STOP INSPECTOR TRUPACT_II 1.0 1.0 1.0 1.0 2.0
STOP RESTSTOPEMPL TRUPACT_II 1420.0 1.0 15.0 1.0 1.323
STOP RURAL_ATSTOP TRUPACT_II 9950.0 1.0 15.0 1.0 1.974
STOP SUBURBAN_ATSTOP TRUPACT_II 9950.0 1.0 15.0 1.0 0.286


EOF
```

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]       PAGE   5

                    RF_CH




           PACKAGE AND MATERIAL CHARACTERISTICS

       DIMENSION  EFFECTIVE    K(0)    FRACTION  FRACTION  DOSE RATE
 MATERIAL  (METERS) DIMENSION METERS SQ.  GAMMA    NEUTRON (MREM/HR)
  TRUPACT 3.500E+00 3.500E+00 7.562E+00 1.000E+00 0.000E+00 1.674E-01

  K(0) IS DOSE RATE CONVERSION FACTOR



                VEHICLE CHARACTERISTICS


VEHICLE NAME           TRUPACT_II
MODE TYPE              HIGHWAY
EXCLUSIVE USE            YES
DOSE RATE (MREM/HR)        5.02E-01
K(0) (SQ. METERS)        1.74E+01
VEHICLE SIZE (M)         8.40E+00
EFFECTIVE SIZE (M)        6.34E+00
NUMBER OF SHIPMENTS         1.00E+00
NUMBER OF CREW            2.00E+00
CREW DISTANCE (M)          4.00E+00
CREW DOSE ADJUSTMENT FACT    1.00E+00
CREW EXPOSER WIDTH (M)      3.50E+00
EFFECTIVE EXPOSER WIDTH     3.50E+00
K(0) (SQ M) CREW EXPOSURE   7.56E+00


 VEHICLE   MATERIAL  NO.PACKAGES
TRUPACT_II
        TRUPACT   3.00E+00


TRANSFER
COEFFICIENTS:   MU     A(1)    A(2)    A(3)    A(4)
   GAMMA   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  NEUTRON   7.420E-03 2.020E-02 6.170E-05 3.170E-08 0.000E+00



DISTANCES (METERS)  FREEWAY SECONDARY  STREET    RAIL    WATER   ADJACENT
OFFLINK:
MINIMUM DISTANCE    3.00E+01  2.70E+01  5.00E+00  3.00E+01  2.00E+02
SIDEWALK + MINIMUM  3.00E+01  3.00E+01  8.00E+00  3.00E+01  2.00E+02
MAXIMUM DISTANCE    8.00E+02  8.00E+02  8.00E+02  8.00E+02  1.00E+03
ONLINK:
OPPOSITE DIRECTION  1.50E+01  3.00E+00  3.00E+00  3.00E+00
ADJACENT VEHICLE                                  4.00E+00
```

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 6

RF_CH

STOP RELATED DATA

	RURAL_NM	SUBURB_NM	RURAL_CO	SUBSURBAN_	TRUCKCREW
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
PERSONS	4.70E+00	3.18E+02	9.70E+00	4.24E+02	1.00E+00
MINIMUM DISTANCE(M)	3.00E+01	3.00E+01	3.00E+01	3.00E+01	1.00E+00
MAXIMUM DISTANCE(M)	8.00E+02	8.00E+02	8.00E+02	8.00E+02	1.00E+00
SHIELDING FACTOR	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
TIME (HR)	1.49E+00	4.80E-02	4.85E-01	2.38E-01	2.26E+00

	INSPECTOR	RESTSTOPEM	RURAL_ATST	SUBURBAN_A
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
PERSONS	1.00E+00	1.42E+03	9.95E+03	9.95E+03
MINIMUM DISTANCE(M)	1.00E+00	1.00E+00	1.00E+00	1.00E+00
MAXIMUM DISTANCE(M)	1.00E+00	1.50E+01	1.50E+01	1.50E+01
SHIELDING FACTOR	1.00E+00	1.00E+00	1.00E+00	1.00E+00
TIME (HR)	2.00E+00	1.32E+00	1.97E+00	2.86E-01

HANDLING RELATED DATA

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 7

RF_CH

LINK RELATED DATA

	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
DISTANCE (KM)	7.37E+02	2.38E+01	2.25E+00	2.50E-01	2.40E+02
PERSONS PER VEHICLE	2.00E+00	2.00E+00	2.00E+00	2.00E+00	2.00E+00
SPEED (KM/HR)	8.86E+01	8.86E+01	8.86E+01	4.43E+01	8.86E+01
POPULATION DENSITY	4.70E+00	3.18E+02	1.82E+03	1.82E+03	9.70E+00
VEHICLE DENSITY	6.54E+02	1.21E+03	3.35E+03	6.70E+03	1.25E+03
ACCIDENT RATE/KM	3.83E-06	3.83E-06	3.83E-06	3.83E-06	2.55E-06
FATALITIES/ACCIDENT	3.53E-03	3.53E-03	3.53E-03	3.53E-03	3.53E-03
ZONE	RURAL	SUBURBAN	URBAN	URBAN	RURAL
ROAD TYPE	FREEWAY	FREEWAY	FREEWAY	FREEWAY	FREEWAY
FARMING FRACTION	5.00E-01	0.00E+00	0.00E+00	0.00E+00	5.00E-01

	SUBURBN_CO	URBAN_CO	URBAN_CO_R
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II
DISTANCE (KM)	1.18E+02	2.83E+01	3.14E+00
PERSONS PER VEHICLE	2.00E+00	2.00E+00	2.00E+00
SPEED (KM/HR)	8.86E+01	8.86E+01	4.43E+01
POPULATION DENSITY	4.24E+02	2.45E+03	2.45E+03
VEHICLE DENSITY	2.34E+03	4.05E+03	8.10E+03
ACCIDENT RATE/KM	2.55E-06	2.55E-06	2.55E-06
FATALITIES/ACCIDENT	3.30E-03	3.53E-03	3.53E-03
ZONE	SUBURBAN	URBAN	URBAN
ROAD TYPE	FREEWAY	FREEWAY	FREEWAY
FARMING FRACTION	0.00E+00	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 8

RF_CH

ISOTOPE RELATED DATA

SETTLING ONLY

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSPENSION FACTOR	50YR INHALATION (REM/CI) EFFECTIVE
TRUPACT				
CS137	8.72E-02	VOL	1.12E+00	3.59E+04
CO60	5.58E-03	PART	1.12E+00	3.70E+04
SR90	8.72E-02	PART	1.12E+00	1.33E+05
PU238	8.63E+03	PART	1.12E+00	1.70E+08
PU239	1.39E+03	PART	1.12E+00	1.85E+08
PU240	3.66E+02	PART	1.12E+00	1.85E+08
AM241	3.14E+00	PART	1.12E+00	1.55E+08
PU241	1.74E+03	PART	1.12E+00	3.33E+06
PU242	5.93E-03	PART	1.12E+00	1.78E+08

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	GROUND FACTOR	INGESTION NUCLIDE	NEUTRON EMISSION NEUTRONS/SEC/CI
TRUPACT						
CS137	1.10E+04	5.69E-02	1.07E-01	1.77E-04	CS-137	0.00E+00
CO60	1.92E+03	2.50E+00	4.66E-01	7.51E-04	CO-60	0.00E+00
SR90	1.06E+04	0.00E+00	2.79E-05	9.08E-08	SR-90	0.00E+00
PU238	3.20E+04	1.81E-03	1.81E-05	2.68E-07	PU-238	0.00E+00
PU239	8.78E+06	7.96E-04	1.57E-05	1.17E-07	PU-239	0.00E+00
PU240	2.39E+06	1.73E-03	1.76E-05	2.57E-07	PU-240	0.00E+00
AM241	1.58E+05	3.24E-02	3.03E-03	8.79E-06	AM-241	0.00E+00
PU241	5.26E+03	2.54E-06	2.68E-07	6.17E-10	PU-241	0.00E+00
PU242	1.37E+08	1.44E-03	1.48E-05	2.13E-07	PU-242	0.00E+00

NUCLIDE	1-YR INHALATION (REM/CI) LUNG	MARROW	THYROID
TRUPACT			
CS137	2.18E+05	6.29E+03	0.00E+00
CO60	1.78E+05	1.07E+04	0.00E+00
SR90	7.03E+05	4.07E+04	0.00E+00
PU238	1.26E+08	1.37E+07	0.00E+00
PU239	1.11E+08	1.30E+07	0.00E+00
PU240	1.11E+08	1.30E+07	0.00E+00
AM241	1.22E+08	8.14E+06	0.00E+00
PU241	2.85E+04	1.33E+04	0.00E+00
PU242	1.04E+08	1.22E+07	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 9

RF_CH

RELEASE RELATED DATA
****

RELEASE FRACTIONS

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
VOL	0.00E+00	4.09E-09	1.68E-05	1.35E-08	3.60E-05	2.40E-05
PART	0.00E+00	1.02E-07	6.71E-08	3.37E-07	3.77E-06	5.01E-06

DEPOSITION VELOCITIES

GROUP	M/SEC
VOL	1.00E-02
PART	1.00E-02

ACCIDENT SEVERITY FRACTIONS
FOR HIGHWAY

ZONE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
RURAL	1.00E+00	6.06E-05	5.86E-06	4.95E-07	7.49E-08	3.00E-10
SUBURBAN	1.00E+00	6.06E-05	5.86E-06	4.95E-07	7.49E-08	3.00E-10
URBAN	1.00E+00	6.06E-05	5.86E-06	4.95E-07	7.49E-08	3.00E-10

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 10

RF_CH

AEROSOLIZED FRACTION OF RELEASED MATERIAL

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
VOL	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
PART	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

RESPIRABLE FRACTION OF AEROSOLS (BELOW 10 MICRONS AED)

GROUP	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
VOL	0.00E+00	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02
PART	0.00E+00	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 11

RF_CH

HEALTH RELATED DATA
****

EARLY MORBIDITY THRESHOLD VALUE FOR LUNG 5.000E+02 REM
EARLY MORBIDITY THRESHOLD VALUE FOR MARROW/WHOLE BODY 5.000E+01 REM
EARLY MORBIDITY THRESHOLD VALUE FOR THYROID 2.000E+02 REM

EARLY FATALITY PROBABILITIES (EF)

DOSE(REM)	EF MARROW	DOSE(REM)	EF LUNG
680.00	1.00000	1525.00	1.00000
670.00	0.99999	1500.00	0.99999
660.00	0.99998	1475.00	0.99997
650.00	0.99996	1450.00	0.99991
640.00	0.99992	1425.00	0.99974
630.00	0.99983	1400.00	0.99933
620.00	0.99967	1375.00	0.99840
610.00	0.99938	1350.00	0.99653
600.00	0.99889	1325.00	0.99306
590.00	0.99808	1300.00	0.98709
580.00	0.99679	1275.00	0.97755
570.00	0.99482	1250.00	0.96331
560.00	0.99192	1225.00	0.94326
550.00	0.98776	1200.00	0.91656
540.00	0.98199	1175.00	0.88274
530.00	0.97423	1150.00	0.84178
520.00	0.96406	1125.00	0.79420
510.00	0.95111	1100.00	0.74095
500.00	0.93502	1075.00	0.68335
490.00	0.91551	1050.00	0.62293
480.00	0.89237	1025.00	0.56130
470.00	0.86552	1000.00	0.50000
460.00	0.83499	975.00	0.44042
450.00	0.80096	950.00	0.38372
440.00	0.76371	925.00	0.33077
430.00	0.72363	900.00	0.28218
420.00	0.68123	875.00	0.23830
410.00	0.63706	850.00	0.19925
400.00	0.59172	825.00	0.16498
390.00	0.54583	800.00	0.13529
380.00	0.50000	775.00	0.10988
370.00	0.45481	750.00	0.08837
360.00	0.41078	725.00	0.07038
350.00	0.36838	700.00	0.05548
340.00	0.32798	675.00	0.04329
330.00	0.28990	650.00	0.03341
320.00	0.25438	625.00	0.02549
310.00	0.22155	600.00	0.01922
300.00	0.19150	575.00	0.01430
290.00	0.16425	550.00	0.01050
280.00	0.13977	525.00	0.00759

```
        270.00  0.11797     500.00  0.00000
        260.00  0.09872
        250.00  0.08188
        240.00  0.06729
        230.00  0.05475
        220.00  0.04408
        210.00  0.03510
        200.00  0.02761
        190.00  0.02143
        180.00  0.01639
        170.00  0.01234
        160.00  0.00913
        150.00  0.00000


           DISPERSAL MODEL RELATED INPUT DATA
           **********************************
   CENTER LINE DISTANCES FROM FRACTION OF PEAK:
  0.9,  0.7,  0.5,  0.3,  0.2,  0.1,  0.05,  0.02,  0.01,  0.005,  0.002,  0.001,
  5.0E-4, 2.0E-4, 1.0E-4, 5.0E-5, 2.0E-5, 1.0E-5, 5.0E-6, 2.0E-6, 1.0E-6, 5.0E-7, 2.0E-7, 1.0E-7

   RELEASE HEIGHT (M)              0.00000E+00
   HEAT FLUX (CAL/S)               0.00000E+00
   SOURCE WIDTH (M)                4.50000E+00
   SOURCE HEIGHT(M)                8.40000E+00
   WIND SPEED (M/S)                5.00000E-01
   ANEMOMETER HEIGHT (M)           1.00000E+01
   AMBIENT TEMPERATURE (K)         2.93000E+02
   ATMOSPHERIC MIXING HEIGHT (M)   5.00000E+02
   RAINFALL RATE (MM/HR)           0.00000E+00
   DEPOSITION VELOCITY (M/S)       1.00000E-02

   BRIGGS DISPERSION COEFFICIENTS USED
   STABILITY CATEGORY              F
   URBAN POPULATION ZONE


          OTHER DISPERSAL ACCIDENT INPUT PARAMETERS
          *****************************************

  BUILDING DOSE FACTOR                         (BDF) = 5.000E-02
  CONTAMINATION CLEAN UP LEVEL (UCI/M**2)  (CULVL) = 2.000E-01
  BREATHING RATE (M**3/SEC)                  (BRATE) = 3.300E-04
  INTERDICTION THRESHOLD (CI/MICRO-CI)  (INTERDICT) = 4.000E+01
  EVACUATION TIME (DAYS)                (EVACUATION) = 1.000E+02
  SURVEY INTERVAL (DAYS)                    (SURVEY) = 1.000E+02
  CAMPAIGN LENGTH (YEARS)                 (CAMPAIGN) = 8.330E-02
  FRACTION OF URBAN AREAS WITH BUILDINGS      (UBF) = 5.200E-01
  FRACTION OF URBAN AREAS WITH SIDEWALKS     (USWF) = 4.800E-01
RATIO OF SIDEWALK PEDESTRIAN DENSITY (RPD)        = 6.000E+00
MAXIMUM IN-TRANSIT DOSE DISTANCE (M) (MITDDIST)  = 3.000E+01
MAXIMUM IN-TRANSIT DOSE VELOCITY (KM/H) (MITDVEL) = 2.400E+01
IACC VALUE: 1=NON-DISPERSAL, 2=DISPERSAL          = 2
REGULATORY CHECK, 1=DO CHECKS, 0=NO CHECKS        = 0
BUILDING SHIELDING OPTION (IUOPT)                 = 2
    RURAL SHIELDING FACTOR    = 1.000E+00
    SUBURBAN SHIELDING FACTOR = 8.700E-01
    URBAN SHIELDING FACTOR    = 1.800E-02
```

552

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]      PAGE  12

                  RF_CH



              INGESTION RELATED DATA


          COMIDA INGESTION FILE USED: R5INGEST.BIN

               COMIDA FILE HEADER
COMIDA2 07/22/03  08:58:40  VER. 1.11A, 1/28/96: AVOIDING USE OF UNIT 6 FOR HP

          DOSE CONVERSION FILE USED IN COMIDA
FGRDCF 07/10/03  21:45:47  VERSION 1.10
IMPLICIT DAUGHTER HALFLIVES (M) LESS THAN  90 AND LESS THAN 0.100 OF PARENT
```

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 13

RF_CH

BACKYARD FARMER INGESTION DOSE (REM/CI DEPOSITED)

NUCLIDE	EFFECTIVE	THYROID
CS-137	1.704E+05	1.590E+05
CO-60	1.328E+04	3.779E+03
SR-90	7.984E+04	3.131E+03
PU-238	7.414E+05	6.848E+00
PU-239	8.229E+05	6.447E+00
PU-240	8.228E+05	6.464E+00
AM-241	8.471E+05	1.136E+01
PU-241	1.624E+04	9.444E-02
PU-242	7.816E+05	6.275E+00

SOCIETAL INGESTION DOSE (PERSON-REM/CI DEPOSITED)

NUCLIDE	GONADS	BREAST	LUNGS	RED MAR	BONE SU	THYROID	REMAIND	EFFECTI
CS-137	2.0E+01	1.8E+01	1.9E+01	1.9E+01	1.8E+01	1.8E+01	2.1E+01	2.0E+01
CO-60	1.6E+00	5.7E-01	4.5E-01	6.8E-01	4.8E-01	4.1E-01	2.6E+00	1.4E+00
SR-90	5.2E-01	5.2E-01	5.2E-01	6.6E+01	1.4E+02	5.2E-01	2.1E+00	1.3E+01
PU-238	2.2E+01	8.0E-04	8.0E-04	1.2E+02	1.5E+03	7.6E-04	5.7E+01	8.2E+01
PU-239	2.5E+01	7.3E-04	7.4E-04	1.3E+02	1.7E+03	7.1E-04	6.1E+01	9.1E+01
PU-240	2.5E+01	7.6E-04	7.7E-04	1.3E+02	1.7E+03	7.1E-04	6.1E+01	9.1E+01
AM-241	2.6E+01	2.5E-03	3.2E-03	1.4E+02	1.7E+03	1.3E-03	6.3E+01	9.3E+01
PU-241	5.5E-01	2.6E-05	4.4E-05	2.7E+00	3.4E+01	1.1E-05	1.1E+00	1.8E+00
PU-242	2.4E+01	7.6E-04	7.5E-04	1.3E+02	1.6E+03	6.9E-04	5.8E+01	8.6E+01

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 14

RF_CH

NON-RADIOLOGICAL DATA (ACCIDENTS AND FATALITIES)
****

HIGHWAY

	ACCIDENT RATE	ACCIDENTS	FATALITIES
RURAL_NM	3.83E-06	2.82E-03	9.96E-06
SUBURBN_NM	3.83E-06	9.12E-05	3.22E-07
URBAN_NM	3.83E-06	8.62E-06	3.04E-08
URBAN_NM_R	3.83E-06	9.58E-07	3.38E-09
RURAL_CO	2.55E-06	6.11E-04	2.16E-06
SUBURBN_CO	2.55E-06	3.00E-04	9.89E-07
URBAN_CO	2.55E-06	7.21E-05	2.54E-07
URBAN_CO_R	2.55E-06	8.01E-06	2.83E-08
TOTALS:	2.55E-05	3.91E-03	1.37E-05

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 15

RF_CH

REGULATORY CHECKS HAVE BEEN DISABLED
********** ****** **** **** ********

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 16

RF_CH

CALCULATIONAL INFORMATION

FOR TRUPACT_II AREAS WITH TOTAL CONTAMINATION RATIO GREATER THAN 40.000
(THE AREAS MARKED WITH AN 'X' ARE INTERDICTED AND HAVE
NO 50 YEAR GROUNDSHINE DOSE AND NO INGESTION DOSE.)

AREA/SEVERITY	1	2	3	4	5	6
1	-	-	-	-	X	X
2	-	-	-	-	X	X
3	-	-	-	-	X	X
4	-	-	-	-	-	X
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
15	-	-	-	-	-	-
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 17

RF_CH

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 18

RF_CH

VOL
DEPOSITION VELOCITY = 0.10E-01 (M/SEC)
DILUTION FACTORS
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM AIR CONCENTRATION = 1.5231E-02 (CI-SEC/M^3/CI-RELEASED)
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM GROUND DEPOSITION = 1.5231E-04 (CI/M^2/CI-RELEASED)

DOWNWIND (M)	AREA (M^2)	DILUTION (CI-S/M^3/CI-RLSE)	DILUTION FRACTION	DEPOSITED (CI/M^2/CI-RLSE)
2.35E+01	9.70E+00	1.37E-02	9.00E-01	1.37E-04
3.16E+01	6.11E+01	1.07E-02	7.00E-01	1.07E-04
4.44E+01	1.94E+02	7.62E-03	5.00E-01	7.62E-05
6.89E+01	5.93E+02	4.57E-03	3.00E-01	4.57E-05
9.35E+01	1.17E+03	3.05E-03	2.00E-01	3.05E-05
1.49E+02	3.08E+03	1.52E-03	1.00E-01	1.52E-05
2.27E+02	7.16E+03	7.62E-04	5.00E-02	7.62E-06
3.82E+02	1.98E+04	3.05E-04	2.00E-02	3.05E-06
5.56E+02	4.11E+04	1.52E-04	1.00E-02	1.52E-06
8.04E+02	8.33E+04	7.62E-05	5.00E-03	7.62E-07
1.31E+03	2.08E+05	3.05E-05	2.00E-03	3.05E-07
1.90E+03	4.15E+05	1.52E-05	1.00E-03	1.52E-07
2.78E+03	8.25E+05	7.62E-06	5.00E-04	7.62E-08
4.71E+03	2.08E+06	3.05E-06	2.00E-04	3.05E-08
7.15E+03	4.20E+06	1.52E-06	1.00E-04	1.52E-08
1.48E+04	1.16E+07	7.62E-07	5.00E-05	7.62E-09
3.08E+04	4.10E+07	3.05E-07	2.00E-05	3.05E-09
4.61E+04	8.49E+07	1.52E-07	1.00E-05	1.52E-09
6.26E+04	1.52E+08	7.62E-08	5.00E-06	7.62E-10
8.56E+04	2.76E+08	3.05E-08	2.00E-06	3.05E-10
1.04E+05	4.00E+08	1.52E-08	1.00E-06	1.52E-10
1.20E+05	5.33E+08	8.21E-09	5.39E-07	8.21E-11

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 19

RF_CH

PART
DEPOSITION VELOCITY = 0.10E-01 (M/SEC)
DILUTION FACTORS
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM AIR CONCENTRATION = 1.5231E-02 (CI-SEC/M^3/CI-RELEASED)
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM GROUND DEPOSITION = 1.5231E-04 (CI/M^2/CI-RELEASED)

DOWNWIND (M)	AREA (M^2)	DILUTION (CI-S/M^3/CI-RLSE)	DILUTION FRACTION	DEPOSITED (CI/M^2/CI-RLSE)
2.35E+01	9.70E+00	1.37E-02	9.00E-01	1.37E-04
3.16E+01	6.11E+01	1.07E-02	7.00E-01	1.07E-04
4.44E+01	1.94E+02	7.62E-03	5.00E-01	7.62E-05
6.89E+01	5.93E+02	4.57E-03	3.00E-01	4.57E-05
9.35E+01	1.17E+03	3.05E-03	2.00E-01	3.05E-05
1.49E+02	3.08E+03	1.52E-03	1.00E-01	1.52E-05
2.27E+02	7.16E+03	7.62E-04	5.00E-02	7.62E-06
3.82E+02	1.98E+04	3.05E-04	2.00E-02	3.05E-06
5.56E+02	4.11E+04	1.52E-04	1.00E-02	1.52E-06
8.04E+02	8.33E+04	7.62E-05	5.00E-03	7.62E-07
1.31E+03	2.08E+05	3.05E-05	2.00E-03	3.05E-07
1.90E+03	4.15E+05	1.52E-05	1.00E-03	1.52E-07
2.78E+03	8.25E+05	7.62E-06	5.00E-04	7.62E-08
4.71E+03	2.08E+06	3.05E-06	2.00E-04	3.05E-08
7.15E+03	4.20E+06	1.52E-06	1.00E-04	1.52E-08
1.48E+04	1.16E+07	7.62E-07	5.00E-05	7.62E-09
3.08E+04	4.10E+07	3.05E-07	2.00E-05	3.05E-09
4.61E+04	8.49E+07	1.52E-07	1.00E-05	1.52E-09
6.26E+04	1.52E+08	7.62E-08	5.00E-06	7.62E-10
8.56E+04	2.76E+08	3.05E-08	2.00E-06	3.05E-10
1.04E+05	4.00E+08	1.52E-08	1.00E-06	1.52E-10
1.20E+05	5.33E+08	8.21E-09	5.39E-07	8.21E-11

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 20

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

1-YEAR DOSE TO LUNG, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.55E-02	2.34E-02	1.17E-01	1.31E+00	1.74E+00
3.16E+01	0.00E+00	2.76E-02	1.82E-02	9.13E-02	1.02E+00	1.36E+00
4.44E+01	0.00E+00	1.97E-02	1.30E-02	6.52E-02	7.29E-01	9.69E-01
6.89E+01	0.00E+00	1.18E-02	7.79E-03	3.91E-02	4.38E-01	5.81E-01
9.35E+01	0.00E+00	7.89E-03	5.19E-03	2.61E-02	2.92E-01	3.88E-01
1.49E+02	0.00E+00	3.95E-03	2.60E-03	1.30E-02	1.46E-01	1.94E-01
2.27E+02	0.00E+00	1.97E-03	1.30E-03	6.52E-03	7.29E-02	9.69E-02
3.82E+02	0.00E+00	7.89E-04	5.19E-04	2.61E-03	2.92E-02	3.88E-02
5.56E+02	0.00E+00	3.95E-04	2.60E-04	1.30E-03	1.46E-02	1.94E-02
8.04E+02	0.00E+00	1.97E-04	1.30E-04	6.52E-04	7.29E-03	9.69E-03
1.31E+03	0.00E+00	7.89E-05	5.19E-05	2.61E-04	2.92E-03	3.88E-03
1.90E+03	0.00E+00	3.95E-05	2.60E-05	1.30E-04	1.46E-03	1.94E-03
2.78E+03	0.00E+00	1.97E-05	1.30E-05	6.52E-05	7.29E-04	9.69E-04
4.71E+03	0.00E+00	7.89E-06	5.19E-06	2.61E-05	2.92E-04	3.88E-04
7.15E+03	0.00E+00	3.95E-06	2.60E-06	1.30E-05	1.46E-04	1.94E-04
1.48E+04	0.00E+00	1.97E-06	1.30E-06	6.52E-06	7.29E-05	9.69E-05
3.08E+04	0.00E+00	7.89E-07	5.19E-07	2.61E-06	2.92E-05	3.88E-05
4.61E+04	0.00E+00	3.95E-07	2.60E-07	1.30E-06	1.46E-05	1.94E-05
6.26E+04	0.00E+00	1.97E-07	1.30E-07	6.52E-07	7.29E-06	9.69E-06
8.56E+04	0.00E+00	7.89E-08	5.19E-08	2.61E-07	2.92E-06	3.88E-06
1.04E+05	0.00E+00	3.95E-08	2.60E-08	1.30E-07	1.46E-06	1.94E-06
1.20E+05	0.00E+00	2.13E-08	1.40E-08	7.03E-08	7.86E-07	1.04E-06

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 21

RF_CH

1-YEAR DOSE TO MARROW/WHOLE BODY, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.91E-03	2.57E-03	1.29E-02	1.44E-01	1.92E-01
3.16E+01	0.00E+00	3.04E-03	2.00E-03	1.00E-02	1.12E-01	1.49E-01
4.44E+01	0.00E+00	2.17E-03	1.43E-03	7.17E-03	8.02E-02	1.07E-01
6.89E+01	0.00E+00	1.30E-03	8.57E-04	4.30E-03	4.81E-02	6.40E-02
9.35E+01	0.00E+00	8.68E-04	5.71E-04	2.87E-03	3.21E-02	4.26E-02
1.49E+02	0.00E+00	4.34E-04	2.86E-04	1.43E-03	1.60E-02	2.13E-02
2.27E+02	0.00E+00	2.17E-04	1.43E-04	7.17E-04	8.02E-03	1.07E-02
3.82E+02	0.00E+00	8.68E-05	5.71E-05	2.87E-04	3.21E-03	4.26E-03
5.56E+02	0.00E+00	4.34E-05	2.86E-05	1.43E-04	1.60E-03	2.13E-03
8.04E+02	0.00E+00	2.17E-05	1.43E-05	7.17E-05	8.02E-04	1.07E-03
1.31E+03	0.00E+00	8.68E-06	5.71E-06	2.87E-05	3.21E-04	4.26E-04
1.90E+03	0.00E+00	4.34E-06	2.86E-06	1.43E-05	1.60E-04	2.13E-04
2.78E+03	0.00E+00	2.17E-06	1.43E-06	7.17E-06	8.02E-05	1.07E-04
4.71E+03	0.00E+00	8.68E-07	5.71E-07	2.87E-06	3.21E-05	4.26E-05
7.15E+03	0.00E+00	4.34E-07	2.86E-07	1.43E-06	1.60E-05	2.13E-05
1.48E+04	0.00E+00	2.17E-07	1.43E-07	7.17E-07	8.02E-06	1.07E-05
3.08E+04	0.00E+00	8.68E-08	5.71E-08	2.87E-07	3.21E-06	4.26E-06
4.61E+04	0.00E+00	4.34E-08	2.86E-08	1.43E-07	1.60E-06	2.13E-06
6.26E+04	0.00E+00	2.17E-08	1.43E-08	7.17E-08	8.02E-07	1.07E-06
8.56E+04	0.00E+00	8.68E-09	5.71E-09	2.87E-08	3.21E-07	4.26E-07
1.04E+05	0.00E+00	4.34E-09	2.86E-09	1.43E-08	1.60E-07	2.13E-07
1.20E+05	0.00E+00	2.34E-09	1.54E-09	7.73E-09	8.65E-08	1.15E-07

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 22

RF_CH

1-YEAR DOSE TO THYROID, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.16E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.44E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.89E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9.35E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.49E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.82E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5.56E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.04E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.31E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.90E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.78E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.71E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7.15E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.48E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.08E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.61E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.56E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.04E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.20E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 23

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

GROUND SURFACE CONTAMINATION TABLE (MICRO CI/M**2)
BEFORE CLEANUP

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	5.09E-01	3.35E-01	1.68E+00	1.88E+01	2.50E+01
3.16E+01	0.00E+00	3.96E-01	2.61E-01	1.31E+00	1.46E+01	1.94E+01
4.44E+01	0.00E+00	2.83E-01	1.86E-01	9.34E-01	1.04E+01	1.39E+01
6.89E+01	0.00E+00	1.70E-01	1.12E-01	5.60E-01	6.27E+00	8.33E+00
9.35E+01	0.00E+00	1.13E-01	7.45E-02	3.74E-01	4.18E+00	5.55E+00
1.49E+02	0.00E+00	5.65E-02	3.73E-02	1.87E-01	2.09E+00	2.78E+00
2.27E+02	0.00E+00	2.83E-02	1.86E-02	9.34E-02	1.04E+00	1.39E+00
3.82E+02	0.00E+00	1.13E-02	7.45E-03	3.74E-02	4.18E-01	5.55E-01
5.56E+02	0.00E+00	5.65E-03	3.73E-03	1.87E-02	2.09E-01	2.78E-01
8.04E+02	0.00E+00	2.83E-03	1.86E-03	9.34E-03	1.04E-01	1.39E-01
1.31E+03	0.00E+00	1.13E-03	7.45E-04	3.74E-03	4.18E-02	5.55E-02
1.90E+03	0.00E+00	5.65E-04	3.73E-04	1.87E-03	2.09E-02	2.78E-02
2.78E+03	0.00E+00	2.83E-04	1.86E-04	9.34E-04	1.04E-02	1.39E-02
4.71E+03	0.00E+00	1.13E-04	7.45E-05	3.74E-04	4.18E-03	5.55E-03
7.15E+03	0.00E+00	5.65E-05	3.73E-05	1.87E-04	2.09E-03	2.78E-03
1.48E+04	0.00E+00	2.83E-05	1.86E-05	9.34E-05	1.04E-03	1.39E-03
3.08E+04	0.00E+00	1.13E-05	7.45E-06	3.74E-05	4.18E-04	5.55E-04
4.61E+04	0.00E+00	5.65E-06	3.73E-06	1.87E-05	2.09E-04	2.78E-04
6.26E+04	0.00E+00	2.83E-06	1.86E-06	9.34E-06	1.04E-04	1.39E-04
8.56E+04	0.00E+00	1.13E-06	7.45E-07	3.74E-06	4.18E-05	5.55E-05
1.04E+05	0.00E+00	5.65E-07	3.73E-07	1.87E-06	2.09E-05	2.78E-05
1.20E+05	0.00E+00	3.05E-07	2.01E-07	1.01E-06	1.13E-05	1.50E-05

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 24

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

MAXIMUM INDIVIDUAL CONSEQUENCE (DOSE IN REM)
FROM INHALATION, CLOUDSHINE, AND GROUNDSHINE EXPOSURE DURING EVACUATION

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.94E-02	2.59E-02	1.30E-01	1.46E+00	1.94E+00
3.16E+01	0.00E+00	3.07E-02	2.02E-02	1.01E-01	1.13E+00	1.51E+00
4.44E+01	0.00E+00	2.19E-02	1.44E-02	7.24E-02	8.10E-01	1.08E+00
6.89E+01	0.00E+00	1.31E-02	8.65E-03	4.34E-02	4.86E-01	6.46E-01
9.35E+01	0.00E+00	8.76E-03	5.77E-03	2.89E-02	3.24E-01	4.30E-01
1.49E+02	0.00E+00	4.38E-03	2.88E-03	1.45E-02	1.62E-01	2.15E-01
2.27E+02	0.00E+00	2.19E-03	1.44E-03	7.24E-03	8.10E-02	1.08E-01
3.82E+02	0.00E+00	8.76E-04	5.77E-04	2.89E-03	3.24E-02	4.30E-02
5.56E+02	0.00E+00	4.38E-04	2.88E-04	1.45E-03	1.62E-02	2.15E-02
8.04E+02	0.00E+00	2.19E-04	1.44E-04	7.24E-04	8.10E-03	1.08E-02
1.31E+03	0.00E+00	8.76E-05	5.77E-05	2.89E-04	3.24E-03	4.30E-03
1.90E+03	0.00E+00	4.38E-05	2.88E-05	1.45E-04	1.62E-03	2.15E-03
2.78E+03	0.00E+00	2.19E-05	1.44E-05	7.24E-05	8.10E-04	1.08E-03
4.71E+03	0.00E+00	8.76E-06	5.77E-06	2.89E-05	3.24E-04	4.30E-04
7.15E+03	0.00E+00	4.38E-06	2.88E-06	1.45E-05	1.62E-04	2.15E-04
1.48E+04	0.00E+00	2.19E-06	1.44E-06	7.24E-06	8.10E-05	1.08E-04
3.08E+04	0.00E+00	8.76E-07	5.77E-07	2.89E-06	3.24E-05	4.30E-05
4.61E+04	0.00E+00	4.38E-07	2.88E-07	1.45E-06	1.62E-05	2.15E-05
6.26E+04	0.00E+00	2.19E-07	1.44E-07	7.24E-07	8.10E-06	1.08E-05
8.56E+04	0.00E+00	8.76E-08	5.77E-08	2.89E-07	3.24E-06	4.30E-06
1.04E+05	0.00E+00	4.38E-08	2.88E-08	1.45E-07	1.62E-06	2.15E-06
1.20E+05	0.00E+00	2.36E-08	1.55E-08	7.80E-08	8.73E-07	1.16E-06

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 25

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

BACKYARD FARMER DOSE - EFFECTIVE
MAXIMUM INDIVIDUAL CONSEQUENCE (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.30E-01	2.17E-01	1.09E+00	1.22E+01	1.62E+01
3.16E+01	0.00E+00	2.57E-01	1.69E-01	8.49E-01	9.49E+00	1.26E+01
4.44E+01	0.00E+00	1.83E-01	1.21E-01	6.06E-01	6.78E+00	9.01E+00
6.89E+01	0.00E+00	1.10E-01	7.25E-02	3.64E-01	4.07E+00	5.41E+00
9.35E+01	0.00E+00	7.34E-02	4.83E-02	2.42E-01	2.71E+00	3.60E+00
1.49E+02	0.00E+00	3.67E-02	2.42E-02	1.21E-01	1.36E+00	1.80E+00
2.27E+02	0.00E+00	1.83E-02	1.21E-02	6.06E-02	6.78E-01	9.01E-01
3.82E+02	0.00E+00	7.34E-03	4.83E-03	2.42E-02	2.71E-01	3.60E-01
5.56E+02	0.00E+00	3.67E-03	2.42E-03	1.21E-02	1.36E-01	1.80E-01
8.04E+02	0.00E+00	1.83E-03	1.21E-03	6.06E-03	6.78E-02	9.01E-02
1.31E+03	0.00E+00	7.34E-04	4.83E-04	2.42E-03	2.71E-02	3.60E-02
1.90E+03	0.00E+00	3.67E-04	2.42E-04	1.21E-03	1.36E-02	1.80E-02
2.78E+03	0.00E+00	1.83E-04	1.21E-04	6.06E-04	6.78E-03	9.01E-03
4.71E+03	0.00E+00	7.34E-05	4.83E-05	2.42E-04	2.71E-03	3.60E-03
7.15E+03	0.00E+00	3.67E-05	2.42E-05	1.21E-04	1.36E-03	1.80E-03
1.48E+04	0.00E+00	1.83E-05	1.21E-05	6.06E-05	6.78E-04	9.01E-04
3.08E+04	0.00E+00	7.34E-06	4.83E-06	2.42E-05	2.71E-04	3.60E-04
4.61E+04	0.00E+00	3.67E-06	2.42E-06	1.21E-05	1.36E-04	1.80E-04
6.26E+04	0.00E+00	1.83E-06	1.21E-06	6.06E-06	6.78E-05	9.01E-05
8.56E+04	0.00E+00	7.34E-07	4.83E-07	2.42E-06	2.71E-05	3.60E-05
1.04E+05	0.00E+00	3.67E-07	2.42E-07	1.21E-06	1.36E-05	1.80E-05
1.20E+05	0.00E+00	1.98E-07	1.30E-07	6.54E-07	7.31E-06	9.72E-06

BACKYARD FARMER DOSE - THYROID
MAXIMUM INDIVIDUAL CONSEQUENCE (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.00E-06	9.77E-05	9.91E-06	3.15E-04	2.83E-04
3.16E+01	0.00E+00	2.33E-06	7.60E-05	7.70E-06	2.45E-04	2.20E-04
4.44E+01	0.00E+00	1.67E-06	5.43E-05	5.50E-06	1.75E-04	1.57E-04
6.89E+01	0.00E+00	9.99E-07	3.26E-05	3.30E-06	1.05E-04	9.43E-05
9.35E+01	0.00E+00	6.66E-07	2.17E-05	2.20E-06	7.00E-05	6.29E-05
1.49E+02	0.00E+00	3.33E-07	1.09E-05	1.10E-06	3.50E-05	3.14E-05
2.27E+02	0.00E+00	1.67E-07	5.43E-06	5.50E-07	1.75E-05	1.57E-05
3.82E+02	0.00E+00	6.66E-08	2.17E-06	2.20E-07	7.00E-06	6.29E-06
5.56E+02	0.00E+00	3.33E-08	1.09E-06	1.10E-07	3.50E-06	3.14E-06
8.04E+02	0.00E+00	1.67E-08	5.43E-07	5.50E-08	1.75E-06	1.57E-06
1.31E+03	0.00E+00	6.66E-09	2.17E-07	2.20E-08	7.00E-07	6.29E-07
1.90E+03	0.00E+00	3.33E-09	1.09E-07	1.10E-08	3.50E-07	3.14E-07
2.78E+03	0.00E+00	1.67E-09	5.43E-08	5.50E-09	1.75E-07	1.57E-07
4.71E+03	0.00E+00	6.66E-10	2.17E-08	2.20E-09	7.00E-08	6.29E-08
7.15E+03	0.00E+00	3.33E-10	1.09E-08	1.10E-09	3.50E-08	3.14E-08
1.48E+04	0.00E+00	1.67E-10	5.43E-09	5.50E-10	1.75E-08	1.57E-08
3.08E+04	0.00E+00	6.66E-11	2.17E-09	2.20E-10	7.00E-09	6.29E-09
4.61E+04	0.00E+00	3.33E-11	1.09E-09	1.10E-10	3.50E-09	3.14E-09
6.26E+04	0.00E+00	1.67E-11	5.43E-10	5.50E-11	1.75E-09	1.57E-09

983	8.56E+04	0.00E+00	6.66E-12	2.17E-10	2.20E-11	7.00E-10	6.29E-10
984	1.04E+05	0.00E+00	3.33E-12	1.09E-10	1.10E-11	3.50E-10	3.14E-10
985	1.20E+05	0.00E+00	1.80E-12	5.85E-11	5.93E-12	1.89E-10	1.69E-10
986							

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 26

RF_CH

INCIDENT-FREE SUMMARY
******** **** *******

IN-TRANSIT POPULATION EXPOSURE IN PERSON-REM

	PASSENGER	CREW	OFF LINK	ON LINK	TOTALS
RURAL_NM	0.00E+00	3.98E-03	7.09E-06	5.13E-04	4.50E-03
SUBURBN_NM	0.00E+00	1.28E-04	1.35E-05	3.06E-05	1.73E-04
URBAN_NM	0.00E+00	1.21E-05	1.51E-07	8.01E-06	2.03E-05
URBAN_NM_R	0.00E+00	2.70E-06	3.35E-08	7.43E-06	1.02E-05
RURAL_CO	0.00E+00	1.29E-03	4.76E-06	3.18E-04	1.62E-03
SUBURBN_CO	0.00E+00	6.34E-04	8.87E-05	2.93E-04	1.02E-03
URBAN_CO	0.00E+00	1.53E-04	2.55E-06	1.22E-04	2.77E-04
URBAN_CO_R	0.00E+00	3.39E-05	5.67E-07	1.13E-04	1.47E-04
RURAL	0.00E+00	5.27E-03	1.19E-05	8.31E-04	6.11E-03
SUBURB	0.00E+00	7.63E-04	1.02E-04	3.23E-04	1.19E-03
URBAN	0.00E+00	2.01E-04	3.30E-06	2.50E-04	4.55E-04
TOTALS:	0.00E+00	6.24E-03	1.17E-04	1.40E-03	7.76E-03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

TRUPACT_II 3.33E-08 REM

STOP EXPOSURE IN PERSON-REM

ANNULAR AREA	RURAL_NM	1.26E-06
ANNULAR AREA	SUBURB_NM	2.75E-06
ANNULAR AREA	RURAL_CO	8.47E-07
ANNULAR AREA	SUBSURBAN_	1.82E-05
LINE-SOURCE	TRUCKCREW	4.73E-03
LINE-SOURCE	INSPECTOR	4.19E-03
ANNULAR AREA	RESTSTOPEM	2.79E-04
ANNULAR AREA	RURAL_ATST	2.92E-03
ANNULAR AREA	SUBURBAN_A	4.22E-04

TOTAL: 1.26E-02

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 27

RF_CH

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	2.82E-03	9.11E-05	8.62E-06	9.57E-07	6.11E-04	3.00E-04	7.21E-05
2	1.71E-07	5.52E-09	5.22E-10	5.80E-11	3.70E-08	1.82E-08	4.37E-09
3	1.65E-08	5.34E-10	5.05E-11	5.61E-12	3.58E-09	1.76E-09	4.22E-10
4	1.40E-09	4.51E-11	4.27E-12	4.74E-13	3.03E-10	1.48E-10	3.57E-11
5	2.11E-10	6.83E-12	6.45E-13	7.17E-14	4.58E-11	2.24E-11	5.40E-12
6	8.47E-13	2.73E-14	2.59E-15	2.87E-16	1.83E-13	8.99E-14	2.16E-14

CATEGORY	URBAN_CO_R
1	8.01E-06
2	4.85E-10
3	4.69E-11
4	3.96E-12
5	6.00E-13
6	2.40E-15

NUMBER OF EARLY FATALITIES FROM INHALATION

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CATEGORY	URBAN_CO_R
1	0.00E+00
2	0.00E+00
3	0.00E+00
4	0.00E+00
5	0.00E+00
6	0.00E+00

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE  28

                 RF_CH





               RADIOLOGICAL CONSEQUENCES
          50 YEAR POPULATION DOSE IN PERSON-REM

CATEGORY                   RURAL_NMSUBURBN_NM             URBAN_NMURBAN_NM_R
RURAL_COSUBURBN_CO URBAN_CO
  1     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  2     2.04E-03 1.38E-01 2.30E+00 2.29E+00 4.21E-03 1.84E-01 3.09E+00
  3     1.35E-03 9.14E-02 1.52E+00 1.52E+00 2.79E-03 1.22E-01 2.05E+00
  4     6.73E-03 4.56E-01 7.59E+00 7.58E+00 1.39E-02 6.07E-01 1.02E+01
  5     6.91E-02 4.67E+00 7.79E+01 7.77E+01 1.43E-01 6.23E+00 1.05E+02
  6     9.06E-02 6.13E+00 1.02E+02 1.02E+02 1.87E-01 8.17E+00 1.37E+02

CATEGORY URBAN_CO_R
  1     0.00E+00
  2     3.09E+00
  3     2.05E+00
  4     1.02E+01
  5     1.05E+02
  6     1.37E+02




        NUMBER OF EARLY MORBIDITY CASES FROM INHALATION


CATEGORY                   RURAL_NMSUBURBN_NM             URBAN_NMURBAN_NM_R
RURAL_COSUBURBN_CO URBAN_CO
  1     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  2     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  3     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  4     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  5     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  6     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00

CATEGORY URBAN_CO_R
  1     0.00E+00
  2     0.00E+00
  3     0.00E+00
  4     0.00E+00
  5     0.00E+00
  6     0.00E+00



     MAXIMUM RISK FOR INDIVIDUAL IN NEAREST ISOPLETH (DOSE IN REM)
  FROM INHALATION, CLOUDSHINE, AND GROUNDSHINE EXPOSURE DURING EVACUATION

CATEGORY                   RURAL_NMSUBURBN_NM             URBAN_NMURBAN_NM_R
RURAL_COSUBURBN_CO URBAN_CO
  1     0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
```

2	6.74E-09	2.18E-10	2.06E-11	2.29E-12	1.46E-09	7.16E-10	1.72E-10
3	4.29E-10	1.39E-11	1.31E-12	1.46E-13	9.29E-11	4.56E-11	1.10E-11
4	1.82E-10	5.88E-12	5.56E-13	6.17E-14	3.94E-11	1.93E-11	4.65E-12
5	3.08E-10	9.95E-12	9.41E-13	1.05E-13	6.67E-11	3.27E-11	7.87E-12
6	1.64E-12	5.30E-14	5.01E-15	5.56E-16	3.55E-13	1.74E-13	4.19E-14

CATEGORY URBAN_CO_R

1	0.00E+00
2	1.91E-11
3	1.22E-12
4	5.16E-13
5	8.74E-13
6	4.65E-15

RADIOLOGICAL CONSEQUENCES IN PERSON REM
50 YEAR SOCIETAL INGESTION DOSE - EFFECTIVE

LINK	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
RURAL_NM	0.00E+00	9.56E-02	6.33E-02	3.04E-01	2.95E+00	3.83E+00
RURAL_CO	0.00E+00	9.56E-02	6.33E-02	3.04E-01	2.95E+00	3.83E+00

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 29

RF_CH

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	TOTAL
RURAL_NM	2.76E-12	3.50E-10	4.21E-11	9.79E-18	3.95E-10
SUBURBN_NM	6.03E-12	7.66E-10	9.19E-11	2.14E-17	8.64E-10
URBAN_NM	9.49E-12	1.21E-09	1.45E-10	3.37E-17	1.36E-09
URBAN_NM_R	1.05E-12	1.34E-10	1.61E-11	3.74E-18	1.51E-10
RURAL_CO	1.23E-12	1.57E-10	1.88E-11	4.38E-18	1.77E-10
SUBURBN_CO	2.64E-11	3.35E-09	4.03E-10	9.37E-17	3.78E-09
URBAN_CO	1.07E-10	1.36E-08	1.63E-09	3.79E-16	1.53E-08
URBAN_CO_R	1.19E-11	1.51E-09	1.81E-10	4.21E-17	1.70E-09
RURAL	3.99E-12	5.07E-10	6.09E-11	1.42E-17	5.72E-10
SUBURB	3.24E-11	4.12E-09	4.95E-10	1.15E-16	4.65E-09
URBAN	1.29E-10	1.64E-08	1.97E-09	4.58E-16	1.85E-08
TOTALS:	1.66E-10	2.10E-08	2.52E-09	5.88E-16	2.37E-08

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 30

RF_CH

SOCIETAL INGESTION RISK - PERSON-REM

LINK	GONADS	EFFECTIVE
RURAL_NM	4.99E-09	1.84E-08
RURAL_CO	1.08E-09	4.00E-09
TOTAL	6.08E-09	2.24E-08

SOCIETAL INGESTION RISK BY ORGAN - PERSON-REM

LINK	BREAST	LUNGS	RED MARR	BONE SUR	THYROID	REMAINDER
RURAL_NM	6.65E-13	6.79E-13	2.71E-08	3.37E-07	6.64E-13	1.27E-08
RURAL_CO	1.44E-13	1.47E-13	5.87E-09	7.31E-08	1.44E-13	2.75E-09
TOTAL	8.09E-13	8.27E-13	3.30E-08	4.11E-07	8.08E-13	1.55E-08

EXPECTED RISK VALUES - OTHER

LINK	EARLY FATALITY	EARLY MORBIDITY
RURAL_NM	0.00E+00	0.00E+00
SUBURBN_NM	0.00E+00	0.00E+00
URBAN_NM	0.00E+00	0.00E+00
URBAN_NM_R	0.00E+00	0.00E+00
RURAL_CO	0.00E+00	0.00E+00
SUBURBN_CO	0.00E+00	0.00E+00
URBAN_CO	0.00E+00	0.00E+00
URBAN_CO_R	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 31

RF_CH

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RURAL_NM 5.80E+03 PERSONS
SUBURBN_NM 1.27E+04 PERSONS
URBAN_NM 6.87E+03 PERSONS
URBAN_NM_R 7.62E+02 PERSONS
RURAL_CO 3.89E+03 PERSONS
SUBURBN_CO 8.34E+04 PERSONS
URBAN_CO 1.16E+05 PERSONS
URBAN_CO_R 1.29E+04 PERSONS

TOTAL 2.42E+05 PERSONS

PASQUILL CATEGORY F
TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RURAL_NM 4.03E+03 PERSONS
SUBURBN_NM 2.73E+05 PERSONS
URBAN_NM 1.56E+06 PERSONS
URBAN_NM_R 1.56E+06 PERSONS
RURAL_CO 8.32E+03 PERSONS
SUBURBN_CO 3.63E+05 PERSONS
URBAN_CO 2.10E+06 PERSONS
URBAN_CO_R 2.10E+06 PERSONS

RF_CH

LINK: RURAL_NM   EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	1.64E-13	8.80E-18	1.07E-18	3.97E-18	1.64E-13
TRUPACT	CO60	9.63E-16	4.02E-20	4.83E-21	7.67E-20	9.63E-16
TRUPACT	SR90	5.69E-18	2.26E-18	2.71E-19	7.18E-23	8.22E-18
TRUPACT	PU238	2.26E-12	2.86E-10	3.43E-11	4.61E-18	3.22E-10
TRUPACT	PU239	1.89E-13	5.01E-11	6.01E-12	6.44E-19	5.63E-11
TRUPACT	PU240	1.09E-13	1.32E-11	1.58E-12	1.90E-19	1.49E-11
TRUPACT	AM241	3.10E-14	9.48E-14	1.14E-14	2.81E-19	1.37E-13
TRUPACT	PU241	5.29E-16	1.13E-12	1.36E-13	1.38E-20	1.26E-12
TRUPACT	PU242	1.47E-18	2.06E-16	2.47E-17	2.59E-24	2.32E-16

TOTAL: 3.95E-10

LINK: SUBURBN_NM   EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	3.59E-13	1.92E-17	2.34E-18	8.69E-18	3.59E-13
TRUPACT	CO60	2.10E-15	8.79E-20	1.06E-20	1.68E-19	2.11E-15
TRUPACT	SR90	1.24E-17	4.94E-18	5.93E-19	1.57E-22	1.80E-17
TRUPACT	PU238	4.95E-12	6.25E-10	7.50E-11	1.01E-17	7.05E-10
TRUPACT	PU239	4.13E-13	1.09E-10	1.31E-11	1.41E-18	1.23E-10
TRUPACT	PU240	2.39E-13	2.88E-11	3.46E-12	4.16E-19	3.25E-11

TRUPACT	AM241	6.77E-14	2.07E-13	2.49E-14	6.14E-19	3.00E-13
TRUPACT	PU241	1.16E-15	2.47E-12	2.96E-13	3.01E-20	2.76E-12
TRUPACT	PU242	3.21E-18	4.49E-16	5.40E-17	5.66E-24	5.07E-16

TOTAL: 8.64E-10

LINK: URBAN_NM EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	5.65E-13	3.03E-17	3.68E-18	1.37E-17	5.65E-13
TRUPACT	CO60	3.31E-15	1.38E-19	1.66E-20	2.64E-19	3.31E-15
TRUPACT	SR90	1.96E-17	7.78E-18	9.34E-19	2.47E-22	2.83E-17
TRUPACT	PU238	7.79E-12	9.84E-10	1.18E-10	1.59E-17	1.11E-09
TRUPACT	PU239	6.50E-13	1.72E-10	2.07E-11	2.22E-18	1.94E-10
TRUPACT	PU240	3.76E-13	4.54E-11	5.45E-12	6.54E-19	5.12E-11
TRUPACT	AM241	1.07E-13	3.26E-13	3.92E-14	9.66E-19	4.72E-13
TRUPACT	PU241	1.82E-15	3.88E-12	4.66E-13	4.74E-20	4.35E-12
TRUPACT	PU242	5.05E-18	7.08E-16	8.50E-17	8.92E-24	7.98E-16

TOTAL: 1.36E-09

LINK: URBAN_NM_R EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	6.27E-14	3.36E-18	4.08E-19	1.52E-18	6.27E-14
TRUPACT	CO60	3.68E-16	1.54E-20	1.84E-21	2.93E-20	3.68E-16
TRUPACT	SR90	2.17E-18	8.62E-19	1.04E-19	2.74E-23	3.14E-18
TRUPACT	PU238	8.64E-13	1.09E-10	1.31E-11	1.76E-18	1.23E-10
TRUPACT	PU239	7.21E-14	1.91E-11	2.30E-12	2.46E-19	2.15E-11
TRUPACT	PU240	4.17E-14	5.04E-12	6.05E-13	7.26E-20	5.68E-12
TRUPACT	AM241	1.18E-14	3.62E-14	4.35E-15	1.07E-19	5.24E-14
TRUPACT	PU241	2.02E-16	4.31E-13	5.17E-14	5.25E-21	4.83E-13
TRUPACT	PU242	5.61E-19	7.85E-17	9.43E-18	9.89E-25	8.85E-17

TOTAL: 1.51E-10

LINK: RURAL_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	7.34E-14	3.93E-18	4.77E-19	1.78E-18	7.34E-14
TRUPACT	CO60	4.30E-16	1.80E-20	2.16E-21	3.43E-20	4.30E-16
TRUPACT	SR90	2.54E-18	1.01E-18	1.21E-19	3.21E-23	3.68E-18
TRUPACT	PU238	1.01E-12	1.28E-10	1.53E-11	2.06E-18	1.44E-10
TRUPACT	PU239	8.45E-14	2.24E-11	2.69E-12	2.88E-19	2.52E-11
TRUPACT	PU240	4.88E-14	5.89E-12	7.08E-13	8.50E-20	6.65E-12
TRUPACT	AM241	1.38E-14	4.24E-14	5.09E-15	1.26E-19	6.13E-14
TRUPACT	PU241	2.37E-16	5.04E-13	6.06E-14	6.15E-21	5.65E-13
TRUPACT	PU242	6.56E-19	9.19E-17	1.10E-17	1.16E-24	1.04E-16

TOTAL: 1.77E-10

LINK: SUBURBN_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	1.57E-12	8.43E-17	1.02E-17	3.80E-17	1.57E-12
TRUPACT	CO60	9.22E-15	3.85E-19	4.62E-20	7.35E-19	9.22E-15
TRUPACT	SR90	5.45E-17	2.16E-17	2.60E-18	6.87E-22	7.87E-17
TRUPACT	PU238	2.17E-11	2.74E-09	3.28E-10	4.41E-17	3.09E-09
TRUPACT	PU239	1.81E-12	4.79E-10	5.76E-11	6.17E-18	5.39E-10
TRUPACT	PU240	1.04E-12	1.26E-10	1.52E-11	1.82E-18	1.42E-10
TRUPACT	AM241	2.96E-13	9.07E-13	1.09E-13	2.69E-18	1.31E-12
TRUPACT	PU241	5.07E-15	1.08E-11	1.30E-12	1.32E-19	1.21E-11
TRUPACT	PU242	1.41E-17	1.97E-15	2.36E-16	2.48E-23	2.22E-15

TOTAL: 3.78E-09

LINK: URBAN_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

```
MATERIAL  ISOTOPE  GROUND   INHALATN  RESUSP    CLOUDSH   TOTAL
TRUPACT   CS137    6.35E-12 3.41E-16  4.13E-17  1.54E-16  6.35E-12
TRUPACT   CO60     3.73E-14 1.56E-18  1.87E-19  2.97E-18  3.73E-14
TRUPACT   SR90     2.20E-16 8.74E-17  1.05E-17  2.78E-21  3.18E-16
TRUPACT   PU238    8.76E-11 1.11E-08  1.33E-09  1.78E-16  1.25E-08
TRUPACT   PU239    7.31E-12 1.94E-09  2.33E-10  2.49E-17  2.18E-09
TRUPACT   PU240    4.22E-12 5.10E-10  6.13E-11  7.36E-18  5.76E-10
TRUPACT   AM241    1.20E-12 3.67E-12  4.40E-13  1.09E-17  5.31E-12
TRUPACT   PU241    2.05E-14 4.37E-11  5.24E-12  5.33E-19  4.89E-11
TRUPACT   PU242    5.68E-17 7.96E-15  9.55E-16  1.00E-22  8.97E-15
                            TOTAL: 1.53E-08

LINK: URBAN_CO_R     EXPECTED VALUES OF POPULATION RISK IN PERSON-REM
MATERIAL  ISOTOPE  GROUND   INHALATN  RESUSP    CLOUDSH   TOTAL
TRUPACT   CS137    7.05E-13 3.78E-17  4.59E-18  1.71E-17  7.05E-13
TRUPACT   CO60     4.14E-15 1.73E-19  2.08E-20  3.30E-19  4.14E-15
TRUPACT   SR90     2.45E-17 9.71E-18  1.17E-18  3.09E-22  3.53E-17
TRUPACT   PU238    9.73E-12 1.23E-09  1.47E-10  1.98E-17  1.39E-09
TRUPACT   PU239    8.12E-13 2.15E-10  2.58E-11  2.77E-18  2.42E-10
TRUPACT   PU240    4.69E-13 5.67E-11  6.81E-12  8.17E-19  6.40E-11
TRUPACT   AM241    1.33E-13 4.07E-13  4.89E-14  1.21E-18  5.89E-13
TRUPACT   PU241    2.27E-15 4.85E-12  5.82E-13  5.91E-20  5.43E-12
TRUPACT   PU242    6.31E-18 8.84E-16  1.06E-16  1.11E-23  9.96E-16
                            TOTAL: 1.70E-09
EOI
END OF RUN
SUCCESSFUL COMPLETION
```

```
[TRAGIS]
TRAGIS VERSION=1.5.4
MODE=H
NETWORK VERSION=4.0
CENSUS DATA=2000
BUFFER ZONE=800
[ROUTEINFO]
FROM CITY=ORNL
FROM STATE=TN
FROM SUBNET=
TO CITY=WIPP
TO STATE=NM
TO SUBNET=
[AR]
RURAL - KM= 327.9
SUBURBAN - KM= 105.5
URBAN - KM=   5.9
TOTAL - KM= 439.2
RURAL POP DENSITY=  13.9
SUBURBAN POP DENSITY= 281.4
URBAN POP DENSITY=2083.0
[NM]
RURAL - KM= 112.4
SUBURBAN - KM=   6.7
URBAN - KM=   1.0
TOTAL - KM= 120.0
RURAL POP DENSITY=   4.2
SUBURBAN POP DENSITY= 412.6
URBAN POP DENSITY=2043.7
[TN]
```

```
RURAL - KM= 403.0
SUBURBAN - KM= 172.6
URBAN - KM=  25.2
TOTAL - KM= 600.8
RURAL POP DENSITY=  16.4
SUBURBAN POP DENSITY= 313.1
URBAN POP DENSITY=2249.6
[TX]
RURAL - KM= 802.3
SUBURBAN - KM= 234.5
URBAN - KM=  35.2
TOTAL - KM=1072.0
RURAL POP DENSITY=  11.3
SUBURBAN POP DENSITY= 360.1
URBAN POP DENSITY=2309.9
[TOTAL]
RURAL - KM=1645.7
SUBURBAN - KM= 519.2
URBAN - KM=  67.3
TOTAL - KM=2232.1
RURAL POP DENSITY=  12.6
SUBURBAN POP DENSITY= 329.2
URBAN POP DENSITY=2263.7

TRAGIS ROUTING ENGINE VERSION 1.5.4     -- HIGHWAY DATA NETWORK  4.0

FROM:   ROCKY FLATS          CO      LEAVING  : 08/22/08 12:29
TO  :   WIPP                 NM      ARRIVING : 08/23/08 01:01


ROUTING PARAMETERS USED TO CALCULATE THE ROUTE-

 ROUTING TYPE: WIPP PREFERRED ROUTE WITH 2 DRIVER(S)
  PREFERRED ROADS    TIME BIAS: 1.00  MILE BIAS: 0.00, TOLL BIAS: 1.00
  NONPREFERRED ROADS  TIME BIAS: 0.00  MILE BIAS: 1.00, TOLL BIAS: 1.00, PENALTY FACTOR: 30.0

 CONSTRAINTS USED ON ROUTE:
  PROHIBIT USE OF LINKS PROHIBITING TRUCK USE
  PROHIBIT USE OF FERRY CROSSING
  PROHIBIT USE OF ROADS WITH RADIOACTIVE MATERIALS PROHIBITION


 MILES HWY SIGN   CITY        DIR JUNCTION STATE  DIST  TIME DATE    HOUR
--------------------------------------------------------------------------------
   0.0             ROCKY FLATS             CO     0.0 0:00 08/22/08 12:29
   2.3 LOCAL       ROCKY FLATS  W  S93 LOCL  CO     2.3 0:04 08/22/08 12:33
   3.0 S93         MARSHALL     S  S128S93   CO     5.4 0:09 08/22/08 12:38
   8.2 S128        BROOMFIELD      U36 S128  CO    13.6 0:21 08/22/08 12:50
   9.1 U36         THORNTON     S  I25 X217  CO    22.7 0:30 08/22/08 12:59
 205.1 I25         TRINIDAD        I25 X13   CO   227.8 3:28 08/22/08 15:57
  13.7 I25         CROSSING STATE BORDER CO/NM  BD   241.5 3:39 08/22/08 16:08
                   REST  30 MINUTES
 170.7 I25         SANTA FE     SE I25 X290  NM   412.2 6:34 08/22/08 19:03
  68.6 U285        ENCINO       W  U285U60   NM   480.8 7:51 08/22/08 20:20
  14.0 U285  U60   VAUGHN       SW U285U54   NM   494.7 8:05 08/22/08 20:34
   3.9 U285  U54   VAUGHN       SE U285U54   NM   498.6 8:09 08/22/08 20:38
                   REST 30 MINUTES
```

```
 90.1 U285       ROSWELL     N  U285U70   NM  588.7 10:09 08/22/08 22:38
  7.5 U285  U70  ROSWELL     W  U380U70   NM  596.2 10:17 08/22/08 22:46
 73.4 U285       CARLSBAD    NW U285LCBR  NM  669.6 11:32 08/23/08 00:01
  8.7 LCBR       CARLSBAD    E  U62 LCBR  NM  678.3 11:42 08/23/08 00:11
 25.3 U62   U180 TOWER HILL  E  U62 LOCL  NM  703.6 12:08 08/23/08 00:37
 12.1 LOCAL      WIPP                     NM  715.7 12:32 08/23/08 01:01

TOTAL ELAPSED TIME: 12:32    TOTAL TRIP MILEAGE:  715.7    IMPEDANCE:  692.3


MILEAGE BY STATE :
CO:  241.5  NM:  474.2

MILEAGE BY SIGN TYPE:
1-INTERSTATE:  389.5     2-US:  291.9    3-STATE:  11.2     6-LOCAL:  23.1


MILEAGE BY LANE TYPE:
 1-MULTI-LANE CONTROLLED ACCESS:  398.7    3-MULTI-LANE DIVIDED HIGHWAY:  240.0
           5-PRINCIPLE ROAD:  42.7           6-THROUGH ROAD:   3.0
               7-OTHER:   31.3

MILEAGE BY TRIBAL LANDS:
 TOTAL OUTSIDE TRIBAL LANDS    :  715.7
 TOTAL INSIDE TRIBAL LANDS     :    0.0




TRAGIS ROUTING ENGINE VERSION 1.5.4      --  2000 CENSUS DATA

POPULATION DENSITY WITHIN  800 METER BUFFER ZONE:
FROM: ROCKY FLATS            CO
TO  : WIPP                   NM
--------------------------------------------------------------------------------
               >0.0  22.7  59.7  139   326   821  1861  3326  5815
ST MILES    0  -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
--------------------------------------------------------------------------------
CO 241.5  58.73 39.49 31.88 18.84 16.76 20.88 21.93 13.44 11.37  5.69  2.44
NM 474.2 255.62 132.12 55.27 14.83  7.44  3.03  2.00  2.33  1.47  0.07  0.00

TOTALS
  715.7 314.35 171.61 87.15 33.67 24.20 23.91 23.93 15.77 12.84  5.76  2.44
PERCENTAGES
        43.93 23.98 12.18  4.70  3.38  3.34  3.34  2.20  1.79  0.80  0.34

BASIS:  2000 CENSUS DATA

RADTRAN INPUT DATA     RURAL  SUBURBAN    URBAN
WEIGHTED POPULATION
PEOPLE/SQ. MI.          15.3    1051.5    6229.1
PEOPLE/SQ. KM.           5.9     406.0    2405.1


DISTANCE                                TOTALS
MILES            606.8    87.8    21.0    715.7
KILOMETERS       976.5   141.3    33.9   1151.8
PERCENTAGES       84.8    12.3     2.9
```

BASIS (PEOPLE/SQ MI.) <139 139-3326 >3326

POPULATION WITHIN 800 METER BUFFER ZONE BY STATE:
CO 167553 NM 18093

TOTAL POPULATION WITHIN 800 METER BUFFER ZONE: 185646

APPENDIX B: STATE SPECIFIC COLLECTIVE DOSES FROM ROUTINE, INCIDENT FREE TRANSPORTATION

Collective doses are presented for both single shipments and the total number of shipments from the particular site. Crew doses are not calculated for the total number of shipments, since a different crew would be used and since crew doses are limited by ALARA. Doses are tabulated by state.

