Appendix H

Traffic and Transportation

This section evaluates the radiological and non-radiological impacts of onsite shipments of LLW, MLLW (including melters), TRU waste, and ILAW to treatment and disposal facilities, offsite shipments of MLLW from Hanford to offsite treatment facilities and back, and the shipment of construction and capping materials. This appendix also presents the impacts of shipments of LLW and MLLW from offsite generators to Hanford treatment and disposal facilities and shipments of TRU waste from Hanford to the Waste Isolation Pilot Plant (WIPP) for disposal. The impacts of shipments of LLW, MLLW, and TRU from offsite generators to Hanford and from Hanford to WIPP are presented for the States of Washington and Oregon. The impacts of shipments of LLW, MLLW, and TRU from offsite generators to Hanford were calculated for the States of Washington and Oregon using methods and data that are consistent with the *Waste Management Programmatic Environmental Impact Statement* (WM-PEIS, DOE 1997a). Estimated impacts of transporting TRU waste to WIPP are scaled from information presented in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997b).

Estimates in the environmental impact statement (EIS) of radiological and non-radiological impacts of transporting various types of waste are presented in the following sections. This analysis addresses radiological hazards of waste transported under routine and accident conditions, and chemical hazards of waste transportation accidents, as well as physical hazards (that is, fatalities) projected to occur from traffic accidents involving waste shipments. Health effects from routine vehicular emissions are also quantified. The physical (or non-radiological) hazards and the impacts of routine vehicular emissions are independent of the cargo being transported. Total integrated radiological and non-radiological impacts are calculated. Note that all of the methods used in this appendix to calculate transportation impacts are commonly used in U.S. Department of Energy (DOE) environmental documents. Potential impacts of sabotage or acts of terrorism are also addressed. Finally, the transportation impacts associated with the *Final Waste Management Programmatic Environmental Impact Statement* (WM PEIS, DOE 1997a) are compared to the transportation impacts in this EIS.

H.1 Description of Methods

The methods used in this EIS to calculate the impacts of transporting waste, construction, and capping materials are described in the following section. Section H.1.1 describes the RADTRAN 4 computer code that was used to calculate the radiological routine (or incident-free) doses and accident risks to the public and transport crews associated with the alternatives examined in the EIS. The method used to calculate physical (non-radiological) routine risks is described in Section H.1.2. The method used to calculate non-radiological accident risks is described in Section H.1.3; the method used to calculate the impacts of accidental releases of hazardous chemicals is described in Section H.1.4.

H.1.1 Radiological Impact Analysis Methodology

RADTRAN 4 (Neuhauser and Kanipe 1992) was used to estimate collective impacts to populations from routine transportation of radioactive material and collective population risks from accidents during transport. RADTRAN 4 is organized into eight models:

- material model
- transportation model
- population distribution models
- material models: isotopic compositions and properties
- accident severity and package behavior models
- meteorological dispersion model
- health-effects model
- economic model.

The code uses these models to calculate the potential population dose from normal (routine or incident-free) transportation and to calculate the risk to the population from user-defined accident scenarios.

Collective Population Doses from Routine (Incident-Free) Transport. The RADTRAN 4 incident-free models calculate doses to people on or near the transportation routes from low-level external radiation emitted from the loaded shipping containers. RADTRAN 4 calculates incident-free doses to the following population groups:

- **Persons along the route (referred to as *off-link population*)**. RADTRAN 4 calculates population doses to all persons living or working within 0.8 km (0.5 mi) on each side of a transportation route.

- **Persons sharing the route (*on-link population*)**. Collective doses are calculated for persons in vehicles sharing the transportation route, traveling in the same or in opposite directions.

- **Persons at stops**. RADTRAN 4 calculates collective doses to persons who may be exposed to a shipment while it is at a stop. For truck shipments to/from offsite locations, stops may be made for refueling, food, or rest. For onsite truck shipments, stop times are set to zero because of the short transport distances.

- **Crew members**. Incident-free doses to truck crew members are calculated.

The total collective population doses are the sum of the doses to the off-link population, on-link population, and persons at stops. Worker doses include the doses to truck crewmembers. Note the population doses resulting from onsite shipments are doses to Hanford Site workers that may be adjacent to or nearby a truck shipment of radioactive waste. Onsite shipments of radioactive waste would not expose a member of the public to any significant radioactive dose rate because Hanford Site access restrictions prevent the shipment from approaching locations where a member of the public could be. One exception would be shipments from the 300 Area or 400 Area to the 200 Areas treatment and disposal facilities. The highway from the 300 Area and 400 Area to the Wye Barricade is publicly accessible, and a member of the public (that is, a non-Hanford worker) could conceivably be on the highway at the time a waste shipment is being transported. However, many shipments of radioactive materials from the 300 Area and 400 Area to the 200 East and 200 West Areas are currently conducted during off-shift hours (for example, nights and weekends) and often require closure of the road between the 300 or 400 Area and the Wye Barricade. Consequently, except for this small potential dose to a non-Hanford worker member of the public, the doses to the public referred to in this appendix from onsite shipments are actually doses to Hanford workers who may be driving to/from or at their work locations as a waste shipment passes by. Doses to the public who are non-Hanford workers are associated with shipments of MLLW to offsite treatment facilities and back, offsite shipments of TRU waste to WIPP, and LLW, MLLW, and TRU shipments from offsite generators through Washington and Oregon to Hanford.

