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Environmental Assessment

for

Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste

September 1996

Sandia National Laboratories/New Mexico

U.S. Department of Energy
Kirtland Area Office
Albuquerque, New Mexico

MASTER

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DEPARTMENT OF ENERGY
FINDING OF NO SIGNIFICANT IMPACT

SANDIA NATIONAL LABORATORIES/NEW MEXICO
OFFSITE TRANSPORTATION OF
LOW-LEVEL RADIOACTIVE WASTE

The United States Department of Energy has prepared an Environmental Assessment (DOE/EA 1180) which analyzes the potential environmental effects of shipping existing and forecasted low-level waste to low-level waste disposal sites at one or more of the following locations: the Hanford Reservation, the Savannah River Site, Nevada Test Site, Chem Nuclear, Envirocare and U.S. Ecology.

FINDING: The Environmental Assessment identifies relevant issues of environmental concern [Chapter 3, page 3-1 thru 3-21]. Next, the Environmental Assessment makes a convincing case that the impacts of identified issues are insignificant [Chapter 4, pages 4-1 to 4-14]. Therefore, the Department of Energy finds that there would be no significant impact from proceeding with its proposal to transport low-level radioactive waste (LLW) from Sandia National Laboratories, New Mexico to the Hanford Reservation, the Savannah River Site, the Nevada Test Site, Chem Nuclear, Envirocare and U.S. Ecology. Department of Energy makes this Finding of No Significant Impact pursuant to the National Environmental Policy Act of 1969 [42 U.S.C. 4321 et seq.], the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act [40 CFR 1500] and the DOE National Environmental Policy Act Implementing Procedures [10 CFR part 1021]. Based on the Environmental Assessment that analyzes the potential environmental effects that would be expected to occur if LLW were transported by highway to Department of Energy disposal sites or commercial sites, the proposed action does not constitute a major federal action that would significantly affect the human environment within the meaning of the National Environmental Policy Act. Therefore, no environmental impact statement is required for this proposal.

Signed in Albuquerque, New Mexico this 20 day of November, 1996

Brenda A. Harmeson
for Michael J. Zamorski
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DOE/EA-1180

September 1996

ENVIRONMENTAL ASSESSMENT FOR SANDIA NATIONAL LABORATORIES/NEW MEXICO OFFSITE TRANSPORTATION OF LOW-LEVEL RADIOACTIVE WASTE

U.S. Department of Energy
Kirtland Area Office
Albuquerque, New Mexico

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ACRONYMS

A/A	Albuquerque International Airport
AADT	average annual daily traffic
ABC/AQCB	Albuquerque/Bernalillo County Air Quality Control Board
ACRR	Annular Core Research Reactor; SNL/NM
AIA	Albuquerque International Airport
ALARA	As Low As Reasonably Achievable
ASME	American Society of Mechanical Engineers
ATSF	Atchesion, Topeka, and Santa Fe Railroad
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAW	dry active waste
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DR	Disposal Request
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDA	U.S. Energy Research Development Agency
ERP	Environmental Restoration Program
FONSI	Finding of No Significant Impact
Hanford	The Hanford Reservation; Hanford, WA
HCF	Hot Cell Facility; SNL/NM
HDDVs	Heavy Duty Diesel Powered Vehicles
HERMES	High-Energy Radiation Megawatt Electron Source
HSWA	Hazardous and Solid Waste Amendments
ICRP	International Committee on Radiation Protection
INEL	Idaho National Engineering Laboratory; Idaho Falls, ID
ISS	Interim Storage Site
KAFB	Kirtland Air Force Base; Albuquerque, NM
LANL	Los Alamos National Laboratory; Los Alamos, NM
LCF	latent cancer fatality
LLW	low-level waste
MFP	miscellaneous fission products
MWL	Mixed Waste Landfill; SNL/NM
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NTS	The Nevada Test Site; NV
PBFA-II	Particle Beam Fusion Accelerator II
PEIS	Programmatic Environmental Impact Statement
PM_{10}	particulate matter

ACRONYMS (Continued)

PPE	Personal Protective Equipment
QF	quality factor
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RMWMF	Radioactive and Mixed Waste Management Facility; SNL/NM
SABRE	Sandia Accelerator and Beam Research Experiment
SAR	Safety Analysis Report
SIP	State Implementation Plan
SNTP	Space Nuclear Thermal Propulsion
SNL/NM	Sandia National Laboratories, New Mexico
SPR	Single Pulse Reactor; SNL/NM
SRS	Savannah River Site; Aiken, SC
TA	Technical Area; SNL/NM
TI	transportation index
TSP	total suspended particulates
USNRC	(see NRC)
WAC	Waste Acceptance Criteria

CHEMICAL ABBREVIATIONS

Ce	Cerium
Cm	Curium
Co	Cobalt
CO	Carbon Monoxide
Cs	Cesium
Fe	Iron
H-3	Tritium
Mn	Manganese
Nb	Niobium
NO_X	Nitrous Oxide
O_2	Ozone
S	Sulfur
Th	Thorium
U	Uranium
Zn	Zinc
Zr	Zirconium

UNIT ABBREVIATIONS

Ci	Curie
dBA	decibel
ft	feet
gal	gallon
gm	gram
hr	hour
in	inch
K	degrees Kelvin
kg	kilogram
km	kilometer
l	liter
%	percent
lb	pound
m	meter
mi	mile
person-rem	radiation dose equivalent to population
ppm	parts per million
R	roentgen (unit of radiation exposure)
rad	unit of absorbed dose
rem	unit of radiation dose equivalent
yr	year

SYSTEM INTERNATIONAL PREFIXES

Exponent	Prefix	Symbol
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

Note: Alternate exponential notation may be expresses as follows 1×10^{-3} = 1.0E-03

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SUMMARY

Background

Sandia National Laboratories, New Mexico (SNL/NM) is managed and operated by Sandia Corporation, a Lockheed Martin Company. SNL/NM is located on land owned by the U.S. Department of Energy (DOE) within the boundaries of the Kirtland Air Force Base (KAFB) in Albuquerque, New Mexico. The major responsibilities of SNL/NM are the support of national security and energy projects. Low-level radioactive waste (LLW) is generated by some of the activities performed at SNL/NM in support of the DOE.

From 1957 to 1988, LLW generated by various programs conducted by SNL/NM was disposed of at the Mixed Waste Landfill (MWL) located in Technical Area III (TA-III). This site, however, has not been able to accept LLW since 1989 due to DOE requirements prohibiting further disposal. Current inventories of LLW at SNL/NM are now stored at generator storage sites or in containers (outdoors) above the inactive MWL disposal site.

DOE proposes to transport the LLW to a site where it can be properly disposed of. In addition, to meet future work requirements, SNL/NM must have a disposal option available for newly generated waste so that continued accumulation and indefinite storage of LLW do not persist.

Proposed Action

Based on the decision to dispose of low-level waste offsite, DOE proposes to transport existing and forecasted inventories of LLW by highway to DOE waste disposal sites at either the Nevada Test Site (NTS), or the Hanford Reservation (Hanford), or at one of three commercial sites, Envirocare (Utah), U.S. Ecology (Washington State), or Chem Nuclear (Barnwell, South Carolina). In addition, the Savannah River Site (SRS) has been included in the analysis because SRS currently accepts LLW from a limited number of offsite generators. However, due to SRS's limited disposal capacity it is unlikely that LLW would be accepted from SNL/NM.

Waste shipments would be prepared at SNL/NM's Radioactive and Mixed Waste Management Facility (RMWMF) as part of routine waste management activities. The LLW would be packaged in either 55-gallon (gal) steel drums or 4'x4'x7' or 4'x2'x7' steel boxes and transported to the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear or Envirocare in eighteen-wheel tractor-trailer conveyances. The LLW would be shipped in accordance with all Department of Transportation (DOT) and DOE requirements following the most direct routes possible, using interstate highways to the maximum extent practicable.

Existing inventories of LLW would be shipped over a period of three to four consecutive years, with the actual shipment schedule to be determined after the waste acceptance criteria (WAC) have been met and the site(s) has agreed to accept the waste. For the purpose of this assessment, it is anticipated that the shipments would primarily occur during fiscal years 1997, 1998, and 1999. However, since shipping dates are not yet certain, the labels "first," "second," and "third" year of the campaign have been substituted for actual years. The Federal government's fiscal year is from October 1 through September 30.

The inventory of existing SNL/NM LLW included in the proposed action has a volume of approximately 222 m^3 (7770 ft^3) with a mass of approximately 50,000 kg (110,000 lbs). Of this inventory, approximately eighty-five percent (85%) was accumulated since the closing of the SNL/NM MWL, and the remaining fifteen percent (15%) are materials that had not previously been declared waste by SNL/NM. Forecasted LLW (waste that is expected to be generated at SNL/NM by ongoing activities over the course of this proposed action) would also be shipped during the same period and in subsequent years at a substantially lower rate.

The forecasted inventory of LLW is expected to be generated at a rate similar to that of the past: approximately 37 m^3 (1300 ft^3) per year. However, the exact quantities and radionuclide inventory of the future waste cannot be predicted precisely. Therefore, the volume of forecasted waste for the impact assessment for the proposed action was conservatively modeled to be equal to that of the entire inventory of existing waste. Thus, the total volume of both existing and forecasted waste modeled in this environmental assessment is 444 m^3 (15,540 ft^3).

It is expected that approximately 28 to 45 truck loads of (a maximum annual average of 15 shipments) LLW packages would be required for all waste shipments for the first three years. The exact number of shipments required would be a function of the packaging of the LLW and the rate of waste generation. The exclusive use of 55-gal drums would maximize the number of shipments, while the exclusive use of 4'x4'x7' boxes would minimize the number of shipments. Thus, for the first 3 years there could be a maximum of 28 box shipments or 45 drum shipments.

There is the potential for the Environmental Restoration Project (ERP) to generate LLW in the future. Due to unknown quantities and characteristics of the ER LLW it was not included in this EA. However, the ERP has prepared the Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico (DOE/EA-1140), and received a Finding of No Significant Impact (FONSI) in March 1996.

This environmental assessment (EA) covers the shipment of wastes from SNL/NM to a disposal site. The onsite activities for the preparation of the LLW for shipment (e.g., sorting, repackaging, labeling) have been addressed in the EA for the RMWMF, which received a FONSI in June 1993. The handling of the LLW at the NTS, Hanford, SRS, Chem Nuclear, Envirocare, or U.S. Ecology disposal sites is addressed in additional documents: the Environmental Impact Statement (EIS) for the Nevada Test Site and Offsite Locations in the State of Nevada (DOE, 1996), the site EIS for the Hanford Reservation prepared for ERDA in 1975, and the site EIS for the SRS (DOE, 1995). Envirocare, Chem Nuclear, and U.S. Ecology are not required to have an EIS because they are commercially owned and operated.

Alternatives To The Proposed Action

The following alternatives to the proposed action were considered:

- Take no action and continue to store LLW at SNL/NM indefinitely
- Transport LLW by rail from SNL/NM to the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare

One other alternative was discussed but not analyzed in detail because various technical, regulatory, and/or legal constraints render it either impossible or impractical to implement:

- Disposal at other DOE sites

Environmental Impacts Of The Proposed Action

The maximum expected radiation dose to the public in any single year during the proposed action would be approximately 2.0 person-rem for the NTS option, 4.6 person-rem for the Hanford option, 4.6 person-rem for the SRS and Chem Nuclear option, 3.0 for the Envirocare option, and 4.6 for U.S. Ecology option. For the NTS option, this dose implies a potential increase of 1/1000th future cancer death within the entire exposed population. Thus, the cancer fatality risk to an individual member of the potentially exposed public of (153,102 for the NTS) would be less than 1 chance in 153 million for the NTS option, less than 1 chance in 124 million for the Hanford and U.S. Ecology options (potentially exposed population of 274,224), less than 1 chance in 124 million for the SRS and Chem Nuclear option, and less than 1 chance in 150 million for the Envirocare option (potentially exposed population of 226,000).

Environmental Impacts Of The Alternatives To The Proposed Action

For the alternative of shipping the LLW in drums by rail to the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare, the maximum expected radiation dose to the public in any single year would be approximately 0.37 person-rem for the NTS option, 0.22 person-rem for the Hanford and U.S. Ecology options, 0.30 person-rem for the SRS and Chem Nuclear option, and 0.21 person-rem for the Envirocare option. For the NTS rail alternative, this would result in an increased potential of 1 in 5200 for the entire exposed population; for Hanford and U.S. Ecology, 1 in 9,000; for SRS and Chem Nuclear, 1 in 6,600; and for Envirocare 1 in 9,000. Because there is no direct rail service from SNL/NM to Albuquerque and from Las Vegas to the NTS, for rail shipments to the NTS the LLW would have to be transferred from truck to rail at Albuquerque, New Mexico, and from rail to truck at Las Vegas, Nevada. For rail shipments to all other proposed disposal sites, only the transfer at Albuquerque from truck to rail would be required. The intermodal transfer of the waste should most likely involve the use of a crane if the shipments were made with transportainers or a fork lift if the shipments were made with boxes. The waste packages would be transferred directly from rail car to truck bed. The total dose estimate for the NTS rail alternative is higher than that for the other alternatives because the potential for exposing workers and the public is greater when wastes must be transferred from one mode of transport to another.

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1. PURPOSE AND NEED FOR ACTION

Under requirements described in the DOE Order 5820.2A, "Radioactive Waste Management," it is the policy of the DOE to manage LLW operations at its facilities "to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure that no legacy requiring remedial action remains after operations have been terminated." Within this responsibility, the DOE must ensure that LLW is systematically managed and disposed of "so that the radioactive components are contained and the overall system cost effectiveness is maximized."

These DOE radioactive waste management policies apply to SNL/NM which is managed and operated for the DOE by Sandia Corporation, a subsidiary of the Lockheed Martin Company. SNL/NM is located on land owned by the DOE within the boundaries of the KAFB in Albuquerque, New Mexico. The major responsibilities of SNL/NM are the support of national security and energy projects. The primary mission of SNL/NM is the design and development of non-nuclear portions of weapons systems. These systems include the arming, fusing and firing systems used in nuclear ordnance. Safety, reliability, and survivability of weapons systems receive primary emphasis.

In addition to designing and developing weapons systems, SNL/NM conducts nuclear reactor safety studies for the U.S. Nuclear Regulatory Commission (NRC); develops safe transport and storage systems for nuclear wastes; develops radioactive waste disposal techniques; and conducts pulsed power, thermonuclear fusion, solar energy, vertical-axis wind turbine, and fossil fuel and geothermal energy research. Many of these activities have and continue to require the generation of small quantities of LLW.

Current inventories of LLW at SNL/NM are now stored at generator storage sites, or in containers stored outside and above ground at the inactive MWL disposal site. The DOE has constructed the RMWMF in TA-III as a centralized facility for staging, characterizing, compacting, repackaging, and certifying LLW generated at SNL/NM (DOE, 1993). The RMWMF became operational in January 1996. Building 6596 in TA-V has been modified and is used for the storage of LLW at SNL/NM.

Consistent with the requirements to mange LLW with public health and safety as a major priority and to ensure that no legacy requiring remedial action remain following operations, the DOE has elected to transport the LLW offsite for final disposal at either the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare. This EA evaluates the proposal for transporting LLW to each of these disposal sites, and evaluates a no action alternative.

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2. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

2.1. Proposed Action

The DOE proposes to package and ship existing and forecasted SNL/NM waste to LLW disposal sites at either the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare.* The waste would be prepared for disposal at the RMWMF as part of SNL/NM's routine waste management activities. LLW generated by activities conducted at SNL/NM, including, but not limited to, that of normal radiological control, health physics operations, and Research and Development (R&D) activities, is currently stored onsite at SNL/NM either at each SNL/NM generator site, at Building 6596, or outdoors in containers above ground at the inactive MWL disposal site. In order to continue to assure long-term operational and R&D activities that generate LLW at SNL/NM in support of DOE programs, the DOE proposes near-term disposal (and then continuing disposal) of its LLW inventory as opposed to long-term onsite storage.

This EA addresses only the shipment of LLW from SNL/NM to a disposal site. The onsite activities for the preparation of the LLW for shipment (e.g., sorting, repackaging, labeling) are addressed in the RMWMF EA (DOE, 1993). A FONSI was issued for the RMWMF EA in June 1993. The handling of the LLW at the NTS, Hanford, or SRS disposal sites is addressed in the site EIS for the NTS and Offsite Locations in the State of Nevada (DOE, 1996), in the site EIS for the Hanford Reservation (ERDA, 1975), and the draft EIS for the Savannah River Site (DOE, 1995), respectively. Since U.S. Ecology, Chem Nuclear, and Envirocare are commercially owned and operated, they are not required to have a National Environmental Policy Act (NEPA) document for their outside activities.

Existing inventories of LLW would be shipped over three to four consecutive years, with the actual shipment schedule to be determined after the WAC have been met and the disposal site(s) has agreed to accept the waste. Forecasted LLW (waste that is expected to be generated at SNL/NM by current and future activities over the course of this proposed action) would also be shipped during these and subsequent fiscal years.

The inventory of existing and forecasted SNL/NM LLW for which shipments are planned has a volume of approximately 444 m^3 (15,540 ft^3) with a mass of about 50,000 kg (110,000 lbs). The transportation activities proposed under this EA would continue at an annual level consistent with the forecasted waste generation rate and will be covered by this EA and its associated NEPA determination.

The LLW would be packaged in either 55-gal steel drums or 4'x4'x7' or 4'x2'x7' steel boxes (DOT 7A containers) and transported to either the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare by 18-wheel tractor-trailer conveyances using large trailers. The LLW would be packaged and shipped in accordance with all applicable DOT and DOE requirements, and transported following the most direct routes possible and using interstate highways to the maximum extent practicable. Representative highway routes are discussed in Section 3.0

*It should be noted that low-level mixed waste (i.e., waste with a hazardous chemical and a radiological component) is not covered under the proposed action.

The existing inventory of LLW has been accumulated since the closing of the SNL/NM MWL in 1988. The volume of existing and forecasted waste to be shipped is approximately 444 m^3 (15,540 ft^3) over the three-year period at an annual rate of approximately 148 m^3 (5200 ft^3). The proposed action accommodates existing and newly generated waste. The exact quantities of waste and the radionuclide inventory of the forecasted waste cannot be predicted precisely, although it is expected that the activities at SNL/NM would generate the forecasted LLW at a rate similar to that generated by previous activities.

Furthermore, the nature of the waste would be similar in form and content and generated at a rate consistent with the annual rate of generation for that time period since LLW has been in temporary storage. To provide a conservative estimate, the amount of forecasted waste for a three-year period was modeled to be equal to the amount of waste generated over an actual six-year period between 1989 and 1994. This amount is 222 m^3.

2.1.1. Existing SNL/NM LLW Inventories

SNL/NM's existing LLW inventory is currently categorized into eight groups based on internal SNL/NM documentation criteria submitted by the various SNL/NM waste generators. No Resource Conservation and Recovery Act (RCRA) constituent wastes are included in the proposed action. Table A-1 in Appendix A shows the radionuclide inventory for each waste stream considered for this proposed action.

TA-I Laboratory Trash

This waste stream consists primarily of personal protective clothing or equipment (PPE) and other radiological lab trash. A limited number of radioactive sources may be included as well. The inventory of TA-I laboratory trash has a total mass of 47.4 kg (104 lbs) and a volume of 0.601 m^3 (21 ft^3). It is expected that three, 55-gal drums would be required to package this waste. The total activity for this waste is estimated at 2.4E-2 Ci.

TA-II Tritiated Waste Associated with Neutron Generators - Laboratory Trash

This waste stream consists of PPE and other laboratory trash associated with destructive testing. These tritiated waste materials, associated with neutron generator work, have accumulated over an extended period. The physical/chemical state of the tritium in the waste was modeled as oxides (specifically tritiated water, which imposes higher biological dose conversion factors than tritium gas) for more conservative accident risk estimates. Because tritium decay is by beta emission only, no radiation would be expected to escape the package under incident-free transportation operations. These wastes may contain trace amounts of Er^{68}, Th^{232}, and Zr^{95}. The minute quantity of these radionuclides present, however, is not expected to contribute substantially to the total radioactivity.

A total mass of 468 kg (1030 lbs) and a volume of 5.69 m^3 (199 ft^3) of waste has been accumulated. The total activity for this waste is estimated at 43.9 Ci and was modeled as activity associated with tritium.

TA-II Neutron Generator Components - Neutron Generators

This waste stream consists of equipment associated with components of neutron generators and may contain tritium gas, tritium compounds, or metals permeated by tritium. A total mass of 2720 kg (5980 lbs) with a volume of 24.98 m^3 (874.3 ft^3) has been accumulated. The total activity of this waste is estimated to be 300 Ci and was modeled as activity associated with tritium. It is expected that one hundred and twenty, 55-gal drums would be required to package this waste.

TA-III Tritiated Waste

This waste stream consists of two types of waste: soil cuttings from monitoring wells and auger waste borings, and PPE used in these activities. A total mass of 24,900 kg (54,800 lbs) with a volume of 21.4 m^3 (749 ft^3) has been accumulated. The activity of the PPE waste is estimated to be 0.005 Ci and was modeled as activity associated with tritium. The soil cuttings have a specific activity below the DOT regulatory limit of 2.0E-9 Ci/gm for designation as radioactive material (49 CFR §173.403). However, this waste stream was included in the transportation risk analysis.

TA-IV Waste

Two lots of waste have accumulated from operations in TA-IV. One lot consists of "dry active waste" (DAW): activation products from Particle Beam Fusion Accelerator II (PBFA-II) experiments dispersed among cleaning materials, clothing, and other waste from normal operations. A total of 1700 kg (3470 lbs) with a volume of 54.6 m^3 (1910 ft^3) of waste has been accumulated. The maximum specific activity of the waste at the time it was generated was estimated to be 6.2E-9 Ci/gm. For accident risk analysis, this total inventory was modeled as 0.01 Ci of sulfur-35, the predominant radionuclide in the originator's inventory based on the original activity in the waste stream. When this waste lot is actually shipped, the specific activity is expected to be less than 1.0E-9 Ci/gm due to radioactive decay of the contaminants. For transportation purposes this would be less than the DOT regulatory limit (2.0E-9 Ci/gm or greater) for designation as radioactive material. All other radionuclides expected to exist in this waste have estimated specific activities that are smaller by factors of 10,000 or more and are not included in the analysis.

The other lot of waste is characterized as "laboratory trash" and consists of a wide variety of radioactive constituents and materials ranging from cleaning materials to spent laboratory radiation sources. A total of 125 kg (275 lbs) of waste with a volume of 0.5 m^3 (17.5 ft^3) has been accumulated.

TA-V Waste

Wastes resulting from normal Hot Cell Facility (HCF), Annular Core Research Reactor (ACRR), and Single Pulse Reactor (SPR) operations and maintenance range from cleaning wipes to hardware that have been contaminated with cobalt-60, cesium-137, and "miscellaneous fission products" (MFP). A total of 4710 kg (10,400 lbs) of waste with a volume of 91.8 m^3 (3,210 ft^3) has been accumulated. The specific activities of a majority of the lots are below the DOT regulatory limit of 2.0E-9 Ci/gm and, thus, for transportation purposes would not be considered radioactive waste.

One lot of TA-V waste, described as "15 poly bags of decon debris," contains 1.26 Ci or 99 percent of the total activity in the TA-V wastes, but this lot constitutes only 2 percent of the total volume of TA-V wastes. Therefore, this lot was modeled separately from the remaining TA-V waste and is described here as "Hot" Trash because of its relatively high level of radioactivity. The remainder of the TA-V LLW is described as "Cold" Trash because of its relatively low radioactivity. This Cold Trash was modeled as containing 4.5E-02 Ci.