Table B. 1 New Mexico Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	ANL_E	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.00E-03	6.80E-05	6.53E-06			
CH	OFF-LINK	5.26E-06	6.83E-06	8.42E-08	4.26E-04	5.53E-04	6.82E-06
CH	ON-LINK	4.16E-03	1.74E-05	7.21E-06	3.37E-01	1.41E-03	5.84E-04
RH	OFF-LINK	1.23E-05	1.59E-05	1.95E-07	1.02E-03	1.32E-03	1.62E-05
RH	ON-LINK	9.68E-04	4.05E-05	1.16E-05	8.03E-02	3.36E-03	9.59E-04
	BATTELLE	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.00E-03	6.80E-05	6.53E-06			
CH	OFF-LINK	5.26E-06	6.83E-06	8.46E-08	5.26E-06	6.83E-06	8.46E-08
CH	ON-LINK	4.16E-03	1.74E-05	7.31E-06	4.16E-03	1.74E-05	7.31E-06
	BETTIS	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.07E-04	3.62E-05	6.59E-06			
CH	OFF-LINK	1.04E-06	5.29E-06	8.48E-08	1.04E-06	5.29E-06	8.48E-08
CH	ON-LINK	8.41E-04	9.26E-06	7.24E-06	8.41E-04	9.26E-06	7.24E-06
RH	OFF-LINK	2.42E-06	1.24E-05	1.97E-07	9.68E-06	4.95E-05	7.88E-07
RH	ON-LINK	1.96E-03	2.15E-05	1.69E-05	7.83E-03	8.60E-05	6.74E-05
	BROOKHAVEN	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.05E-04	3.62E-05	6.48E-06			
CH	OFF-LINK	1.04E-06	5.30E-06	9.44E-08	8.45E-04	4.32E-03	7.70E-05
CH	ON-LINK	8.37E-05	9.26E-06	6.93E-06	6.83E-02	7.55E-03	5.65E-03
	INL/ANLW	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.96E-04	1.28E-04	1.48E-05			
CH	OFF-LINK	6.78E-07	1.87E-05	1.92E-07	8.97E-03	2.47E-01	2.54E-03
CH	ON-LINK	5.65E-04	3.37E-05	1.70E-05	7.47E+00	4.46E-01	2.25E-01
RH	OFF-LINK	1.64E-06	4.50E-05	2.02E-05	6.77E-04	1.86E-02	8.34E-03
RH	ON-LINK	1.31E-03	7.87E-05	9.20E-04	5.44E-01	3.26E-02	3.81E-01
	KAPL	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.05E-04	3.62E-05	7.56E-06			
CH	OFF-LINK	1.04E-06	5.30E-06	1.08E-07	1.44E-04	7.37E-04	1.50E-05
CH	ON-LINK	8.37E-04	9.26E-06	1.00E-05	1.16E-01	1.29E-03	1.39E-03
RH	OFF-LINK	2.41E-06	1.24E-05	2.51E-07	5.03E-04	2.58E-03	5.25E-05
RH	ON-LINK	1.95E-03	2.15E-05	2.34E-05	4.07E-01	4.49E-03	4.88E-03
	LANL	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.07E-03	1.86E-04	2.70E-05			
CH	OFF-LINK	7.37E-06	1.66E-05	2.87E-06	1.51E-02	3.39E-02	5.87E-03
CH	ON-LINK	4.25E-04	4.75E-05	8.05E-06	8.69E-01	9.73E-02	1.65E-02
RH	OFF-LINK	1.72E-05	3.85E-05	6.68E-06	5.50E-04	1.23E-03	2.14E-04
RH	ON-LINK	9.90E-04	1.11E-04	1.87E-05	3.17E-02	3.54E-03	5.99E-04
	LBL/LLNL	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.69E-03	3.92E-04	8.62E-05			
CH	OFF-LINK	1.09E-05	4.12E-05	1.49E-06	1.11E-03	4.20E-03	1.52E-04
CH	ON-LINK	4.97E-03	9.74E-05	9.35E-05	5.07E-01	9.94E-03	9.54E-03
	MATERIALSCOMMAND	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.07E-04	3.62E-05	5.40E-06			
CH	OFF-LINK	1.04E-06	5.29E-06	8.09E-08	1.04E-06	5.29E-06	8.09E-08
CH	ON-LINK	8.41E-04	9.26E-06	3.83E-06	8.41E-04	9.26E-06	3.83E-06

Table B.1 New Mexico Incident-free Collective Dose (person-rem) continued

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	MURR	NM_R	NM_S	NM_U			
	CREW	3.00E-03	6.80E-05	7.02E-06			
CH	OFF-LINK	5.26E-06	6.83E-06	9.08E-08	5.26E-06	6.83E-06	9.08E-08
	ON-LINK	4.16E-03	1.74E-05	7.41E-06	4.16E-03	1.74E-05	7.41E-06
	NTS	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.69E-03	3.92E-04	8.62E-05			
CH	OFF-LINK	1.09E-05	4.12E-05	3.92E-06	3.41E-03	1.29E-02	1.23E-03
	ON-LINK	5.12E-04	1.00E-04	9.63E-05	1.61E-01	3.15E-02	3.02E-02
	ORNL	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.05E-04	3.62E-05	6.48E-06			
CH	OFF-LINK	1.04E-06	5.30E-06	9.48E-08	3.92E-04	2.01E-03	3.59E-05
	ON-LINK	8.37E-04	9.26E-06	7.02E-06	3.17E-01	3.51E-03	2.66E-03
RH	OFF-LINK	9.63E-04	5.76E-05	1.03E-05	2.61E+00	1.56E-01	2.80E-02
	ON-LINK	2.41E-06	1.24E-05	2.21E-07	6.53E-03	3.35E-02	5.98E-04
	RF	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.98E-03	1.28E-04	1.48E-05			
CH	OFF-LINK	7.62E-06	1.45E-05	1.98E-07	1.07E-02	2.04E-02	2.79E-04
	ON-LINK	5.51E-04	3.29E-05	1.66E-05	7.77E-01	4.63E-02	2.34E-02
	RICHLAND	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	3.98E-03	1.28E-04	1.48E-05			
CH	OFF-LINK	7.62E-06	1.45E-05	1.98E-07	1.07E-02	2.04E-02	2.79E-04
	ON-LINK	5.51E-04	3.29E-05	1.66E-05	7.77E-01	4.63E-02	2.34E-02
RH	OFF-LINK	6.33E-03	2.04E-04	2.37E-05	1.11E+01	3.57E-01	4.13E-02
	ON-LINK	1.77E-05	3.38E-05	4.62E-07	3.10E-02	5.90E-02	8.08E-04
	SNL	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	2.55E-03	1.75E-04	3.86E-05			
CH	OFF-LINK	5.73E-06	1.63E-06	6.88E-07	4.01E-05	1.14E-05	4.82E-06
	ON-LINK	3.54E-04	4.47E-05	4.31E-05	2.48E-03	3.13E-04	3.02E-04
RH	OFF-LINK	4.06E-03	2.78E-04	6.15E-05	2.68E-01	1.84E-02	4.06E-03
	ON-LINK	1.33E-05	3.82E-06	1.60E-06	8.80E-04	2.52E-04	1.06E-04
	SRS	NM_R	NM_S	NM_U	NM_R	NM_S	NM_U
	CREW	6.05E-04	3.62E-05	6.48E-06			
CH	OFF-LINK	1.04E-06	5.30E-06	9.48E-08	2.02E-03	1.04E-02	1.85E-04
	ON-LINK	8.37E-04	9.26E-06	7.02E-06	1.64E+00	1.81E-02	1.37E-02
RH	OFF-LINK	9.63E-04	5.76E-05	1.03E-05	1.54E-01	9.22E-03	1.65E-03
	ON-LINK	2.41E-06	1.24E-05	2.21E-07	3.85E-04	1.98E-03	3.53E-05

Table B. 2 Alabama Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	SRS	AL_R	AL_S	AL_U	AL_R	AL_S	AL_U
	CREW	1.22E-03	6.01E-04	3.74E-05	1.58E-02	1.08E-01	1.66E-03
CH	OFF-LINK	8.07E-06	5.51E-05	8.50E-07	5.43E-01	4.94E-01	8.91E-02
CH	ON-LINK	2.78E-04	2.53E-04	4.56E-05	1.29E-03	8.82E-03	1.36E-04
RH	OFF-LINK	8.07E-06	5.51E-05	8.50E-07	4.45E-02	4.05E-02	7.30E-03
RH	ON-LINK	2.78E-04	2.53E-04	4.56E-05	1.58E-02	1.08E-01	1.66E-03

Table B. 3 Arkansas Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BETTIS	AR_R	AR_S	AR_U	AR_R	AR_S	AR_U
	CREW	1.77E-03	5.70E-04	3.51E-05			
CH	OFF-LINK	9.81E-06	5.56E-05	5.24E-07	9.81E-06	5.56E-05	5.24E-07
CH	ON-LINK	3.29E-04	1.77E-04	3.44E-05	3.29E-04	1.77E-04	3.44E-05
RH	OFF-LINK	2.28E-05	1.29E-04	1.22E-06	9.12E-05	5.17E-04	4.88E-06
RH	ON-LINK	7.66E-04	4.11E-04	8.00E-05	3.06E-03	1.64E-03	3.20E-04
	BROOKHAVEN	AR_R	AR_S	AR_U	AR_R	AR_S	AR_U
	CREW	1.77E-03	5.70E-04	3.50E-05			
CH	OFF-LINK	9.81E-06	5.56E-05	5.71E-06	8.00E-03	4.54E-02	4.66E-03
CH	ON-LINK	3.29E-04	2.65E-04	3.43E-05	2.68E-01	2.16E-01	2.80E-02
	KAPL	AR_R	AR_S	AR_U	AR_R	AR_S	AR_U
	CREW	1.77E-03	5.70E-04	3.50E-05			
CH	OFF-LINK	9.81E-06	5.56E-05	5.71E-06	1.36E-03	7.73E-03	7.94E-04
CH	ON-LINK	3.29E-04	1.77E-04	3.43E-05	4.57E-02	2.45E-02	4.76E-03
RH	OFF-LINK	2.28E-05	1.29E-04	1.33E-05	4.77E-03	2.70E-02	2.78E-03
RH	ON-LINK	7.66E-04	4.11E-04	7.98E-05	1.60E-01	8.59E-02	1.67E-02
	MATERIALSCOMMAND	AR_R	AR_S	AR_U	AR_R	AR_S	AR_U
	CREW	1.77E-03	5.70E-04	3.51E-05			
CH	OFF-LINK	9.81E-06	5.56E-05	5.24E-07	9.81E-06	5.56E-05	5.24E-07
CH	ON-LINK	3.29E-04	1.77E-04	3.44E-05	3.29E-04	1.77E-04	3.44E-05
	ORNL	AR_R	AR_S	AR_U	AR_R	AR_S	AR_U
	CREW	1.77E-03	5.70E-04	3.19E-05			
CH	OFF-LINK	9.81E-06	5.56E-05	4.76E-07	3.72E-03	2.11E-02	1.80E-04
CH	ON-LINK	3.29E-04	1.77E-04	1.99E-05	1.25E-01	6.69E-02	7.53E-03
RH	OFF-LINK	2.28E-05	1.29E-04	1.10E-06	6.18E-02	3.50E-01	2.99E-03
RH	ON-LINK	7.66E-04	4.11E-04	4.61E-05	2.08E+00	1.11E+00	1.25E-01

Table B. 4 Arizona Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	LBL/LLNL	AZ_R	AZ_S	AZ_U	AZ_R	AZ_S	AZ_U
	CREW	2.88E-03	2.05E-04	2.53E-05			
CH	OFF-LINK	9.18E-06	3.01E-05	4.95E-07	9.37E-04	3.07E-03	5.05E-05
CH	ON-LINK	5.63E-04	1.04E-04	5.13E-05	5.74E-02	1.06E-02	5.23E-03
	NTS	AZ_R	AZ_S	AZ_U			
	CREW	2.88E-03	2.05E-04	2.14E-05	AZ_R	AZ_S	AZ_U
CH	OFF-LINK	9.18E-06	3.01E-05	4.19E-07	2.88E-03	9.44E-03	1.32E-04
CH	ON-LINK	5.63E-04	1.04E-04	3.47E-05	1.77E-01	3.26E-02	1.09E-02

Table B. 5 California Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	LBL/LLNL	CA_R	CA_S	CA_U	CA_R	CA_S	CA_U
	CREW	4.49E-03	5.27E-04	2.27E-04			
CH	OFF-LINK	1.45E-05	6.67E-05	5.26E-06	1.48E-03	6.80E-03	5.36E-04
CH	ON-LINK	1.83E-03	5.04E-04	6.43E-04	1.87E-01	5.14E-02	6.56E-02
	NTS	CA_R	CA_S	CA_U	CA_R	CA_S	CA_U
	CREW	2.19E-03	1.00E-04	1.25E-05			
CH	OFF-LINK	3.22E-06	1.23E-05	2.04E-07	1.01E-03	3.85E-03	6.40E-05
CH	ON-LINK	8.94E-04	9.60E-05	3.52E-05	2.81E-01	3.01E-02	1.10E-02

Table B. 6 Colorado Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	INL/ANLW	CO_R	CO_S	CO_U	CO_R	CO_S	CO_U
	CREW	1.73E-03	7.11E-04	1.87E-04			
CH	OFF-LINK	8.46E-06	1.04E-04	3.40E-06	1.12E-01	1.38E+00	4.50E-02
CH	ON-LINK	3.83E-04	3.62E-04	2.60E-04	5.07E+00	4.79E+00	3.43E+00
RH	OFF-LINK	1.17E-03	2.52E-04	1.62E-03	4.85E-01	1.04E-01	6.69E-01
RH	ON-LINK	2.44E-04	6.52E-06	9.61E-06	1.01E-01	2.70E-03	3.98E-03
	RF	CO_R	CO_S	CO_U	CO_R	CO_S	CO_U
	CREW	1.29E-03	6.34E-04	1.87E-04			
CH	OFF-LINK	5.26E-06	9.80E-05	3.44E-06	7.41E-03	1.38E-01	4.85E-03
CH	ON-LINK	3.51E-04	3.24E-04	2.60E-04	4.95E-01	4.56E-01	3.66E-01
	RICHLAND	CO_R	CO_S	CO_U	CO_R	CO_S	CO_U
	CREW	1.73E-03	7.14E-04	2.05E-04			
CH	OFF-LINK	8.50E-06	1.05E-04	3.73E-06	1.20E-02	1.48E-01	5.26E-03
CH	ON-LINK	4.71E-04	3.65E-04	2.76E-04	6.63E-01	5.14E-01	3.89E-01
RH	OFF-LINK	1.98E-05	2.44E-04	8.69E-06	3.46E-02	4.27E-01	1.52E-02
RH	ON-LINK	1.10E-03	8.48E-04	6.42E-04	1.91E+00	1.48E+00	1.12E+00

Table B. 7 Nevada Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	NTS	NV_R	NV_S	NV_U	NV_R	NV_S	NV_U
	CREW	3.53E-04	1.19E-04	7.12E-05			
CH	OFF-LINK	2.39E-06	1.59E-05	1.88E-06	7.49E-04	4.98E-03	5.90E-04
	ON-LINK	1.23E-04	1.10E-04	3.13E-04	3.87E-02	3.44E-02	9.82E-02

Table B. 8 Georgia Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	SRS	GA_R	GA_S	GA_U	GA_R	GA_S	GA_U
	CREW	1.02E-03	7.84E-04	1.44E-04			
CH	OFF-LINK	7.99E-06	1.07E-04	2.63E-06	1.56E-02	2.08E-01	5.14E-03
	ON-LINK	3.55E-04	5.81E-04	3.97E-04	6.93E-01	1.13E+00	7.75E-01
RH	OFF-LINK	1.59E-06	1.90E-03	1.38E-02	2.54E-04	3.04E-01	2.21E+00
	ON-LINK	2.48E-04	1.18E-02	6.62E-03	3.97E-02	1.89E+00	1.06E+00

Table B. 9 Louisiana Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	SRS	LA_R	LA_S	LA_U	LA_R	LA_S	LA_U
	CREW	1.12E-03	5.20E-04	3.14E-05			
CH	OFF-LINK	5.29E-06	4.85E-05	6.88E-07	1.03E-02	9.47E-02	1.34E-03
	ON-LINK	1.97E-04	1.54E-04	3.06E-05	3.85E-01	3.01E-01	5.98E-02
RH	OFF-LINK	7.92E-05	7.26E-04	1.03E-05	1.27E-02	1.16E-01	1.65E-03
	ON-LINK	2.95E-03	2.31E-03	4.58E-04	4.72E-01	3.69E-01	7.33E-02

Table B. 10 Mississippi Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	SRS	MS_R	MS_S	MS_U	MS_R	MS_S	MS_U
	CREW	9.33E-04	3.84E-04	2.31E-05			
CH	OFF-LINK	5.84E-06	3.89E-05	5.18E-07	1.14E-02	7.60E-02	1.01E-03
	ON-LINK	2.62E-04	2.10E-04	4.18E-05	5.12E-01	4.10E-01	8.16E-02
RH	OFF-LINK	8.74E-05	5.82E-04	7.75E-06	1.40E-02	9.32E-02	1.24E-03
	ON-LINK	3.92E-03	3.14E-03	6.26E-04	6.28E-01	5.03E-01	1.00E-01

Table B. 11 South Carolina Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	SRS	SC_R	SC_S	SC_U			
	CREW	7.77E-05	4.32E-05	2.16E-06	9.22E-04	8.22E-03	5.88E-05
CH	OFF-LINK	4.72E-07	4.21E-06	3.01E-08	4.28E-02	4.61E-02	4.67E-03
	ON-LINK	2.19E-05	2.36E-05	2.39E-06	1.13E-03	1.01E-02	7.21E-05
RH	OFF-LINK	7.07E-06	6.30E-05	4.51E-07	5.25E-02	5.65E-02	5.72E-03
	ON-LINK	3.28E-04	3.53E-04	3.58E-05	9.22E-04	8.22E-03	5.88E-05

Table B. 12 Idaho Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	INL/ANLW	ID_R	ID_S	ID_U	ID_R	ID_S	ID_U
	CREW	9.84E-04	1.46E-04	1.18E-05			
CH	OFF-LINK	4.18E-06	1.78E-05	1.90E-07	5.53E-02	2.35E-01	2.51E-03
	ON-LINK	2.46E-04	8.74E-05	2.33E-05	3.25E+00	1.16E+00	3.09E-01
RH	OFF-LINK	2.47E-04	1.63E-05	1.37E-03	1.02E-01	6.75E-03	5.69E-01
	ON-LINK	4.16E-05	3.63E-07	1.03E-05	1.72E-02	1.50E-04	4.26E-03
	RICHLAND	ID_R	ID_S	ID_U	ID_R	ID_S	ID_U
	CREW	1.93E-03	4.28E-04	4.39E-05			
CH	OFF-LINK	9.36E-06	4.46E-05	1.97E-06	1.32E-02	6.29E-02	2.77E-03
	ON-LINK	4.84E-04	2.55E-04	8.64E-05	6.82E-01	3.59E-01	1.22E-01
RH	OFF-LINK	2.18E-05	1.04E-04	1.75E-06	3.80E-02	1.81E-01	3.06E-03
	ON-LINK	1.13E-03	5.94E-04	2.01E-04	1.97E+00	1.04E+00	3.52E-01

Table B. 13 Illinois Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	ANLE	IL_R	IL_S	IL_U	IL_R	IL_S	IL_U
	CREW	1.67E-03	7.75E-04	6.11E-05			
CH	OFF-LINK	1.05E-05	7.64E-05	9.05E-07	8.53E-04	6.19E-03	7.33E-05
	ON-LINK	4.07E-04	3.89E-04	8.04E-05	3.30E-02	3.15E-02	6.51E-03
RH	OFF-LINK	2.55E-03	1.19E-03	2.11E-06	2.12E-01	9.86E-02	1.75E-04
	ON-LINK	2.45E-05	1.78E-04	1.87E-04	2.03E-03	1.47E-02	1.55E-02
	BATTELLE	IL_R	IL_S	IL_U	IL_R	IL_S	IL_U
	CREW	9.85E-04	4.85E-04	2.73E-05			
CH	OFF-LINK	5.87E-06	4.36E-05	3.57E-07	5.87E-06	4.36E-05	3.57E-07
	ON-LINK	2.41E-04	2.44E-04	5.22E-05	2.41E-04	2.44E-04	5.22E-05

Table B. 14 Indiana Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BATTELLE	IN_R	IN_S	IN_U	IN_R	IN_S	IN_U
	CREW	8.90E-04	4.34E-04	4.87E-05			
CH	OFF-LINK	6.11E-06	4.34E-05	7.37E-07	6.11E-06	4.34E-05	7.37E-07
	ON-LINK	2.10E-04	2.11E-04	6.67E-05	2.10E-04	2.11E-04	6.67E-05

Table B. 15 Kansas Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	MURR	KS_R	KS_S	KS_U	KS_R	KS_S	KS_U
	CREW	1.56E-03	3.74E-04	8.98E-05			
CH	OFF-LINK	7.03E-06	4.65E-05	3.06E-06	7.03E-06	4.65E-05	3.06E-06
	ON-LINK	1.42E-04	5.93E-05	4.53E-05	1.42E-04	5.93E-05	4.53E-05

Table B. 16 Kentucky Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BETTIS	KY_R	KY_S	KY_U	KY_R	KY_S	KY_U
	CREW	1.21E-03	8.09E-04	8.44E-05			
CH	OFF-LINK	9.54E-06	8.21E-05	1.21E-06	9.54E-06	8.21E-05	1.21E-06
	ON-LINK	3.42E-04	4.43E-04	1.40E-04	3.42E-04	4.43E-04	1.40E-04
RH	OFF-LINK	1.43E-04	1.23E-03	1.55E-05	5.71E-04	4.92E-03	6.18E-05
	ON-LINK	5.12E-03	6.63E-03	1.24E-03	2.05E-02	2.65E-02	4.95E-03

Table B. 17 Maryland Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BROOKHAVEN	MD_R	MD_S	MD_U	MD_R	MD_S	MD_U
	CREW	3.08E-05	6.64E-05	8.31E-06			
CH	OFF-LINK	2.27E-07	8.64E-06	1.14E-06	1.85E-04	7.05E-03	9.28E-04
	ON-LINK	1.22E-05	4.96E-05	1.64E-05	9.99E-03	4.04E-02	1.34E-02
	KAPL	MD_R	MD_S	MD_U	MD_R	MD_S	MD_U
	CREW	3.08E-05	6.64E-05	8.31E-06			
CH	OFF-LINK	2.27E-07	8.64E-06	1.14E-06	3.16E-05	1.20E-03	1.58E-04
	ON-LINK	1.22E-05	4.96E-05	1.64E-05	1.70E-03	6.89E-03	2.28E-03
RH	OFF-LINK	5.30E-07	2.01E-05	2.65E-06	1.11E-04	4.20E-03	5.53E-04
	ON-LINK	2.86E-05	1.15E-04	3.81E-05	5.98E-03	2.41E-02	7.96E-03
	MURR	MD_R	MD_S	MD_U	MD_R	MD_S	MD_U
	CREW	7.59E-04	3.17E-04	6.48E-05			
CH	OFF-LINK	4.14E-06	4.55E-05	9.49E-07	4.14E-06	4.55E-05	9.49E-07
	ON-LINK	7.23E-05	5.26E-05	2.39E-05	7.23E-05	5.26E-05	2.39E-05

Table B. 18 Missouri Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	ANL_E	MO_R	MO_S	MO_U	MO_R	MO_S	MO_U
	CREW	1.57E-03	8.54E-04	5.17E-05			
CH	OFF-LINK	1.23E-05	9.52E-05	7.64E-07	9.98E-04	7.71E-03	6.19E-05
	ON-LINK	3.01E-04	2.83E-04	3.96E-05	2.44E-02	2.29E-02	3.20E-03
RH	OFF-LINK	2.87E-05	2.21E-04	1.77E-06	2.38E-03	1.84E-02	1.47E-04
	ON-LINK	6.98E-04	6.58E-04	9.60E-05	5.80E-02	5.46E-02	7.97E-03
	BATTELLE	MO_R	MO_S	MO_U	MO_R	MO_S	MO_U
	CREW	1.57E-03	8.54E-04	5.17E-05			
CH	OFF-LINK	1.23E-05	9.52E-05	7.64E-07	1.23E-05	9.52E-05	7.64E-07
	ON-LINK	3.01E-04	2.83E-04	3.96E-05	3.01E-04	2.83E-04	3.96E-05

Table B. 19 New Jersey Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BROOKHAVEN	NJ_R	NJ_S	NJ_U	NJ_R	NJ_S	NJ_U
	CREW	2.17E-04	3.65E-04	8.97E-05			
CH	OFF-LINK	1.62E-06	5.76E-05	2.38E-06	1.32E-03	4.70E-02	1.94E-03
	ON-LINK	1.12E-04	2.39E-04	1.33E-04	9.14E-02	1.95E-01	1.08E-01
	KAPL	NJ_R	NJ_S	NJ_U	NJ_R	NJ_S	NJ_U
	CREW	2.17E-04	3.65E-04	8.97E-05			
CH	OFF-LINK	1.62E-06	5.76E-05	2.38E-06	2.25E-04	8.01E-03	3.31E-04
	ON-LINK	1.12E-04	2.39E-04	1.33E-04	1.56E-02	3.32E-02	1.85E-02
RH	OFF-LINK	3.77E-06	1.34E-04	5.52E-06	7.88E-04	2.80E-02	1.15E-03
	ON-LINK	2.60E-04	5.56E-04	3.10E-04	5.43E-02	1.16E-01	6.48E-02

Table B. 20 New York Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BROOKHAVEN	NY_R	NY_S	NY_U	NY_R	NY_S	NY_U
	CREW	1.14E-04	4.59E-04	3.66E-04			
CH	OFF-LINK	4.06E-07	8.81E-05	1.19E-05	3.31E-04	7.19E-02	9.71E-03
	ON-LINK	1.87E-05	1.65E-04	4.72E-04	1.53E-02	1.35E-01	3.85E-01
	KAPL	NY_R	NY_S	NY_U	NY_R	NY_S	NY_U
	CREW	4.95E-03	5.94E-04	5.76E-05			
CH	OFF-LINK	3.15E-05	7.33E-05	1.33E-06	4.38E-03	1.02E-02	1.84E-04
	ON-LINK	8.14E-04	2.13E-04	7.44E-05	1.13E-01	2.96E-02	1.03E-02
RH	OFF-LINK	3.15E-05	7.33E-05	1.33E-06	6.58E-03	1.53E-02	2.77E-04
	ON-LINK	8.14E-04	2.13E-04	7.44E-05	1.70E-01	4.45E-02	1.55E-02

Table B. 21 Ohio Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BATTELLE	OH_R	OH_S	OH_U	OH_R	OH_S	OH_U
	CREW	4.32E-04	3.98E-04	3.68E-05			
CH	OFF-LINK	3.44E-06	3.98E-05	5.48E-07	3.44E-06	3.98E-05	5.48E-07
	ON-LINK	1.55E-04	2.08E-04	3.69E-05	1.55E-04	2.08E-04	3.69E-05
	BETTIS	OH_R	OH_S	OH_U	OH_R	OH_S	OH_U
	CREW	1.18E-03	7.99E-04	8.91E-05			
CH	OFF-LINK	8.11E-06	8.51E-05	1.32E-06	8.11E-06	8.51E-05	1.32E-06
	ON-LINK	4.25E-04	4.18E-04	1.17E-04	4.25E-04	4.18E-04	1.17E-04
RH	OFF-LINK	1.21E-04	1.27E-03	1.98E-05	4.86E-04	5.10E-03	7.91E-05
	ON-LINK	6.36E-03	6.26E-03	1.76E-03	2.54E-02	2.50E-02	7.02E-03

Table B. 22 Oklahoma Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	ANL_E	OK_R	OK_S	OK_U	OK_R	OK_S	OK_U
	CREW	2.31E-03	6.90E-04	8.67E-05			
CH	OFF-LINK	1.19E-05	8.02E-05	1.40E-06	9.66E-04	6.49E-03	1.13E-04
	ON-LINK	5.56E-04	2.52E-04	9.93E-05	4.50E-02	2.04E-02	8.04E-03
RH	OFF-LINK	2.78E-05	1.87E-04	2.72E-06	2.31E-03	1.55E-02	2.26E-04
	ON-LINK	1.30E-03	5.86E-04	1.84E-04	1.08E-01	4.86E-02	1.53E-02
	BATTELLE	OK_R	OK_S	OK_U	OK_R	OK_S	OK_U
	CREW	2.31E-03	6.90E-04	8.67E-05			
CH	OFF-LINK	1.19E-05	8.02E-05	1.40E-06	1.19E-05	8.02E-05	1.40E-06
	ON-LINK	5.56E-04	2.52E-04	9.93E-05	5.56E-04	2.52E-04	9.93E-05
	MURR	OK_R	OK_S	OK_U	OK_R	OK_S	OK_U
	CREW	1.86E-03	3.61E-04	4.93E-05			
CH	OFF-LINK	7.59E-06	4.16E-05	7.82E-07	7.59E-06	4.16E-05	7.82E-07
	ON-LINK	2.23E-04	6.60E-05	2.03E-05	2.23E-04	6.60E-05	2.03E-05

Table B. 23 Oregon Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	RICHLAND	OR_R	OR_S	OR_U	OR_R	OR_S	OR_U
	CREW	1.63E-03	1.74E-04	1.37E-05			
CH	OFF-LINK	5.46E-06	1.95E-05	2.05E-07	7.70E-03	2.74E-02	2.88E-04
	ON-LINK	3.90E-04	9.90E-05	2.65E-05	5.49E-01	1.39E-01	3.73E-02
RH	OFF-LINK	1.28E-05	4.52E-05	4.76E-07	2.23E-02	7.90E-02	8.31E-04
	ON-LINK	9.06E-04	2.30E-04	6.15E-05	1.58E+00	4.03E-01	1.08E-01

Table B. 24 Pennsylvania Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BETTIS	PA_R	PA_S	PA_U	PA_R	PA_S	PA_U
	CREW	1.18E-04	2.28E-04	8.73E-05			
CH	OFF-LINK	9.82E-07	3.63E-05	1.40E-06	9.82E-07	3.63E-05	1.40E-06
	ON-LINK	4.83E-05	1.67E-04	1.88E-04	4.83E-05	1.67E-04	1.88E-04
RH	OFF-LINK	2.28E-06	8.43E-05	3.25E-06	9.12E-06	3.37E-04	1.30E-05
	ON-LINK	1.12E-04	3.88E-04	4.37E-04	4.50E-04	1.55E-03	1.75E-03
	BROOKHAVEN	PA_R	PA_S	PA_U	PA_R	PA_S	PA_U
	CREW	7.26E-04	6.50E-04	6.53E-05			
CH	OFF-LINK	6.30E-06	7.28E-05	1.13E-05	5.14E-03	5.94E-02	9.22E-03
	ON-LINK	2.98E-04	4.74E-04	1.20E-04	2.43E-01	3.87E-01	9.75E-02
	KAPL	PA_R	PA_S	PA_U	PA_R	PA_S	PA_U
	CREW	7.26E-04	6.50E-04	6.53E-05			
CH	OFF-LINK	6.30E-06	7.28E-05	1.13E-05	8.76E-04	1.01E-02	1.57E-03
	ON-LINK	2.98E-04	4.74E-04	1.20E-04	4.14E-02	6.59E-02	1.66E-02
RH	OFF-LINK	1.47E-05	1.69E-04	2.63E-05	3.07E-03	3.54E-02	5.49E-03
	ON-LINK	6.94E-04	1.10E-03	2.79E-04	1.45E-01	2.31E-01	5.83E-02

Table B. 25 Tennessee Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BETTIS	TN_R	TN_S	TN_U	TN_R	TN_S	TN_U
	CREW	1.35E-03	6.92E-04	1.24E-04			
CH	OFF-LINK	8.28E-06	8.48E-05	2.05E-06	8.28E-06	8.48E-05	2.05E-06
	ON-LINK	4.43E-04	3.96E-04	1.75E-04	4.43E-04	3.96E-04	1.75E-04
RH	OFF-LINK	1.92E-05	1.97E-04	4.77E-06	7.68E-05	7.89E-04	1.91E-05
	ON-LINK	1.03E-03	9.21E-04	4.08E-04	4.13E-03	3.68E-03	1.63E-03
	BROOKHAVEN	TN_R	TN_S	TN_U	TN_R	TN_S	TN_U
	CREW	2.68E-03	1.52E-03	1.86E-04			
CH	OFF-LINK	1.95E-05	1.68E-04	3.33E-05	1.59E-02	1.37E-01	2.72E-02
	ON-LINK	8.80E-04	8.69E-04	2.64E-04	7.18E-01	7.09E-01	2.15E-01
	KAPL	TN_R	TN_S	TN_U	TN_R	TN_S	TN_U
	CREW	2.68E-03	1.52E-03	1.86E-04			
CH	OFF-LINK	1.95E-05	1.68E-04	3.33E-05	2.71E-03	2.33E-02	4.63E-03
	ON-LINK	8.80E-04	8.69E-04	2.64E-04	1.22E-01	1.21E-01	3.67E-02
RH	OFF-LINK	4.54E-05	3.89E-04	7.76E-05	9.49E-03	8.14E-02	1.62E-02
	ON-LINK	2.05E-03	2.03E-03	6.14E-04	4.28E-01	4.24E-01	1.28E-01
	MATERIALS COMMAND	TN_R	TN_S	TN_U			
	CREW	2.68E-03	1.52E-03	1.55E-04	TN_R	TN_S	TN_U
CH	OFF-LINK	1.95E-05	1.68E-04	2.56E-06	1.95E-05	1.68E-04	2.56E-06
	ON-LINK	8.80E-04	8.70E-04	1.39E-04	8.80E-04	8.70E-04	1.39E-04
	ORNL	TN_R	TN_S	TN_U	TN_R	TN_S	TN_U
	CREW	2.18E-03	9.32E-04	1.50E-04			
CH	OFF-LINK	1.43E-05	1.02E-04	2.55E-06	5.43E-03	3.87E-02	9.66E-04
	ON-LINK	7.14E-04	5.33E-04	2.12E-04	2.71E-01	2.02E-01	8.05E-02
RH	OFF-LINK	3.34E-05	2.38E-04	5.94E-06	9.06E-02	6.44E-01	1.61E-02
	ON-LINK	1.67E-03	1.24E-03	4.95E-04	4.51E+00	3.36E+00	1.34E+00

Table B. 26 Texas Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	ANL_E	TX-R	TX-S	TX_U	TX-R	TX-S	TX_U
	CREW	1.39E-03	1.02E-04	1.13E-05			
CH	OFF-LINK	2.84E-06	1.51E-05	1.94E-07	2.30E-04	1.22E-03	1.57E-05
CH	ON-LINK	2.76E-04	3.39E-05	2.50E-05	2.24E-02	2.75E-03	2.02E-03
RH	OFF-LINK	2.32E-03	1.70E-04	1.68E-06	1.93E-01	1.41E-02	1.39E-04
RH	ON-LINK	6.63E-06	3.53E-05	8.46E-05	5.50E-04	2.93E-03	7.02E-03
	BATTELLE	TX-R	TX-S	TX_U	TX-R	TX-S	TX_U
	CREW	1.39E-03	1.02E-04	1.09E-04			
CH	OFF-LINK	2.84E-06	1.51E-05	1.88E-06	2.84E-06	1.51E-05	1.88E-06
CH	ON-LINK	2.76E-04	3.39E-05	2.29E-04	2.76E-04	3.39E-05	2.29E-04
	BETTIS	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	4.33E-03	1.26E-03	1.88E-04			
CH	OFF-LINK	2.10E-05	1.69E-04	3.45E-06	2.10E-05	1.69E-04	3.45E-06
CH	ON-LINK	8.62E-04	4.20E-04	2.06E-04	8.62E-04	4.20E-04	2.06E-04
RH	OFF-LINK	7.24E-03	2.11E-03	8.01E-06	2.89E-02	8.43E-03	3.21E-05
RH	ON-LINK	4.87E-05	3.93E-04	4.79E-04	1.95E-04	1.57E-03	1.92E-03
	BROOKHAVEN	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	2.68E-03	1.52E-03	1.70E-03			
CH	OFF-LINK	2.07E-05	1.77E-04	2.96E-05	1.69E-02	1.44E-01	2.41E-02
CH	ON-LINK	5.33E-04	5.05E-04	1.20E-03	4.35E-01	4.12E-01	9.77E-01
	KAPL	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	4.33E-03	1.26E-03	2.09E-04			
CH	OFF-LINK	2.10E-05	1.69E-04	3.88E-06	2.91E-03	2.35E-02	5.39E-04
CH	ON-LINK	8.62E-04	4.20E-04	2.29E-04	1.20E-01	5.84E-02	3.18E-02
RH	OFF-LINK	2.43E-02	7.09E-03	9.02E-06	5.09E+00	1.48E+00	1.89E-03
RH	ON-LINK	4.87E-05	3.93E-04	5.33E-04	1.02E-02	8.22E-02	1.11E-01
	MATERIALSCOMMAND	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	1.52E-03	1.28E-03	5.18E-05			
CH	OFF-LINK	1.17E-05	1.30E-04	9.09E-07	1.17E-05	1.30E-04	9.09E-07
CH	ON-LINK	3.03E-04	4.43E-04	5.68E-05	3.03E-04	4.43E-04	5.68E-05
	MURR	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	1.39E-03	1.41E-04	4.67E-05			
CH	OFF-LINK	2.84E-06	1.58E-05	8.04E-07	2.84E-06	1.58E-05	8.04E-07
CH	ON-LINK	2.76E-04	6.09E-05	4.96E-05	2.76E-04	6.09E-05	4.96E-05
	ORNL	TX_R	TX_S	TX_U	TX_R	TX_S	TX_U
	CREW	4.33E-03	1.27E-03	2.09E-04			
CH	OFF-LINK	2.10E-05	1.69E-04	3.87E-06	7.94E-03	6.41E-02	1.47E-03
CH	ON-LINK	8.63E-04	4.21E-04	2.28E-04	3.27E-01	1.60E-01	8.65E-02
RH	OFF-LINK	7.24E-03	2.12E-03	9.01E-06	1.96E+01	5.74E+00	2.44E-02
RH	ON-LINK	4.87E-05	3.94E-04	5.32E-04	1.32E-01	1.07E+00	1.44E+00

Table B. 27 Utah Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	INL/ANLW	UT_R	UT_S	UT_U	UT_R	UT_S	UT_U
	CREW	8.16E-04	2.87E-04	8.87E-06			
CH	OFF-LINK	4.42E-06	2.81E-05	1.41E-07	5.85E-02	3.72E-01	1.87E-03
CH	ON-LINK	1.35E-04	1.27E-04	1.20E-05	1.78E+00	1.68E+00	1.58E-01
RH	OFF-LINK	7.15E-05	3.04E-07	4.95E-03	2.96E-02	1.26E-04	2.05E+00
RH	ON-LINK	3.22E-04	1.64E-05	1.36E-05	1.33E-01	6.79E-03	5.65E-03
	INL/ANLW	UT-R	UT_S	UT_U	UT-R	UT_S	UT_U
	CREW	1.01E-03	2.79E-04	8.10E-06			
CH	OFF-LINK	4.24E-06	2.71E-05	1.29E-07	5.97E-03	3.81E-02	1.82E-04
CH	ON-LINK	1.80E-04	1.22E-04	6.52E-06	2.54E-01	1.72E-01	9.19E-03
RH	OFF-LINK	1.07E-05	6.86E-05	3.00E-07	1.87E-02	1.20E-01	5.24E-04
RH	ON-LINK	4.57E-04	3.11E-04	1.52E-05	7.98E-01	5.42E-01	2.66E-02

Table B. 28 Virginia Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BROOKHAVEN	VA_R	VA_S	VA_U	VA_R	VA_S	VA_U
	CREW	1.52E-03	1.24E-03	7.86E-05			
CH	OFF-LINK	6.84E-04	9.92E-04	2.96E-05	5.58E-01	8.09E-01	2.41E-02
CH	ON-LINK	2.50E-03	2.04E-03	2.23E-04	2.04E+00	1.66E+00	1.82E-01
	KAPL	VA_R	VA_S	VA_U	VA_R	VA_S	VA_U
	CREW	1.52E-03	1.24E-03	5.76E-05			
CH	OFF-LINK	6.84E-04	9.92E-04	1.04E-05	9.50E-02	1.38E-01	1.44E-03
CH	ON-LINK	8.40E-03	6.86E-03	1.13E-04	1.17E+00	9.53E-01	1.58E-02
RH	OFF-LINK	2.68E-05	2.96E-04	2.41E-05	5.60E-03	6.18E-02	5.03E-03
RH	ON-LINK	1.60E-03	2.30E-03	2.64E-04	3.33E-01	4.82E-01	5.51E-02
	MATERIALSCOMMAND	VA_R	VA_S	VA_U	VA_R	VA_S	VA_U
	CREW	1.75E-03	1.42E-03	1.53E-04			
CH	OFF-LINK	7.83E-04	1.13E-03	2.76E-06	7.83E-04	1.13E-03	2.76E-06
CH	ON-LINK	1.94E-03	1.57E-03	3.00E-04	1.94E-03	1.57E-03	3.00E-04

Table B. 29 Washington Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	RICHLAND	WA_R	WA_S	WA_U	WA_R	WA_S	WA_U
	CREW	3.29E-04	3.89E-05	2.49E-05			
CH	OFF-LINK	5.98E-07	5.66E-06	6.36E-07	5.97E-03	3.81E-02	1.82E-04
CH	ON-LINK	7.28E-05	2.05E-05	4.52E-05	2.54E-01	1.72E-01	9.19E-03
RH	OFF-LINK	8.95E-06	8.47E-05	9.52E-06	1.87E-02	1.20E-01	5.24E-04
RH	ON-LINK	1.09E-03	3.07E-04	6.77E-04	7.98E-01	5.42E-01	2.66E-02

Table B. 30 West Virginia Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	BETTIS	WV_R	WV_S	WV_U	WV_R	WV_S	WV_U
	CREW	4.70E-05	6.10E-05	5.94E-06			
CH	OFF-LINK	4.27E-07	7.33E-06	9.69E-08	4.27E-07	7.33E-06	9.69E-08
	ON-LINK	1.90E-05	4.39E-05	6.73E-06	1.90E-05	4.39E-05	6.73E-06
RH	OFF-LINK	6.39E-06	1.10E-04	1.45E-06	2.56E-05	4.39E-04	5.80E-06
	ON-LINK	2.84E-04	6.57E-04	1.01E-04	1.14E-03	2.63E-03	4.03E-04
	BROOKHAVEN	WV_R	WV_S	WV_U	WV_R	WV_S	WV_U
	CREW	6.80E-05	1.55E-04	3.78E-06			
CH	OFF-LINK	7.61E-07	1.76E-05	5.11E-08	6.21E-04	1.44E-02	4.17E-05
	ON-LINK	2.76E-05	1.12E-04	4.28E-06	2.25E-02	9.14E-02	3.49E-03
	KAPL	WV_R	WV_S	WV_U	WV_R	WV_S	WV_U
	CREW	6.80E-05	1.55E-04	3.78E-06			
CH	OFF-LINK	7.61E-07	1.76E-05	5.11E-08	1.06E-04	1.87E-05	1.92E-07
	ON-LINK	2.76E-05	1.12E-04	4.28E-06	3.84E-03	3.37E-05	1.70E-05
	OFF-LINK	1.14E-05	2.63E-04	7.65E-07	2.38E-03	4.50E-05	2.02E-05
RH	ON-LINK	4.13E-04	1.68E-03	6.41E-05	8.64E-02	7.87E-05	9.20E-04
	ON-LINK	WV_R	WV_S	WV_U	WV_R	WV_S	WV_U

Table B. 31 Wyoming Incident-free Collective Dose (person-rem)

		SINGLE SHIPMENT			TOTAL SHIPMENTS		
	INL/ANLW	WY_R	WY_S	WY_U	WY_R	WY_S	WY_U
	CREW	3.02E-03	1.40E-04	1.42E-05			
CH	OFF-LINK	1.67E-05	1.74E-07	2.18E-07	2.21E-01	2.30E-03	2.88E-03
	ON-LINK	8.14E-05	9.47E-06	1.33E-05	1.08E+00	1.25E-01	1.76E-01
RH	OFF-LINK	3.88E-05	4.05E-07	1.52E-06	1.61E-02	1.68E-04	6.31E-04
	ON-LINK	1.90E-04	2.20E-05	3.10E-04	7.87E-02	9.11E-03	1.28E-01
	RICHLAND	WY_R	WY_S	WY_U	WY_R	WY_S	WY_U
	CREW	3.03E-03	1.40E-04	8.85E-06			
CH	OFF-LINK	5.29E-06	1.67E-05	1.68E-07	5.29E-06	1.67E-05	1.68E-07
	ON-LINK	4.75E-04	5.41E-05	9.16E-06	4.75E-04	5.41E-05	9.16E-06
RH	OFF-LINK	7.92E-05	2.50E-04	2.52E-06	7.92E-05	2.50E-04	2.52E-06
	ON-LINK	7.11E-03	8.10E-04	1.37E-04	7.11E-03	8.10E-04	1.37E-04

550601

Attachment 2

Sandia National Laboratories
Waste Isolation Pilot Plant

Summary Report for Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant

	Print	Signature	Date
Author:	Ruth F. Weiner (6765)	[signature] for	12/11/08
Author:	Sean C. Dunagan (6711)	[signature]	12/11/08
Technical Review:	Lori J. Dotson (6712)	[signature] for	12/11/08
QA Review:	Mario J. Chavez (6710)	[signature] for	12/11/08
Management Review:	Moo Y. Lee (6711)	[signature]	12/11/08

WIPP:1.6.4:PM:QA-L:549453

EXECUTIVE SUMMARY

This TA, an update to the SEIS-II (DOE, 1997b), evaluated the impacts associated with the transportation of CH-TRU and RH-TRU waste from waste generator sites to the WIPP, using the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considered the impacts of transporting these wastes. Only transportation by truck was considered.

The TA used updated census data (U.S. Census Bureau 2006), changes in the number of shipments due to the use of different shipping containers, new TRU waste inventories, and WebTRAGIS to deterimine the routes instead of HIGHWAY. In addition, the analysis was conducted using an improved version of RADTRAN, Version 6 for the loss-of-lead shielding calculations and Version 5.6 for all other calculations. The improvements to RADTRAN, as well as the use of updated inventory (DOE 2008a) to calculate more realistic parameter values like a smaller TI, have resulted in smaller doses than those calculated in the SEIS-II for the same set of receptors. The number of shipments represents a more realistic value as it was determined using the most recent inventory (DOE 2008a) and the current and anticipated shipping containers. The use of WebTRAGIS resulted in more accurate routes and a more accurate simulation. The total population has increased with the new census data and has shifted from both urban and rural areas to suburbs. The net result is relatively larger doses to suburban than to urban populations. This TA also used a different methodology with respect to vehicle densities which played a significant role in the increase in the suburbs areas.

The analyses of radiological and non-radiological impacts incorporated different conservatisms and different degrees of conservatism, so that no conclusions can really be drawn by comparing them. The radiologic impacts are generally smaller than those in the SEIS-II, mostly because of the more precise analytical methods available. There are only a few instances (e.g., the rest stop employee, inspectors) where calculated doses are not insignificant, and these are largely due to conservative assumptions, in particular the simple addition of the number of shipments to which the receptor is exposed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acronyms

ALARA	As low as reasonably achievable (refers to occupational radiation exposure)
ANL	Argonne National Laboratory
ANL-E	Argonne National Laboratory – East
ANL-W	Argonne National Laboratory – West
AP	analysis plan
BAPL, BT	Bettis Atomic Power Laboratory
BCL, BL	Battelle Columbus Laboratories
BN	Brookhaven National Laboratory
BTS	(US Department of Transportation) Bureau of Transportation Statistics
BW	Babcock & Wilcox
CH	contact-handled
COTS	commercial off-the-shelf
DOE	(U.S.) Department of Energy
DOT	(U.S.) Department of Transportation
EIS	environmental impact statement
EPA	(U.S.) Environmental Protection Agency
ETEC	Energy Technology Engineering Center
FR	Federal Register
GE-VNC	General Electric - Vallecitos Nuclear Center
HRCQ	Highway Route Controlled Quantity
IDLH	immediately dangerous to life and health
INL, IN	Idaho National Laboratory
ISCORS	Interagency Steering Committee on Radiation Standards
KAPL, KA	Knolls Atomic Power Laboratory
K-NFS	Knolls Atomic Power Laboratory - Nuclear Fuel Services
LANL, LA	Los Alamos National Laboratory
LBNL, LB	Lawrence Berkeley National Laboratory
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LOS	Loss of (lead gamma) Shielding
MC	U.S. Army Materials Command
MEI	maximally exposed individual
MURR, MU	Missouri University Research Reactor
NAAQS	National Ambient Air Quality Standard.
NIOSH	National Institute of Occupational Safety and Health
NM	New Mexico
NRC	(U.S.) Nuclear Regulatory Commission
NRD	NRD L.L.C.
NTS, NT	Nevada Test Site
ORNL, OR	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PM_{10}	(respirable) particulate matter
R	Rural
RAM	radioactive material

RF	Rocky Flats Environmental Technology Site
RH	remote-handled
RITA	(DOT) Research and Innovative Technology Administration
RL	Richland (Hanford Works)
RMEI	reasonably maximally exposed individual
ROD	record of decision
S	Suburban
SA, SNL	Sandia National Laboratories
SEIS	supplemental environmental impact statement
SPRU	Separations Process Research Unit
SRS	Savannah River Site
SWB	Standard Waste Box
TA	transportation analysis
TDOP	Ten-Drum Overpack
TI	transportation index
TRAGIS	Transportation Geographic Information System
TRAMPAC	TRUPACT Authorized Methods for Payload Control
TRU	transuranic
TRUPACT	Transuranic Packaging Transporter
U	Urban
VOC	volatile organic compound
WAC	waste acceptance criteria
WID	Waste Isolation Division
WIPP	Waste Isolation Pilot Plant
WM PEIS	Waste Management Programmatic Environmental Impact Statement

1 INTRODUCTION AND OBJECTIVES

This Transportation Analysis (TA) is carried out in accordance with the Analysis Plan (AP) 141 "Analysis Plan for Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant". The scientific approach is described in detail in Weiner et al. (2006). Input data to the codes used (RADTRAN/RADCAT1, WebTRAGIS, MICROSHIELD) are provided in the cited Analysis Plan AP-141. Input data to the post-processing calculations is provided in the attached CD.

The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, is the only facility licensed to dispose of transuranic (TRU) waste generated by U.S. Department of Energy (DOE) defense activities. TRU waste has been or is retrievably stored at 27 DOE sites across the United States.

This TA evaluates the impacts associated with the transportation of TRU waste from waste generator sites to the WIPP. The TA uses the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considers the impacts of transporting these wastes. The TA evaluates the impacts of remote-handled TRU (RH-TRU) waste being shipped in shielded containers, including the potential disposal of Uranium-233 (U-233) from Oak Ridge National Laboratory (OR). Only transportation by truck is considered in this analysis.

The impacts of transporting TRU waste to WIPP that have been analyzed are:

(1) number of traffic accidents, fatalities, and injuries likely to occur as a result of transporting the TRU waste round trip between WIPP and the generator sites.
(2) radiological impacts from routine, incident-free transportation that could be associated with the external radiation from a TRU waste transportation package. This radiation exposes the general public and transportation workers to very low levels of radiation both during transportation and while a shipment is stopped.
(3) health effects that could result from inhaling vehicle emissions (diesel exhaust) while the vehicle travels through urban areas.
(4) minor accidents and incidents that do not result in the release of any radioactive material (this is a deviation from AP-141).
(5) accidents that are severe enough to breach the TRU waste package, releasing some of the radioactive and hazardous material being shipped.
(6) accidents in which some of the lead gamma shield in RH waste packages slumps or is lost, resulting in the loss of gamma shielding.

These impacts have been analyzed for all of the transportation routes, as well as for impacts specific to the New Mexico (NM) residents along the transportation routes.

This TA presents information similar to the final *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (WIPP SEIS-II) (DOE 1997b), with the addition of impacts specific to NM, and results of the improved analytical techniques and codes currently available. This TA does not consider alternative actions as in the WIPP SEIS-II.

1 RADCAT generates input files for RADTRAN.

This TA contains new information produced since the WIPP SEIS-II, including 2000 U.S. Census data, which has been included in the routing code WebTRAGIS that is used together with RADTRAN (Johnson and Michelhaugh 2003), changes in the number of shipments due to the use of different transportation containers, changes in the TRU waste inventories, and improvements in the RADTRAN program and code (Weiner et al. 2006).

2 BACKGROUND

In the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997a), DOE analyzed the potential environmental impacts of the management (treatment and storage) of TRU waste at DOE sites. The *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* [63 FR 3629 (1998)] [TRU Waste Record of Decision (ROD)] (DOE 1998) documented DOE's decision that each DOE site that has generated or will generate TRU waste will prepare and store its TRU waste onsite, with one exception: Sandia National Laboratories (SNL) will transfer its TRU waste to the Los Alamos National Laboratory (LANL). In the ROD, DOE also stated that in the future, it may decide to ship TRU waste from sites where it may be impractical to prepare them for disposal to sites where DOE has or will have the necessary capability. The sites designated in the ROD to receive such shipments of TRU waste are the Idaho National Engineering and Environmental Laboratory (INEEL), [now the Idaho National Laboratory (INL)], the Oak Ridge Reservation (ORR), the Savannah River Site (SRS), and the Hanford Site. Since the issuance of the TRU Waste ROD, DOE decided to ship TRU waste from three other sites—the Mound Plant, Battelle Columbus Laboratories (BCL), and the Energy Technology Engineering Center (ETEC)—to the Hanford Site or the SRS.