Incident-free doses calculated by RADTRAN 4 are generally based on extrapolating the dose rate emitted from the package as a function of distance from a point source. The public and worker doses are dependent upon parameters, such as population density, shipping distance, exposure distance, exposure duration, stop times, traffic density, and the Transportation Index (TI) of the package or packages. The TI is defined as the highest package dose rate (mrem per hour) that would be received by an individual located at a distance of 1 m (3.3 ft) from the external surface of the package. The values used for this and other parameters are presented in Table H.1.

RADTRAN 4 calculations are performed for each origin/destination pair. Onsite population densities and shipping distances are based on Hanford map distances and occupancies in buildings along the routes. The HIGHWAY computer code (Johnson et al. 1993) was used to determine the population densities and shipping distances in Washington and Oregon for shipments from offsite generators to Hanford.

The shipment origins, destinations, shipping distances, and number of shipments to be transported onsite in the Alternatives are presented later in this Appendix. The capacities of the various onsite shipment types are shown below:

- LLW Category 1 and non-conforming LLW – 7.5 m^3/shipment; Category 3 – 3.4 m^3/shipment

- CH MLLW – 3.4 m^3/shipment RH MLLW – 0.6 m^3/shipment; WTP melters – 175 m^3/shipment (one melter/shipment); elemental lead and mercury – 0.5 m^3/shipment

- TRU Drums – 3.4 m^3/shipment; TRU boxes – 5.7 m^3/shipment

- ILAW – 1 ILAW canister/shipment – 2.6 m^3/shipment.

Radioactive Waste Shipping Regulations and Packaging

The two key federal government agencies responsible for ensuring the safety of transporting radioactive materials are the U.S. Department of Transportation (DOT) and U.S. Nuclear Regulatory Commission (NRC). DOT regulations for the safe transportation of radioactive materials are found in Title 49 of the Code of Federal Regulations (49 CFR). NRC regulations are found in 10 CFR 71. These regulations establish a comprehensive set of requirements that assure appropriate packaging (or shipping container) commensurate with the hazard presented by the shipment is used, vehicle (tractor-trailer, railcar) safety and reliability routes are selected to minimize risk where appropriate, drivers are appropriately trained and accredited, and shipments are manifested and placarded in accordance with the level of hazard.

The most important element of ensuring safety is the packaging or shipping containers used to transport the waste materials. Federal regulations, which DOE must comply with for offsite shipments, establish two types of packagings that will be used for offsite transport of waste materials; Type A and Type B. The levels of radioactivity and the specific radionuclides contained in the wastes determine whether a shipment can be transported in a Type A or Type B package. In general, low hazard (i.e., low radioactive content) shipments are transported in Type A packages and high hazard (high radioactive content) shipments must be transported in Type B containers. Type A packages would be used for most LLW and MLLW shipments. These waste types are characterized by relatively low radiation levels and radionuclide concentrations. Type A packages are required to withstand a series of tests referred to as normal conditions of transport without functional failure. Type A packaging tests include a water spray test, drop test, stacking test, and penetration test. Examples of Type A containers used for transporting LLW and MLLW include 210-L (55-gal.) steel drums, steel boxes, and various sizes of concrete and steel shielded cylindrical containers. Type B packages, on the other hand, are used for radioactive materials that have relatively high radionuclide concentrations and/or relatively high concentrations of transuranic radionuclides, such as plutonium and americium. TRU waste and ILAW canisters would be shipped in Type B packages. Type B packages must withstand a series of hypothetical accident conditions that are designed to simulate severe accidents (including impact, puncture, thermal, and water immersion environments) in addition to the normal conditions of transport. Examples of Type B packages include the massive spent nuclear fuel shipping casks and the TRUPACT container being used to transport TRU wastes to WIPP. Properly designed, manufactured, tested, and maintained packaging systems are the backbone of DOE's transportation safety program.