Thorium Dioxide Fuel Rods and Powder

A large quantity of thorium-232 (natural) in the form of ThO_2 pellets and ThO_2 powder, has been stored for approximately 25 years. The pellets are stored in 18 boxes measuring 3'x3'x6' with a total activity of 0.56 Ci. The majority of pellets are encapsulated in zirconium rods (two lots consist of unencapsulated pellets). The total weight of pelletized waste is approximately 10,000 kg (22,046 lbs) of which approximately 6,500 kg (14,300 lbs) is estimated to be ThO_2. The pellets would likely be packaged for shipment by placing each of the 18 boxes into a 4'x4'x7' steel box. The ThO_2 powder is presently stored in 192 cans containing 11 kg (24 lbs) each. The inventory of the powder includes 0.2 Ci. The thorium powder would probably be packaged for shipment by placing two cans each into a 55-gal drum. The drums could either be shipped in groups loaded onto a truck trailer or further packaged by placing up to eight drums into a 4'x4'x7' box.

TA-V Ion Exchange Resins

The total weight of the ion exchange resins is estimated to be 12,000 kg (26,400 lbs) with a volume of 9.75 m^3 (341 ft^3) and a total activity of 3.3E-3 Ci. However, the average specific activity for the entire quantity of resins is 3E-10 Ci/g or less, which is less than the DOT regulatory limit of 2.0E-9 Ci/g for defining waste as radioactive for the purposes of transportation.

Additional Waste Streams

SNL/NM has many uncharacterized waste streams or materials that have yet to be classified as waste. Some of the waste is being temporarily stored onsite, while other waste streams are forecasted by various departments based on planned or scheduled work.

An example of an uncharacterized waste stream is the current inventory of uranium in different forms. This inventory consists of depleted uranium, U^{238}, and natural uranium-contaminated materials. This inventory includes approximately 5850 kg (12,870 lbs) with a volume of 19.2 m^3 (672 ft^3). The total activity of this waste is 1.0 Ci.

For purposes of this EA, it should be noted that although future waste streams have not been identified, they will occur and are expected to be similar to those already identified.

2.1.2. Forecasted (Future) Waste Streams

The waste streams discussed in Section 2.1.1 were generated over a period of approximately 6 years. It is expected that the nature of LLW generation at SNL/NM in the future would be similar to that of the past. Therefore, future waste disposal requirements were calculated based on past waste accumulation and these quantities were factored into the proposed action.

The existing SNL/NM inventory discussed in Section 2.1.1 is approximately 222 m^3 (7770 ft^3) and was generated over a period of approximately 6 years (fiscal years 1989 through 1994) at an annual rate of approximately 37 m^3/yr (1300 ft^3/yr). This rate is expected to continue into the future and the impacts associated with transportation of these wastes are expected to be consistent with and bounded by the impacts described in this EA. Thus, this EA provides coverage for future year shipments of LLW beyond the current SNL/NM inventory. Cumulative impacts have been analyzed to include the waste that would be generated if the DOE-proposed Medical Isotope Production Program at SNL/NM is performed (see Section 4.2.6.3).

There is the potential for the ERP to generate LLW in the future. Due to unknown quantities and characteristics of the ER LLW it was not included in this EA. However, the ERP has prepared the Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico, (DOE/EA-1140), and received a FONSI in March 1996.

2.1.3. Shipment - First Three Years

The analysis of the proposed action is based on transporting "average" packages. The content and form of actual shipments of LLW to a disposal site would be dictated by the WAC of the receiving site. The receiving site specifies WAC for waste shipments, such as those for the curie content for packages. Since no specific packages have been approved for disposal, it is not possible at this time to model precisely the specific waste shipments that would take place as part of the proposed action. To establish a representative estimate of the risks associated with the proposed action, the concept of an average package was developed. An average package is defined by assuming that all of the waste is packaged in a single type of packaging (i.e., 55-gal drum or 4'x4'x7' waste box). The total number of such packagings that would be required to prepare the waste inventory for shipment is then estimated. The average radionuclide inventory per package is estimated, and the shipping campaign is defined in terms of shipping average packages. Once the total number of packages has been determined, the number of shipments necessary to carry out the proposed action can be established. Calculations are not made for 4'x2'x7' boxes because calculation for 55-gallon drums or 4'x4'x7' boxes provide data for the smallest and greatest number of shipments.

The expected risk associated with the proposed action is based on the transportation of average packages. Actual shipments would involve the shipment of packages with radionuclide inventories that vary from the average inventory. Thus, some actual shipments of LLW would present a potentially higher risk than the risk associated with a single shipment of average packages, while other actual shipments would present a lower risk. The risk could range from essentially no radiological risk to a maximum risk associated with the most hazardous truckload of waste that could possibly be configured from the waste inventory. This maximum risk is estimated as the "Maximum Truck Shipment Risk" (see Section 4.2.2). However, the total risk associated with the entire shipping campaign would be accurately defined by the total number of average shipments. In addition, an administrative limit has been established for worker exposure to ensure that the as low as reasonably achievable (ALARA) principle for radiation exposure is practiced. In this case, the additive risk of all average shipments would be equivalent to the additive risk of all of the actual shipments, some involving smaller than average radionuclide inventories and some involving larger than average inventories.

At the present planning phase, it is still uncertain how each waste stream would actually be packaged. For example, some waste could be packaged in 55-gal drums, some in 4'x2'x7' boxes and other waste packaged in 4'x4'x7' waste boxes; or all of the waste could be packaged in one type of container. For this reason two different average package models were developed: an average drum and an average 4'x4'x7' box. To define the possible range of risk associated with the proposed action, a risk assessment was performed for two shipping campaigns: 1) all waste is packaged and shipped in 55-gal drums, and 2) all waste is packaged and shipped in 4'x4'x7' boxes.

Specific shipping campaigns for the first three years, such as the one illustrated in Table 2.1, represent realistic configurations of waste containers. Because the composition of each truck shipment is dependent on the specific waste disposal request (DR) and the acceptance criteria of the receiving site at the time waste lots are ready for disposal, load configuration cannot be determined in advance. For this reason, the radionuclide inventory of the current waste was averaged across the total number of packagings that would be required to ship the waste. It is also uncertain what the exact packaging for each waste stream would be. Thus, two specific shipping campaigns were developed to establish a number of shipments. One campaign is based on all of the average waste being packaged and shipped in 55-gal drums, and the other is based on all of the average waste being shipped in 4'x4'x7' boxes (DOT 7A steel containers). The number of drums or boxes required was based on an estimated volume of 0.21 m^3/drum (7.4 ft^3/drum) and 3.2 m^3/box (111ft^3/box) for waste packaging (Shleien, 1992). The volumetric inventories of current waste in Table A-1 was used to define the number of packagings that would be required. A total of 2487 drums or 178 boxes would be required. Based on the estimates for packagings needed, a shipping campaign for the average waste is illustrated in Table 2.1.

The volumes of waste expected to be shipped each year are based on estimates from SNL/NM LLW waste management organizations. Based on the waste disposal application process with the NTS, it is anticipated that only TA-IV waste would be shipped during the first year of the proposed action. During the two subsequent years, SNL/NM expects to ship approximately half of its remaining waste each year.

Table 2.1 Comparisons of Transportation Campaign Waste Packages for SNL/NM Waste Inventory

Shipping Campaign		Package Type	
		Drums	4'x4'x7' Boxes
First Year	Packages	261	19
	Truck Shipments	5	4
Second Year	Packages	1112	70
	Truck Shipments	20	12
Third Year	Packages	1114	70
	Truck Shipments	20	12
Total	Packages	2487	178
	Truck Shipments	45	28

2.2. Alternatives To The Proposed Action

This section discusses several alternatives to the proposed action. Section 2.2.1 discusses impacts associated with a no action alternative. Section 2.2.2 discusses the alternative of undertaking the proposed action using rail as the primary mode of overland transportation. Section 2.3 discusses the alternative of disposal of the SNL/NM LLW at other DOE sites.

2.2.1. No Action

If SNL/NM does not ship LLW offsite for disposal, the LLW inventory will increase as continuing operations, R&D and environmental restoration activities generate new wastes. This waste material would then be placed in indefinite storage either inside facilities or outside in transportainers. As described below, there is limited space within existing facilities and there are concerns associated with increasing the inventory of LLW for long-term storage outdoors at SNL/NM.

SNL/NM currently stores LLW at several locations throughout the laboratory. (The impacts associated with the no action alternative are discussed further in Section 4.3.1.) Currently the main storage area for LLW is the Radioactive and Mixed Waste Facility (RMWMF) Building 6920, which is located in TA-III. Because storage of LLW at the RMWMF is primarily outdoors, every precaution must be taken to minimize the possibility of releases, and the WAC for this site are more restrictive than those for an indoor site. Wastes that do not meet the RMWMF WAC must be stored by the SNL/NM generator, usually at or near the point of generation in individual laboratories or storage rooms. However, because a centralized storage location is used in terms of maintaining and tracking inventories, it is preferable that wastes be stored at the RMWMF, if possible, where they are under the control of the SNL/NM waste management staff.

Because many of the LLW containers are stored outdoors at the RMWMF, containers are more susceptible to corrosion and labels must be replaced frequently. In addition, ongoing ERP investigations require removal of waste stored at the inactive MWL. For these reasons, SNL/NM has modified Building 6596, located in TA-V, for the storage of LLW. This facility will serve as the main radioactive waste storage area for SNL/NM with an estimated maximum waste storage capacity of 300 m^3 (10,500 ft^3). The existing LLW inventory is approximately 222 m^3 (7770 ft^3). SNL/NM has a mixed waste inventory of 65 m^3 (2275 ft^3).

Indefinite storage of LLW at SNL/NM controlled sites increases the potential for workers to be exposed to radiation during weekly inspections and container maintenance. This is particularly so at the RMWMF where containers exposed to the elements require more frequent maintenance than containers stored indoors. The current configuration of LLW storage at the outdoor storage site has waste stored in both drums and boxes. These containers are stored on the site as well as being housed in transportainers. To allow both workers and visitors access to the outdoor storage site, an external dose rate limit of 5 mrem/hr at one foot from the surface of any container has been established. Two transportainers currently on the site have external dose rate levels of 2 mrem/hr at one foot, and three 4'x4'x7' boxes have external dose rate levels of 5 mrem/hr at one foot. While the majority of the 27 transportainers and approximately 20 boxes that currently contain LLW have undetectable exposure rates, the continual introduction of LLW will increase these exposure rates. To provide storage for increasing quantities of LLW while maintaining exposure levels of less than 5 mrem/hr at one foot, either more storage units will have to be added or the waste will have to be reconfigured in such a way as to reduce the exposure. With increased waste handling, workers will receive more exposure as well as increased potential for accidental release of radioactive waste. Continued long-term storage could possibly result in the need to operate additional outdoor storage areas. Additional storage could result in some environmental alteration because of the need to clear vegetation.

In addition to the small generator-controlled storage locations and the RMWMF, SNL/NM is currently storing some LLW in several of the Manzano bunkers at KAFB. These bunkers are owned by KAFB and leased to SNL/NM. However, the lease agreement with the Air Force stipulates that SNL/NM must vacate the bunkers within 30 days if requested to do so. Therefore, the Manzano bunkers are not considered to be a reliable source for long-term storage.

2.2.2. Rail Transportation

Rail could be used as the primary mode of overland transportation for shipping SNL/NM's LLW to the disposal sites addressed in this EA. Because SNL/NM no longer has a rail spur this alternative would involve transporting the waste by truck from SNL/NM to the Santa Fe Railroad yard near downtown Albuquerque, then transferring the rail cars to a train at the downtown rail yard for shipment. If the waste were being shipped to the NTS, the rail shipment would terminate at Las Vegas, Nevada, because there is no rail spur at the NTS. The waste would be transferred to truck in Las Vegas and transported via highway to the NTS. If the waste was being shipped to the other four sites, it would be shipped directly with the only intermodal transfer at the railroad yard in Albuquerque. If rail were used, the waste packagings would be shipped in 40'x8'x8' transportainers with 60 drums to a transportainer, 2 transportainers per rail car, or sixteen 4'x4'x7' boxes per rail car. For shipments to the NTS, each transportainer would be loaded onto a single truck at Las Vegas, Nevada, for the trip to the NTS.

2.3. Alternatives Considered But Eliminated From Detailed Analysis

Other DOE LLW disposal sites exist at the Idaho National Engineering Laboratory (INEL), Los Alamos National Laboratory (LANL), and the Oak Ridge Reservation. SNL/NM LLW could be disposed of at any of these sites. However, none of these sites currently accepts LLW generated at offsite facilities. Furthermore, because the shipping distances, via approved routes, are less than the greatest distances considered for the proposed disposal sites, the potential impacts and risks of these alternative sites fall within the bounding analysis of the proposed action.

3. AFFECTED ENVIRONMENTS

3.1 Resources Considered But Not Analyzed in Detail

Resources and resource topics considered, but not analyzed in detail because they were not areas that would be potentially impacted by the transportation of LLW, include the following:

- climate
- topography
- archeological artifacts
- historical resources
- economic impacts to industry and business
- threatened and endangered species
- water resources

These resources were not included in the discussion of impacts because the proposed action does not involve excavation, major construction activities, discharges that could affect water quality, or an activity that could otherwise affect the natural and cultural resources SNL/NM.

3.2 SNL/NM

SNL/NM is located primarily on land owned by the DOE within the boundaries of the KAFB in Albuquerque, New Mexico (Figure 3.1). The SNL/NM facilities are 4 km (2.5 mi) south of I-40 and about 10 km (6.2 mi) east of downtown Albuquerque. Besides being the closest population center to KAFB, Albuquerque is the largest population center in the State of New Mexico with 384,736 residents recorded in the 1990 census (DOC, 1990). The city's population count includes the permanent residents in the KAFB housing areas.

Although SNL/NM is surrounded by KAFB and most SNL/NM facilities are located on DOE land, some parts of the facility are located on U.S. Air Force property for which SNL/NM has obtained land use permits. SNL/NM consists of five technical areas and additional remote test areas, all located in the eastern half of the 190-km^2 (74-mi^2) military reservation. A 91-km^2 (22,500-acre) area of the Manzano Mountains east of KAFB has been withdrawn from the U.S. Forest Service for the exclusive use of the U.S. Air Force and the DOE. Currently, SNL/NM is able to use some of this land by applying for and receiving 5-year permits. The mountainous terrain toward the eastern edge of this withdrawal area serves as a buffer zone for high-explosive tests, explosives storage, and other hazardous operations. Areas to the west and south, by agreements with the State of New Mexico and Isleta Pueblo, serve as buffer zones for certain other test operations. Figure 3.2 shows land boundaries within and adjacent to KAFB (SNL, 1993).

KAFB itself is situated on two broad alluvial fans bisected by the Tijeras Arroyo, an east-west canyon. These alluvial fans are bounded by the Manzano Mountains (Cibola National Forest) to the east and the Rio Grande to the west. Elevations in the Albuquerque area range from a low of 1,500 m (4,900 ft) at the Rio Grande to a high of 3,300 m (11,000 ft) at the crest of the Sandia Mountains adjacent to Albuquerque. KAFB is at a mean elevation of 1,630 m (5,350 ft) (SNL, 1993).

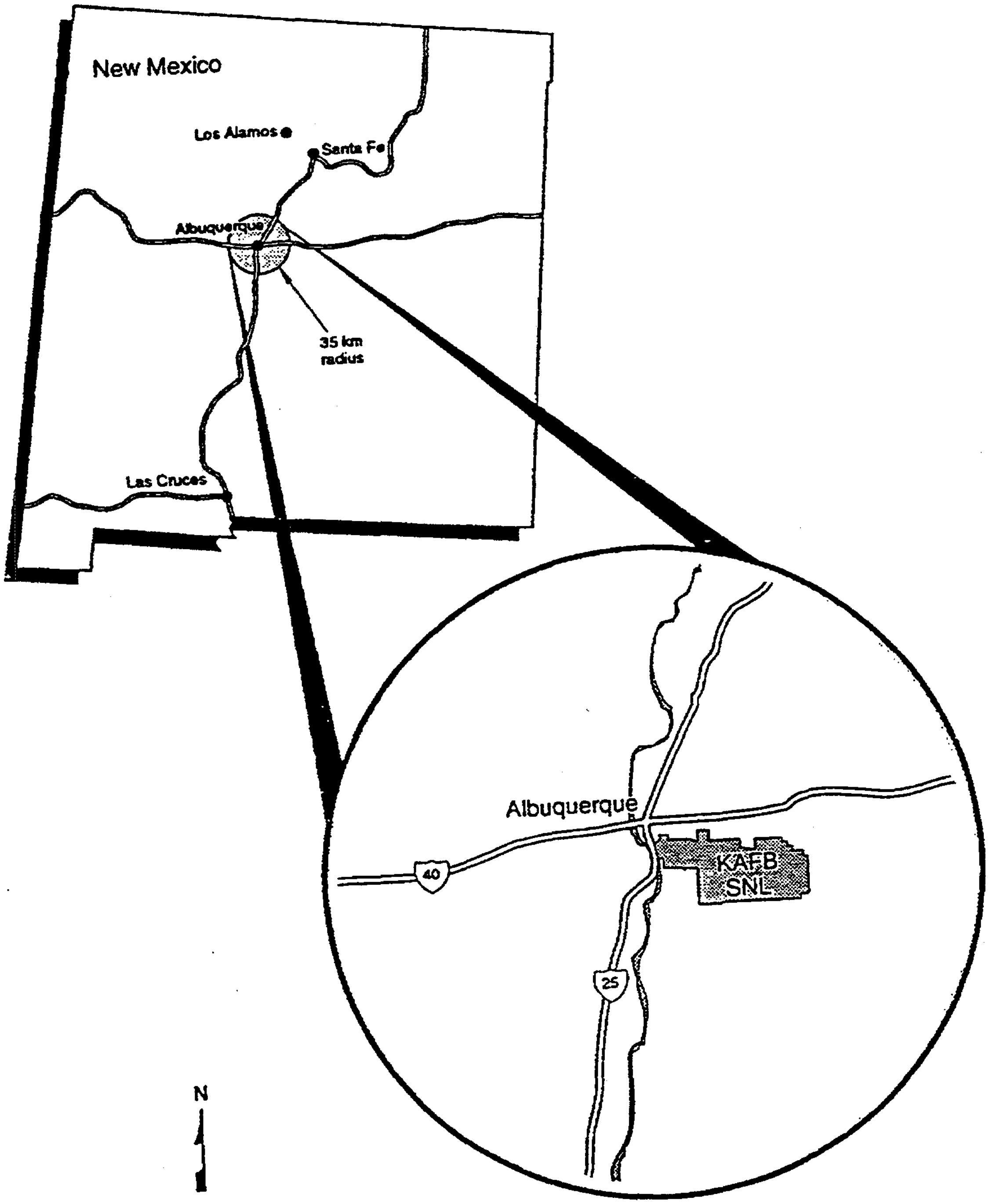

Figure 3.1
General Location Map, SNL/NM, Albuquerque, New Mexico
[based on SNL, 1993, Figure 1-1]

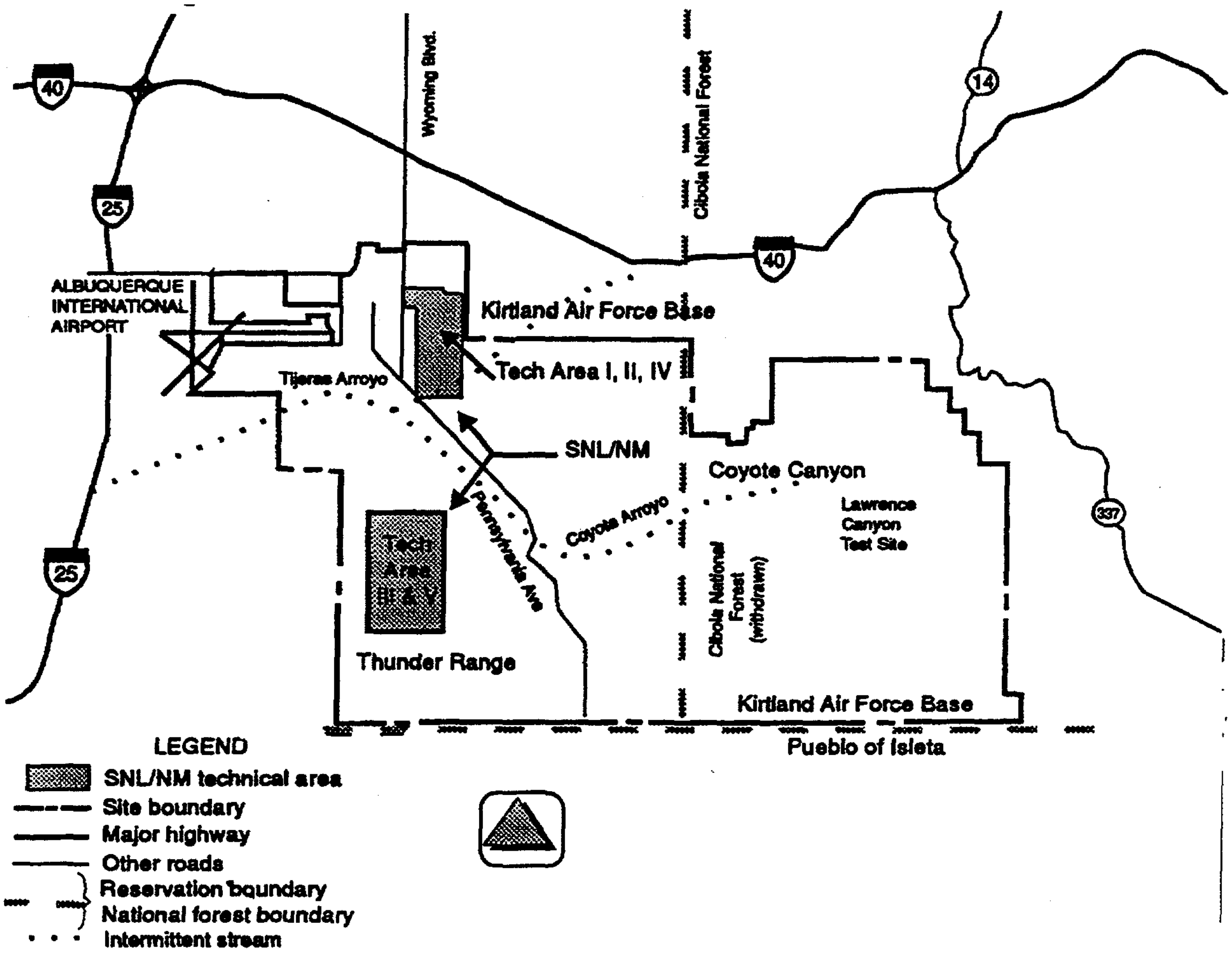

Figure 3.2
Land boundaries Within and Adjacent to SNL/NM and KAFB (SNL, 1993)

3.2.2 Air Quality

The Clean Air Act, Section 176 (c), requires the Environmental Protection Agency (EPA) to establish rules to ensure that Federal agencies actions conform with State Implementation Plans (SIPs). These plans are designed to eliminate or reduce the severity and number of violations of the National Ambient Air Quality Standards (NAAQS). As a result, the EPA promulgated the "General Conformity" rule (58 FR 63214-63259) in November of 1993. This rule applies in areas that are considered "nonattainment" or "maintenance" areas for any of six criteria air pollutants (ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter, and lead). A nonattainment area is one in which the air quality in an area exceeds the allowable NAAQS for one or more pollutants, while a maintenance area is one that has been reassigned from nonattainment to attainment. The conformity rule covers both direct and indirect emissions of criteria pollutants that are caused by Federal actions and which exceed the threshold emission levels shown in 40 CFR 93.153(b). Each affected State is required by Section 176(c) of the 1990 Clear Air Act amendments to devise a SIP, which is designed to achieve the NAAQS.

DOE has integrated the requirements of the conformity rule with those of its NEPA process wherein, for actions not exempted, the total emissions from the proposed action are evaluated to determine if they are above *de minimus* thresholds and if they are regionally significant.