In the Amended ROD (2008b), DOE decided to ship up to 8,764 cubic meters of contact-handled TRU (CH-TRU) waste and up to 255 cubic meters of RH-TRU waste as needed from Argonne National Laboratory (ANL), Bettis Atomic Power Laboratory (BAPL), Babcock & Wilcox (BW), General Electric - Vallecitos Nuclear Center (GE-VNC), Hanford, Knolls Atomic Power—Nuclear Fuel Services (K-NFS), Knolls Atomic Power Laboratory (KAPL), Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), NRD L.L.C. (NRD), Paducah Gaseous Diffusion Plant (PGDP), Nevada Test Site (NTS), Separations Process Research Unit (SPRU) and Sandia National Laboratories (SNL), to INL for treatment and characterization prior to shipment to WIPP for disposal. Table 1 indicates the CH-TRU and RH-TRU Waste Volumes to be shipped to INL (DOE 2008c).

Table 1 CH-TRU and RH-TRU Waste Volumes to be Shipped to INL (DOE 2008c)

Waste Generator Sites	TRU Waste Volume (m^3)	
	CH-TRU	RH-TRU
Argonne National Laboratory (ANL), IL	88	43
Bettis Atomic Power Laboratory (BAPL), PA	70	4
Babcock & Wilcox (BW), Lynchburg, VA	46	-
General Electric—Vallecitos Nuclear Center (GE-VNC), Sunol, CA	35	105
Hanford Reservation, WA	6,500	-
Knolls Atomic Power Laboratory (KAPL), Schenectady, NY	-	83
Knolls Atomic Power—Nuclear Fuel Services (K-NFS), TN	130	-
Lawrence Berkeley National Laboratory (LBNL), CA	1	-
Lawrence Livermore National Laboratory (LLNL), CA	1,125	-
Nevada Test Site (NTS), NV	670	-
NRD L.L.C., (NRD), Grand Island, NY	15	-
Paducah Gaseous Diffusion Plant	4	-
SNL, Albuquerque, NM	30	20
Separations Process Research Unit (SPRU), Schenectady, NY	50	-
Total	8,764	255

Source: Inventory data gathered for 2009 WIPP Compliance Recertification Application Update. Only the portion of the Hanford waste inventory that could be expected to move to INL is included for Hanford.

In its final WIPP SEIS-II, DOE analyzed the potential environmental impacts associated with disposing of TRU waste at WIPP. DOE's Proposed Action was to open WIPP and dispose of 175,600 cubic meters of post-1970 defense TRU waste. In addition, DOE analyzed several alternative actions, including an alternative that would dispose of a greater volume of TRU waste (336,000 cubic meters) than under the Proposed Action and that would consolidate waste from some DOE sites at ORR, SRS, and Hanford (Action Alternative 1).

Since the time the WIPP SEIS-II was issued, many decommissioning activities have taken place at sites across the DOE complex. In addition, some of the TRU wastes at sites with small quantities of such wastes have been consolidated at sites having greater capabilities to characterize the waste. These decommissioning activities have resulted in the identification of sites that were not thought to contain TRU wastes at the time the WIPP SEIS-II was prepared.

Another development that could not be assessed in the WIPP SEIS-II is the availability of shipping containers that are capable of carrying larger CH-TRU volumes (TRUPACT-III), heavier CH-TRU waste (HalfPACT), and RH-TRU waste stored in shielded containers and shipped in HalfPACTs. The impact of the TRUPACT-III was evaluated in DOE (2006b). An example of the potential reduction of shipments when HalfPACTs are used was displayed in the WIPP SEIS-II. The impact of using shielded containers has not been evaluated. For this reason, this report assesses the impacts of using these new containers to ship and store waste.

The OR building 3019 Complex is being considered for decommissioning. This TA considers the WIPP to be the ultimate disposal site for the U-233 TRU waste that may be generated as part of this decommissioning process. The environmental impact of transporting this U-233 waste to the WIPP is included in this analysis and TA.

3 APPROACH

This TA includes:

1. Inventory analysis and determination of shipment numbers,
2. Shielding calculations to determine a realistic TI (Transportation Index),
3. Calculation of impacts of routine, incident-free transportation, including analysis of uncertainty in external dose rate and transportation package inventory,
4. Calculation of the impacts of transportation accidents, including accidents involving a release of radioactive material (RAM), severe accidents, accidents involving loss of lead shielding, and minor accidents not affecting the radioactive cargo, and
5. Impact and consequence calculations included health effects.

Impacts were evaluated for CH-TRU and RH-TRU wastes. The results were compiled to identify the total impact from TRU waste shipments between generator sites and the WIPP site.

3.1 Inventory Analysis

The inventory documented in DOE (2008a) in combination with the information on the U-233 waste from OR and the most recent ROD (2008b) was used for the calculation in this TA. As identified in DOE (2008a), this inventory represents the waste as it was on December 31, 2006. The inventory was used to determine the number for shipments from the different sites to WIPP directly and to WIPP through an intermediate site.

3.1.1 Number of Shipments

The number of shipments have been determined based on the type of waste RH-TRU or CH-TRU, the volume of waste, the form of the waste (i.e., the type of container it is in), and the mass of the waste.

Restrictions on the number of packages per vehicle, identified in the CH-TRAMPAC (DOE 2005) and the RH-TRAMPAC (DOE 2006c), are shown in Table 2.

Table 2 Authorized CH-Waste Payload Containers

Payload Container Type	Number in Payload[1]	
	TRUPACT-II	HalfPACT
55-Gallon Drum	14	7
Standard Pipe Overpack[2]	14	7
S100 Pipe Overpack	14	7
S200 Pipe Overpack	14	7
S300 Pipe Overpack	14	7
85-Gallon Drum[3]	8	4
100-Gallon Drum	6	3
Standard Waste Box (SWB)	2	1
Ten-Drum Overpack (TDOP)	1	N/A

[1] Payloads shall be comprised of a single payload container type.
[2] Standard pipe overpacks must be assembled into seven packs of 6-inch standard pipe overpacks or 12-inch standard pipe overpacks only.
[3] The term "85-gallon drum" in this document includes 75- to 88- gallon drums.

Tables 3 and 4 show the weight limits for the various containers that may be used.

Table 3 CH Payload Containers

Payload Container Type	Maximum Gross Weight (lbs)	Empty Weight (lbs)
55-Gallon Drum	1,000	60
Standard Pipe Overpack (6-inch diameter)	328	153
Standard Pipe Overpack (12-inch diameter)	547	407
S100 Pipe Overpack	550	153
S200 Pipe Overpack	547	407
S300 Pipe Overpack	547	407
85-Gallon Drum[1]	1,000	81
100-Gallon Drum	1,000	95
SWB	4,000	640
TDOP	6,700	1,700

[1] The term "85-gallon drum" in this document includes 75- to 88- gallon drums.

Table 4 CH Payload Assemblies Maximum Gross Weight Limits

Assembly	Maximum Gross Weight (lbs)
TRUPACT-II Payload (Contents)	7,265
HalfPACT Payload (Contents)	7,600

By using the HalfPACT, 21 heavy drums per shipment can be transported as opposed to 14 heavy drums using the TRUPACT-II. This is possible as a result of the low gross weight associated with the HalfPACTs. This was identified in the SEIS-II as a potential means of reducing the number of shipments.

In order to have a shipment of three TRUPACT-IIs, the content of the drums must average 142 kg (312 lbs) or less.

RH-TRU waste is transported in either a RH-72B or a 10-160B cask. A RH-72B is loaded with a RH-TRU waste canister that can transport up to 8,000 lbs by direct loading of the waste or packaging the waste in three 55-gallon drums. The empty weight of an RH-TRU waste canister ranges from 1,100 lbs to 1,762 lbs, depending upon the type of lid. For this analysis it is assumed that an empty canister weights 1,762 lbs.

10-160B casks can transport up to 14,500 lbs, with a ten 55-gallon drum capacity (DOE 2007).

The following restrictions were used to identify the number of shipments for cases where shielded containers are utilized (Crawford and Taggart 2007):

- Shielded containers will only be loaded with 30-gallon drums;
- Shielded containers will be shipped in packs of three, with one 3-pack shipped in one HalfPACT;
- The inventory used to estimate the number of shielded containers is found in Crawford and Taggart (2007). Crawford and Taggart (2007) used the 2004 inventory report (DOE 2006A) to estimate the number of shielded containers that could be used;
- Shielded containers maximum empty weight is 1,816 lbs (Moody 2008, Enclosure C); and
- Shielded containers can have a maximum of 405 lbs of waste, with total contents at a maximum of 444 lbs (Moody 2008, Enclosure C).

The inventory spreadsheet (DOE 2008a) provides the following data:

- The number of drums, standard waste boxes (SWBs) and 10-drum overpacks (TDOPs) in each waste stream, scaled to the WIPP capacity.
- The total weight of material, in kg, in each waste stream.
- The radioactive inventory of each waste stream.

Tables 3 and 4 show the weight limits and payload for vehicles transporting CH waste. The weight per 14-drum TRUPACT-II, two-SWB TRUPACT-II, and one-TDOP TRUPACT-II was calculated from the mass in kilograms per waste stream and the number of containers per waste stream. If the result exceeded the payload limit for the TRUPACT in Table 4, the number of TRUPACTs was recalculated so that the payload was not exceeded, always rounding up the number of containers and TRUPACTs to the next higher integer. The number of shipments from each site was then determined by considering three TRUPACTs per vehicle. Modifications using HalfPACTs were made where appropriate. A similar calculation was made for the RH waste streams, noting that there could be only one RH-72B cask per truck , and an RH-72B could hold three drums of waste.

Table 5 shows the number of shipments from each site, compared with the number of shipments from WIPP SEIS-II, Tables E-1 (Proposed Action) and E-2.

Table 5 Shipments from each site

NUMBERS OF CH SHIPMENTS							NUMBERS OF RH SHIPMENTS				
	DRUMS IN TRUPACTS	**SWB IN TRUPACTS**	**TDOP IN TRUPACTS**	**HALF PACKS**	**TOTAL**	**TABLE E-1***	**RH-72B**	**HALF PACKS**	**10-160B****	**TOTAL**	**TABLE E-2**
ANL-E	81	-	-	-	81	28	-	83	-	83	-
ANL-W	24	-	-	1	25	-	266	-	-	266	-
BL	1	-	-	-	1	-	-	-	-	-	-
BN	158	177	477	4	816	-	-	-	-	-	-
BT	1	-	-	-	1	-	4	-	-	4	-
IN	11096	1936	160	11	13203	5782	410	4	-	414	-
KN	139	-	-	-	139	-	-	209	-	209	-
LA	1493	534	-	20	2047	5009	32	-	-	32	367
LB/LL	62	40	-	-	102	162	-	-	-	-	-
MC	-	-	-	1	1	-	-	-	-	-	-
MU	1	-	-	-	1	-	-	-	-	-	-
NT	50	254	10	1	314	86	-	-	-	-	-
OR	379	-	-	-	379	251	1516	494	-	2710	1276
OR (U-233)	-	-	-	-	0	-	700	-	-	700	-
RF	892	411	95	11	1409	2485	-	-	-	-	-
RL	888	412	100	9	1409	13666	1483	264		1747	3178
SA	7	-	-	-	7	-	66	-	-	66	-
SR	670	376	885	22	1953	2238	39	54	67	160	-
Total	**15942**	**4140**	**1727**	**80**	**21889**	**29707**	**4516**	**1107**	**67**	**6391**	**4821**

*Does not include 59 shipments from Mound Laboratories
** These packages may not be used, in which case this material would be in RH-72B casks

3.1.2 Radionuclides for TI and Other Input Parameters

The TI represents the radiation dose rate at 1 meter (3.3 feet) from the surface of the shipping package and is dependent on the waste density, distribution of radionuclides, quantity of radionuclides per shipment, mix of waste types, self-shielding provided by the waste and shielding provided by the package. The TI may, therefore, be sensitive to smaller quantities of gamma-emitting radionuclides such as cobalt-60 (Co-60) and cesium-137 (Cs-137). Different TIs were calculated for CH-TRU and for RH-TRU wastes.

The TIs were calculated using MICROSHIELD (Version 7.0) and the radionuclide inventory presented in DOE (2008a). These TI values are more realistic than the regulatory maximum (10 mrem/hr at 2 meters according to 10 CFR 71.47(b)(3), or 14 mrem/hour for a TRUPACT at one meter[2]) because they are calculated using the expected inventory to be received at the WIPP.

Results of the MICROSHIELD calculations are shown in Table 6. Uncertainty in the inventories was estimated to be +/- 10% for CH-TRU and +/- 30% for RH-TRU (DOE 1996). The value used in SEIS-II for the TI for CH-TRU was TI=4 mrem/hr.

2 The TI for cargo with a critical dimension of approximately 5 meters is calculated by RADTRAN to be 14 mrem/hr for the regulatory maximum dose rate of 10 mrem/hr at 2 m.

Table 6 Calculated TI for the TA. TI units are mrem/hr

Packaging	TI	+ Deviation	- Deviation	SEIS TI
TRUPACT	0.167	0.184	0.151	4
HalfPACT	0.104	0.144	0.0936	--
RH-72B	2.505	3.270	1. 759	10

Risk and health effects calculations were performed using RADTRAN and WebTRAGIS (Johnson and Michelhaugh 2000). RADTRAN is the product of about 30 years of development and is a flexible analytical tool for assessing the risks and consequences of transporting radioactive material. RADTRAN 4 was used for the calculations performed in the WIPP SEIS-II. This TA uses the latest updated versions of RADTRAN: Version 6 for the loss-of-lead shielding calculation and Version 5.6 for all other calculations, which are the same in Versions 6 and 5.6. Both RADTRAN 6 and RADTRAN 5.6 are validated and verified (Dennis et al. 2008). Inputs and assumptions used in the RADTRAN calculations are shown in Table 7. A sample RADTRAN input and output file is in Appendix A and all files used are included on the attached CD.

WebTRAGIS is the updated version of the routing code HIGHWAY, which was used for the WIPP SEIS-II. WebTRAGIS is a much improved version of HIGHWAY, the routing code used in the SEIS-II. As implied, it incorporates a geographic information system which provides increased precision in route selection. The population densities shown in Table 7 along the different routes to be taken to the WIPP were determined by the code WebTRAGIS.

Table 7 RADTRAN Inputs and Assumptions for the TA

Parameter	CH-TRU Waste	RH-TRU Waste
Configuration		
Mode of Transportation	Truck	Truck
Package Type	TRUPACT-II, TRUPACT-III[a], HalfPACT	HalfPACT (for shielded containers), RH-72B cask
Packages per Shipment	3	1 (72 B cask, 10-160B) or 3 (HalfPACTs)
Package critical dimension (m)	8.4 (TRUPACT-II and HalfPACT), 6.1[a] (TRUPACT-III)	3.6 (72B cask), 3.3[a] (10-160B), 7.4 (HalfPACTs)
Shipment Speed (kilometer/hour)		
Urban[b]	88.6 non-rush hour; 44.3 rush hour	88.6 non-rush hour; 44.3 rush hour
Suburban (S)[b]	88.6 non-rush hour;	88.6
Rural (R)[b]	88.6	88.6
Stop model		
Truck stop time[c]	20 minutes/845 km	20 minutes/845 km
Maximum truck stop time[c]	50 minutes /845 km	50 minutes/845 km.
Inspection time	1 hour	1 hour
Walkaround inspection time	10 minutes/161 km	10 minutes/161 km
Average population exposed at the stop[c]	7	7
Public exposure distance[c]	1 meters to 15 meters	1 meters to 15 meters
Inspector exposure distance	1 meter	1 meter

Table 7 RADTRAN Inputs and Assumptions for the TA (continued)

Parameter	CH-TRU Waste	RH-TRU Waste
Crew exposure distance[d]	1 meter (each crew member for half of stop time)	1 meter (each crew member for half of stop time)
Resident public near stops	R or S population density as appropriate (route dependent)	R or S population density as appropriate (route dependent)
Distance of resident public from truck[e]	30 to 800 meters	30 to 800 meters
Normal Exposure Data		
Number of crew members	2	2
Effective distance from closest surface of source to crew	4 meters	4 meters
Number of people per public vehicle[f]	2	2
Accident Exposure Data		
Number of accident severity categories[e]	6	6
Accident severity category frequency[f] (Conditional probabilities)	(NUREG/CR 6672 values)	(NUREG/CR 6672 values)

Source: WIPP SEIS-II unless noted otherwise
[a] McCauslin (2008)
[b] 88.6 km/hr = 55 mph; rush hour speed = half of non-rush hour speed (DOE 2002)
[c] Griego et al. (1996) ; this is a deviation from the AP-141
[d, e] DOE (2002)
[f] Sprung et al. (2000)

3.2 Routing

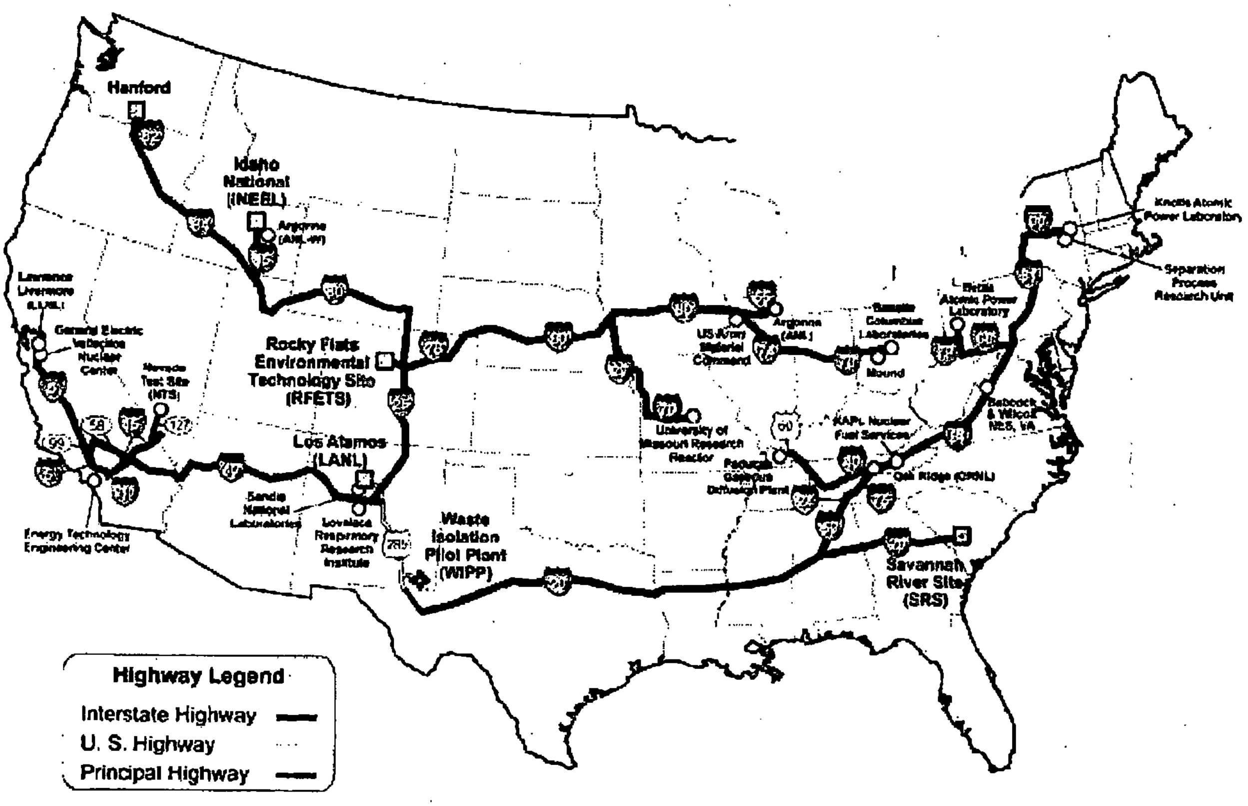


Figure 1 Highways Used for Transportation of Waste to the WIPP

Highway routes for exclusive-use Highway Route Controlled Quantity (HRCQ) vehicles are analyzed using WebTRAGIS, from the following origins to the WIPP. WebTRAGIS files are included on the attached CD:

- Argonne National Laboratory – East (IL)
- Battelle Memorial Institute (OH)
- Bettis Laboratory (Pittsburgh, PA)
- Brookhaven National Laboratory (NY)
- Idaho National Laboratory/ Argonne - West (ID)
- Knolls Atomic Power Laboratory (NY)
- Los Alamos National Laboratory (NM)
- Lawrence Berkeley National Laboratory (CA)
- Army Materials Command (VA)
- Missouri University Research Reactor (MO)
- Nevada Test Site (NV)
- Oak Ridge National Laboratory (TN)
- Rocky Flats Environmental Test Site (CO)
- Richland/Hanford Works (WA)
- Sandia National Laboratories (NM)
- Savannah River Site (SC)

WebTRAGIS includes the specific origin sites; HIGHWAY routing origins were in almost all cases the nearest city node. For example, routing from Argonne – East is from the laboratory location itself in WebTRAGIS, rather than from the node south of Chicago closest to the laboratory, as HIGHWAY required. The route lengths and population density distributions produced by WebTRAGIS are comparable to those produced by HIGHWAY. Table 8 shows the comparison for Argonne – East.

Table 8 Comparison of WebTRAGIS and HIGHWAY routes from Argonne—East to the WIPP

WEBTRAGIS						HIGHWAY
Miles	km	Route	Location	Intersection	State	(from SEIS II p. E-4)
1.8	2.9		DARIEN S	I55 X273	IL	Cass Avenue to I-55, north of ANL-E, 1.6 kilometers (1 mile)
109.8	176.6		NORMAL NW	I55 I74	IL	I-55 to I-294, southwest of Chicago, IL, 8 kilometers (5 miles)
6.8	10.9	I74	BLOOMINGTON SW	I55 I74	IL	I-294 to I-80, south of Chicago, IL, 29 kilometers (18 miles)
59.3	95.4		SPRINGFIELD E	I55 I72	IL	I-80 to I-57, near Tinley Park, 8 kilometers (5 miles)
5.1	8.2	I72	SPRINGFIELD S	I55 I72	IL	
73.5	118.2		EDWARDSVILLE SE	I270I55	IL	
9.5	15.3	I70	COLLINSVILLE W	I255I55	IL	
18.5	29.8		COLUMBIA NW	I255X6	IL	
2.9	4.7		crossing state border	r IL/MO	BD	I-57 to I-55, near Sikeston, MO, 592 kilometers (368 miles)
3.7	6.0		ST LOUIS S	I270I55	MO	I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
5.8	9.3		ST LOUIS SW	I270I44	MO	I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
274.9	442.2		JOPLIN SW	I44 X1	MO	I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
0.3	0.5		crossing state border	r MO/OK	BD	I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
15.7	25.3		MIAMI E	I44 X313	OK	
72.4	116.5	TWRT $	CATOOSA S	I44 X241	OK	
19.1	30.7		OAKHURST E	I44 X221	OK	
86.1	138.5	TTRT$	EDMOND SE	I35 I44	OK	
4.4	7.1	I44	OKLAHOMA CITY NE	I35 I44	OK	
11	17.7		OKLAHOMA CITY W	I40 I44	OK	
125.3	201.5		SAYRE S	I40 X20	OK	
20.7	33.3		crossing state border	r OK/TX	BD	I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
139.6	224.5		VEGA S	I40 X36	TX	
36.2	58.2		crossing state border	r NM/TX	BD	
97.7	157.1		SANTA ROSA	I40 X273	NM	
38.4	61.8		VAUGHN E	U54 U60	NM	US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
0.7	1.1	U60	VAUGHN SE	U285U54	NM	
90.1	144.9		ROSWELL N	U285U70	NM	
7.5	12.1	U70	ROSWELL W	U380U70	NM	
73.4	118.1		CARLSBAD NW	U285LCBR	NM	
8.7	14.0		CARLSBAD E	U62 LCBR	NM	
25.3	40.7	U180	TOWER HILL E	U62 LOCL	NM	US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
12.1	19.5		WIPP		NM	WIPP North Access Road to WIPP, 18 kilometers (11 miles)
TOTAL KM	2342.4					2337.6

WebTRAGIS provides rural, suburban, and urban distances and population densities, which are electronically imported into RADTRAN 5.6 and 6; this utility was not available for the SEIS II. The rural, suburban, and urban population bins in WebTRAGIS are, however, the same as in HIGHWAY. The total population has increased and has shifted from both urban and rural areas to suburbs, and more bypasses routed through suburban populations are available. The net result is relatively larger doses to suburban than to urban populations from routine radioactive materials (RAM) transportation. The population bins in WebTRAGIS are:

- rural: 0 to 139 persons/mi^2 (0 to 53.73 persons/km^2)
- suburban: 139 to 3326 persons/mi^2 (53.73 to 1286 persons/km^2)
- urban: more than 3326 persons/mi^2 (more than 1286 persons/km^2)

WebTRAGIS uses census data from the 2000 census. Updated population data to 2006 were provided in the 2008 Statistical Abstract (U.S. Census Bureau 2008). Table 13 of U.S. Census Bureau (2008) shows the percent increase in population for each of the 50 states of the United States, as well as for the U. S. as a whole, and Table 21 shows the percent increase in population for the 50 largest metropolitan areas in the U.S. Data from these two tables were combined to give population multipliers for states along WIPP routes for which the collective dose (including numbers of shipments) and the population increase were significant enough to make a correction.

The population multipliers used are shown in Table 9. "Significant" was taken to mean either that the collective dose for all routes through a state exceeded 10^{-8} person-rem without the population multiplier, or that the multiplier was 1.01 or larger (e.g., multipliers of 1.005 or 0.96 were not considered significant). The state-specific multiplier was applied to rural and suburban routes through the state, and the multiplier for the largest metropolitan area in that state was applied to the urban routes. The U.S. multiplier was applied to ingestion doses. For computational efficiency, and because multiplication is commutative, the multipliers were applied to the collective doses calculated using RADTRAN rather than to the WebTRAGIS populations.

Table 9 Population multipliers

State	Rural, Suburban, Urban Designation	Population Multiplier
Arizona	R, S	1.202
	U	1.242
Arkansas	R, S	1.051
	U	1.051
California	R, S	1.076
	U	1.15
Colorado	R, S	1.105
	U	1.105
Georgia	R, S	1.144
	U	1.21
Idaho	R, S	1.133
	U	1.133
Illinois	R, S	1.033
	U	0.959
Maryland	R, S	1.037
	U	1.041
Missouri	R, S	1.044
	U	1.044
Nevada	R, S	1.249
	U	1.292
New Mexico	R,S	1.075
	U	1.075
Oklahoma	R, S	1.037
	U	1.07
Pennsylvania	R, S	1.013
	U	1.025
Oregon	R, S,	1.082
	U	1.109
Tennessee	R, S	1.061
	U	1.109
Texas	R,S	1.127
	U	1.175
Utah	R, S	1.142
	U	1.102
Virginia	R, S	1.08
	U	1.103

3.3 *Risk Calculations*

3.3.1 Calculations for Routine, Incident-free Transportation

Calculations for routine, incident-free transportation evaluated the same scenarios that are used in the WIPP SEIS-II. In the scenarios, some individuals will be exposed to a single shipment while others would be exposed to multiple shipments. Transportation crew members are monitored with radiation dosimeters to limit exposures. All of these exposure scenarios include a very large degree of conservatism by assuming that the effect of multiple shipments that take place over a period of time is cumulative, when in fact the effect is not cumulative (Mossman 2008). The scenarios for radiation dose assessment are:

- A person in a traffic jam next to a truck transporting TRU waste. For this assessment, the exposure distance is assumed to be 2 meter (6.6 feet) and the exposure time is assumed to be 30 minutes. The person is assumed to be exposed only once.
- An inspector of trucks ready for departure from a site. For this assessment, it is assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for an hour, although Weiner and Neuhauser (1992) clocked inspectors at Raton Pass at 45 minutes. The inspector would work at the same job for 10 years, and there would be two shifts working the same job. The number of shipments inspected by an individual would depend on the total number of shipments from a site and the rate at which they are shipped.
- A state safety inspector. For this assessment, it is assumed the inspector would be involved in 20 percent of the inspection over a 10-year period with an average exposure distance of approximately 1 meter (3.3 feet). Inspections could occur at the originating facility, upon arrival at WIPP, or in the corridor states at ports of entry for trucks. To allow for queues, a truck inspection time of 1 hour was be used. To bound the state inspector dose, the route on which the majority of waste enters NM was be used.
- A person residing along a shipment route. For this assessment, it is assumed that the individual would be exposed to every waste shipment for 70 years, at a distance of approximately 30 meters (98 feet).
- A rest stop employee. For this assessment, a stop duration of 50 minutes and an exposure distance of 1 to 15 meters (3 to 45 feet) is assumed. It was also assumed that the individual will be exposed to approximately 20 percent of all CH-TRU and RH-TRU waste shipments sent to WIPP over a 10-year period. This assumption is made on the basis that all trucks stop at the same location, an individual works for 10 years at the truck stop, and 3 shifts work at the truck stop.
- A driver of a truck hauling TRU waste. For this assessment, doses were assessed for both when the truck is moving and when it is stopped. An exposure distance of 4 meters (13 feet) is assumed. Doses received while the trucks are stopped are assumed to be due to walkaround inspections every 100 miles (160 km) and to rest stops for refueling, and food. The walkaround inspections are conservatively assumed to take 10 minutes (DOE 2002). Although the average rest stop time (Griego et al. 1996) is 20 minutes, the time used in this analysis is 50 minutes, which is the longest rest stop time reported in Griego et al. (1996). Semi-detached trailer trucks stop to refuel when the fuel tanks are half empty, and the distance calculated for this is 845 km (DOE 2002). A truck driver, rather than a service attendant, is assumed to refuel the truck. It should be noted that no matter what the estimated impacts are, current regulations state that any monitored crew member

who receives a radiation dose that approaches 2 rem (the administrative limit for occupational doses) in any given year is to be reassigned to other duties involving no further dose for the remainder of the year.

3.3.2 *Results for Routine Incident-Free Transportation*

3.3.2.1 Doses During Transit

Table 10 shows the per-shipment dose rates for CH shipments, compared to the analogous results reported in Table E-12 of the SEIS. Table 11 shows these collective doses converted to LCF(Latent Cancer Fatality) risk using the currently accepted risk factor of 6×10^{-4} LCF/rem (6×10^{-2} LCF/Sv) (ISCORS 2002). LCF risk should also be interpreted to include the risk of no LCF; a LCF risk of 1.87×10^{-7}, for example, implies a probability of no LCF of essentially 1 (i.e., a 100% probability that there will be no latent cancer fatality). Moreover, collective dose cannot be interpreted simply; the NRC advises that collective dose (e.g., person-rem) be used only in comparative analyses and should not be used as a risk assessment tool nor as a predictor of cancer risk (Ryan 2007). This TA reports collective dose and LCF risk, but cautions the reader to interpret these in light of the NRC position.

Table 10 Collective doses per CH shipment

	DOSE RATE = 0.5 mrem/hr*			SEIS DOSE RATE = 4 mrem/hr		
	DOSE FROM ROUTINE TRANSPORTATION -- PERSON-REM					
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	1.26E-02	3.20E-04	6.93E-03	3.00E-02	5.30E-03	9.70E-03
BATTELLE	1.40E-02	3.78E-04	7.68E-03	-	-	-
BETTIS	1.57E-02	5.95E-04	6.20E-03	-	-	-
BROOKHAVEN	1.95E-02	2.49E-03	1.19E-02	-	-	-
INL/ANL-W	8.59E-03	2.08E-04	2.35E-03	-	-	-
KAPL	2.41E-02	2.46E-03	2.30E-02	-	-	-
LANL	3.28E-03	2.68E-05	4.80E-04	2.00E-02	2.50E-03	6.30E-03
LBL	1.25E-02	1.80E-04	8.84E-03	3.00E-02	4.80E-03	8.50E-03
MATERIALS COMMAND	1.35E-02	2.32E-03	7.87E-03	-	-	-
MURR	1.00E-02	1.87E-04	5.23E-03	-	-	-
NTS	1.01E-02	1.31E-04	2.98E-03	2.00E-02	1.90E-03	6.40E-03
ORNL	1.21E-02	3.85E-04	4.35E-03	3.00E-02	4.50E-03	8.20E-03
ROCKY FLATS	6.23E-03	1.28E-04	1.54E-03	1.00E-02	2.00E-03	4.00E-03
RICHLAND (HANFORD)	1.59E-02	2.81E-04	4.04E-03	3.00E-02	3.30E-03	7.50E-03
SANDIA	2.76E-03	8.05E-06	4.42E-04	-	-	-
SRS	1.32E-02	4.54E-04	5.11E-03	3.00E-02	5.40E-03	8.90E-03

*External dose rate from three TRUPACTs.

Table 11 Calculated per-shipment LCF risk from routine CH transportation

	LCF			LCF – SEIS		
	OCCUPA-TIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPA-TIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	7.59E-06	1.92E-07	4.16E-06	1.80E-05	3.18E-06	5.82E-06
BATTELLE	8.40E-06	2.27E-07	4.61E-06	-	-	-
BETTIS	9.41E-06	3.57E-07	3.72E-06	-	-	-
BROOKHAVEN	1.17E-05	1.50E-06	7.13E-06	-	-	-
INL/ANL-W	5.15E-06	1.25E-07	1.41 E-06	-	-	-
KAPL	1.45E-05	1.48E-06	1.38E-05	-	-	-
LANL	1.97E-06	1.61E-08	2.88E-07	1.20E-05	1.50E-06	3.78E-06
LBL	7.53E-06	1.08E-07	5.30E-06	1.80E-05	2.88E-06	5.10E-06
MATERIALS COMMAND	8.11E-06	1.39E-06	4.72E-06	-	-	-
MURR	6.01E-06	1.12E-07	3.14E-06	-	-	-
NTS	6.07E-06	7.86E-08	1.79E-06	1.20E-05	1.14E-06	3.84E-06
ORNL	7.25E-06	2.31E-07	2.61E-06	1.80E-05	2.70E-06	4.92E-06
ROCKY FLATS	3.74E-06	7.74E-08	9.24E-07	6.00E-06	1.20E-06	2.40E-06
RICHLAND (HANFORD)	9.53E-06	1.68E-07	2.42E-06	1.80E-05	1.98E-06	4.50E-
SANDIA	1.66E-06	4.83E-09	2.65E-07	-	-	-
SRS	7.92E-06	2.72E-07	3.07E-06	1.80E-05	3.24E-06	5.34E-06

Parameter values that account for the difference between doses in the present study and those in the SEIS, in addition to increased population and changed population distribution, include smaller, more realistic TIs, route-specific population densities instead of the average values R=6 persons/km^2, S = 719 persons/km^2 and U=3861 persons/km^2 (SEIS, p. E-5), the uniform speed of 88.6 km/hr on all freeways during non-rush hours instead of 88.6 km/hr in rural areas, 40.3 km/hr in suburban areas, and 24.2 km/hr in urban areas (SEIS Table E-10), and updated vehicle densities. The majority of these differences, like a smaller TI, decrease the dose, but a few would increase the doses. In general, the use of more realistic parameter values, supported by data or supplementary (e.g., MICROSHIELD) calculations, have resulted in lower doses than reported in SEIS-II.

Figure 2 is an example of the effect of TI on dose and shows that the dose is directly proportional to TI. Figure 2 also suggests that using the regulatory maximum TI or a "conservative" TI can greatly overestimate the collective dose from routine transportation.

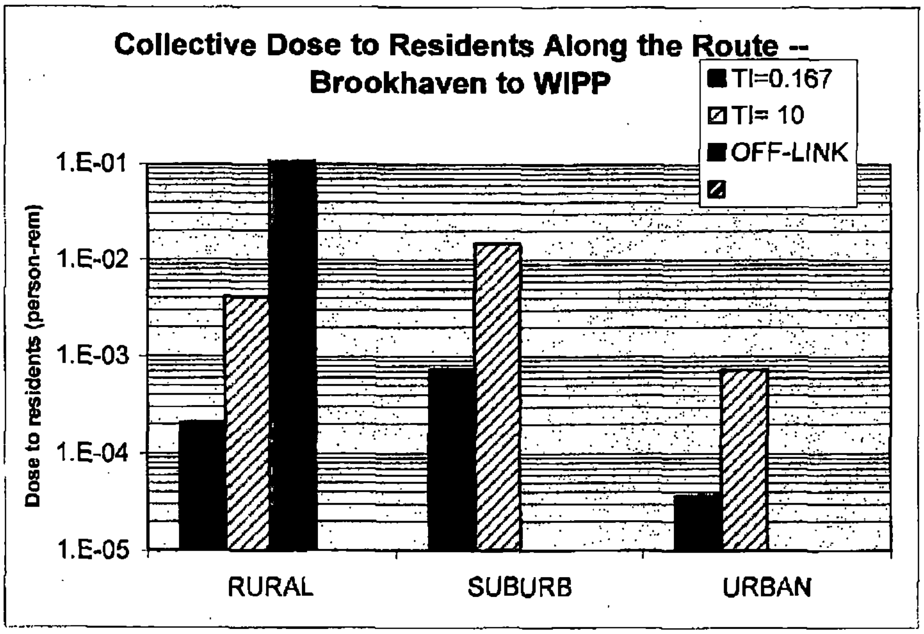


Figure 2. Effect of TI on collective dose along the route. Solid bars are values in this TA; striped bars are values in the SEIS Appendix E.

Overestimating the TI ensures that the risk will not be underestimated, but can overstate the dose or collective dose by an order of magnitude or more. RADTRAN 5.6 allows uncertainty in TI to be incorporated into the dose calculation and provides a more accurate statement of the probable dose and associated error in the dose estimate.

Tables 12 and 13 present the collective doses and LCF risks, respectively, for CH-TRU transportation when the TI is calculated from a +/- 10% uncertainty in the transported inventory (Table 6). The LCF risk is so small, as shown in Table 12, that the uncertainty does not make a significant difference in the case of routine CH-TRU transportation. It is nonetheless more accurate to express the TI as an average value and a range. Figures 3, 4, and 5 shows the uncertainties in in-transit crew dose, maximum individual in-transit dose, and collective in-transit dose, from routine transportation. The figures show the per-shipment doses. In distributing the input TI, calculated from the curie content, the assumption was that the curie content was equally likely to be overestimated as underestimated.

Table 12 Per-shipment CH-TRU doses accounting for 10% uncertainty in inventory

SITES	DOSE RATE = 0.167 mrem/hr per TRUPACT			DOSE RATE = 0.184 mrem/hr per TRUPACT			DOSE RATE = 0.151 mrem/hr per TRUPACT		
	DOSE FROM ROUTINE TRANSPORTATION -- PERSON-REM								
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	1.26E-02	3.06E-04	6.51E-03	1.39E-02	3.37E-04	7.17E-03	1.14E-02	2.77E-04	5.89E-03
BATTELLE	1.40E-02	3.65E-04	7.25E-03	1.54E-02	4.03E-04	7.99E-03	1.27E-02	3.30E-04	6.56E-03
BETTIS	1.57E-02	5.63E-04	5.92E-03	1.73E-02	6.20E-04	6.52E-03	1.42E-02	5.09E-04	5.35E-03
BROOKHAVEN	1.96E-02	9.74E-04	8.34E-03	2.15E-02	1.07E-03	9.19E-03	1.77E-02	8.80E-04	7.54E-03
INL/ANL-W	1.22E-02	1.96E-04	2.57E-03	1.34E-02	2.16E-04	2.83E-03	1.10E-02	1.77E-04	2.32E-03
KAPL	2.41E-02	8.95E-04	8.81E-03	2.65E-02	9.86E-04	9.71E-03	2.18E-02	8.09E-04	7.97E-03
LANL	3.28E-03	2.49E-05	4.47E-04	3.62E-03	2.75E-05	4.92E-04	2.97E-03	2.25E-05	4.04E-04
LBL	1.26E-02	1.62E-04	8.26E-03	1.38E-02	1.79E-04	9.10E-03	1.14E-02	1.47E-04	7.46E-03
MATERIALS COMMAND	1.35E-02	5.32E-04	5.76E-03	1.49E-02	5.86E-04	6.35E-03	1.22E-02	4.81E-04	5.21E-03
MURR	1.00E-02	1.79E-04	4.88E-03	1.10E-02	1.98E-04	5.38E-03	9.06E-03	1.62E-04	4.41E-03
NTS	1.01E-02	1.16E-04	2.62E-03	1.11E-02	1.28E-04	2.88E-03	9.15E-03	1.05E-04	2.37E-03
ORNL	1.21E-02	3.53E-04	3.99E-03	1.33E-02	3.88E-04	4.40E-03	1.09E-02	3.19E-04	3.61E-03
ROCKY FLATS	6.23E-03	1.17E-04	1.40E-03	6.87E-03	1.29E-04	1.55E-03	5.64E-03	1.06E-04	1.27E-03
RICHLAND (HANFORD)	1.58E-02	2.56E-04	3.72E-03	1.74E-02	2.82E-04	4.09E-03	1.43E-02	2.31E-04	3.36E-03
SRS	1.32E-02	4.19E-04	4.69E-03	1.45E-02	4.62E-04	5.17E-03	1.19E-02	3.79E-04	4.24E-03

Table 13 Per-shipment CH-TRU LCF risk accounting for 10% uncertainty in inventory

	DOSE RATE = 0.167 mrem/hr per TRUPACT			DOSE RATE = 0.184 mrem/hr per TRUPACT			DOSE RATE = 0.151 mrem/hr per TRUPACT		
	LCF RISK FROM ROUTINE TRANSPORTATION								
	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE	OCCUPATIONAL	ALONG ROUTE	SHARING ROUTE
ANL-E	7.59E-06	1.84E-07	3.91E-06	8.36E-06	2.02E-07	4.30E-06	6.86E-06	1.66E-07	3.53E-06
BATTELLE	8.40E-06	2.19E-07	4.35E-06	9.25E-06	2.42E-07	4.79E-06	7.59E-06	1.98E-07	3.93E-06
BETTIS	9.41E-06	3.38E-07	3.55E-06	1.04E-05	3.72E-07	3.91E-06	8.51E-06	3.05E-07	3.21E-06
BROOKHAVEN	1.17E-05	5.84E-07	5.00E-06	1.29E-05	6.44E-07	5.51E-06	1.06E-05	5.28E-07	4.52E-06
INL/ANL-W	7.29E-06	1.18E-07	1.54E-06	8.03E-06	1.29E-07	1.70E-06	6.59E-06	1.06E-07	1.39E-06
KAPL	1.45E-05	5.37E-07	5.29E-06	1.59E-05	5.91E-07	5.83E-06	1.31E-05	4.85E-07	4.78E-06
LANL	1.97E-06	1.50E-08	2.68E-07	2.17E-06	1.65E-08	2.95E-07	1.78E-06	1.35E-08	2.42E-07
LBL	7.53E-06	9.75E-08	4.95E-06	8.30E-06	1.07E-07	5.46E-06	6.81E-06	8.82E-08	4.48E-06
MATERIALS COMMAND	8.11E-06	3.19E-07	3.46E-06	8.93E-06	3.52E-07	3.81E-06	7.33E-06	2.89E-07	3.13E-06
MURR	6.01E-06	1.08E-07	2.93E-06	6.63E-06	1.19E-07	3.23E-06	5.44E-06	9.73E-08	2.65E-06
NTS	6.07E-06	6.94E-08	1.57E-06	6.69E-06	7.65E-08	1.73E-06	5.49E-06	6.28E-08	1.42E-06
ORNL	7.25E-06	2.12E-07	2.40E-06	7.98E-06	2.33E-07	2.64E-06	6.55E-06	1.91E-07	2.17E-06
ROCKY FLATS	3.74E-06	7.03E-08	8.42E-07	4.12E-06	7.75E-08	9.28E-07	3.38E-06	6.36E-08	7.62E-07
RICHLAND (HANFORD)	9.49E-06	1.53E-07	2.23E-06	1.05E-05	1.69E-07	2.46E-06	8.58E-06	1.39E-07	2.02E-06
SRS	7.92E-06	2.52E-07	2.81E-06	8.73E-06	2.77E-07	3.10E-06	7.16E-06	2.27E-07	2.54E-06

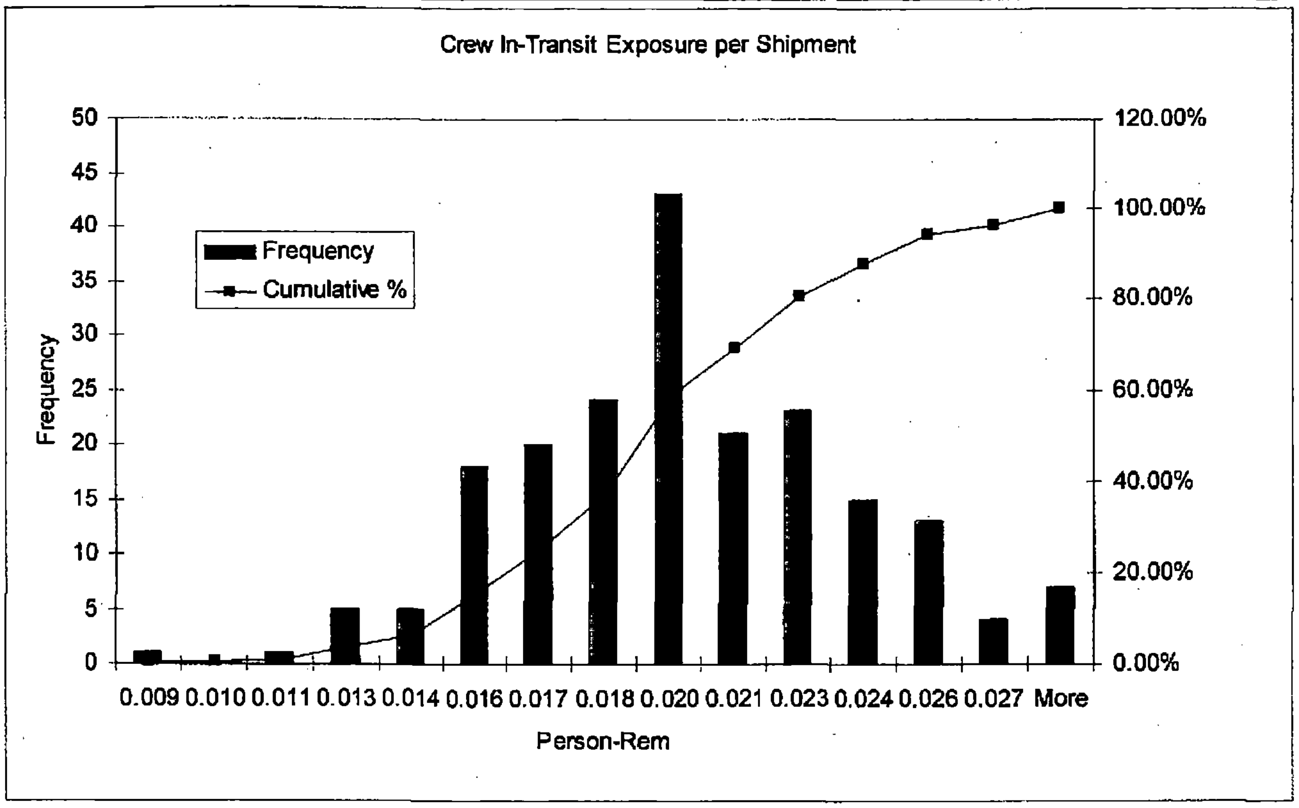


Figure 3 Crew in-transit dose per shipment.

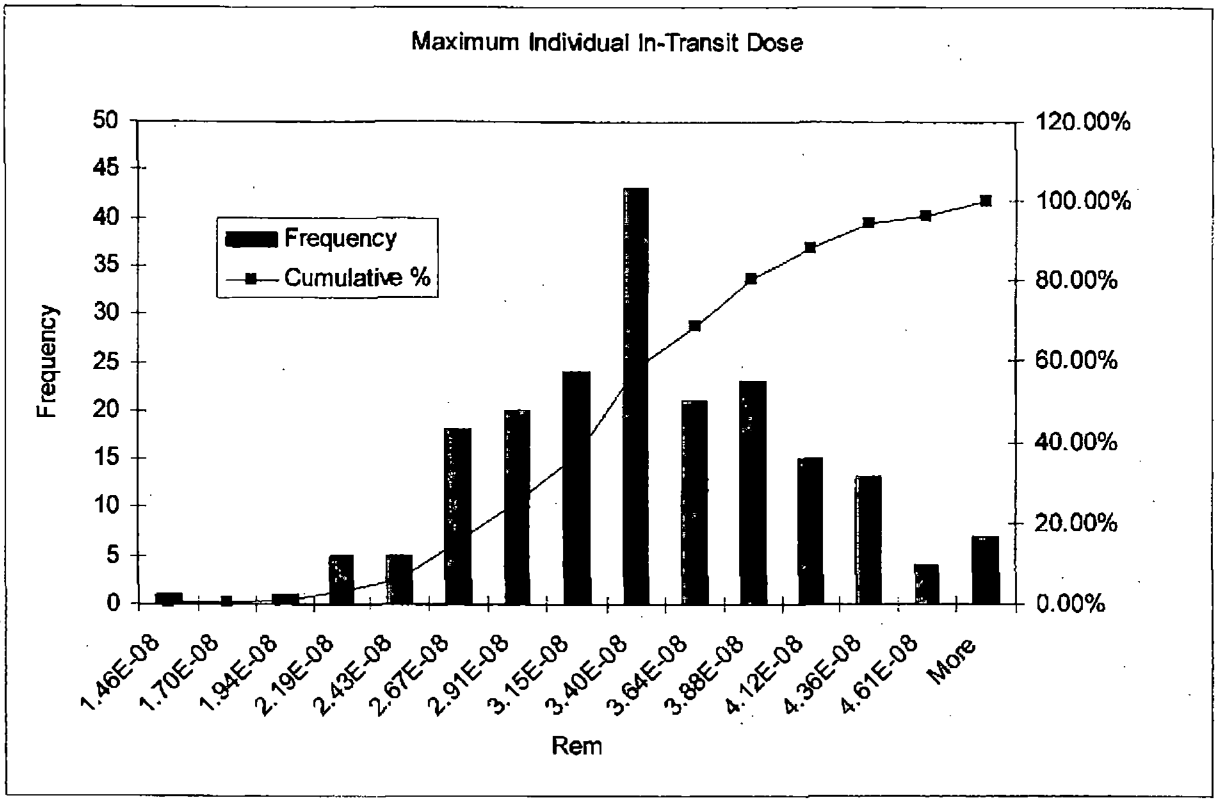


Figure 4 Maximum individual in-transit dose per shipment.

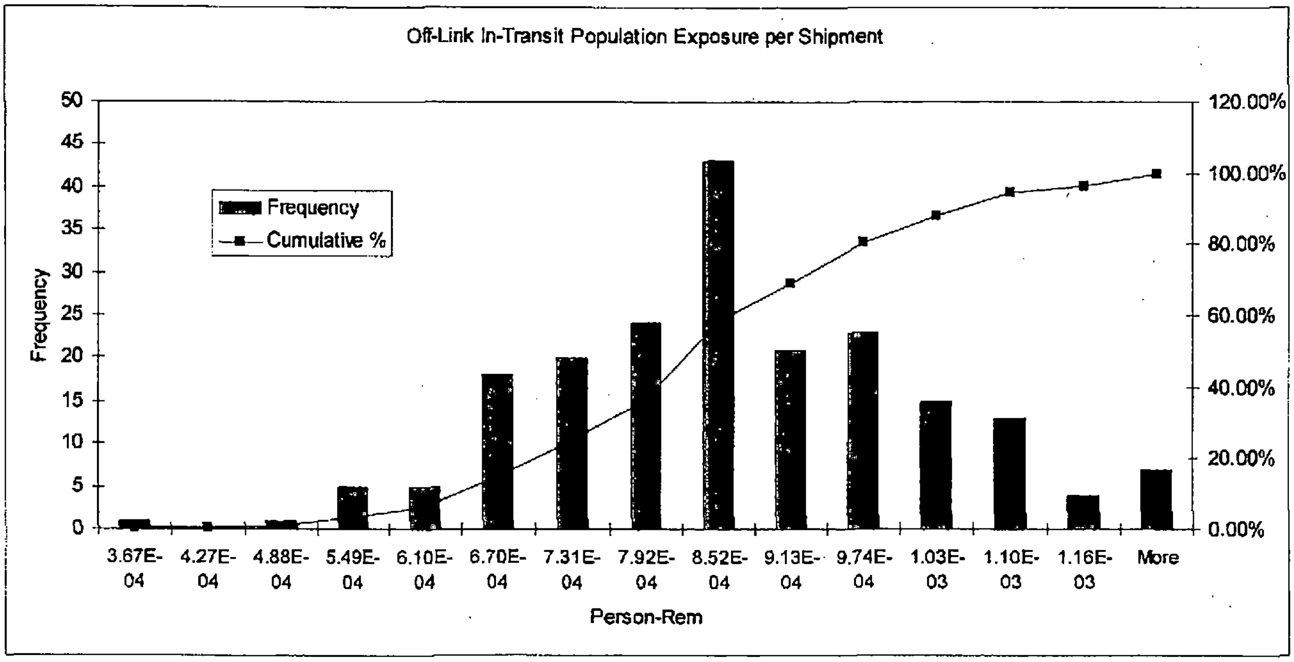


Figure 5 In-transit collective dose along the route, per shipment.

While the doses in routine transportation are directly proportional to TI, the relationship of these doses to other parameters is more complex. Figure 6 shows collective dose to occupants of vehicles that share the route with the radioactive cargo as a function of vehicle density (vehicles per hour) on the route. The SEIS used the traditional values: R=470, S= 760, U=2800 vehicles per hour, while the TA used for state or regional vehicle density data from state reports from the years 2000 to 2003 (Weiner et al. 2006, Appendix D). The TA values in Figure 6 were obtained by multiplying the vehicle density by the route segment to which it applied and adding the products for all the routes[3]. The SEIS values were obtained by multiplying the traditional vehicle densities by the total rural, suburban, and urban distances for all the routes. Using the traditional vehicle densities would underestimate doses, all other parameters being equal.

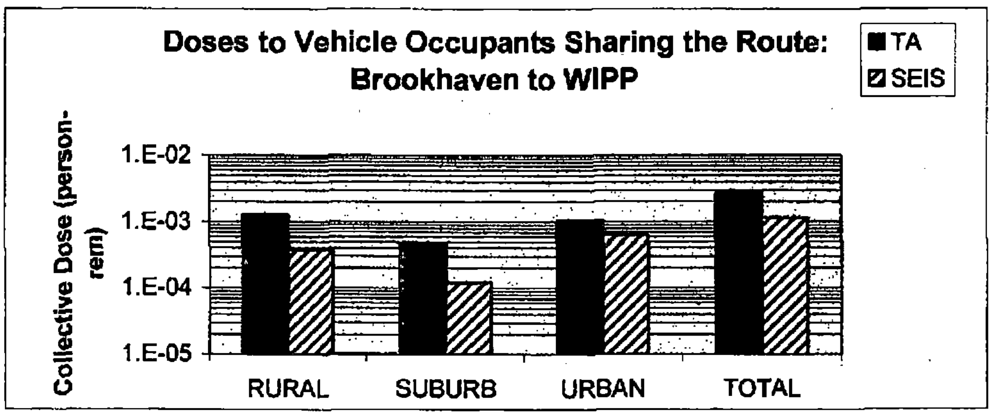


Figure 6 Comparison of the effect of vehicle densities on collective dose for vehicles sharing the route.

The in-transit dose to the maximally exposed individual along the route, per shipment; is 3.38 x 10^{-8} rem (3.38 x 10^{-5} mrem). For a truck passing at 24 km/hr (the conservative value used historically), that individual would be exposed for perhaps 0.4 minutes, and would have received 2.7 x 10^{-7} rem (2.7 x 10^{-4} mrem) of average background radiation. The dose per CH shipment is thus 12.5% of average U.S. background (360 mrem/year).

Tables 14 and 15 show the per-shipment doses and LCF for the public from RH-TRU transportation. The TI used in SEIS-II was 10 mrem/hr. Since the dose and the LCF risk are both proportional to the TI, comparison with SEIS-II values is provided only for people along the route.

3 Rush-hour vehicle densities and speeds were not included in the presentation. Their inclusion complicates the presentation without adding information or insight, or changing the result.

Table 14 Per-shipment doses from routine RH transportation.

DOSE FROM ROUTINE RH TRANSPORTATION – PERSON-REM				
	OCCUPATIONAL	ALONG ROUTE TI=2.5	SHARING ROUTE	ALONG ROUTE TI=10
ANL-E	1.88E-02	6.73E-03	5.05E-03	2.69E-02
BETTIS	2.33E-02	1.27E-02	3.50E-02	5.08E-02
INL/ANL-W	1.28E-02	9.81E-03	3.50E-03	3.92E-02
KAPL	1.20E-01	3.32E-02	1.97E-02	1.33E-01
LANL	4.87E-03	6.24E-05	1.12E-03	2.50 E-04
ORNL	1.79E-02	1.08E-02	5.62E-03	4.32E-02
SANDIA	4.10E-03	4.40E-03	1.87E-05	1.76E-02
RICHLAND (HANFORD)	2.35E-02	7.53E-03	1.67E-02	3.01E-02
SRS	9.18E-01	3.40E-02	3.40E-02	1.36E-01

Table 15 Per-shipment LCF risk from routine RH transportation

LCF RISK FROM ROUTINE RH TRANSPORTATION – PERSON-REM				
SITE	OCCUPATIONAL	ALONG ROUTE TI=2.5	SHARING ROUTE	ALONG ROUTE TI=10
ANL-E	1.13E-05	4.04E-06	3.03E-06	1.62E-05
BETTIS	1.40E-05	7.62E-06	2.10E-05	3.05E-05
INL/ANL-W	7.68E-06	5.89E-06	2.10E-06	2.35E-05
KAPL	7.20E-05	1.99E-05	1.18E-05	7.98E-05
LANL	2.92E-06	3.74E-08	6.72E-07	1.50E-07
ORNL	1.08E-05	6.48E-06	3.37E-06	2.59E-05
SANDIA	2.46E-06	2.64E-06	1.12E-08	1.06E-05
RICHLAND (HANFORD)	1.41E-05	4.52E-06	1.00E-05	1.81E-05
SRS	5.50E-04	2.04E-05	2.04E-05	8.16 E-05

In sum, doses calculated in this TA are smaller than those calculated in the SEIS-II for the same receptors as in SEIS-II.

3.1.5.2 Stops

Table 16 shows the doses at stops for transportation from each of the origin sites to the WIPP, and includes the most comparable data from Appendix E, Table E-12 of SEIS-II, and Table 17 shows the LCF risk. The modeling of stops was entirely different in this TA from that in the SEIS, so that the difference in results is not surprising. The improvements to RADTRAN have allowed for a more realistic representation of the transportation stops.

The model used in SEIS-II calculated only the collective dose to people who shared the stop with the truck carrying radioactive cargo, and assumed that 50 people at a fixed distance of 20 meters shared the stop. The SEIS II model also used stop times that were a uniform fraction of the distance traveled; e.g., that the truck stopped for one hour every 60 miles. These restrictions were a function of the computer capabilities for which RADTRAN 4 had been designed.

RADTRAN 5.6 and 6 allow structuring of any desired group of receptors located at different distances and for different lengths of time, with differing shielding. The groups of receptors analyzed in this TA are the people who share the stop with the radioactive cargo, residents who live around the stop, the truck crew, and rest stop employee, inspectors, and persons in a traffic jam next to the truck. Crew doses at rest stops are added to the doses accumulated at the mandated 100-mile (161-km) walkaround stops. Inspection stops have a different receptor and different exposure times; inspection doses can be calculated at the same time as for other stops, as can the receptor caught in a traffic jam.