Table H.1. General RADTRAN 4 Parameters for Onsite Waste Shipments[(a)]

Parameter	Value
Transport Index (dose rate at 1 m from shipping container, mrem/hr)[(b)]	
LLW and MLLW	1
CH TRU Waste	3
RH TRU Waste	7
Leachate in 5000-gal tanker truck	0.08[(c)]
ILAW	14[(d)]
Number of Truck Crew	2
Average Vehicular Speed (km/hr)	
Rural	88
Suburban	40
Urban	24
Stop Time (hr/km)	NA (No stops for onsite shipments)
Number of People Exposed While Stopped	
Average Exposure Distance at Stops	
Number of People per Vehicle Sharing Route	2
Population Densities (persons/km^2)	Route-specific
One-Way Traffic Count (vehicles/hr)	
Rural	470
Suburban	780
Urban	2800

(a) Source of the parameter values is Neuhauser and Kanipe (1992), except where indicated otherwise.
(b) Source: WM PEIS (DOE 1997a).
(c) Based on preliminary shielding calculations performed using the MICROSHIELD™ Computer Code, Version 5.0 (Grove Engineering 1996).
(d) Based on regulatory maximum external dose rate of 10 mrem/hr at 2 m from the shipping container.

Population density information for onsite shipments was obtained from the Spent Nuclear Fuel Programmatic EIS (DOE 1995). For shipments from unspecified locations to the 200 West Area, it was assumed that the origin of the shipment is the 300 Area, the onsite waste generators farthest from the 200 West Area. These shipments were assumed to travel a one-way distance of 40 km (25 mi) through a region defined by three population densities: 1.6 km (1 mi) through a region defined by the 300 Area population density (660 persons/km^2 or 1700 persons/mi^2); 6.4 km (4 mi) through a region defined by the 200 West Area population density (120 persons/km^2 or 300 persons/mi^2); and 32 km (20 mi) through a region with the 600 Area population density (0.14 persons/km^2 or 0.35 persons/mi^2). This analysis is conservative because most of the onsite personnel will be in buildings located on one side of the road or the other, although the code assumes a uniform population density on both sides of the road. Also, many of the shipments will come from the 200 East and 200 West Areas, a much shorter shipping distance than from the 300 Area. For intra-200 West Area shipments (for example, from the Central Waste Complex

[CWC] to the Waste Receiving and Processing Facility [WRAP] or the T Plant Complex to the Low Level Burial Grounds [LLBGs]), a distance of 1 mile (1.6 km) was assumed, and the 200 West Area population density was used. For shipments from the 200 West Area to offsite treatment facilities, a 48-km (30-mi) shipping distance was used. The shipments were assumed to travel 3.2 km (2 mi) in the 300 Area population density region, 6.4 km (4 mi) in the 200 West Area region, and 38.4 km (24 mi) in the 600 Area. ILAW shipments to a 200 East Area disposal facility were modeled as a 1.6 km (1 mi) shipment, 10 percent of which is through an area defined by a population density of 660 persons/km^2 (1700 persons/mi^2) and 90 percent in an area defined by a population density of 0.14 persons/km^2 (0.35 persons/mi^2). ILAW shipments to a 200 West Area disposal facility were modeled as a 16-km (10-mi) shipment, 10 percent of which is through an area defined by a population density of 660 persons/km^2 (1700 persons/mi^2) and 90 percent in an area defined by a population density of 0.14 persons/km^2 (0.35 persons/mi^2).

Table H-2 presents the shipping data for Alternative Group A, Hanford Only waste volume. The table provides the origin and destination for each shipment, the projected waste volume, and the number of shipments. For Alternative Group A, Lower Bound and Upper Bound volume cases, additional wastes are received from offsite generators. The impacts of the shipments from offsite generators are discussed separately in Section H.5. They are not added to the Hanford Only waste-volume case because the analyses of offsite shipments were conducted only for transport through Washington and Oregon.

Shipping data for Alternative Group B is similar to Group A except for ILAW and MLLW shipments. In Group B, the ILAW disposal facility is assumed to be located in the 200 West Area (was assumed to be located near PUREX in Group A); consequently, the shipping distance for ILAW canisters is longer in Alternative Group B than Group A. For MLLW, wastes that were assumed to be shipped offsite are instead shipped to a new treatment facility assumed to be located in the 200 West Area. This significantly reduces the shipping distances for these wastes in Alternative Group B.

Shipping data for Alternative Group C is similar to Group A. The differences between Group C and A are in the technologies deployed to treat and dispose of the waste. For example, LLW is assumed to be disposed in a single, expandable unlined trench in Group C whereas it is disposed of in deeper, wider, lined trenches in Group A. Both the expandable and deeper, wider, unlined disposal facilities are assumed to be located in the 200 West Area, and therefore there would be only minimal differences in shipping data between the two Alternative Groups. Similarly, MLLW is assumed to be disposed in a single expandable lined trench in Group C and deeper, wider lined trenches in Group A. Because both types of lined-trench disposal facilities are assumed to be located in the 200 East Area, there would be no differences in shipping data.