The nonattainment areas for the transportation routes described in Section 3.3 are as follows: For the NTS option, the nonattainment areas are associated with; Kingman, Arizona; and Las Vegas, Nevada. Albuquerque, New Mexico has been upgraded to a maintenance area. For the Hanford and U.S. Ecology options, the nonattainment areas are Albuquerque, New Mexico; Denver, Colorado Springs and Fort Collins, Colorado; Ogden, Utah; and Boise, Idaho. For the SRS and Chem Nuclear options, the nonattainment areas are Albuquerque, New Mexico; Memphis, Nashville, and Chattanooga, Tennessee; and Atlanta, Georgia. For the Envirocare option, the nonattainment areas are Albuquerque, New Mexico; Denver, Fort Collins, Colorado Springs, Colorado; and Salt Lake City, Utah.

For Albuquerque, ambient air quality is regulated by the Albuquerque/Bernalillo County Air Quality Control Board (ABC/AQCB). The ABC/AQCB also monitors compliance with Federal and State air quality regulations. The Air Pollution Control Division under the Albuquerque City Environmental Health Department has set up several ambient air sampling stations throughout the city, including the area 3 km (2 mi) northwest of SNL/NM, to monitor total suspended particulates (TSP), ozone, particulate matter (PM_{10}), carbon monoxide (CO), and nitrous oxide (NO_x). Bernalillo County, which includes Albuquerque, is designated by the EPA as a moderate nonattainment area from vehicle emissions of carbon monoxide.

3.2.3 Noise Sources

Noise sources in the vicinity of SNL/NM can be categorized into two major groups: transportation and stationary sources. Transportation sources are associated with moving vehicles that generally result in producing fluctuating noise levels above the ambient noise level for a short period of time. Transportation sources included those of aircraft, motor vehicles, and rail operations. Nonfluctuating noise levels can result from transportation sources such as a busy highway heard from a distance, which sounds like a constant low hum. Stationary noise sources are those that either do not move or that move relatively short distances. Noise-level fluctuations from stationary sources are caused by operational characteristics and other factors. Stationary noise sources in the vicinity of SNL/NM include ventilation systems, air compressors, generators, power transformers, and earth-moving equipment.

Motor vehicle (highway) noise is also prevalent at SNL/NM and predominant along proposed and alternative transportation routes. Onsite traffic, as well as traffic on roadways and major highways proposed for use, contributes to the overall noise levels. The fluctuation of highway noise (over long periods of time) is associated with the time of day in which peak and off-peak traffic occurs. In addition, noise levels are influenced by vehicle type, road surface conditions (wet or dry), and exhaust systems.

3.2.4 Other Issues Necessary to Support Analyses of Alternatives

A brief discussion of the major technical areas at SNL/NM and the processes ongoing within each is provided here as background for the proposed action and alternatives analysis. SNL/NM is divided into five TAs: I, II, III, IV, and V. In addition, there are three test areas outside the technical areas. Each area is briefly described in the following subsections.

3.2.4.1 TA-I

TA-I has the largest population: approximately 5,000 employees. This area includes a number of small laboratories that generate LLW during R&D activities. No large LLW storage areas are located in TA-I.

3.2.4.2 TA-II

TA-II routinely generates LLW at laboratories and testing facilities that handle neutron generators that contain tritium. No large LLW storage areas are located in TA-II.

3.2.4.3 TA-III

TA-III is located 8 km (5 mi) south of TA-I and is composed of 20 test facilities and two inactive radioactive waste disposal sites. Little LLW is currently generated in TA-III, but this may change as soon as Environmental Restoration Program activities at the inactive LLW disposal site begin in 1996. The RMWMF, located in TA-III, serves as SNL/NM's centralized staging facility for the characterization, compaction, certification, storage, and packaging of LLW. LLW destined for offsite disposal will be prepared for shipment under controlled conditions at the RMWMF.

3.2.4.4 TA-IV

TA-IV consists of several inertial confinement fusion research and pulsed power research facilities. LLW is currently generated at three TA-IV accelerators — the Particle Beam Fusion Accelerator-II, the High-Energy Radiation Megavolt Electron Source-III, and the Sandia Accelerator and Beam Research Experiment (known as PBFA-II, HERMES-III, and SABRE, respectively). No LLW storage areas are located in TA-IV.

3.2.4.5 TA-V

TA-V houses two research reactors (the Annular Core Research Reactor [ACRA] and the SPR) in two reactor facilities: an intense gamma irradiation facility and the HCF. LLW is generated during R&D activities and routine maintenance activities at both reactors and the HCF. Building 6596, which used as the centralized LLW storage facility staging, is located in TA-V.

3.2.4.6 Other Test Facilities

SNL/NM has three test areas outside of the five technical areas. They are located south of TA-III and in the canyon on the west side of the Manzano Mountains. Coyote Canyon Test Field, Lawrence Canyon, and the Thunder Range areas comprise the remaining SNL/NM test areas. These areas have historically produced little LLW and have no LLW storage sites.

3.3 Transportation Routes From SNL/NM

Normally, LLW is transported in containers that are approved by the DOT, the NRC, and the DOE, and that meet the requirements of the waste receiver. The proposed action would follow this procedure. If LLW were transported by commercial truck, the waste would be transported along interstate or other primary highways well suited to cargo-truck transport. If wastes were transported by rail, existing commercial rail routes and schedules would be used.

The highway route characteristics for the five options are shown in Table 3-1:

Table 3.1 Highway Route Distances From SNL/NM To Each Proposed Disposal Site

Disposal Site	Rural Distance	Suburban Distance	Urban Distance	Total Distance
Hanford & U.S. Ecology	2324 km (1441 mi)	224 km (139 mi)	36 km (22 mi)	2584 km (1602 mi)
NTS	945 km (586 mi)	68 km (42 mi)	25 km (16 mi)	1038 km (643 mi)
SRS & Chem Nuclear	2130 km (1320 mi)	473 km (293 mi)	53 km (33 mi)	2556 km (1585 mi)
Envirocare	1533 km (950 mi)	156 km (97 mi)	33 km (21 mi)	1722 km (1068 mi)

Population along the representative routes for the five options are shown in Table 3.2:

Table 3.2 Potentially Exposed Populations Along Highway Routes From SNL/NM To Each Proposed Disposal Site*

Disposal Site	Potentially Exposed Population
Hanford & U.S. Ecology	274,224
NTS	153,102
SRS & Chem Nuclear	226,000
Envirocare	226,000

* Derived using population densities along highway links (Source: Highway 5.0 code)

The railway characteristics for the five alternatives are shown in Table 3.3:

Table 3.3 Railway Route Distances From SNL/NM To Each Proposed Disposal Site

Disposal Site	Rural Distance	Suburban Distance	Urban Distance	Total Distance
Hanford & U.S. Ecology	2720 km (1686 mi)	220 km (136 mi)	35 km (22 mi)	2975 km (1845 mi)
NTS	1511 km (937 mi)	61 km (38 mi)	10 km (6 mi)	1582 km (981 mi)
SRS Chem Nuclear	2960 km (1835 mi)	662 km (410 mi)	78 km (48 mi)	3700 km (2294 mi)
Envirocare	1894 km (1115 mi)	196 km (122 mi)	35 km (22 mi)	2024 km (1258 mi)

The potentially exposed populations residing along side the rail routes from SNL/NM to each of these alternatives are estimated in Table 3.4:

Table 3.4 Potentially Exposed Populations Along Railway Routes From SNL/NM To Each Proposed Disposal Site

Disposal Site	Potentially Exposed Population
Hanford & U.S. Ecology	269,111
NTS	72,864
SRS & Chem Nuclear	682,000
Envirocare	250,000

3.3.1 Roads from SNL/NM to NTS

A representative transportation route between SNL/NM TA-III and the NTS is outlined in Table 3.5 and depicted in Figure 3.3

3.3.2 Roads from SNL/NM to Hanford and U.S. Ecology

A representative route between SNL/NM TA-III and Hanford and U.S. Ecology is shown in Table 3.6 and Figure 3.4

3.3.3 Roads from SNL/NM to the Savannah River Site and Chem Nuclear

A representative route between SNL/NM and TA-III and SRS and Chem Nuclear is shown in Table 3.7 and Figure 3.5.

Table 3.5 A Representative Truck Route from TA-III, SNL/NM, to the Entry Gate at the NTS

Roadway	Road Type	From	To	Setting*	Distance (km)	Traffic (Veh/hr)	Pop. Density (Indiv/km^2)
Pennsylvania St	Local	SNL/NM, TA-III	Wyoming Blvd		6.0		
Wyoming Blvd	Local	Pennsylvania St	KAFB Wyoming Gate	Urban[1]	3.0		
Wyoming Blvd	Local	KAFB Wyoming Gate	I-40 West On Ramp 164	Suburban[2] Urban	1.4 1.8	780 2800	915.7 2684.7
I-40	Interstate	Albuquerque, NM	AZ Border	Rural[3] Suburban Urban	238.2 20.1 7.2	470 780 2800	7.2 498.1 2104.7
I-40	Interstate	AZ Border	Kingman, AZ	Rural Suburban Urban	473.8 20.3 1.6	470 780 2800	1.7 340.2 2142.9
U.S. 93	Primary Highway	Kingman, AZ	NV Border	Rural	115.9	470	1.9
U.S. 93/U.S. 95	Primary Highway	NV Border	Mercury, NV	Rural Suburban Urban	117.2 25.9 14.7	470 780 2800	3.0 568.7 2464.6
Local	Local	Mercury, NV	NTS Guard Station 100	Rural	10.0		
Total		SNL/NM, TA-III	NTS Guard Station 100	Rural Suburban Urban	961.1 67.7 28.3		

* Aggregate Data of Population-Density Zones (Neuahauser, 1992)

1 Urban refers to an area that has a mean population density of 3.861 persons/km^2 and a minimum of 1.670 persons/km^2

2 Suburban refers to an area that has a mean population density of 719 persons/km^2 and a range of 67 to 1,670 persons/km^2

3 Rural refers to an area that has a mean population density of 6 persons/km^2 and a range of 1 to 66 persons/km^2

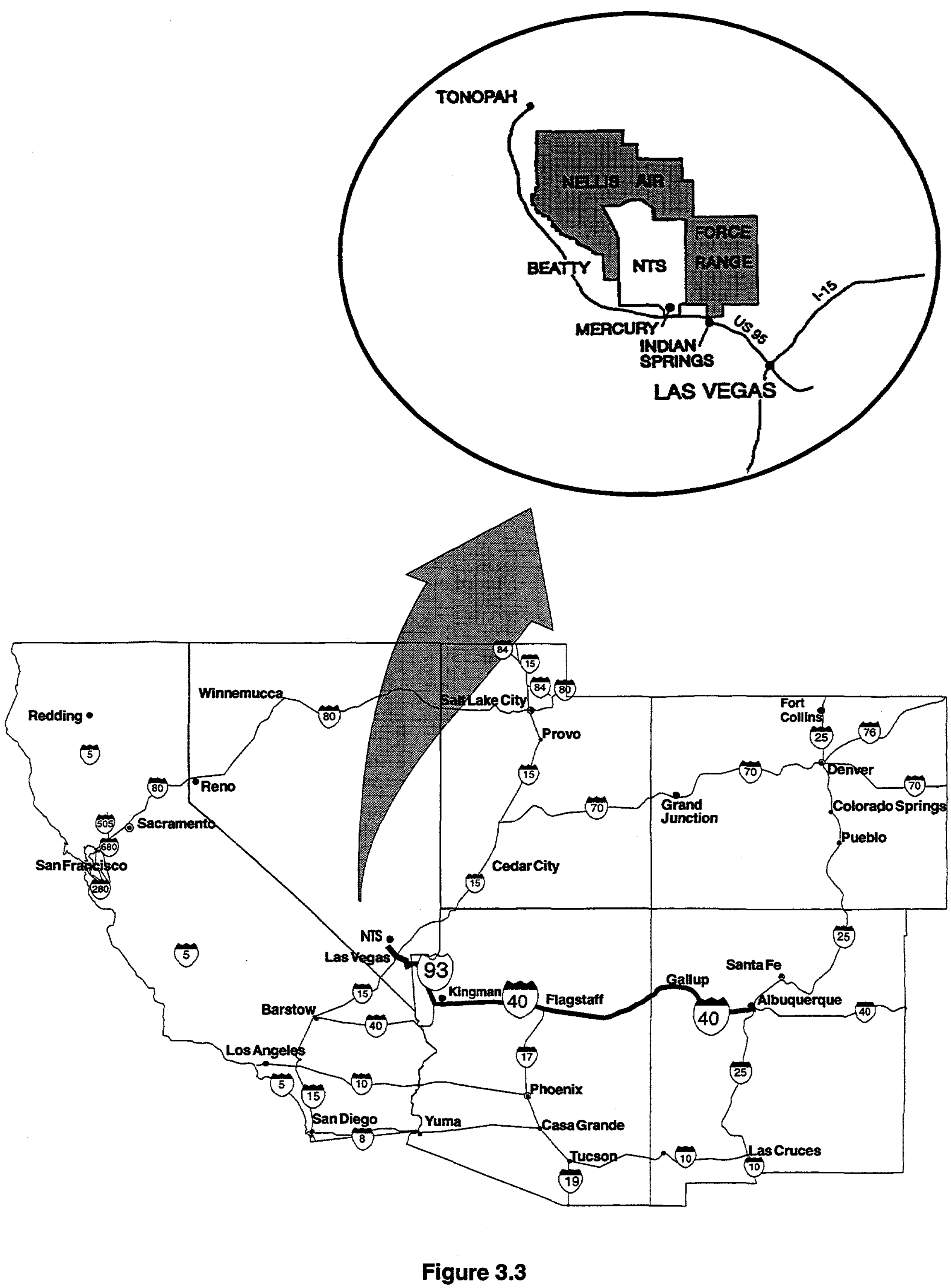

Figure 3.3
Highways from Albuquerque, NM, to the NTS, With an Area Map of the NTS

Table 3.6 A Representative Truck Route from TA-III, SNL/NM, to the Entry Gate at the Hanford Site and U.S. Ecology

Roadway	Road Type	From	To	Setting	Distance (km)	Traffic (Veh/hr)	Pop. Density (Indiv/km^2)
Pennsylvania St	Local	SNL/NM, TA-III	Wyoming Blvd		6.0		
Wyoming Blvd	Local	Pennsylvania St	KAFB Wyoming Gate	Urban	3.0		
Wyoming Blvd	Local	KAFB Wyoming Gate	I-40 West On Ramp 164	Suburban Urban	1.4 1.8	780 2800	915.7 2684.7
I-40/I-25	Interstate	Albuquerque, NM	CO Border	Rural Suburban Urban	355.0 26.6 3.0	470 780 2800	4.1 349.1 2450.9
I-25	Interstate	CO Border	WY Border	Rural Suburban Urban	379.3 83.6 18.2	470 780 2800	5.6 406.4 2067.3
I-25/I-80	Interstate	WY Border	UT Border	Rural Suburban Urban	557.8 32.5 0.3	470 780 2800	2.0 392.5 1764.7
I-80/I-84	Interstate	UT Border	ID Border	Rural Suburban Urban	212.3 23.3 2.3	470 780 2800	4.3 319.0 2394.2
I-84	Interstate	ID Border	OR Border	Rural Suburban Urban	404.7 31.8 5.9	470 780 2800	5.9 344.8 2095.1
I-84/I-82	Interstate	OR Border	WA Border	Rural Suburban Urban	316.2 16.4 2.1	470 780 2800	4.4 360.9 1930.8
I-82	Interstate	WA Border	Richland, WA	Rural Suburban	52.5 3.8	470 780	4.9 218.8
Local	Local	Richland, WA	Hanford Area 200 Gate	Rural Suburban Urban	46.4 4.4 2.4	470 780 2800	2.1 459.7 1995.1
Total		SNL/NM, TA-III	Hanford, Area 200 Gate	Rural Suburban Urban	2330.2 223.8 36.0		

* Aggregate Data of Population-Density Zones (Neuahauser, 1992)

1 Urban refers to an area that has a mean population density of 3.861 persons/km^2 and a minimum of 1.670 persons/km^2

2 Suburban refers to an area that has a mean population density of 719 persons/km^2 and a range of 67 to 1,670 persons/km^2

3 Rural refers to an area that has a mean population density of 6 persons/km^2 and a range of 1 to 66 persons/km^2

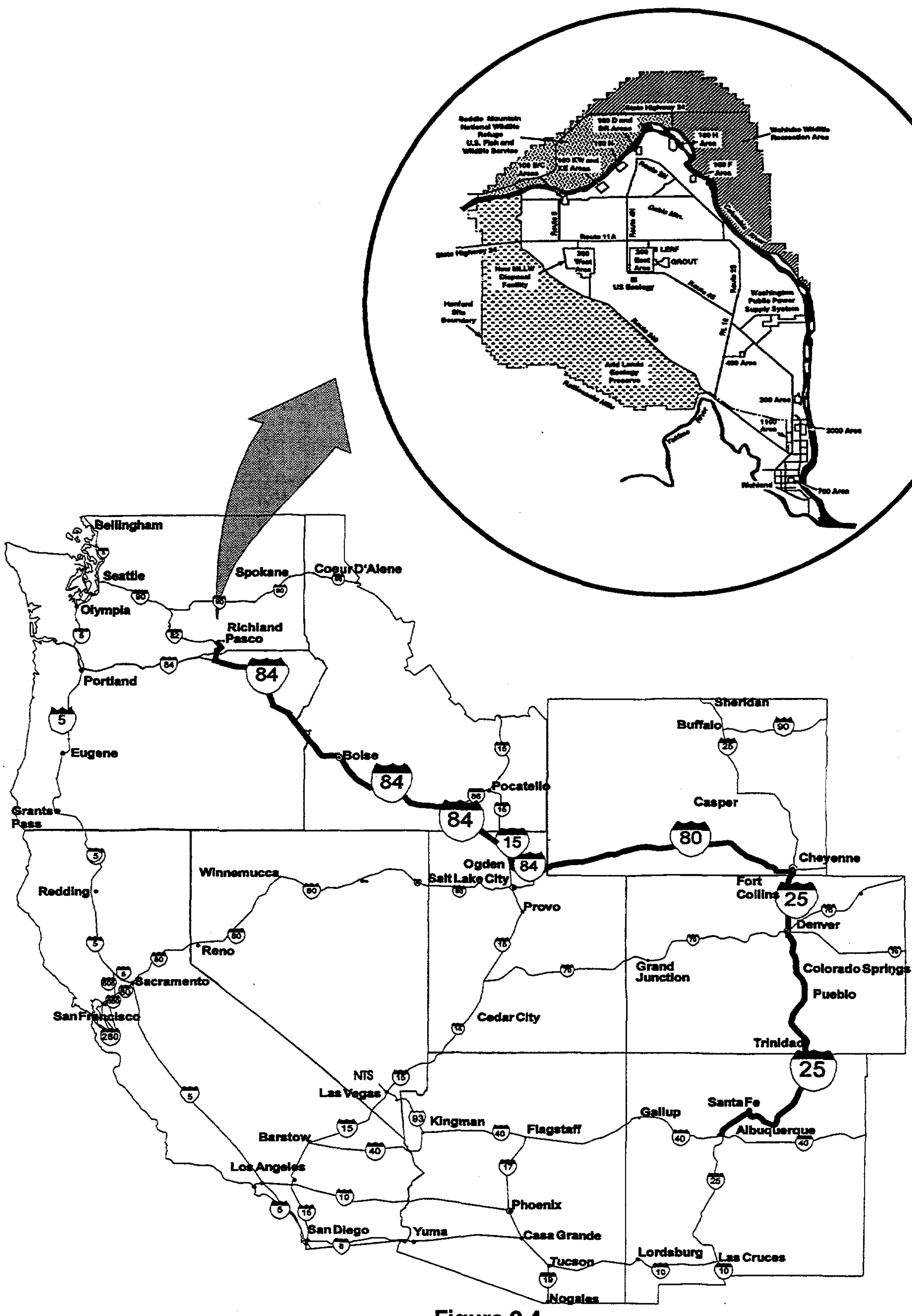

Figure 3.4
Highways from Albuquerque, NM, to Richland, WA, With Area Map of the Hanford Site and U.S. Ecology

Table 3.7 A Representative Truck Route from TA-III, SNL/NM to the Entry Gate at the SRS and Chem Nuclear

Roadway	Road Type	From	To	Setting	Distance (km)	Traffic (Veh/hr)	Pop. Density (Indiv/km^2)
Pennsylvania St	Local	SNL/NM, TA-III	Wyoming Blvd		6.0		
Wyoming Blvd	Local	Pennsylvania St	KAFB Wyoming Gate	Urban	3.0		
Wyoming Blvd	Local	KAFB Wyoming Gate	I-40 On Ramp 164	Suburban Urban	1.4 1.8	780 2800	915.7 2684.7
I-40	Interstate	Albuquerque	Texas Border	Rural Suburban Urban	268 7.1 6.1	470 780 2800	3.1 463.0 2681.0
I-40	Interstate	Texas Border	Oklahoma Border	Rural Suburban Urban	267 13.6 5.3	470 780 2800	2.0 600.0 1798.0
I-40	Interstate	Oklahoma Border	Arkansas Border	Rural Suburban Urban	462 76 5.3	470 780 2800	9.2 274.0 2073.0
I-40	Interstate	Arkansas Border	Tennessee Border	Rural Suburban Urban	375 80 3.1	470 780 2800	11.4 306.0 1838.0
I-40/I-175	Interstate	Tennessee Border	Georgia Border	Rural Suburban Urban	429 120 17	470 780 2800	12.7 372.0 1993.0
I-75/I-20	Interstate	Georgia Border	SC Border	Rural Suburban Urban	236 158 14.6	470 780 2800	14.6 341.0 2258.0
I-20	Interstate	SC Border	N. Augusta, SC	Rural	1.6	470	22.7
SC 230/ SC 125	Highway	N. Augusta, SC	Clearwater, SC	Rural Suburban	1.0 7.1	470 780	8.9 670.0
SC 125	Highway	Clearwater, SC	SRS	Rural Suburban	33.5 3.5	470 780	33.5 3.5

* Aggregate Data of Population-Density Zones (Neuahauser, 1992)

1 Urban refers to an area that has a mean population density of 3.861 persons/km^2 and a minimum of 1.670 persons/km^2

2 Suburban refers to an area that has a mean population density of 719 persons/km^2 and a range of 67 to 1,670 persons/km^2

3 Rural refers to an area that has a mean population density of 6 persons/km^2 and a range of 1 to 66 persons/km^2

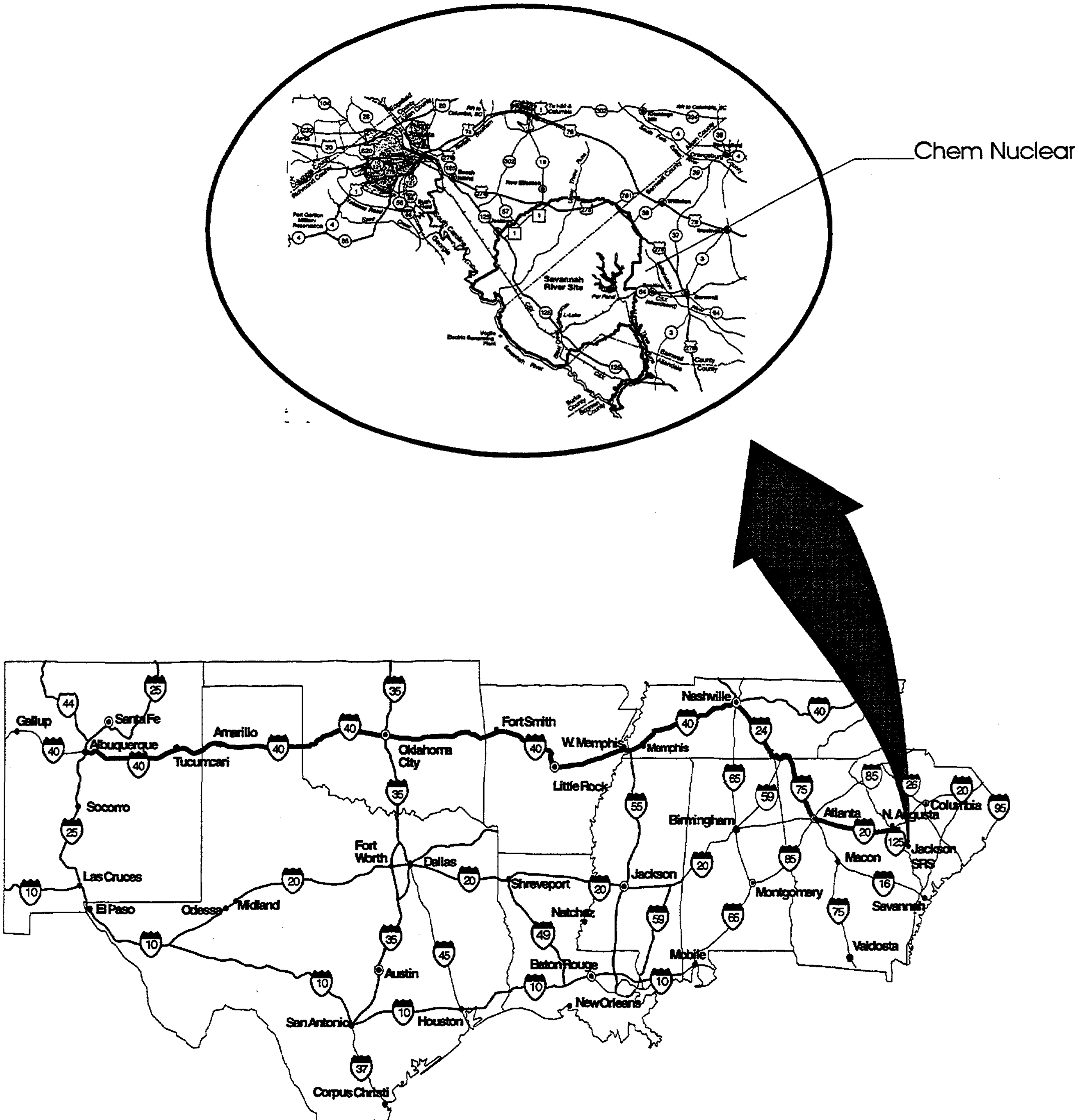

Figure 3.5
Highways from Albuquerque, NM, to Aiken, South Carolina, With an Area Map of the SRS and Chem Nuclear

3.3.4 Roads from SNL/NM to Envirocare

A representative route between SNL/NM TA-III and Envirocare near Clive, Utah, is shown in Table 3.8 and Figure 3.6.