Table 16 Per-CH shipment collective doses for 50-minute stops

SHIPMENT ORIGIN	DOSE (PERSON-REM): 50-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	1.80E-05	2.76E-04	2.00E-01
Battelle Columbus	7.11E-05	5.69E-03	-
Bettis Lab	2.63E-04	6.29E-03	-
Brookhaven NL	1.68E-04	1.02E-02	-
Idaho NL/Argonne West	4.18 E-05	6.61E-03	2.00E-01
Knolls Atomic Power Lab	9.37E-05	1.05E-02	-
Los Alamos NL	4.71E-06	1.80E-03	3.00E-02
Lawrence Berkeley NL	3.31E-05	6.74E-03	1.00E-01
Army Materials Command	1.13E-04	8.02E-03	-
Missouri U. Research Reactor	3.65E-05	5.41E-03	-
Nevada Test Site	1.90E-05	5.49E-03	1.00E-01
Oak Ridge NL	7.25E-05	8.59E-03	1.00E-01
Rocky Flats	2.54E-05	3.34E-03	7.00E-02
Richland (Hanford)	5.43E-05	3.34E-03	2.00E-01
Sandia NL	4.34E-06	1.51E-03	-
Savannah River NL	1.12E-04	7.56E-03	1.00E-01

Table 17 Per-CH shipment LCF for 50-minute stop

SHIPMENT ORIGIN	LCF: 50-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	1.08E-08	1.66E-07	1.20E-04
Battelle Columbus	4.27E-08	3.41E-06	-
Bettis Lab	1.58E-07	3.77E-06	-
Brookhaven NL	1.01E-07	6.10E-06	-
Idaho NL/Argonne West	2.53E-08	3.97E-06	1.20E-04
Knolls Atomic Power Lab	5.62E-08	6.27E-06	-
Los Alamos NL	2.83E-09	1.08E-06	1.80E-05
Lawrence Berkeley NL	1.99E-08	4.05E-06	6.00E-05
Army Materials Command	6.78E-08	4.81E-06	-
Missouri Univ. Research Reactor	2.19E-08	3.24E-06	-
Nevada Test Site	1.14E-08	3.30E-06	6.00E-05
Oak Ridge NL	4.35E-08	5.15E-06	6.00E-05
Rocky Flats	1.52E-08	2.01E-06	4.20E-05
Richland (Hanford)	3.26E-08	2.01E-06	1.20E-04
Sandia NL	2.60E-09	9.04E-07	-
Savannah River NL	6.69E-08	4.54E-06	6.00E-05

The data used in calculating doses to people sharing the stop were obtained from Griego et al. (1996), who visited truck stops in New Mexico and measured the time that large semi-detached trailer trucks were at the stop as well as the distance between the truck at a fuel tank and the nearest building. The latter was assumed to provide complete shielding from external radiation. The longest time observed by Griego et al. (1996) was 50 minutes, as reflected in the data in Tables 16 and 17. The average time observed was 20 minutes. Tables 18 and 19 show collective doses and LCF for 20-minute stops.

Table 18 Per-CH shipment doses for a 20- minute stop

DOSE(PERSON-REM): 20-MINUTE STOP			
SHIPMENT ORIGIN	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	7.19E-06	1.10E-04	2.00E-01
Battelle Columbus	2.84E-05	2.28E-03	-
Bettis Lab	1.05E-04	2.52E-03	-
Brookhaven NL	6.71E-05	4.07E-03	-
Idaho NL/Argonne West	1.67E-05	2.65E-03	2.00E-01
Knolls Atomic Power Lab	3.75E-05	4.18E-03	-
Los Alamos NL	1.88E-06	7.21E-04	3.00E-02
Lawrence Berkeley NL	1.33E-05	2.70E-03	1.00E-01
Army Materials Command	4.52E-05	3.21E-03	-

Table 18 Per-CH shipment doses for a 20- minute stop (continued)

DOSE(PERSON-REM): 20-MINUTE STOP			
SHIPMENT ORIGIN	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Missouri Univ. Research Reactor	1.46E-05	2.16E-03	-
Nevada Test Site	7.60E-06	2.20E-03	1.00E-01
Oak Ridge NL	2.90E-05	3.44E-03	1.00E-01
Rocky Flats	1.01E-05	1.34E-03	7.00E-02
Richland (Hanford)	2.17E-05	1.34E-03	2.00E-01
Sandia NL	1.74E-06	6.02E-04	-
Savannah River NL	4.46E-05	3.03E-03	1.00E-01

Table 19 Per-CH shipment LCF risk for a 20-minute stop.

SHIPMENT ORIGIN	LCF: 20-MINUTE STOP		
	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-12
Argonne NL East	4.31E-09	6.62E-08	1.20E-04
Battelle Columbus	1.71E-08	1.37E-06	-
Bettis Lab	6.31E-08	1.51E-06	-
Brookhaven NL	4.02E-08	2.44E-06	-
Idaho NL/Argonne West	1.00E-08	1.59E-06	1.20E-04
Knolls Atomic Power Lab	2.25E-08	2.51E-06	-
Los Alamos NL	1.13E-09	4.33E-07	1.80E-05
Lawrence Berkeley NL	7.95E-09	1.62E-06	6.00E-05
Army Materials Command	2.71E-08	1.92E-06	-
Missouri Univ. Research Reactor	8.77E-09	1.30E-06	-
Nevada Test Site	4.56E-09	1.32E-06	6.00E-05
Oak Ridge NL	1.74E-08	2.06E-06	6.00E-05
Rocky Flats	6.09E-09	8.02E-07	4.20E-05
Richland (Hanford)	1.30E-08	8.02E-07	1.20E-04
Sandia NL	1.04E-09	3.61E-07	-
Savannah River NL	2.68E-08	1.82E-06	6.00E-05

Tables 20 and 21 show the doses and LCF risks for 50-minute RH-shipment stops.

Table 20 Per-shipment stop doses (person-rem) from routine RH transportation

SITE	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-13
ANL-E	5.97E-04	2.64E-02	-
BETTIS	1.52E-02	6.29E-03	-
INL/ANL-W	9.90E-05	6.61E-03	2.00E-01
KAPL	2.17E-04	1.05E-02	-
LANL	1.10E-05	1.80E-03	4.00E-02
ORNL	1.57E-04	8.59E-03	2.00E-01
ROCKY FLATS	5.89E-05	3.34E-03	-
RICHLAND (HANFORD)	1.29E-04	3.34E-03	2.00E-01
SANDIA	1.01E-05	3.51E-03	-
SRS	2.15E-04	7.56E-03	-

Table 21 Per-shipment stop LCF risk from routine RH transportation

SITE	RESIDENTS OUTSIDE STOP	PEOPLE SHARING STOP	APP. E TABLE E-13
ANL-E	3.58E-07	1.58E-05	-
BETTIS	9.11E-06	3.77E-06	-
INL/ANL-W	5.94E-08	3.97E-06	1.20E-04
KAPL	1.30E-07	6.27E-06	-
LANL	6.58E-09	1.08E-06	2.40E-05
ORNL	9.40E-08	5.15E-06	1.20E-04
ROCKY FLATS	3.54E-08	2.01E-06	-
RICHLAND (HANFORD)	7.73E-08	2.01E-06	1.20E-04
SANDIA	6.06E-09	2.11E-06	-
SRS	1.29E-07	4.54E-06	-

The in-transit dose to the (reasonably) maximally exposed individual (RMEI) for each shipment is calculated to be 3.33×10^{-8} rem (3.33×10^{-6} Sv; 3.33×10^{-5} mrem) for a CH shipment and 7.76×10^{-8} rem for a RH shipment. Table 22 shows the cumulative dose to this individual from routine transport of all shipments, CH and RH, even though the putative damage done by doses from these shipments is not cumulative (Tenforde 2008)[4]. The WIPP is currently projected to have an operating life of 35 years (1998 to 2033), and annual doses assume a uniform distribution of shipments over that time period.

4 Doses do not accumulate. The assumption in adding doses from shipments is that the damage done by these doses accumulates. However, since the shipments are not continuous – there is a sizable lapse of time between them – the receptor organism recovers between shipments in part from any damage done. The partial recovery is used routinely in therapeutic radiation treatment; therapeutic doses are fractionated and delivered in relatively small fractions with several days or weeks of recovery allowed between doses.

Table 23 shows doses and LCF risk to the rest stop employee.

Table 22 Dose and LCF risk from all shipments to the RMEI

ORIGIN SITE	MAXIMUM DOSE (rem)	LCF	ANNUAL MAX DOSE (rem)	FRACTION OF AVERAGE ANNUAL BACKGROUND
ANL-E	9.19E-06	5.51E-09	2.62E-07	7.29E-07
ANL-W	2.15E-05	1.29E-08	6.14E-07	1.71E-06
BATTELLE	3.38E-08	2.03E-11	9.66E-10	2.68E-09
BNL	2.76E-05	1.66E-08	7.88E-07	2.19E-06
BETTIS	3.44E-07	2.07E-10	9.83E-09	2.73E-08
INL	4.78E-04	2.87E-07	1.37E-05	3.80E-05
KAPL	2.09E-05	1.25E-08	5.97E-07	1.66E-06
LANL	7.17E-05	4.30E-08	2.05E-06	5.69E-06
LBL	3.45E-06	2.07E-09	9.85E-08	2.74E-07
MAT. COMMAND	3.38E-08	2.03E-11	9.66E-10	2.68E-09
MURR	3.38E-08	2.03E-11	9.66E-10	2.68E-09
NTS	1.06E-05	6.37E-09	3.03E-07	8.43E-07
ORNL	2.23E-04	1.34E-07	6.37E-06	1.77E-05
RF	4.76E-05	2.86E-08	1.36E-06	3.78E-06
RL	1.83E-04	1.10E-07	5.23E-06	1.45E-05
SNL	5.35E-06	3.21E-09	1.53E-07	4.24E-07
SRS	7.84E-05	4.71E-08	2.24E-06	6.22E-06

Table 23 Doses and calculated LCF risks to the rest stop employee for all shipments

SHIPMENT ORIGIN	REST STOP EMPLOYEE					
	DOSE (rem)				LCF RISK	
	50-MINUTE STOP	20-MINUTE STOP	50-MIN. STOP ANNUAL DOSE	FRACTION OF BACKGROUND	50-MINUTE STOP	20-MINUTE STOP
Argonne NL East	6.06E-02	2.43E-02	1.73E-02	0.048	3.64E-05	1.46E-05
Battelle Columbus	1.26E-04	5.03E-05	3.59E-05	0.000	7.55E-08	3.02E-08
Bettis Lab	2.61E-03	1.04E-03	7.46E-04	0.002	1.57E-06	6.27E-07
Brookhaven NL	1.39E-01	5.55E-02	3.96E-02	0.110	8.32E-05	3.33E-05
Idaho NL/Argonne W	1.68E+00	6.69E-01	4.78E-01	1.33	1.00E-03	4.03E-04
Knolls Atomic Power	1.09E-01	4.36E-02	3.11E-02	0.086	6.54E-05	2.62E-05
Los Alamos NL	6.37E-02	2.55E-02	1.82E-02	0.051	3.82E-05	1.53E-05
Lawrence Berkeley NL	1.15E-02	4.59E-03	3.28E-03	0.009	6.89E-06	2.76E-06
Army Materials Com	1.34E-04	5.36E-05	3.83E-05	0.0001	8.04E-08	3.22E-08
Missouri Univ. Research Reactor	3.78E-05	1.51E-05	1.08E-05	0.0000	2.27E-08	9.07E-09
Nevada Test Site	3.61E-02	1.45E-02	1.03E-02	0.029	2.17E-05	8.67E-06
Oak Ridge NL	5.02E-02	2.01E-02	1.43E-02	0.04	3.01E-05	1.21E-05
Rocky Flats	7.86E-02	3.14E-02	2.25E-02	0.062	4.72E-05	1.89E-05
Richland (Hanford)	1.45E+00	5.80E-01	4.14E-01	1.15	8.70E-04	3.48E-04
Sandia NL	4.04E-03	1.61E-03	1.15E-03	0.003	2.42E-06	9.69E-07
Savannah River NL	2.35E+00	9.41E-01	6.72E-01	1.87	1. 41E-03	5.64E-04

The relatively significant doses for the routes from the Idaho, Richland (Hanford) and the Savannah River Site are artifacts of assuming that the effect of the shipments is cumulative. If these shipments are spaced uniformly throughout the 35 years of WIPP operation and the rest stop employee is exposed to 20% of them for 10 years, he or she will be exposed to about 175 shipments per year, or about one shipment every other day. The dose from each shipment is about 2.2 mrem, a small enough dose that the receptor would recover from its effects before being exposed to the next shipment. Multiplying the dose from a shipment by a number of shipments spaced a day or more apart is a significant conservatism. This consideration applies throughout this analysis.

The relatively significant collective doses for the routes from Brookhaven and the Knolls Atomic Power Laboratory result from the long distances that shipments from these sites travel, because the number of stops is directly proportional to the distance traveled.

Table 24 shows the dose and LCF to state inspectors. The assumption in calculating this table was that there would be one stop in each state. The dose to a state inspector at a one-hour stop was calculated to be 0.0022 rem (2.2 mrem) for an average CH shipment and 0.00723 rem (7.23 mrem) for an average RH shipment. A state inspector was assumed to be exposed to 20% of the shipments during a ten-year period.

Table 24 Doses and calculated LCF risks to state inspectors

STATE	NUMBER OF SHIPMENTS		10-YEAR			
	CH	RH	DOSE TO INSPECTOR (rem)	LCF RISK	ANNUAL DOSE TO INSPECTOR (rem)	FRACTION OF BACK GROUND
AL	1953	160	1.09E+00	6.54E-04	0.312	0.87
AR	1336	2923	4.81E+00	2.89E-03	1.376	4
AZ	416	0	1.83E-01	1.10E-04	0.052	0.15
CA	416	0	1.83E-01	1.10E-04	0.052	0.15
CO	16046	3498	1.21E+01	7.27E-03	3.462	10
GA	1953	160	1.09E+00	6.54E-04	0.312	0.87
ID	14637	2427	9.95E+00	5.97E-03	2.843	8
IL	82	83	1.56E-01	9.37E-05	0.045	0.12
IN	1	-	6.80E+00	4.08E-03	1.944	5
KS	1	4	6.22E-03	3.73E-06	0.002	0.00
KY	1	4	6.22E-03	3.73E-06	0.002	0.00
LA	1953	160	1.09E+00	6.54E-04	0.312	0.87
MD	955	209	7.22E-01	4.33E-04	0.206	0.57
MO	83	83	1.57E-01	9.39E-05	0.045	0.12
MS	1953	160	1.09E+00	6.54E-04	0.312	0.87
NJ	955	209	7.22E-01	4.33E-04	0.206	0.57
NM	22888	5691	1.83E+01	1.10E-02	5.229	15
NV	314		1.38E-01	8.29E-05	0.039	0.11
NY	955	209	7.22E-01	4.33E-04	0.206	0.57
OH	2	4	6.66E-03	4.00E-06	0.002	0.01
OK	83	83	1.57E-01	9.39E-05	0.045	0.12

Table 24 Doses and calculated LCF risks to state inspectors (continued)

STATE	NUMBER OF SHIPMENTS		10-YEAR			
	CH	RH	DOSE TO INSPECTOR (rem)	LCF RISK	ANNUAL DOSE TO INSPECTOR (rem)	FRACTION OF BACK GROUND
OR	1409	1747	3.15E+00	1.89E-03	0.899	2
PA	956	213	7.29E-01	4.37E-04	0.208	0.58
SC	1953	160	1.09E+00	6.54E-04	0.312	0.87
TN	1336	2923	4.81E+00	2.89E-03	1.376	4
TX	3372	3166	6.06E+00	3.64E-03	1.732	5
UT	14637	2416	9.93E+00	5.96E-03	2.838	8
VA	956	209	7.23E-01	4.34E-04	0.207	0.57
WA	1409	1747	3.15E+00	1.89E-03	0.899	2
WV	956	213	7.29E-01	4.37E-04	0.208	0.58
WY	14637	2416	9.93E+00	5.96E-03	2.838	8

Table 24 should be read with the same caution as Table 23. Nevertheless, inspectors would receive significant external doses. Under the suggested protocol, a New Mexico inspector would inspect about 163 shipments per year, or about one every other day (a Colorado inspector would inspect about 117 shipments per year). Weiner and Neuhauser (1992) proposed that, because of their somewhat extended proximity to the radioactive cargo, state inspectors should be considered radiation workers and should wear dosimeters in accordance with ALARA. This would almost certainly apply to New Mexico and inspectors in other states where the dose would exceed background. Inspection doses were projected in this study to exceed background in two-thirds of the states traversed. The projection is conservative in that it does not recognize that many of these states have different ports of entry, so that different inspectors would be involved. New Mexico, for example, has three interstate ports of entry (four, if the Big Spring, Texas cutoff is used).

The dose and risk to an inspector at each origin site are shown in Table 25. Each inspector was assumed to be exposed to half of the shipments, in accordance with the analysis plan. However, those sites shipping a large number of shipments (Idaho NL, Oak Ridge, Hanford, and probably Savannah River) would probably use more than two inspectors, if only because of the time required to inspect the number of shipments leaving those sites. All origin sites have ALARA practices in place in any case.

Table 25 Doses and calculated LCF risks to inspectors at shipment origins

	10-YR CH SHIPMENT DOSE (rem)	10-YR RH SHIPMENT DOSE (rem)	LCF RISK	ANNUAL DOSE	FRACTION OF BACK GROUND
Argonne NL East	2.55E-02	8.57E-02	6.68E-05	1.11E-02	0.03
Battelle Columbus	7.86E-03	2.75E-01	1.70E-04	2.83E-02	0.08
Bettis Lab	3.14E-04	-	1.89E-07	3.14E-05	0.0001
Brookhaven NL	2.57E-01	-	1.54E-04	2.57E-02	0.07
Idaho NL/Argonne West	3.14E-04	4.13E-03	2.67E-06	4.45E-04	0.00
Knolls Atomic Power Lab	4.15E+00	4.27E-01	2.75E-03	4.58E-01	1.27
Los Alamos NL	4.37E-02	2.16E-01	1.56E-04	2.59E-02	0.07
Lawrence Berkeley NL	6.43E-01	3.34E-02	4.06E-04	6.77E-02	0.19
Army Materials Command	3.21E-02	-	1.92E-05	3.21E-03	0.01
Missouri Univ. Research Reactor	3.14E-04	-	1.89E-07	3.14E-05	0.0001
Nevada Test Site	3.14E-04	-	1.89E-07	3.14E-05	0.0001
Oak Ridge NL	9.87E-02	-	5.92E-05	9.87E-03	0.03
Rocky Flats	1.19E-01	2.80E+00	1.75E-03	2.92E-01	0.81
Richland (Hanford)	4.43E-01	-	2.66E-04	4.43E-02	0.12
Sandia NL	4.43E-01	1.80E+00	1.35E-03	2.25E-01	0.62
Savannah River NL	2.11E-03	6.82E-02	4.22E-05	7.03E-03	0.02

The final special receptor is an individual in a traffic jam, 2 meters laterally from a WIPP-bound truck, for 30 minutes, unshielded by the vehicle he or she is occupying. The doses that such an individual would receive are:

- 5.23×10^{-4} rem (0.523 mrem) from a CH-TRU vehicle[5].
- 1.19×10^{-3} rem (1.19 mrem) from a RH-TRU vehicle.

3.3.3 Accident Calculations

NRC-certified Type B packages used to ship CH-TRU and RH-TRU waste must undergo a series of performance tests which simulate accident conditions (10 CFR Part 71 Subpart E). The packages pass if no radioactive material is released as a result of the tests.

The WIPP SEIS-II assumed that 9 percent of truck accidents involving Type B containers or casks could result in radioactive material releases and could be more severe than test conditions. This was considered a conservative assumption (DOE 1997b). This assumption was not maintained for this TA. Instead, the more accurately calculated conditional probabilities of accidents (severity fractions) were used, as discussed further. The calculation of accident dose risk includes multiplication by the large semi-detached truck accident rate for each state (obtained from Bureau of Transportation Statistics data (BTS 2008).

Two analyses were conducted for radiological impacts due to transportation accidents. The first analysis assesses the radiological impact due to an accident occurring on each rural, suburban, and urban segment of each state traversed during transportation from each of the origin sites to the WIPP. The second analysis (severe accident analysis, Section 3.3.3.2) assessed four bounding accidents. For the WIPP SEIS-II, the radiological inventory assumed that every TRU waste package would be filled with waste containers to the maximum level of radionuclides and hazardous materials allowed by the planning-basis waste acceptance criteria (DOE 1996). This analysis used the maximum curie content for a TRUPACT and a RH-72B from the most recent WIPP inventory report (DOE 2008a); the curie content was from a Savannah River waste stream for CH waste and a Bettis Atomic Power Laboratory for RH waste. The compared inventories are shown in Table 26.

5 See the SRS_CH and SRS_RH RADTRAN outputs.

Table 26 Bounding Case Radionuclide Inventories for CH-TRU and RH-TRU Waste Accidents

	CH-TRU WASTE		RH-TRU WASTE	
Radionuclide	SEIS-II INVENTORY(CURIES PER TRUPACT-II)	NEW INVENTORY (CURIES PER TRUPACT-II)[1]	SEIS-II INVENTORY (CURIES PER RH-72B)	NEW INVENTORY (CURIES PER RH-72B)[1]
Co-60	6.40E-04	5.58E-03	2.5	13.4
Sr-90	0.01	0.087	49	263.6
Cs-137	0.01	0.087	49	263.6
U-233	Not found in inventory	Not found in inventory	0.03	0.161
U-235	Not found in inventory	Not found in inventory	1.10E-03	5.92E-03
U-238	Not found in inventory	Not found in inventory	7.10E-05	3.82E-04
Pu-238	990	8630.7	1,000	5379.5
Pu-239	16	139.5	20	107.6
Pu-240	4.2	36.6	10	53.8
Am-241	3.6	31.4	12	64.6
Pu-241	200	1743.6	10	53.8
Pu-242	6.80E-04	5.93E-03	Not found in inventory	Not found in inventory

[1] DOE (2008a)

Accident severity fractions (conditional probabilities) define the seriousness of an accident in terms of mechanical and thermal loads. The WIPP SEIS-II retained the severity classification scheme use by the NRC (1977) as shown in Table 27.

Table 27 Fractional Truck Accident Occurrences by Accident Severity Category and Population Density Zone used in the WIPP SEIS-II

Accident Severity Category	Fractional Occurrences	Rural	Suburban	Urban
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5E-5	0.8	0.1	0.1
VIII	1.5E-5	0.9	0.05	0.05

Source: NRC 1977.

The data presented in Table 27 were generated using the best engineering judgment available. Since publication of NRC (1977), two studies have developed these data further. The first of these studies (Fischer et al. 1987, NUREG/CR 4829) examined relevant truck and rail accident data from 1973 through 1986, constructed event trees to estimate the probabilities of each type of accident, and represented the accident severities as functions of thermal and mechanical stress on the transportation package. The

second study (Sprung et al. 2000, NUREG/CR-6672) refined and updated the event trees, and using both finite element analysis and data from cask tests, developed release fractions for 19 severity cases for truck accidents (and 21 severity cases for rail accidents) that encompass the universe of accidents, including the most probable (no release) accidents. The severity cases, related severity fractions (conditional probabilities), and release fractions from Sprung et al. (2000) are currently used for analysis of accidents involving Type B casks. In DOE (2002), the 19 severity cases and associated severity and release fractions were reduced to six by probability weighting. In addition, recognizing that no data supported the dependence of accident severity on population zone, the same severity fractions were used in all three population zones. The resulting accident scheme used in this TA is shown in Table 28.

Table 28 Fractional Truck Accident Occurrences by Accident Severity Category

Severity Category	Severity Fraction	Gas	Volatile	Particulates
1	0.99993	0.00000	0.00000	0.00000
2	6.06E-05	1.36E-01	4.09E-09	1.02E-07
3	5.86E-06	8.39E-01	1.68E-05	6.71E-08
4	4.95E-07	4.49E-01	1.35E-08	3.37E-07
5	7.49E-08	8.35E-01	3.60E-05	3.77E-06
6	3.00E-10	8.40E-01	2.40E-05	5.01E-06

Source: Sprung et al. (2000) (NUREG/CR-6672) ; DOE (2002).

3.3.3.1 Impact of Lead Loss or Slump

An accident can also cause the slumping or loss of lead gamma shielding (LOS), which would in turn results in an external dose to a receptor that exceeds the TI and can even exceed the regulatory maximum dose (10 mrem/hr at 2 meters). Sprung et al. (2000) developed a set of severity fractions for loss of lead gamma shielding, these were used in the analysis. In addition, Boyd et al. (2006) developed a factor by which to multiply the TI to reflect loss of shielding which was used in this analysis.

3.3.3.2 Severe Accident Calculations

For the severe accident calculations, two types of accidents were assumed to involve the breach of a CH-TRU shipping container and two types of accident were assumed to involve the breach of an RH-TRU shipping container. The accidents were assumed to occur under conditions which maximize the impacts to exposed populations (as used in the WIPP SEIS-II: urban area, stable meteorological conditions, breach containers engulfed in fire for two hours). The WIPP SEIS-II calculated an inhalation dose from resuspended material using a resuspension particle half-life of 365 days. However, Cederwall et al. (1987) and other studies measuring resuspended particles indicate that 100 days is already exceedingly conservative. Anspaugh (1990) suggests that a likely resuspension half life is 15 days. RADTRAN calculates the resuspension dose by assuming that released and aerosolized material is resuspended (and inhaled) for the entire time that the receptor is exposed, to fallout from the accident. This assumption is consonant with current transportation risk analysis practice (see e.g., DOE 2008d, Volume 2). The exposure time used in this analysis was 24 hours, with no change in the fraction resuspended. Accident

probability was calculated using current severity category data and joint frequency distributions of meteorological data (DOE 2002).

The following assumptions were made regarding the bounding-case transportation accident scenarios in the WIPP SEIS-II and were retained for this TA:

- Impacts were analyzed without regard to the likelihood of the accident occurring, and are thus consequences rather than risks. Risks are reported as well.
- The waste shipment would be three fully-loaded shipping containers (TRUPACT-II) or a fully loaded RH-72B. The inventory was chosen to maximally bound the impact by loading of the shipping containers up to the values shown in Table 26 for the current inventory. Since the doses in an accident are directly proportional to the activity of each radionuclide, the average (of each radionuclide, of waste streams, of containers) can be estimated from the bounding case.
- Accidents are the severity categories showing the largest releases (generally 5 and 6 in Table 25).
- Two percent (0.02) of the aerosolized, airborne radioactive waste material is released to the environment in a respirable form (less than 10 microns in diameter), consistent with recent analyses (Sprung et al. 2000; DOE 2002; DOE 2008d).
- Radioactive material is evenly distributed throughout the waste volume.
- One CH-TRU accident and one RH-TRU accident were assumed to occur in the urban portion of a nonspecific, large metropolitan area with the average population density of the most populous city in the U. S., of 2,570 persons per square kilometer (7,140 persons per square mile) (U.S. Census Bureau 2006).[6]
- Accidents occur during very stable meteorological conditions, limiting dispersion of the radioactive material plume and maximizing radiation doses.
- In the accident scenarios, one shipping container is breached and subsequently engulfed in fire for two hours.
- Receptors were exposed to the emitted material for 24 hours[7]

The bounding radionuclide inventories for CH-TRU and RH-TRU waste are shown in Table 26. These values were used for this TA.

3.3.4 Results of Accident Calculations

The per-shipment dose risks per CH shipment from accidents involving a release, are shown in Table 29. Dose risks include both the consequence and probability of accidents. Ingestion doses are listed separately because the receptors are the entire society, not the people along the routes. Table 30 shows the collective per shipment dose risks for all CH shipments. In the case of accidents, multiplying by the number of shipments is accurate because it increases the probability that a shipment will be involved in each type of accident. Another, more conservative, approximation is inherent in these dose risk results: the rural, suburban, and urban route segments are combined to form virtual rural, suburban, and urban route segments for each state. However, an accident will occur at only one place, so combining the populations (e.g., all rural populations) will overestimate the collective dose for that route segment. The

6 This is a deviation from the AP-141
7 This is a deviation from the AP-141

urban dose risks will be relatively accurately represented only in states that have only one urban population center. Collective dose risks for CH shipments are shown in Table 30. Tables 31 and 32 show the collective dose risks for a single RH shipment and for all RH shipments, respectively.

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX					
R	1.10E-10	1.66E-10	9.33E-11	1.65E-10	3.40E-11					
S	9.20E-10	1.47E-09	1.39E-10	1.27E-09	2.11E-10					
U	1.50E-09	1.51E-09	2.20E-10	2.79E-09	1.24E-10					
INGESTION	1.44E-09	1.85E-09	4.58E-09	2.69E-09	1.50E-09					
BATTELLE	IL	IN	MO	NM	OH	OK	TX			
R	6.05E-11	6.81E-11	1.66E-10	9.20E-11	3.40E-11	1.65E-10	3.36E-11			
S	5.18E-10	5.56E-10	1.47E-09	1.37E-10	4.52E-10	1.27E-09	2.08E-10			
U	3.44E-10	1.20E-09	1.51E-09	2.17E-10	7.94E-10	2.75E-09	2.32E-09			
INGESTION	8.80E-10	8.32E-10	1.85E-09	4.73E-09	3.85E-10	2.78E-09	1.55E-09			
BNL	AK	MC	NJ	NM	NY	PA	TN	TX	VA	WV
R	4.67E-10	6.54E-12	4.17E-11	5.41E-11	1.13E-11	2.20E-10	8.56E-10	7.30E-10	3.13E-10	3.95E-11
S	3.04E-09	2.85E-10	1.71E-09	3.18E-10	2.81E-09	2.92E-09	8.43E-09	7.26E-09	3.97E-09	1.05E-09
U	3.41E-09	5.21E-10	5.12E-09	7.41E-10	2.77E-08	4.88E-09	1.75E-08	1.33E-07	3.56E-09	4.28E-10
INGESTION	7.37E-09	7.64E-11	4.65E-10	2.83E-09	2.63E-10	2.14E-09	1.04E-08	8.85E-09	3.82E-09	2.94E-10
BETTIS	AK	KY	NM	OH	PA	TN	TX	WV		
R	1.78E-10	1.67E-10	1.82E-11	8.02E-11	1.15E-11	1.21E-10	2.47E-10	7.43E-12		
S	1.46E-06	1.65E-09	1.06E-10	9.67E-10	4.86E-10	1.43E-09	2.32E-09	1.46E-10		
U	1.43E-09	3.14E-09	2.19E-10	1.72E-09	2.26E-09	4.23E-09	5.75E-09	2.72E-10		
INGESTION	2.83E-09	1.78E-09	9.56E-09	9.79E-10	1.17E-10	1.77E-09	4.83E-09	6.85E-11		
INL/ANL-W	CO	ID	NM	UT	WY					
R	3.15E-10	1.86E-10	4.40E-11	1.32E-10	2.65E-10					
S	4.47E-09	9.06E-10	9.63E-10	9.65E-10	9.62E-10					
U	1.87E-08	1.23E-09	1.69E-09	6.40E-10	1.41E-09					
INGESTION	5.91E-09	4.11E-09	2.06E-09	2.31E-09	1.27E-08					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	4.67E-10	6.54E-12	4.17E-11	5.41E-11	8.75E-10	2.20E-10	8.56E-10	7.37E-10	3.13E-10	3.95E-11
S	3.04E-09	2.85E-10	1.71E-09	3.18E-10	2.34E-09	2.92E-09	8.43E-09	6.93E-09	3.97E-09	1.05E-09
U	3.41E-09	5.21E-10	5.12E-09	6.83E-10	3.13E-09	4.88E-09	1.75E-08	1.59E-08	3.56E-09	4.28E-10
INGESTION	7.37E-09	7.64E-11	4.65E-10	2.84E-09	1.14E-08	2.14E-09	1.04E-08	1.43E-08	3.82E-09	2.94E-10
LANL	NM									
R	3.82E-10									
S	9.85E-10									

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents (continued)

U	1.27E-08									
INGESTION	1.42E-08									
LBL	AZ	CA	NM							
R	3.92E-10	4.32E-10	5.66E-10							
S	1.47E-09	2.29E-09	2.47E-09							
U	2.54E-09	2.16E-08	1.14E-08							
INGESTION	1.23E-08	1.20E-08	1.72E-08							
MCA	AK	NM	TN	TX	VA					
R	5.32E-10	5.43E-11	5.35E-10	4.13E-10	3.53E-10					
S	3.47E-09	3.18E-10	8.04E-09	5.30E-09	5.01E-09					
U	4.17E-09	6.83E-10	2.01E-08	3.74E-09	1.11E-08					
INGESTION	8.40E-09	2.84E-09	1.04E-08	5.03E-09	4.38E-09					
MURR	KS	MO	NM	OK	TX					
R	2.84E-10	1.66E-10	2.75E-10	3.13E-10	1.00E-10					
S	2.16E-09	2.10E-09	4.10E-10	1.97E-09	6.21E-10					
U	1.03E-09	5.59E-09	7.08E-10	4.59E-09	3.33E-09					
INGESTION	5.24E-09	2.65E-09	1.40E-08	6.61E-09	4.58E-09					
NTS	AZ	CA	NV	NM						
R	3.92E-10	9.62E-11	1.00E-10	5.61E-10						
S	1.47E-09	4.23E-10	7.66E-10	2.46E-09						
U	2.54E-09	8.38E-10	6.16E-09	1.13E-08						
INGESTION	1.71E-08	1.23E-08	5.87E-09	1.54E-09						
OAK RIDGE	AK	NM	TN	TX						
R	5.32E-10	5.41E-11	6.30E-10	7.37E-10						
S	3.47E-09	3.18E-10	5.15E-09	6.87E-09						
U	4.17E-09	7.41E-10	1.57E-08	1.92E-08						
INGESTION	8.40E-09	2.83E-09	8.43E-09	1.43E-08						
ROCKY FLATS	CO	NM								
R	1.77E-10	3.95E-10								
S	3.78E-09	8.64E-10								
U	1.70E-08	1.51E-09								

Table 29 Per-shipment dose risks for CH-TRU shipment potential accidents (continued)

INGESTION	4.00E-09	1.27E-08								
RICHLAND	CO	ID	NM	OR	UT	WA	WY			
R	2.85E-10	3.74E-10	3.95E-10	1.66E-10	1.14E-10	3.03E-10	2.40E-10			
S	4.04E-09	2.05E-09	8.64E-10	6.79E-10	8.36E-10	2.39E-10	8.70E-10			
U	1.857E-08	8.35E-09	1.51E-09	8.891E-10	5.79E-10	2.66E-09	7.45E-10			
INGESTION	5.35E-09	5.00E-09	1.27E-08	4.45E-09	2.58E-09	1.27E-09	1.15E-08			
SNL	NM									
R	2.97E-10									
S	9.76E-11									
U	5.24E-09									
INGESTION	8.87E-09									
SRS	AL	GA	LA	MS	NM	SC	TX			
R	4.04E-10	2.6E-10	2.75E-10	3.41E-10	5.41E-11	2.55E-11	7.59E-10			
S	3.17E-09	3.99E-09	2.89E-09	2.61E-09	3.18E-10	2.62E-10	5.55E-09			
U	3.81E-09	1.19E-08	3.19E-09	2.72E-09	7.42E-10	2.63E-10	1.26E-08			
INGESTION	5.06E-09	3.17E-09	4.83E-09	4.90E-09	2.83E-09	3.50E-09	1.44E-08			

Table 30 Collective dose risks for CH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX				
R	2.95E-08	1.41E-08	8.15E-09	1.39E-08	3.11E-09				
S	2.47E-07	1.25E-07	1.21E-08	1.07E-07	1.93E-08				
U	5.48E-07	1.28E-07	1.92E-08	2.42E-07	1.19E-08				
INGESTION	1.24E-07	1.59E-07	3.94E-07	2.32E-07	1.29E-07				
BATTELLE	IL	IN	MO	NM	OH	OK	TX		
R	2.00E-10	6.81E-11	1.73E-10	9.89E-11	3.40E-11	1.71E-10	3.79E-11		
S	1.71E-09	5.56E-10	1.53E-09	1.47E-10	4.52E-10	1.32E-09	2.34E-10		
U	1.55E-09	1.20E-09	1.58E-09	2.33E-10	7.94E-10	2.94E-09	2.73E-09		
INGESTION	9.33E-10	8.82E-10	1.96E-09	5.01E-09	4.08E-10	2.95E-09	1.64E-09		
BROOKHAVEN	AK	MD	NJ	NM	NY	PA	TN	TX	VA
R	4.58E-07	5.54E-09	4.87E-04	4.75E-08	9.38E-09	1.82E-07	7.42E-07	6.72E-07	2.76E-07
S	2.98E-06	2.41E-07	4.84E-03	2.79E-07	2.33E-06	2.42E-06	7.30E-06	6.68E-06	3.50E-06
U	3.25E-03	4.43E-07	8.89E-02	6.50E-07	2.32E-05	4.08E-06	1.59E-05	1.28E-04	3.21E-06
INGESTION	6.38E-06	6.61E-08	4.02E-07	2.45E-06	2.28E-07	1.85E-06	9.00E-06	7.66E-06	3.31E-06
BETTIS	AK	KY	NM	OH	PA	TN	TX	WV	
R	2.14E-10	1.67E-10	1.96E-11	8.02E-11	1.16E-11	1.28E-10	2.78E-10	5.49E-09	
S	1.75E-06	1.65E-09	1.14E-10	9.67E-10	4.92E-10	1.52E-09	2.61E-09	1.46E-07	
U	4.23E-09	3.14E-09	2.35E-10	1.72E-09	2.32E-09	4.69E-09	6.76E-09	5.95E-08	
INGESTION	3.00E-09	1.89E-09	1.01E-08	1.04E-09	1.24E-10	1.88E-09	5.12E-09	7.26E-11	
INL/ANL-W	CO	ID	NM	UT	WY				
R	4.60E-06	2.79E-06	6.26E-07	1.99E-06	3.17E-06				
S	6.92E-07	1.44E-07	1.45E-07	1.54E-07	1.22E-07				
U	5.92E-05	3.99E-06	5.20E-06	2.02E-06	3.67E-06				
INGESTION	6.45E-07	4.49E-07	2.25E-07	2.52E-07	1.39E-06				
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA
R	7.80E-08	9.43E-10	1.42E-05	8.08E-09	1.24E-07	3.10E-08	1.26E-07	1.15E-07	4.70E-08
S	5.08E-07	4.11E-08	1.34E-04	4.75E-08	3.31E-07	4.11E-07	1.24E-06	1.09E-06	5.96E-07
U	9.43E-05	7.54E-08	3.07E-04	1.02E-07	4.47E-07	6.95E-07	2.70E-06	2.60E-06	5.46E-07
INGESTION	1.09E-06	1.13E-08	6.85E-08	4.18E-07	1.68E-06	3.15E-07	1.53E-06	2.11E-06	5.63E-07
LANL	NM								
R	8.41E-07								
S	2.17E-06								
U	2.79E-05								
INGESTION	3.08E-05								
LBL	AZ	CA	NM						
R	4.81E-08	4.74E-08	6.21E-08						
S	1.80E-07	2.51E-07	2.71E-07						
U	3.22E-07	2.53E-06	1.25E-06						
INGESTION	1.33E-06	1.30E-06	1.86E-06						
MCA	AK	NM	TN	TX	VA				
R	6.39E-10	5.84E-11	9.08E-10	4.65E-10	3.81E-10				
S	4.17E-09	3.42E-10	8.94E-09	5.97E-09	5.41E-09				
U	0.00E+0	7.34E-10	2.01E-08	4.40E-09	1.22E-08				

	0								
INGESTION	8.90E-09	3.01E-09	1.10E-08	5.33E-09	4.64E-09				
MURR	KS	MO	NM	OK	TX				
R	2.10E-10	1.28E-10	2.18E-10	2.40E-10	8.34E-11				
S	1.60E-09	1.62E-09	3.25E-10	1.51E-09	5.16E-10				
U	5.47E-09	4.30E-09	5.61E-10	3.63E-09	2.88E-09				
INGESTION	4.17E-09	2. 10E-09	1.11E-08	5.25E-09	3.65E-09				
NTS	AZ	CA	NV	NM					
R	1.48E-07	3.25E-08	3.92E-08	1.89E-07					
S	5.55E-07	1.43E-07	3.01E-07	8.31E-07					
U	9.93E-07	3.03E-07	2.50E-06	3.83E-06					
INGESTION	5.70E-06	4.10E-06	1.95E-06	5.13E-07					
OAK RIDGE	AK	NM	TN	TX					
R	2.42E-07	2.20E-08	2.53E-07	3.15E-07					
S	1.58E-06	1.30E-07	2.07E-06	2.93E-06					
U	0.00E+00	3.02E-07	6.59E-06	8.55E-06					
INGESTION	3.37E-06	1.14E-06	3.39E-06	5.74E-06					
ROCKY FLATS	CO	NM							
R	2.76E-07	5.98E-07							
S	5.89E-06	1.31E-06							
U	2.65E-05	2.29E-06							
INGESTION	5.97E-06	1.90E-05							
RICHLAND	CO	ID	NM	OR	UT	WA	WY		
R	4.44E-07	5.97E-07	5.98E-07	2.53E-07	1.83E-07	4.27E-07	3.17E-06		
S	6.29E-06	3.27E-06	1.31E-06	1.04E-06	1.35E-06	3.37E-07	1.22E-07		
U	2.89E-05	1.33E-05	2.29E-06	1.39E-06	8.99E-07	3.74E-06	3.67E-06		
INGESTION	5.67E-09	7.70E-09	1.95E-08	4.72E-09	2.73E-09	1.35E-09	1.22E-08		
SNL	NM								
R	2.14E-09								
S	7.04E-10								
U	3.78E-08								
INGESTION	6.31E-08								
SRS	AL	GA	LA	MS	NM	SC	TX		
R	9.73E-05	5.81E-07	5.37E-07	6.66E-07	1.14E-07	4.98E-08	1.67E-06		
S	9.99E-04	8.91E-06	5.64E-06	5.10E-06	6.68E-07	5.12E-07	1.22E-05		
U	1.00E-03	2.81E-05	6.24E-06	5.32E-06	1.56E-06	5.14E-07	2.88E-05		
INGESTION	1.05E-05	6.56E-06	1.00E-05	1.01E-05	5.86E-06	7.25E-06	2.98E-05		

Table 31 Per-shipment dose risks for RH-TRU shipment potential accidents

ANL-EAST	IL	MO	NM	OK	TX					
R	5.15E-10	7.86E-10	4.33E-10	7.81E-10	1.59E-10					
S	4.30E-09	6.98E-09	6.46E-10	6.03E-09	9.74E-10					
U	7.01E-09	7.16E+10	1.02E-09	1.18E-08	5.81E-09					
INGESTION	2.55E-09	3.17E-09	8.04E-09	4.76E-09	2.65E-09					
BETTIS	AR	KY	NM	OH	PA	TN	TX	WV		
R	9.13E-11	8.55E-11	9.31E-12	4.11E-11	5.88E-12	6.23E-11	1.26E-10	3.81E-12		
S	5.95E-10	8.46E-10	5.45E-11	4.96E-10	2.49E-10	7.33E-10	1.19E-09	7.51E-11		
U	7.16E-10	1.47E-09	1.12E-10	1.40E-10	1.16E-09	2.17E-09	4.02E-10	1.39E-10		
INGESTION	1.45E-09	9.09E-10	4.88E-10	5.00E-10	5.96E-11	9.02E-09	2.46E-09	3.49E-11		
INL/ANL-W	CO	ID	NM	UT	WY					
R	1.00E-10	5.90E-11	1.25E-11	4.18E-11	8.44E-11					
S	1.42E-09	2.88E-10	3.97E-10	3.07E-10	3.06E-10					
U	5.92E-09	3.92E-10	5.18E-10	2.03E-10	4.49E-10					
INGESTION	3.09E-09	2.15E-09	1.07E-08	1.21E-09	6.62E-09					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	7.42E-10	1.04E-11	6.63E-11	8.59E-11	1.39E-09	3.49E-10	1.36E-09	1.17E-09	4.97E-10	6.28E-11
S	4.83E-09	4.53E-10	2.71E-09	5.05E-10	3.72E-09	4.64E-09	1.34E-08	1.10E-08	6.31E-09	1.66E-09
U	5.41E-09	6.50E-10	8.12E-09	2.38E-08	4.98E-09	7.75E-09	2.79E-08	2.52E-08	5.65E-09	2.30E-11
INGESTION	4.26E-09	4.41E-11	2.69E-10	1.63E-09	6.61E-09	1.23E-09	6.00E-09	8.27E-09	2.21E-09	1.70E-10
LANL	NM									
R	8.05E-10									
S	2.07E-09									
U	2.66E-08									
INGESTION	1.53E-08									
OAK RIDGE	AR	NM	TN	TX						
R	8.45E-10	8.59E-11	1.00E-09	8.59E-11						
S	5.50E-09	5.05E-10	8.18E-09	5.05E-10						
U	6.62E-09	1.17E-09	2.50E-08	3.05E-08						
INGESTION	4.85E-09	1.63E-09	4.87E-09	8.27E-09						
ROCKY FLATS	CO	NM								
R	1.10E-04	6.27E-10								
S	2.36E-03	1.37E-09								
U	2.70E-08	2.40E-09								
INGESTION	2.31E-09	1.07E-08								
RICHLAND	CO	ID	NM	OR	UT	WA	WY			

Table 31 Per-shipment dose risks for RH-TRU shipment potential accidents (continued)

R	4.53E-10	5.93E-10	6.27E-10	1.08E-09	1.81E-10	4.42E-11	3.81E-10		
S	6.42E-09	3.25E-09	1.37E-09	1.27E-09	1.33E-09	4.81E-10	1.38E-09		
U	2.95E-08	7.02E-09	2.40E-09	1.41E-09	9.19E-10	4.21E-09	1.18E-09		
INGESTION	3.09E-09	4.19E-09	1.07E-08	2.57E-09	1.49E-09	7.36E-10	6.62E-09		
SNL	**NM**								
R	4.71E-10								
S	1.55E-10								
U	8.31E-09								
INGESTION	6.84E-09								
SRS	AL	GA	LA	MS	NM	SC	TX		
R	6.41E-10	4.13E-10	5.59E-10	5.42E-10	8.59E-11	2.97E-11	1.17E-09		
S	5.03E-09	6.33E-09	4.58E-09	4.15E-09	5.05E-10	3.05E-10	1.09E-08		
U	6.06E-09	1.88E-08	4.97E-09	1.68E-18	1.59E-09	3.07E-10	3.84E-08		
INGESTION	2.93E-09	1.83E-09	3.57E-09	2.62E-09	1.63E-09	1.48E-10	8.27E-09		
INGESTION	2.93E-09	1.83E-09	3.57E-09	2.62E-09	1.63E-09	1.48E-10	8.27E-09		

Table 32 Collective dose risks for RH-TRU shipment potential accidents for all shipments

ANL-EAST	IL	MO	NM	OK	TX					
R	1.38E-07	2.10E-06	3.78E-08	6.58E-08	1.46E-08					
S	1.15E-06	2.15E+13	5.64E-08	5.08E-07	8.92E-08					
U	2.56E-06	2.15E+13	8.91E-08	1.03E-06	5.55E-07					
INGESTION	2.20E-07	2.73E-07	6.92E-07	4.10E-07	2.28E-07					
BETTIS	AR	KY	NM	OH	PA	TN	TX	WV		
R	1.10E-10	8.55E-11	1.00E-11	4.11E-11	5.96E-12	6.61E-11	1.42E-10	3.81E-12		
S	7.15E-10	8.46E-10	5.86E-11	4.96E-10	2.52E-10	7.78E-10	1.34E-09	7.51E-11		
U	2.17E-09	1.47E-09	1.21E-10	1.40E-10	1.19E-09	2.40E-09	4.72E-10	1.39E-10		
INGESTION	1.54E-09	9.64E-10	5.17E-10	5.30E-10	6.32E-11	9.56E-09	2.61E-09	3.70E-11		
INL/ANL-W	CO	ID	NM	UT	WY					
R	1.46E-06	8.84E-07	1.78E-07	6.31E-07	1.12E-06					
S	2.20E-07	4.57E-08	5.97E-08	4.91E-08	4.28E-08					
U	1.64E-06	1.27E-06	1.59E-06	6.42E-07	1.29E-06					
INGESTION	3.37E-07	3.37E-07	1.17E-06	1.32E-07	7.23E-07					
KAPL	AK	MD	NJ	NM	NY	PA	TN	TX	VA	WV
R	1.24E-07	1.50E-09	1.28E-06	1.28E-08	1.96E-07	4.91E-08	2.01E-07	1.83E-07	7.46E-08	8.73E-09
S	8.07E-07	6.53E-08	5.24E-05	7.55E-08	5.26E-07	6.53E-07	1.98E-06	1.72E-06	9.47E-07	2.31E-07
U	1.50E-04	9.40E-08	1.57E-04	3.55E-06	7.10E-07	1.10E-06	4.31E-06	4.12E-06	8.66E-07	3.20E-09
INGESTION	6.28E-07	6.50E-09	3.96E-08	2.40E-07	9.74E-07	1.81E-07	8.84E-07	1.22E-06	3.26E-07	2.50E-08
LANL	NM									
R	1.77E-06									
S	4.56E-06									
U	5.85E-05									
INGESTION	3.32E-05									
OAK RIDGE	AR	NM	TN	TX						
R	3.85E-07	3.50E-08	4.02E-07	3.67E-08						
S	2.51E-06	2.06E-07	3.29E-06	2.16E-07						
U	2.21E-06	6.64E-07	2.05E-06	1.36E-05						

Table 32 Collective dose risks for RH-TRU shipment potential accidents for all shipments (continued)

INGESTION	1.95E-06	6.55E-07	1.96E-06	3.32E-06						
ROCKY FLATS	CO	NM								
R	1.71E-01	9.50E-07								
S	3.67E+00	2.08E-06								
U	4.20E-05	3.64E-06								
INGESTION	4.03E-05	1.60E-05								
RICHLAND	CO	ID	NM	OR	UT	WA	WY			
R	7.06E-07	9.47E-07	9.50E-07	1.65E-06	2.91E-07	4.85E-08	1.89E-07			
S	1.00E-05	5.19E-06	2.08E-06	1.94E-06	2.14E-06	6.45E-07	1.86E-06			
U	4.59E-05	1.12E-05	3.64E-06	2.21E-06	1.43E-06	1.08E-06	3.88E-06			
INGESTION	4.62E-06	6.26E-06	1.60E-05	3.84E-06	2.23E-06	1.10E-06	9.89E-06			
SNL	NM									
R	1.18E-09									
S	3.90E-10									
U	2.09E-08									
INGESTION	1.67E-08									
SRS	AL	GA	LA	MS	NM	SC	TX			
R	8.51E-04	3.22E-07	2.85E-07	3.69E-07	6.28E-08	2.75E-08	8.98E-07			
S	6.67E-03	4.92E-06	3.00E-06	2.81E-06	3.70E-07	2.83E-07	8.36E-06			
U	8.05E-03	1.44E-05	3.25E-06	2.93E-06	8.60E-07	2.85E-07	2.44E-05			
INGESTION	2.07E-06	1.30E-06	1.98E-06	1.86E-06	1.16E-06	1.43E-07	5.86E-06			

3.3.4.1 Severe Accident

Figures 7 and 8 show the dose from the severe no-fire accident involving an RH72-B cask carrying the bounding inventory of RH-TRU waste. The accident is postulated to occur in an urban area with a population of 2570 persons per km^2, the largest population density of any U.S metropolitan area in 2005, the most recent year for which validated metropolitan population data are available (U.S. Census Bureau 2006). The semi-logarithmic plot (Figure 7) shows the dramatic decrease of dose with distance; the log-log plot of Figure 8 shows the dose values more precisely. Table 33 is a tabulation of the data reflected in Figures 7 and 8.

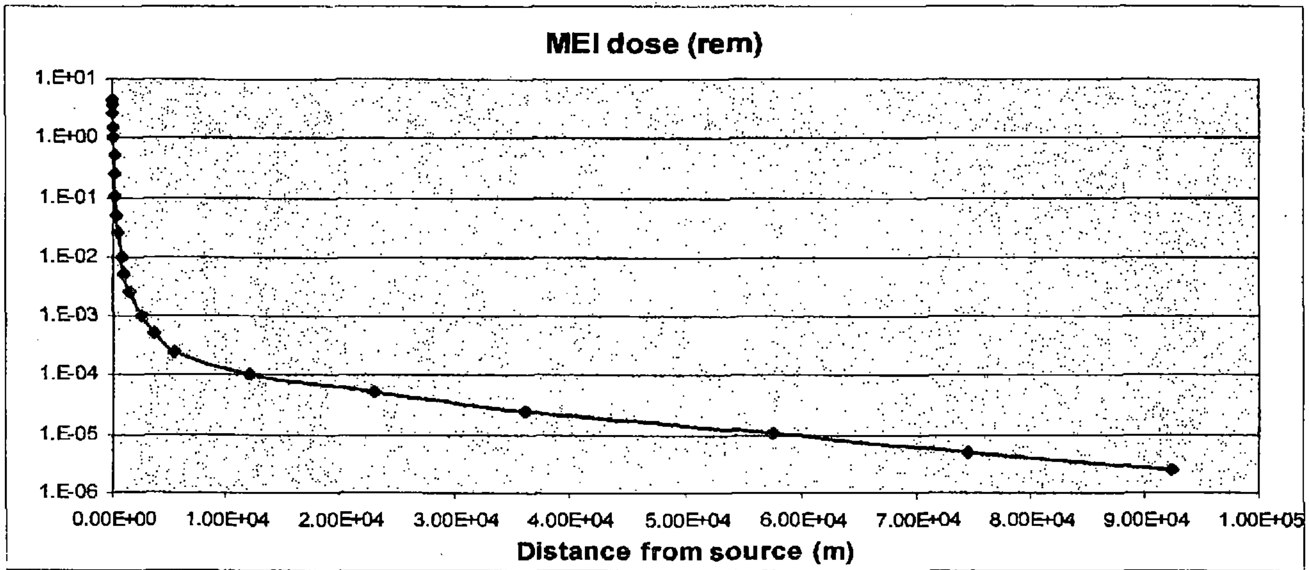


Figure 7 Dose to the MEI from a severe accident in an urban area.

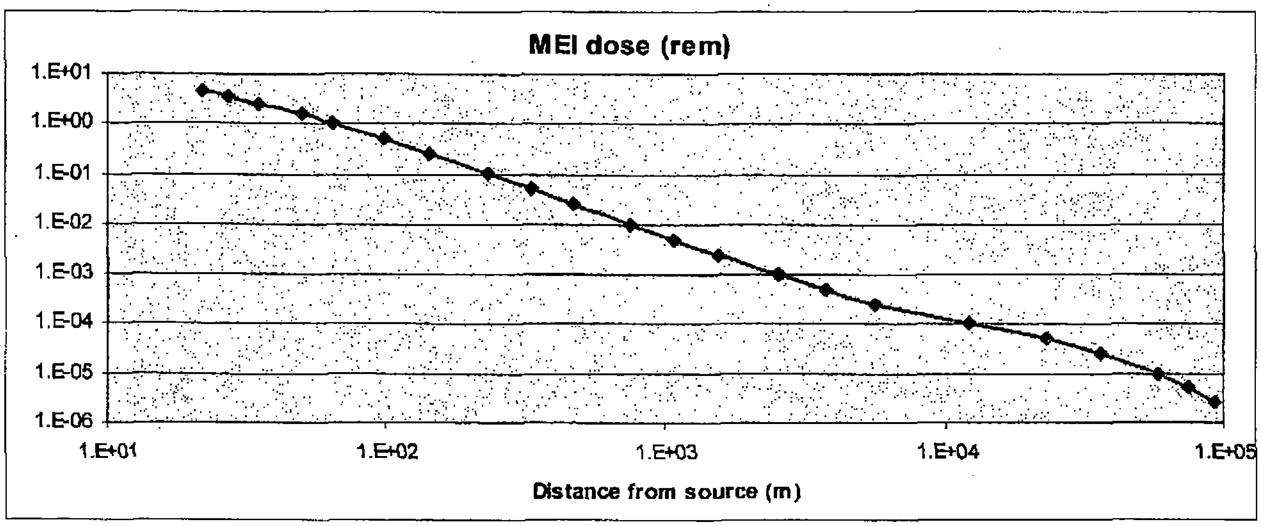


Figure 8 Dose to the MEI from a severe accident in an urban area (log-log).

Table 33 Variation of MEI dose with downwind distance from the source

Distance from source (m)	MEI dose (rem)	Distance from source (m)	MEI dose (rem)
2.23E+01	4.59E+00	1.08E+03	5.10E-03
2.74E+01	3.56E+00	1.54E+03	2.54E-03
3.54E+01	2.54E+00	2.52E+03	1.02E-03
5.04E+01	1.53E+00	3.72E+03	5.10E-04
6.53E+01	1.02E+00	5.54E+03	2.54E-04
9.85E+01	5.10E-01	1.22E+04	1.02E-04
1.45E+02	2.54E-01	2.29E+04	5.10E-05
2.35E+02	1.02E-01	3.61E+04	2.54E-05
3.35E+02	5.10E-02	5.76E+04	1.02E-05
4.76E+02	2.54E-02	7.46E+04	5.10E-06
7.56E+02	1.02E-02	9.23E+04	2.54E-06

Figure 9 shows the maximum MEI dose as a function of distance from the source for the case where the accident involves a car fire (release elevation: 100 m; emitted heat: 1000 calories). Data from the no-fire accident depicted in Figure 7 is shown on the graph for comparison. Conditions in the two cases were the same except for the fire, and the same model was used for both. As the graph shows, an elevated release results in moving the maximum dose to the MEI downwind; the maximum occurs at

$$x = H/\sqrt{2}$$

where x is the downwind distance in meters and H is the release height in meters (Wark et al. 1998). The dose to the RMEI from the fire accident, as modeled, is also much less than the dose from the no-fire accident at distances less than a kilometer from the accident. The doses from the two accidents are the same, and are about 100 mrem, about 7 km from the source.

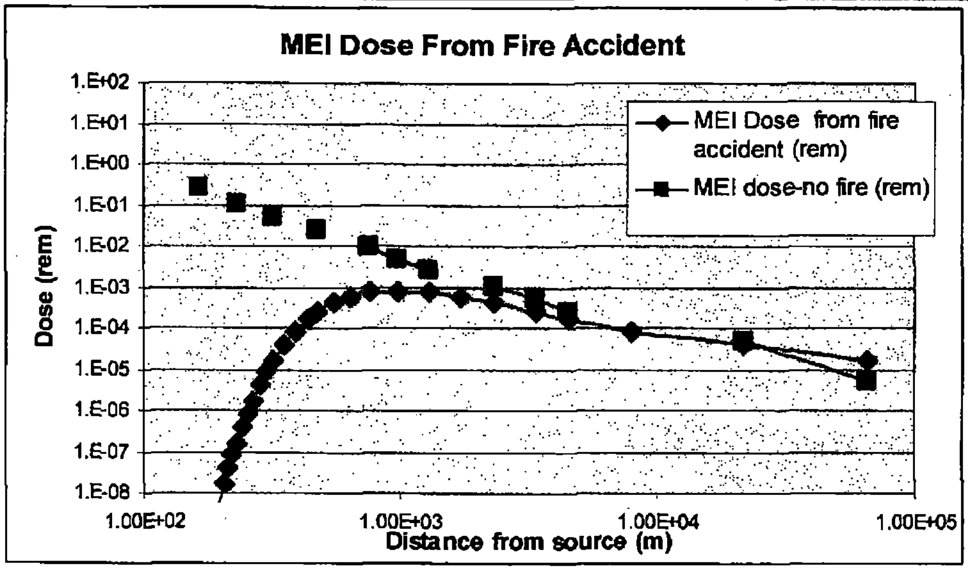


Figure 9 MEI doses from an accident that involved a fire and one that did not involve a fire.

Figure 10 compares the dose risks from a ground-level release with those from an elevated release. The data shown are from an accident involving a TRUPACT, but the differences between ground-level and elevated releases are about the same for an accident with a RH-72B. The elevated release accident includes both fire and impact; the ground-level release is from an impact-only accident.

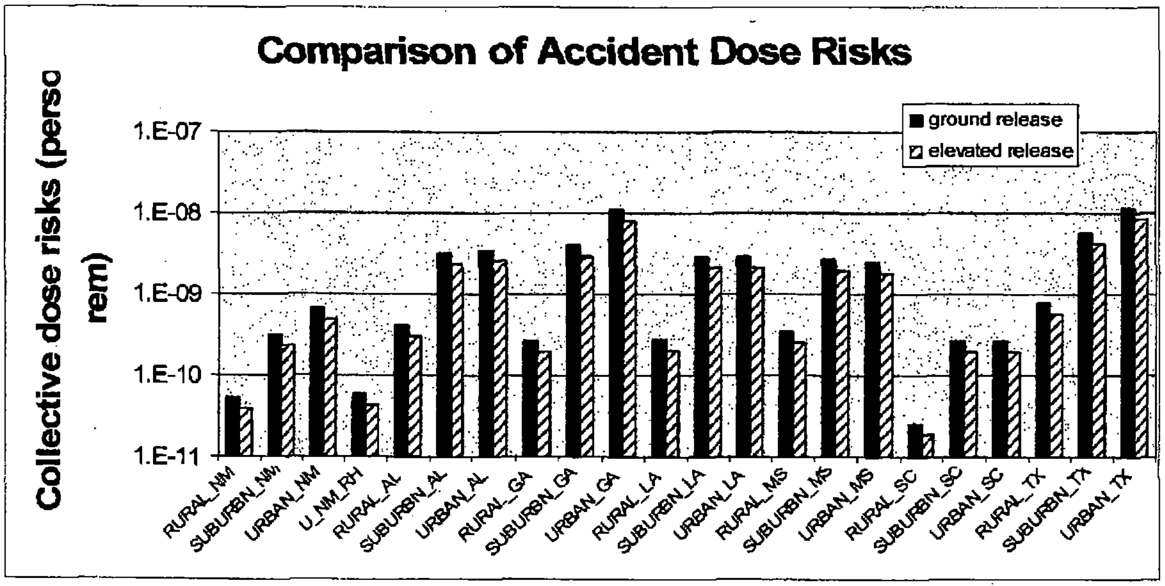


Figure 10 Comparison of accident dose risks from a ground level and an elevated release.