Alternative Group A also forms the base for Alternative Groups D and E. The main differences between these alternatives and the effects on shipping data are as follows. Treatment of all waste types is identical in all three Groups. The difference between the three Alternative Groups is in the location of disposal facilities for LLW (three locations in or near the 200 East Area in Alternative Group D versus 200 West Area for Group A). Because most of these wastes were assumed to be transported from the 300 Area to 200 Area disposal facilities to bound the impacts, the exact locations of the disposal facilities have little impact on the results.

Table H.2. Shipping Data – Alternative Group A, Hanford Only Waste Volume

Waste Stream	Origin	Destination	Waste Volume, m^3	Number of Shipments[(a)]
LLW				
WRAP				
1b - LLW Cat. 1	300 Area	WRAP	3326	443
2c - LLW Cat. 3	300 Area	WRAP	1462	430
T Plant Complex				
1b2 - LLW Cat. 1	WRAP	T-Plant	274	37
2c2 - LLW Cat. 3	WRAP	T-Plant	143	42
Offsite Commercial Facilities	CWC	Comm Treat	299	40
Repackage in HICs or Trench Grouting				
2a - LLW Cat 3 Direct Disposal	300 Area	LLBG	35,372	10,404
2c1 - LLW Cat 3 from WRAP	WRAP	LLBG	1318	388
2c2 - LLW Cat 3 from T Plant	T-Plant	LLBG	214	63
LLBG				
1a - LLW Cat 1 Direct Disposal	300 Area	LLBG	66,522	8870
1a - LLW Cat 1 from stream 11	300 Area	LLBG	158	21
1b1 - LLW Cat 1 from WRAP	WRAP	LLBG	3034	405
1b2 - LLW Cat 1 from T Plant	T-Plant	LLBG	411	55
6 - Non-Conforming LLW	Comm Treat	LLBG	598	80
MLLW				
WRAP				
11 - Wastes ready for disposal	300 Area	WRAP	187	55
13 - Waste verification	CWC	WRAP	2684	789
13 - Post treatment verification	WRAP	CWC	2684	789
MLLW reclassified as LLW	WRAP	LLBG	18	5
Modified T Plant				
12 - RH MLLW	CWC	T-Plant	2839	4732
Commercial Treatment Facilities				
13A - CH Standard (non-thermal)	CWC	Offsite	20,108	2801
13B - CH Standard (thermal)	CWC	ORR	6727	946
14 - Elemental Lead	CWC	Offsite	600	1200
15 - Elemental Mercury	CWC	Offsite	21	42
MW Enhanced Trench Design				
11 - Wastes ready for disposal	300 Area	MW Trench	26,682	7848
22 - WTP Melters	200E Area	MW Trench	3205	18
11 - From WRAP verification	WRAP	MW Trench	187	55
12 - RH MLLW from Modified T Plant	T-Plant	MW Trench	4066	6777
13A - CH Standard (non-thermal)	Offsite	MW Trench	36,195	5602
13B - CH Standard (thermal)	ORR	MW Trench	6054	946
14 - Elemental Lead	Offsite	MW Trench	1200	2400
15 - Elemental Mercury	Offsite	MW Trench	42	84

Table H2. (contd)

Waste Stream	Origin	Destination	Waste Volume, m^3	Number of Shipments[(a)]
TRU				
WRAP				
4A - Retrievably Stored Drums in Trenches	LLBG	WRAP	3714	1092
9 - Drums	300 Area	WRAP	5933	1745
9 - SWBs	300 Area	WRAP	20,937	3673
Storage in T Plant Complex				
#17 - K-Basin Sludge	K-Basin	T-Plant	139	41
WIPP	See Section H.5			
LLBG				
4A - TRU drums assayed in trench as LLW				
4A - Empty containers sent to LLBG for disposal	WRAP	LLBG	371	49
9 - drums assayed in WRAP as LLW	WRAP	LLBG	305	41
10A - Newly generated CH Non-standard	300 Area	CWC	492	145
10B - Newly-generated RH Waste	300 Area	CWC	2112	3520
10 - TRU Waste Processed at T-Plant	T-Plant	LLBG	215	29
ILAW				
Immobilized Low Activity Waste	WTP	200 E Disposal	211,000	97,235

(a) Due to rounding, the number of shipments may not match exactly the result of dividing the volume shipped by the shipment capacity.
RH = remote-handled
CH = contact-handled
LDR = land disposal restriction
WTP = Waste Treatment Plant.
ORR = Oak Ridge Reservation
SWB = Standard Waste Box
NWPF = New Waste Processing Facility

Shipping data for the No Action Alternative is presented in Table H.3. Key differences between the No Action Alternative and the other alternatives are that many waste streams are stored rather than being treated and disposed. This substantially reduces the amount of transportation required to manage solid wastes.