3.3.5 Nonattainment Areas Along Representative Routes

Along the representative routes from SNL/NM to the NTS, there are three nonattainment areas (see Table 3.9); from SNL/NM to Hanford and U.S. Ecology, six nonattainment areas (see Table 3.10); from SNL/NM to SRS and Chem Nuclear, five nonattainment areas (see Table 3.11), and from SNL/NM to Envirocare, six nonattainment areas (see Table 3.12).

Table 3.8 A Representative Truck Route From TA-III, SNL/NM to the Entry Gate at Envirocare, Clive

Roadway	Road Type	From	To	Setting	Distance (km)	Traffic (Veh/hr)	Pop. Density (Indiv/km^2)
Pennsylvania St	Local	SNL/NM, TA-III	Wyoming Blvd		6.0		
Wyoming Blvd	Local	Pennsylvania St	KAFB Wyoming Gate	Urban	3.0		
Wyoming Blvd	Local	KAFB Wyoming Gate	I-40 West On Ramp 164	Suburban Urban	1.4 1.8	780 2800	915.7 2684.7
I-40/I-25	Interstate	Albuquerque, NM	CO Border	Rural Suburban Urban	355.0 26.6 3.0	470 780 2800	4.1 349.1 2450.9
I-25	Interstate	CO Border	WY Border	Rural Suburban Urban	379.3 83.6 18.2	470 780 2800	5.6 406.4 2067.3
I-25/I-80	Interstate	WY Border	UT Border	Rural Suburban Urban	557.8 32.5 0.3	470 780 2800	2.0 392.5 1764.7
I-80	Interstate	UT Border	Knolls, UT	Rural Suburban Urban	235.0 13.0 6.6	470 780 2800	3.6 536.0 2382.0
Local	Local	Knolls, UT	Envirocare	Rural	4.8	470	0.0

* Aggregate Data of Population-Density Zones (Neuahauser, 1992)

1 Urban refers to an area that has a mean population density of 3.861 persons/km^2 and a minimum of 1.670 persons/km^2
2 Suburban refers to an area that has a mean population density of 719 persons/km^2 and a range of 67 to 1,670 persons/km^2
3 Rural refers to an area that has a mean population density of 6 persons/km^2 and a range of 1 to 66 persons/km^2

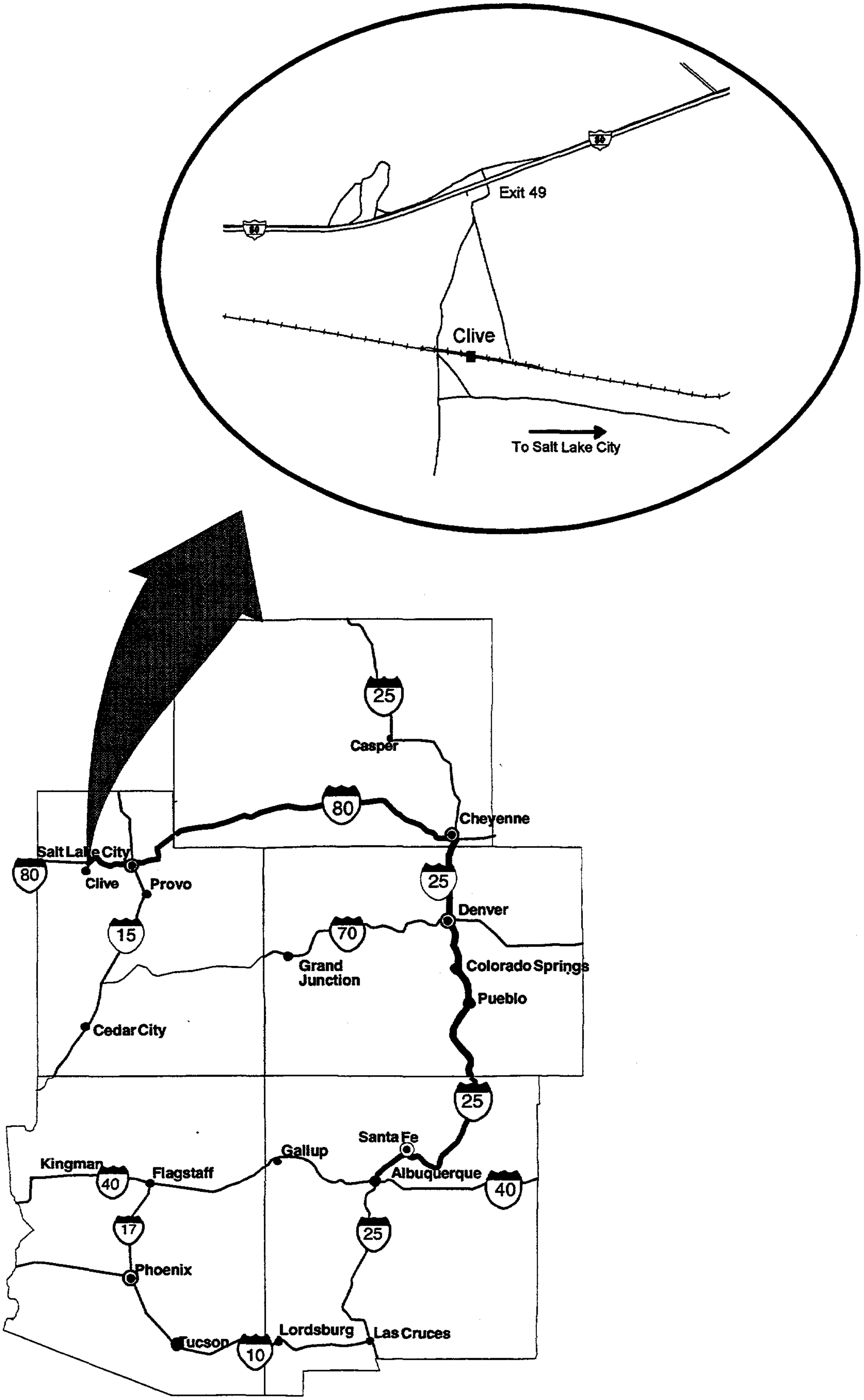

Figure 3.6
Highways from Albuquerque, NM to Clive, Utah, With an Area Map of the Envirocare Site

Table 3.9 EPA Nonattainment Areas Along a Representative Highway Route from SNL/NM to the Nevada Test Site

DESIGNATED AREA	CRITERIA POLLUTANTS			
	CARBON MONOXIDE	OZONE	TSP	PM_{10}
NEW MEXICO				
Bernalillo County	X		X	
ARIZONA				
Mojave County				X
Navajo County			X	
NEVADA				
Clark County	X		X	X

PM_{10}=Total suspended particulates with standards measured as particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers

Table 3.10 EPA Nonattainment Areas Along a Representative Highway Route from SNL/NM to the Hanford Site (U.S. Ecology)

COUNTIES	CRITERIA POLLUTANTS			
	CARBON MONOXIDE	OZONE	TSP	PM_{10}
NEW MEXICO				
Bernalillo County	X		X	
COLORADO				
El Paso County	X		X	
Douglas County	X	X		X
Denver County	X	X	X	X
Adams County	X	X		X
Arapahoe County	X	X		X
Weld County	X			
Larimer County	X			
UTAH				
Weber County	X			X
IDAHO				
Ada County	X			X

PM_{10}=Total suspended particulates with standards measured as particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers

Table 3.11 EPA Nonattainment Areas Along a Representative Highway Route from SNL/NM to Savannah River Site (Chem Nuclear)

CRITERIA POLLUTANTS				
DESIGNATED AREAS	**CO**	**OZONE**	**TSP**	**PM_{10}**
NEW MEXICO				
Bernalillo County	X		X	
TENNESSEE				
Shelby County (Memphis)	X	X		
Davidson County (Nashville)		X	X	
Rutherford County		X		
Sumner County		X		
Williamson County		X		
Wilson County		X		
Fayette County				
Hamilton County (Chattanooga)			X	
GEORGIA				
Cherokee County		X		
Clayton County		X		
Cobb County		X		
Coweta County		X		
De Kalb County		X		
Douglas County		X		
Fayette County		X		
Forsyth County		X		
Fulton County		X		
Gwinnett County		X		
Henry County		X		
Paulding County		X		
Rockdale County		X		

Table 3.12 EPA Nonattainment Area Along a Representative Highway Route from SNL/NM to Envirocare

COUNTIES	CRITERIA POLLUTANTS			
	CARBON MONOXIDE	OZONE	TSP	PM_{10}
NEW MEXICO				
Bernalillo County	X		X	
COLORADO				
El Paso County	X		X	
Douglas County	X	X		X
Denver County	X	X	X	X
Adams County	X	X		X
Arapahoe County	X	X		X
Weld County	X			
Larimer County	X			
UTAH				
Salt Lake County	X	X		X

PM_{10}=Total suspended particulate with standards measured as particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers

3.4 Potentially Affected Population

3.4.1 Workers

Personnel routinely working with the materials described by this action may receive low levels of external exposure to radiation (gamma and x-ray). The dose and impact estimates of LLW storage and processing are contained in the Environmental Assessment for the Radioactive and Mixed Waste Management Facility (DOE/EA-0466, DOE, 1993). For personnel involved with shipments of LLW (e.g., truck crews), the dose rates in the cabs of tractor trucks carrying radioactive waste are required by regulations to be less than 2 mrem/hr (49 CFR173).

3.4.2 General Public

During routine transportation operations, individuals near the shipping containers could receive low levels of external exposure to radiation (gamma and x-ray). No internal exposures would be received since the LLW would be contained within the shipping containers. The various groups of persons potentially at risk from routine operations resulting from overland transportation would be members of the general public. These include the following:

- Persons Along the Transportation Route: This group, often referred to as the off-link population, generally receives the smallest dose. Population doses to persons within 800 m (0.5 mi) on each side of the transport route are estimated.

- Persons Sharing the Transportation Route: Population doses to persons in vehicles traveling in the same direction (including passing vehicles) and in the opposite direction (collectively referred to as the on-link population) are estimated, although their doses, too, are expected to be very small.

- Persons at Stops: Population doses to persons at fuel and rest stops, tire inspection stops, etc., along the route are estimated. In this analysis the stop time was derived by using 0.011 hr/km (.018 hr/mi) as the stop rate for truck shipments (based on national trucking data for long haul shipments). The general public population exposed during each stop was estimated at 50 persons, and the average exposure distance for these persons was 20 m (65 ft). For rail shipments, the stop time in rail yards was derived by using 0.033 hr/km (0.053 hr/mi) (Woodin, 1986). The distribution of both workers and members of the public who live or pass by close to a rail yard is modeled as a uniformly distributed population typical of the suburban population density associated with each particular rail route. The population potentially exposed to radioactive shipments during rail yard stops is estimated by assigning this route-specific, average suburban population density to an area surrounding the radioactive shipment modeled as an annulus with an inner radius of 10 m (32.8 ft) and an outer radius of 400 m (1312 ft). Based on population data from the computerized rail atlas INTERLINE (ORNL, 1992b), the following rail stop populations for the specific rail routes were estimated in Table 3.13:

Table 3.13 Population Density and Potentially Exposed Populations At Each Rail Stop

Route	Rail Stop Population Density	Potentially Exposed Population at Each Rail Stop
SNL/NM - Las Vegas	323 km^{-2}	162
SNL/NM - Hanford/U.S. Ecology	383 km^{-2}	193
SNL/NM - SRS/Chem Nuclear	342 km^{-2}	172
SNL/NM - Envirocare	385 km^{-2}	194

3.4.3 Truck/Rail Route from SNL/NM to NTS

A representative truck/rail route between SNL/NM TA-III and the NTS is shown in Table 3.14.

3.4.4 Truck/Rail Route from SNL/NM to Hanford and U.S. Ecology

A representative truck/rail route between SNL/NM TA-III and Hanford and U.S. Ecology is shown in Table 3.15.

3.4.5 Truck/Rail Route from SNL/NM to SRS and Chem Nuclear

A representative truck/rail route between SNL/NM TA-III and SRS and Chem Nuclear is shown in Table 3.16.

3.4.6 Truck/Rail Route from SNL/NM to Envirocare

A representative truck/rail route between SNL/NM TA-III and Envirocare is shown in Table 3.17.

Table 3.14 A Representative Truck and Rail Route from TA-III, SNL, to NTS

Truck Route From SNL/NM to ATSF Rail Yard, Albuquerque, NM			
Road Type	**From**	**To**	**Distance (km)**
Local	SNL/NM, TA-III	KAFB Gibson Gate	10
Local	KAFB Gibson Gate	ATSF Rail Yard, 2nd St. and Woodward	8
Rail Route From Albuquerque To Las Vegas			
Rail Road	**From**	**To**	**Distance (km)**
ATSF	Albuquerque, NM	Dalies, NM	9
ATSF	Dalies, NM	Grants, NM	61
ATSF	Grants, NM	Flagstaff, AZ	283
ATSF	Flagstaff, AZ	Barstow, CA	401
Union Pacific	Barstow, CA	Las Vegas, NV	164
Truck Route From Las Vegas, Nevada to NTS			
Road Type	**From**	**To**	**Distance (km)**
Local	Union Pacific Rail Yard	U.S. 95B	1
Highway	U.S. 95B	U.S. 95	7
Highway	U.S. 95B and U.S. 95	Mercury, NV.	51
Local	Mercury, NV.	NTS Guard Station 100	10

Table 3.15 A Representative Truck and Rail Route from TA-III, SNL, to Hanford and U.S. Ecology

Truck Route From SNL/NM to ATSF Rail Yard, Albuquerque, NM			
Road Type	**From**	**To**	**Distance (km)**
Local	SNL/NM, TA-III	KAFB Gibson Gate	10
Local	KAFB Gibson Gate	ATSF Rail Yard, 2nd St. and Woodward	8
Rail Route From Albuquerque To Hanford and U.S. Ecology			
Rail Road	**From**	**To**	**Distance (km)**
ATSF	Albuquerque, NM	Denver, CO	564
Union Pacific	Denver, CO	Cheyenne, WY	110
Union Pacific	Cheyenne, WY	Pocatello, ID	543
Union Pacific	Pocatello, ID	Richland, WA	594
United States Government	Richland, WA	Hanford Reservation	36

Table 3.16 A Representative Truck and Rail Route from TA-III, SNL/NM, to SRS and Chem Nuclear

Truck Route From SNL/NM to ATSF Rail Yard, Albuquerque, NM			
Road Type	**From**	**To**	**Distance (km)**
Local	SNL/NM, TA-III	KAFB Gibson Gate	10
Local	KAFB Gibson Gate	ATSF Rail Yard, 2nd St. and Woodward	8
Rail Route From Albuquerque To SRS			
Rail Road	**From**	**To**	**Distance (km)**
ATSF	Albuquerque, NM.	Belen, NM	18
ATSF	Belen, NM	Amarillo, TX	345
ATSF	Amarillo, TX	Avard, OK	215
ATSF	Avard, OK	Wellington, KS	100
ATSF	Wellington, KS	Kansas City, MO	225
ATSF	Kansas City, MO	Lomax, IL	245
ATSF	Lomax, IL	Joliet, IL	52
CSXT	Joliet, IL	Terre Haute, IN	192
CSXT	Terre Haute, IN	Henderson, KY	116
CSXT	Henderson, KY	Nashville, TN	158
CSXT	Nashville, TN	Dalton, GA	197
CSXT	Dalton, GA	Atlanta, GA	93
CSXT	Atlanta, GA	Augusta, GA	175
CSXT	Augusta, GA	SRS, SC	46

Table 3.17 A Representative Truck and Rail Route from TA-III, SNL, to Envirocare

Truck Route From SNL/NM to ATSF Rail Yard, Albuquerque, NM			
Road Type	**From**	**To**	**Distance (km)**
Local	SNL/NM, TA-III	KAFB Gibson Gate	10
Local	KAFB Gibson Gate	ATSF Rail Yard, 2nd St. and Woodward	8
Rail Route From Albuquerque To Envirocare, Clive, Utah			
Rail Road	**From**	**To**	**Distance (km)**
ATSF	Albuquerque, NM	Denver, CO	573
Union Pacific	Denver, CO	Laramie, WY.	156
Union Pacific	Laramie, WY	Ogden, UT	419
Union Pacific	Ogden, UT	Salt Lake City, UT	64
Union Pacific	Salt Lake City, UT	Clive, UT	74

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4. ENVIRONMENTAL IMPACTS

4.1. Overview

The proposal to transport LLW offsite for disposal has been designed in a manner consistent with the requirements of DOE Order 5820.2A, "Radioactive Waste Management," as well as applicable Federal, State, and local requirements. The procedures for preparing LLW for shipment and transport are designed to meet the radiation protection standards and environmental protection standards (chemical hazards) as established in DOE Order 5480.11, "Radiation Protection for Occupational Workers"; P.L. 91-512; the RCRA; and the WAC for the selected disposal site.

Waste packaging requirements for LLW include DOE Order 1540.1, "Materials Transportation and Traffic Management"; Title 49 CFR 173.474, "Quality Control for Construction of Packaging"; and Title 49 CFR 173.475, "Quality Control Requirements Prior to Shipment of Radioactive Materials." Other sections of the DOT regulations in Title 49 govern packaging features and waste configurations related to nuclear heating, radiation level limitations, and activity limits.

Finally, waste generators are required to develop a waste certification program as required by DOE Order 5820.2A to ensure that the appropriate WAC are met. The standards for this program derive from the American Society of Mechanical Engineers (ASME) NQA-1 Quality Assurance Program (ASME, 1994) and its supplements.

This chapter considers the potential environmental impacts associated with the transportation of approximately 444 m^3 (15,540 ft^3) of LLW generated by SNL/NM's facilities on KAFB and sent to the NTS (Mercury, Nevada); the Hanford Reservation or U.S. Ecology near Richland, Washington; the Savannah River Site or Chem Nuclear near Aiken, South Carolina; or Envirocare at Clive, Utah. The purpose of the shipments is to permanently dispose of the LLW at appropriate DOE disposal sites. The environmental impact analysis examines both routine and accident conditions associated with overland transport of the LLW to either the NTS, SRS, Chem Nuclear, Envirocare, U.S. Ecology, or Hanford. Radiological (i.e., impacts from potential exposure to radioactivity) and nonradiological impacts (i.e., impacts such as those caused by truck accidents) are estimated. Potentially affected groups of people would include State safety inspectors or disposal site inspectors, truck crews, and members of the general public.

4.2. Proposed Action

The potential impacts associated with transporting approximately 444 m^3 of SNL/NM LLW are illustrated and discussed in this section. The shipments are modeled according to the transportation campaign as defined in Section 2.1.3 for the average waste stream. In order to bound the potential risk from accidents, transportation of LLW in this EA was modeled for two different shipping configurations representing a maximum and minimum number of shipments:

1. Sixty 55-gal drums per truck (120 drums per rail car for the rail alternative), and

2. Six 4'x4'x7' waste boxes per truck (16 boxes per rail car for the rail alternative).

Section 4.2.1 describes impacts of routine operations. Section 4.2.2 describes risks of highway accidents. Section 4.2.3 describes the total radiological impacts of the proposed action, and Section 4.2.4 describes the total nonradiological impacts of transportation.

4.2.1. Impacts of Routine Operations

Workers and Public

Impacts for all of the options of the proposed action are shown in Tables 4.1 through 4.4 based on risk estimates in Table 4.5. The estimates for impacts associated with the option of shipping the waste to Hanford, U.S. Ecology, SRS, Chem Nuclear, and Envirocare are roughly double the estimates for the option of shipping to the NTS. The largest contributor to incident-free impacts is the exposure to the public during rest stops, followed by the exposure to the truck crew. The dose estimates in Tables 4.1 through 4.4 represent total dose across all the persons within each population group. Thus, for the NTS option, the dose estimates for the public at rest stops of 0.16 person-rem for the first year (0.13 for shipments of boxes) would be spread across 50 persons at each stop over a total of 11.6 hours of rest stops per shipment 0.011 hr/km x 1057 km (.018 hr/mi).

The incident-free impacts vary according to the distance over which the waste must be shipped and the potentially exposed population living along the transportation route modeled in the RADTRAN dose assessment. The potentially exposed populations along these routes are estimated from the route distances and the appropriate population densities. This information is derived using the Highway 5.0 code, a routing model that computes population densities along all highway links (ORNL, 1992a). These parameters are combined with the width of the transportation corridor in which incident-free consequences are modeled by RADTRAN 4. This width is 1.6 km (1 mi).

Dose estimates for "drums only" are higher than for "boxes only," because more truck shipments are required when wastes are packaged in drums. A truck loaded with waste packaged in drums can transport approximately 13 m^3 (435 ft^3) of waste (60 drums), while a truck loaded with boxed waste can transport approximately 19 m^3 (665 ft^3) of waste (6 boxes). The Transportation Index (TI) for a truckload of average waste packaged in drums is calculated to be 2.3 mrem/hr, and for a truckload of boxed waste the TI is 4.6 mrem/hr. These two parameters, the number of shipments and the TI, yield higher dose estimates for the "drums only" scenario than for the "boxes only" scenario.

Maximally Exposed Individual

The term maximally exposed individual refers to an individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters (98 ft).

The maximally exposed individual dose estimates as presented in Tables 4.1 through 4.4 demonstrate the relatively low dose that a single individual might likely receive. The differences between the maximally exposed individual dose estimates and the dose estimates for the public population groups demonstrate the impact of population groups on dose estimates.

"Traffic Jam" Maximally Exposed Individual

The dose to an individual who is situated next to an average shipment of SNL/NM LLW was estimated to establish a perspective on possible "off-normal," nonaccident impacts associated with the proposed action. The dose estimate for an individual who remains next to an average shipment for 2 hours at a distance of 2 m (6.5 ft) is 2.3 mrem (1.2E-06 Latent Cancer Fatalities [LCFs]) for a shipment of drums and 4.0 mrem (2.0E-06 LCFs) for a shipment of 4'x4'x7' boxes. See Appendix C1, for a discussion on health effect models.