Table 34 compares the consequences of the severe accident in the most heavily populated urban area for the RH-72B and one TRUPACT. This table reflects the results shown in Table 33 and Figure 7: the consequences of an accident that involves a fire are less than those of a no-fire accident because of the

dilution created by an elevated release. Also, the worst case of those shown in Table 34, the no-fire RH-72B accident, results in a radiation dose to the MEI smaller than the maximum annual occupational dose recommended in 10 CFR Part 20 (5 rem).

Table 34 Consequences of the postulated severe accident in an urban area. Shipments contain the bounding radionuclide inventory.

	RH-72B	TRUPACT	RH-72B LCF RISK	TRUPACT LCF RISK
		No Fire		
total dose (person-rem)	92.8	2.89	5.57E-02	1.73E-03
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	0.12	0.12	-	-
total persons	330	330	-	-
average dose (rem)	0.28	0.009	-	-
MEI dose (rem)	3.14	0.168	1.88E-03	1.01E-04
		Fire		
total dose(p-rem)	97.2	83.8	5.83E-02	5.03E-02
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	0.12	0.12	-	-
total persons	330	330	-	-
average dose (rem)	0.29	0.25	-	-
MEI dose (rem)	3.62E-04	1.94E-05	2.17E-07	1.16E-08

Table 35 shows the consequences of an accident involving a TRUPACT and a RH72-B carrying an average inventory, which was calculated by dividing the average activity of the bounding case radionuclides for CH-TRU and RH-TRU (from DOE 2008a) and dividing by the average number of CH-TRU and RH-TRU shipments, respectively.

Table 35 Consequences of the postulated severe accident in an urban area. Shipments contain the average radionuclide inventory.

	RH-72B	TRUPACT	RH-72B LCF RISK	TRUPACT LCF RISK
		No Fire		
total dose(p-rem)	9.28E+01	6.70E-02	5.57E-02	4.02E-05
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	1.20E-01	1.20E-01	-	-
total persons	3.30E+02	3.30E+02	-	-
Average dose (rem)	2.81E-01	2.03E-04	-	-
MEI dose (rem)	3.14E+00	3.20E-03	1.88E-03	1.92E-06
		Fire		
total dose(p-rem)	9.72E+01	5.70E-02	5.83E-02	3.42E-05
total area sq m	1.20E+05	1.20E+05	-	-
total area sq km	1.20E-01	1.20E-01	-	-
total persons	3.30E+02	3.30E+02	-	-
average dose (rem)	2.95E-01	1.73E-04	-	-
MEI dose (rem)	3.62E-04	4.03E-07	2.17E-07	2.42E-10

3.3.4.2 "No-release" Accidents

More than 99.99% of the traffic accidents that involve a Type B container[8] are postulated to result in no impact at all on the radioactive cargo or its packaging (Sprung et al. 2000). However, a truck involved in such an accident will sit in or near the spot where the accident occurred, often for many hours, and will continue to emit ionizing radiation externally. Table 36 shows the doses sustained by members of the public if such an accident were to happen in a very densely populated area.

Table 36 Doses from a "no-release" accident

	Dose	LCF RISK	Population/sq. km	Distance from accident (m)	Exposure time (hrs)
TRUPACT (person-rem)	4.95E-03	2.97E-06	2750	30 - 800	10
TRUPACT-MEI (rem)	9.69E-05	5.81E-08	-	30	10
RH-72B (person-rem)	2.15E-02	1.29E-05	2750	30-800	10
RH-72B-MEI (rem)	2.26E-04	1.36E-07	-	30	10

3.3.4.3 Impact of Lead Loss or Slump

An accident involving a lead-shielded container like the RH-72B can also cause the slumping or loss of lead gamma shielding (LOS), which would in turn results in an external dose that exceeds the TI and can even exceed the regulatory maximum dose (10 mrem/hr at 2 meters). Boyd et al. (2006) have developed a factor by which to multiply the TI to reflect loss of lead gamma shielding; this model has been incorporated into RADTRAN. The model relies on conditional probabilities and severity fractions for loss of lead gamma shielding (Sprung et al. 2000). These are shown in Table 37.

Table 37 Description of LOS Cases

LOS case	LOS accident condition	Fraction of shield lost	Conditional Probability
1	End impact	0.052	1.71E-06
2	End impact	0.158	4.63E-07
3	End impact	0.264	3.21E-08
4	End impact	0.368	2.53E-10
5	Corner impact	0.033	2.20E-05
6	Corner impact	0.096	5.97E-06
7	Corner impact	0.158	4.14E-07
8	Corner impact	0.255	3.27E-09
9	Lead melt (T > 350°C)	0.029	4.90E-05
10	Lead melt with puncture (T > 350°C)	0.5	1.66E-09

8 All packaging used to ship TRU waste is shipped in Type B containers.

The RADTRAN LOS model was used to determine dose estimates to the public during an extreme spent nuclear fuel transportation accident. Results varied according to the following: type of accident condition, percent of lead slump, distance to shipment, time spent in the area. The RADTRAN input file was setup using data obtained from and two LOS stops were modeled, one each for rural/suburban and urban routes with the same shipment vehicle. Data shown in Table 37 was used to construct the conditional probability and slump fraction portion of the input. Table 38 provides stop related data used to setup the example problem.

Table 38. LOS Stop Input Parameters

Name	Vehicle	People	Inner Distance (m)	Outer Distance (m)	Shielding Factor	Exposure Time (hr)
LOSR/S	RH72b	1	1	100	1	0.67
LOSU	RH72b	1	1	100	1	0.46

The LOS stops with exposure durations of 0.46 and 0.67 hours are intended to mimic the resident population dose prior to arrival of first-responders and ultimate evacuation. These times are based on the average emergency response times per population zone. Therefore, it is assumed that the public will remain exposed to the accident for up to 0.67 hours in a rural or suburban setting and 0.46 hours in an urban setting until emergency crews arrive and evacuate members of the nearby public. The LOS model provides results for average dose, maximum dose at two meters, and LOS dose-risk. The results presented below were calculated for one representative shipment from Los Alamos National Laboratory to the WIPP.

Figures 11 and 12 present how the average dose is affected by slump fraction and distance from the accident. All results were normalized to one person. The dose received can be significant with increasing slump and proximity to the accident. Since the LOS model, when determining average or maximum dose, makes no automatic account for population zone, the only differentiating factor between the rural and urban results is the emergency response time.

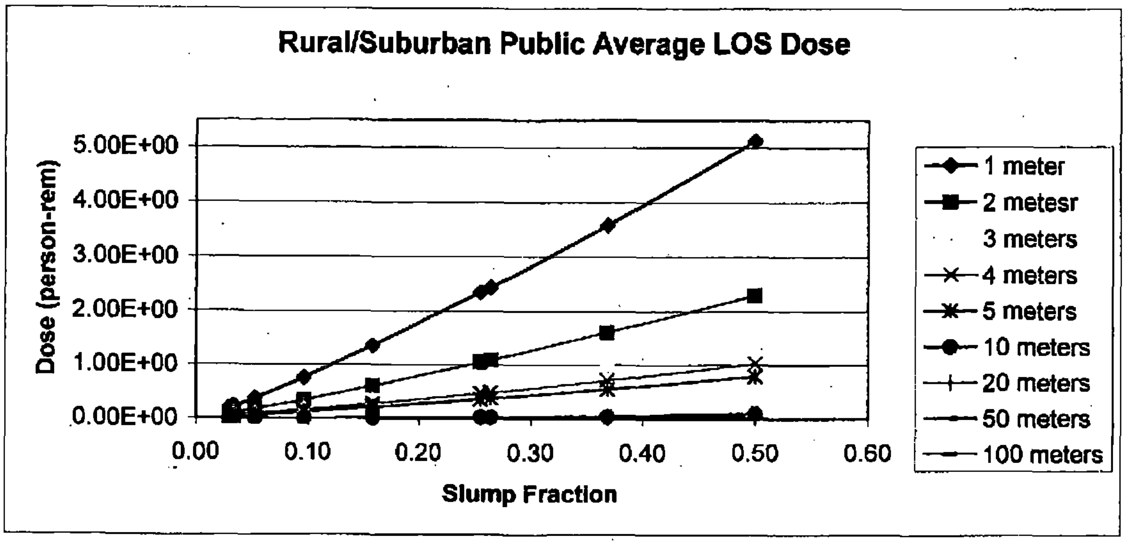


Figure 11 Rural and Suburban Public Average LOS Dose

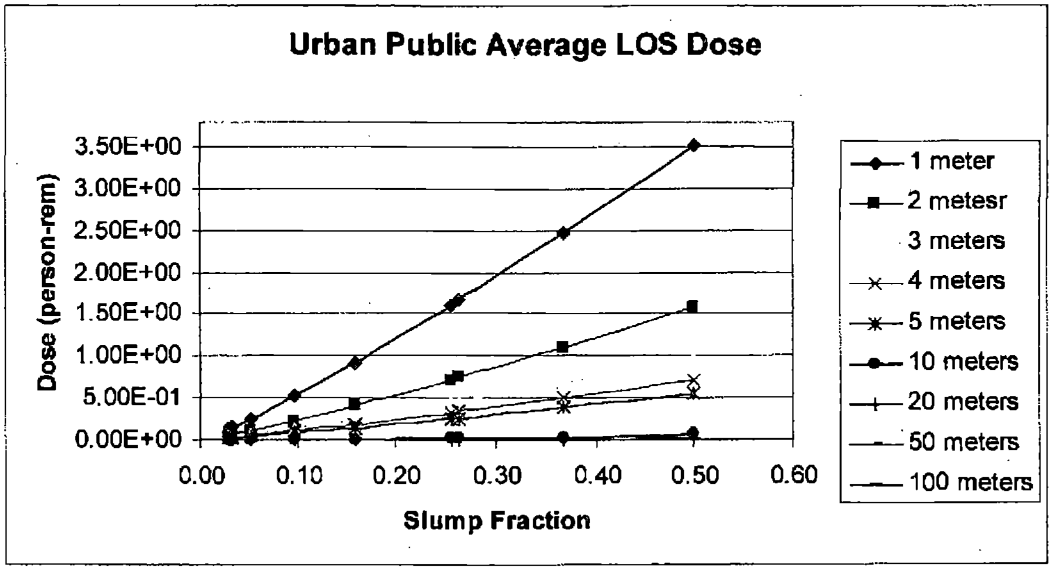


Figure 12 Urban Public Average LOS Dose

Finally, Figure 13 shows the maximum LOS dose at 2 meters. It is unlikely that in an accident scenario anyone would ever approach the cask at such proximity, but this value serves as a comparison to how the LOS maximum deviates from the regulatory maximum.

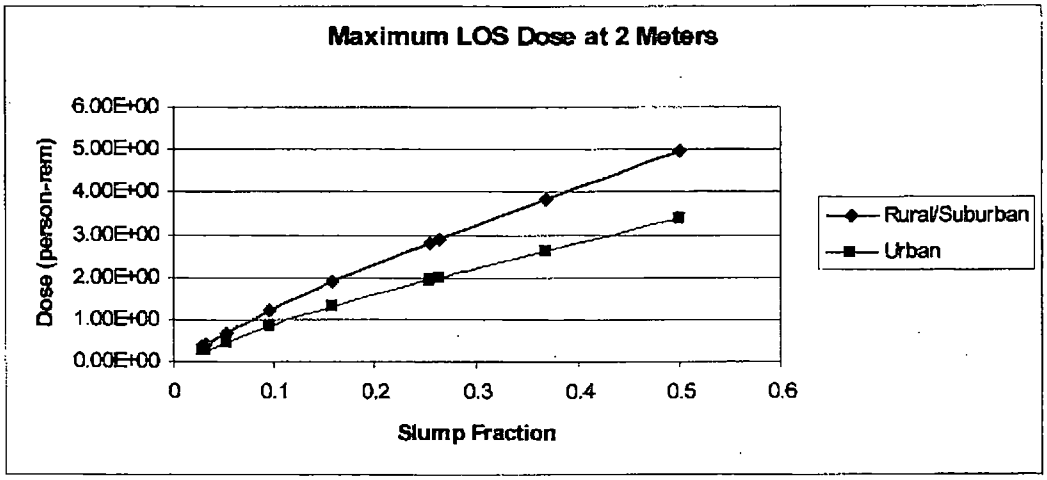


Figure 13 Maximum LOS Dose at 2 meters for rural/suburban and urban population zones

3.3.5 Other Impact Calculations

3.3.5.1 Nonradiological Impacts

The nonradiological impacts associated with the transportation of TRU waste to WIPP were calculated using the number of shipments from Table 5. No assumption was made that the carrier drivers of TRU waste would be more careful than other truck drivers on the nation's roads.

The WebTRAGIS code was used to estimate the distances from the various sites to WIPP and to estimate the corresponding population density fractions. The rural, suburban, and urban population route mileages along a given route were multiplied by state-specific accident and fatality rates to obtain route-specific impacts. For states, the most reliable data are the state-specific Department of Transportation (DOT) validated data from the DOT Research and Innovative Technology Administration (RITA) web site of the Bureau of Transportation Statistics: http://www.bts.gov/, (USDOT 2008) which was used.

Route-specific data per shipment accident, injury, and fatality rates were multiplied by the appropriate number of route shipments to obtain the aggregate number of accidents, injuries, and fatalities. Because this analysis is not dependent on whether a truck is transporting full or empty TRU waste containers, twice the one-way mileage was used. The impacts, including the total impact, are shown in Table 39.

Table 39 Non-radiological (traffic) accidents and fatalities

	ACCIDENTS/ SHIPMENT	FATALITIES/ SHIPMENT	SHIPMENTS	ACCIDENTS	FATALITIES	ACCIDENTS/ YEAR
Argonne NL East	6.97E-03	2.39E-06	164	2.29	7.84E-04	0.005
Battelle Columbus	7.50E-03	2.66E-05	1	0.02	5.32E-05	5.7E-04
Bettis Lab	8.82E-03	3.12E-05	5	0.09	3.12E-04	0.003
Brookhaven NL	1.00E-05	3.54E-08	816	0.02	5.78E-05	5.7E-04
Idaho NL/Argonne West	7.10E-03	2.50E-05	13908	197.49	6.95E-01	5.65
Knolls Atomic Power Lab	1.16E-02	4.09E-05	348	8.07	2.85E-02	0.23
Los Alamos NL	2.32E-03	8.20E-06	2079	9.65	3.41E-02	0.28
Lawrence Berkeley NL	7.14E-03	2.52E-05	102	1.46	5.14E-03	0.041
Army Materials Command	7.47E-03	3.19E-02	1	0.01	6.38E-02	2.9E-04
Missouri U. Research Reactor	5.84E-03	2.06E-05	1	0.01	4.12E-05	2.9E-04
Nevada Test Site	6.03E-03	2.13E-05	314	3.79	1.34E-02	0.10
Oak Ridge NL	7.03E-03	2.48E-05	3089	43.43	1.53E-01	1.24
Rocky Flats	3.91E-03	1.37E-05	1409	11.02	3.86E-02	0.31
Richland (Hanford)	8.88E-03	3.48E-05	3156	56.05	2.20E-01	1.60
Sandia NL	1.96E-03	6.92E-06	73	0.29	1.01E-03	0.008
Savannah River NL	7.58E-03	2.68E-05	2113	32.03	1.13E-01	0.92
TOTAL	-	-	27579	365.71	1.37	10.44

The distance traveled in an urban population zone and the impact factor truck emissions (EPA 1991; Biwer and Butler 1999) were used to estimate additional urban-area pollution health effects due to TRU waste shipments. The impact factor, 5×10^{-8} per km (8×10^{-8} per mile) (Biwer and Butler 1999) estimates the latent cancer fatality (LCF) risk per urban mile traveled. The volume of exhaust emissions in an urban area by a single truck shipment should be quite small. The WIPP SEIS-II showed that LCFs attributed to diesel exhaust exposure in an urban area are very small relative to the impact of accidents, fatalities, or injuries.

Table 40 shows the LCF risk calculated using the Biwer and Butler (1999) risk factor. Comparison with the results shown in Table 38 indicates that the LCF risk from exhaust emissions is comparable to (about 2/3 of) the calculated number of traffic fatalities. Both analyses are dominated by shipments from Idaho NL and Hanford.

Table 40 Calculated LCF risk from vehicle pollution.

ORIGIN SITE	URBAN (km)	2XURBAN (km)	SHIPMENTS	SHIPMENT-(km)	LCF RISK
Argonne NL East	41.9	83.8	164	1.4E+04	6.9E-04
Battelle Columbus	49	98.0	1	9.8E+01	4.9E-06
Bettis Lab	101.9	203.8	5	1.0E+03	5.1E-05
Brookhaven NL	162.8	325.6	816	2.7E+05	1.3E-02
Idaho NL/Argonne West	627.5	1255.0	13908	1.7E+07	8.7E-01
Knolls Atomic Power Lab	109.9	219.8	348	7.6E+04	3.8E-03
Los Alamos NL	2.1	4.2	2079	8.7E+03	4.4E-04
Lawrence Berkeley NL	56.4	112.8	102	1.2E+04	5.8E-04
Army Materials Command	47.3	94.6	1	9.5E+01	4.7E-06
Missouri U. Research Reactor	40.3	80.6	1	8.1E+01	4.0E-06
Nevada Test Site	26.8	53.6	314	1.7E+04	8.4E-04
Oak Ridge NL	61.3	122.6	3089	3.8E+05	1.9E-02
Rocky Flats	33.9	67.8	1409	9.6E+04	4.8E-03
Richland (Hanford)	51.9	103.8	3156	3.3E+05	1.6E-02
Sandia NL	6.5	13.0	73	9.5E+02	4.7E-05
Savannah River NL	64.7	129.4	2113	2.7E+05	1.4E-02
TOTAL	1484.2		27579	4.1E+07	0.946

SEIS-II cites 0.1 LCF risk from vehicle pollution (Table E-9) – almost an order of magnitude less than the TA calculation. This difference does not appear to have an obvious explanation: the total mileage is about the same for SEIS-II and this TA, the fraction of miles that are urban miles is about the same for this TA (0.042) as for the normal array of RADTRAN 4 (0.05), and the number of shipments is less in this TA. The only difference is that for this TA, the accidents and fatalities were calculated in RADTRAN, which uses the same input data throughout, and whose calculations have been verified (Dennis et al. 2008). RADTRAN 4 did not have this capability.

3.3.5.2 Hazardous Chemical Impacts

Hazardous chemicals in TRU mixed waste occur as volatile organic compounds (VOCs) and metals. Accidents involving hazardous chemicals and metals were evaluated as acute-release events with respect to potential exposures and associated impacts. During routine, incident-free transportation, exposure to hazardous non-radioactive constituents of the transported waste would not occur because the hazardous components in the waste are completely contained in the transportation container/cask. Thus, no impacts to human health are posed by the hazardous, non-radioactive waste components under routine, incident-free transportation.

An accident in which the shipping container is breached constitutes a source of hazardous chemical exposures. The hazardous chemical assessment was conservatively based on a very severe transportation accident involving one shipping container. In the WIPP-SEIS II, it was assumed that a fire would engulf all three shipping containers; this is not assumed for this TA as a fire would reduce the potential VOC emissions. As in the WIPP SEIS-II, this bounding-case accident scenario was based on the assumption that the entire releasable fraction of each chemical considered is used. The assumptions used in the radiological accident assessment provide the basis for the impacts of accidents involving the chemical components of the waste. The hazardous chemical impact compared to the maximum airborne chemical concentrations allowed by regulation and the immediately dangerous to life or health (IDLH) values. IDLH values, originally developed by the National Institute of Occupational Safety and Health (NIOSH) for emergency response purposes, are based on a 30-minute exposure period for an individual who inhales 10 cubic meters (353 cubic feet) of contaminated air. They were used in the WIPP SEIS-II, and are used in this TA, because no ambient concentration values exist to which chemically hazardous emissions can be compared. The hazardous constituents analyzed for these accident scenarios and the IDLH values and IDLH-equivalent intake values are shown in Table 41.

Table 41 Chemical Constituents Analyzed in CH-TRU Waste

Chemical Name	IDLH (Parts per million)	IDLH (milligrams per cubic meter)
Carbon Tetrachloride	200	1278
Chloroform	500	2480
Methylene Chloride	2300	8119
1,1,2,2-Tetrachloroethane	100	700
Chlorobenzene	1000	4680
Methyl Ethyl Ketone	3000	9000
Toluene	500	1915
1,2 Dichloroethane	50	206
Beryllium	N/A	4
Cadmium	N/A	9
Lead	N/A	100
Mercury	N/A	10

Source: WIPP SEIS-II

The following assumptions were used to maximize the hazardous chemical concentrations within the breached shipping container:

- Nonflammable VOCs with planning-basis WAC (Waste Acceptance Criteria)-prescribed limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be at those limits.
- Flammable VOCs were assumed to have a maximum concentration of 500 parts per million because they are limited to that in planning-basis WAC.
- VOCs without planning-basis WAC limits are assumed to be present at the maximum concentrations identified to date during sampling of CH-TRU waste.
- Heavy metals (lead, mercury, beryllium, and cadmium) are assumed to be uniformly mixed in the waste container and found in the containers in average amounts. Metals would be released as particulates; therefore, the calculations used to determine the radioactive material particulate releases are applied to these as well.
- VOC emission were assumed to exhibit ideal gas behavior.
- Plastics and organic materials and matrices were considered sources of VOCs. Other constituents were considered sources of particulate matter (this assumption is a deviation from AP-141).

Carbon tetrachloride, trichloroethylene, and methylene chloride are considered potential carcinogens by the EPA, and 1,1,1-trichloroethane may produce adverse somatic effects.

Respirable particulate matter (PM_{10}) is also considered a health hazard by EPA, which has set a National Ambient Air Quality Standard (NAAQS) for PM_{10} of 150 $\mu g/m^3$ (40 CFR Part 50).

The air concentrations of each hazardous chemical for the maximally exposed member of the public at the scene of the accident were determined using the Gaussian dispersion model in RADTRAN (Wark et al. 1998). Ground-level concentrations were calculated along the centerline of the plume. Emitted gases were treated like ideal gases, and emitted aerosols were treated as fine particulate matter. Emitted particulate matter was considered to be aerosolized.

Plume depletion effects from particulate settlement (by gravitational or chemical effects) were considered for particulate matter only. Each accident was postulated to occur during a period of very stable meteorological conditions (Pasquill Stability Class F, wind speed of 0.5 meter per second) to introduce additional conservatism into the analyses.

The effective height of the plume from the accident was estimated to be approximately 100 meters (about 300 feet), which will account for the buoyancy rise associated with the thermal effects from the accident. The maximum airborne chemical concentration inhaled by a member of the public was calculated by calculating the air concentration along the plume centerline using the Gaussian dispersion equation:

$$CHI = \frac{Q}{\pi u \sigma_y \sigma_z} \exp(-\frac{H^2}{2\sigma_z^2})$$

where:

CHI = concentration at ground level
Q = source emission rate (leak rate)
u = wind speed
σ_y, σ_z are meteorological constants that are a function of downwind distance and stability class[9]
H = effective plume height

The inhaled concentration is then calculated by assuming a breathing rate of 3.3 x 10^{-4} m^3/sec.

The plume is depleted of particulates by assuming deposition velocity of 1 cm/sec (0.01 m/sec). This equation and its solutions are modeled in RADTRAN.

The concentration of airborne particulate matter may be compared to the national ambient air quality standard for 10-micron particulate matter (PM_{10}): 0.150 mg/m^3 24-hour average not to be exceeded more than once per year (40 CFR Part 50). No analogous standard exists for VOCs; EPA regulated VOCs from stationary sources on the basis of prevention of significant deterioration (40 CFR 51.166) in a particular air basin.

The inventory of non-radioactive, potentially hazardous waste constituents in DOE 2008a provided the basis for calculation of impacts. This inventory is more detailed and specific as to material composition than the inventory of SEIS-II. DOE 2008a provides a list of the non-radioactive constituents of TRU waste: Table 42 shows these together with the most likely physical/chemical group for them. Beryllium, cadmium, and lead were considered particulate matter, and no data were found

Table 42 Non-radioactive constituents of CH-TRU wastes

NON-RADIOACTIVE WASTE CONSTITUENTS	PHYSICAL/ CHEMICAL GROUP	RELEASE FRACTION, NO FIRE	RELEASE FRACTION, FIRE	CH Total (kg)	RH Total (kg)	CH (kg/TRUPACT)	RH (kg/TRUPACT)
Aluminum-based metals and alloys	particulate	7.339E-07	4.57E-06	2.25E+06	4.06E+04	3.08E+02	7.14E+00
Cellulosics	particulate	7.339E-07	4.57E-06	1.12E+07	1.11E+05	1.54E+03	1.95E+01
Cements	particulate	7.339E-07	4.57E-06	1.27E+07	5.53E+04	1.73E+03	9.72E+00
Inorganic Matrix	particulate	7.339E-07	4.57E-06	1.71E+07	3.59E+06	2.34E+03	6.30E+02
Iron-based metals and alloys	no release	-	-	-	-	-	-
Organic matrix	volatile	2.40E-05	7.68E-05	6.82E+06	5.12E+03	9.34E+02	9.00E-01
Other inorganic materials	particulate	7.339E-07	4.57E-06	5.26E+06	1.59E+05	7.21E+02	2.79E+01

[9]The meteorological constants σ_y and σ_z may be interpreted as the standard deviation of the emission distribution in the crosswind and vertical directions, respectively. However, there have been several empirical measurements of these constants, resulting in several empirical formulas for calculating them, so they are generally considered empirical functions of the downwind distance and Fickian diffusion, rather than being identified by a somewhat idealized mathematical formulation.

Table 42 Non-radioactive constituents of CH-TRU wastes (continued)

NON-RADIOACTIVE WASTE CONSTITUENTS	PHYSICAL/ CHEMICAL GROUP	RELEASE FRACTION, NO FIRE	RELEASE FRACTION, FIRE	CH Total (kg)	RH Total (kg)	CH (kg/TRUPACT)	RH (kg/TRUPACT)
Other metals	no release	-	-	-	-	-	-
Plastics	volatile	2.40E-05	7.68E-05	1.27E+07	1.40E+05	1.74E+03	2.46E+01
Rubber	particulate	7.339E-07	4.57E-06	1.07E+06	2.42E+04	1.47E+02	4.25E+00
Soils and gravel	particulate	7.339E-07	4.57E-06	1.53E+06	1.33E+06	2.10E+02	2.34E+02
Vitrified	particulate	7.339E-07	4.57E-06		1.48E+03		2.60E-01
Packaging material, plastic	volatile	2.40E-05	7.68E-05	3.27E+06	7.29E+04	4.48E+02	1.28E+01
Packaging Material, steel	no release	-	-	-	-	-	-
Packaging Material, cellulosics	volatile	7.339E-07	4.57E-06	6.98E+05		9.57E+01	
Packaging Material, lead	particulate	7.339E-07	4.57E-06		7.33E+04		1.29E+01

Release fractions for each physical/chemical group are those in Table 28; severity categories 3 and 5 of Table 28 included fire, so the release fractions associated with these severity categories were included only in the "accident with fire" analysis.

3.3.5.3 Results

Figure 14 shows the decrease in VOC emissions as a function of downwind distance from the source for the no-fire accident involving CH-TRU waste, and Figure 15 shows this decrease for an accident involving fire.

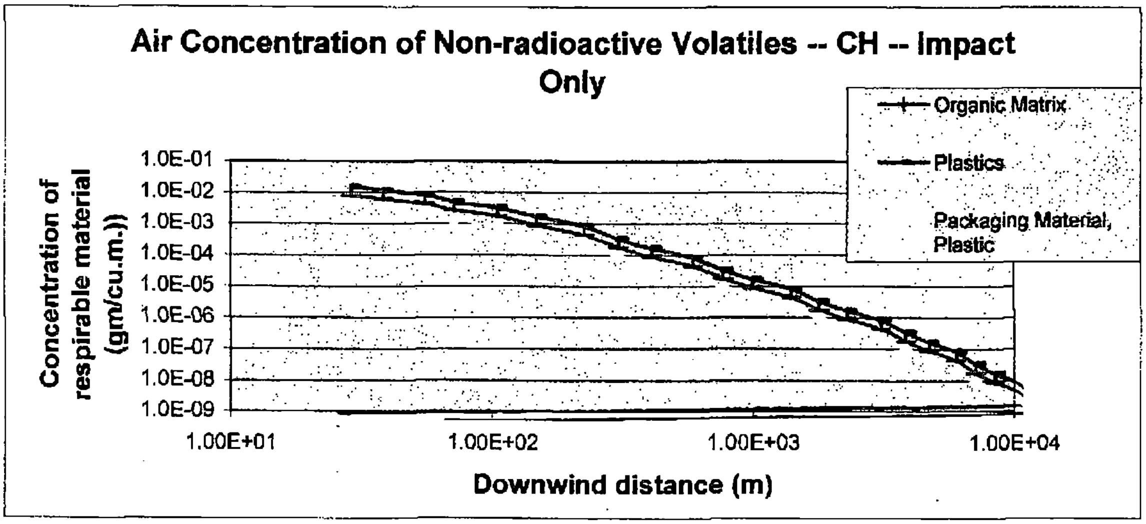


Figure 14 Air concentration of non-radioactive volatile substances, for an impact-only accident.

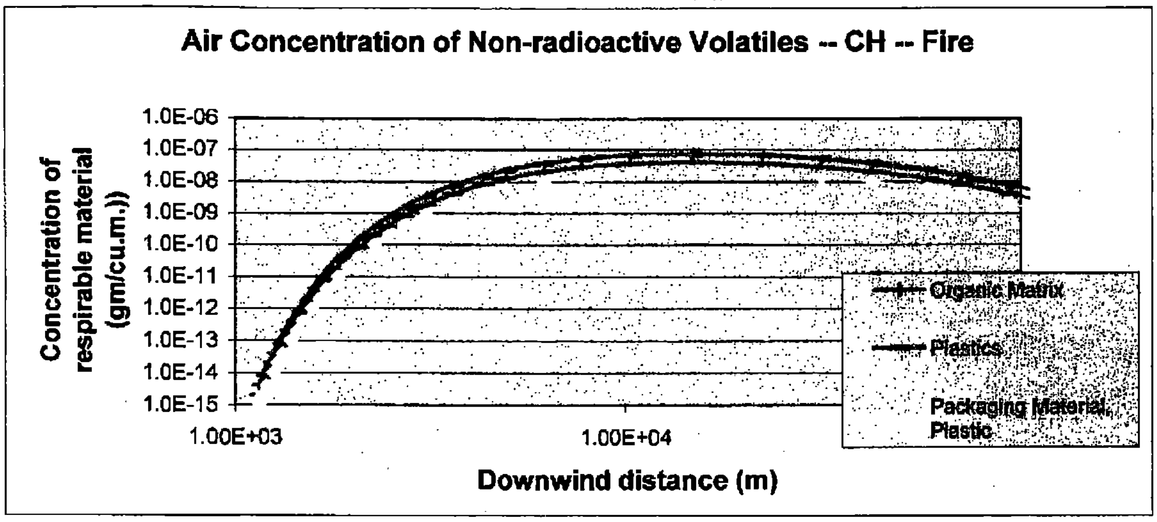


Figure 15 Air concentration of non-radioactive volatile substances, for an accident involving impact and fire.

The shapes of these curves, and the displacement of the maximum ground-level concentration to about 7 km. downwind, is about the same for particulate releases and for volatile releases from an RH-72B package, because the release height and fire temperature are the same in all cases.

Table 43 shows the air concentration for releases of non-radioactive materials for both a TRUPACT and a RH-72B for both impact-only accidents and accidents involving a fire. The concentrations were compared to the total IDLH values for volatile releases and to the National Ambient Air Quality Standard (NAAQS; 40 CFR Part 50) for 10-micron particulate matter (PM_{10}).

Table 43 Air concentrations of non-radioactive releases

	VOLATILE	PARTICULATE
CH- No Fire (gm/m^3)	0.00493	9.69E-04
Percent of IDLH or NAAQS	0.018%	646%
CH-Fire (gm/ m^3)	5.42E-07	1.38E-05
Percent of IDLH or NAAQS	1.93E-6%	9.20%
RH-No Fire (gm/ m^3)	0.00173	4.13E-04
Percent of IDLH or NAAQS	0.006%	27.5%
RH-Fire (gm/ m^3)	8.34E-07	4.31E-07
Percent of IDLH or NAAQS	2.97E-6%	0.288%

All but three of the eleven non-volatile components were assumed to release aerosolized particulate matter (Table 41). This assumption is exceedingly conservative, since aerosolized releases in impact-only traffic accidents are unlikely. The particulate release fractions are based on Type B casks carrying spent fuel, which would release material only through the seals, so that only aerosolized material would be released from the cask (Sprung 2000). The particulate release fraction is thus more applicable to the RH-72B cask than to the TRUPACT. Since the material in the TRUPACT is in sealed drums or standard waste boxes, soils and gravel, and possibly some of the inorganic matrices, are the only non-volatile constituents that would be released in particles 10 microns or less in diameter in an impact-only accident. Any releases of other non-volatile materials would be in larger particle sizes.

4 SUMMARY

This TA, an update to the SEIS-II (DOE, 1997b), evaluated the impacts associated with the transportation of CH-TRU and RH-TRU waste from waste generator sites to the WIPP, using the updated estimates of the quantities and characteristics of TRU wastes from DOE (2008a) and considered the impacts of transporting these wastes. Only transportation by truck was considered.

The TA used updated census data (U.S. Census Bureau 2006), changes in the number of shipments due to the use of different shipping containers, new TRU waste inventories, and WebTRAGIS to deterimine the routes instead of HIGHWAY. In addition, the analysis was conducted using an improved version of RADTRAN, Version 6 for the loss-of-lead shielding calculations and Version 5.6 for all other calculations. The improvements to RADTRAN, as well as the use of updated inventory (DOE 2008a) to calculate more realistic parameter values like a smaller TI, have resulted in smaller doses than those calculated in the SEIS-II for the same set of receptors. The number of shipments represents a more realistic value as it was determined using the most recent inventory (DOE 2008a) and the current and anticipated shipping containers. The use of WebTRAGIS resulted in more accurate routes and a more accurate simulation. The total population has increased with the new census data and has shifted from both urban and rural areas to suburbs. The net result is relatively larger doses to suburban than to urban populations. This TA also used a different methodology with respect to vehicle densities which played a significant role in the increase in the suburbs areas.

The analyses of radiological and non-radiological impacts incorporated different conservatisms and different degrees of conservatism, so that no conclusions can really be drawn by comparing them. The radiologic impacts are generally smaller than those in the SEIS-II, mostly because of the more precise analytical methods available. There are only a few instances (e.g., the rest stop employee, inspectors) where calculated doses are not insignificant, and these are largely due to conservative assumptions, in particular the simple addition of the number of shipments to which the receptor is exposed.

5 REFERENCES

10 CFR Part 71 Subpart E; US Code of Federal Regulations, Volume 10 (Energy), Part 71, Washington, DC 2008

40 CFR Part 50, US Code of Federal Regulations, Volume 40 (Environmental Protection), Part 50 (National Ambient Air Quality Standards), Washington, DC 2008

Anspaugh, L. R. 1990 "Environmental Behavior of Plutonium," Health Phys. 58, S5 (1990).

Biwer, B.M., and J.P. Butler, 1999. "Vehicle Emission Unit Risk Factors for Transportation Risk Assessments." *Risk Analysis,* 19(6):1157-1171.

Boyd, A.M., Worthy, D.K., Weiner, R.F. Osborn, D.M. "Benchmarking RADTRAN Loss of Shielding Model for a Spent Fuel Cask" International High-Level Radioactive Waste Conference, Las Vegas, NV, May, 2006

BTS (US Department of Transportation, Bureau of Transportation Statistics, Research and Innovative Technology Administration), 2008. "National Transportation Statistics 2008", Washington, DC 2008. http://www.bts.gov/ (retrieved 11/2008)..

Cederwall, R.T., Ricker,Y.E., Cederwall,P.L., Homan, D.N., and Anspaugh, L.R., "Measurements of Airborne Radionuclide Concentrations Near the Nevada Test Site from Atmospheric Testing," Health Phys. 52, S75-S76 (1987)

Crawford, B, and Taggart, D. 2007. Analysis of RH TRU wastes for Containment in Lead Shielded Containers. Los Alamos National Laboratory Carlsbad Operations, Simple Analysis Report INV-SAR-08, Rev 0.

Dennis, M.L., Osborn, D. O., Weiner, R. F., Heames, T.J. 2008. *Verification and Validation of RADTRAN 6.0* SAND2008-4556, Sandia National Laboratories, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1995. *Engineered Alternatives Cost/Benefit Study Final Report,* WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996. *Waste Acceptance Criteria for the Waste Isolation Pilot Plant,* DOE/WIPP 94-069, Revision 5, April, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1997a. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (Volumes 1 through 5), DOE/EIS-0200-F, Washington, DC, May.

DOE (U.S. Department of Energy), 1997b. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement.* DOE/EIS-0026-S-2, Washington, DC, September. (WIPP SEIS-II).

DOE (U.S. Department of Energy), 1998. *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* (TRU Waste ROD). 63 FR 3629. January 23, 1998.

DOE (U.S. Department of Energy), 2002. Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250F. Summary, Volumes I and II. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

DOE (U.S. Department of Energy), 2005. Contact Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC), Rev. 2. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2006a. Transuranic Baseline Inventory Report – 2004, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/TRU-2006-3344.

DOE (U.S. Department of Energy), 2006b. WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small-Quantity Sites and Impacts from Using the TRUPACT-III. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2006c. Remote Handled Transuranic Waste Authorized Methods for Payload Control (RH-TRAMPAC), Rev. 0. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE (U.S. Department of Energy), 2007. CNS 10-160B RH Cask Program Guidance, Revision 1. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/WIPP-06-3336

DOE (U.S. Department of Energy), 2008a. Annual Transuranic Baseline Inventory Report – 2007, U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. DOE/TRU-2008-3379.

DOE (U.S. Department of Energy), 2008b. Amendment to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste. March 7, 2008.

DOE (U.S. Department of Energy), 2008c. Supplement Analysis for the Treatment of Transuranic Waste at the Idaho National Laboratory. U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM. February 2008. DOE/EIS-0200-SA03.

DOE (U.S. Department of Energy), 2008d. Supplemental Environmental Impact Statement for. a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250F–S1. Summary, Volumes I and II. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management

EPA (U.S. Environmental Protection Agency) 1991. Mobile Sources. Volume II of Supplement A to Compilation of Air Pollutant Emission Factors. AP-42. [Washington, D.C.]: U.S. Environmental Protection Agency.

Fischer, L.E.; Chou, C.K.; Gerhard, M.A.; Kimura, C.Y.; Martin, R.W.; Mensing, R.W.; Mount, M.E.; and Witte, M.C. 1987. Shipping Container Response to Severe Highway and Railway Accident

Conditions. NUREG/CR-4829. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Griego, N.R.; Smith, J.D.; and Neuhauser, K.S. 1996. Investigation of RADTRAN Stop Model Input Parameters for Truck Stops. [SAND96-0714C]. Albuquerque, New Mexico: Sandia National Laboratories

ISCORS (Interagency Steering Committee on Radiation Standards). 2002. *A Method for Estimating Radiation Risk from TEDE.* ISCORS Technical Report No. 1, Washington, DC

Johnson, P.E. and Michelhaugh, R.D. 2000. Transportation Routing Analysis Geographic Information System (WebTRAGIS) User's Manual. ORNL/TM-2000/86. Oak Ridge, Tennessee: Oak Ridge National Laboratory.

McCauslin, S. 2008. Input Used as References. U.S. Department of Energy, Carlsbad, NM. ERMS# 549454.

Moody, D.C. 2008. Shielded container Planned Change Request Letter to Juan Reyes, U.S. Department of Energy, Carlsbad, NM. ERMS# 549327.

Mossman, K. 2008. 188th Meeting of the NRC Advisory Committee on Nuclear Waste and Materials. Meeting Transcript pp 207-208, April 8, 2008, US Nuclear Regulatory Commission, Rockville, MD. http://www.nrc.gov/reading-rm/doc-collections/acnw/tr/2008/188-4-8.pdf

NRC (U.S. Nuclear Regulatory Commission), 1977. *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170, Washington, D.C.

Ryan, M.T. 2007, Letter to Chairman Dale Klein "Report of the French Academy of Sciences 'the Dose-Effect Relationship and Estimating the Carcinogenic Effect of Low Doses of Ionizing Radiation'" January 7, 2007, Rockville, MD.

Sprung, J.L.; Ammerman, D.J.; Breivik, N.L.; Dukart, R.J.; Kanipe, F.L.; Koski, J.A.; Mills, G.S.; Neuhauser, K.S.; Radloff, H.D.; Weiner, R.F.; and Yoshimura, H.R. 2000. Reexamination of Spent Fuel Shipment Risk Estimates. NUREG/CR-6672. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Tenforde, Thomas, 2008. U.S. Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, 188th Meeting, April 8, 2008, P. 207 et seq, USNRC, Washington, DC.

U. S. Census Bureau. 2006. State and Metropolitan Area Data Book : 2006, Bureau of the Census, Washington, DC. http://www.census.gov/prod/www/abs/smadb.htm.

U. S. Census Bureau. 2008. *The 2008 Statistical Abstract of the United States*, Bureau of the Census, Washington, DC. http://www.census.gov/compendia/statab

DOT (U.S. Department of Transportation). 2008. National Transportation Statistics
2008, Bureau of Transportation Statistics, Research and Innovative Technology Administration, Washington, DC. http://www.rita.dot.gov/

Wark, K., Warner, C.F., Davis, W.T. *Air Pollution, Its Origin and Control, 1998.* Addison-Wesley-Longman, Menlo Park, CA Section 4-4.

Weiner, R. F. and Neuhauser, K. S., 1992. "Near-Field Radiation Doses From Spent Fuel Transportation". International High-Level Waste Management Conference, Las Vegas, NV.

Weiner, R.F D.M. Osborn, D. Hinojosa, B.M. O'Donnell, D.J. Orcutt, T.J. Heames. 2006 *RADCAT2.3 User Guide*, Sandia National Laboratories, June 2006

APPENDIX A: RADTRAN AND WEBTRAGIS FILES

Sample RADTRAN and WebTRAGIS files are included in this Appendix. the complete set of these files is on an accompanying CD.

```
RUN DATE: [ 07-OCT-08 AT 16:21:24 ]       PAGE  1


 RRRR  AAA  DDDD  TTTTT RRRR  AAA  N  N 55555     6
 R  R  A  A  D  D   T   R  R  A  A NN N 5        6
 R  R  A  A  D  D   T   R  R  A  A N NN 5        6
 RRRR  A  A  D  D   T   RRRR  A  A N  NN 5555    6666
 R R   AAAAA D  D   T   R R   AAAAA N  N    5    6  6
 R  R  A  A  D  D   T   R  R  A  A N  N 5  5    6  6
 R  R  A  A  DDDD   T   R  R  A  A N  N 5555  *  666

                RADTRAN 5.6  FEBRUARY 20, 2006

                    INPUT ECHO
                    ----------



 && MAX SRS CH CURIE CONTENT
 && NO URBAN STOPS_ADD U+S TIMES
 && STOP TIME IS AVERAGE; CALCULATE MAX OFF-LINE
 && ADD VEHCILE DESNITIES!!!!! ADD VEHICLE DENSITIES
 TITLE RF_CH
 INPUT STANDARD
STD: 0 10 18                    && DIMEN=NSEV NRAD NAREAS
STD: 1 3 3 0                    && PARM=IRNKC IANA ISEN IPSQSB
STD: .TRUE. .FALSE.                 && FORM = UNIT, SI-UNITS?
STD: 2.3E12                     && NEVAL FOR CF252
STD: 9.25E5 5.77E6 1.27E6           && RPCTHY FOR I125, I129, I131
STD: 0.0 0.0 0.0 0.0 0.0          && TRANSFER GAMMA
STD: 7.42E-3 2.02E-2 6.17E-5 3.17E-8 0.0  && TRANSFER NEUTRON
STD: 30  24                     && MITDDIST  MITDVEL
STD: 1  2  .0018                && ITRAIN FMINCL DDRWEF
STD:   33   68   105  244  369        && CENTER LINE
STD:  561  1018  1628  2308  4269        && DISTANCES
STD:  5468 11136  13097 21334 40502          && FOR AVERAGE
STD: 69986 89860 120878 0 0 0 0 0 0 0 0 0 0 0 0  && US CLOUD
STD: 4.59E+02 1.53E+03 3.94E+03 1.25E+04 3.04E+04 6.85E+04 1.76E+05 4.45E+05
STD: 8.59E+05 2.55E+06 4.45E+06 1.03E+07 2.16E+07 5.52E+07 1.77E+08 4.89E+08
STD: 8.12E+08 1.35E+09 0 0 0 0 0 0 0 0 0 0 0 0    && AREADA
STD: 3.42E-03 1.72E-03 8.58E-04 3.42E-04 1.72E-04 8.58E-05 3.42E-05 1.72E-05
STD:  8.58E-06 3.42E-06 1.72E-06 8.58E-07 3.42E-07 1.72E-07 8.58E-08 5.42E-08
STD:  4.30E-08 3.42E-08 0 0 0 0 0 0 0 0 0 0 0 0   && DFLEV
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0 && RADIST
STD: 0.5                   && SMLPKG
STD: 1.0  0.87  0.018            && SHIELDING FACTORS RR  RS  RU
STD:  30  30  800             && OFFLINK {FREEWAY}
STD:  27  30  800             && OFFLINK {NON-FREEWAY}
STD:   5   8  800             && OFFLINK {CITY STREETS}
STD:  30  30  800             && OFFLINK {RAILWAY}
STD: 200 200 1000               && OFFLINK {WATERWAY}
```

```
STD: 15 3 3 3 4             && ONLINK {FWAY NONFWY STREET RAIL ADJ}
STD: 6.0 4 40.0             && RPD FNOATT INTERDICT
STD: 0.05 0.2 3.3E-4        && BDF CULVL BRATE
STD: 0.9 0.1                && UBF USWF
STD: 1.0 10.0 1.0           && EVACUATION SURVEY CAMPAIGN

          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]       PAGE  2

                    RF_CH

STD: 0.0 0.0   1.5E-8 5.3E-8    && HIGHWAY - RURAL - NONRAD
STD: 0.0 0.0   3.7E-9 1.3E-8    && HIGHWAY - SUBURBAN - NONRAD
STD: 0.0 0.0   2.1E-9 7.5E-9    && HIGHWAY - URBAN - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - R - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - S - NONRAD
STD: 0.0 0.0   1.81E-9 2.64E-8   && GENERAL FREIGHT - U - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - R - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - S - NONRAD
STD: 0.0 0.0   1.27E-7 1.85E-6   && DEDICATED RAIL - U - NONRAD
STD: 0.0 0.0 0.0 0.0 0.0 0.0     && PSPROB
STD: 0.67 0.67 0.42             && TIMENDE NON-DISPERSAL EVAC TIME (LCF&EARLY)
STD: 2 2 1                      && FLAGS=IUOPT IACC REGCHECK
STD: 5E-4, 4E-4, 1.0E-4          && LCFCON(1), LCFCON(2), GECON
STD: R5INGEST.BIN                && INGESTION FILE
 OUTPUT CI_REM
 FORM UNIT
 DIMEN 6 10 18
 PARM 1 3 3 2
 SEVERITY
   NPOP=1
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

   NPOP=2
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

   NPOP=3
     NMODE=1
      0.99993
  6.06E-5 5.86E-6 4.95E-7 7.49E-8 3.0E-10

 RELEASE
   GROUP=VOL
     RFRAC
       0.0
  4.09E-9 1.68E-5 1.35E-8 3.6E-5 2.4E-5

     AERSOL
       0.0
  1.0 1.0 1.0 1.0 1.0

     RESP
       0.0

```

```
            RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE   3

                      RF_CH

 0.02 0.02 0.02 0.02 0.02

    LOS
      0.0
 0.0 0.0 0.0 0.0 0.0

    DEPVEL 0.01
  GROUP=PART
    RFRAC
      0.0
 1.02E-7 6.71E-8 3.37E-7 3.77E-6 5.01E-6

    AERSOL
      0.0
 1.0 1.0 1.0 1.0 1.0

    RESP
      0.0
 0.02 0.02 0.02 0.02 0.02

    LOS
      0.0
 0.0 0.0 0.0 0.0 0.0

    DEPVEL 0.01
RISKIND
  0 0.0 0.0 4.5 8.4 0.5 10.0 293.0 500.0 0.0 2 6 2
PACKAGE TRUPACT 0.1674 1.0 0.0 3.5
  CS137 0.0872 VOL
  CO60 0.00558 PART
  SR90 0.0872 PART
  PU238 8630.0 PART
  PU239 1390.0 PART
  PU240 366.0 PART
  AM241 3.14 PART
  PU241 1740.0 PART
  PU242 0.00593 PART
END
VEHICLE -1 TRUPACT_II 5.02E-01 1.0 0.0 8.4 1.0 2.0 4.0 1.0 3.5
    TRUPACT 3.0
FLAGS
  IACC 2
  IUOPT 2
  REGCHECK 0
MODSTD
  DISTOFF FREEWAY 3.00E01 3.00E01 8.00E02
  DISTOFF SECONDARY 2.70E01 3.00E01 8.00E02
  DISTOFF STREET 5.00E00 8.00E00 8.00E02
  DISTON
      FREEWAY 1.50E01
      SECONDARY 3.00E00
      STREET 3.00E00
      ADJACENT 4.00E00
```

172

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE  4

                    RF_CH

 BDF 5.00E-02
 BRATE 3.30E-04
 CULVL 2.00E-01
 EVACUATION 1.00E02
 GECON 1.00E-04
 INTERDICT 4.00E01
 LCFCON 5.75E00 5.75E-04
 SURVEY 1.00E02
 UBF 5.20E-01
 USWF 4.80E-01
 CAMPAIGN 8.33E-02
 MITDDIST 3.00E01
 MITDVEL 2.40E01
 RPD 6.00E00
 RR 1.00E00
 RU 1.80E-02
 RS 8.70E-01
 SMALLPKG 5.00E-01
 RPCTHYROID
    I131    1.27E06
EOF
LINK RURAL_NM TRUPACT_II 736.8 88.6 2.0 4.7 654.0 3.83E-6 0.00353 R 1 0.5
LINK SUBURBN_NM TRUPACT_II 23.8 88.6 2.0 318.1 1208.0 3.83E-6 0.00353 S 1 0.0
LINK URBAN_NM TRUPACT_II 2.25 88.6 2.0 1823.2 3347.0 3.83E-6 0.00353 U 1 0.0
LINK URBAN_NM_RH TRUPACT_II 0.25 44.3 2.0 1820.0 6700.0 3.83E-6 0.00353 U 1 0.0
LINK RURAL_CO TRUPACT_II 239.7 88.6 2.0 9.7 1248.0 2.55E-6 0.00353 R 1 0.5
LINK SUBURBN_CO TRUPACT_II 117.5 88.6 2.0 423.8 2342.0 2.55E-6 0.0033 S 1 0.0
LINK URBAN_CO TRUPACT_II 28.26 88.6 2.0 2451.0 4051.0 2.55E-6 0.00353 U 1 0.0
LINK URBAN_CO_RH TRUPACT_II 3.14 44.3 2.0 2450.0 8102.0 2.55E-6 0.00353 U 1 0.0

STOP RURAL_NM TRUPACT_II 4.7 30.0 800.0 1.0 1.489
STOP SUBURB_NM TRUPACT_II 318.1 30.0 800.0 1.0 0.048
STOP RURAL_CO TRUPACT_II 9.7 30.0 800.0 1.0 0.485
STOP SUBSURBAN_CO TRUPACT_II 423.8 30.0 800.0 1.0 0.238
STOP TRUCKCREW TRUPACT_II 1.0 1.0 1.0 1.0 2.26
STOP INSPECTOR TRUPACT_II 1.0 1.0 1.0 1.0 2.0
STOP RESTSTOPEMPL TRUPACT_II 1420.0 1.0 15.0 1.0 1.323
STOP RURAL_ATSTOP TRUPACT_II 9950.0 1.0 15.0 1.0 1.974
STOP SUBURBAN_ATSTOP TRUPACT_II 9950.0 1.0 15.0 1.0 0.286


EOF
```

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE   5

                    RF_CH



          PACKAGE AND MATERIAL CHARACTERISTICS

        DIMENSION  EFFECTIVE    K(0)    FRACTION  FRACTION  DOSE RATE
  MATERIAL  (METERS) DIMENSION METERS SQ.   GAMMA    NEUTRON  (MREM/HR)
  TRUPACT 3.500E+00 3.500E+00 7.562E+00 1.000E+00 0.000E+00 1.674E-01

  K(0) IS DOSE RATE CONVERSION FACTOR



              VEHICLE CHARACTERISTICS


VEHICLE NAME              TRUPACT_II
MODE TYPE                 HIGHWAY
EXCLUSIVE USE             YES
DOSE RATE (MREM/HR)       5.02E-01
K(0) (SQ. METERS)         1.74E+01
VEHICLE SIZE (M)          8.40E+00
EFFECTIVE SIZE (M)        6.34E+00
NUMBER OF SHIPMENTS       1.00E+00
NUMBER OF CREW            2.00E+00
CREW DISTANCE (M)         4.00E+00
CREW DOSE ADJUSTMENT FACT   1.00E+00
CREW EXPOSER WIDTH (M)      3.50E+00
EFFECTIVE EXPOSER WIDTH     3.50E+00
K(0) (SQ M) CREW EXPOSURE   7.56E+00


 VEHICLE    MATERIAL   NO.PACKAGES
TRUPACT_II
         TRUPACT    3.00E+00


TRANSFER
COEFFICIENTS:   MU      A(1)     A(2)     A(3)     A(4)
   GAMMA   0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  NEUTRON   7.420E-03 2.020E-02 6.170E-05 3.170E-08 0.000E+00



DISTANCES (METERS)  FREEWAY SECONDARY  STREET    RAIL    WATER   ADJACENT
OFFLINK:
MINIMUM DISTANCE    3.00E+01 2.70E+01 5.00E+00 3.00E+01 2.00E+02
SIDEWALK + MINIMUM  3.00E+01 3.00E+01 8.00E+00 3.00E+01 2.00E+02
MAXIMUM DISTANCE    8.00E+02 8.00E+02 8.00E+02 8.00E+02 1.00E+03
ONLINK:
OPPOSITE DIRECTION  1.50E+01 3.00E+00 3.00E+00 3.00E+00
ADJACENT VEHICLE                                   4.00E+00
```

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 6

RF_CH

STOP RELATED DATA

	RURAL_NM	SUBURB_NM	RURAL_CO	SUBSURBAN_	TRUCKCREW
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
PERSONS	4.70E+00	3.18E+02	9.70E+00	4.24E+02	1.00E+00
MINIMUM DISTANCE(M)	3.00E+01	3.00E+01	3.00E+01	3.00E+01	1.00E+00
MAXIMUM DISTANCE(M)	8.00E+02	8.00E+02	8.00E+02	8.00E+02	1.00E+00
SHIELDING FACTOR	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
TIME (HR)	1.49E+00	4.80E-02	4.85E-01	2.38E-01	2.26E+00

	INSPECTOR	RESTSTOPEM	RURAL_ATST	SUBURBAN_A
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
PERSONS	1.00E+00	1.42E+03	9.95E+03	9.95E+03
MINIMUM DISTANCE(M)	1.00E+00	1.00E+00	1.00E+00	1.00E+00
MAXIMUM DISTANCE(M)	1.00E+00	1.50E+01	1.50E+01	1.50E+01
SHIELDING FACTOR	1.00E+00	1.00E+00	1.00E+00	1.00E+00
TIME (HR)	2.00E+00	1.32E+00	1.97E+00	2.86E-01

HANDLING RELATED DATA

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 7

RF_CH

LINK RELATED DATA

	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II	TRUPACT_II
DISTANCE (KM)	7.37E+02	2.38E+01	2.25E+00	2.50E-01	2.40E+02
PERSONS PER VEHICLE	2.00E+00	2.00E+00	2.00E+00	2.00E+00	2.00E+00
SPEED (KM/HR)	8.86E+01	8.86E+01	8.86E+01	4.43E+01	8.86E+01
POPULATION DENSITY	4.70E+00	3.18E+02	1.82E+03	1.82E+03	9.70E+00
VEHICLE DENSITY	6.54E+02	1.21E+03	3.35E+03	6.70E+03	1.25E+03
ACCIDENT RATE/KM	3.83E-06	3.83E-06	3.83E-06	3.83E-06	2.55E-06
FATALITIES/ACCIDENT	3.53E-03	3.53E-03	3.53E-03	3.53E-03	3.53E-03
ZONE	RURAL	SUBURBAN	URBAN	URBAN	RURAL
ROAD TYPE	FREEWAY	FREEWAY	FREEWAY	FREEWAY	FREEWAY
FARMING FRACTION	5.00E-01	0.00E+00	0.00E+00	0.00E+00	5.00E-01

	SUBURBN_CO	URBAN_CO	URBAN_CO_R
VEHICLE	TRUPACT_II	TRUPACT_II	TRUPACT_II
DISTANCE (KM)	1.18E+02	2.83E+01	3.14E+00
PERSONS PER VEHICLE	2.00E+00	2.00E+00	2.00E+00
SPEED (KM/HR)	8.86E+01	8.86E+01	4.43E+01
POPULATION DENSITY	4.24E+02	2.45E+03	2.45E+03
VEHICLE DENSITY	2.34E+03	4.05E+03	8.10E+03
ACCIDENT RATE/KM	2.55E-06	2.55E-06	2.55E-06
FATALITIES/ACCIDENT	3.30E-03	3.53E-03	3.53E-03
ZONE	SUBURBAN	URBAN	URBAN
ROAD TYPE	FREEWAY	FREEWAY	FREEWAY
FARMING FRACTION	0.00E+00	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 8

RF_CH

ISOTOPE RELATED DATA

SETTLING ONLY

NUCLIDE	CURIES PER PKG	RELEASE GROUP	RESUSPENSION FACTOR	50YR INHALATION (REM/CI) EFFECTIVE
TRUPACT				
CS137	8.72E-02	VOL	1.12E+00	3.59E+04
CO60	5.58E-03	PART	1.12E+00	3.70E+04
SR90	8.72E-02	PART	1.12E+00	1.33E+05
PU238	8.63E+03	PART	1.12E+00	1.70E+08
PU239	1.39E+03	PART	1.12E+00	1.85E+08
PU240	3.66E+02	PART	1.12E+00	1.85E+08
AM241	3.14E+00	PART	1.12E+00	1.55E+08
PU241	1.74E+03	PART	1.12E+00	3.33E+06
PU242	5.93E-03	PART	1.12E+00	1.78E+08

NUCLIDE	HALF LIFE	GAMMA ENERGY	CLOUD FACTOR	GROUND FACTOR	INGESTION NUCLIDE	NEUTRON EMISSION NEUTRONS/SEC/CI
TRUPACT						
CS137	1.10E+04	5.69E-02	1.07E-01	1.77E-04	CS-137	0.00E+00
CO60	1.92E+03	2.50E+00	4.66E-01	7.51E-04	CO-60	0.00E+00
SR90	1.06E+04	0.00E+00	2.79E-05	9.08E-08	SR-90	0.00E+00
PU238	3.20E+04	1.81E-03	1.81E-05	2.68E-07	PU-238	0.00E+00
PU239	8.78E+06	7.96E-04	1.57E-05	1.17E-07	PU-239	0.00E+00
PU240	2.39E+06	1.73E-03	1.76E-05	2.57E-07	PU-240	0.00E+00
AM241	1.58E+05	3.24E-02	3.03E-03	8.79E-06	AM-241	0.00E+00
PU241	5.26E+03	2.54E-06	2.68E-07	6.17E-10	PU-241	0.00E+00
PU242	1.37E+08	1.44E-03	1.48E-05	2.13E-07	PU-242	0.00E+00