To provide a conservative analysis, waste sent from Hanford for thermal treatment was assumed to go to the Oak Ridge Reservation (ORR). For shipments of waste from Hanford to the ORR for treatment and then back to Hanford for disposal, per-shipment impacts were taken directly from a previous Environmental Assessment (EA) that evaluated the impacts of transporting LLW from the ORR to Hanford (DOE 2001). No adjustments were made to reflect the assumed larger shipping capacities used in the EA (eighty 55-gal drums per shipment in the ORR EA versus 18 drums per shipment assumed in this EIS), except the numbers of shipments were calculated using 18 drums per shipment. Important parameters that remained the same included the radiological inventories, external radiation dose rates, packaging-system release parameters, fractional occurrences of accidents in the various severity categories, and dosimetry parameters. Note that the ORR EA conducted route-specific impact analyses for these

Table H.3. Shipping Data for the No Action Alternative

Waste Stream	Origin	Destination	Volume Shipped, m^3	Number of Shipments[(a)]
		LLW		
WRAP				
1b - LLW Cat. 1	300 Area	WRAP	3326	443
2c - LLW Cat. 3	300 Area	WRAP	1462	430
T-Plant Complex				
1b2 - LLW Cat. 1	WRAP	T-Plant	274	37
2c2 - LLW Cat. 3	WRAP	T-Plant	143	42
Repackage in HICs or Trench Grouting				
2a - LLW Cat 3 Direct Disposal	300 Area	LLBG	35,372	10,404
2c1 - LLW Cat 3 from WRAP	WRAP	LLBG	1318	388
2c2 - LLW Cat 3 from T Plant	T-Plant	LLBG	214	63
LLBG				
1a - LLW Cat 1 Direct Disposal	300 Area	LLBG	66,522	8870
1a - LLW Cat 1 from stream 11	300 Area	LLBG	158	21
1b1 - LLW Cat 1 from WRAP	WRAP	LLBG	3034	405
1b2 - LLW Cat 1 from T Plant	T-Plant	LLBG	411	55
		MLLW		
WRAP				
11 - Wastes ready for disposal	300 Area	WRAP	187	55
13 - Waste verification	CWC	WRAP	2684	789
13 - Post treatment verification	CWC	WRAP	36	11
MLLW reclassified as LLW	WRAP	LLBG	18	5
Commercial Treatment Facilities				
13B - CH Standard (thermal)	CWC	ORR	360	106
MW Existing Trenches				
11 - Wastes ready for disposal	300 Area	MW Trench	25,942	7630
CH-MLLW	CWC	MW Trench		
RH-MLLW	CWC	MW Trench		
11 - From WRAP verification	WRAP	MW Trench	113	33
13B - CH Standard (thermal)	ORR	MW Trench	360	106
14 - Elemental Lead	300 Area	CWC	155	310
15 - Elemental Mercury	300 Area	CWC	8	16
		TRU		
WRAP				
4A - Retrievably Stored Drums in Trenches	LLBG	WRAP	3714	1092
9 - CH - Standard Containers (55-gal drums and SWBs)				
Drums	300 Area	WRAP	5933	1745
SWBs	300 Area	WRAP	20,937	3673
Storage in T Plant Complex				
17 - K-Basin Sludge	K-Basin	T-Plant	139	41
WIPP	Hanford	WIPP	See Section H.5	

Table H3. (contd)

Waste Stream	Origin	Destination	Volume Shipped, m^3	Number of Shipments[(a)]
LLBG				
4A - Empty containers sent to LLBG for disposal	WRAP	LLBG	371	50
9 - drums assayed in WRAP as LLW	WRAP	LLBG	305	41
10A - Newly generated CH Non-standard	300 Area	CWC	492	145
10B - Newly-generated RH Waste	300 Area	CWC	2112	3520

(a) Due to rounding, the number of shipments may not match exactly the result of dividing the volume shipped by the shipment capacity.
RH = remote-handled
CH = contact-handled
LDR = land disposal restriction
WTP = Waste Treatment Plant.
ORR = Oak Ridge Reservation
SWB = Standard Waste Box
NWPF = New Waste Processing Facility

shipments. Also note that the incident-free dose risk to the public and truck crews should be comparable to those calculated here because the external dose rates are assumed to be the same in the ORR EA as they are at Hanford. Radiological accident risks should be slightly higher than those calculated for Hanford because the radionuclide inventories assumed here are for only eighteen 55-gal drums of waste. Those used in the ORR EA assumed eighty 55-gal drums per shipment. Finally, the ORR EA did not estimate the number of accidents projected to occur during the shipments. These impacts were estimated in this EIS by multiplying the estimated non-radiological fatalities due to traffic accidents by the ratio of the mean national accident rate to the mean national fatality rate given by Saricks and Tompkins (1999, Table 4). This ratio amounts to about one fatality per 46 heavy-combination truck accidents. The reader is referred to DOE (2001) for additional information about the ORR shipments. Shipments to non-thermal treatment facilities were assumed to be transported to a facility adjacent to the Hanford Site.