Table 4.1 Maximum Annual Incident-Free Impacts for Highway Shipments of SNL/NM LLW to the NTS

Nevada Test Site - Incident-Free Impacts - Total Dose Estimates for All Highway Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	9.3E-03	4.7E-06	3.8E-02	1.9E-05	3.8E-02	1.9E-05
	Boxes*	7.8E-03	3.9E-06	2.4E-02	1.2E-05	2.4E-02	1.2E-06
Public On Link	Drums	6.0E-02	3.0E-05	0.24	1.2E-04	0.24	1.2E-04
	Boxes	4.9E-02	2.5E-05	0.15	7.4E-05	0.15	7.4E-05
Public Stops	Drums	0.43	2.1E-04	1.7	8.6E-04	1.7	8.6E-4
	Boxes	0.35	1.8E-04	1.1	5.4E-04	1.1	5.4E-04
Total Public	Drums	0.50	2.5E-04	2.0	1.0E-03	2.0	1.0E-03
	Boxes	0.41	2.1E-04	1.2	6.2E-04	1.2	5.2E-04
Crew	Drums	0.16	6.4E-05	0.64	2.6E-04	0.64	2.6E-04
	Boxes	0.13	5.4E-05	0.40	1.6E-04	0.40	1.6E-04
Total (Public and Crew)	Drums	0.66	3.3E-04	2.6	1.3E-03	2.6	1.3E-03
	Boxes	0.55	2.7E-04	1.6	8.2E-04	1.6	8.2E-04
Maximally Exposed Individual	Drums	1.1E-06	5.7E-10	4.6E-06	2.2E-09	4.6E-06	2.2E-09
	Boxes	9.4E-07	4.7E-10	2.8E-06	1.4E-09	2.8E-06	1.4E-09

* 4'x4'x7' Steel boxes

Table 4.2 Maximum Annual Incident-Free Impacts for Highway Shipment of SNL/NM LLW to Hanford and U.S. Ecology

Hanford Reservation - Incident-Free Impacts - Total Dose Estimates for Highway All Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	9.2E-03	4.6E-06	3.6E-02	1.8E-05	3.6E-02	1.8E-05
	Boxes*	7.7E-03	3.8E-06	2.4E-02	1.2E-05	2.4E-02	1.2E-05
Public On Link	Drums	7.1E-02	3.6E-05	0.28	1.4E-04	0.28	1.4E-04
	Boxes	5.9E-02	3.0E-5	0.18	8.8E-05	0.18	8.8E-05
Public Stops	Drums	1.1	5.3E-04	4.2	2.2E-03	4.2	2.2E-03
	Boxes	0.88	4.4E-04	2.6	1.3E-03	2.6	1.3E-03
Total Public	Drums	1.1	5.7E-04	4.6	2.2.E-03	4.6	2.2E-03
	Boxes	0.95	4.7E-04	2.8	1.4E-03	2.8	1.4E-03
Crew	Drums	0.39	1.6E-04	1.6	6.2E-04	1.6	6.2E-04
	Boxes	0.32	1.3E-04	0.98	3.8E-04	0.98	3.8E-04
Total (Public and Crew)	Drums	1.5	7.6E-04	6.0	3.0E-03	6.0	3.0E-03
	Boxes	1.3	6.3E-04	3.8	1.9E-03	3.8	1.9E-03
Maximally Exposed Individual	Drums	1.1E-06	5.7E-10	4.6E-06	2.2E-09	4.6E-06	2.2E-09
	Boxes	9.4E-07	4.7E-10	2.8E-06	1.4E-09	2.8E-06	1.4E-09

* 4'x4'x7' Steel boxes

Table 4.3 Maximum Annual Incident-Free Impacts for Highway Shipment of SNL/NM LLW to SRS and Chem Nuclear

Savannah River Site - Incident-free Impacts - Total Dose Estimates for All Highway Shipments							
Risk Group	**Packaging**	**First Year**		**Second Year**		**Third Year**	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	1.4E-02	7.1E-06	5.6E-02	2.8E-05	5.6E-02	2.8E-05
	Boxes*	1.2E-02	5.9E-06	3.6E-02	1.8E-05	3.6E-02	1.8E-05
Public On Link	Drums	7.5E-02	3.7E-05	0.30	1.5E-04	0.30	1.5E-04
	Boxes	6.2E-02	3.1E-05	0.18	9.4E-05	0.18	9.4E-05
Public Stops	Drums	1.1	5.4E-04	4.4	2.2E-03	4.4	2.2E-03
	Boxes	0.90	4.5E-04	2.8	1.4E-03	2.8	1.4E-03
Total Public	Drums	1.2	5.9E-04	4.6	2.4E-03	4.6	2.4E-03
	Boxes	0.98	4.9E-04	3.0	1.4E-03	3.0	1.4E-03
Crew	Drums	0.40	1.6E-04	1.6	6.4E-04	1.6	6.4E-04
	Boxes	0.33	1.3E-04	1.0	4.0E-04	1.0	4.0E-04
Total (Public and Crew)	Drums	1.6	7.9E-04	6.2	3.26E-03	6.2	3.2E-03
	Boxes	1.3	6.5-04	4.0	1.8E-03	4.0	1.8E-03
Maximally Exposed Individual	Drums	1.1E-06	5.7E-10	4.6E-06	2.2E-09	4.6E-06	2.2E-09
	Boxes	9.4E-07	4.7E-10	2.8E-06	1.4E-09	2.8E-06	1.4E-09

* 4'x4'x7' Steel boxes

Table 4.4 Maximum Annual Incident-Free Impacts for Highway Shipment of SNL/NM LLW to Envirocare

Envirocare - Incident Free Impacts - Total Dose Estimates For all Highway Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	7.2E-03	3.6E-06	2.9E-02	1.4E-05	2.9E-02	1.4E-05
	Boxes*	5.9E-03	3.0E-06	1.8E-02	8.9E-06	1.8E-02	8.9E-06
Public On Link	Drums	5.2E-02	2.6E-05	0.21	1.0E-04	0.21	1.0E-04
	Boxes	4.3E-02	2.1E-05	0.13	6.4E-05	0.13	6.3E-05
Public Stops	Drums	0.70	3.5E-04	2.8	1.4E-03	2.8	1.4E-03
	Boxes	0.58	2.9E-04	1.8	8.8E-04	1.8	8.8E-04
Total Public	Drums	0.76	3.8E-04	3.0	1.5E-03	3.0	1.5E-03
	Boxes	0.63	3.2E-04	1.9	9.5E-04	1.9	9.5E-04
Crew	Drums	0.26	1.0E-04	1.0	4.1E-04	1.0	4.1E-04
	Boxes	0.22	8.6E-05	0.65	2.6E-04	0.65	2.6E-04
Total (Public and Crew)	Drums	1.0	5.1E-04	4.1	2.0E-03	4.1	2.0E-03
	Boxes	0.85	4.2E-04	2.5	1.3E-03	2.5	1.3E-03
Maximally Exposed Individual	Drums	1.1E-06	5.7E-10	4.5E-06	2.3E-09	4.5E-06	2.3E-09
	Boxes	9.4E-07	4.7E-10	2.8E-06	1.4E-09	2.8E-06	1.4E-09

* 4'x4'x7' Steel boxes

4.2.2. Risks of Highway Accidents

As can be seen from the risk estimates in Table 4.5, the truck transportation risk associated with the option of shipping the waste to Hanford, U.S. Ecology, SRS, Chem Nuclear, and Envirocare is roughly a factor of two higher than that for the NTS option. The risks vary according to the distance over which the waste must be shipped and the potentially exposed population living along the transportation route modeled in the RADTRAN risk assessment. As stated in Section 4.2.1, the distance of a representative highway route between SNL/NM and the NTS is roughly half the distance of a route from SNL/NM to the other sites (see Table 3.1), and the potentially exposed population along the representative route from SNL/NM to the NTS is also roughly half that for the route from SNL/NM to the other sites. The annual risk estimates in Table 4.5 are calculated by generating route specific risk estimates per truck shipment with RADTRAN 4, and then multiplying the number of shipments per year by the risk associated with each shipment.

Acute radiological accident facilities were estimated to be 0.0 in the RADTRAN 4 analysis.

Table 4.5 Maximum Annual Accident Risk Estimates for Highway Shipment of SNL/NM LLW to All Proposed Disposal Sites

Accident Risk Estimates - Dose Risk and LCF Risk - All Highway Shipments							
Disposal Site Option	Packaging	First Year		Second Year		Third Year	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
NTS	Drums	1.9E-03	9.4E-07	7.6E-03	3.8E-06	7.6E-03	3.8E-06
	Boxes*	2.3E-03	1.2E-06	7.0E-03	3.4E-06	7.0E-03	3.4E-06
Hanford & U.S. Ecology	Drums	3.6E-03	1.8E-06	1.4E-02	7.2E-06	1.4E-02	7.2E-06
	Boxes	4.5E-03	2.2E-06	1.3E-02	6.8E-06	1.3E-02	6.8E-06
SRS & Chem Nuclear	Drums	5.2E-03	2.6E-06	2.1E-02	1.0E-05	2.1E-02	1.0E-05
	Boxes	6.4E-03	3.2E-06	1.9E-02	9.6E-06	1.9E-02	9.6E-06
Envirocare	Drums	2.9E-03	1.5E-06	1.2E-02	5.8E-06	1.2E-02	5.8E-06
	Boxes	3.6E-03	1.8E-06	1.1E-02	5.4E-06	1.1E-02	5.4E-06

* 4'x4'x7' Steel boxes

<u>Bounding Truck Accident Analysis</u>

A bounding accident analysis for the truck shipments was performed to establish a perspective on both high end credible accident consequences and the probability of such consequences. The bounding truck accident analysis is defined from a RADTRAN 4 analysis of the most potentially hazardous truck shipment that could be configured from the current LLW inventory such that the risk associated with this shipment would be greater than the risk associated with any other possible shipment configurations of SNL/NM LLW. For this proposed action, the truck shipment analyzed for the bounding accident analysis would be a truck load of 60 drums, each containing 2 cans of thorium dioxide powder (see Section 2.1.1 for a description of this waste stream). In the event of a severe accident, the thorium powder would be the most dispersible of any of the SNL/NM LLW streams.

The bounding truck accident analysis was quantified by performing a RADTRAN 4 accident risk analysis for the thorium powder truck shipment for each of the disposal option routes. The individual route link results were reviewed to identify the single highest link-specific consequence estimate and its associated expected accident frequency (a combination of the expected number of accidents for a specific link and the accident severity category probability associated with the highest consequence estimate). In Table 4.6 the consequence estimates and the expected frequency of the bounding accident analysis are shown for each disposal route option.

The bounding accident for each option is the same. This is because the RADTRAN 4 accident analysis identifies a specific section of the route from KAFB through Albuquerque enroute to the interstate highway as the route segment with the greatest potential consequences. This link is located in an urban setting and the conveyance travels on city streets through densely populated areas and congested streets. All other urban route segments through which the truck shipments must pass (e.g., Denver, Colorado; Las Vegas, Nevada; Nashville, Tennessee) involve the use of highway and interstate roads through population areas that are less dense than that for the Albuquerque link. Several of the other urban segments have population densities very close to (but never equal to or greater than) the link in Albuquerque.

Table 4.6 Bounding Truck Accident Analysis

Disposal Option	Dose Estimate (Person-rem)	Expected Frequency (Accidents/Truck Shipment)	Risk (Person-rem/Truck Shipment)
NTS	2620	1.2E-08	3.1E-05
Hanford & U.S. Ecology	2620	1.2E-08	3.1E-05
SRS & Chem Nuclear	2620	1.2E-08	3.1E-05
Envirocare	2620	1.2E-08	3.1E-05

4.2.3. Total Radiological Impacts of the Proposed Action

The total estimated radiological impact associated with the proposed action is the sum of the incident-free impact estimates and the accident risk estimates. The total is summed across all of the individual population groups for incident-free impacts (truck crew, general public) and the accident risk estimate. The results are shown in Table 4.7. A comparison of Table 4.6 to the incident-free impact estimates in Tables 4.1 through 4.4 and the accident risk estimates in Table 4.7 shows that incident-free impacts dominate the potential consequences associated with the proposed action.

Table 4.7 Total Radiological Impacts for Highway Shipment of SNL/NM LLW to All Proposed Disposal Sites

Total Impact Estimates - Incident-Free Impact and Accident Risk							
Disposal Site Option	**Packaging**	**First Year**		**Second Year**		**Third Year**	
		Drums: 5 Shipments Boxes: 4 Shipments		Drums: 20 Shipments Boxes: 12 Shipments		Drums: 20 Shipments Boxes: 12 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
NTS	Drums	0.66	3.3E-04	2.6	1.3E-03	2.6	1.3E-03
	Boxes*	0.55	2.7E-04	1.6	8.2E-04	1.6	8.2E-04
Hanford & U.S. Ecology	Drums	1.5	7.6E-04	6.0	3.0E-03	6.0	3.0E-03
	Boxes	1.3	6.3E-04	3.8	1.9E-03	3.8	1.9E-03
SRS & Chem Nuclear	Drums	1.6	7.9E-04	6.2	3.2E-03	6.2	3.2E-03
	Boxes	1.3	6.5E-04	4.0	1.8E-03	4.0	1.8E-03
Envirocare	Drums	1.0	5.1E-04	4.1	2.0E-03	4.1	2.0E-03
	Boxes	0.85	4.2E-04	2.5	1.3E-03	2.5	1.3E-03

* 4'x4'x7' Steel boxes

4.2.4. Nonradiological Impacts of Transportation

4.2.4.1. Nonradiological Incident-Free Health Effects and Accident Risks

Nonradiological incident-free impacts and accident risks estimates are summarized in Table 4.8. See Appendix C for a discussion of the methodology.

Nonradiological accident fatality risk estimates are approximately two orders of magnitude higher than the radiological accident risk estimates. This difference can be attributed to the fact that nonradiological fatalities can occur even in very low severity accidents and to the fact that nonradiological risks are estimated over twice the distance compared to that of radiological risks. This is because for nonradiological risks the entire round trip distance is relevant to the impact assessment, whereas for radiological transportation risks there are no transportation risks once the waste has been delivered to its disposal site.

Table 4.8 Maximum Annual Nonradiological Fatalities Associated with Highway Shipments of SNL/NM LLW to Proposed Disposal Sites

Year	Disposal Site Option	Annual Incident-Free Health Effects from Vehicle Emissions (LCFs)	Annual Traffic Accident Fatalities (Deaths)	
		All Population Groups	Public	Workers
First Year (5 Shipments)	NTS	1.0E-04	2.0E-03	1.2E-03
	Hanford & U.S. Ecology	1.4E-04	5.1E-03	2.8E-03
	SRS & Chem Nuclear	2.1e-04	4.8e-03	1.4e-03
	Envirocare	3.0e-05	8.4e-04	2.4e-04
Second Year (20 Shipments)	NTS	4.0E-04	8.0E-03	5.8E-03
	Hanford & U.S. Ecology	2.8E-04	1.1E-02	1.4E-03
	SRS & Chem Nuclear	4.2E-04	9.6E-03	2.7E-03
	Envirocare	1.3E-04	3.3E-03	9.5E-04
Third Year (20 Shipments)	NTS	4.0E-04	8.0E-03	5.8E-04
	Hanford & U.S. Ecology	2.8E-04	1.1E-02	1.43E-03
	SRS & Chem Nuclear	4.2E-04	9.6E-03	2.7E-03
	Envirocare	1.3E-04	3.3E-03	9.5E-04

A comparison of the health effects estimates associated with the radiological incident-free impacts in Tables 4.1 through 4.4 indicates that the nonradiological health risks are similar to the radiological health risks. The nonradiological incident-fee impacts are associated with truck emissions from the shipping campaign.

4.2.4.2. Air Quality Impacts

In Section 3.3, the nonattainment areas associated with the representative highway routes are listed. For the NTS option, the nonattainment areas are associated with the areas of Kingman, Arizona; and Las Vegas, Nevada . For the Hanford and U.S. Ecology option, the nonattainment areas are associated with the urban areas of Colorado Springs, Colorado; Denver, Colorado; Ogden, Utah; and Boise, Idaho. For SRS and Chem Nuclear, the nonattainment areas are associated with Memphis, Nashville, and Chattanooga, Tennessee; and Atlanta, Georgia. The nonattainment areas for Envirocare are Colorado Springs and Denver, Colorado; and Salt Lake City, Utah. Albuquerque, New Mexico is a maintenance area.

The entire shipping campaign for the SNL/NM waste would involve 45 truck shipments of drums or 28 truck shipments of 4'x4'x7' boxes over a 3-year period, and an average of 15 shipments per year thereafter. All of the nonattainment areas lie along interstate highways. This shipping campaign would cause no discernible increase on the daily rate of truck shipments for these nonattainment areas.

A brief analysis was undertaken to determine the impact of the proposed shipments relative to the threshold emission levels in nonattainment areas described by the EPA in its air conformity regulations (40 CFR 93.153 [b][1]). The EPA's general conformity rule (58 FR 63214, November 30, 1993) requires Federal agencies to prepare a written conformity analysis and determination for proposed activities only in those cases where the total emissions of an activity exceed the threshold emission levels. Thus, where it can be demonstrated that emissions from a proposed new activity fall below the thresholds, these emissions are considered to be *de minimus* and require no formal analysis.

The proposed routes to the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, and Envirocare, and associated nonattainment areas, were evaluated for maximum road miles proposed to be traveled for each criteria pollutant. CO, ozone, and PM_{10} were the three criteria pollutants used. The maximum road miles traveled through a nonattainment area would be 93 km (56 mi) (includes return trip) though Denver County and adjacent counties in the Denver/Boulder non-attainment area. This distance (56 miles) conservatively includes a return truck trip even though the return trip is not part of SNL/NM's proposed action (no LLW on truck), and it is likely that commercial vehicles would not return to Albuquerque by the same route.

The EPA threshold for carbon monoxide (CO) for all nonattainment and maintenance areas is 200,000 pounds (100 tons) per year for any new proposed activity. The EPA threshold for ozone (measured by its precursor, NO_x) for "ozone attainment areas outside an ozone transport region" (such as Denver County) is 200,000 pounds (100 tons) per year. The EPA threshold for PM_{10} for all "moderate" nonattainment areas is 200,000 pounds (100 tons) per year for any new proposed activity. Emission factors for CO and ozone for various motor vehicles types have been modeled for the year 1990 (Goel, 1991). Emission factors for PM_{10} have been calculated using EPA's February 1995 model for that criteria pollutant. Heavy duty diesel powered vehicles (HDDVs) are defined to be any diesel-powered motor vehicle designated primarily for the transportation of property and rated at more than 8,500 pounds of gross vehicles weight. For HDDVs, including the standard commercial semi-tractor vehicles that would be used for pulling waste shipments, the average emissions for CO is established at 11.03 grams per mile (gm/mi), while the NO_x (an ozone precursor) emission rate is 22.91 grams per mile (gm/mi). Finally, the emission factor for PM_{10} is 14.87 grams per mile (gm/mi).

Using a maximum of 20 shipments (truck round trips) per year (5 trips first year, 20 for the second, 20 for the third, and 20 average annual trips thereafter), the CO emission rate was estimated for the maximum distance traveled through a nonattainment area (Denver/Boulder Area). This emission rate was approximately 12.35 kg (27.23 lbs) of CO per year. This amount of emissions is clearly a *de minimus* amount at approximately 10,000 times less than the threshold standard.

Using a maximum of 20 shipments per year (truck round trips), an ozone emission rate was established for the maximum distance traveled within a nonattainment area (Denver/Boulder Area). This emission rate was approximately 25.68 kg (56.51 lbs) of NO_x per year (NO_x is a precursor to ozone). This amount of emissions is clearly a *de minimus* amount at approximately 10,000 times less than the threshold standard.

Finally, using 20 shipment per year, a PM_{10} rule was established for the maximum distance within a nonattainment area (Denver/Boulder Area). The emission rate was 16.65 kg (36.68 lb) of PM_{10} per year. This amount is clearly *de minimus* at 10,000 times less than the threshold standard of 100 tons/yr.

Because the Denver/Boulder area example maximizes road miles traveled through a nonattainment area, and also conservatively estimates emission factors, it is assumed that this example "bounds" the impacts within other nonattainment areas for the proposed action. Therefore, the air emissions within all nonattainment areas along shipment routes are well below the threshold emission levels established by the EPA, and thus require no formal conformity analysis.

4.2.5. Noise Impacts

Since the dominant noise source along the route is from the passage of vehicles, the issue is whether or not the proposed transportation shipping campaign would significantly increase the traffic flow and thus the noise level. Even if the worst case were assumed — all shipments occur on the same day — no noticeable change in common highway noise along any part of the routes between SNL/NM and the NTS, Hanford, U.S. Ecology, SRS, Chem Nuclear, or Envirocare would be expected.

4.2.6. Cumulative Impacts — Estimated Doses for the Proposed Action

Cumulative impacts are those that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. (See 40 CFR §1508.7 and CEQ, 1978).

To calculate cumulative radiological impact, estimated maximum annual doses from the proposed action and from other radioactive waste shipments occurring at the same facilities, along the same routes, and projected to occur concurrently during the proposed action, are added together. This approach neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the total cumulative dose (Ullrich et al., 1987; Miller et al., 1989).

The following discussion focuses, in two parts, on the cumulative radiological impacts that the proposed action would have on the workers and the general public who would be exposed as a result of the proposed action. The first section describes the results of the "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," NUREG-0170 (USNRC, 1977). The doses estimated from the proposed action are related to natural background radiation and estimates from NUREG-0170.

4.2.6.1. NUREG-0170 and Other Studies on Population Exposures

The proposed action is similar in many respects to other radioactive waste transportation activities that are taking place in the same locations and along similar routes. The "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0170" (USNRC, 1977), considered the risk of transporting various types of packages of radioactive wastes, including the shipment of spent nuclear fuel and secondary transport[1] along transportation corridors similar to those that would be used for the proposed action. More recent studies of radioactive waste shipments indicate no substantial change in the number and characteristics of shipments have occurred that would invalidate the general result of NUREG-0170 (Weiner, 1991).

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1 Secondary transport is the shipment by light-duty vehicles of consignments of a large variety of packages (Type A and small Type B packages) in cities and suburbs along secondary roadways and city streets.

For individuals residing near principal transportation routes, NUREG-0170 estimates that the average annual individual dose from radioactive waste transportation activities is about 0.09 mrem. Recently, Weiner (1991), using RADTRAN 4, estimated that a the maximally exposed individual member of the public would not receive more than 0.14 mrem if exposed to the in-transit passage of all of the approximately 1,600,000 radioactive waste packages shipped in the United States in a single year. This is, of course, not a realistic scenario, but it does place an upper bound on the individual in-transit dose from other shipments.

Mills and Neuhauser (1994) estimated the individual in-transit dose for a person located 30 m (99 ft) from an average route segment as only 0.00009 mrem. However, the number of LLW shipments that could occur annually in the vicinity of SNL/NM as a result of the proposed action could exceed the average LLW traffic on the nation's roadways. NUREG-0170 used annual shipment levels for the United States as a whole to obtain maximally exposed individual dose estimates. The two classes of shipments considered in NUREG-0170 that can be used to conservatively model traffic in the SNL/NM and Albuquerque, New Mexico vicinity are spent fuel shipments (250 commercial reactor shipments were modeled in NUREG-0170) and secondary transport. NUREG-0170 estimated that the dose to an individual living 30 m (99 ft) from a roadway on which all 250 spent fuel shipments pass would be 0.009 mrem and that no individual would receive more than an additional 0.009 mrem from secondary transport, for a maximum total of 0.018 mrem from these sources.

4.2.6.2. Estimated Individual Doses for the Proposed Action

Public Doses

The maximally exposed individual dose estimates as presented in Tables 4.1 through 4.4 demonstrate the relatively low dose that a single individual might receive from incident-free transportation. The difference between the maximally exposed individual dose estimates and the dose estimates of the various population groups demonstrate the effect of population distributions on dose estimates. It should be noted that the maximally exposed individual dose represents an estimate of the dose that would be received by the same individual if that individual were to be exposed to each shipment of LLW.