NUCLIDE	1-YR INHALATION (REM/CI) LUNG	MARROW	THYROID
TRUPACT			
CS137	2.18E+05	6.29E+03	0.00E+00
CO60	1.78E+05	1.07E+04	0.00E+00
SR90	7.03E+05	4.07E+04	0.00E+00
PU238	1.26E+08	1.37E+07	0.00E+00
PU239	1.11E+08	1.30E+07	0.00E+00
PU240	1.11E+08	1.30E+07	0.00E+00
AM241	1.22E+08	8.14E+06	0.00E+00
PU241	2.85E+04	1.33E+04	0.00E+00
PU242	1.04E+08	1.22E+07	0.00E+00

```
            RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE  9

                   RF_CH

                 RELEASE RELATED DATA
                 ********************





                  RELEASE FRACTIONS

GROUP    SEVER: 1 SEVER: 2 SEVER: 3 SEVER: 4 SEVER: 5 SEVER: 6
   VOL 0.00E+00 4.09E-09 1.68E-05 1.35E-08 3.60E-05 2.40E-05
  PART 0.00E+00 1.02E-07 6.71E-08 3.37E-07 3.77E-06 5.01E-06


                DEPOSITION VELOCITIES
                 GROUP    M/SEC
                    VOL  1.00E-02
                   PART  1.00E-02


              ACCIDENT SEVERITY FRACTIONS
                  FOR   HIGHWAY

ZONE     SEVER: 1 SEVER: 2 SEVER: 3 SEVER: 4 SEVER: 5 SEVER: 6
RURAL      1.00E+00 6.06E-05 5.86E-06 4.95E-07 7.49E-08 3.00E-10
SUBURBAN   1.00E+00 6.06E-05 5.86E-06 4.95E-07 7.49E-08 3.00E-10
URBAN      1.00E+00 6.06E-05 5.86E-06 4.95E-07 7.49E-08 3.00E-10
```

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE  10

                   RF_CH


          AEROSOLIZED FRACTION OF RELEASED MATERIAL


GROUP    SEVER: 1 SEVER: 2 SEVER: 3 SEVER: 4 SEVER: 5 SEVER: 6
   VOL 0.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00
  PART 0.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00


        RESPIRABLE FRACTION OF AEROSOLS (BELOW 10 MICRONS AED)


GROUP    SEVER: 1 SEVER: 2 SEVER: 3 SEVER: 4 SEVER: 5 SEVER: 6
   VOL 0.00E+00 2.00E-02 2.00E-02 2.00E-02 2.00E-02 2.00E-02
  PART 0.00E+00 2.00E-02 2.00E-02 2.00E-02 2.00E-02 2.00E-02
```

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 11

RF_CH

HEALTH RELATED DATA
****

EARLY MORBIDITY THRESHOLD VALUE FOR LUNG 5.000E+02 REM
EARLY MORBIDITY THRESHOLD VALUE FOR MARROW/WHOLE BODY 5.000E+01 REM
EARLY MORBIDITY THRESHOLD VALUE FOR THYROID 2.000E+02 REM

EARLY FATALITY PROBABILITIES (EF)

DOSE(REM)	EF MARROW	DOSE(REM)	EF LUNG
680.00	1.00000	1525.00	1.00000
670.00	0.99999	1500.00	0.99999
660.00	0.99998	1475.00	0.99997
650.00	0.99996	1450.00	0.99991
640.00	0.99992	1425.00	0.99974
630.00	0.99983	1400.00	0.99933
620.00	0.99967	1375.00	0.99840
610.00	0.99938	1350.00	0.99653
600.00	0.99889	1325.00	0.99306
590.00	0.99808	1300.00	0.98709
580.00	0.99679	1275.00	0.97755
570.00	0.99482	1250.00	0.96331
560.00	0.99192	1225.00	0.94326
550.00	0.98776	1200.00	0.91656
540.00	0.98199	1175.00	0.88274
530.00	0.97423	1150.00	0.84178
520.00	0.96406	1125.00	0.79420
510.00	0.95111	1100.00	0.74095
500.00	0.93502	1075.00	0.68335
490.00	0.91551	1050.00	0.62293
480.00	0.89237	1025.00	0.56130
470.00	0.86552	1000.00	0.50000
460.00	0.83499	975.00	0.44042
450.00	0.80096	950.00	0.38372
440.00	0.76371	925.00	0.33077
430.00	0.72363	900.00	0.28218
420.00	0.68123	875.00	0.23830
410.00	0.63706	850.00	0.19925
400.00	0.59172	825.00	0.16498
390.00	0.54583	800.00	0.13529
380.00	0.50000	775.00	0.10988
370.00	0.45481	750.00	0.08837
360.00	0.41078	725.00	0.07038
350.00	0.36838	700.00	0.05548
340.00	0.32798	675.00	0.04329
330.00	0.28990	650.00	0.03341
320.00	0.25438	625.00	0.02549
310.00	0.22155	600.00	0.01922
300.00	0.19150	575.00	0.01430
290.00	0.16425	550.00	0.01050
280.00	0.13977	525.00	0.00759

```
      270.00  0.11797      500.00  0.00000
      260.00  0.09872
      250.00  0.08188
      240.00  0.06729
      230.00  0.05475
      220.00  0.04408
      210.00  0.03510
      200.00  0.02761
      190.00  0.02143
      180.00  0.01639
      170.00  0.01234
      160.00  0.00913
      150.00  0.00000


          DISPERSAL MODEL RELATED INPUT DATA
          **********************************
  CENTER LINE DISTANCES FROM FRACTION OF PEAK:
 0.9,  0.7,  0.5,  0.3,  0.2,  0.1,  0.05,  0.02,  0.01,  0.005,  0.002,  0.001,
 5.0E-4, 2.0E-4, 1.0E-4, 5.0E-5, 2.0E-5, 1.0E-5, 5.0E-6, 2.0E-6, 1.0E-6, 5.0E-7, 2.0E-7, 1.0E-7

  RELEASE HEIGHT (M)            0.00000E+00
  HEAT FLUX (CAL/S)           0.00000E+00
  SOURCE WIDTH (M)             4.50000E+00
  SOURCE HEIGHT(M)             8.40000E+00
  WIND SPEED (M/S)           5.00000E-01
  ANEMOMETER HEIGHT (M)           1.00000E+01
  AMBIENT TEMPERATURE (K)         2.93000E+02
  ATMOSPHERIC MIXING HEIGHT (M)    5.00000E+02
  RAINFALL RATE (MM/HR)        0.00000E+00
  DEPOSITION VELOCITY (M/S)       1.00000E-02

  BRIGGS DISPERSION COEFFICIENTS USED
  STABILITY CATEGORY              F
  URBAN POPULATION ZONE


        OTHER DISPERSAL ACCIDENT INPUT PARAMETERS
        *****************************************

  BUILDING DOSE FACTOR                 (BDF) = 5.000E-02
  CONTAMINATION CLEAN UP LEVEL (UCI/M**2)  (CULVL) = 2.000E-01
  BREATHING RATE (M**3/SEC)            (BRATE) = 3.300E-04
  INTERDICTION THRESHOLD (CI/MICRO-CI)  (INTERDICT) = 4.000E+01
  EVACUATION TIME (DAYS)          (EVACUATION) = 1.000E+02
  SURVEY INTERVAL (DAYS)              (SURVEY) = 1.000E+02
  CAMPAIGN LENGTH (YEARS)           (CAMPAIGN) = 8.330E-02
  FRACTION OF URBAN AREAS WITH BUILDINGS     (UBF) = 5.200E-01
  FRACTION OF URBAN AREAS WITH SIDEWALKS     (USWF) = 4.800E-01
RATIO OF SIDEWALK PEDESTRIAN DENSITY (RPD)       = 6.000E+00
MAXIMUM IN-TRANSIT DOSE DISTANCE (M) (MITDDIST)  = 3.000E+01
MAXIMUM IN-TRANSIT DOSE VELOCITY (KM/H) (MITDVEL) = 2.400E+01
IACC VALUE: 1=NON-DISPERSAL, 2=DISPERSAL        = 2
REGULATORY CHECK, 1=DO CHECKS, 0=NO CHECKS       = 0
BUILDING SHIELDING OPTION (IUOPT)            = 2
   RURAL SHIELDING FACTOR   = 1.000E+00
   SUBURBAN SHIELDING FACTOR = 8.700E-01
   URBAN SHIELDING FACTOR   = 1.800E-02
```

552

```
          RUN DATE: [ 07-OCT-08 AT 16:21:24 ]        PAGE  12

               RF_CH



             INGESTION RELATED DATA


          COMIDA INGESTION FILE USED: R5INGEST.BIN

               COMIDA FILE HEADER
COMIDA2 07/22/03  08:58:40  VER. 1.11A, 1/28/96: AVOIDING USE OF UNIT 6 FOR HP

          DOSE CONVERSION FILE USED IN COMIDA
FGRDCF 07/10/03  21:45:47  VERSION 1.10
IMPLICIT DAUGHTER HALFLIVES (M) LESS THAN  90 AND LESS THAN 0.100 OF PARENT
```

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 13

RF_CH

BACKYARD FARMER INGESTION DOSE (REM/CI DEPOSITED)

NUCLIDE	EFFECTIVE	THYROID
CS-137	1.704E+05	1.590E+05
CO-60	1.328E+04	3.779E+03
SR-90	7.984E+04	3.131E+03
PU-238	7.414E+05	6.848E+00
PU-239	8.229E+05	6.447E+00
PU-240	8.228E+05	6.464E+00
AM-241	8.471E+05	1.136E+01
PU-241	1.624E+04	9.444E-02
PU-242	7.816E+05	6.275E+00

SOCIETAL INGESTION DOSE (PERSON-REM/CI DEPOSITED)

NUCLIDE	GONADS	BREAST	LUNGS	RED MAR	BONE SU	THYROID	REMAIND	EFFECTI
CS-137	2.0E+01	1.8E+01	1.9E+01	1.9E+01	1.8E+01	1.8E+01	2.1E+01	2.0E+01
CO-60	1.6E+00	5.7E-01	4.5E-01	6.8E-01	4.8E-01	4.1E-01	2.6E+00	1.4E+00
SR-90	5.2E-01	5.2E-01	5.2E-01	6.6E+01	1.4E+02	5.2E-01	2.1E+00	1.3E+01
PU-238	2.2E+01	8.0E-04	8.0E-04	1.2E+02	1.5E+03	7.6E-04	5.7E+01	8.2E+01
PU-239	2.5E+01	7.3E-04	7.4E-04	1.3E+02	1.7E+03	7.1E-04	6.1E+01	9.1E+01
PU-240	2.5E+01	7.6E-04	7.7E-04	1.3E+02	1.7E+03	7.1E-04	6.1E+01	9.1E+01
AM-241	2.6E+01	2.5E-03	3.2E-03	1.4E+02	1.7E+03	1.3E-03	6.3E+01	9.3E+01
PU-241	5.5E-01	2.6E-05	4.4E-05	2.7E+00	3.4E+01	1.1E-05	1.1E+00	1.8E+00
PU-242	2.4E+01	7.6E-04	7.5E-04	1.3E+02	1.6E+03	6.9E-04	5.8E+01	8.6E+01

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 14

RF_CH

NON-RADIOLOGICAL DATA (ACCIDENTS AND FATALITIES)
****

HIGHWAY

	ACCIDENT RATE	ACCIDENTS	FATALITIES
RURAL_NM	3.83E-06	2.82E-03	9.96E-06
SUBURBN_NM	3.83E-06	9.12E-05	3.22E-07
URBAN_NM	3.83E-06	8.62E-06	3.04E-08
URBAN_NM_R	3.83E-06	9.58E-07	3.38E-09
RURAL_CO	2.55E-06	6.11E-04	2.16E-06
SUBURBN_CO	2.55E-06	3.00E-04	9.89E-07
URBAN_CO	2.55E-06	7.21E-05	2.54E-07
URBAN_CO_R	2.55E-06	8.01E-06	2.83E-08
TOTALS:	2.55E-05	3.91E-03	1.37E-05

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 15

RF_CH

REGULATORY CHECKS HAVE BEEN DISABLED
********** ****** **** **** ********

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 16

RF_CH

CALCULATIONAL INFORMATION

FOR TRUPACT_II AREAS WITH TOTAL CONTAMINATION RATIO GREATER THAN 40.000
(THE AREAS MARKED WITH AN 'X' ARE INTERDICTED AND HAVE
NO 50 YEAR GROUNDSHINE DOSE AND NO INGESTION DOSE.)

AREA/SEVERITY	1	2	3	4	5	6
1	-	-	-	-	X	X
2	-	-	-	-	X	X
3	-	-	-	-	X	X
4	-	-	-	-	-	X
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
15	-	-	-	-	-	-
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 17

RF_CH

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 18

RF_CH

VOL
DEPOSITION VELOCITY = 0.10E-01 (M/SEC)
DILUTION FACTORS
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM AIR CONCENTRATION = 1.5231E-02 (CI-SEC/M^3/CI-RELEASED)
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM GROUND DEPOSITION = 1.5231E-04 (CI/M^2/CI-RELEASED)

DOWNWIND (M)	AREA (M^2)	DILUTION (CI-S/M^3/CI-RLSE)	DILUTION FRACTION	DEPOSITED (CI/M^2/CI-RLSE)
2.35E+01	9.70E+00	1.37E-02	9.00E-01	1.37E-04
3.16E+01	6.11E+01	1.07E-02	7.00E-01	1.07E-04
4.44E+01	1.94E+02	7.62E-03	5.00E-01	7.62E-05
6.89E+01	5.93E+02	4.57E-03	3.00E-01	4.57E-05
9.35E+01	1.17E+03	3.05E-03	2.00E-01	3.05E-05
1.49E+02	3.08E+03	1.52E-03	1.00E-01	1.52E-05
2.27E+02	7.16E+03	7.62E-04	5.00E-02	7.62E-06
3.82E+02	1.98E+04	3.05E-04	2.00E-02	3.05E-06
5.56E+02	4.11E+04	1.52E-04	1.00E-02	1.52E-06
8.04E+02	8.33E+04	7.62E-05	5.00E-03	7.62E-07
1.31E+03	2.08E+05	3.05E-05	2.00E-03	3.05E-07
1.90E+03	4.15E+05	1.52E-05	1.00E-03	1.52E-07
2.78E+03	8.25E+05	7.62E-06	5.00E-04	7.62E-08
4.71E+03	2.08E+06	3.05E-06	2.00E-04	3.05E-08
7.15E+03	4.20E+06	1.52E-06	1.00E-04	1.52E-08
1.48E+04	1.16E+07	7.62E-07	5.00E-05	7.62E-09
3.08E+04	4.10E+07	3.05E-07	2.00E-05	3.05E-09
4.61E+04	8.49E+07	1.52E-07	1.00E-05	1.52E-09
6.26E+04	1.52E+08	7.62E-08	5.00E-06	7.62E-10
8.56E+04	2.76E+08	3.05E-08	2.00E-06	3.05E-10
1.04E+05	4.00E+08	1.52E-08	1.00E-06	1.52E-10
1.20E+05	5.33E+08	8.21E-09	5.39E-07	8.21E-11

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 19

RF_CH

PART
DEPOSITION VELOCITY = 0.10E-01 (M/SEC)
DILUTION FACTORS
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM AIR CONCENTRATION = 1.5231E-02 (CI-SEC/M^3/CI-RELEASED)
AT DOWNWIND LOCATION = 2.0382E+01 (M)
MAXIMUM GROUND DEPOSITION = 1.5231E-04 (CI/M^2/CI-RELEASED)

DOWNWIND (M)	AREA (M^2)	DILUTION (CI-S/M^3/CI-RLSE)	DILUTION FRACTION	DEPOSITED (CI/M^2/CI-RLSE)
2.35E+01	9.70E+00	1.37E-02	9.00E-01	1.37E-04
3.16E+01	6.11E+01	1.07E-02	7.00E-01	1.07E-04
4.44E+01	1.94E+02	7.62E-03	5.00E-01	7.62E-05
6.89E+01	5.93E+02	4.57E-03	3.00E-01	4.57E-05
9.35E+01	1.17E+03	3.05E-03	2.00E-01	3.05E-05
1.49E+02	3.08E+03	1.52E-03	1.00E-01	1.52E-05
2.27E+02	7.16E+03	7.62E-04	5.00E-02	7.62E-06
3.82E+02	1.98E+04	3.05E-04	2.00E-02	3.05E-06
5.56E+02	4.11E+04	1.52E-04	1.00E-02	1.52E-06
8.04E+02	8.33E+04	7.62E-05	5.00E-03	7.62E-07
1.31E+03	2.08E+05	3.05E-05	2.00E-03	3.05E-07
1.90E+03	4.15E+05	1.52E-05	1.00E-03	1.52E-07
2.78E+03	8.25E+05	7.62E-06	5.00E-04	7.62E-08
4.71E+03	2.08E+06	3.05E-06	2.00E-04	3.05E-08
7.15E+03	4.20E+06	1.52E-06	1.00E-04	1.52E-08
1.48E+04	1.16E+07	7.62E-07	5.00E-05	7.62E-09
3.08E+04	4.10E+07	3.05E-07	2.00E-05	3.05E-09
4.61E+04	8.49E+07	1.52E-07	1.00E-05	1.52E-09
6.26E+04	1.52E+08	7.62E-08	5.00E-06	7.62E-10
8.56E+04	2.76E+08	3.05E-08	2.00E-06	3.05E-10
1.04E+05	4.00E+08	1.52E-08	1.00E-06	1.52E-10
1.20E+05	5.33E+08	8.21E-09	5.39E-07	8.21E-11

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 20

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

1-YEAR DOSE TO   LUNG, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.55E-02	2.34E-02	1.17E-01	1.31E+00	1.74E+00
3.16E+01	0.00E+00	2.76E-02	1.82E-02	9.13E-02	1.02E+00	1.36E+00
4.44E+01	0.00E+00	1.97E-02	1.30E-02	6.52E-02	7.29E-01	9.69E-01
6.89E+01	0.00E+00	1.18E-02	7.79E-03	3.91E-02	4.38E-01	5.81E-01
9.35E+01	0.00E+00	7.89E-03	5.19E-03	2.61E-02	2.92E-01	3.88E-01
1.49E+02	0.00E+00	3.95E-03	2.60E-03	1.30E-02	1.46E-01	1.94E-01
2.27E+02	0.00E+00	1.97E-03	1.30E-03	6.52E-03	7.29E-02	9.69E-02
3.82E+02	0.00E+00	7.89E-04	5.19E-04	2.61E-03	2.92E-02	3.88E-02
5.56E+02	0.00E+00	3.95E-04	2.60E-04	1.30E-03	1.46E-02	1.94E-02
8.04E+02	0.00E+00	1.97E-04	1.30E-04	6.52E-04	7.29E-03	9.69E-03
1.31E+03	0.00E+00	7.89E-05	5.19E-05	2.61E-04	2.92E-03	3.88E-03
1.90E+03	0.00E+00	3.95E-05	2.60E-05	1.30E-04	1.46E-03	1.94E-03
2.78E+03	0.00E+00	1.97E-05	1.30E-05	6.52E-05	7.29E-04	9.69E-04
4.71E+03	0.00E+00	7.89E-06	5.19E-06	2.61E-05	2.92E-04	3.88E-04
7.15E+03	0.00E+00	3.95E-06	2.60E-06	1.30E-05	1.46E-04	1.94E-04
1.48E+04	0.00E+00	1.97E-06	1.30E-06	6.52E-06	7.29E-05	9.69E-05
3.08E+04	0.00E+00	7.89E-07	5.19E-07	2.61E-06	2.92E-05	3.88E-05
4.61E+04	0.00E+00	3.95E-07	2.60E-07	1.30E-06	1.46E-05	1.94E-05
6.26E+04	0.00E+00	1.97E-07	1.30E-07	6.52E-07	7.29E-06	9.69E-06
8.56E+04	0.00E+00	7.89E-08	5.19E-08	2.61E-07	2.92E-06	3.88E-06
1.04E+05	0.00E+00	3.95E-08	2.60E-08	1.30E-07	1.46E-06	1.94E-06
1.20E+05	0.00E+00	2.13E-08	1.40E-08	7.03E-08	7.86E-07	1.04E-06

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 21

RF_CH

1-YEAR DOSE TO MARROW/WHOLE BODY, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.91E-03	2.57E-03	1.29E-02	1.44E-01	1.92E-01
3.16E+01	0.00E+00	3.04E-03	2.00E-03	1.00E-02	1.12E-01	1.49E-01
4.44E+01	0.00E+00	2.17E-03	1.43E-03	7.17E-03	8.02E-02	1.07E-01
6.89E+01	0.00E+00	1.30E-03	8.57E-04	4.30E-03	4.81E-02	6.40E-02
9.35E+01	0.00E+00	8.68E-04	5.71E-04	2.87E-03	3.21E-02	4.26E-02
1.49E+02	0.00E+00	4.34E-04	2.86E-04	1.43E-03	1.60E-02	2.13E-02
2.27E+02	0.00E+00	2.17E-04	1.43E-04	7.17E-04	8.02E-03	1.07E-02
3.82E+02	0.00E+00	8.68E-05	5.71E-05	2.87E-04	3.21E-03	4.26E-03
5.56E+02	0.00E+00	4.34E-05	2.86E-05	1.43E-04	1.60E-03	2.13E-03
8.04E+02	0.00E+00	2.17E-05	1.43E-05	7.17E-05	8.02E-04	1.07E-03
1.31E+03	0.00E+00	8.68E-06	5.71E-06	2.87E-05	3.21E-04	4.26E-04
1.90E+03	0.00E+00	4.34E-06	2.86E-06	1.43E-05	1.60E-04	2.13E-04
2.78E+03	0.00E+00	2.17E-06	1.43E-06	7.17E-06	8.02E-05	1.07E-04
4.71E+03	0.00E+00	8.68E-07	5.71E-07	2.87E-06	3.21E-05	4.26E-05
7.15E+03	0.00E+00	4.34E-07	2.86E-07	1.43E-06	1.60E-05	2.13E-05
1.48E+04	0.00E+00	2.17E-07	1.43E-07	7.17E-07	8.02E-06	1.07E-05
3.08E+04	0.00E+00	8.68E-08	5.71E-08	2.87E-07	3.21E-06	4.26E-06
4.61E+04	0.00E+00	4.34E-08	2.86E-08	1.43E-07	1.60E-06	2.13E-06
6.26E+04	0.00E+00	2.17E-08	1.43E-08	7.17E-08	8.02E-07	1.07E-06
8.56E+04	0.00E+00	8.68E-09	5.71E-09	2.87E-08	3.21E-07	4.26E-07
1.04E+05	0.00E+00	4.34E-09	2.86E-09	1.43E-08	1.60E-07	2.13E-07
1.20E+05	0.00E+00	2.34E-09	1.54E-09	7.73E-09	8.65E-08	1.15E-07

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 22

RF_CH

1-YEAR DOSE TO THYROID, INHALATION PATHWAY
BDF = 1 (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.16E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.44E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.89E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9.35E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.49E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.82E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5.56E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.04E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.31E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.90E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.78E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.71E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7.15E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.48E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3.08E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4.61E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.56E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.04E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.20E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 23

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

GROUND SURFACE CONTAMINATION TABLE (MICRO CI/M**2)
BEFORE CLEANUP

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	5.09E-01	3.35E-01	1.68E+00	1.88E+01	2.50E+01
3.16E+01	0.00E+00	3.96E-01	2.61E-01	1.31E+00	1.46E+01	1.94E+01
4.44E+01	0.00E+00	2.83E-01	1.86E-01	9.34E-01	1.04E+01	1.39E+01
6.89E+01	0.00E+00	1.70E-01	1.12E-01	5.60E-01	6.27E+00	8.33E+00
9.35E+01	0.00E+00	1.13E-01	7.45E-02	3.74E-01	4.18E+00	5.55E+00
1.49E+02	0.00E+00	5.65E-02	3.73E-02	1.87E-01	2.09E+00	2.78E+00
2.27E+02	0.00E+00	2.83E-02	1.86E-02	9.34E-02	1.04E+00	1.39E+00
3.82E+02	0.00E+00	1.13E-02	7.45E-03	3.74E-02	4.18E-01	5.55E-01
5.56E+02	0.00E+00	5.65E-03	3.73E-03	1.87E-02	2.09E-01	2.78E-01
8.04E+02	0.00E+00	2.83E-03	1.86E-03	9.34E-03	1.04E-01	1.39E-01
1.31E+03	0.00E+00	1.13E-03	7.45E-04	3.74E-03	4.18E-02	5.55E-02
1.90E+03	0.00E+00	5.65E-04	3.73E-04	1.87E-03	2.09E-02	2.78E-02
2.78E+03	0.00E+00	2.83E-04	1.86E-04	9.34E-04	1.04E-02	1.39E-02
4.71E+03	0.00E+00	1.13E-04	7.45E-05	3.74E-04	4.18E-03	5.55E-03
7.15E+03	0.00E+00	5.65E-05	3.73E-05	1.87E-04	2.09E-03	2.78E-03
1.48E+04	0.00E+00	2.83E-05	1.86E-05	9.34E-05	1.04E-03	1.39E-03
3.08E+04	0.00E+00	1.13E-05	7.45E-06	3.74E-05	4.18E-04	5.55E-04
4.61E+04	0.00E+00	5.65E-06	3.73E-06	1.87E-05	2.09E-04	2.78E-04
6.26E+04	0.00E+00	2.83E-06	1.86E-06	9.34E-06	1.04E-04	1.39E-04
8.56E+04	0.00E+00	1.13E-06	7.45E-07	3.74E-06	4.18E-05	5.55E-05
1.04E+05	0.00E+00	5.65E-07	3.73E-07	1.87E-06	2.09E-05	2.78E-05
1.20E+05	0.00E+00	3.05E-07	2.01E-07	1.01E-06	1.13E-05	1.50E-05

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 24

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

MAXIMUM INDIVIDUAL CONSEQUENCE (DOSE IN REM)
FROM INHALATION, CLOUDSHINE, AND GROUNDSHINE EXPOSURE DURING EVACUATION

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.94E-02	2.59E-02	1.30E-01	1.46E+00	1.94E+00
3.16E+01	0.00E+00	3.07E-02	2.02E-02	1.01E-01	1.13E+00	1.51E+00
4.44E+01	0.00E+00	2.19E-02	1.44E-02	7.24E-02	8.10E-01	1.08E+00
6.89E+01	0.00E+00	1.31E-02	8.65E-03	4.34E-02	4.86E-01	6.46E-01
9.35E+01	0.00E+00	8.76E-03	5.77E-03	2.89E-02	3.24E-01	4.30E-01
1.49E+02	0.00E+00	4.38E-03	2.88E-03	1.45E-02	1.62E-01	2.15E-01
2.27E+02	0.00E+00	2.19E-03	1.44E-03	7.24E-03	8.10E-02	1.08E-01
3.82E+02	0.00E+00	8.76E-04	5.77E-04	2.89E-03	3.24E-02	4.30E-02
5.56E+02	0.00E+00	4.38E-04	2.88E-04	1.45E-03	1.62E-02	2.15E-02
8.04E+02	0.00E+00	2.19E-04	1.44E-04	7.24E-04	8.10E-03	1.08E-02
1.31E+03	0.00E+00	8.76E-05	5.77E-05	2.89E-04	3.24E-03	4.30E-03
1.90E+03	0.00E+00	4.38E-05	2.88E-05	1.45E-04	1.62E-03	2.15E-03
2.78E+03	0.00E+00	2.19E-05	1.44E-05	7.24E-05	8.10E-04	1.08E-03
4.71E+03	0.00E+00	8.76E-06	5.77E-06	2.89E-05	3.24E-04	4.30E-04
7.15E+03	0.00E+00	4.38E-06	2.88E-06	1.45E-05	1.62E-04	2.15E-04
1.48E+04	0.00E+00	2.19E-06	1.44E-06	7.24E-06	8.10E-05	1.08E-04
3.08E+04	0.00E+00	8.76E-07	5.77E-07	2.89E-06	3.24E-05	4.30E-05
4.61E+04	0.00E+00	4.38E-07	2.88E-07	1.45E-06	1.62E-05	2.15E-05
6.26E+04	0.00E+00	2.19E-07	1.44E-07	7.24E-07	8.10E-06	1.08E-05
8.56E+04	0.00E+00	8.76E-08	5.77E-08	2.89E-07	3.24E-06	4.30E-06
1.04E+05	0.00E+00	4.38E-08	2.88E-08	1.45E-07	1.62E-06	2.15E-06
1.20E+05	0.00E+00	2.36E-08	1.55E-08	7.80E-08	8.73E-07	1.16E-06

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 25

RF_CH

PASQUILL CATEGORY F
VEHICLE TRUPACT_II

BACKYARD FARMER DOSE - EFFECTIVE
MAXIMUM INDIVIDUAL CONSEQUENCE (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.30E-01	2.17E-01	1.09E+00	1.22E+01	1.62E+01
3.16E+01	0.00E+00	2.57E-01	1.69E-01	8.49E-01	9.49E+00	1.26E+01
4.44E+01	0.00E+00	1.83E-01	1.21E-01	6.06E-01	6.78E+00	9.01E+00
6.89E+01	0.00E+00	1.10E-01	7.25E-02	3.64E-01	4.07E+00	5.41E+00
9.35E+01	0.00E+00	7.34E-02	4.83E-02	2.42E-01	2.71E+00	3.60E+00
1.49E+02	0.00E+00	3.67E-02	2.42E-02	1.21E-01	1.36E+00	1.80E+00
2.27E+02	0.00E+00	1.83E-02	1.21E-02	6.06E-02	6.78E-01	9.01E-01
3.82E+02	0.00E+00	7.34E-03	4.83E-03	2.42E-02	2.71E-01	3.60E-01
5.56E+02	0.00E+00	3.67E-03	2.42E-03	1.21E-02	1.36E-01	1.80E-01
8.04E+02	0.00E+00	1.83E-03	1.21E-03	6.06E-03	6.78E-02	9.01E-02
1.31E+03	0.00E+00	7.34E-04	4.83E-04	2.42E-03	2.71E-02	3.60E-02
1.90E+03	0.00E+00	3.67E-04	2.42E-04	1.21E-03	1.36E-02	1.80E-02
2.78E+03	0.00E+00	1.83E-04	1.21E-04	6.06E-04	6.78E-03	9.01E-03
4.71E+03	0.00E+00	7.34E-05	4.83E-05	2.42E-04	2.71E-03	3.60E-03
7.15E+03	0.00E+00	3.67E-05	2.42E-05	1.21E-04	1.36E-03	1.80E-03
1.48E+04	0.00E+00	1.83E-05	1.21E-05	6.06E-05	6.78E-04	9.01E-04
3.08E+04	0.00E+00	7.34E-06	4.83E-06	2.42E-05	2.71E-04	3.60E-04
4.61E+04	0.00E+00	3.67E-06	2.42E-06	1.21E-05	1.36E-04	1.80E-04
6.26E+04	0.00E+00	1.83E-06	1.21E-06	6.06E-06	6.78E-05	9.01E-05
8.56E+04	0.00E+00	7.34E-07	4.83E-07	2.42E-06	2.71E-05	3.60E-05
1.04E+05	0.00E+00	3.67E-07	2.42E-07	1.21E-06	1.36E-05	1.80E-05
1.20E+05	0.00E+00	1.98E-07	1.30E-07	6.54E-07	7.31E-06	9.72E-06

BACKYARD FARMER DOSE - THYROID
MAXIMUM INDIVIDUAL CONSEQUENCE (REM)

CNTR LINE	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
2.35E+01	0.00E+00	3.00E-06	9.77E-05	9.91E-06	3.15E-04	2.83E-04
3.16E+01	0.00E+00	2.33E-06	7.60E-05	7.70E-06	2.45E-04	2.20E-04
4.44E+01	0.00E+00	1.67E-06	5.43E-05	5.50E-06	1.75E-04	1.57E-04
6.89E+01	0.00E+00	9.99E-07	3.26E-05	3.30E-06	1.05E-04	9.43E-05
9.35E+01	0.00E+00	6.66E-07	2.17E-05	2.20E-06	7.00E-05	6.29E-05
1.49E+02	0.00E+00	3.33E-07	1.09E-05	1.10E-06	3.50E-05	3.14E-05
2.27E+02	0.00E+00	1.67E-07	5.43E-06	5.50E-07	1.75E-05	1.57E-05
3.82E+02	0.00E+00	6.66E-08	2.17E-06	2.20E-07	7.00E-06	6.29E-06
5.56E+02	0.00E+00	3.33E-08	1.09E-06	1.10E-07	3.50E-06	3.14E-06
8.04E+02	0.00E+00	1.67E-08	5.43E-07	5.50E-08	1.75E-06	1.57E-06
1.31E+03	0.00E+00	6.66E-09	2.17E-07	2.20E-08	7.00E-07	6.29E-07
1.90E+03	0.00E+00	3.33E-09	1.09E-07	1.10E-08	3.50E-07	3.14E-07
2.78E+03	0.00E+00	1.67E-09	5.43E-08	5.50E-09	1.75E-07	1.57E-07
4.71E+03	0.00E+00	6.66E-10	2.17E-08	2.20E-09	7.00E-08	6.29E-08
7.15E+03	0.00E+00	3.33E-10	1.09E-08	1.10E-09	3.50E-08	3.14E-08
1.48E+04	0.00E+00	1.67E-10	5.43E-09	5.50E-10	1.75E-08	1.57E-08
3.08E+04	0.00E+00	6.66E-11	2.17E-09	2.20E-10	7.00E-09	6.29E-09
4.61E+04	0.00E+00	3.33E-11	1.09E-09	1.10E-10	3.50E-09	3.14E-09
6.26E+04	0.00E+00	1.67E-11	5.43E-10	5.50E-11	1.75E-09	1.57E-09

983	8.56E+04	0.00E+00	6.66E-12	2.17E-10	2.20E-11	7.00E-10	6.29E-10
984	1.04E+05	0.00E+00	3.33E-12	1.09E-10	1.10E-11	3.50E-10	3.14E-10
985	1.20E+05	0.00E+00	1.80E-12	5.85E-11	5.93E-12	1.89E-10	1.69E-10
986							

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 26

RF_CH

INCIDENT-FREE SUMMARY
******** **** *******

IN-TRANSIT POPULATION EXPOSURE IN PERSON-REM

	PASSENGER	CREW	OFF LINK	ON LINK	TOTALS
RURAL_NM	0.00E+00	3.98E-03	7.09E-06	5.13E-04	4.50E-03
SUBURBN_NM	0.00E+00	1.28E-04	1.35E-05	3.06E-05	1.73E-04
URBAN_NM	0.00E+00	1.21E-05	1.51E-07	8.01E-06	2.03E-05
URBAN_NM_R	0.00E+00	2.70E-06	3.35E-08	7.43E-06	1.02E-05
RURAL_CO	0.00E+00	1.29E-03	4.76E-06	3.18E-04	1.62E-03
SUBURBN_CO	0.00E+00	6.34E-04	8.87E-05	2.93E-04	1.02E-03
URBAN_CO	0.00E+00	1.53E-04	2.55E-06	1.22E-04	2.77E-04
URBAN_CO_R	0.00E+00	3.39E-05	5.67E-07	1.13E-04	1.47E-04
RURAL	0.00E+00	5.27E-03	1.19E-05	8.31E-04	6.11E-03
SUBURB	0.00E+00	7.63E-04	1.02E-04	3.23E-04	1.19E-03
URBAN	0.00E+00	2.01E-04	3.30E-06	2.50E-04	4.55E-04
TOTALS:	0.00E+00	6.24E-03	1.17E-04	1.40E-03	7.76E-03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

TRUPACT_II 3.33E-08 REM

STOP EXPOSURE IN PERSON-REM

ANNULAR AREA	RURAL_NM	1.26E-06
ANNULAR AREA	SUBURB_NM	2.75E-06
ANNULAR AREA	RURAL_CO	8.47E-07
ANNULAR AREA	SUBSURBAN_	1.82E-05
LINE-SOURCE	TRUCKCREW	4.73E-03
LINE-SOURCE	INSPECTOR	4.19E-03
ANNULAR AREA	RESTSTOPEM	2.79E-04
ANNULAR AREA	RURAL_ATST	2.92E-03
ANNULAR AREA	SUBURBAN_A	4.22E-04

TOTAL: 1.26E-02

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 27

RF_CH

ACCIDENT SUMMARY
******** *******

NUMBER OF EXPECTED ACCIDENTS

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	2.82E-03	9.11E-05	8.62E-06	9.57E-07	6.11E-04	3.00E-04	7.21E-05
2	1.71E-07	5.52E-09	5.22E-10	5.80E-11	3.70E-08	1.82E-08	4.37E-09
3	1.65E-08	5.34E-10	5.05E-11	5.61E-12	3.58E-09	1.76E-09	4.22E-10
4	1.40E-09	4.51E-11	4.27E-12	4.74E-13	3.03E-10	1.48E-10	3.57E-11
5	2.11E-10	6.83E-12	6.45E-13	7.17E-14	4.58E-11	2.24E-11	5.40E-12
6	8.47E-13	2.73E-14	2.59E-15	2.87E-16	1.83E-13	8.99E-14	2.16E-14

CATEGORY	URBAN_CO_R
1	8.01E-06
2	4.85E-10
3	4.69E-11
4	3.96E-12
5	6.00E-13
6	2.40E-15

NUMBER OF EARLY FATALITIES FROM INHALATION

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CATEGORY	URBAN_CO_R
1	0.00E+00
2	0.00E+00
3	0.00E+00
4	0.00E+00
5	0.00E+00
6	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24]   PAGE 28

RF_CH

RADIOLOGICAL CONSEQUENCES
50 YEAR POPULATION DOSE IN PERSON-REM

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	2.04E-03	1.38E-01	2.30E+00	2.29E+00	4.21E-03	1.84E-01	3.09E+00
3	1.35E-03	9.14E-02	1.52E+00	1.52E+00	2.79E-03	1.22E-01	2.05E+00
4	6.73E-03	4.56E-01	7.59E+00	7.58E+00	1.39E-02	6.07E-01	1.02E+01
5	6.91E-02	4.67E+00	7.79E+01	7.77E+01	1.43E-01	6.23E+00	1.05E+02
6	9.06E-02	6.13E+00	1.02E+02	1.02E+02	1.87E-01	8.17E+00	1.37E+02

CATEGORY	URBAN_CO_R
1	0.00E+00
2	3.09E+00
3	2.05E+00
4	1.02E+01
5	1.05E+02
6	1.37E+02

NUMBER OF EARLY MORBIDITY CASES FROM INHALATION

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CATEGORY	URBAN_CO_R
1	0.00E+00
2	0.00E+00
3	0.00E+00
4	0.00E+00
5	0.00E+00
6	0.00E+00

MAXIMUM RISK FOR INDIVIDUAL IN NEAREST ISOPLETH (DOSE IN REM)
FROM INHALATION, CLOUDSHINE, AND GROUNDSHINE EXPOSURE DURING EVACUATION

CATEGORY	RURAL_NM	SUBURBN_NM	URBAN_NM	URBAN_NM_R	RURAL_CO	SUBURBN_CO	URBAN_CO
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

2	6.74E-09	2.18E-10	2.06E-11	2.29E-12	1.46E-09	7.16E-10	1.72E-10
3	4.29E-10	1.39E-11	1.31E-12	1.46E-13	9.29E-11	4.56E-11	1.10E-11
4	1.82E-10	5.88E-12	5.56E-13	6.17E-14	3.94E-11	1.93E-11	4.65E-12
5	3.08E-10	9.95E-12	9.41E-13	1.05E-13	6.67E-11	3.27E-11	7.87E-12
6	1.64E-12	5.30E-14	5.01E-15	5.56E-16	3.55E-13	1.74E-13	4.19E-14

CATEGORY URBAN_CO_R

1	0.00E+00
2	1.91E-11
3	1.22E-12
4	5.16E-13
5	8.74E-13
6	4.65E-15

RADIOLOGICAL CONSEQUENCES IN PERSON REM
50 YEAR SOCIETAL INGESTION DOSE - EFFECTIVE

LINK	SEVER: 1	SEVER: 2	SEVER: 3	SEVER: 4	SEVER: 5	SEVER: 6
RURAL_NM	0.00E+00	9.56E-02	6.33E-02	3.04E-01	2.95E+00	3.83E+00
RURAL_CO	0.00E+00	9.56E-02	6.33E-02	3.04E-01	2.95E+00	3.83E+00

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 29

RF_CH

EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	TOTAL
RURAL_NM	2.76E-12	3.50E-10	4.21E-11	9.79E-18	3.95E-10
SUBURBN_NM	6.03E-12	7.66E-10	9.19E-11	2.14E-17	8.64E-10
URBAN_NM	9.49E-12	1.21E-09	1.45E-10	3.37E-17	1.36E-09
URBAN_NM_R	1.05E-12	1.34E-10	1.61E-11	3.74E-18	1.51E-10
RURAL_CO	1.23E-12	1.57E-10	1.88E-11	4.38E-18	1.77E-10
SUBURBN_CO	2.64E-11	3.35E-09	4.03E-10	9.37E-17	3.78E-09
URBAN_CO	1.07E-10	1.36E-08	1.63E-09	3.79E-16	1.53E-08
URBAN_CO_R	1.19E-11	1.51E-09	1.81E-10	4.21E-17	1.70E-09

RURAL	3.99E-12	5.07E-10	6.09E-11	1.42E-17	5.72E-10
SUBURB	3.24E-11	4.12E-09	4.95E-10	1.15E-16	4.65E-09
URBAN	1.29E-10	1.64E-08	1.97E-09	4.58E-16	1.85E-08
TOTALS:	1.66E-10	2.10E-08	2.52E-09	5.88E-16	2.37E-08

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 30

RF_CH

SOCIETAL INGESTION RISK - PERSON-REM

LINK	GONADS	EFFECTIVE
RURAL_NM	4.99E-09	1.84E-08
RURAL_CO	1.08E-09	4.00E-09
TOTAL	6.08E-09	2.24E-08

SOCIETAL INGESTION RISK BY ORGAN - PERSON-REM

LINK	BREAST	LUNGS	RED MARR	BONE SUR	THYROID	REMAINDER
RURAL_NM	6.65E-13	6.79E-13	2.71E-08	3.37E-07	6.64E-13	1.27E-08
RURAL_CO	1.44E-13	1.47E-13	5.87E-09	7.31E-08	1.44E-13	2.75E-09
TOTAL	8.09E-13	8.27E-13	3.30E-08	4.11E-07	8.08E-13	1.55E-08

EXPECTED RISK VALUES - OTHER

LINK	EARLY FATALITY	EARLY MORBIDITY
RURAL_NM	0.00E+00	0.00E+00
SUBURBN_NM	0.00E+00	0.00E+00
URBAN_NM	0.00E+00	0.00E+00
URBAN_NM_R	0.00E+00	0.00E+00
RURAL_CO	0.00E+00	0.00E+00
SUBURBN_CO	0.00E+00	0.00E+00
URBAN_CO	0.00E+00	0.00E+00
URBAN_CO_R	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

RUN DATE: [07-OCT-08 AT 16:21:24] PAGE 31

RF_CH

TOTAL EXPOSED POPULATION: INCIDENT-FREE

RURAL_NM 5.80E+03 PERSONS
SUBURBN_NM 1.27E+04 PERSONS
URBAN_NM 6.87E+03 PERSONS
URBAN_NM_R 7.62E+02 PERSONS
RURAL_CO 3.89E+03 PERSONS
SUBURBN_CO 8.34E+04 PERSONS
URBAN_CO 1.16E+05 PERSONS
URBAN_CO_R 1.29E+04 PERSONS

TOTAL 2.42E+05 PERSONS

PASQUILL CATEGORY F
TOTAL EXPOSED POPULATION: ACCIDENT
(PERSONS UNDER PLUME FOOTPRINT FOR A SINGLE ACCIDENT)

RURAL_NM 4.03E+03 PERSONS
SUBURBN_NM 2.73E+05 PERSONS
URBAN_NM 1.56E+06 PERSONS
URBAN_NM_R 1.56E+06 PERSONS
RURAL_CO 8.32E+03 PERSONS
SUBURBN_CO 3.63E+05 PERSONS
URBAN_CO 2.10E+06 PERSONS
URBAN_CO_R 2.10E+06 PERSONS

RF_CH

LINK: RURAL_NM EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	1.64E-13	8.80E-18	1.07E-18	3.97E-18	1.64E-13
TRUPACT	CO60	9.63E-16	4.02E-20	4.83E-21	7.67E-20	9.63E-16
TRUPACT	SR90	5.69E-18	2.26E-18	2.71E-19	7.18E-23	8.22E-18
TRUPACT	PU238	2.26E-12	2.86E-10	3.43E-11	4.61E-18	3.22E-10
TRUPACT	PU239	1.89E-13	5.01E-11	6.01E-12	6.44E-19	5.63E-11
TRUPACT	PU240	1.09E-13	1.32E-11	1.58E-12	1.90E-19	1.49E-11
TRUPACT	AM241	3.10E-14	9.48E-14	1.14E-14	2.81E-19	1.37E-13
TRUPACT	PU241	5.29E-16	1.13E-12	1.36E-13	1.38E-20	1.26E-12
TRUPACT	PU242	1.47E-18	2.06E-16	2.47E-17	2.59E-24	2.32E-16

TOTAL: 3.95E-10

LINK: SUBURBN_NM EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	3.59E-13	1.92E-17	2.34E-18	8.69E-18	3.59E-13
TRUPACT	CO60	2.10E-15	8.79E-20	1.06E-20	1.68E-19	2.11E-15
TRUPACT	SR90	1.24E-17	4.94E-18	5.93E-19	1.57E-22	1.80E-17
TRUPACT	PU238	4.95E-12	6.25E-10	7.50E-11	1.01E-17	7.05E-10
TRUPACT	PU239	4.13E-13	1.09E-10	1.31E-11	1.41E-18	1.23E-10
TRUPACT	PU240	2.39E-13	2.88E-11	3.46E-12	4.16E-19	3.25E-11

TRUPACT	AM241	6.77E-14	2.07E-13	2.49E-14	6.14E-19	3.00E-13
TRUPACT	PU241	1.16E-15	2.47E-12	2.96E-13	3.01E-20	2.76E-12
TRUPACT	PU242	3.21E-18	4.49E-16	5.40E-17	5.66E-24	5.07E-16

TOTAL: 8.64E-10

LINK: URBAN_NM EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	5.65E-13	3.03E-17	3.68E-18	1.37E-17	5.65E-13
TRUPACT	CO60	3.31E-15	1.38E-19	1.66E-20	2.64E-19	3.31E-15
TRUPACT	SR90	1.96E-17	7.78E-18	9.34E-19	2.47E-22	2.83E-17
TRUPACT	PU238	7.79E-12	9.84E-10	1.18E-10	1.59E-17	1.11E-09
TRUPACT	PU239	6.50E-13	1.72E-10	2.07E-11	2.22E-18	1.94E-10
TRUPACT	PU240	3.76E-13	4.54E-11	5.45E-12	6.54E-19	5.12E-11
TRUPACT	AM241	1.07E-13	3.26E-13	3.92E-14	9.66E-19	4.72E-13
TRUPACT	PU241	1.82E-15	3.88E-12	4.66E-13	4.74E-20	4.35E-12
TRUPACT	PU242	5.05E-18	7.08E-16	8.50E-17	8.92E-24	7.98E-16

TOTAL: 1.36E-09

LINK: URBAN_NM_R EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	6.27E-14	3.36E-18	4.08E-19	1.52E-18	6.27E-14
TRUPACT	CO60	3.68E-16	1.54E-20	1.84E-21	2.93E-20	3.68E-16
TRUPACT	SR90	2.17E-18	8.62E-19	1.04E-19	2.74E-23	3.14E-18
TRUPACT	PU238	8.64E-13	1.09E-10	1.31E-11	1.76E-18	1.23E-10
TRUPACT	PU239	7.21E-14	1.91E-11	2.30E-12	2.46E-19	2.15E-11
TRUPACT	PU240	4.17E-14	5.04E-12	6.05E-13	7.26E-20	5.68E-12
TRUPACT	AM241	1.18E-14	3.62E-14	4.35E-15	1.07E-19	5.24E-14
TRUPACT	PU241	2.02E-16	4.31E-13	5.17E-14	5.25E-21	4.83E-13
TRUPACT	PU242	5.61E-19	7.85E-17	9.43E-18	9.89E-25	8.85E-17

TOTAL: 1.51E-10

LINK: RURAL_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	7.34E-14	3.93E-18	4.77E-19	1.78E-18	7.34E-14
TRUPACT	CO60	4.30E-16	1.80E-20	2.16E-21	3.43E-20	4.30E-16
TRUPACT	SR90	2.54E-18	1.01E-18	1.21E-19	3.21E-23	3.68E-18
TRUPACT	PU238	1.01E-12	1.28E-10	1.53E-11	2.06E-18	1.44E-10
TRUPACT	PU239	8.45E-14	2.24E-11	2.69E-12	2.88E-19	2.52E-11
TRUPACT	PU240	4.88E-14	5.89E-12	7.08E-13	8.50E-20	6.65E-12
TRUPACT	AM241	1.38E-14	4.24E-14	5.09E-15	1.26E-19	6.13E-14
TRUPACT	PU241	2.37E-16	5.04E-13	6.06E-14	6.15E-21	5.65E-13
TRUPACT	PU242	6.56E-19	9.19E-17	1.10E-17	1.16E-24	1.04E-16

TOTAL: 1.77E-10

LINK: SUBURBN_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

MATERIAL	ISOTOPE	GROUND	INHALATN	RESUSP	CLOUDSH	TOTAL
TRUPACT	CS137	1.57E-12	8.43E-17	1.02E-17	3.80E-17	1.57E-12
TRUPACT	CO60	9.22E-15	3.85E-19	4.62E-20	7.35E-19	9.22E-15
TRUPACT	SR90	5.45E-17	2.16E-17	2.60E-18	6.87E-22	7.87E-17
TRUPACT	PU238	2.17E-11	2.74E-09	3.28E-10	4.41E-17	3.09E-09
TRUPACT	PU239	1.81E-12	4.79E-10	5.76E-11	6.17E-18	5.39E-10
TRUPACT	PU240	1.04E-12	1.26E-10	1.52E-11	1.82E-18	1.42E-10
TRUPACT	AM241	2.96E-13	9.07E-13	1.09E-13	2.69E-18	1.31E-12
TRUPACT	PU241	5.07E-15	1.08E-11	1.30E-12	1.32E-19	1.21E-11
TRUPACT	PU242	1.41E-17	1.97E-15	2.36E-16	2.48E-23	2.22E-15

TOTAL: 3.78E-09

LINK: URBAN_CO EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

```
MATERIAL  ISOTOPE  GROUND   INHALATN  RESUSP   CLOUDSH   TOTAL
TRUPACT   CS137    6.35E-12 3.41E-16 4.13E-17 1.54E-16 6.35E-12
TRUPACT   CO60     3.73E-14 1.56E-18 1.87E-19 2.97E-18 3.73E-14
TRUPACT   SR90     2.20E-16 8.74E-17 1.05E-17 2.78E-21 3.18E-16
TRUPACT   PU238    8.76E-11 1.11E-08 1.33E-09 1.78E-16 1.25E-08
TRUPACT   PU239    7.31E-12 1.94E-09 2.33E-10 2.49E-17 2.18E-09
TRUPACT   PU240    4.22E-12 5.10E-10 6.13E-11 7.36E-18 5.76E-10
TRUPACT   AM241    1.20E-12 3.67E-12 4.40E-13 1.09E-17 5.31E-12
TRUPACT   PU241    2.05E-14 4.37E-11 5.24E-12 5.33E-19 4.89E-11
TRUPACT   PU242    5.68E-17 7.96E-15 9.55E-16 1.00E-22 8.97E-15
                          TOTAL: 1.53E-08

LINK: URBAN_CO_R     EXPECTED VALUES OF POPULATION RISK IN PERSON-REM
MATERIAL  ISOTOPE  GROUND   INHALATN  RESUSP   CLOUDSH   TOTAL
TRUPACT   CS137    7.05E-13 3.78E-17 4.59E-18 1.71E-17 7.05E-13
TRUPACT   CO60     4.14E-15 1.73E-19 2.08E-20 3.30E-19 4.14E-15
TRUPACT   SR90     2.45E-17 9.71E-18 1.17E-18 3.09E-22 3.53E-17
TRUPACT   PU238    9.73E-12 1.23E-09 1.47E-10 1.98E-17 1.39E-09
TRUPACT   PU239    8.12E-13 2.15E-10 2.58E-11 2.77E-18 2.42E-10
TRUPACT   PU240    4.69E-13 5.67E-11 6.81E-12 8.17E-19 6.40E-11
TRUPACT   AM241    1.33E-13 4.07E-13 4.89E-14 1.21E-18 5.89E-13
TRUPACT   PU241    2.27E-15 4.85E-12 5.82E-13 5.91E-20 5.43E-12
TRUPACT   PU242    6.31E-18 8.84E-16 1.06E-16 1.11E-23 9.96E-16
                          TOTAL: 1.70E-09
EOI
END OF RUN
SUCCESSFUL COMPLETION

[TRAGIS]
TRAGIS VERSION=1.5.4
MODE=H
NETWORK VERSION=4.0
CENSUS DATA=2000
BUFFER ZONE=800
[ROUTEINFO]
FROM CITY=ORNL
FROM STATE=TN
FROM SUBNET=
TO CITY=WIPP
TO STATE=NM
TO SUBNET=
[AR]
RURAL - KM= 327.9
SUBURBAN - KM= 105.5
URBAN - KM=  5.9
TOTAL - KM= 439.2
RURAL POP DENSITY= 13.9
SUBURBAN POP DENSITY= 281.4
URBAN POP DENSITY=2083.0
[NM]
RURAL - KM= 112.4
SUBURBAN - KM=  6.7
URBAN - KM=  1.0
TOTAL - KM= 120.0
RURAL POP DENSITY=  4.2
SUBURBAN POP DENSITY= 412.6
URBAN POP DENSITY=2043.7
[TN]
```

```
RURAL - KM= 403.0
SUBURBAN - KM= 172.6
URBAN - KM= 25.2
TOTAL - KM= 600.8
RURAL POP DENSITY= 16.4
SUBURBAN POP DENSITY= 313.1
URBAN POP DENSITY=2249.6
[TX]
RURAL - KM= 802.3
SUBURBAN - KM= 234.5
URBAN - KM= 35.2
TOTAL - KM=1072.0
RURAL POP DENSITY= 11.3
SUBURBAN POP DENSITY= 360.1
URBAN POP DENSITY=2309.9
[TOTAL]
RURAL - KM=1645.7
SUBURBAN - KM= 519.2
URBAN - KM= 67.3
TOTAL - KM=2232.1
RURAL POP DENSITY= 12.6
SUBURBAN POP DENSITY= 329.2
URBAN POP DENSITY=2263.7

TRAGIS ROUTING ENGINE VERSION 1.5.4      -- HIGHWAY DATA NETWORK  4.0

FROM:   ROCKY FLATS          CO      LEAVING  : 08/22/08 12:29
TO :   WIPP              NM          ARRIVING : 08/23/08 01:01


ROUTING PARAMETERS USED TO CALCULATE THE ROUTE-

 ROUTING TYPE: WIPP PREFERRED ROUTE WITH 2 DRIVER(S)
  PREFERRED ROADS    TIME BIAS: 1.00  MILE BIAS: 0.00, TOLL BIAS: 1.00
  NONPREFERRED ROADS  TIME BIAS: 0.00  MILE BIAS: 1.00, TOLL BIAS: 1.00, PENALTY FACTOR: 30.0

 CONSTRAINTS USED ON ROUTE:
  PROHIBIT USE OF LINKS PROHIBITING TRUCK USE
  PROHIBIT USE OF FERRY CROSSING
  PROHIBIT USE OF ROADS WITH RADIOACTIVE MATERIALS PROHIBITION


 MILES HWY SIGN   CITY        DIR JUNCTION STATE  DIST TIME DATE    HOUR
------------------------------------------------------------------------------
  0.0          ROCKY FLATS          CO     0.0 0:00 08/22/08 12:29
  2.3 LOCAL      ROCKY FLATS  W   S93 LOCL   CO    2.3 0:04 08/22/08 12:33
  3.0 S93      MARSHALL    S   S128S93    CO    5.4 0:09 08/22/08 12:38
  8.2 S128      BROOMFIELD      U36 S128   CO    13.6 0:21 08/22/08 12:50
  9.1 U36      THORNTON    S  I25 X217   CO   22.7 0:30 08/22/08 12:59
205.1 I25      TRINIDAD       I25 X13    CO  227.8 3:28 08/22/08 15:57
 13.7 I25      CROSSING STATE BORDER CO/NM    BD   241.5 3:39 08/22/08 16:08
           REST  30 MINUTES
170.7 I25      SANTA FE    SE  I25 X290   NM   412.2 6:34 08/22/08 19:03
 68.6 U285      ENCINO      W   U285U60    NM   480.8 7:51 08/22/08 20:20
 14.0 U285  U60  VAUGHN      SW  U285U54    NM   494.7 8:05 08/22/08 20:34
  3.9 U285  U54  VAUGHN      SE  U285U54    NM   498.6 8:09 08/22/08 20:38
           REST  30 MINUTES
 90.1 U285      ROSWELL     N   U285U70    NM   588.7 10:09 08/22/08 22:38
```

```
 7.5 U285  U70  ROSWELL     W  U380U70   NM  596.2 10:17 08/22/08 22:46
73.4 U285       CARLSBAD    NW U285LCBR  NM  669.6 11:32 08/23/08 00:01
 8.7 LCBR       CARLSBAD    E  U62 LCBR  NM  678.3 11:42 08/23/08 00:11
25.3 U62  U180  TOWER HILL  E  U62 LOCL  NM  703.6 12:08 08/23/08 00:37
12.1 LOCAL      WIPP                     NM  715.7 12:32 08/23/08 01:01

TOTAL ELAPSED TIME: 12:32    TOTAL TRIP MILEAGE:  715.7    IMPEDANCE:  692.3


MILEAGE BY STATE :
CO:  241.5  NM:  474.2

MILEAGE BY SIGN TYPE:
1-INTERSTATE: 389.5      2-US: 291.9     3-STATE:  11.2     6-LOCAL:  23.1


MILEAGE BY LANE TYPE:
 1-MULTI-LANE CONTROLLED ACCESS:  398.7     3-MULTI-LANE DIVIDED HIGHWAY:  240.0
          5-PRINCIPLE ROAD:  42.7            6-THROUGH ROAD:    3.0
               7-OTHER:  31.3

MILEAGE BY TRIBAL LANDS:
 TOTAL OUTSIDE TRIBAL LANDS   :  715.7
 TOTAL INSIDE TRIBAL LANDS    :   0.0




TRAGIS ROUTING ENGINE VERSION 1.5.4     --  2000 CENSUS DATA

POPULATION DENSITY WITHIN  800 METER BUFFER ZONE:
FROM: ROCKY FLATS            CO
TO  : WIPP                 NM
----------------------------------------------------------------------------
           >0.0  22.7  59.7   139   326   821  1861  3326  5815
ST MILES    0  -22.7 -59.7  -139  -326  -821 -1861 -3326 -5815 -9996 >9996
----------------------------------------------------------------------------
CO 241.5  58.73 39.49 31.88 18.84 16.76 20.88 21.93 13.44 11.37  5.69  2.44
NM 474.2 255.62 132.12 55.27 14.83  7.44  3.03  2.00  2.33  1.47  0.07  0.00

TOTALS
  715.7 314.35 171.61 87.15 33.67 24.20 23.91 23.93 15.77 12.84  5.76  2.44
PERCENTAGES
         43.93 23.98 12.18  4.70  3.38  3.34  3.34  2.20  1.79  0.80  0.34

BASIS:  2000 CENSUS DATA

RADTRAN INPUT DATA       RURAL  SUBURBAN    URBAN
WEIGHTED POPULATION
PEOPLE/SQ. MI.          15.3    1051.5    6229.1
PEOPLE/SQ. KM.           5.9     406.0    2405.1