Radiological Accident Risks. RADTRAN 4 performs accident risk assessment by combining the probabilities and consequences of accidents to produce a risk value. RADTRAN 4 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences (for example, fender benders) to those with low frequencies and high consequences (accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

Accident analysis in RADTRAN 4 is performed using an accident severity and package release model. The user can define up to 20 severity categories for 3 population densities (urban, suburban, and rural), each category increasing in magnitude. Severity categories are related to fire, puncture, crush, and immersion environments created in vehicular accidents. For this study, the eight severity categories defined in NUREG-0170 (NRC 1977) were adopted. Severity Category I represents minor accidents in which the packaging system retains confinement of the cargo (that is, no release). Higher severity categories represent more severe accident conditions with correspondingly higher releases and lower probabilities.

Each severity category has an assigned conditional probability (or the probability, given an accident occurs that it will be of the specified severity). The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are also a function of the physical-chemical properties of the materials transported. RADTRAN 4 default values for similar generic materials were used in this analysis. For example, Category 1 solid wastes were modeled as a generic small-powder-material form. Using this definition, the Category 1 LLW solids will have an aerosol fraction of 0.10 (that is, 10 percent aerosol-size particles) and a respirable fraction of 0.05 (or 5 percent of the aerosol-size particles are also respirable-size particles). These parameters were used for all onsite shipments of solid materials, including Category 1 LLW, Category 3 LLW, Greater than Class 3 (GTC3) LLW, MLLW, and TRU waste. LLW Category 1 organic liquid wastes were assigned to a generic liquid material form in which the aerosol and respirable fractions are set to 1.0. Table H.4 shows the input parameters used in this analysis of onsite and offsite shipments in 55-gal drums and boxes as well as ILAW canisters. Note that the release fractions used are very conservative for ILAW, which will be transported in a massive steel container that is much less likely to fail in accident conditions than a drum or box shipment. Concentrations of radioactive materials that were used to calculate the per-shipment inventories of each material, taken from the Technical Information Document FH (2003), are shown in Table H.5. Note that only a few streams are presented in Table H.5. Readers are referred to the Technical Information Document (FH 2003) for information on other waste streams.

For accidents that result in a release of radioactive material, RADTRAN 4 assumes the material is dispersed into the environment according to standard Gaussian diffusion models. The code allows the user to choose two different methods for modeling the atmospheric transport of radionuclides after a potential accident. The user can either input Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this analysis, the default standard cloud option (uses time-integrated concentrations) within RADTRAN 4 was used.

RADTRAN 4 calculates the population dose from the released radioactive material for four exposure pathways. These pathways are

1. external dose from exposure to the passing cloud of radioactive material

2. external dose from radionuclides deposited on the ground by the passing plume

3. internal dose from inhalation of airborne radioactive contaminants

4. internal dose from ingestion of contaminated food.

Standard radionuclide uptake and dosimetry models are incorporated into RADTRAN 4. The computer code combines the accident consequences and frequencies of each severity category, sums over the severity categories, and then integrates over all the shipments. Accident-risk impacts that are provided in the form of a collective population dose (person-rem over the entire shipping campaign) are then converted to population risk using health-effects conversion factors. The dose to risk factors, which

Table H.4. RADTRAN 4 Accident Parameters for Trucks

Accident Rate **Onsite**[a] – Hanford Sitewide Average – 1.14E-7 accidents per mile			
Fractional Occurrence by Severity Category (Conditional Probability Given an Accident Occurs)[a]			
Severity Category			
I	0.55		
II	0.36		
III	0.07		
IV	0.016		
V	0.0028		
VI	0.0011		
VII	8.5E-5		
VIII	1.5E-5		
Fractional Occurrence by Population Zone (Conditional Probability Given an Accident Occurs of the Specified Severity)[a]			
	Rural	**Suburban**	**Urban**
I	0.1	0.1	0.8
II	0.1	0.1	0.8
III	0.3	0.4	0.3
IV	0.3	0.4	0.3
V	0.5	0.3	0.3
VI	0.7	0.2	0.1
VII	0.8	0.1	0.1
VIII	0.9	0.05	0.05
Release Fraction (Fraction of Container Contents Released from Shipment by Severity Category)[b]			
I	0		
II	0.01		
III	0.1		
IV	1		
V	1		
VI	1		
VII	1		
VIII	1		

(a) Data taken from NUREG-0170 (NRC 1977) for Type A shipments (see Text Box on Page H.6).
(b) Source: Green et al. (1996).