This dose estimate is small compared to estimates of expected exposures from background radiation. Along the transportation corridors that would be used in implementing the proposed action, the average annual effective dose equivalent for a member of the general population from all sources of radiation other than the proposed action is expected to be approximately 360 mrem (NAS, 1990).

Worker Doses

Worker doses were estimated for conveyance crew members. Conveyance crew members would receive a maximum total dose of 0.64 person-rem/yr for drums and 0.4 person-rem/yr for boxes. Based on conveyance crew models of 2 crew members per truck, the maximally exposed individual crew dose would be 0.32 rem/yr (320 mrem/yr) for a single truck crew member who participated in every single shipment within any particular year.

4.2.6.3. Estimated Individual Doses from Other Proposed Action

An additional source of radiation exposure to both the public and workers could result if the DOE converts the ACRR at SNL/NM from weapons research to medical isotope production. Potential impacts associated with transportation activities associated with the medical isotope production program have been estimated and are shown in Table 4.9. These shipments would involve the shipment of LLW specifically generated from the medical isotope production to an offsite facility for disposal, the shipment of unirradiated isotope targets from a production facility to SNL/NM, and the shipment of isotopic products from SNL/NM to the Albuquerque International Airport (AIA) for air cargo shipment to radiopharmaceutical facilities throughout the United States. The highest annual dose estimate to the public from the medical isotope production program transportation activity was estimated as 5.4 person-rem and a maximally exposed individual dose estimate of 1.7E-04 rem/yr (0.17 mrem/yr) for a member of the public, and 2.54 rem/yr (2541 mrem/yr) to a member of the truck crew who participated in each truck shipment of targets, LLW, and isotope products.

4.2.7. Environmental Justice

The dominant radiological risk associated with incident-free transportation of LLW is the exposure to the public during rest stops, followed by exposure to the truck crew. These exposures are put into perspective in comparison to a hypothetical maximally exposed individual dose estimate; i.e., an individual who would be exposed to each shipment of LLW. The MEI estimate is small compared to estimates of expected exposures from background radiation.

Individual access and use of the public highways, or the rest stops that would be used by trucks shipping LLW, is not limited or restricted to any particular population group, economically disadvantaged or advantaged. As discussed in Section 4.2, the number of radiation-related LCFs among transportation workers and the public combined is less than 1.3E-03. The same is true for vehicle emissions contributed by the LLW transportation program. Transportation accidents would not be expected to contribute additional radiological impacts to populations in vicinity of the accident.

Although it is expected that the percentage of total population comprised of minority or low-income households would vary along the rail and highway routes for the proposed action, the impacts from LLW shipments is estimated to be negligible. There is, therefore, no disproportionate impact to those minority or low-income households along the routes. These groups would be subject to the same negligible impacts as the general population.

4.2.8. Summary of Cumulative Transportation Effect

Table 4.9 contains a summary of the potential cumulative doses estimates to individuals of specific impact groups for three potential sources; the SNL/NM offsite shipments (the proposed action of this EA), the proposed SNL/NM medical isotope production program, and the NUREG-0170 risk assessment of transporting spent nuclear fuel and secondary transport along transportation corridors similar to those that would be used for the proposed action. As discussed earlier, ER LLW was not included in this EA and not included in the Cumulative Impacts.

Table 4.9 Cumulative Individual Annual Radiation Dose for Impact Groups Individuals

Maximally Exposed Individual Doses From Various Related Activities (mrem/yr)					
Impact Group	Isotopic Production	SNL/NM Off-Site Shipments	NUREG-0170	Total Annual Dose	Annual Dose Limit
Public	0.17	0.001[1]	0.018	0.19	100
Truck Crew	2541[2]	720	870[2]	4131	5000

1 NRC Radiation Worker dose limits - 5000 mrem/yr -- NRC Public exposure guidelines - 100 mrem/yr

2 These values are the sum for truck and van maximally exposed individual crew members from Table 4-8 in NUREG-0170. Estimated worker dose assumes same individual drives all shipments during a year.

4.3. Impacts Associated with Alternatives to the Proposed Action

4.3.1. Impacts Associated with No Action

This alternative would entail no offsite transportation of LLW from SNL/NM to a disposal site. Hence there would be no radiological exposure to the general public during incident-free operation. However, activities that must be performed at the various storage sites (ISS, Building 6596, the RMWMF, and the various point-of-generation locations) discussed in Section 2.1.1 result in some routine radiation exposures to SNL/NM personnel. These activities include weekly inspections of storage areas to identify deteriorating or leaking containers and to confirm inventories, the placement of new waste, the replacement of labels degraded by exposure to the sun and inclement weather, the repackaging of waste as containers degrade, the checking of radiation monitors, and the replacement of warning signs. If a leak or spill were to occur, additional doses would most likely be received by responding personnel. Any increase in worker exposures would result in an increase in cancer risk to workers. Several storage containers currently have external dose rate levels approaching 5 mrem/hr at one foot. To maintain exposure levels of less than 5 mrem/hr at one foot, either more storage units would have to be added or the waste would have to be reconfigured in such a way as to reduce the exposure. Steps that are taken to keep these exposures as low as possible include limiting the time that employees spend in each storage area, prohibiting the storage of liquids at outdoor storage areas, ensuring that all emergency equipment is properly maintained, and minimizing the amount of radioactive waste generated at SNL/NM. The dose and impact estimates of LLW storage and processing are contained in DOE/EA-0466, the Environmental Assessment for the Radioactive and Mixed Waste Management Facility (DOE, 1993).

Continued storage of LLW onsite at SNL/NM cannot be equated with permanent disposal. Ultimately, the LLW would still have to be permanently disposed of.

4.3.2. Impacts of the Rail Transportation Alternative

The potential impacts associated with transporting approximately 444 m^3 (15,540 ft^3) of SNL/NM LLW by rail are discussed in this section. The shipments of LLW are modeled according to the transportation campaign as defined in Section 2.1.3 for the average waste stream. In order to bound the potential risk from accidents, transportation of LLW in this EA was modeled for two different shipping configurations: 1) 120 drums per rail car, and 2) sixteen 4'x4'x7' boxes per rail car. Section 4.3.3.1 describes expected impacts associated with routine, or incident-free, rail operations. Section 4.3.3.2 describes potential risks associated with accident conditions. The total risks and impacts associated with the rail transportation alternative are discussed in Sections 4.3.3.3 and 4.3.3.4. The shipping campaign for the rail option is illustrated in Table 4.10.

Table 4.10 Rail Transportation Campaign for Average Waste Inventory of SNL/NM LLW

Shipping Campaign			
		Package Type	
		Drums	4'x4'x7' Boxes
First Year	Packages	522	48
	Rail Car Shipments	6	4
Second Year	Packages	1112	70
	Rail Car Shipments	10	6
Third Year	Packages	1114	70
	Rail Car Shipments	10	6
Total	Packages	2748	16
	Rail Car Shipments	26	16

4.3.2.1. Impacts of Routine Rail Operations

Impacts for both options of the rail transportation alternative are shown in Tables 4.11 through 4.15. The estimates for impacts associated with the option of shipping the waste to Hanford, U.S. Ecology, SRS, Chem Nuclear, and Envirocare are noticeably lower than for the option of shipping waste to the NTS. This trend is the opposite of that observed for truck shipments to Hanford, U.S. Ecology, SRS, Chem Nuclear, and Envirocare and the NTS (Section 4.2.1). This difference occurs because, as described in Section 2.2.2, the rail shipments from SNL/NM to the NTS would involve an intermodal transfer of the LLW from rail to truck at Las Vegas, Nevada. The estimated dose to the handlers for this intermodal transfer is shown in Table 4.11. This intermodal transfer is the largest single contributor to the total dose estimate, approximately an order of magnitude larger than the contribution of the next highest risk group (dose to persons at stops). No such intermodal transfer would be needed for rail shipments to the other options.

A comparison of the impacts associated with the rail alternative to the impacts associated with the proposed action (Tables 4.3, 4.4) shows that the incident-free risk can be lower for the rail alternative than for the proposed action. For the option of shipping to the NTS, even with the need to transfer the LLW from rail to truck for the link between Las Vegas and the NTS, the total incident-free impacts for rail are slightly lower than for trucks for the shipments of drums, but approximately four times higher for the shipments of boxes. This is because rail shipments of drums would be containerized in standardized transportainers before being loaded on a rail car. These transportainers would be loaded directly on trucks at Las Vegas. In contrast, the 4'x4'x7' boxes would not be containerized and would require individual handling. The result is that intermodal handler dose estimates for shipments of drums are approximately a factor of six lower than estimates for shipments of boxes.

For the other options, the comparison between rail impacts and truck impacts is more straightforward since intermodal transfer would not be required. The dose estimates for the rail alternatives are lower than for the truck alternatives. The primary reason for this difference is that the dose to persons during rail stops is far less than during truck stops. Rail stops are modeled as occurring at rail yards, while truck stops are modeled as occurring at rest areas open to the public. The general public rarely comes in close proximity to trains during rail stops at rail yards.

4.3.2.2. Risk of Rail Accidents

As can be seen from the risk estimates in Tables 4.11 and 4.12, the rail transportation accident risk associated with the option of shipping the waste to Hanford is roughly a factor of four higher than that for the NTS option. The risks vary according to the distance over which the waste must be shipped and the potentially exposed population living along the transportation route modeled in the RADTRAN risk assessment. The distance of a representative railway/highway route between SNL/NM and the NTS is 1583 km (981 mi), 1480 km (918 mi) by rail, and 103 km (64 mi) by truck. From SNL/NM to Hanford, the rail distance is 2979 km (1847 mi), almost twice the distance from SNL/NM to the NTS. For the SRS/Chem Nuclear option, the distance of a representative rail route is 3700 km (2794 mi). For the Envirocare option, the distance is 2024 km (1258 mi). The potentially exposed population along the representative railway/highway route from SNL/NM to the NTS modeled for the risk assessment is 72,864. For the route from SNL/NM to Hanford the population estimate would be 269,111. The potentially exposed population along the representative rail route to SRS/Chem Nuclear is 682,000. For the Envirocare option the potentially exposed population is 250,000. The rail route distance and population data are extracted from INTERLINE 5.0, a DOE computerized rail routing model (ORNL, 1992b).

Table 4.11 Maximum Annual Incident-Free Impacts for Rail Shipment of SNL/NM LLW to the NTS

Nevada Test Site - Incident-free Impacts - Total Dose Estimates for All Rail Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 3 Shipments Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	7.8E-03	3.9E-06	2.6E-02	1.3E-03	2.6E-02	1.3E-03
	Boxes*	1.0E-02	5.0E-06	3.01E-02	1.5e-05	3.01E-02	1.5e-05
Public On Link	Drums	3.9E-02	1.9E-05	0.13	6.4E-05	0.13	6.4E-05
	Boxes	4.8E-02	2.4E-05	0.14	7.2E-05	0.14	7.2E-05
Public Stops	Drums	6.5E-02	3.2E-05	0.22	1.1E-04	0.22	1.1E-04
	Boxes	0.12	5.9E-05	0.35	1.8E-04	0.35	1.8E-04
Total Public	Drums	0.11	5.6E-05	0.37	1.9E-04	0.37	1.9E-04
	Boxes	0.18	8.8E-05	0.53	2.6E-04	0.53	2.6E-04
Crew	Drums	6.2E-02	2.5E-05	0.21	8.3E-05	0.21	8.3E-05
	Boxes	8.6E-02	3.4E-05	0.26	1.0E-04	0.26	1.0E-04
Intermodal Handlers	Drums	0.69	2.8E-04	2.3	9.2E-04	2.3	9.2E-04
	Boxes	3.8	1.5E-03	12.0	4.6E-03	12.0	4.6E-03
Total (Public, Crew, and Handlers)	Drums	0.86	4.3E-04	2.9	1.4E-03	2.9	1.4E-03
	Boxes	4.1	2.1E-03	12	6.2E-03	12	6.2E-03
Maximally Exposed Individual	Drums	3.8E-06	1.9E-09	1.3E-05	6.4E-09	1.3E-05	6.4E-09
	Boxes	5.7E-06	2.9E-09	1.7E-05	8.6E-09	1.7E-05	8.6E-09

* 4'x4'x7' Steel boxes

Table 4.12 Maximum Annual Incident-Free Impacts for Rail Shipment of SNL/NM LLW to Hanford

Hanford Reservation - Incident-free Impacts - Total Dose Estimates for All Rail Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 3 shipments *Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Off Link	Drums	1.7E-02	8.3E-06	5.6E-02	2.8E-05	5.6E-02	2.8E-05
	Boxes	2.2E-02	1.1E-05	6.5E-02	3.3E-05	6.5E-02	3.3E-05
On Link	Drums	3.2E-02	1.6E-05	0.11	5.3E-03	0.11	5.3E-03
	Boxes	3.3E-02	1.7E-05	0.10	5.0E-05	0.10	5.0E-05
Stops	Drums	1.7E-02	8.4E-06	5.6E-02	2.8E-05	5.6E-02	2.8E-05
	Boxes	2.0E-02	1.0E-05	6.0E-02	3.0E-05	6.0E-02	3.0E-05
Total Public	Drums	6.5E-02	3.3E-05	0.22	1.1E-04	0.22	1.1E-04
	Boxes	7.5E-02	3.8E-05	0.23	1.4E-04	0.23	1.4E-04
Crew	Drums	6.3E-02	2.5E-05	0.21	8.4E-05	0.21	8.4E-05
	Boxes	8.5E-02	3.4E-05	0.25	1.0E-04	0.25	1.0E-04
Intermodal Handlers	Drums	0.35	1.4E-04	1.2	4.6E-04	1.2	4.6E-04
	Boxes	1.9	7.7E-04	5.8	2.3E-03	5.8	2.3E-03
Total (Public and Crew)	Drums	0.41	2.4E-04	1.6	7.9E-04	1.6	7.9E-04
	Boxes	2.1	1.0E-03	6.3	3.1E-03	6.3	3.1E-03
Maximally exposed individual	Drums	2.5E-06	1.2E-09	8.3E-06	4.1E-09	8.3E-06	4.1E-09
	Boxes	3.0E-06	1.5E-09	8.9E-06	4.5E-09	8.9E-06	4.5E-09

* 4'x4'x7' Steel boxes

Table 4.13 Maximum Annual Incident-Free Impacts for Rail Shipment of SNL/NM LLW to SRS and Chem Nuclear

Savannah River Site - Incident-Free Impacts - Total Dose For All Rail Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 3 Shipments *Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	3.7E-02	1.9E-05	0.12	6.2E-05	0.12	6.2E-05
	Boxes	5.1E-02	2.5E-05	0.15	7.6E-05	0.15	7.6E-05
Public On Link	Drums	3.3E-03	1.9e-05	0.11	5.5E-05	0.11	5.5E-05
	Boxes	3.6E-02	1.8E-05	0.11	5.3E-05	0.11	5.3E-05
Public Stops	Drums	5.1E-02	9.7E-06	6.5E-02	3.2E-05	6.5E-02	3.2E-05
	Boxes	2.4E-02	1.2E-05	7.1E-02	3.5E-05	7.1E-02	3.5E-05
Total Public	Drums	9.0E-02	4.5E-05	0.30	1.5E-04	0.30	1.5E-04
	Boxes	0.11	5.5E-05	0.33	1.6E-04	0.33	1.6E-04
Crew	Drums	7.3E-02	2.9E-05	0.24	9.7E-05	0.24	9.7E-05
	Boxes	9.8E-02	3.9E-05	0.29	1.2E-04	0.29	1.2E-04
Intermodal Handlers	Drum	0.35	1.4E-04	1.2	4.6E-04	1.2	4.6E-04
	Boxes	1.9	7.7E-04	5.8	2.3E-03	5.8	2.3E-03
Total (Public, Crew, and Handlers)	Drums	0.51	2.5E-04	1.7	8.5E-04	1.7	8.5E-04
	Boxes	2.1	1.1E-03	6.4	3.2E-03	6.4	3.2E-03
Maximally Exposed Individual	Drums	2.5E-06	1.2E-09	8.3E-06	4.1E-09	8.3E-06	4.1E-09
	Boxes	3.0E-06	1.5E-09	8.9E-06	4.5E-09	8.9E-06	4.5E-09

* 4'x4'x7' Steel boxes

Table 4.14 Maximum Annual Incident-Free Impacts for Rail Shipment of SNL/NM LLW to Envirocare

Savannah River Site - Incident-Free Impacts - Total Dose For All Rail Shipments							
Risk Group	Packaging	First Year		Second Year		Third Year	
		Drums: 3 Shipments *Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off Link	Drums	1.5E-02	7.6E-06	5.1E-02	2.5E-05	5.1E-02	2.5E-05
	Boxes	6.7E-02	9.8E-06	5.9E-02	2.9E-05	5.9E-02	2.9E-05
Public On Link	Drums	3.1E-02	1.6E-06	0.10	5.2E-05	0.10	5.2E-05
	Boxes	3.3E-02	1.6E-05	9.9E-03	4.9E-05	9.9E-03	4.9E-05
Public Stops	Drums	1.7E-02	8.3E-06	5.6E-02	2.8E-05	5.6E-02	2.8E-05
	Boxes	2.0E-02	9.9E-06	5.9E-02	3.0E-05	5.9E-02	3.0E-05
Total Public	Drums	6.3E-02	3.2E-05	0.21	1.1E-04	0.21	1.1E-04
	Boxes	7.2E-02	3.6E-05	0.22	1.1E-04	0.22	1.1E-04
Crew	Drums	5.1E-02	2.0E-05	0.17	6.8E-05	0.17	6.8E-05
	Boxes	6.7E-02	2.7E-05	0.20	8.1E-05	0.20	8.1E-05
Intermodal Handlers	Drum	0.35	1.4E-04	1.2	4.6E-04	1.2	4.6E-04
	Boxes	1.9	7.7E-04	5.8	2.3E-03	5.8	2.3E-03
Total (Public, Crew, and Handlers)	Drums	0.46	2.3E-04	1.5	7.6E-04	1.5	7.6E-04
	Boxes	2.1	1.0E-03	6.2	3.2E-03	6.2	3.2E-03
Maximally Exposed Individual	Drums	1.1E-06	5.7E-10	4.5E-06	2.3E-09	4.5E-06	2.3E-09
	Boxes	1.6E-06	7.9E-10	4.2E-06	2.1E-09	4.2E-06	2.1E-09

* 4'x4'x7' Steel boxes

Table 4.15 Maximum Annual Accident Risk Estimates for Rail Shipment of SNL/NM LLW to All Sites

Accident Risk Estimates - Dose Risk and LCF Risk - All Rail Shipments							
Disposal Site Option	Packaging	First Year		Second Year		Third Year	
		Drums: 3 Shipments *Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
NTS	Drums	6.6E-03	3.3E-06	2.2E-02	1.1E-05	2.2E-02	1.1E-05
	Boxes	9.3E-03	4.7E-06	2.8E-02	1.4E-05	2.8E-02	1.4E-05
Hanford & U.S. Ecology	Drums	2.5E-02	1.3E-05	8.5E-02	4.2E-05	8.5E-02	4.2E-05
	Boxes	3.5E-02	1.8E-05	0.11	5.3E-05	0.11	5.3E-05
SRS & Chem Nuclear	Drums	6.3E-02	3.1E-05	0.21	1.0E-04	0.21	1.0E-04
	Boxes	8.6E-02	4.3E-05	0.26	1.3E-04	0.26	1.3E-04
Envirocare	Drums	2.4E-02	1.2E-05	8.1E-02	4.1E-05	8.1E-02	4.1E-05
	Boxes	3.4E-02	1.7E-05	0.10	5.1E-05	0.10	5.1E-05

* 4'x4'x7' Steel boxes

A comparison of the accident risks associated with truck shipments and rail shipments shows that, for the option of shipping to the NTS, rail accident risk estimates are higher by a factor of approximately three; for the option of shipping to Hanford, rail risk estimates are higher by a factor of approximately six or seven; for SRS/Chem Nuclear, rail risks are a factor of 10 higher than truck risks; and for Envirocare, rail risks are seven times higher. The relatively large discrepancy between rail and truck risks for the SRS/Chem Nuclear option can be attributed to the significantly larger rail distances and associated populations living along the rail route (see Section 3.3).

<u>Bounding Accident Analysis - Rail Option</u>

A bounding accident analysis for the rail option shipments was performed to establish a perspective on both high end credible accident consequences and the probability of such an outcome. The bounding rail option accident analysis is defined as the most potentially hazardous rail shipment that could be configured from the current LLW inventory such that the risk associated with this shipment would be greater than the risk associated with any other possible shipment configuration of SNL/NM LLW. For this proposed action, the cargo for the bounding accident analysis would be entirely of packages containing 2 cans of thorium dioxide powder (see Section 2.1.1 for a description of this waste stream). In the event of a severe accident, the thorium powder would be the most dispersible of any of the SNL/NM LLW streams.

The bounding rail accident analysis was quantified by performing a RADTRAN 4 accident risk analysis for the thorium powder rail car shipment for each of the disposal option routes. The individual route link results were reviewed to identify the single highest link specific consequence estimate and its associated expected accident frequency (a combination of the expected number of accidents for a specific link and the accident severity category probability associated with the highest consequence estimate). On Table 4.16 the consequence estimates and the expected frequency of the bounding accident analysis is shown for each disposal route option.

The bounding accident for each option is the same. This is because the route segment with the greatest potential consequences is a specific section of the truck route from KAFB to the Atchesion, Topeka, and Santa Fe (ATSF) rail yard in Albuquerque as. This link is located in an urban setting and the conveyance travels on city streets through densely populated areas and congested streets. The actual rail urban route segments through which the rail shipments must pass (e.g., Kansas City, Missouri; Las Vegas, Nevada; Salt Lake City, Utah) involve the use of rail roads through population densities that are less than that of the truck link in Albuquerque.

Table 4.16 Bounding Rail Option Accident Analysis

Disposal Option	Dose Estimate (Person-rem)	Expected Frequency (Accidents/ Shipment)	Risk (Person-rem/ Shipment)
NTS	2280	3.5E-08	8.0 E-5
Hanford & U.S. Ecology	2280	3.5E-08	8.0 E-5
SRS & Chem Nuclear	2280	3.5E-08	8.0 E-5
Envirocare	2280	3.5E-08	8.0 E-5

4.3.2.3. Total Radiological Impacts of the Rail Alternative

The total estimated radiological impact associated with the proposed action is the sum of the incident-free impact estimates and the accident risk estimates. The total is summed across all of the individual risk groups for incident-free impacts (rail crew, general public) and the accident risk estimate. The results are shown in Table 4.17.

Table 4.17 Total Radiological Impacts for Rail Shipment of SNL/NM LLW to All Sites

Total Radiological Impact Estimates - Incident-Free Impact and Accident Risk							
Disposal Site Option	Packaging	First Year		Second Year		Third Year	
		Drums: 3 Shipments *Boxes: 2 Shipments		Drums: 10 Shipments Boxes: 6 Shipments		Drums: 10 Shipments Boxes: 6 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
NTS	Drums	0.86	4.3E-04	2.9	1.4E-03	2.9	1.4E-03
	Boxes	4.1	2.1E-03	12	6.2E-03	12	6.2E-03
Hanford & U.S. Ecology	Drums	0.41	2.0E-04	1.6	7.9E-04	1.6	7.9E-04
	Boxes	2.1	1.0E-03	6.3	3.1E-03	6.3	3.1E-03
SRS & Chem Nuclear	Drums	0.51	2.5E-04	1.7	8.5E-04	1.7	8.5E-04
	Boxes	2.1	1.1e-03	6.4	3.2E-03	6.4	3.2E-03
Envirocare	Drums	0.46	2.3E-04	1.5	7.6E-04	1.5	7.6E-04
	Boxes	2.1	1.0E-03	6.2	3.1E-03	6.2	3.1E-03

* 4'x4'x7' Steel boxes

4.3.2.4. Nonradiological Impacts of Rail Transportation

The rail transportation model assessed the impacts of transporting SNL/NM LLW by regularly scheduled commercial rail. Thus, there would be no additional increase in rail traffic over the routes between SNL/NM and the proposed disposal sites. No increase in the existing nonradiologic risks and impacts that currently exist from regularly scheduled rail traffic would occur as a result of the proposed action.