DISTANCE                              TOTALS
MILES            606.8     87.8    21.0    715.7
KILOMETERS       976.5    141.3    33.9   1151.8
PERCENTAGES       84.8     12.3     2.9
```

BASIS (PEOPLE/SQ MI.) <139 139-3326 >3326

POPULATION WITHIN 800 METER BUFFER ZONE BY STATE:
CO 167553 NM 18093

TOTAL POPULATION WITHIN 800 METER BUFFER ZONE: 185646

Trone, Janis R

From: Weiner, Ruth
Sent: Saturday, December 06, 2008 5:05 PM
To: Trone, Janis R
Subject: signature authority

Janis
You have my signature authority for the "Summary Report for Update to Disposal Phase Supplemental Environmental Impact Statement Transportation Analysis of the Waste Isolation Pilot Plant" and DRC's pertaining to it. Thanks

Ruth F. Weiner Ph.D.
Sandia National Laboratories
Phone: 505-284-8406
Fax: 505-844-0244
Email: rfweine@sandia.gov

Trone, Janis R

From: Dotson, Lori J
Sent: Wednesday, December 03, 2008 1:42 PM
To: Trone, Janis R; Dunagan, Sean
Subject: Signature Authority

I hereby grant Janis Trone Signature Authority for me on the Transportation SEIS DRCs and associated forms. Thanks.

-Lori
(505)259-5870

Trone, Janis R

From: Chavez, Mario Joseph
Sent: Wednesday, December 03, 2008 1:25 PM
To: Trone, Janis R
Cc: Dunagan, Sean
Subject: NEPA report Signature Authority

Attachments: QA_DRC.doc

Hi Janis,

Sean wants to get this NEPA report out by Tomorrow. As you know I will be gone tomorrow and out of e-mail contact. So I am giving you signature and resolution authority for the attached DRC and Report. Please let me know if you have any questions, I will talk to Sean later this afternoon to see if there are any sticking points.

Thanks,

Mario

From: Chavez, Mario Joseph
Sent: Wednesday, December 03, 2008 11:10 AM
To: Dunagan, Sean
Subject: RE: NEPA report

Sean, attached are my final comments I added a few more, shouldn't be a biggie. Other then the request for an Executive Summary the document looks good. Let me know if you have any questions. Also I am out of here after Today and not checking e-mail until Sunday so if you want it out before Monday I can pass my comments on to Janis and ask her to resolve them for me otherwise talk to you on Monday.

QA_DRC.doc (209 KB)

From: Dunagan, Sean
Sent: Tuesday, December 02, 2008 4:14 PM
To: Chavez, Mario Joseph
Subject: RE: NEPA report

Thanks. I will try to get you a copy of the CD tomorrow.

Sean Dunagan

From: Chavez, Mario Joseph
Sent: Tuesday, December 02, 2008 4:10 PM
To: Dunagan, Sean
Subject: RE: NEPA report

Sean,

Attached are a DRAFT of my comments, I need the CD and I still need to go over the AP to make sure we didn't miss or add anything. Main thing is I think you need an Executive summary to bottom line the report. I will finish my AP review and once I get the CD I should be able to finalize my comments shortly thereafter.

Thanks

Mario
<< File: QA_DRC.doc >>

From: Dunagan, Sean
Sent: Monday, December 01, 2008 1:04 PM
To: Chavez, Mario Joseph
Subject: RE: NEPA report

Thanks.

Sean Dunagan

From: Chavez, Mario Joseph
Sent: Monday, December 01, 2008 1:04 PM
To: Dunagan, Sean
Subject: RE: NEPA report

I'll have comments for you by COB Wednesday

From: Dunagan, Sean
Sent: Monday, December 01, 2008 12:43 PM
To: Chavez, Mario Joseph; Lee, Moo
Subject: NEPA report

If possible, could you estimate when you will have your reviews completed for this document? The DOE customer is asking. Thanks.

Sean Dunagan
Sandia National Laboratories
4100 National Parks Highway
Building NPHA/502
Carlsbad, NM 88220
Work: (575) 234-0127
Work (ABQ direct): (505) 845-0406
Fax: (575) 234-0061
Cell: (575) 302-1318

Attachment 3

WIPP Technical Analysis

Updated Impacts from Shipping TRU Waste from Small-Quantity Sites and Impacts from Using the TRUPACT-III

Technical Report

Final

U.S. Department of Energy
Carlsbad Field Office
Carlsbad, New Mexico

July 2006

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

AMWTF	Advanced Mixed Waste Treatment Facility
AMWTP	Advanced Mixed Waste Treatment Project
ANL	Argonne National Laboratory
BAPL	Bettis Atomic Power Laboratory, Pittsburgh, PA
BCL	Battelle Columbus Laboratories
BWXT	Babcock and Wilcox, Lynchburg, VA
CFR	Code of Federal Regulations
CH-TRU	contact-handled transuranic
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ETEC	Energy Technology Engineering Center
FEIS	final environmental impact statement
FEMA	Federal Emergency Management Agency
GE - VNC	General Electric - Vallecitos Nuclear Center
HEPA	high-efficiency particulate air
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
KAPL	Knolls Atomic Power Laboratory, Schenectady, NY
K-NFS	Knolls Atomic Power Laboratory, Nuclear Fuel Services, Erwin, TN
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LWB	Large Waste Box
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
MOU	Memorandum of Understanding
mrem	millirem
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
RH-TRU	remote-handled transuranic
ROD	Record of Decision
RWMC	Radioactive Waste Management Complex
SNL	Sandia National Laboratories
SPRU	Separations Process Research Unit
SRS	Savannah River Site
SWB	Standard Waste Box
TI	Transport Index
TRU	transuranic

List of Acronyms and Abbreviations (cont)

TRUPACT-II	Transuranic Package Transporter-II
TRUPACT-III	Transuranic Package Transporter-III
WIPP	Waste Isolation Pilot Plant
WIPP SEIS-II	WIPP Disposal Phase Supplemental Environmental Impact Statement
WM PEIS	Waste Management Programmatic Environmental Impact Statement
WVDP	West Valley Demonstration Project

WIPP Technical Analysis: Updated Impacts from Shipping TRU Waste from Small-Quantity Sites and Impacts from Using the TRUPACT-III

1.0 Introduction

The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, is the only facility licensed to dispose of transuranic (TRU) waste generated by U.S. Department of Energy (DOE) defense activities. TRU waste is retrievably stored at 27 DOE sites across the United States.

> ***TRU waste*** is waste that contains alpha particle-emitting radionuclides with atomic numbers greater than uranium (92) and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram of waste. TRU waste is categorized as either contact-handled (CH) or remote-handled (RH), based on the radiation level at the surface of the waste container.

In the *Waste Management Programmatic Environmental Impact Statement* (WM PEIS) (DOE 1997a), DOE analyzed the potential environmental impacts of the management (treatment and storage) of TRU waste at DOE sites. The *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* (63 Fed. Reg. 3629 (1998)) (TRU Waste ROD) (DOE 1998) documented DOE's decision that each DOE site that has generated or will generate TRU waste will prepare and store its TRU waste onsite, with one exception: that Sandia National Laboratories (SNL) will transfer its TRU waste to the Los Alamos National Laboratory (LANL). In the ROD, DOE also stated that in the future, it may decide to ship TRU waste from sites where it may be impractical to prepare them for disposal to sites where DOE has or will have the necessary capability. The sites designated in the ROD to receive such shipments of TRU waste were the Idaho National Engineering and Environmental Laboratory (INEEL) (now the Idaho National Laboratory[INL]), the Oak Ridge Reservation (ORR), the Savannah River Site (SRS), and the Hanford Site. Since the issuance of the TRU Waste ROD, DOE decided to ship TRU waste from three other sites—the Mound Plant, Battelle Columbus Laboratories (BCL), and the Energy Technology Engineering Center (ETEC)—to the Hanford Site or SRS.

In its final *Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (WIPP SEIS-II) (DOE 1997b), DOE analyzed the potential environmental impacts associated with disposing of TRU waste at WIPP. DOE's Proposed Action was to open WIPP and dispose of 175,600 cubic meters of post-1970 defense TRU waste. In addition, DOE analyzed several action alternatives, including an alternative that would dispose of a larger volume of TRU waste (336,000 cubic meters) than under the Proposed Action and that would consolidate waste from some DOE sites at ORR, SRS, and Hanford (Action Alternative 1).

Since the time the WIPP-SEIS-II was issued, many decommissioning activities have taken place at sites across the DOE complex. In addition, some of the TRU wastes at sites with small quantities of such wastes have been consolidated at sites having greater capabilities to characterize the waste. Perhaps the most significant result from the decommissioning activities has been the generation of newer estimates of the quantity and characteristics of TRU waste remaining at small-quantity sites. These decommissioning activities have also resulted in the identification of sites which were not thought to contain TRU wastes at the time the SEIS-II was prepared. This technical report provides an updated estimate of the quantities and characteristics of TRU wastes remaining at small-quantity sites and considers the impacts of transporting these wastes to INL for management (treatment and storage), and subsequent transport to WIPP for disposal. Only transportation by truck is considered in this analysis.

Another development that could not be assessed in the SEIS-II is the availability of shipping containers that are capable of carrying larger volumes of waste. One of these containers, the Transuranic Package Transporter-III (TRUPACT-III), is expected to be licensed by the U.S. Nuclear Regulatory Commission (NRC) in the near future. For this reason, this report assesses the impacts of using TRUPACT-III containers to ship large-volume waste containers of CH-TRU waste both to INL and directly to WIPP.

One of the waste management activities at INL for CH-TRU waste would be volume-reduction. During this activity, the waste from six 55-gallon drums would be compacted to fit into one 100-gallon drum. The resulting volume after compaction would be 30 percent of the pre-compaction volume. This report also assesses the impacts of shipping CH-TRU waste stored in large-volume boxes at LANL and at SRS directly to WIPP in the TRUPACT-III. There would be no volume-reduction of these wastes prior to shipment to WIPP.

For RH-TRU waste, only the waste from small-quantity sites is analyzed. These sites are Argonne National Laboratory (ANL) in Illinois; Bettis Atomic Power Laboratory (BAPL) in Pennsylvania; General Electric – Vallecitos Nuclear Center (GE-VNC) in California; Knolls Atomic Power Laboratory (KAPL) in New York State; and SNL in New Mexico. The RH-TRU waste from these sites is assumed to be transferred to INL for management prior to shipment to WIPP. No volume-reduction would take place at INL for RH-TRU waste. For all the sites except BAPL, the wastes are assumed to be shipped to INL in the 10-160B. Because of high radiation levels, the waste from BAPL would be shipped in the RH-72B. At INL, all the RH-TRU waste would be placed in a three-drum canister prior to shipment to WIPP in the RH-72B. At the present time, the RH-72B is the only authorized RH-TRU waste cask that can be received at WIPP.

This technical report considers the impacts of:

- Packaging and shipping CH-TRU and RH-TRU waste from small-quantity sites to INL.
- Packaging and shipping (1) large boxes from the Nevada Test Site (NTS) and Hanford to INL using the TRUPACT-III, and (2) 85-gallon overpacks from Hanford to INL using the HalfPACT (a half-capacity Transuranic Package Transporter-II [TRUPACT-II]).
- Packaging and shipping large boxes from SRS and LANL to WIPP using the TRUPACT-III.
- Packaging and shipping RH-TRU wastes from ANL, BAPL, GE-VNC, KAPL, and SNL to INL.
- Characterizing, treating, and repackaging CH-TRU wastes shipped to INL into 100-gallon drums, each containing the waste from six 55-gallon drums, for subsequent shipment to WIPP in the TRUPACT-II or HalfPACT. The TRUPACT-II is assumed to contain six 100-gallon drums; the HalfPACT is assumed to contain three 100-gallon drums. For shipments arriving at INL in the TRUPACT-III, a volume-reduction to 30 percent of the initial waste volume received is assumed, and the resulting compacted waste is assumed to be placed in 100-gallon drums. These drums would be loaded into the TRUPACT-II for shipment to WIPP.
- Because of weight restrictions, only two TRUPACT-IIs and one HalfPACT can be placed on a trailer for shipment to WIPP, instead of three TRUPACT-IIs per trailer used for shipments from the generator sites to INL. To simplify the analysis, it was conservatively assumed that for CH-TRU waste shipments from INL to WIPP, a shipment would consist of two TRUPACT-IIs or two HalfPACTs.

- For RH-TRU waste, repackaging activities at INL are assumed to consist of receiving the waste in the 10-160B, placing it in a three-drum canister, and shipping it to WIPP in the RH-72B. No volume-reduction would occur.

DOE is considering the extent to which these activities have already been addressed in the WM PEIS and/or WIPP SEIS-II or whether additional environmental documentation and analysis may be required under the National Environmental Policy Act (NEPA). This technical report was prepared pursuant to DOE's NEPA implementing regulations (Title 10 of the Code of Federal Regulations [CFR] §1021.314(c)) to determine whether these new activities represent a "substantial change to the proposed action," or if there are significant new circumstances or information relevant to the environmental concerns and bearing on the proposed activities and their impacts (see also 40 CFR §1502.9(c)). A supplement analysis will be prepared on the basis of this report if necessary.

1.1 Consolidation of TRU Waste From Small-Quantity Sites

The SEIS-II evaluated the impacts associated with the packaging, treatment, and disposal of TRU waste from 27 sites where it was retrievably stored. These 27 sites included 15 small-quantity sites with less than 700 cubic meters of TRU waste stored onsite.[1] The small-quantity sites analyzed in the SEIS-II are shown in Table 1, column 1. In the SEIS-II, DOE proposed to reduce overall risk by removing the TRU waste from small-quantity sites and by consolidating and characterizing such waste at four hub sites – large-quantity sites where large volumes of TRU waste are currently stored. While the hub locations varied by alternative, the Eastern U.S hub sites were SRS (CH-TRU waste only) and ORR (RH-TRU waste only). The Western U.S. hub sites were Hanford (for most Western small-quantity sites) and LANL (for the two small-quantity sites located in New Mexico). In the SEIS-II, TRU waste from the small-quantity sites would be managed (characterized, treated as needed, and stored) at the hub sites until it could be disposed of at WIPP. Since the SEIS-II was published, some consolidation activities have taken place but several new sites have been found to have TRU waste. The net effect is a reduction in the number of small-quantity sites from 15 to 10. These 10 sites are listed in Table 1, column 2. The SEIS-II considered several hub sites; in the current analysis, all the characterization and treatment would occur at DOE-operated facilities in Idaho.

In addition to the TRU waste at the 10 sites listed in Table 1, column 2, this analysis also considers (1) the treatment of Hanford and Lawrence Livermore National Laboratory (LLNL) CH-TRU waste at the Idaho facilities, and (2) the shipment of a significant quantity of CH-TRU waste from SRS and LANL directly to WIPP using the TRUPACT-III. The TRUPACT-III can handle a larger volume of waste—5.66 cubic meters—than the TRUPACT-II—3 to 4 cubic meters, depending on the configuration of the packaging. Because the TRUPACT-III is able to handle larger volumes of waste, its use would reduce the amount of size reduction that must take place and, in so doing, lessen worker exposure.

[1] In addition, DOE has decided to send TRU waste from three other sites to Hanford or SRS for storage prior to disposal at WIPP. These sites are BCL, ETEC, and the Mound Plant. For the Mound TRU waste, DOE issued a *Revision to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* on July 25, 2001 (66 Fed. Reg. 38646) (DOE 2001). For the BCL and ETEC TRU waste, DOE issued a *Revision to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* on September 6, 2002 (67 Fed Reg. 56989) (DOE 2002a).

Table 1. Comparison of Small-Quantity Sites Considered in SEIS-II and in This Report

Small-Quantity Sites Considered in SEIS-II	Small-Quantity Sites Considered in This Report
ARCO Medical Products Company	
Ames Laboratory – Iowa State University	
Argonne National Laboratory (ANL), IL	Argonne National Laboratory (ANL), IL
Argonne National Laboratory – West (now INL), ID	
	Babcock & Wilcox (BWXT), Lynchburg, VA
Battelle Columbus Laboratories (BCL)	
Bettis Atomic Power Laboratory (BAPL), PA	Bettis Atomic Power Laboratory (BAPL), PA
Energy Technology Engineering Center (ETEC)	
	General Electric – Vallecitos Nuclear Center (GE-VNC), CA
	Knolls Atomic Power Laboratory (KAPL), NY
	Knolls Atomic Power Laboratory – Nuclear Fuel Services (K-NFS), TN
Lawrence Berkeley National Laboratory (LBNL), CA	Lawrence Berkeley National Laboratory (LBNL), CA
Mound Plant, OH	
Nevada Test Site (NTS), NV	Nevada Test Site (NTS), NV
Paducah Gaseous Diffusion Plant, KY	
Sandia National Laboratories (SNL), NM	Sandia National Laboratories (SNL), NM
	Separations Process Research Unit (SPRU), NY
U.S. Army Material Command	
University of Missouri Research Reactor	
West Valley Demonstration Project (WVDP), NY	

1.2 Waste Destinations

Figure 1 shows the destinations of CH- and RH-TRU waste being considered in this analysis. For most of the sites, both the CH-TRU and RH-TRU waste would be sent to INL. The transportation analysis assumes that the CH-TRU waste would be sent to the Radioactive Waste Management Complex (RWMC) and that the RH-TRU waste would be sent to the Materials and Fuels Complex (MFC). There is some uncertainty as to whether the RH-TRU waste would be managed at the MFC or the Idaho Nuclear Technology and Engineering Center (INTEC), formerly called the Idaho Chem Plant. The transportation impacts would not be significantly different if the INTEC were used instead of the MFC. In addition, from a facility accident perspective, the accident consequences would not be significantly different.

The dotted line in Figure 1 from INL to WIPP shows that all the waste shipped to INL would eventually be shipped to WIPP. The dotted lines from LANL and SRS to WIPP represent the large volume of CH-TRU waste at these sites that would be shipped directly to WIPP. Only RH-TRU waste from small-quantity sites is being considered in this analysis. As shown in Figure 1, all RH-TRU waste would be sent to INL prior to shipment to WIPP.

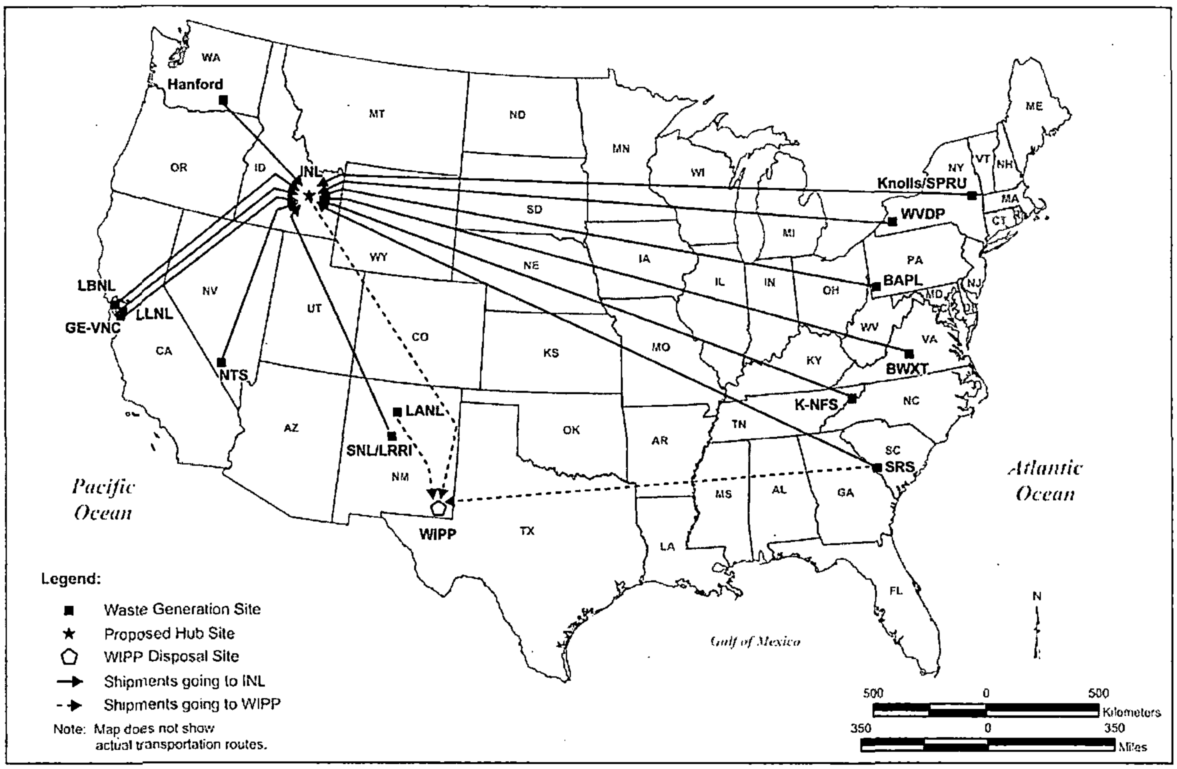


Figure 1. Approximate Locations of the Small-Quantity Sites and Sites Shipping Directly to WIPP

1.3 Waste Volumes

Table 2 shows the volumes of CH-TRU and RH-TRU waste at the various sites being considered in this analysis. The total volume of all TRU waste shipped as part of this assessment is approximately 17,200 cubic meters. The volume of RH-TRU waste shipped is approximately 100 cubic meters. The CH-TRU waste from LANL and SRS, a total of about 11,000 cubic meters, is assumed to go directly to WIPP. The remaining 6,200 cubic meters of CH- and RH-TRU waste would be transferred to INL for management (treatment and storage) before being sent to WIPP. At INL, CH-TRU waste management activities are assumed to reduce the volume of waste to 30 percent of the original volume received. Thus, the 6,100 cubic meters of CH-TRU waste received at INL would be reduced to about 1,860 cubic meters prior to shipment to WIPP. For the 100 cubic meters of RH-TRU waste received and managed at INL, no volume reduction is assumed to occur prior to shipping the waste to WIPP.

2.0 Transportation Regulations

The regulatory standards for packaging and transporting radioactive materials are designed to achieve four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation, by specific limitations on the allowable radiation levels;

Table 2. CH-TRU and RH-TRU Waste Volumes Considered in this Analysis

Small-Quantity Sites	TRU Waste Volume (cubic meters)	
	CH-TRU	**RH-TRU**
Argonne National Laboratory (ANL), IL		39.44
Bettis Atomic Power Laboratory (BAPL), PA	18.9	3.12
Babcock & Wilcox (BWXT), Lynchburg, VA	45.14	
General Electric – Vallecitos Nuclear Center (GE-VNC), CA	20.18	2.91
Hanford Reservation, WA	5345.97	
Knolls Atomic Power Laboratory (KAPL), NY		48.55
Knolls Atomic Power Laboratory – Nuclear Fuel Services (K-NFS), TN	170.1	
Los Alamos National Laboratory (LANL), NM	3479.2	
Lawrence Berkeley National Laboratory (LBNL), CA	0.208	
Lawrence Livermore National Laboratory (LLNL), CA	162.1	
Nevada Test Site (NTS), NV	291	
Sandia National Laboratories (SNL), NM	27.56	4.42
Separations Process Research Unit (SPRU), NY	50.13	
Savannah River Site (SRS), SC	7484.1	
Total for Small-Quantity Sites	632.2	98.44
Total for All Sites	17094.6	98.44

- Provide proper containment of the radioactive material in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria);

- Prevent nuclear criticality (an unplanned nuclear chain reaction that may occur as a result of concentrating too much fissile material in one place); and

- Provide physical protection against theft and sabotage during transit.

The U.S. Department of Transportation (DOT) regulates the transportation of hazardous materials in interstate commerce by land, by air, and on navigable water. As outlined in a 1979 Memorandum of Understanding (MOU) with the NRC, the DOT specifically regulates the carriers of radioactive materials and the conditions of transport such as routing, handling and storage, and vehicle and driver requirements. The DOT also regulates the labeling, classification, and marking of radioactive material packages.

The NRC regulates the packaging and transport of radioactive material for its licensees, which includes commercial shippers of radioactive materials. Under an agreement with the DOT, the NRC sets the standards for packages containing fissile materials and Type B packages. The NRC also establishes safeguards and security regulations to minimize the theft, diversion, or attack on certain shipments.

DOE, through its management directives, orders, and contractual agreements, ensures the protection of public health and safety by imposing standards on its transportation activities that are equivalent to those of the NRC and the DOE. DOE has the authority, granted by a 1973 MOU between the DOT and the Atomic Energy Commission, to certify DOE-owned packages. DOE may design, procure, and certify its own packages, for use by DOE and its contractors, if the packages provide for a level of safety that is equivalent to that provided in 10 CFR Part 71.

The DOT also has requirements that help reduce transportation impacts. For example, there are requirements for drivers, packaging, labeling, marking, and placarding. There are also requirements that specify the maximum dose rate associated with radioactive material shipments, which helps reduce incident-free transportation doses.

The Federal Emergency Management Agency (FEMA) is responsible for establishing policies for, and coordinating civil emergency management, planning, and interaction with, federal executive agencies that have emergency response functions in the event of a transportation incident. FEMA coordinates federal and state participation in developing emergency response plans and is responsible for the development of the interim Federal Radiological Emergency Response Plan. This plan is designed to coordinate federal support to state and local governments, upon request, during the event of a transportation incident.

Other agencies regulating the handling and transport of radioactive materials include the U.S. Postal Service, the Occupational Safety and Health Administration, and the U.S. Environmental Protection Agency.

Radioactive materials are transported in Excepted packages, Industrial packages, Type A packages, or Type B packages. The amount of radioactive material determines which package must be used. Excepted packages are used to transport materials with extremely low levels of radioactivity and must meet only general design requirements. Industrial packages are used to transport materials which present a limited hazard to the public and environment, such as contaminated equipment and radioactive waste solidified in materials such as concrete.

All the packages being used to transport CH-TRU and RH-TRU waste are Type B packages. Type B packages must be used whenever the concentration of TRU materials in the waste is greater than 100 nanocuries per gram. All the materials being considered in this analysis meet this criterion. Type B packages are designed to retain their radioactive contents under both normal and accident conditions. Under accident conditions, a Type B package must withstand:

- Free drop for 9 meters (30 feet) onto an unyielding surface in a way most likely to cause damage to the cask
- For some low-density, light-weight packages, a dynamic crush test consisting of dropping a 500-kilogram (1,100-pound) mass from 9 meters (30 feet) onto the package resting on an unyielding surface
- Free drop from 1 meter (40 inches) onto the end of a 15-centimeter (6-inch) diameter vertical steel bar
- Exposure for not less than 30 minutes to temperatures of 800 degrees Celsius (1,475 degrees Fahrenheit)
- For all packages, immersion in at least 15 meters (50 feet) of water for 8 hours
- For some packages, immersion in at least 0.9 meter (3 feet) of water for 8 hours in an orientation most likely to result in leakage
- For some packages, immersion in at least 200 meters (660 feet) of water for 1 hour.

Compliance with these requirements is demonstrated by using a combination of simple calculational methods, computer modeling techniques, or full-scale or scale-model testing of casks.

3.0 Transportation Routes

To assess incident-free and transportation accident impacts, route characteristics were determined for shipments from the sites listed in Table 1. For all the small-quantity sites, all CH-TRU and RH-TRU waste was assumed to travel to INL for management, then transported to WIPP for emplacement. Even though Hanford and LLNL are not classified as small-quantity sites, the CH-TRU waste from Hanford and LLNL are assumed to travel to INL before being shipped to WIPP. For SRS and LANL, the CH-TRU waste is assumed to travel directly to WIPP. Representative highway routes have been analyzed using the routing computer code WebTRAGIS (Johnson and Michelhaugh 2000). The routes have been selected to maximize travel on WIPP-approved routes (DOE 2006a). For travel to INL from the small-quantity sites in the northeastern part of the United States (BAPL in Pennsylvania; KAPL and the Separations Process Research Unit [SPRU] in New York State), rather than using the routes to WIPP, the selected routes hooked into the approved routes from BCL and Mound to INL. The alternative would have been to follow the approved southern routes west to WIPP, followed by travel north to INL along the INL-to-WIPP approved route. Similarly, for SRS and K-NFS shipments, the routes hooked into the Interstate-80 (I-80) corridor routes through northern Illinois, rather than going west to WIPP and then north to INL. Route characteristics include total shipment distance between each origin and destination and the fractions of travel in rural, suburban, and urban population density zones. Population densities were determined using data from the 2000 census. Table 3 shows the truck route distances and the population densities along the transportation routes.

The WebTRAGIS computer code predicts highway routes for transporting radioactive materials within the United States. The WebTRAGIS database is a computerized road atlas that currently describes approximately 386,000 kilometers (240,000 miles) of roads. Complete descriptions of the interstate highway system, U.S. highways, most of the principal state highways, and a number of local and community highways are identified in the database. The WebTRAGIS computer code selects routes based on a number of criteria, one of which maximizes the use of interstate highways. In addition, the user can block states, route segments, and/or nodes to force the selection of specific routes. This blocking feature was used to maximize travel on the WIPP-approved routes Although the selected routes may not be the actual routes used to ship the waste some time in the future, they are considered representative of the actual shipment routes that will be used. The code is updated periodically to reflect current road conditions, and it has been benchmarked against reported mileages and observations of commercial truck firms.

The WebTRAGIS computer code also is designed to simulate the routing of the U.S. rail system. Since only highway transportation is being considered in this analysis, the capability of selecting rail routes using the WebTRAGIS database was not used.

In analyzing the transportation routes to INL, there is some uncertainty regarding where the RH-TRU waste would be managed. Two possible facilities have been identified: either INTEC or the MFC. The transportation analysis assumed that the RH-TRU waste would be managed at the MFC because the route selected by WebTRAGIS to access INL for the MFC is considered bounding. For most of the facilities located at INL, WebTRAGIS selects Interstate 15 to access the region, then exits Interstate 15 at Blackfoot, about 25 miles south of Idaho Falls, and uses U.S. Highway 26 to access the site. When MFC is selected as the final destination, WebTRAGIS selects a longer route: Interstate 15 to the U.S. Highway 20 interchange near Idaho Falls. The code probably selects this route because a greater fraction of the travel is on interstate highways, even though it is longer and more of the route traverses more highly populated areas. By selecting the MFC as the destination for the RH-TRU waste shipments, the transportation impacts are bounded.

Table 3. Truck Route Distances and Population Densities

Origin	Waste Type	Distances (kilometers)			Population Densities (person per square kilometer)		
		Rural	Suburban	Urban	Rural	Suburban	Urban
Truck Routes to INL							
ANL	RH-TRU	2191.6	350.2	27.2	10.2	288.6	2252.1
BWXT	CH-TRU	3078.0	911.5	70.8	12.5	292.9	2227.2
BAPL	CH-TRU	2651.6	665.2	68.4	11.6	310.7	2260.9
	RH-TRU	2667.1	674.7	70.4	11.7	311.7	2259.1
GE	CH-TRU	1214.5	258.7	89.6	8.5	379.0	2574.3
	RH-TRU	1224.6	258.7	89.6	8.4	379.0	2574.3
Hanford	CH-TRU	737.8	103.8	16.5	7.4	346.0	2199.7
KAPL	RH-TRU	3088.8	1010.8	88.4	12.5	307.0	2245.6
K-NFS	CH-TRU	2741.5	755.7	52.4	12.2	298.1	2226.1
LBNL	CH-TRU	1197.2	248.7	87.8	8.5	383.4	2656.7
LLNL	CH-TRU	1209.6	254.3	83.6	8.4	374.7	2583.2
NTS	CH-TRU	1142.1	106.6	20.4	4.3	353.8	2354.0
SNL	CH-TRU	1569.5	276.7	48.7	7.7	358.2	2338.1
	RH-TRU	1585.0	286.2	50.7	7.8	358.9	2332.4
SPRU	CH-TRU	3073.3	1001.3	86.4	12.5	306.3	2246.8
Truck Routes to WIPP							
LANL	CH-TRU	552.1	32.8	1.9	5.9	244.3	1839.9
SRS	CH-TRU	1723.8	650.7	64.5	13.2	316.0	2170.7
INL	CH-TRU	1961.7	262.8	40.0	6.9	353.5	2320.5
	RH-TRU	1977.2	272.3	42.1	7.0	354.4	2314.4

4.0 Shipments

The number of shipments from a given site is a function of the waste characteristics as determined by the waste's configuration, volume, and quantity of the various isotopes present. The site-specific waste characteristics determine whether the waste is CH-TRU waste or RH-TRU waste. Once the waste type is specified, then the number of shipments depends on the waste container and shipping cask to be used for the wastes. These dependent relationships are developed in Tables 4 though 6. Table 4 shows the number of containers per cask for the various container and shipping cask configurations encountered at the sites being considered in this analysis.

Table 4. Waste Types, Casks, and Containers

Waste Type	Shipping Cask	Container[a]	Container Volume (cubic meters)	Number of Containers per Cask
CH-TRU	TRUPACT-II (3 per truck)	55-Gallon Drum	0.208	14
CH-TRU	TRUPACT-II (3 per truck)	SWB	1.90	2
CH-TRU	TRUPACT-II (2 per truck)	100-Gallon Drum	0.378	6
CH-TRU	HalfPACT (3 per truck)	85-Gallon Drum	0.321	4
CH-TRU	HalfPACT (2 per truck)	100-Gallon Drum	0.378	3
CH-TRU	TRUPACT-III	LWB	5.66	1
RH-TRU	10-160B	55-Gallon Drum	0.208	10
RH-TRU	10-160B	30-Gallon Drum	0.135	10
RH-TRU	RH-72B	55-Gallon Drum	0.208	3

a. SWB = Standard Waste Box; LWB = Large Waste Box.

Table 5 shows shipment configurations by generator site. Table 6 shows the number of shipments and shipment miles considered in this analysis. In calculating the number of shipments, no thermal or gas generation limits are assumed to apply so that the maximum number of containers could always be shipped. Sections 4.1 and 4.2 describe how the information in these tables was used to develop the number of shipments to INL, and then subsequently to WIPP, as well as the number of shipments from SRS and LANL directly to WIPP.[2]

4.1 CH-TRU Waste

Three container configurations are being considered for the TRUPACT-II: two Standard Waste Boxes (SWBs), each having a volume of 1.9 cubic meters; fourteen 55-gallon drums; or six 100-gallon drums. The 100-gallon-drum configuration would result from the volume-reduction activity at INL; each drum would contain the waste from six 55-gallon drums. As a result of compaction, the volume of CH-TRU waste shipped from INL to WIPP would be 30 percent of the original volume received at INL.

Previous analyses for radioactive material shipments did not consider using the TRUPACT-III shipping container. The container being considered for the TRUPACT-III is the Large Waste Box (LWB), which has a volume of 5.66 cubic meters. The CH-TRU waste arriving at INL in TRUPACT-IIIs is assumed to be volume-reduced. This compacted waste would be packaged in 100-gallon drums and would leave INL in TRUPACT-IIs.

[2] The shipment data specified in Table 6 were used to calculate the number of shipment kilometers shown in Table 3.

Table 5. Waste Shipment Configurations by Generator Site

Site	CH-TRU Waste			RH-TRU Waste		
	Cask	Container	Number of Containers	Cask	Container	Number of Containers
Argonne National Laboratory (ANL), IL				10-160B	30-Gallon Drum	349
Babcock & Wilcox (BWXT), Lynchburg, VA	TRUPACT-II	55-Gallon Drum	217			
Bettis Atomic Power Laboratory (BAPL), PA	TRUPACT-II	SWB	10	RH-72B	55-Gallon Drum	15
General Electric – Vallecitos Nuclear Center (GE-VNC), CA	TRUPACT-II	55-Gallon Drum	97	10-160B	55-Gallon Drum	14
Hanford Reservation, WA	HalfPACT	85-Gallon Drum	2885			
	TRUPACT-III	LWB	885			
Knolls Atomic Power Laboratory (KAPL), NY				10-160B	55-Gallon Drum	235
Knolls Atomic Power Laboratory – Nuclear Fuel Services (K-NFS), TN	TRUPACT-II	55-Gallon Drum	818			
Los Alamos National Laboratory (LANL), NM	HalfPACT	85-Gallon Drum	4812			
	TRUPACT-III	LWB	556			
Lawrence Berkeley National Laboratory (LBNL), CA	HalfPACT	55-Gallon Drum	1			
Lawrence Livermore National Laboratory (LLNL), CA	TRUPACT-III	LWB	31			
Nevada Test Site (NTS), NV[b]	TRUPACT-III	LWB	83			
Sandia National Laboratories (SNL), NM	TRUPACT-II	55-Gallon Drum	70	10-160B	55-Gallon Drum	13
	HalfPACT	85-Gallon Drum	1			
	TRUPACT-III	LWB	4			
Separations Process Research Unit (SPRU), NY	TRUPACT-II	55-Gallon Drum	241			
Savannah River Site (SRS), SC	TRUPACT-II	SWB	6			
	TRUPACT-III	LWB	1313			

Table 6. Number of Shipments and Shipment Miles to INL and WIPP for Sites Considered in this Analysis

Generator Sites	Number of Shipments to INL		Total Shipment Miles to INL		Number of Shipments from Generator Site or INL to WIPP		Total Shipment Miles from Generator Site or INL to WIPP	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Argonne National Laboratory (ANL), IL		35		89,916		117		268,115
Babcock & Wilcox (BWXT), Lynchburg, VA	6		24,361		4		9,058	0
Bettis Atomic Power Laboratory (BAPL), PA	2	5	6,770	17,061	2	5	4,529	11,458
General Electric – Vallecitos Nuclear Center (GE-VNC), CA	3	2	4,689	3,146	2	5	4,529	11,458
Hanford Reservation, WA	1126		966,269		420		951,088	
Knolls Atomic Power Laboratory (KAPL), NY		24		100,512		79		181,035
Knolls Atomic Power Laboratory – Nuclear Fuel Services (K-NFS), TN	20		70,993		12		27,174	
Los Alamos National Laboratory (LANL), NM					957		561,582	
Lawrence Berkeley National Laboratory (LBNL), CA	1		1,534		1		2,264	
Lawrence Livermore National Laboratory (LLNL), CA	39		60,352		11		24,909	
Nevada Test Site (NTS), NV	83		105,337		20		45,290	
Sandia National Laboratories (SNL), NM	7	4	13,264	7,688	3	8	6,793	18,333
Separations Process Research Unit (SPRU), NY	6		24,966		4		9,058	
Savannah River Site (SRS), SC					1314		3,204,834	
Total	1293	70	1,278,535	218,323	2750	214	4,851,109	490,398

The configuration of the containers sometimes imposes a limit on the number of containers that can be shipped. Thus, it can be seen from the information in Table 4 that only four 85-gallon drums or three 100-gallon drums can be shipped in a HalfPACT, rather than seven standard 55-gallon drums. Only six 100-gallon drums can be placed in a TRUPACT-II rather than the standard fourteen 55-gallon drums. CH-TRU waste arriving at INL in 85-gallon drums in the HalfPACT would be compacted; this waste would leave INL in 100-gallon drums. Shipments arriving in HalfPACTs are assumed to leave in HalfPACTs.

CH-TRU waste management activities at INL would optimize the number of shipments going to WIPP. Based on weight restrictions, the most common CH-TRU waste shipment configuration leaving INL for WIPP would be a trailer with two TRUPACT-II casks and one HalfPACT. To consistently use this shipment configuration would mean that some of the CH-TRU waste arriving at INL in either the TRUPACT-III or TRUPACT-II would be shipped from INL in the HalfPACT.

Rather than model this complex reconfiguration, it was conservatively assumed that (1) the shipping configuration from INL would be two TRUPACT-IIs or two HalfPACT casks per shipment, and (2) the shipments would not mix wastes from the various generator sites. It was further assumed that CH-TRU waste arriving in a HalfPACT would be shipped to WIPP in a HalfPACT. Clearly, these assumptions increase the number of shipments from INL to WIPP. However, by considering the waste from each generator site separately rather than mixing waste streams at INL, the estimated number of shipments from INL can be calculated more readily. Furthermore, by keeping site-specific radionuclide inventories separate, the analysis of transportation impacts, particularly severe accident impacts, becomes more straightforward.

For each generator site, all the curies or the radionuclides shipped to INL would be transferred to WIPP, with only the concentration of the radionuclides increasing as a result of compaction and with no mixing with the radionculides from the other generator sites. As a further simplification, the external dose rate expressed for the TRUPACT-II and HalfPACT is not anticipated to change as a result of compaction. While compaction would increase the concentration of the radionuclides by more than a factor of three, the density of the inert materials associated with the waste would increase by the same amount. It is assumed that the higher density of the inert materials would provide additional shielding to offset the effect of the higher radionuclide concentration. Thus, the Transport Index (TI), defined as the maximum radiation level in millirem (mrem) per hour (rounded to the nearest tenth) at 1 meter from the external surface of the package, would be unchanged following compaction and placement in 100-gallon drums.

4.2 RH-TRU Waste

As shown in Table 4, two shipment casks are being considered for RH-TRU waste. The 10-160B is the primary cask that would be used. RH-TRU waste from BAPL would be shipped in the RH-72B. All the RH-TRU waste arriving at INL in the 10-160B would be repackaged at INL. This operation would not involve any volume-reduction. The waste would be placed in canisters holding three 55-gallon drums. At the time of shipment to WIPP, the canisters would be placed in the RH-72B. Because the 10-160B can hold ten 55-gallon drums and the RH-72B can hold only three 55-gallon drums, RH-TRU waste management activities at INL would result in an increase in the number of shipments of RH-TRU waste leaving INL by a ratio of 10/3, or 3.33.

5.0 Incident-Free Transportation

Radiological dose during normal, incident-free transportation of radioactive materials results from exposure to the external radiation field that surrounds the shipping containers. The dose is a function of the number

of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers.

Radiological impacts were determined for crew workers and the general population during normal, incident-free transportation. For truck shipments, the crew are drivers of the shipment vehicles. Also considered are the crew exposures while in close proximity to the shipping containers during inspection. The general population consists of individuals within 800 meters (2,625 feet) of the road (off-link), sharing the road (on-link), and at stops. Collective doses for the crew and general population were calculated using the RADTRAN 5 computer code (Neuhauser et al. 2000).

Table 6 shows the number of shipments to WIPP to be higher than the number of shipments to INL for both CH-TRU and RH-TRU waste. The number of RH-TRU waste shipments would be higher because of the requirement to ship RH-TRU waste to WIPP in the RH-72B. For CH-TRU waste, the number of shipments shown in Table 6 is higher because there are 957 shipments from LANL and 1,314 shipments from SRS that go directly to WIPP. If these shipments are subtracted from the 2,750 shipments of CH-TRU waste arriving at WIPP, then the remainder, 479, represents the number of shipments from INL. Thus, waste management activities at INL would reduce the number of shipments to WIPP from 1,293 shipments to 479—37 percent of the number of CH-TRU waste shipments received at INL.

By mixing the CH-TRU waste streams coming into INL, it would probably be possible to further reduce the number of shipments to WIPP such that the ratio of CH-TRU waste shipments leaving INL to the number arriving at INL might be closer to the volume-reduction factor of 30 percent. Using a ratio above the 30-percent factor shows that the analysis is conservative.

5.1 Collective Dose Scenarios

Calculating collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information such as the shipment distances in various population density zones to determine the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors. Table 7 contains the unit risk factors for truck shipments.

Each waste type was assigned an external radiation dose rate representative of its constituents and shipping container. Using the RADTRAN 5 computer code, this yields the regulatory maximum dose rate at 2 meters (7 feet) from the vehicle, which is 10 mrem per hour. RH-TRU waste was assigned a dose rate of 10 mrem per hour at 1 meter, and CH-TRU waste was assigned a dose rate of 4 mrem per hour at 1 meter (DOE 1997a).

Incident-free nonradiological fatalities were also evaluated using unit risk factors. These fatalities would result from exhaust and fugitive dust emissions from highway traffic and are associated with 10-micrometer particles. The nonradiological unit risk factor for truck transport used in this analysis was 1.5×10^{-11} fatalities per kilometer per persons per square kilometer. These unit risk factors were estimated from data in Biwer and Butler (1999) and have been adjusted to account for more current diesel exhaust emission factors, a fleet average fugitive dust emission factor for roads, an age-adjusted mortality rate, and an average 10-micrometer particle risk factor. The distances used in the nonradiological analyses were doubled to reflect the round-trip distances, because these impacts could occur whether or not the shipments contain radioactive material.

Table 7. Unit Risk Factors for Incident-Free Truck Transportation

Receptor	Type of Zone	Truck Shipments
Public		
Off-link (rem per [persons per square kilometer] per kilometer)	Rural	2.89×10^{-8}
	Suburban	3.18×10^{-8}
	Urban	3.18×10^{-8}
On-link (person-rem per kilometer per vehicle per hour)	Rural	9.53×10^{-6}
	Suburban	2.75×10^{-5}
	Urban	9.88×10^{-5}
Residents near rest/refueling and walk-around stops (person-rem per [persons per square kilometer] per kilometer)	Rural	5.50×10^{-9}
	Suburban	5.50×10^{-9}
	Urban	5.50×10^{-9}
Public including workers at rest/refueling stops (person-rem per kilometer)	Rural	7.86×10^{-6}
	Suburban	7.86×10^{-6}
	Urban	7.86×10^{-6}
Workers		
Dose in moving vehicle (person-rem per kilometer)	Rural	4.52×10^{-5}
	Suburban	4.76×10^{-5}
	Urban	4.76×10^{-5}
Inspections at origin and destination (person-rem)	Suburban	0.018
Walk-around inspection (person-rem per kilometer)	Rural	1.93×10^{-5}
	Suburban	1.93×10^{-5}
	Urban	1.93×10^{-5}

5.2 Maximally Exposed Individual (MEI) Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1995). The maximum individual doses for routine transport offsite were estimated for transportation workers and for members of the public. For truck shipments, the three scenarios for members of the public were:

- A person caught in traffic and located 1 meter (3 feet) away from the surface of the shipping container for 30 minutes;
- A resident living 30 meters (98 feet) from the highway used to transport the shipping container; and
- A service station worker working at a distance of 20 meters (66 feet) from the shipping container for 1 hour. This worker was assumed to be exposed for 2,000 hours per year.

In general, the hypothetical maximally exposed individual (MEI) doses were accumulated for all shipments. However, for the scenario involving an individual caught in traffic next to a truck, the radiological exposures were calculated for only one event because it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the maximum exposed transportation worker is the driver who was assumed to drive shipments for up to 1,000 hours per year for 10 years. In the MEI scenarios, the exposure rate for the shipments depended on the type of waste being transported. Also, the maximum exposure rate for the truck driver was 2 mrem per hour (10 CFR Part 71.47(b)(4)).

6.0 Transportation Accidents

The offsite transportation accident analysis considers the impacts of accidents during the transportation of waste by truck. Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Transportation accident impacts have been assessed using accident analysis methodologies developed by the NRC. This section provides an overview of the methodologies; the reader can obtain a detailed description from the referenced reports.

Accidents that could potentially breach a shipping container are represented by a spectrum of accident severities and radioactive release conditions. Historically, most transportation accidents involving radioactive materials have resulted in little or no release of radioactive material from the shipping container. Consequently, the analysis of accident risks takes into account a spectrum of accidents ranging from high-probability accidents of low severity to hypothetical high-severity accidents that have a correspondingly low probability of occurrence. This accident analysis calculates the probabilities and consequences from this spectrum of accidents.

To provide DOE and the public with a reasonable assessment of radioactive waste transportation accident impacts, two types of analyses were performed. First, an accident risk assessment was performed that takes into account the probabilities and consequences of the spectrum of potential accident severities using NRC's methodologies (NRC 1977; Fischer et al. 1987; Sprung et al. 2000). For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 80 kilometers (50 miles) were multiplied by the accident probabilities to yield collective dose risk using the RADTRAN 5 computer code (Neuhauser et al. 2000). Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum credible severity in each population zone. An accident is considered credible if its probability of occurrence is greater than 1×10^{-7} per year (1 in 10 million per year). The accident consequence assessment for MEIs and population groups was performed using the RISKIND computer code (Yuan et al. 1995).

The impacts for specific alternatives were calculated in units of dose (rem or person-rem). Impacts are further expressed as health risks in terms of estimated latent cancer fatalities (LCFs) in exposed populations. The health risk conversion factors used were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991). The nonradiological impacts from transportation accidents (traffic fatalities) were also estimated.

6.1 Transportation Accident Rates

For calculating accident risks and consequences, state-specific accident rates were taken from data provided in Saricks and Tompkins (1999) for heavy combination trucks. For calculating the nonradiological impacts from transportation accidents, the same report provided state-specific fatality rates for heavy combination trucks.

6.2 Conditional Probabilities and Release Fractions

Accident severity categories for potential radioactive waste transportation accidents are described in three NRC reports: NUREG-0170 (NRC 1977) for radioactive waste in general; a report commonly referred to as the Modal Study (Fischer et al. 1987); and a reassessment of NUREG-0170 (Sprung et al. 2000). The latter two reports address only spent nuclear fuel. The Modal Study represents a refinement of the NUREG-0170 methodology, and the recent reassessment analysis, which compares more recent results to NUREG-0170, represents a further refinement of both studies. Even though CH-TRU and RH-TRU waste cannot be considered spent nuclear fuel, many of the modeling techniques developed in Fischer et al. (1987) and Sprung et al. (2000) can be applied to the modeling of severe accidents for these types of waste. Thus, this

section presents the results of analyses that extend the results presented by Sprung et al. to fuel types other than spent nuclear fuel.

Each of the risk analyses considers a spectrum of accidents of varying severity. Each first determines the conditional probability that the accident will be of a specified severity. Then, based on the accident environment associated with each severe accident, each models the behavior of the material being shipped and the response of the packaging. The models estimate the fraction of each species of radioactive material that might be released for each of the severe accidents being considered. Each of the NRC risk assessments has considered a different breakdown of the severe accident environment. The analyses presented in NUREG-0170 divides the accident environment into eight accident severity categories.

The probability for the severity category was estimated using the following formula:

$$P_{Sci} = \sum_{j} P_{Cj}$$

where:

> j represents the cases included in severity category i
> P_{Cj} is the case j probability
> P_{Sci} is the accident severity i probability

The probability weighting of the release fractions is calculated using the following formula:

$$RF_{Sci,m} = \frac{\sum_{j,m} RF_{Cj} * P_{Cj}}{P_{Sci}}$$

The "i" and "j" subscripts in the above equation are the same as those used for the probability calculation. The "m" subscript represents the various material classes. The abbreviation "RF" (release fraction) is the fraction of the material in the cask released for a given material type. The two equations above are general and have been used to reduce the accident severity categories in NUREG-0170 from eight to the six accident severity categories carried through this assessment. Use of these two equations reduces the level of detail carried into subsequent calculations without changing the overall risk estimate. Tables 8 through 10 show the six accident severity categories used to model the transportation accident risk for all the waste materials that may be shipped to INL and/or WIPP as part of this analysis. The release fractions and severities shown in Table 8 are those used in the SEIS-II for the TRUPACT-II (DOE 1997b).

Table 8. Conditional Probabilities and Release Fractions for CH-TRU Waste Truck Shipments Using the TRUPACT-II

Severity Category	Conditional Probability	Release Fraction
1	0.91	0
2	0.070	8.0×10^{-9}
3	0.016	2.0×10^{-7}
4	2.8×10^{-3}	8.0×10^{-5}
5	1.1×10^{-3}	2.0×10^{-4}
6	1.0×10^{-4}	2.0×10^{-4}

Table 9 shows the conditional probabilities and release fractions assumed for the TRUPACT-III. Since the license application for certification of the TRUPACT-III has not been filed, the conditional probabilities and release fractions have not been specified. However, since both the TRUPACT-II and TRUPACT-III use similar containers and must meet the same hypothetical accident text conditions, it is reasonable to assume that the conditional probabilities and release fractions are the same.

Table 9. Conditional Probabilities and Release Fractions for CH-TRU Waste Truck Shipments Using the TRUPACT-III

Severity Category	Conditional Probability	Release Fraction
1	0.91	0
2	0.070	8.0×10^{-9}
3	0.016	2.0×10^{-7}
4	2.8×10^{-3}	8.0×10^{-5}
5	1.1×10^{-3}	2.0×10^{-4}
6	1.0×10^{-4}	2.0×10^{-4}

The conditional probabilities and release fractions for the 10-160B containing RH-TRU waste are shown in Table 10. These release fractions were developed for the *West Valley Demonstration Project Waste Management Environmental Impact Statement* (DOE 2003).

Table 10. Conditional Probabilities and Release Fractions for RH-TRU Waste Truck Shipments Using the 10-160B

Severity Category	Conditional Probability	Release Fraction
1	0.99993	0
2	6.2×10^{-5}	2.6×10^{-5}
3	5.6×10^{-6}	2.4×10^{-5}
4	5.2×10^{-7}	2.6×10^{-5}
5	7.0×10^{-8}	6.2×10^{-5}
6	2.2×10^{-10}	6.7×10^{-5}

The RADTRAN 5 computer code was used to estimate accident unit risk factors (units of person-rem per kilometer per person per square kilometer) for each radionuclide in the various waste forms. A Microsoft Access® database was used to combine the unit risk factors with data on conditional probabilities, release fractions, accident rates, population densities, route distances, and radionuclide inventories to calculate the total accident dose risk. For each type of shipment category, the accident unit risk factors were first multiplied by the number of shipment kilometers through each population zone being traversed by the waste shipments, and then by the population density associated with that population zone. By summing over all population zones traversed by the waste form and then over all waste forms being considered, the total accident dose risk for all waste shipments from each site was obtained.

6.3 Shipment Inventories

The radionuclide inventories for the small-quantity sites being analyzed for shipment in this technical report are presented in Tables 11 and 12 for CH-TRU waste and RH-TRU waste, respectively.

Table 11. CH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)									
	BAPL and SPRU	K-NFS	LBNL	SNL	NTS	LLNL	Hanford	LANL	SRS	GE and BWXT
Ac-225	--	--	--	4.63×10^{-8}	2.49×10^{-6}	--	--	5.50×10^{-8}	1.25×10^{-13}	--
Ac-227	--	--	--	3.45×10^{-5}	1.84×10^{-7}	--	--	8.49×10^{-8}	1.59×10^{-11}	4.85×10^{-5}