Table H.5. Radionuclide Concentrations (Ci/m^3) Used to Calculate Per-Shipment Inventories[(a)]

Radionuclide	LLW Cat 1	LLW Cat 3	MLLW	TRU Waste	ILAW
Am-241	6.41E-6	7.94E-3	0	3.17E+0	1.1E-1
C-14	7.02E-5	2.25E-5	0	0	0
Cm-244	0	1.00E-3	0	0	1.1E-3
Co-60	1.07E-3	5.27E-2	3.18E-8	0	4.4E-2
Cs-137/Ba-137m	1.01E-4	9.77E+0	1.70E-6	8.17E-2	9.6E+0
Fe-55	2.46E-3	5.24E-2	0	0	0
H-3	4.49E+0	1.62E-3	0	0	0
Mn-54	3.29E-3	7.78E-3	0	0	0
Ni-59	2.60E-4	8.87E-6	0	0	1.8E-3
Ni-63	8.62E-4	8.75E-2	0	0	1.7E-1
Pu-238	2.16E-6	1.97E-3	0	7.21E-1	5.1E-4
Pu-239	3.11E-5	9.44E-3	0	2.74E+0	3.2E-2
Pu-240	7.87E-6	3.73E-3	0	1.54E+0	5.5E-3
Pu-241	2.11E-4	2.23E-1	0	5.77E+1	7.5E-2
Pu-242	1.77E-8	1.70E-6	0	6.25E-5	4.7E-7
Sr-90 / Y-90	1.20E-4	1.24E+1	1.60E-7	6.73E-2	4.7E+1
Tc-99	1.37E-5	9.59E-3	1.17E-3	0	1.6E-2
U-233	0	1.49E-5	0	0	1.4E-3
U-234	0	1.89E-2	0	0	4.6E-4
U-235	0	5.40E-4	1.13E-7	0	1.9E-5
U-236	0	2.44E-3	0	0	1.5E-5
U-238	0	3.04E-2	1.18E-4	0	5.1E-4

(a) Source: FH 2003.

were taken from the International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991), infer 4.0E-4 latent cancer fatalities (LCFs) per person-rem for workers and 5.0E-4 LCF/person-rem for the general public.

H.1.2 Physical (Non-Radiological) Routine Risks

Non-radiological routine impacts consist of fatalities from pollutants, such as diesel exhaust emitted from vehicles. This category of impacts is not related to the radiological characteristics of the cargo.

Spreadsheet calculations were performed using unit-risk factors (fatalities per km of travel) to derive estimates of the non-radiological impacts. The non-radiological impacts were calculated by multiplying the unit risk factors by the total shipping distances for all of the shipments in each shipping option. Non-radiological unit risk factors for incident-free transport were taken from Rao et al. (1982).

H.1.3 Non-Radiological Accident Risks in Transit

The non-radiological accident impacts of traffic accidents associated with the transportation of radioactive waste are assumed to be comparable to the impacts associated with general transportation activities in the United States. A unit factor (fatalities per km or fatalities per mi) is multiplied by the shipping distance to calculate non-radiological impacts from vehicular accidents. The fatalities are due to vehicular impacts with solid objects, rollovers, or collisions and are not related to the radioactive nature of the cargo being transported. For onsite shipments, the fatality data developed by Saricks and Tompkins (1999) for primary highways in the state of Washington was used in the calculations. Separate unit factors were used to develop estimates of the number of accidents involving the shipments and the number of fatalities resulting from the accidents.

H.1.4 Hazardous Chemical Impact Analysis

The impact of accidental releases of hazardous chemicals from the various waste shipments was addressed differently than accidental releases of LLW, MLLW, and TRU waste. A maximum credible accident involving each shipment was postulated. Hazardous chemical release and atmospheric dispersion calculations were then performed to determine the maximum downwind concentration to which an individual would be exposed. The downwind concentrations were compared to safe exposure levels for each chemical (Emergency Response Planning Guidelines [ERPGs] or Temporary Emergency Exposure Limits [TEELs]; see Section H.6) to determine the potential public and worker impacts.

The formula used to estimate the downwind concentrations of hazardous chemicals is

$$Concentration = \frac{Source\ Inventory \times Respirable\ Release\ Fraction \times \frac{E}{Q}}{Release\ Duration}$$

where E/Q is the atmospheric dispersion coefficient.

Hazardous chemical concentrations for the highest-volume waste streams are presented in Table H.5.

Source inventories for each material shipped were taken from the Technical Information Document (FH 2003). Where necessary, adjustments were made to the 55-gal drum inventories in Table H.6 to account for different waste container sizes and shipment capacities. Release duration was assumed in all cases to be 2 hr. Derivations of the remaining variables in the formula are described in the following paragraphs.