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7. GLOSSARY

Absorbed Dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.
Accelerator	See Particle Accelerator.
Activity	See Radioactivity.
Average Annual Daily Traffic (AADT)	The total number of vehicles traveling in one direction on a defined road segment per year divided by 365. If multiple counts exist for an area, the smallest count is reported in this EA. This procedure helps ensure a conservative estimate of the impacts of the proposed action on local vehicle traffic and vehicle emissions.
Biological Dose Conversion Factor	See Dose Conversion Factor.
Building 6596	SNL/NM research facility to be converted to a LLW storage facility.
Building 6920	SNL/NM Radioactive and Mixed Waste Management Facility (RMWMF).
Characterization	A term applied to waste and to the procedure by which it is sampled, categorized, and labeled for and before processing, storage, or transport.
Ci, µCi, nCi	Curie, microcurie, and nanocurie; special unit of radioactivity. One Ci is 3.7×10^{10} nuclear transformations per second. One µCi equals 10^{-6} Ci, while one nCi equals 10^{-9} Ci; 10 nCi/g equals one part per million.
Committed Dose Equivalent	Dose Equivalent is the product of absorbed dose measured in rad (or measured in gray [Gy]) in tissue and a quality factor. It is expressed in units of rem or seivert. Committed Dose Equivalent is the predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose.
Committed Effective Dose Equivalent	The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. It is expressed in units of rem (or sievert) (WHC, 1994).
Compaction	Reduction of waste volumes by hydraulic press, in the cases where such reduction would not itself cause a hazard.
Decibel	(1) The unit for the measurement of the intensity of sound, one decibel representing the faintest sound that can be heard by the human ear; (2) the unit which expresses the difference in power between two acoustic or electric signals, equal to one tenth the common logarithm of the ratio of the two levels (Williams, 1991).
Decontamination	The removal of unwanted material (typically radioactive material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.
Dose	The quantity of radiation absorbed, per unit mass, by the body or by any portion or the body (10 CFR 20.4[a]).

Dose Conversion Factor	*dose* in the units of concern. Frequently used as the factor that expresses the *committed effective dose equivalent* to a person from the intake (inhalation or ingestion) of a unit activity of a given radionuclide (Shleien, 1992).
Dose Equivalent	The product of absorbed dose in tissue, a quality factor, and other modifying factors. Absorbed dose (expressed in units of rad) is the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. A quality factor is the principal modifying factor used to calculate the dose equivalent from the absorbed dose. Dose equivalent is expressed in units of rem.
Dose Rate	The radiation dose delivered per unit of time measured, for example, in rem per hour (Shleien, 1992).
Effects	Synonymous with impacts. Includes ecological, aesthetic, historic, cultural, economic, social, or health impacts, whether direct, indirect, or cumulative. Under NEPA, the effects of beneficial, as well as detrimental, actions must be considered (DOE, 1994b).
Environmental Restoration	Measures taken to clean up and stabilize or restore a site that has been contaminated with hazardous substances (DOE, 1994b).
Gamma Rays	Electromagnetic radiation emitted in the process of unclear transition or radioactive decay.
General Public	The general populace; does not include radiation workers.
Generator	Any person, by site location, whose act or process produces hazardous waste identified or listed in 40 CFR 261 (RCRA, Sections 144.2; 146.3; 270.2).
Hazardous Material	Any substance or material that poses an unreasonable risk to health, safety, and/or property.
Hot Cell	A heavily shielded compartment containing remote handling equipment for highly radioactive materials (DOE, 1994b).
Impacts	See Effects.
Latent Cancer Fatality	A fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure.
Low-Level Waste(LLW)	Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or by-product material. Test specimens of fissionable material irradiated for research and development may be regarded as LLW only if the concentration of transuranics is less than 100 nCi/gm.
Maximally Exposed Individual	An individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters.
Mixed Waste	Waste containing both hazardous (chemically toxic) and radioactive components.
Neutron Generator	A piece of equipment that enhances a nuclear chain reaction in a nuclear warhead through the electrical acceleration of ions onto a target of fissionable material.

Nonattainment Area	Geographic area which does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act (ExEnt, 1989).
Offsite	Anything, such as roads, buildings, streams, and people, located outside or beyond the restricted public access boundaries. Any site that is not onsite.
Particle Accelerator	A device that accelerates electrically charged atomic or subatomic particles, such as electrons, protons, or ions, to high energies. Also known as accelerator (Parker, 1989).
Person-rem	Unit of estimating dose from radiation exposure to a population. Equal to the average individual dose times the number of people in the population exposed.
Population Dose	Population dose is expressed in person-rem and is used in estimating possible effects to a human population exposed to known hazardous materials, such as radioactivity. Equal to the average individual dose (in rems) times the number of people exposed.
Quality Factor	The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor (QF).
Probability	The annual probability of occurrence of a single accident or event sequence.
Rad Radioactivity	The unit of absorbed dose equal to 100 ergs/gm (0.01 J/kg) in any medium. (1) The spontaneous nuclear decay of a material with a corresponding release of energy in the form of particles and/or electromagnetic radiation. (2) The property characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel) (DOE, 1994b).
Radiation Worker	An individual who works with or around radiation or who, in the course of completing a task, may be exposed to radiation.
Radioactive Waste	Solid, liquid, or gaseous materials of negligible economic value that contain radionuclides in excess of threshold quantities except for radioactive material from post-weapons test activities.
Release Fraction	The fraction of the total inventory of radioactive or hazardous particulate or vapor released to the atmosphere during an accident.
rem	See Roentgen Equivalent Man.
Risk	A measure of the product of the probability and the consequences of an accident expressed in either qualitative or quantitative terms.
Roentgen Equivalent Man (rem)	(1) Unit used to express human biological doses as a result of exposure to various types of ionizing radiation. (2) Unit of radiation that charges atoms, equal to the amount that produces the same damage to humans as 1 roentgen of high-voltage x-rays. The relation of the rem to other dose units depends on the biological effect under consideration and on the conditions/type of irradiation (DOE, 1994b).
Site	The land area that a facility occupies. The area of land owned or controlled by the DOE for the principal purpose of constructing and operating a facility and limited by the site boundary.

"Traffic Jam" Maximally Exposed Individual — An individual member of the public who is sharing the highway with the LLW conveyance during a traffic stoppage resulting in traffic jam conditions. The exposure to this individual is modeled with a 2-hour traffic stoppage with an exposure distance of 2 m (6.5 ft). This dose estimate is performed for a single truck shipment to establish an estimate of a potential dose resulting from a realistic traffic situation.

Transportation Index (TI) — A dimensionless number (rounded up to the nearest first decimal place) displayed on the label of a package to designate the degree of control to be exercised by the carrier during transportation (10 CFR 71.4). For this EA, the TI is the number expressing the maximum radiation level in millirem per hour to be measured at 1 meter (3.25 ft) from the external surface of the outermost package on a conveyance.

Waste Streams — Typical and average quantities of waste by category produced by a facility or an organization annually.

APPENDICES FOR THE ENVIRONMENTAL ASSESSMENT FOR SANDIA NATIONAL LABORATORIES/NEW MEXICO OFFSITE TRANSPORTATION OF LOW-LEVEL RADIOACTIVE WASTE

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ACRONYMS

ALARA	As Low As Reasonably Achievable
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAW	dry active waste
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DR	Disposal Request
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
Hanford	The Hanford Reservation; Hanford, WA
ICRP	International Committee on Radiation Protection
LCF	latent cancer fatality
LLW	low-level waste
NAS	National Academy of Sciences
NRC	U.S. Nuclear Regulatory Commission
NTS	The Nevada Test Site; NV
QF	quality factor
SAR	Safety Analysis Report
SNL/NM	Sandia National Laboratories, New Mexico
TA	Technical Area; SNL/NM
TI	transportation index
WAC	Waste Acceptance Criteria

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APPENDIX A

INPUT PARAMETERS FOR TRANSPORTATION RISK ANALYSIS

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APPENDIX A:

INPUT PARAMETERS FOR TRANSPORTATION RISK ANALYSIS

A.1 Waste Stream Radionuclide Inventories

The estimated waste inventories covered by the proposed action are illustrated in Table A.1. The estimates of mass, volume, and radionuclide inventories were supplied by Sandia National Laboratories, New Mexico (SNL/NM) waste generators.

A2. Accident Severity Category Data

Figures A.1 (for truck) and A.2 (for rail) present a two-dimensional representation of the spectrum of severe environments that could result from transportation accidents (NRC, 1977). The full range of credible accident outcomes are encompassed by the accident severity categories: from "fender benders" to horrific, violent accidents that subject the conveyances and cargos to extreme physical stresses (via crush or puncture forces), or extreme thermal stresses (via intense and prolonged fire), or a combination of both types of stresses. The mapping of the spectrum of all credible accident outcomes into a two-dimensional space defined by two-accident parameters (physical force vs. thermal stress) is synonymous to the development of accident scenarios for risk assessment of fixed facilities (such as nuclear power plants or waste disposal sites). This "accident spectrum" approach to modeling accident outcomes is used for transportation risk assessment rather than the "accident scenario" approach that is commonly used for the risk analysis of fixed facilities. See Section C.4 for a discussion on the transportation accident analysis method used in this analysis.

The likelihood that any given accident would result in a particular accident environment is modeled by assigning conditional probabilities to each of the accident severity categories. A conditional probability is defined as the probability that an accident, given that it occurs, would be of a certain severity. The Department of Energy (DOE) has endorsed the use of conditional probabilities developed by the Nuclear Regulatory Commission (NRC) for the eight accident severity category schemes used in this Environmental Assessment (EA) (NRC, 1977). These probabilities are listed in Table A.2.

The severity categories for truck accidents are shown in Figure A.2. The ordinate in Figure A.2 is crush force. Research has shown that the dominant factors in the determination of motor carrier accident severity are crush force, fire duration, and puncture (Foley, 1974). The severity categories for rail accidents are shown in Figure A.2. The ordinate in this case is impact velocity. For defining accident severity, analysis of train accidents (Larson, 1975) indicates that impact velocity is more meaningful than crush force from cargo interactions. The severity categories include all accidents with a probability of occurrence of one in a million or greater for the entire campaign of up to 45 shipments, a probability well within the levels found acceptable by the U.S. Environmental Protection Agency (EPA) and other agencies (Hallenbeck, 1986).

Table A.1 Waste Stream Radionuclide Inventories

Waste Stream Data and Radionuclide Inventories in Curies*														
Waste Stream	TA-I Lab Trash	TA-II Lab Trash	TA-II Neutron Generators[a]	TA-III Lab Trash	TA-III Soil Cutting	TA-IV Dry Active Wastes	TA-IV Lab Trash	TA-V "Hot" Trash	TA-V "Cold" Trash	TA-V Resins	ThO_2 Pellets	ThO_2 Powder	Total	"Average" Drum	"Average" Box
Mass (kg)	47.4	468	2720	76	24824	1700	125	0.66	4709.34	12000	1000	2112	49782.4		
Volume (m^3)	0.601	5.69	24.98	6.37	21.4	54.6	0.5	1.84	89.96	9.75	2.73	3.63	222.051		
Drums	3	27	118	30	332	258	3	4	327	46	130	96	1374		
Boxes	1	2	8	2	7	18	1	1	21	3	18	7	89		
Ce^{144}								2.70e-01	3.00e-03	1.40e-03			2.74e-01	2.00e-04	3.08e-03
Co^{60}	1.37e-03								3.10e-02	8.18e-04			3.32e-02	2.42e-05	3.73e-04
Cm^{244}							2.80e-03						2.80e-03	2.04e-06	3.15e-05
Cs^{134}								3.80e-02	4.00e-04				3.84e-02	2.79e-05	4.31e-04
Cs^{137}	1.17e-02						1.80e-03	7.30e-01	7.91e-03	1.21e-05			7.51e-01	5.47e-04	8.44e-03
Fe^{55}							1.00e-03						1.00e-03	7.28e-07	1.12e-05
H^3		4.39e+01	3.00e+02	5.00e-03	8.00e-05					1.00e-04			3.44e+02	2.50e-01	3.86e+00
Mn^{54}										6.25e-04			6.25e-04	4.55e-07	7.02e-06
Nb^{95}								1.40e-01	1.50e-03				1.42e-01	1.03e-04	1.59e-03
S^{35}						1.06e-02							1.06e-02	7.71e-06	1.19e-04
Th^{232}							6.20e-04				5.76e-01	2.02e-01	7.78e-01	5.66e-04	8.74e-03
U^{238}	1.00e-02									1.45e-04			1.01e-02	7.38e-06	1.14e-04
Zn^{65}										2.10e-04			2.10e-04	1.53e-07	2.36e-06
Zr^{95}								7.70e-02	8.00e-04				7.78e-02	5.66e-05	8.74e-04
Total	2.40e-2	43.9	300	5.00e-03	8.00e-05	1.06e-02	7.02e-03	1.26	4.46e-02	3.3e-03	5.57e-01	2.02e-01	346.12	-	-

*A curie is a special unit of radioactivity. One curie is 3.7×10^{10} nuclear transformations per second.

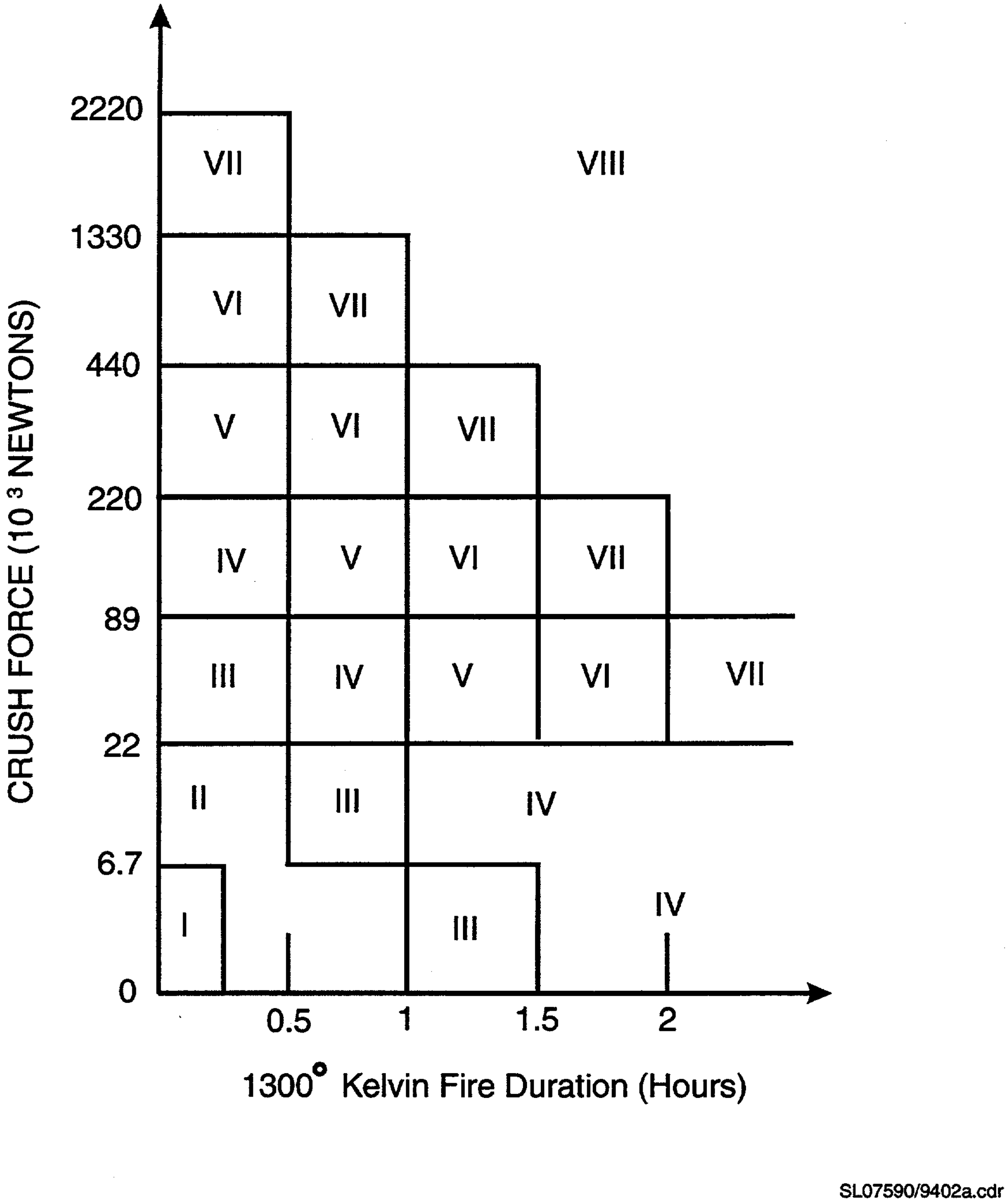

Figure A-1 Accident Severity Category Classification Scheme - Motor Trucks

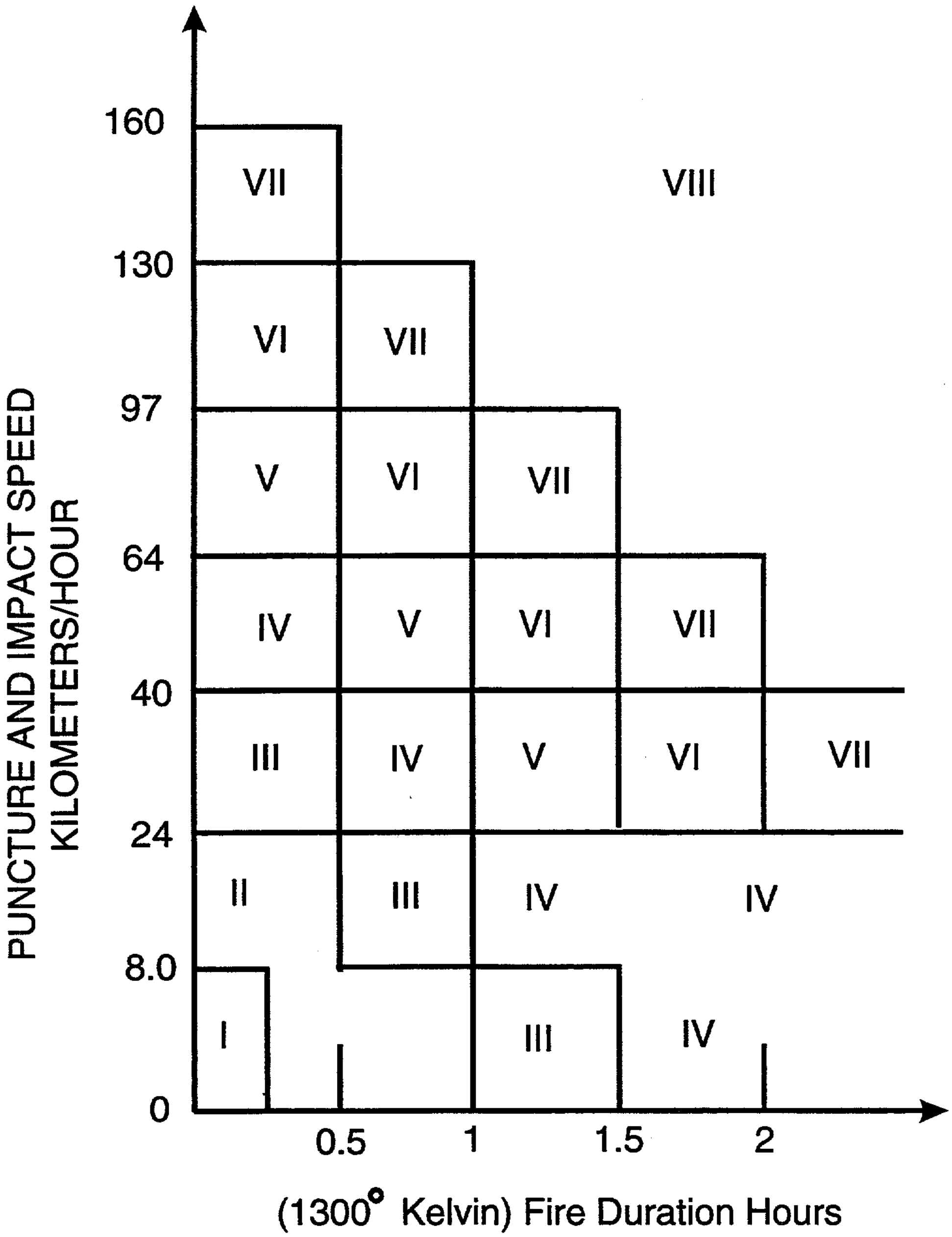

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Figure A-2 Accident Severity Category Classification Scheme - Train

Table A.2 RADTRAN 4 Accident Probability Data by Mode

RADTRAN Input Parameter	Values Used in This Study		
	Truck		Rail
Conditional Probability of Accident Severity Category 1	Urban	.583	.572
	Suburban	.435	.313
	Rural	.462	.356
Conditional Probability of Accident Severity Category 2	Urban	.382	.343
	Suburban	.285	.188
	Rural	.302	.214
Conditional Probability of Accident Severity Category 3	Urban	.0278	.0772
	Suburban	.221	.451
	Rural	.176	.385
Conditional Probability of Accident Severity Category 4	Urban	.00636	.00772
	Suburban	.05060	.0451
	Rural	.04030	.00385
Conditional Probability of Accident Severity Category 5	Urban	7.24E-04	5.14E-04
	Suburban	.00664	.00338
	Rural	.01180	.00641
Conditional Probability of Accident Severity Category 6	Urban	1.46E-4	1.86E-05
	Suburban	.00174	1.63E-04
	Rural	.00647	6.48E-04
Conditional Probability of Accident Severity Category 7	Urban	1.13E-5	8.57E-06
	Suburban	6.72E-5	3.76E-05
	Rural	5.71E-4	3.42E-04
Conditional Probability of Accident Severity Category 8	Urban	9.94E-7	7.15E-07
	Suburban	5.93E-6	3.13E-06
	Rural	1.13E-4	6.41E-05

Other researchers have used six-category (Wilmot, 1981) and twenty-category schemes (Fischer, 1987) to describe the same spectrum of highway accidents. All schemes give approximately the same results when applied to similar problems and are essentially interchangeable (Fischer, 1990; Whitlow, 1992). Consistent with the general principles of probabilistic risk assessment, extremely low probability events (Helton, 1991) are not considered reasonably foreseeable, and therefore are not included among the accident-severity categories. Thus, for example, a maximum credible accident, although physically possible, has a probability so remote (i.e., improbable) as to render its occurrence not reasonably foreseeable.

Given that an accident of a particular accident severity occurs, the behavior of the radioactive material packaging and of the radioactive material in the accident environment is modeled by the use of release fractions (see Appendix C.4.1). The release fractions used in this analysis were developed by the DOE for the purpose of modeling the behavior of radioactive material shipments involving multiple Type A packages (Finley, 1988). These release fractions are shown in Table A.3. The meaning of the release fractions can be illustrated by example. Should a truck accident occur with sufficient force or fire to result in a category 1 severity environment, then the Type A packages on the shipment would not fail (release fraction = 0.0) and none of the radioactive material would be released into the environment. Should a truck accident of severity 3 occur, then ten percent (10%) of the radioactive material in the shipment would escape through failed packages (release fraction = 0.1). Should a truck accident of severity 5 or higher occur, then one hundred percent (100%) of the radioactive material in the shipment would be released (release fraction = 1.0).