Ac-228	--	--	--	1.52×10^{-4}	1.69×10^{-18}	--	--	6.29×10^{-11}	6.04×10^{-17}	--
Ag-109m	--	--	--	5.26×10^{-6}	--	--	--	--	--	--
Am-241	4.44×10^{-4}	4.61×10^{-1}	4.48×10^{-1}	3.77×10^{-1}	3.35×10^{-1}	1.06	1.66	3.80×10^{-1}	5.81×10^{-1}	3.601
Am-242	--	--	--	1.96×10^{-3}	--	--	--	--	--	--
Am-242m	--	--	--	1.99×10^{-3}	--	--	--	--	--	--
Am-243	2.08×10^{-6}	--	1.85×10^{-1}	5.76×10^{-4}	1.13×10^{-3}	--	--	2.51×10^{-7}	--	0.0385
At-217	--	--	--	4.63×10^{-8}	2.49×10^{-6}	--	--	5.51×10^{-8}	1.25×10^{-13}	--
Ba-137m	1.08	--	--	3.03	2.39×10^{-5}		1.81×10^{-2}	7.01×10^{-7}	--	--
Bi-210	--	--	--	4.59×10^{-4}	8.91×10^{-5}	--	--	4.94×10^{-10}	3.49×10^{-10}	--
Bi-211	--	--	--	3.41×10^{-5}	1.82×10^{-7}	--	--	8.40×10^{-8}	1.57×10^{-11}	--
Bi-212	--	--	--	3.55×10^{-4}	1.46×10^{-5}	--	--	1.13×10^{-10}	5.82×10^{-17}	5.00×10^{-3}
Bi-213	--	--	--	4.62×10^{-8}	2.48×10^{-6}	--	--	5.50×10^{-8}	1.25×10^{-13}	--
Bi-214	--	--	--	2.08×10^{-3}	2.27×10^{-4}	--	--	1.86×10^{-9}	1.84×10^{-9}	--
Bk-249	--	--		--	--	--	--	9.10×10^{-13}	--	--
C-14	2.79×10^{-5}	--	--	--	2.31×10^{-7}	--	6.17×10^{-5}	--	--	0.0150
Cd-109	--	--	--	5.32×10^{-6}	--	--	--	--	--	--
Ce-144	--	--	--	1.48×10^{-5}	--	--	--	--	--	5.00×10^{-4}
Cf-249	4.02×10^{-14}	--	--	--	1.04×10^{-5}	--	--	8.31×10^{-9}	--	--
Cf-250	--	--	--	--	1.28×10^{-4}	--	--	--	--	--
Cf-251	1.89×10^{-15}	--	--	--	--	--	--	--	--	--
Cf-252	--	--	--	--	7.55×10^{-5}	--	--	--	--	--
Cm-242	--	--	--	1.64×10^{-3}	--	--	--	--	--	2.80×10^{-3}
Cm-243	2.35×10^{-6}	--	--	1.65×10^{-2}	4.22×10^{-7}	--	--	--	--	1.00×10^{-4}
Cm-244	1.33×10^{-4}	--	5.72×10^{-1}	1.99×10^{-1}	2.08×10^{-3}	1.10		1.85×10^{-3}	--	2.65×10^{-3}
Cm-245	1.43×10^{-8}	--	--	--	1.38×10^{-8}	--	--	1.68×10^{-11}	--	--
Cm-246	2.44×10^{-9}	--	--	--	4.71×10^{-7}	--	--	--	--	--
Cm-247	5.58×10^{-15}	--	--	--	--	--	--	--	--	--
Cm-248	1.01×10^{-14}	--	--	--	3.76×10^{-8}	--	--	--	--	--
Co-60	4.89×10^{-2}	--	--	1.99×10^{-3}	--	--	--	5.43×10^{-12}	--	8.50×10^{-5}

Table 11. CH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)									
	BAPL and SPRU	K-NFS	LBNL	SNL	NTS	LLNL	Hanford	LANL	SRS	GE and BWXT
Cs-134	--	--	--	7.83×10^{-4}	--	--		1.50×10^{-14}	--	2.65×10^{-5}
Cs-137	1.13	--	--	3.24	2.55×10^{-5}	--	1.82×10^{-2}	7.49×10^{-7}	--	8.50×10^{-3}
Eu-152	4.89×10^{-2}	--	--	--	8.33×10^{-4}	--	--	4.55×10^{-12}	--	--
Eu-154	4.90×10^{-2}	--	--	5.39×10^{-3}	3.10×10^{-4}	--	--	1.99×10^{-11}	--	3.85×10^{-4}
Eu-155	--	--	--	7.50×10^{-5}	--	--	--	1.80×10^{-9}	--	--
Fe-55	--	--	--	--	--	--	--	--	--	0.0240
Fr-221	--	--	--	4.62×10^{-8}	2.48×10^{-6}	--	--	5.50×10^{-8}	1.25×10^{-13}	--
Fr-223	--	--	--	4.71×10^{-7}	2.51×10^{-9}	--	--	1.16×10^{-9}	2.17×10^{-13}	--
Gd-152	--	--	--	--	3.58×10^{-17}	--	--	2.75×10^{-25}	--	--
H-3	--	--	--	7.40×10^{-4}	4.70×10^{-5}	--	1.87×10^{-4}	1.43×10^{-2}	--	2.90×10^{-4}
I-129	3.66×10^{-7}	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	8.50×10^{-4}
Kr-85	--	--	--	1.31×10^{-2}	1.31×10^{-4}	--	--	--	--	--
Mn-54	--	--	--	--	--	--	--	--	--	2.40×10^{-5}
Ni-59	4.02×10^{-3}	--	--	--	--	--	--	--	--	--
Ni-63	1.96×10^{-1}	--	--	--	--	--	--	--	--	--
Np-237	2.97×10^{-6}	--	--	5.86×10^{-3}	5.87×10^{-6}	--	--	2.89×10^{-6}	3.22×10^{-6}	5.50×10^{-5}
Np-238	--	--	--	9.83×10^{-6}	--	--	--	--	--	--
Np-239	--	--	--	5.68×10^{-4}	1.11×10^{-3}	--	--	2.47×10^{-7}	--	--
Np-240m	--	--	--	--	9.31×10^{-10}	--	--	1.19×10^{-11}	--	--
Pa-231	--	--	--	2.34×10^{-4}	4.61×10^{-7}	--	--	6.33×10^{-11}	6.82×10^{-11}	--
Pa-233	--	--	--	5.81×10^{-3}	5.82×10^{-6}	--	--	2.86×10^{-6}	3.19×10^{-6}	--
Pa-234	--	--	--	4.82×10^{-7}	1.83×10^{-10}	--	--	1.62×10^{-8}	--	--
Pa-234m	--	--	--	3.71×10^{-4}	1.40×10^{-7}	--	--	1.25×10^{-5}	--	--
Pb-209	--	--	--	4.63×10^{-8}	2.48×10^{-6}	--	--	5.50×10^{-8}	1.25×10^{-13}	--
Pb-210	--	--	--	4.64×10^{-4}	9.01×10^{-5}	--	--	5.00×10^{-10}	3.54×10^{-10}	--
Pb-211	--	--	--	3.41×10^{-5}	1.82×10^{-7}	--	--	8.42×10^{-8}	1.57×10^{-11}	--
Pb-212	--	--	--	3.54×10^{-4}	1.45×10^{-5}	--	--	1.12×10^{-10}	5.81×10^{-17}	3.45×10^{-3}
Pb-214	--	--	--	2.09×10^{-3}	2.27×10^{-4}	--	--	1.87×10^{-9}	1.84×10^{-9}	--
Pm-147	4.89×10^{-2}	--	--	2.86×10^{-2}	--	--	--	--	--	--
Po-210	--	--	--	4.64×10^{-4}	9.01×10^{-5}	--	--	5.00×10^{-10}	3.53×10^{-10}	--

Table 11. CH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)									
	BAPL and SPRU	K-NFS	LBNL	SNL	NTS	LLNL	Hanford	LANL	SRS	GE and BWXT
Po-211	--	--	--	1.04×10^{-7}	5.54×10^{-10}	--	--	2.56×10^{-10}	4.79×10^{-14}	--
Po-212	--	--	--	2.26×10^{-4}	9.28×10^{-6}	--	--	$7.19 \times 10^{-}$	3.71×10^{-17}	--
Po-213	--	--	--	4.52×10^{-8}	2.43×10^{-6}	--	--	5.38×10^{-8}	1.22×10^{-13}	--
Po-214	--	--	--	2.09×10^{-3}	2.27×10^{-4}	--	--	1.87×10^{-9}	1.84×10^{-9}	--
Po-215	--	--	--	3.41×10^{-5}	1.82×10^{-7}	--	--	8.42×10^{-8}	1.57×10^{-11}	--
Po-216	--	--	--	3.53×10^{-4}	1.45×10^{-5}	--	--	1.12×10^{-10}	5.80×10^{-17}	--
Po-218	--	--	--	2.05×10^{-3}	2.23×10^{-4}	--	--	1.83×10^{-9}	1.81×10^{-9}	--
Pr-144	--	--	--	1.45×10^{-5}	--	--	--	--	--	--
Pu-236	--	--	--	--	--	--	--	--	--	1.30×10^{-4}
Pu-238	4.89×10^{-2}	7.82×10^{-2}	1.22×10^{-3}	7.18×10^{-2}	1.50×10^{-1}	2.28×10^{-1}	6.03	6.42	6.77×10^{1}	1.4450
Pu-239	3.82×10^{-5}	9.32×10^{-1}	--	1.91×10^{-1}	2.63	1.30	2.68	2.56×10^{-1}	1.32×10^{1}	1.0000
Pu-240	7.80×10^{-5}	3.14×10^{-1}	2.43×10^{-2}	2.08×10^{-2}	5.70×10^{-2}	5.84×10^{-1}	7.58×10^{-1}	2.04×10^{-2}	3.26×10^{-1}	8.00×10
Pu-241	8.34×10^{-3}	1.64	--	2.80×10^{-1}	1.23	1.79×10^{1}	5.38×10^{1}	1.53×10^{-1}	6.49	2.35×10^{1}
Pu-242	6.07×10^{-7}	2.42×10^{-6}	4.86×10^{-2}	3.19×10^{-9}	8.09×10^{-5}	--	2.07×10^{-4}	1.16×10^{-5}	--	5.00×10^{-3}
Pu-244	3.49×10^{-14}	--	--	--	9.21×10^{-10}	--	--	1.18×10^{-11}	--	--
Ra-223	--	--	--	3.45×10^{-5}	1.84×10^{-7}	--	--	8.50×10^{-8}	1.59×10^{-11}	--
Ra-224	--	--	--	3.53×10^{-4}	1.45×10^{-5}	--	--	1.12×10^{-10}	5.79×10^{-17}	--
Ra-225	--	--	--	4.63×10^{-8}	2.49×10^{-6}	--	--	5.51×10^{-8}	1.25×10^{-13}	--
Ra-226	--	--	--	2.11×10^{-3}	2.30×10^{-4}	--	--	1.89×10^{-9}	1.86×10^{-9}	4.85×10^{-3}
Ra-228	--	--	--	1.80×10^{-4}	2.00×10^{-18}	--	--	7.42×10^{-11}	7.13×10^{-17}	6.00×10^{-4}
Rh-106	--	--	--	4.48×10^{-6}	--	--	--	5.66×10^{-15}	--	--
Rn-219	--	--	--	3.41×10^{-5}	1.82×10^{-7}	--	--	8.40×10^{-8}	1.57×10^{-11}	--
Rn-220	--	--	--	3.53×10^{-4}	1.45×10^{-5}	--	--	1.12×10^{-10}	5.80×10^{-17}	--
Rn-222	--	--	--	2.09×10^{-3}	2.27×10^{-4}	--	--	1.87×10^{-9}	1.84×10^{-9}	--
Ru-106	--	--	--	4.53×10^{-6}	--	--	--	5.72×10^{-15}	--	2.50×10^{-4}
Sb-125	--	--	--	--	--	--	--	1.95×10^{-10}	--	--
Se-79	6.95×10^{-6}	--	--	--	--	--	--	--	--	--
Sm-147	--	--	--	1.92×10^{-12}	--	--	--	--	--	--
Sm-151	5.41×10^{-3}	--	--	1.14×10^{-2}	--	--	--	--	--	--
Sr-90	1.13	--	--	3.07	8.63×10^{-8}	--	6.86×10^{-3}	4.95×10^{-7}	--	0.0155
Tc-99	2.47×10^{-4}	1.47×10^{-4}	--	6.63×10^{-5}	--	--	3.75×10^{-8}	--	--	3.41×10^{-4}

Table 11. CH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)									
	BAPL and SPRU	K-NFS	LBNL	SNL	NTS	LLNL	Hanford	LANL	SRS	GE and BWXT
Te-125m	--	--	--	--	--	--	--	4.72×10^{-11}	--	--
Th-227	--	--	--	3.36×10^{-5}	1.79×10^{-7}	--	--	8.28×10^{-8}	1.55×10^{-11}	--
Th-228	--	9.86×10^{-7}	--	3.56×10^{-4}	1.47×10^{-5}	--	--	1.14×10^{-10}	5.87×10^{-17}	0.0110
Th-229	--	--	--	4.63×10^{-8}	2.49×10^{-6}	--	--	5.52×10^{-8}	1.25×10^{-13}	2.50×10^{-3}
Th-230	--	--	--	3.53×10^{-7}	1.09×10^{-9}	--	--	2.72×10^{-7}	4.69×10^{-7}	4.51×10^{-4}
Th-231	--	--	--	5.05×10^{-4}	1.36×10^{-7}	--	--	1.76×10^{-7}	2.62×10^{-7}	--
Th-232	2.97×10^{-15}	1.72×10^{-7}	--	1.64×10^{-4}	4.48×10^{-18}	--	2.47×10^{-6}	7.02×10^{-11}	1.18×10^{-16}	3.15×10^{-4}
Th-234	--	--	--	3.71×10^{-4}	1.41×10^{-7}	--	--	1.25×10^{-5}	--	--
Tl-207	--	--	--	3.39×10^{-5}	1.81×10^{-7}	--	--	8.37×10^{-8}	1.56×10^{-11}	--
Tl-208	--	--	--	1.27×10^{-4}	5.22×10^{-6}	--	--	4.05×10^{-11}	2.09×10^{-17}	--
Tl-209	--	--	--	1.02×10^{-9}	5.46×10^{-8}	--	--	1.21×10^{-9}	2.75×10^{-15}	--
U-232	7.05×10^{-7}	9.86×10^{-7}	--	--	1.43×10^{-5}	--	--	4.87×10^{-11}	--	0.0280
U-233	--	8.90×10^{-5}	2.31×10^{-2}	9.89×10^{-5}	1.66×10^{-3}	--	2.95×10^{-3}	2.04×10^{-5}	1.57×10^{-10}	0.0105
U-234	1.05×10^{-4}	6.25×10^{-6}	--	7.84×10^{-3}	1.05×10^{-5}	--	1.81×10^{-3}	1.05×10^{-3}	4.18×10^{-3}	0.0490
U-235	1.37×10^{-6}	2.98×10^{-7}	--	5.11×10^{-4}	1.37×10^{-7}	--	2.14×10^{-5}	1.78×10^{-7}	2.65×10^{-7}	2.05×10^{-5}
U-236	1.57×10^{-5}	--	--	3.09×10^{-9}	1.13×10^{-8}	--	8.96×10^{-10}	2.79×10^{-8}	1.97×10^{-7}	6.00×10^{-5}
U-237	--	--	--	6.87×10^{-6}	5.48×10^{-6}	--	--	3.77×10^{-6}	1.59×10^{-4}	--
U-238	6.32×10^{-9}	2.37×10^{-5}	--	3.75×10^{-4}	1.42×10^{-7}	--	2.23×10^{-4}	1.26×10^{-5}	--	1.00×10^{-4}
U-240	--	--	--	-	9.12×10^{-10}	--	--	1.17×10^{-11}	--	--
Y-90	1.13	--	--	3.03	8.54×10^{-8}	--	6.86×10^{-3}	4.89×10^{-7}	--	--
Zr-93	5.92×10^{-5}	--	--	--	--	--	--	--	--	--

Table 12. RH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)					
	Hanford	LANL	ANL	BAPL	KAPL	GE-VNS
Ac-225	--	5.1×10^{-17}	3.87×10^{-9}		6.84×10^{-12}	
Ac-227	--	1.99×10^{-10}	2.43×10^{-10}		3.47×10^{-10}	1.10×10^{-5}
Ac-228	--	8.62×10^{-19}	8.84×10^{-18}		2.47×10^{-13}	
Am-241	1.4	2.08×10^{-4}	0.0838	1.27	2.17×10^{-4}	0.7489
Am-243	--	--	2.64×10^{-7}	5.96×10^{-3}	3.77×10^{-7}	8.0×10^{-3}
At-217	--	5.1×10^{-17}	3.87×10^{-9}		6.84×10^{-12}	
Ba-137m	171	0.122	0.354	3100	0.515	
Bi-210	--	7.61×10^{-14}	5.79×10^{-13}		1.78×10^{-11}	
Bi-211	--	1.97×10^{-10}	2.4×10^{-10}		3.44×10^{-10}	
Bi-212	--	8.66×10^{-19}	8.88×10^{-18}		7.41×10^{-8}	1.04×10^{-3}
Bi-213	--	5.09×10^{-17}	3.86×10^{-9}		6.83×10^{-12}	
Bi-214	--	2.98×10^{-13}	3.2×10^{-12}		6.75×10^{-11}	
C-14	--	--		7.98×10^{-2}	1.32×10^{-5}	3.12×10^{-3}
Cd-113m	--	--	4.93×10^{-3}		--	
Ce-144	--	--	1.67×10^{-11}		--	1.04×10^{-4}
Cf-249	--	--		1.15×10^{-10}	2.85×10^{-14}	
Cf-251	--	--		5.40×10^{-12}	3.59×10^{-16}	
Cf-252	--	--			1.33×10^{-17}	
Cm-242	--	--	1.27×10^{-23}		--	5.83×10^{-4}
Cm-243	--	--		6.72×10^{-3}	1.07×10^{-7}	2.08×10^{-5}
Cm-244	--	--	1.55×10^{-3}	0.382	1.08×10^{-5}	5.50×10^{-4}
Cm-245	--	--		4.07×10^{-5}	3.48×10^{-9}	
Cm-246	--	--		6.96×10^{-6}	4.53×10^{-10}	
Cm-247	--	--		1.60×10^{-11}	1.07×10^{-15}	
Cm-248	--	--	--	2.88×10^{-11}	2.12×10^{-15}	--
Co-60	0.591	--	1.96×10^{-3}	140	--	1.77×10^{-5}
Cs-134	--	--	7.34×10^{-7}		--	5.52×10^{-6}
Cs-135	--	--	--		2.87×10^{-6}	--
Cs-137	186	0.131	0.379	3220	0.551	6.319
Eu-152	--	--	1.44×10^{-6}	140	--	

Table 12. RH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)					
	Hanford	LANL	ANL	BAPL	KAPL	GE-VNS
Eu-154	--	--	6.84×10^{-5}	140	--	8.02×10^{-5}
Eu-155	--	6.57×10^{-5}	8.53×10^{-5}		--	
Fe-55	--	--	1.26×10^{-3}		--	4.99×10^{-3}
Fr-221	--	5.09×10^{-17}	3.86×10^{-9}		6.83×10^{-12}	
Fr-223	--	2.72×10^{-12}	3.31×10^{-12}		4.74×10^{-12}	
H-3	--	--			--	6.03×10^{-5}
I-129	--	--		1.05×10^{-3}	2.62×10^{-7}	
K-40	--	--			--	1.77×10^{-4}
Kr-85	--	--	3.40×10^{-3}		--	
Mn-54	--	--	2.07×10^{-11}		--	4.99×10^{-6}
Nb-93m	--	--	7.64×10^{-6}		8.73×10^{-7}	
Ni-59	--	--		11.5	1.25×10^{-6}	
Ni-63	--	--		5.60×10^{2}	0.000135	
Np-237	--	1.31×10^{-9}	1.38×10^{-5}	8.47×10^{-3}	6.08×10^{-6}	1.14×10^{-5}
Np-239	--	--	2.6×10^{-7}		3.72×10^{-7}	
Np-240m	--	--			1.24×10^{-14}	
Pa-231	--	5.47×10^{-10}	7.38×10^{-10}		6.93×10^{-10}	
Pa-233	--	1.3×10^{-9}	1.37×10^{-5}		6.02×10^{-6}	
Pa-234	--	4.71×10^{-12}	6.52×10^{-10}		2.91×10^{-12}	
Pa-234m	--	3.62×10^{-9}	5.01×10^{-7}		2.24×10^{-9}	
Pb-209	--	5.1×10^{-17}	3.87×10^{-9}		6.84×10^{-12}	
Pb-210	--	7.7×10^{-14}	5.86×10^{-13}		1.8×10^{-11}	
Pb-211	--	1.97×10^{-10}	2.4×10^{-10}		3.44×10^{-10}	
Pb-212	--	8.63×10^{-19}	8.85×10^{-18}		7.39×10^{-8}	7.18×10^{-4}
Pb-214	--	2.98×10^{-13}	3.21×10^{-12}		6.76×10^{-11}	
Pd-107	--	--			1.2×10^{-7}	
Pm-147	--	--	2.52×10^{-4}	140	4.22×10^{-4}	
Po-210	--	7.7×10^{-14}	5.86×10^{-13}		1.44×10^{-11}	
Po-211	--	6×10^{-13}	7.32×10^{-13}		1.05×10^{-12}	
Po-212	--	5.52×10^{-19}	5.66×10^{-18}		4.72×10^{-8}	
Po-213	--	4.99×10^{-17}	3.78×10^{-9}		6.69×10^{-12}	

Table 12. RH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)					
	Hanford	LANL	ANL	BAPL	KAPL	GE-VNS
Po-214	--	2.98×10^{-13}	3.21×10^{-12}		6.76×10^{-11}	
Po-215	--	1.97×10^{-10}	2.4×10^{-10}		3.44×10^{-10}	
Po-216	--	8.62×10^{-19}	8.84×10^{-18}		7.38×10^{-8}	
Po-218	--	2.93×10^{-13}	3.16×10^{-12}		6.65×10^{-11}	
Pr-144	--	--	1.64×10^{-11}		--	
Pu-236	--	--			--	2.71×10^{-5}
Pu-238	0.358	1.11×10^{-4}	0.0764	140	0.0202	0.3016
Pu-239	0.581	0.0211	0.146	0.109	5.4×10^{-5}	0.2076
Pu-240	0.309	2.29×10^{-4}	0.0319	0.223	1.35×10^{-5}	0.1663
Pu-241	77.5	1.86×10^{-3}	0.248	23.8	0.00192	4.8853
Pu-242	1.01×10^{-4}	1.37×10^{-7}		1.74×10^{-3}	5.16×10^{-8}	1.04×10^{-3}
Pu-243	--	--			1.06×10^{-15}	
Pu-244	--	--		9.95×10^{-11}	1.23×10^{-14}	
Ra-223	--	1.99×10^{-10}	2.43×10^{-10}		3.48×10^{-10}	
Ra-224	--	8.61×10^{-19}	8.83×10^{-18}		7.37×10^{-8}	
Ra-225	--	5.1×10^{-17}	3.87×10^{-9}		6.84×10^{-12}	
Ra-226	--	3.02×10^{-13}	3.25×10^{-12}		6.84×10^{-11}	1.01×10^{-3}
Ra-228	--	1.02×10^{-18}	1.04×10^{-17}		2.92×10^{-13}	1.25×10^{-4}
Rh-106	--	1.09×10^{-12}	2.97×10^{-9}		--	
Rn-219	--	1.97×10^{-10}	2.4×10^{-10}		3.44×10^{-10}	
Rn-220	--	8.62×10^{-19}	8.85×10^{-18}		7.38×10^{-8}	
Rn-222	--	2.99×10^{-13}	3.21×10^{-12}		6.77×10^{-11}	
Ru-106	--	1.1×10^{-12}	3×10^{-9}		--	5.21×10^{-5}
Sb-125	--	4.57×10^{-6}	3.07×10^{-5}		--	
Sb-126	--	--	1.01×10^{-6}		3.35×10^{-7}	
Sb-126m	--	--	7.23×10^{-6}		2.39×10^{-6}	
Se-79	--	--		1.99×10^{-2}	7.36×10^{-7}	
Sm-147	--	--	7.74×10^{-12}		3.13×10^{-15}	
Sm-151	0.199	--	0.0166	15.5	8.25×10^{-3}	
Sn-121m	--	--			2.14×10^{-5}	
Sn-126	--	--	7.24×10^{-6}		2.4×10^{-6}	

Table 12. RH-TRU Waste Isotopic Inventory by Generator Site

Radionuclide	Radionuclide Concentration (curies per cubic meter)					
	Hanford	LANL	ANL	BAPL	KAPL	GE-VNS
Sr-90	124	0.128	0.214	3220	0.524	3.22×10^{-3}
Tc-99	4.43×10^{-6}		8.86×10^{-5}	0.704	0.000151	7.08×10^{-5}
Te-125m	--	1.11×10^{-6}	7.42×10^{-6}		--	
Th-227	--	1.94×10^{-10}	2.36×10^{-10}		3.39×10^{-10}	
Th-228	--	8.73×10^{-19}	8.95×10^{-18}		7.47×10^{-8}	2.29×10^{-3}
Th-229	--	5.11×10^{-17}	3.87×10^{-9}		6.85×10^{-12}	5.21×10^{-4}
Th-230	--	4.56×10^{-11}	8.2×10^{-10}		9.91×10^{-9}	9.36×10^{-5}
Th-231	--	8.25×10^{-7}	1.28×10^{-6}		5.08×10^{-7}	
Th-232	0.00576	1.28×10^{-18}	1.71×10^{-17}	8.47×10^{-12}	2.95×10^{-13}	6.56×10^{-5}
Th-234	1.93×10^{-3}	3.63×10^{-9}	5.02×10^{-7}		2.24×10^{-9}	
Tl-207	1.90×10^{-4}	1.96×10^{-10}	2.39×10^{-10}		3.42×10^{-10}	
Tl-208	1.39×10^{-7}	3.11×10^{-19}	3.19×10^{-18}		2.66×10^{-8}	
Tl-209	--	1.12×10^{-18}	8.5×10^{-11}		1.5×10^{-13}	
U-232	--	--		2.02×10^{-3}	2.44×10^{-7}	5.93×10^{-3}
U-233	5.76×10^{-3}	6.58×10^{-14}	1.53×10^{-6}		2.78×10^{-9}	2.19×10^{-3}
U-234	1.93×10^{-3}	1.69×10^{-7}	6.52×10^{-6}	0.298	3.44×10^{-5}	0.01019
U-235	1.90×10^{-4}	8.35×10^{-7}	1.3×10^{-6}	3.92×10^{-3}	5.14×10^{-7}	$4.27\ 10^{-6}$
U-236	1.39×10^{-7}	9.37×10^{-10}	2.56×10^{-8}	4.47×10^{-2}	4.88×10^{-6}	1.25×10^{-5}
U-237	--	4.58×10^{-8}	6.09×10^{-6}		4.71×10^{-8}	
U-238	1.82×10^{-5}	3.66×10^{-9}	5.07×10^{-7}	1.81×10^{-5}	2.26×10^{-9}	$2.08\ 10^{-5}$
U-240	--	--			1.21×10^{-14}	
Y-90	123	0.127	0.211	3220	0.518	
Zr-93	--	--	1.07×10^{-5}	0.169	1.85×10^{-5}	

The radionuclide inventories for CH-TRU waste were provided by DOE's Carlsbad Field Office to serve as the basis for this analysis. No estimates of the isotopic distribution were provided for the CH-TRU waste from the GE-VNC or the BWXT facilities. However, the Carlsbad data did provide an estimate for a maximally loaded drum at the West Valley Demonstration Project (WVDP) facility in western New York State. A preliminary assessment revealed that the WVDP inventory, which was stated to be the maximum inventory that might be present in a 55-gallon drum of RH-TRU or CH-TRU waste, could not be used as a basis for all shipments because the maximum inventory was far too conservative to enable it to be shipped. Discussions were held with personnel from WVDP, who stated that the isotope distribution was based on data sheets produced during the cleanout of the plutonium purification section of the WVDP facility. They further stated that, in reviewing other information also produced during the cleanout, dividing the isotopic distribution by a factor of 872 would provide a conservative upper bound for the isotopic concentrations in an average drum. Once that division was made, it was evident from the cesium-237 (Cs-137) and cobalt-60 (Co-60) concentrations that the waste would be classified as CH-TRU waste. These adjusted isotopic concentrations were used for the CH-TRU waste to be shipped from the GE-VNC or BWXT facilities. This was considered reasonable because the plutonium at these facilities might have come from WVDP or from the reprocessing of spent fuel similar to the spent fuel reprocessed at WVDP.

The isotopic distribution was not available for the GE-VNC RH-TRU waste. Once again, the isotopic distribution was developed from information provided by WVDP personnel. As was done for the CH-TRU waste, the first step was to reduce the isotope concentrations in the limiting drum by the same factor of 872. This was followed by one additional adjustment to make the waste stream RH-TRU. During the cleanout of the head end of the WVDP facility, it was observed that the Cs-237 concentration, expressed in curies, was about equal to the total concentration of all the americium and plutonium isotopes, also expressed in curies. Thus, the Cs-237 concentration was increased by this amount. Without such an increase, the waste could have been handled as CH-TRU waste.

In making the shipment checks on the RH-TRU waste to be shipped in the 10-160B, it was determined that the isotopic inventory given for the BAPL waste stream exceeded 20-curies of total plutonium and also exceeded 3000 A2s. If either of these limits are exceeded, the waste cannot be shipped in the 10-160B. Although the 20-curie limit is more restrictive, NRC recently removed this regulatory requirement for shipping wastes in Type B packages. Based on discussions with the holder of the 10-160B certificate of compliance, the 20-curie limit is in the process of being removed from the certificate. However, there are no plans to request a removal of the 3000 A2 limit from the certificate. In order to ship the RH-TRU waste from BAPL, it was necessary to assume that such waste would be shipped in the RH-72B instead of the 10-160B. Although the RH-72B can hold only three 55-gallon drums (as opposed to the ten held by the 10-160B), the RH-72B does not have the 3000 A2 restriction. Therefore, the RH-TRU waste at BAPL would be shipped in the RH-72B.

6.4 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Because neutral meteorological conditions are the most frequently occurring atmospheric stability conditions in the United States, these conditions are most likely to be present in the event of an accident involving a radioactive waste shipment. On the basis of observations from National Weather Service surface meteorological stations at 177 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 59 percent of the time, stable conditions (Pasquill Class E and F) occur 33 percent of the time, and unstable conditions (Pasquill Class A and B) occur 8 percent of the time (CRWMS M&O 1999).

For the accident consequence assessment, doses were assessed under stable (Class F with 0.89 meter [2.92 feet] per second windspeed) atmospheric conditions. Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. Class F meteorology in combination with windspeeds of 0.89 meter per second generally occur no more than 12 percent of the time. Results calculated for stable conditions represent a worst-case weather situation.

6.5 Population Density Zones

Three population density zones (rural, suburban, and urban) were used for the offsite population risk assessment. These zones respectively correspond to three mean population densities of 6, 719, and 3,861 persons per square kilometer. The actual population densities in the three zones were based on an aggregation of the 12 population density zones provided in the WebTRAGIS output and on data from the 2000 census.

6.6 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 80 kilometers (50 miles) of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (cloudshine) from the passing cloud, ingestion of contaminated crops, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground.

6.7 Health Risk Conversion Factors

The DOE Office of Environmental Policy and Guidance (DOE 2002b) recommends the use of 6×10^{-4} LCFs per person-rem from radiological exposures for both members of the public and occupational workers. In the SEIS-II, a smaller value of 5×10^{-4} was used for occupational workers, reflecting a difference in average age between a member of the general public and an occupational worker. Although LCFs are the predominant health risk associated with low-level radiation doses (that is, doses below the thresholds for acute effects), they are not the only potential detrimental health effect. Risks of other delayed health effects such as non-fatal cancers and hereditary effects should also be acknowledged. International Commission on Radiological Protection Publication 60 (ICRP 1991) has estimated that the total detrimental health effects per person-rem are 7.3×10^{-4} for members of the public and 5.6×10^{-4} for workers.

7.0 Human Health Impacts

7.1 Transportation Impacts

Table 13 lists the impacts of transporting CH-TRU waste from the small-quantity sites to INL, and then from INL and from SRS and LANL to WIPP. An estimated 0.013 fatalities would occur as a result of the shipments from the small-quantity sites to INL; an additional 0.006 fatalities would occur during subsequent shipment to WIPP. Thus, the total number of fatalities associated with transporting CH-TRU waste from small-quantity sites to INL and then to WIPP would be 0.02. The fatalities associated with shipping CH-TRU waste from the large-quantity sites to INL is estimated to be 0.053. The impacts from subsequently shipping these wastes to WIPP, including the CH-TRU waste shipped directly from SRS and LANL to WIPP, would be 0.233 fatalities. Thus, the total number of fatalities associated with all CH-TRU waste shipments is estimated to be 0.30.

Table 13. Transportation Impacts for CH-TRU Waste

Origin	Destination	Incident-Free Public (person-rem)	Incident-Free Worker (person-rem)	Radiological Accident Dose Risk (person-rem)	Incident-Free Public (LCFs)	Incident-Free Worker (LCFs)	Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
Small-Quantity Site Shipments to INL										
BWXT	RWMC at INL	0.568	0.907	1.34×10^{-2}	3.41×10^{-4}	5.44×10^{-4}	8.07×10^{-6}	8.34×10^{-5}	5.01×10^{-4}	1.48×10^{-3}
BAPL	RWMC at INL	0.157	0.262	3.72×10^{-3}	9.41×10^{-5}	1.57×10^{-4}	2.23×10^{-6}	2.35×10^{-5}	1.30×10^{-4}	4.07×10^{-4}
GE	RWMC at INL	0.135	0.185	3.37×10^{-3}	8.09×10^{-5}	1.11×10^{-4}	2.02×10^{-6}	3.05×10^{-5}	6.98×10^{-5}	2.94×10^{-4}
K-NFS	RWMC at INL	1.610	2.721	3.28×10^{-2}	9.66×10^{-4}	1.63×10^{-3}	1.97×10^{-5}	2.25×10^{-4}	1.47×10^{-3}	4.31×10^{-3}
LBNL	RWMC at INL	0.015	0.039	2.95×10^{-5}	8.84×10^{-6}	2.33×10^{-5}	1.77×10^{-8}	1.02×10^{-5}	2.29×10^{-5}	6.52×10^{-5}
NTS	RWMC at INL	0.692	2.803	0.0190	4.15×10^{-4}	1.68×10^{-3}	1.14×10^{-5}	2.26×10^{-4}	1.59×10^{-3}	3.92×10^{-3}
SNL	RWMC at INL	0.159	0.401	5.86×10^{-3}	9.55×10^{-5}	2.41×10^{-4}	3.51×10^{-6}	4.73×10^{-5}	2.78×10^{-4}	6.65×10^{-4}
SPRU	RWMC at INL	0.607	0.926	1.63×10^{-2}	3.64×10^{-4}	5.55×10^{-4}	9.79×10^{-6}	9.70×10^{-5}	5.08×10^{-4}	1.53×10^{-3}
Total		3.942	8.245	0.095	2.37×10^{-3}	4.95×10^{-3}	5.67×10^{-5}	7.43×10^{-4}	4.56×10^{-3}	0.0127
Small-Quantity Site Shipments from INL to WIPP										
SQS waste at INL	WIPP	1.542	3.706	0.0343	9.25×10^{-4}	2.22×10^{-3}	2.06×10^{-5}	2.99×10^{-4}	2.42×10^{-3}	5.89×10^{-3}
Total Fatalities - Small-Quantity Sites to INL and from INL to WIPP 0.019										
Large-Quantity Site Shipments to INL										
Hanford	RWMC at INL	9.716	36.732	0.1706	5.83×10^{-3}	2.20×10^{-2}	1.02×10^{-4}	2.63×10^{-3}	0.0195	0.0501
LLNL	RWMC at INL	0.567	1.523	0.0227	3.40×10^{-4}	9.14×10^{-4}	1.36×10^{-5}	3.76×10^{-4}	8.99×10^{-4}	0.0025
Total		10.284	38.254	0.1933	6.17×10^{-3}	0.0230	1.16×10^{-4}	3.00×10^{-3}	0.0204	0.0527
Large-Quantity Site Shipments from INL and Direct Shipments to WIPP										
LQS waste at INL	WIPP	13.56	32.34	0.248	8.14×10^{-3}	0.0194	1.49×10^{-4}	2.58×10^{-3}	0.0209	0.0511
LANL	WIPP	5.78	22.02	9.23×10^{-3}	3.47×10^{-3}	0.0132	5.54×10^{-6}	4.26×10^{-4}	0.0133	0.0304
SRS	WIPP	27.59	73.19	2.073	0.0166	0.0439	1.24×10^{-3}	0.0145	0.0759	0.1521
Total		46.94	127.55	2.331	0.0282	0.0765	1.40×10^{-3}	0.0175	0.1100	0.2336
Total Fatalities from Large-Quantity Site Shipments 0.286										
All Shipments		62.70	177.76	2.650	0.0376	0.1067	0.0016	0.0216	0.1374	0.3048
Total Fatalities Associated with all CH-TRU Waste Shipments: 0.30										

Acronyms: RWMC = Radioactive Waste Management Complex; SQS = small-quantity site; LQS = large-quantity site.

Table 14 shows that the impacts of transporting RH-TRU waste from the small-quantity sites to INL would be 0.015 fatalities; the impacts of transporting such waste from INL to WIPP would be 0.034 fatalities. Thus, the total number of fatalities associated with the transport of RH-TRU waste would be 0.05.

The above estimated impacts total 0.35 fatalities. Of that total, 0.07 fatalities are attributed to transporting RH-TRU waste (0.05 fatalities) and CH-TRU waste (0.02 fatalities) from small-quantity sites; 0.29 fatalities are attributed to transporting CH-TRU waste from large-quantity sites. Of the total estimated fatalities, over 80 percent of the impacts are associated with the transport of CH-TRU waste from large-quantity sites.

7.1.1 Incident-Free Radiation Doses to MEIs

Table 15 lists the incident-free radiation doses for the MEI scenarios. The maximally exposed worker would be a driver who would receive a radiation dose of about 20 rem based on driving a truck for 1,000 hours per year for 10 years. This is equivalent to a probability of an LCF of about 1.2×10^{-2}.

The maximally exposed member of the public would be a person working at a service station who would receive a radiation dose of about 0.31 rem over the entire shipping campaign. This is equivalent to a probability of an LCF of about 1.8×10^{-4}.

7.1.2 Impacts from Severe Transportation Accidents

In addition to analyzing the radiological and nonradiological risks of transporting CH- and RH-TRU waste, DOE assessed the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents. These severe accidents have a probability of occurrence of about 1×10^{-7} per year. The consequences of these accidents were determined through the inhalation, groundshine, resuspension, and immersion pathways.

The following assumptions were used to estimate the consequences of maximum reasonably foreseeable accidents:

- The release height of a plume is 10 meters (33 feet) for both fire- and impact-related accidents. Modeling the heat release rate of accident scenarios involving fire would result in lower consequences than modeling all events with a 10-meter release height.

- Breathing rate for individuals is assumed to be 10,400 cubic meters (13,600 cubic yards) per year (Neuhauser and Kanipe 2000).

- Short-term exposure to airborne contaminants is assumed to be 2 hours.

- Long-term exposure to contamination deposited on the ground is assumed to be 24 hours for the MEI and 7 days for the population, with no interdiction or cleanup.

- The consequences of severe accidents were estimated for urban areas and for the area near WIPP. For urban areas, the consequences for the maximum reasonably foreseeable accident were estimated using 2000 census population density data from 0 to 80 kilometers (50 miles) for the 20 most populous urbanized areas in the country. For the area around WIPP, the consequences for the maximum reasonably foreseeable accident were estimated using the population within 80 kilometers of WIPP, 100,944 people.

Table 14. Transportation Impacts for RH-TRU Waste

		Incident-Free			Incident-Free					
Origin	**Destination**	**Public (person-rem)**	**Worker (person-rem)**	**Radiological Accident Dose Risk (person-rem)**	**Public (LCFs)**	**Worker (LCFs)**	**Radiological Accident Risk (LCFs)**	**Pollution Health Effects**	**Traffic Fatalities**	**Total Fatalities**
Truck Shipments from Small-Quantity Sites										
ANL	MFC at INL	1.506	5.067	5.52×10^{-6}	9.03×10^{-4}	3.04×10^{-3}	3.31×10^{-9}	1.94×10^{-4}	1.90×10^{-3}	6.03×10^{-3}
BAPL	MFC at INL	0.331	0.921	1.48×10^{-3}	1.98×10^{-4}	5.53×10^{-4}	8.87×10^{-7}	6.01×10^{-5}	3.26×10^{-4}	1.14×10^{-3}
GE	MFC at INL	0.075	0.172	3.07×10^{-7}	4.51×10^{-5}	1.03×10^{-4}	1.84×10^{-10}	2.03×10^{-5}	4.67×10^{-5}	2.15×10^{-4}
KAPL	MFC at INL	2.043	5.295	9.99×10^{-6}	1.23×10^{-3}	3.18×10^{-3}	5.99×10^{-9}	3.94×10^{-4}	2.04×10^{-3}	6.84×10^{-3}
SNL	MFC at INL	0.148	0.460	7.93×10^{-7}	8.87×10^{-5}	2.76×10^{-4}	4.76×10^{-10}	2.80×10^{-5}	1.60×10^{-4}	5.52×10^{-4}
Total		4.103	11.915	1.50×10^{-3}	2.46×10^{-3}	7.15×10^{-3}	8.97×10^{-7}	6.97×10^{-4}	4.47×10^{-3}	0.0148
Small-Quantity Site Shipments from INL to WIPP										
SQS waste at INL	WIPP	8.592	28.221	0.0379	5.16E-03	0.0169	2.27×10^{-5}	1.33×10^{-3}	0.0104	0.0338
Total Fatalities associated with Small-Quantity-Site Shipments										
All Shipments		12.694	40.136	0.039	7.617×10^{-3}	0.0241	2.364×10^{-5}	2.03×10^{-3}	0.0149	0.0486
Total Fatalities associated with all RH-TRU Waste Shipments 0.049										

Acronyms: MFC = Materials and Fuels Complex; SQS = small-quantity site; LQS = large-quantity site.

Table 15. Incident-Free Radiation Doses for the MEI Scenarios

Scenario	Radiation Dose (rem)	LCFs
Service station worker (member of the public)	0.31	1.8E-4
Individual in traffic jam (member of the public)	1.2E-2	7.2E-6
Nearby resident (member of the public)	1.2E-3	7.1E-7
Driver (occupational)[a]	20	0.012

a. Driver exposed for 10 years.

- Impacts were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second [2.9 feet per second] and Class F stability). The atmospheric concentrations estimated from these conditions would be exceeded only 5 percent of the time.
- The release fractions used in the analysis were for severity category 6 accidents (see Table 8).
- The consequences of the accidents were estimated using the RISKIND computer code (Yuan et al. 1995).

The container inventories used in the analysis are listed in Table 16. The maximum reasonably foreseeable transportation accident with the highest consequences would involve CH-TRU waste in a LWB shipped from the SRS in a TRUPACT-III shipping container. This waste stream is limiting even after the factor of 3.3 increase in the concentration is considered for all the CH-TRU wastes compacted at INL. The MEI was estimated to receive a radiation dose of about 12 rem from this accident, which is equivalent to an LCF risk of 0.0071.

Table 16. Isotopic Inventory Used in Severe Accident Analysis[a]

Isotope	Total Curies
Am-241	3.29
Pu-238	383.3
Pu-239	74.9
Pu-240	1.84
Pu-241	36.7

a. SRS CH-TRU waste inventory in a LWB.

If the accident occurred in an urban area, the population was estimated to receive a collective radiation dose of about 3,100 person-rem. This is equivalent to about 1.8 LCFs.

If the accident occurred near WIPP, the population was estimated to receive a collective radiation dose of about 4.8 person-rem. This is equivalent to about 0.0029 LCFs.

For perspective, in the SEIS-II, a severe transportation accident involving CH-TRU waste was estimated to result in a radiation dose of 123 rem for the MEI and 31,800 person-rem for the population in an urban area within 80 kilometers of the accident. The probability of an LCF for the MEI was estimated to be 0.06. For the population, 16 LCFs were estimated to occur.

7.2 Facility Impacts

This section describes human health impacts to the public and workers associated with routine operations for treatment of CH-TRU and RH-TRU waste at INL. CH-TRU waste would be treated at the RWMC's

Advanced Mixed Waste Treatment Facility (AMWTF). RH-TRU waste would be treated at either the MFC or the INTEC. Minor impacts could occur during waste packaging and loading at generator sites.

7.2.1 Packaging and Loading Operations at Generator Sites

The routine operations that would occur at sites to prepare TRU waste for shipment to INL would be generally the same at every site. These pre-shipment operations would include reducing size and packaging, adding absorbents to eliminate free liquids, repackaging, and assaying and sampling to ensure that packaging and transportation certification criteria are met. Because the waste volumes and radionuclide content of the waste would be similar, the impacts of packaging and loading at these sites are expected to be similar to or less than the impacts at the generator-storage sites that were analyzed in the WM PEIS (DOE 1997a) or the WIPP SEIS-II (DOE 1997b).

At the smaller sites, existing facilities could be used for packaging, or mobile characterization and/or treatment units could be used, as was assumed in the WIPP SEIS-II. Any emissions from either would be filtered by high-efficiency particulate air (HEPA) filters. The treatment activities performed by the mobile units would be performed on such a small volume of waste that there would be virtually no additional waste, and virtually no radiological or hazardous chemical impacts to workers or the public would be expected (DOE 1997b, page 3-6).

Potential impacts at all sites are expected to be bounded by estimates of lifetime impacts from waste treatment under the Proposed Action in the WIPP SEIS-II. The Proposed Action included 168,000 cubic meters of CH-TRU waste and 7,080 cubic meters of RH-TRU waste. The WIPP SEIS-II estimates of impacts are shown in Table 17.

Table 17. Bounding Lifetime Radiological Impacts (LCFs) of Waste Loading at Any Generator Site[a]

Waste Type	Public MEI	Population	Noninvolved worker MEI
Radiological Impacts (LCF)[b]			
CH-TRU	2E-9	2E-4	3E-9
RH-TRU	6E-11	1E-6	3E-11
Hazardous Chemical (cancer incidence)			
CH-TRU	2E-12	1E-7	6E-12
RH-TRU	2E-11	4E-7	1E-10

a. Taken from the WIPP SEIS-II, pages 5-28 and 5-30 for the Proposed Action.
b. LCF = probability of a latent cancer fatality in an individual, and incidence of latent cancer fatality in a population.

Impacts to involved workers were estimated to be 0.8 radiation-related LCFs in the worker population, while no cancer incidence (2×10^{-5} cancers) would be expected form hazardous chemical exposure. No noncarcinogenic health impacts were predicted. These estimates are expected to bound impacts of waste packaging and loading at generator sites.

7.2.2 Unloading Operations at the INL Facilities

The routine waste unloading operations would occur at the RWMC for CH-TRU waste and at either the MFC or the INTEC for RH-TRU waste. These unloading operations to prepare waste for treatment are expected to have impacts bounded by those presented for loading operations at generator sites presented above.

7.2.3 Waste Treatment Operations at INL

Updated radionuclide inventory information for CH-TRU and RH-TRU waste is available as the basis for estimating the radiological impacts from treatment of this waste at INL. The radionuclide source term for estimating radiation dose to the public and noninvolved workers was determined using the same approach presented in the Advanced Mixed Waste Treatment Project (AMWTP) final environmental impact statement (FEIS) (DOE 1999) for East Zone 3 non-thermal pretreatment lines [page E.3-18]. Table E.3-4 of the AMWTP FEIS provides the radionuclide release fractions and filtration factors to estimate radionuclide emissions; for non-thermal pretreatment lines, these are 0.001 and 1×10^{-6}, respectively, for a total reduction factor of 1×10^{-9}. Atmospheric dispersion factors for the MEI and the noninvolved worker (at the RWMC) were also taken from the AMWTP FEIS, Table E.3-9. Values of 3.0E-7 and 2.0E-6 s/m^3, respectively, were used. No population-weighted atmospheric dispersion factor was given. Therefore, the population-weighted atmospheric dispersion factor was estimated using the ratio of the population dose to offsite MEI dose since the exposure pathways are identical and the dose is directly proportional to the air concentration. Values for population dose and MEI dose are provided for the Non-Thermal Treatment Alternative in Table E.4-2 of the AMWTP FEIS. This ratio is 0.00085 person-rem divided by 0.0031 mrem, or 0.271. NCRP Report No. 123 (NCRP 1996) atmospheric screening factors were used to calculate doses to the offsite MEI, the population, and the onsite noninvolved worker. Table 18 shows the radiation dose and radiological impacts of treating TRU waste at INL. The MEI and population were assumed to be exposed via all exposure pathways (inhalation, plume, external ground, foodstuffs, inadvertent soil ingestion), while the collocated worker was assumed to be exposed via inhalation, plume, and external ground exposure.

Table 18. Radiation Dose and Radiological Impacts of Treating TRU Waste at INL[a]

	Public MEI	**Population**	**Noninvolved Worker MEI**
	Radiation Dose		
Waste Type	Millirem	Person-rem	Millirem
CH-TRU	2.5×10^{-3}	6.8×10^{-4}	2.4×10^{-3}
RH-TRU	1.8×10^{-4}	4.8×10^{-5}	8.9×10^{-5}
Total Waste[b]	2.7×10^{-3}	7.3×10^{-4}	2.5×10^{-3}
	Radiological Impacts (LCF)[c]		
CH-TRU	1×10^{-9}	4×10^{-7}	1×10^{-9}
RH-TRU	1×10^{-10}	3×10^{-8}	5×10^{-11}
Total Waste[b]	1×10^{-9}	4×10^{-7}	1×10^{-9}

a. These impacts are for treating the entire small-quantity site waste inventory of approximately 632 cubic meters of CH-TRU waste and approximately 98 cubic meters of RH-TRU waste as well as treating the CH-TRU inventory shipped to INL from Hanford and LLNL. The latter inventory totals 5508 cubic meters so the total volume of CH-TRU treated at INL totals 6,140 cubic meters.
b. Assumes the same affected individuals and population for CH-TRU and RH-TRU waste.
c. LCF = probability of a latent cancer fatality in an individual, and incidence of latent cancer fatality in a population.

Impacts to the MEI involved worker of 1,500 mrem (probability of LCF = 9×10^{-4}) and to the average involved worker of 81 mrem (probably of LCF = 4.9×10^{-5}) presented in the AMWTP FEIS are conservatively representative of impacts expected for treatment of this waste.

No updated hazardous chemical inventory information is available. Based upon a comparison of the impacts in Table 18 to the radiological impacts presented in the AMWTP FEIS, the impacts from exposure to hazardous chemicals are bounded by hazardous chemical impacts in the AMWTP FEIS.

Contribution of the CH-TRU and RH-TRU waste from different sites to the radiological impacts at INL are shown in Table 19.

Table 19. Generator Site Waste Contribution to Radiological Impacts of Waste Treatment at INL

Site	CH-TRU Waste Contribution		Site	RH-TRU Waste Contribution
Hanford	87.5%		BAPL	94.5%
ANL	9.1%		SNL	1.7%
NTS	1.3%		GE-VNC	3.9%
LLNL	0.9%		SRS	1.8%
BWXT	0.5%		ANL	1.1%
KAPL – NFS	0.4%		KAPL	0.2%
SNL	0.08%			
SPRU	0.04%			
GE – VNC	0.03%			
BAPL	0.01%			
LBNL	0.0003%			

7.2.4 INL Facility Accidents

Impacts of facility accidents described in the AMWTP FEIS (DOE 1999) are representative or conservative estimates of impacts that could occur from CH-TRU and RH-TRU waste that could be shipped from other sites. Because small-quantity site waste would not be thermally treated, only non-thermal events are applicable, eliminating postulated AMWTF accidents involving incineration, microencapsulation, and vitrification. The evaluations of these accident events included quantities of TRU radionuclides that are conservative or representative of TRU concentrations in small-quantity site CH-TRU and RH-TRU waste that could be shipped to INL for treatment. Because concentrations of TRU radionuclides are typically less in RH-TRU waste than CH-TRU waste, these accidents are likely overestimates of RH-TRU accidents. In addition, RH-TRU waste would probably be treated at the MFC or the INTEC. A DOE supplement analysis (DOE 2006b) determined that the impacts of treating waste at the INTEC would not be significantly different from the analysis of waste treatment in the AMWTP FEIS. Table 20 shows applicable accidents and their consequences from the AMWTP FEIS. Waste loading or unloading accidents are adequately represented by the "Dropped waste box outdoors during transfer" event in Table 20.

7.2.5 TRUPACT-III Unloading Accident at WIPP

DOE evaluated the potential impacts that could occur as a result of accidents during the unloading of the TRUPACT-III container at WIPP. The accident involved CH-TRU waste in a LWB from SRS. The radionuclide inventory for the LWB is listed in Table 16. This LWB was assumed to be dropped during unloading in the Waste Handling Building.

Table 20. Accidents and Consequences Involving CH-TRU or RH-TRU Waste Treatment at INL

Accident Description	Locations (evaluation guidelines in parenthesis): 100 meters (100 rem)	EBR-I[a]	Hwy 20/26 rest stop[a]	Nearest INL boundary (25 rem)	Population (estimated LCFs)
Fire involving waste in the box line	1.25 E-4	5.14 E-1	1.70 E-1	2.20 E-1	0.05
Fire involving waste in the drum line	2.01 E-5	8.28 E-2	2.74 E-2	3.54 E-2	0.11
Loss of all AC power	8.74 E-2	3.08 E-3	1.31 E-3	1.59 E-3	0.02
Dropped waste box outdoors during transfer	5.69 E-1	2.01 E-2	8.53 E-3	1.04 E-2	0.001
Fire in TRU waste in the TSA-RE	2.07 E-2	5.83 E+0	2.91 E+0	3.53 E+0	0.005
Wind-borne missile breach of facility	4.77 E-2	2.30 E-4	7.39 E-5	9.60 E-5	0.12
Fire involving waste transfer vehicle	1.15 E-2	3.3 E+0	1.61 E+0	1.91 E+0	0.00005
Design basis seismic event	2.62 E+0	9.31 E-2	3.95 E-2	4.82 E-2	0.98
Type II module fire	1.27 E-2	3.64 E+0	1.78 E+0	2.23 E+0	0.05
Propane-fueled fires[b]	2.62 E+0	3.64 E+0	1.78 E+0	2.23 E+0	1.14

a. Evaluation guidelines do not exist for these locations. The doses are compared with the evaluation guide for the nearest INL site boundary (25 rem).
b. Accidents for Type II module file and design basis seismic event bound the propane-fueled fires.
Source: AMWTP FEIS (DOE 1999), Table 5.14-6.

The following assumptions were used to estimate the consequences of the drop accident:

- The release height of the plume was 10 meters (33 feet).
- The damage ratio was 0.025, the airborne release fraction was 0.001, and the respirable fraction was 0.1 (DOE 2005). The leakpath factor was 0.0003, based on the presence of HEPA filters with an efficiency of 99.97 percent. The total fraction of material released from the LWB was 7.5E-10 (0.025 × 0.001 × 0.1 × (1-0.9997).
- The breathing rate for individuals was assumed to be 10,400 cubic meters (13,600 cubic yards) per year (Neuhauser and Kanipe 2000).
- Short-term exposure to airborne contaminants is assumed to be 2 hours.
- Long-term exposure to contamination deposited on the ground is assumed to be 24 hours for the MEI and 7 days for the population, with no interdiction or cleanup.
- The consequences of the accident were estimated using the population within 80 kilometers of WIPP, 100,944 people.
- Impacts were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second [2.9 feet per second] and Class F stability). The atmospheric concentrations estimated from these conditions would be exceeded only 5 percent of the time.

- The consequences of the accidents were estimated using the RISKIND computer code (Yuan et al. 1995).

The MEI was estimated to receive a radiation dose of about 4.4E-5 rem from this accident, which is equivalent to an LCF risk of 2.7E-8.

The population around WIPP was estimated to receive a collective radiation dose of about 1.8E-5 person-rem from this accident. This is equivalent to about 1.1E-8 LCFs.

8.0 Summary and Conclusions

The WIPP SEIS-II considered the impacts arising from the transportation of CH-TRU and RH-TRU waste from 27 different waste generator sites, 15 of which were classified as small-quantity sites because they had less than 700 cubic meters of waste. The SEIS-II, in addition to evaluating the transportation impacts for transporting waste from the large generator sites, also considered several alternatives that transported waste from the small-quantity sites to larger sites where the waste could be managed (treated as needed and stored) until it could be transported to WIPP for disposal. Since the time the SEIS-II was published, some of the planned consolidation activities have taken place. For example, the BCL TRU waste has been transferred, some to Hanford and some to SRS. Other wastes have been moved to ANL and Hanford. Some of the small-quantity sites still have wastes onsite. Furthermore, as a result of decommissioning activities at other sites, TRU waste has been identified, so new small-quantity sites have been added to the list. The net result is a reduction in the number of small-quantity sites from 15 to 10. The total volume waste at these sites is about 730 cubic meters, of which 630 cubic meters is CH-TRU waste and 100 cubic meters is RH-TRU waste. Since about 17,200 cubic meters of waste was considered in this analysis (approximately 17,100 cubic meters of CH-TRU waste and 100 cubic meters of RH-TRU waste), most of the impacts are associated with transport from the large generator sites. For this reason, the impacts from the small-quantity sites have been analyzed separately and then combined with the rest of the waste stream to obtain the total impacts.

Table 21 summarizes the impacts associated with transporting CH-TRU and RH-TRU waste from the small-quantity sites to INL for management, followed by shipment to WIPP for underground disposal. The data show that although the impacts are small, making an intermediate stop at INL about doubles the impacts.

Table 21. Transportation Impacts Associated with Small-Quantity Sites

Shipments	Incident-Free: Public (LCFs)	Incident-Free: Worker (LCFs)	Radiological Accident Risk (LCFs)	Pollution Health Effects	Traffic Fatalities	Total Fatalities
CH-TRU Shipments to INL	6.17×10^{-3}	0.0230	1.160×10^{-4}	3.003×10^{-3}	0.0204	0.0527
CH-TRU Shipments to WIPP	9.25×10^{-4}	2.22×10^{-3}	2.058×10^{-5}	2.990×10^{-4}	2.42×10^{-3}	5.89×10^{-3}
RH-TRU Shipments to INL	2.46×10^{-3}	7.15×10^{-3}	8.973×10^{-7}	6.967×10^{-4}	4.47×10^{-3}	0.0148
RH-TRU Shipments INL to WIPP	5.16×10^{-3}	0.0169	2.274×10^{-5}	1.334×10^{-3}	0.0104	0.0338
Total	0.0147	0.0493	1.602×10^{-4}	5.333×10^{-3}	0.0377	0.1072

Table 22 compares the range of transportation impacts shown in Table E-28 of the WIPP-SEIS-II for the small-quantity sites with the impacts developed in this analysis. A range is shown for the SEIS-II because the impacts varied based on the alternative considered. In every instance but one, the impacts developed in

this analysis are within the range of impacts in the SEIS-II. The one exception is the Incident Free – Public LCF. Because this impact is the smallest when compared with the other impact measures, the cumulative impacts presented in this analysis for the small-quantity sites are clearly bounded by the range of impacts presented in Table E-28 of the SEIS-II.

Table 22. Comparison of Impacts for Small-Quantity Sites, SEIS-II and Current Analysis

Impact Measure	Range of Impacts Shown in SEIS-II[a]	Impacts Shown in This Analysis
Incident Free – Public LCFs	1.1×10^{-3} to 6.9×10^{-3}	1.5×10^{-2}
Incident Free – Occupational LCFs	0.03 to 0.2	0.05
Pollution Health Effects	3.0×10^{-3} to 0.02	0.0016
Traffic Fatalities	0.03 to 0.2	0.04

a. Total impacts were not calculated in Table E-28 of SEIS-II.

Given all the changes that have taken place between the time the SEIS-II was published and the present, the relative closeness of the results is somewhat unexpected. Not only have many of the estimates of the quantity and distribution of TRU wastes changed, many of the coefficients used in the analysis have changed as well. While similar techniques were used in both analyses, several updates to the risk factors have been made between the time SEIS-II was published and the present. One is the use of a new dose conversion factor for the radiological exposure to occupational workers. The new factor is 6×10^{-4} LCFs per person-rem. In the SEIS-II, a lower occupational dose conversion factor, 5×10^{-4} LCFs per person-rem, was used to take credit for the higher average age of the occupational worker when compared to the general public. Under the current guidance, no distinction is made between the general public and an occupational worker.

The current mileage and population density estimates for people along the route use a newer version of the routing code and use census data from the year 2000 instead of 1990. The truck accident rates and the pollution health effects from vehicle emissions have been updated as well. Thus, even if the same number of shipments had been used in both the SEIS-II analysis and this analysis, the two analyses might have predicted different impacts because of the cumulative effects of these changes.

A comparison of the inventory used in the severe transportation accident analysis shows that the total curies of Pu-238 in the SEIS-II analysis was 990 curies (Table E-15 of the SEIS-II), and the analysis of the LWB from SRS used in this report was 383 curies. Thus, the impacts shown here are smaller than those presented in the SEIS-II.

In the SEIS-II, a severe transportation accident involving CH-TRU waste was estimated to result in a radiation dose of 123 rem for the MEI and 31,800 person-rem for the population within 80 kilometers of the accident. The probability of an LCF for the MEI was estimated to be 0.06. For the population, 16 LCFs were estimated to occur. In this analysis, a severe transportation accident was estimated to result in a radiation dose of 12 rem for the MEI and 3,100 person-rem for a population in an urban area, or 4.8 person-rem if the accident occurred near WIPP. This is equivalent to an LCF risk of 0.0071 for the MEI and 1.8 LCFs for a population in an urban area, or 0.0029 LCFs if the accident occurred near WIPP.

Waste loading and unloading accidents at INL were considered to be adequately represented by the "Dropped waste box outdoors during transfer" event in the AMWTP FEIS. The consequences of that accident were well under the evaluation guidelines and the LCF to the population in the vicinity of the site was estimated to be 0.001. The consequences of the TRUPACT-III unloading accident at WIPP was found to be very small, less than 10^{-7} LCFs to the MEI and the general public in the vicinity of the site.

As a general conclusion, where comparisons can be made, the impacts shown in this report for the small-quantity sites are smaller than the impacts shown in the SEIS-II. The impacts are larger only after the transportation impacts from the large-quantity sites are added to the small-quantity site impacts.

9.0 References

Biwer, B.M., and J.P. Butler, 1999. "Vehicle Emission Unit Risk Factors for Transportation Risk Assessments." *Risk Analysis,* 19(6):1157-1171.

Cashwell et al. (J.W. Cashwell, K.S. Neuhauser, P.C. Reardon, and G.W. McNair), 1986. *Transportation Impacts of the Commercial Radioactive Waste Management Program.* Albuquerque, NM: Sandia National Laboratories; Report No. SAND85-2715.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1999. *Environmental Baseline File for National Transportation.* Las Vegas, Nevada: CRWMS M&O; Report No. B00000000-01717-5705-00116 REV 01.

DOE (U.S. Department of Energy), 1997a. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (Volumes 1 through 5), DOE/EIS-0200-F, Washington, DC, May.

DOE (U.S. Department of Energy), 1997b. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement.* DOE/EIS-0026-S-2, Washington, DC, September.

DOE (U.S. Department of Energy), 1998. *Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste* (TRU Waste ROD). 63 Fed. Reg. 3629. January 23, 1998.

DOE (U.S. Department of Energy), 1999. *Advanced Mixed Waste Treatment Project Final Environmental Impact Statement.* DOE/EIS-0290. U.S. Department of Energy, DOE Idaho Operations Office, Idaho Falls, ID

DOE (U.S. Department of Energy), 2001. *Revision to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste.* 66 Fed. Reg. 38646. July 25, 2001.

DOE (U.S. Department of Energy), 2002a. *Revision to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste.* 67 Fed. Reg. 56989. September 6, 2002.

DOE (U.S. Department of Energy), 2002b. *Radiation Risk Estimation from Total Effective Dose Equivalents.* Washington, DC, U.S. Department of Energy, Memorandum from A. Lawrence, Office of Environmental Policy and Guidance, August 9.

DOE (U.S. Department of Energy), 2003. *West Valley Demonstration Project Waste Management Environmental Impact Statement*, final, DOE/EIS-0337F, prepared by U.S. Department of Energy, West Valley Area Office, West Valley, New York, December 2003.

DOE (U.S. Department of Energy), 2005. *Waste Isolation Pilot Plant Contact Handled (CH) Waste Documented Safety Analysis*, DOE/WIPP-95-2065, Revision 9, September.

DOE (U.S. Department of Energy), 2006a. *WIPP Transuranic Waste Transportation Routes,* U.S. Department of Energy, Carlsbad Field Office, Carlsbad, NM, June 2006, online at http://www.wipp.energy.gov/routes.htm.

DOE (U.S. Department of Energy), 2006b. *Supplement Analysis Regarding Remote-Handled Transuranic Waste Identified in the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement and the Advanced Mixed Waste Treatment Project Final Environmental Impact Statement.* DOE/EIS-0203-F-SA-03, DOE/EIS-0290-SA-01. DOE Idaho Operations Office, Idaho Falls, ID.

Fischer et al. (L.E. Fischer, C.K. Chou, M.A. Gerhard, C.Y. Kimura, R.W. Martin, R.W. Mensing, M. E. Mount, and M.C. Witte), 1987. *Shipping Container Response to Severe Highway and Railway Accident Conditions.* Washington, DC: U.S. Nuclear Regulatory Commission; Report No. NUREG/CR-4829.

ICRP (International Commission on Radiological Protection), 1991. *1990 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 60. Elmsford, NY: Pergamon Press, Annals of the ICRP; 21(1-3).

Johnson, P.E., and R.D. Michelhaugh, 2000. *Transportation Routing Analysis Geographic Information System (WebTRAGIS) User's Manual.* Oak Ridge, TN: Oak Ridge National Laboratory; Report No. ORNL/TM-2000/86.

NCRP (National Council on Radiation Protection and Measurements), 1996. *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground.* NCRP Report No. 123. National Council on Radiation Protection and Measurements. Bethesda, MD.

Neuhauser, K.S., and F.L. Kanipe, 2000. *RADTRAN 5, User Guide.* Albuquerque, NM: Sandia National Laboratories; Report No. SAND2000-1257.

Neuhauser et al. (K.S. Neuhauser, F.L. Kanipe, and R.F. Weiner), 2000. *RADTRAN 5 Technical Manual.* Albuquerque, NM: Sandia National Laboratories; Report No. SAND2000-1256.

NRC (U.S. Nuclear Regulatory Commission), 1977. *Final Environmental Impact Statement on the Transportation of Radioactive Materials By Air and Other Modes.* Washington, DC: U.S. Nuclear Regulatory Commission; Report No. NUREG-0170.

Saricks, C.L., and M.M. Tompkins, 1999. *State-Level Accident Rates of Surface Freight Transportation: A Reexamination.* Argonne, Illinois: Argonne National Laboratory; Report No. ANL/ESD/TM-150.

Sprung et al. (J.L. Sprung, D.J. Ammerman, N.L. Breivik, R.J. Dukart, F.L. Kanipe, J.A. Koski, G.S. Mills, K.S. Neuhauser, H.D. Radloff, R.F. Weiner, and H.R. Yoshimura), 2000. *Reexamination of Spent Fuel Shipment Risk Estimates.* Washington, DC: U.S. Nuclear Regulatory Commission; Report No. NUREG/CR-6672.

Yuan et al. (Y.C. Yuan, S.Y. Chen, B. Biwer, and D.J. LePoire), 1995. RISKIND- A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel, Argonne National Laboratory; Report No. ANL/EAD-1, Argonne, IL.