Table H.6. Maximum Hazardous Chemical Inventories

Hazardous Constituent	TEEL-2 Value (mg/m^3)[(a)]	Chemical Inventory in Maximum 55-Gallon Drum,[(b)] kg			
		MLLW[(c)]	TRU Waste[(d)]	Elemental Mercury	Elemental Lead
Acetone	8500	20.0	0	0	0.2
Ammonium fluoride	12.5	7.9	0	0	0
Ammonium nitrate	50	7.9	0	0	0
Ammonium sulfate	500	15.6	0	0	0
Beryllium	0.025	5.7	0.2	0	0
Butyl alcohol	50	1.1	0.5	0	0
Carbon tetrachloride	100	36.6	1.0	0	0
Cyclohexane	1300	3.8	0	0	0
Ethanol	3300	20.2	0.2	0	0
Hydrazine	0.8	8.6	0	0	0
Isopropyl alcohol	400	29.1	0	0	0
Lead	0.25	0	0	0	204
Mercury	0.1	0	0	27.6	0
Methanol	1000	39.2	0	0	0
Methyl ethyl ketone (MEK)	0.2	23.8	0	0	0
Methyl isobutyl ketone	500	33.0	0	0	0
Nitric acid	15	61.0	0.2	0	0
Phosphoric acid	500	52.4	0.3	0	0
Potassium hydroxide	2	56.3	0	0	0
Propane	2100	0	0.4	0	0
Sodium Hydroxide	40	76.5	6.0	0	0
Styrene	250	1.6	0	0	0
Sulfuric acid	10	3.3	1.5	0	0
Tetrahydrofuran	2000	3.0	0	0	0
Toluene	300	104.0	0	0	0
Uranium	1	340	0	0	0
Xylene	200	52.0	4.2	0	0

Note: 0 indicates no data was provided in the source document.
(a) Source: Craig (2001).
(b) Source: FH (2003).
(c) The source terms are representative of CH MLLW. RH MLLW had a lower hazardous chemical content.
(d) The source term is representative of suspect TRU waste in trenches. Other TRU waste chemical source terms were lower.

The maximum credible accident postulated here is assumed to involve a severe impact followed by a fire. The impact condition is assumed to break up the waste form and cause the waste container to fail so the contained material has an open pathway to the environment. A fire is then assumed to occur, resulting in additional damage and turning the waste material into an aerosol. The aerosol and respirable fractions, used for the radiological materials (for example, with LLW Category 1), were set equal to 0.1 and 0.05, respectively, and were also used to characterize the released hazardous chemicals. Therefore, a combined respirable release fraction of 0.005 was used in the calculations.

Because an accident could occur anywhere and at any time during a shipment, predicting the population distributions and weather conditions at the time of the accident is not possible. For this analysis, the concentrations of the hazardous materials at the location of the maximally exposed individual were calculated. The maximally exposed individual (MEI) for onsite shipments was assumed to be a Hanford Site worker located 100 m (109 yd) downwind from the accident location for the entire duration of the release. The dose to the MEI for offsite shipments would be similar. Downwind air concentrations are also a function of wind speed and atmospheric stability class. Accident-analysis guidance from the U.S. Nuclear Regulatory Commission (NRC) was used to characterize the weather conditions at the time of the accident. The wind speed was assumed to be 1 m/s, and Pasquill stability class F (stable conditions) was assumed. These are low-probability wind conditions that tend to overestimate typical concentrations of released materials. The atmospheric dispersion coefficient or E/Q was calculated using NRC Regulatory Guide 1.145 (NRC 1982). The atmospheric dispersion coefficient at 100 m (109 yd) under Pasquill stability class F and 1 m/s wind speed was calculated to be 3.5E-2 s/m^3.

The impacts to the maximum exposed individual were determined by comparing the downwind concentrations of each hazardous chemical to safe exposure levels. The primary source of the exposure levels is Craig (2001), *ERPGs and TEELs for Chemicals of Concern, Rev. 18*. The safe exposure level assumed here is the TEEL-2 (Temporary Emergency Exposure Limit - 2), as defined by Craig (2001). The TEEL-2 concentration is defined as the maximum concentration in air below which nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

H.2 Results of Transportation-Impact Analysis

This section presents the results of the transportation-impact analysis in support of the EIS. Separate subsections are presented for results of Alternative Groups A through E and the No Action Alternative. The accident-impact analysis results for hazardous chemicals are presented in Section H.6. All of the impacts provided in the table are in fatalities except for the estimated number of traffic accidents. Fatalities are expressed in latent cancer fatalities (LCFs) for radiological impacts and routine non-radiological emissions. For non-radiological accidents, impacts are expressed in terms of the predicted number of traffic accidents and physical-trauma-induced fatalities resulting from the traffic accidents. Note that many of the entries in the table are expressed as fractional fatalities, for example, 1E-1 or 0.1 fatalities. The whole-number totals are determined by summing over all waste types and then rounding the sums to the nearest whole number.