Table A.3 RADTRAN 4 Accident Severity Material Release Fractions*

	Accident Severity Category							
Mode	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Truck	0.0	0.02	0.1	0.1	1.0	1.0	1.0	1.0
Rail	0.0	0.005	0.05	0.05	0.5	0.5	0.5	0.5

*Finley, 1988

APPENDIX B

DEFINITION OF A REPRESENTATIVE SHIPPING CAMPAIGN FOR CURRENT SNL/NM LOW-LEVEL WASTE (LLW)

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APPENDIX B:

DEFINITION OF A SHIPPING CAMPAIGN FOR CURRENT SNL/NM LOW-LEVEL WASTE (LLW)

In order to minimize incident-free doses to the public (along the highways and at stops) and to the truck crew (2 drivers), loading of trucks transporting the various wastes addressed in this Environmental Assessment (EA) would take advantage of the fact that only containers in the outer layer of the cargo are assumed to contribute to the dose rate at one meter from the truck (transportation index [TI] for the shipment) (Finley, 1988). In general, the containers would be loaded so that packages (drums) or boxes with the lowest package dose rates surround containers with higher TIs. Therefore, the shipment TI is calculated on the basis of the average dose rate per package of the outer layer. Drums are assumed to be loaded without any stacking and the dose rate of a row of 20 drums, accounting for inverse distance squared weighting of the individual package dose rates, was calculated to be 4.6 times the average drum dose rate.

As an example of a possible shipping campaign for current SNL/NM LLW, the following scenario is provided. Waste to be shipped in the first year could consist of Dry Active Waste (DAW) and laboratory waste from Technical Area IV (TA-IV) and 103 drums of (tritiated) soil from TA-III, loaded onto two trucks, one with the laboratory waste and the other with the DAW, and with the TA-III drums divided between them. The package dose rate of the TA-III drums of soil is taken to be zero (package dose rate = 0 mrem/hr at one meter from the drum surface) since the beta particles emitted by the tritium do not penetrate the drum wall. By surrounding the TA-IV waste containers with these drums, the shipment TI is reduced to zero; i.e., the incident-free transportation consequence in the first fiscal year is zero.

Four specific truck-loading configurations were developed for both the second and third fiscal years. Each configuration employs drums of waste yielding very little or no dose rate at a distance of one meter (package dose rate = 0.0 to 0.15 mrem/hr at one meter from the package surface) to shield drums containing waste yielding relatively high dose rates at one meter (package dose rate = 0.5 to 20.0 mrem/hr at one meter from the package surface). In each configuration, 60 or fewer drums are arranged in 3 rows with low-dose rate drums placed in the outer rows and the high-dose rate drums in the middle with no stacking. In a few cases involving particularly high-dose-rate drums, low-dose-rate drums must also be placed at the ends of the middle row.

Truck configurations and dose rates for second and third year shipments are presented in Tables B-1 and B-2.

Table B-1
SECOND FISCAL YEAR SHIPMENTS

Truck Configuration 1 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
TA-I Waste	2	2.33	Inner
TA-II Waste	7	0.1	Inner
TA-II Generators	20	0.01	Outer
TA-III Trit'd. Waste	8	0.01	Outer
TA-V High Activity	1	20.0	Inner
TA-V Low Activity	8	0.15	Outer
Average Package Dose Rate of Outer Drums	0.040		
Calculated Truck TI	0.18		
TI Used	0.50		

Truck Configuration 2 (Total of 4 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Cans	20	0.5	Inner
TA-V Low Activity	20	0.15	Outer
TA-III Trit'd. Soil	20	0.0	Outer
Average Package Dose Rate of Outer Drum	0.075		
Calculated Truck TI	0.34		
TI Used	0.50		

Table B-1 (Continued)
SECOND FISCAL YEAR SHIPMENTS

Truck Configuration 3 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Cans	8	0.5	Inner
Thorium Rods	2 Boxes	10.0	Inner
TA-V Low Activity	20	0.15	Outer
TA-III Trit'd. Soil	10	0.0	Outer
Ion Exchange Resins	10	0.0	Outer
Average Package Dose Rate of Outer Drum	0.075		
Calculated Truck TI	0.34		
TI Used	0.50		

Truck Configuration 4 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Rods	2 Boxes	10.0	Inner
TA-V Low Activity	16	0.15	Outer
TA-III Trit'd. Soil	2	0.0	Outer
Ion Exchange Resins	2	0.0	Outer
Average Package Dose Rate of Outer Drum	0.122		
Calculated Truck TI	0.56		
TI Used	1.0		

Table B-2
THIRD FISCAL YEAR SHIPMENTS

Truck Configuration 1 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
TA-II Waste	7	0.1	Inner
TA-II Generators	28	0.01	Outer
TA-III Trit'd. Waste	8	0.01	Outer
TA-V High Activity	1	20.0	Inner
TA-V Low Activity	8	0.15	Outer
Package Dose Rate of Average Outer Drum	0.034		
Calculated Truck TI	0.16		
TI Used	0.50		

Truck Configuration 2 (Total of 4 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Cans	20	0.5	Inner
TA-V Low Activity	20	0.15	Outer
TA-III Trit'd. Soil	20	0.0	Outer
Package Dose Rate of Average Outer Drum	0.075		
Calculated Truck TI	0.34		
TI Used	0.50		

Table B-2 (Continued)
THIRD FISCAL YEAR SHIPMENTS

Truck Configuration 3 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Cans	8	0.5	Inner
Thorium Rods	3 Boxes	10.0	Inner
TA-V Low Activity	20	0.15	Outer
TA-III Trit'd. Soil	20	0.0	Outer
Package Dose Rate of Average Outer Drum	0.075		
Calculated Truck TI	0.34		
TI Used	0.50		

Truck Configuration 4 (Total of 2 Shipments)

Waste/Source	Number of Drums	Package Dose Rate per Drum (mrem/hr at 1m)	Load Location (Row)
Thorium Rods	3 Boxes	10.0	Inner
TA-II Generators	12	0.01	Outer
TA-V Low Activity	16	0.15	Outer
TA-III Trit'd. Soil	3	0.0	Outer
Ion Exchange Resins	12	0.0	Outer
Package Dose Rate of Average Outer Drum	0.058		
Calculated Truck TI	.26		
TI Used	0.50		

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APPENDIX C

IMPACT AND RISK ASSESSMENT METHODOLOGY

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APPENDIX C:

IMPACT AND RISK ASSESSMENT METHODOLOGY

C.1 Representative Transportation Campaign — Current LLW Inventory

This section contains a description of a representative shipping campaign for the current waste inventory. It should be noted that this scenario is included merely to represent a possible shipping configuration. In reality the configuration of drums and boxes on a transporter will be determined at the time of shipment. The shipping campaign and truck load configuration are designed to minimize worker and public doses. Use of this configuration would take advantage of the characteristics of the current inventory, particularly the type of radioactivity emitted by each waste stream. The purpose of developing this representative shipping campaign is twofold: 1) to illustrate a realistic waste management approach to shipping the waste to a disposal site, and 2) to illustrate how SNL/NM intends to implement As Low As Reasonably Achievable (ALARA) principles in its waste management practices. The actual truck shipments and load configurations that might be made would be dictated by such variables as the order in which waste disposal applications are submitted to the disposal site(s) and the order in which specific waste streams are accepted for disposal by the site(s). The shipping campaign described here was not used to model the transportation risks for the proposed action.

The configuration described in this section is specific to the current inventory. It may not be applicable to future waste streams. However, shipping configurations that minimize doses to workers and to the public would be developed for the future waste streams in a similar fashion at the time the characteristics of these waste streams become known.

The transportation of the current inventory of SNL/NM LLW to an offsite disposal facility would be undertaken over a 3-year period expected to begin after approvals are obtained. A representative transportation campaign for transporting these wastes is described in Table C.1. The shipping campaign is configured by defining specific truck loads of LLW. Each truck load is defined as one containing a specific combination of the various waste streams discussed in Section 2.1.1 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste. In order to minimize doses under accident-free (incident-free) conditions to the public (along the highways and at stops) and to the truck crew (two drivers), loading of trucks transporting the various wastes addressed in this shipping campaign would take advantage of the fact that mainly containers in the outer layer of the cargo would measurably contribute to the dose rate at one meter from the truck (Finley, 1988). In general, the containers would be loaded so that packages (drums or boxes) with the lower package dose rates would surround containers with higher package dose rates. The TI for each truck load is calculated on the basis of the average package dose rate per package in the outer layer. It is assumed that drums are not stacked and that the dose rate of a row of 20 drums is calculated to be 4.6 times the average dose rate for all waste drums.

Waste to be shipped the first year of the campaign could consist of TA-IV waste and 103 drums of (tritiated) soil from TA-III to be loaded onto two trucks: one with the laboratory waste and the other with the DAW, with the TA-III drums divided between them. The package dose rate of the TA-III drums of soil is modeled as 0.0 mrem/hr at one meter from the surface of the drums since the beta particles emitted by the tritium in the soil would not penetrate the drum wall. By surrounding the TA-IV waste containers with these drums and essentially using the soil as a shield, the dose rate of the shipment would be reduced to 0.0 mrem/hr at one meter from the truck.

Table C.1 Representative Transportation Campaign for Current Inventory of SNL/NM LLW

Transportation Shipping Campaign For Current Inventory of SNL/NM LLW														
Year	Shipments	Packages Shipped (55-gal Drums Unless Otherwise Noted)												
		TA-I Lab Trash	TA-II Lab Trash	TA-II Neutron Generators	TA-III Lab Trash	TA-III Soil Cuttings	TA-IV Dry Active Waste	TA-IV Lab Trash	TA-V "Hot" Trash	TA-V "Cold" Trash	TA-V Resins	Thorium Pellets	Thorium Powder	Total Containers
First Year	1					53	1 Box							54
	2					50	1 Box	1						52
	3						6 Boxes							6
	4						6 Boxes							6
	5						4 Boxes							4
	Total					103	18	1						122
Second Year	1	2	7	20	7				1	7				44
	2	1	7	20	8				1	8				45
	3					20				20			20 Cans	60
	4					20				20			20 Cans	60
	5					20				20			20 Cans	60
	6					20				20			20 Cans	60
	7					10				20	10	2 Boxes	8 Cans	50
	8					10				20	10	2 Boxes	8 Cans	50
	9					1				16	2	2 Boxes		21
	10					2				15	2	2 Boxes		21
	Total	3	14	40	15	103			2	166	24	8	96	471

Table C.1 Representative Transportation Campaign for Current Inventory of SNL/NM LLW (Concluded)

Transportation Shipping Campaign For Current Inventory of SNL/NM LLW														
Year	Shipments	Packages Shipped (55-gal Drums Unless Otherwise Noted)												
		TA-I Lab Trash	TA-II Lab Trash	TA-II Neutron Generators	TA-III Lab Trash	TA-III Soil Cuttings	TA-IV Dry Active Waste	TA-IV Lab Trash	TA-V "Hot" Trash	TA-V "Cold" Trash	TA-V Resins	Thorium Pellets	Thorium Powder	Total Containers
Third Year	1		7	28	7				1	8				51
	2		7	28	8				1	7				51
	3					20				20			20 Cans	60
	4					20				20			20 Cans	60
	5					20				20			20 Cans	60
	6					20				20			20 Cans	60
	7					20				20		3 Boxes	8 Cans	51
	8					20				20		2 Boxes	8 Cans	50
	9			12		3				16	12	2 Boxes		45
	10			12		3				15	12	3 Boxes		45
	Total		14	80	15	126			2	166	24	10	96	533

Four specific truck-loading configurations have been developed for the second and third year of the campaign. Each configuration would employ the use of drums yielding very little or no dose rate at a distance of one meter (0.0 to 0.15 mrem/hr) to shield drums that contain waste that yields relatively high dose rates at one meter (0.5 to 20.0 mrem/hr). In each configuration, 60 or fewer drums would be arranged in three rows with low-dose-rate drums placed in the outer rows and high-dose-rate drums in the middle, with no stacking of the drums. In a few cases involving drums with particularly high package dose rates, low-dose-rate drums would be placed at the ends of the middle row.

The shipping campaign illustrated in Table C.2 does not specify the destination of each proposed shipment. The actual breakdown as to what waste might be shipped to the NTS versus what waste might be shipped to any of the other proposed disposal sites is not known at this time. The risk assessment in Section 4.0 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste defines upper and lower bounds on the risk associated with the proposed action by estimating the risk of sending all of the shipments to Nevada Test Site (NTS) or any other proposed disposal site.

C.2 Shipping Campaign Used for Transportation Risk Assessment — "Average" Waste

Specific shipping campaigns such as the one illustrated in Table C.2 represent realistic configurations of waste containers. Because the structure of the load is dependent on the specific waste disposal request (DR) and the waste acceptance criteria (WAC) of the receiving site at the time waste lots are ready for disposal, load configuration cannot be determined in advance. For this reason, the radionuclide inventory of the current waste was averaged across the total number of packagings that would be required to ship the waste. It is also uncertain what the exact packaging would be used for each waste stream. Thus, two specific shipping campaigns were developed to establish a number of shipments. One campaign is based on all of the average waste being packaged and shipped in 55-gal drums, and the other is based on all of the average waste being shipped in 4'x4'x7' boxes (Department of Transportation [DOT] 7A steel containers). The number of drums or boxes that would be required was estimated by allowing for 0.21 m^3/drum (7.4 ft^3/drum) and 3.2 m^3/box (111ft^3/box) for waste packaging (Shleien, 1992). The volumetric inventories of current waste in Table A.1 were used to define the number of packagings that would be required. A total of 2487 drums or 178 boxes would be required. The estimated number of packages required is also shown in Table A.1.

Based on the estimates for packagings needed, a shipping campaign for the average waste is illustrated in Table 4.2 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste. The forecasted inventory of waste was incorporated into the transportation risk assessment in Chapter 4.0 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste by doubling the number of shipments shown in Table 4.2 for the second and third year of the campaign. This was done to establish an upper estimate for transportation impacts that bounds the uncertainty associated with the generation of forecasted wastes.

The volumes of waste expected to be shipped each year is based on estimates from SNL/NM LLW waste management organizations. Based on the waste disposal application process with the NTS, it is anticipated that only TA-IV waste would be shipped during the first year of the proposed action. During the two subsequent years, SNL/NM expects to ship approximately half of its remaining waste each year.

C.3 Measurements of Radiation Exposure

An individual may be exposed externally to ionizing radiation from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. In calculating an external dose, one may assume that the dose is distributed uniformly over the body. An external dose is delivered only during the actual time of exposure to the radiation source. However, when radionuclides are deposited in various body tissues and organs, the dose and effects are not uniform. A few organs in the body may receive a large dose; others may receive none. An internal dose continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. An internal dose is calculated for 50 years following the initial exposure, and the result is expressed as the committed effective dose equivalent (CEDE). The effective dose is the sum of the external dose and the committed effective dose from internal sources.

Potential radiological impacts are measured by estimating the highest radiation exposure any single person might receive, as well as the collective exposure to a particular population (e.g., all those living in the vicinity of a transportation route). Two primary units of radiation measurement are used in this EA to estimate these impacts, the rem and person-rem. The rem (roentgen equivalent man) is a measure of radiation damage to biological tissue. Specifically, it is the amount of damage done when 1 gram of biological tissue absorbs 100 ergs of x-ray (or gamma-ray) energy. Absorbed radiation energy is measured directly in rad (radiation absorbed dose); one rad is the absorption of 100 ergs of energy by 1 gram of absorbing substance. Thus, one rem is the biological damage done when one rad of x-ray or gamma rays is absorbed. Rems and rads are quite large, so radiation doses are usually measured in millirems (mrem, or 1/1000 of a rem) or millirads (mrad, or 1/1000 of a rad).

The concept of dose equivalent accounts for the different amounts of biological damage done by various types of ionizing radiation (alpha, gamma, etc.). The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor (QF). For gamma radiation and x-rays, the QF is 1.0; thus, the dose equivalent in mrem is equal to the dose in mrad.

In this study dose equivalents from incident-free transportation activities are the basis for quantifying incident-free impacts. For brevity, incident-free dose equivalents are referred to as "doses." Doses would have no probabilistic contributions to the likelihood of their occurrence. That is, the incident-free doses are not modeled as functions of random events. The activities that contribute to the estimation of doses are modeled as occurring with no uncertainty. While uncertainty exists regarding the specific activities of incident-free transportation.

Accident risk is based on the mathematical combination of a probabilistic model of the random occurrence of accident events and expected doses for a given set of accident risk analyses are CEDE risks. For brevity, the CEDE risks are referred to as "dose risks."

The maximum annual allowable radiation exposure from operational activities established by the DOE, as well as by the NRC, to protect individual members of the general public is 100 mrem (DOE Order 5400.5, 1993). It is estimated that the average individual in the United States receives a dose of about 360 mrem per year from all sources, including natural and medical sources of radiation (NAS, 1990). For perspective, a modern chest x-ray results in an approximate dose of 8 mrem, while a diagnostic hip x-ray results in an approximate dose of 83 mrem (Shleien, 1992). For further perspective, an individual must receive an acute exposure of approximately 600 rem (600,000 mrem) before there is a high probability of near-term death (NAS, 1990).

Radiation exposure to a population or a group of persons is measured in person-rem. The total population exposure — all the persons-rems — is derived by adding up all the individual doses in the exposed group. This measurement is particularly important when trying to take into account the potential impacts of very small doses on very large populations (e.g., all those living along the truck route).

Health effects may be calculated from doses by multiplying the dose by an appropriate conversion factor, known as a risk factor. This risk factor has the dimensions of health effect per unit dose per person and may include a time factor. The National Academy of Sciences (NAS) study on the biological effects of ionizing radiation includes a number of examples of such risk factors (NAS, 1990). These risk factors have been developed from epidemiological studies of health effects in populations exposed to ionizing radiation, primarily the Atomic Bomb Survivors Life Study (NAS, 1990) and occupational exposure studies.

Thus, with such a conversion, the estimated exposures can be converted into estimated numbers of health effects. Because the exposures predicted in this study are far below those known to cause immediate fatality, or even illness, only delayed health effects are estimated. A delayed effect is measured in latent cancer fatalities (LCFs), defined as a fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure. The conversion factor used in this EA is 0.0005 LCFs/person-rem for the general public and 0.0004 LCFs/person-rem for workers (NRC, 1991). Worker groups tend to be healthy adults and do not represent as broad a spectrum of susceptible people (e.g., children) as does the general population. Applying the conversion factor to the general population, a collective dose of 2,000 person-rem is estimated to result in one additional LCF.

Genetic effects in subsequent generations are another type of health effect that may occur as a result of low-level radiation exposure such as that associated with the proposed action in this EA. The conversion factor is smaller, and the uncertainty is greater than for LCFs. The International Committee on Radiation Protection (ICRP) has recommended a conversion factor about five times lower than that used to estimate cancer fatalities (ICRP, 1991). For comparison with the latter, in a general population, a collective dose of 10,000 person-rem is estimated to result in one additional genetic effect in all subsequent generations.

C.4 Incident-Free Highway Transportation

The transportation risk analysis was performed using the RADTRAN 4 computer code (Neuhauser, 1992). RADTRAN 4 models have been developed to provide very conservative estimates of impact. For example, RADTRAN 4 postulates that, in the event of an accident, people would not be evacuated for 24 hours. In actuality, people would probably be evacuated sooner, thereby reducing the time of exposure. In addition, the RADTRAN 4 accident dispersal characteristics of combustible materials were used to yield conservative estimates of accident dose risk.

Detailed information regarding the route and population distribution for the transportation routes to the NTS, the Hanford Reservation, U.S. Ecology, the SRS, Chem Nuclear, and Envirocare is required for RADTRAN 4 modeling. This information was obtained using the HIGHWAY computer program (ORNL, 1992a). HIGHWAY is essentially a computerized atlas that can be used to minimize a combination of distance and driving time for a highway route between two points while maximizing use of interstate system highways. This feature allows the user to establish baseline routes for shipments of radioactive wastes that conform to DOT routing regulations, which require that interstate system highways be used to the maximum extent possible. The population density distribution is calculated for several segments of the highway route, segments representing rural, suburban, and urban population densities. Population densities are determined using 1990 Federal Census Bureau data. The Census Bureau updates the census data every 10 years. There is no other national database available for population densities. Use of the Census Bureau's decennial data is consistent with the government's and private industries' practice of using this data to model population characteristics.

The routes that might ultimately be taken cannot be predicted with 100-percent precision because of routing variables due to such conditions as weather, road construction or repair, or accidents involving other vehicles. Moreover, if routes are consistent with DOT regulations, State authorities can change the route that must be used for transportation. The representative routes analyzed in this EA, based on conformity with general DOT criteria, provide a basis for comparing potential impacts associated with using different disposal sites for the SNL/NM waste. These routes are described in Section 3.0 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste.

During routine transportation operations, individuals near the shipping containers could receive low levels of external exposure to radiation (gamma and x-rays). No internal exposures would be received since the LLW would be contained within the shipping containers. Population exposure models are described in detail in the RADTRAN 4 technical manual (Neuhauser, 1991). The various groups of persons potentially at risk from routine operations resulting from overland transportation would be the truck crew and the general public:

- Conveyance: Dose rates in the cabs of tractor trucks carrying radioactive waste are required by regulation to be less than 2 mrem/hr (49 CFR 173). All trucks are modeled as having two-person crews. All rail shipments are modeled as having five-person crews.

- Persons Along the Transportation Route: This group, often referred to as the off-link population, generally receives the smallest doses. Population doses to persons within 800 m (0.5 mi) on each side of the transport route are estimated.

- Persons Sharing the Transportation Route: Population doses to persons in vehicles traveling in the same direction (including passing vehicles) and in the opposite direction (collectively referred to as the on-link population) are estimated, although their doses, if existent at all, are also usually very small.

- Intermodal Handlers: Because Sandia railroad spur maintenance has been discontinued, rail shipments directly from the laboratory site are no longer possible. Instead, all rail shipments must be trucked to the ATSF intermodal transfer yard at Woodward and Second streets in Albuquerque. The transfer from truck to rail requires intermodal handling to be addressed in the estimation of shipment risks. A different model was used for each of the two types of packagings:

  Drums Exposures to handlers, during transfer of cargo containers containing drums from trucks to a rail car, were modeled as 5 individuals at 1 meter from a container for 90 minutes. This model may also be interpreted as 15 individuals at 1 meter from a container for 30 minutes.

  Boxes Exposures to handlers, during transfer of individual boxes from trucks to a rail car, were modeled as 5 individuals at 1 meter from a box for 6 hours. This model may also be interpreted as 30 individuals at 1 meter from a box for 1 hour.

- Persons at Stops: Population doses to persons at fuel and rest stops, tire inspection stops, etc., along the route are estimated. In this analysis the stop time was derived by using 0.011 hr/km (.018 hr/mi) as the stop rate for truck shipments (based on national trucking data for long haul shipments). The general public population exposed during each stop was estimated at 50 persons, and the average exposure distance for these persons was 20 m (65 ft). For rail shipments, the stop time in rail yards was derived by using 0.033 hr/km (0.053 hr/mi) (Woodin, 1986). The distribution of both workers and members of the public who live or pass by close to a rail yard is modeled as a uniformly distributed population typical of the suburban population density associated with a particular rail route. The population potentially exposed to radioactive shipments during rail yard stops is estimated by assigning this rail route specific average suburban population density to an area surrounding the radioactive shipment modeled as an annulus with an inner radius of 10 m (32.8 ft) and an outer radius of 400 m (1312 ft). Based on population data from the computerized rail atlas INTERLINE (ORNL, 1992b), the following average suburban population densities for the specific routes were estimated in Table C.2:

Table C.2 Average Suburban Population Densities

Route	Rail Stop Population Density	Potentially Exposed Population
SNL/NM - Las Vegas	323 km^{-2}	162
SNL/NM - Hanford	383 km^{-2}	193
SNL/NM - SRS	342 km^{-2}	172
SNL/NM - Envirocare	385 km^{-2}	194

- Maximally Exposed Individual: This term refers to an individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters (98 ft).

- "Traffic Jam" Maximally Exposed Individual: This term refers to an individual member of the public who is sharing the highway with the LLW conveyance during a traffic stoppage resulting in traffic jam conditions. The exposure to this individual is modeled with a 2-hour traffic stoppage with an exposure distance of 2 m (6.5 ft). This dose estimate is performed for a single truck shipment to establish an estimate of a potential dose resulting from a realistic traffic situation.

C.5 Incident-Free Rail Transportation

The incident-free rail transportation impact assessment was performed using the RADTRAN 4 computer code just as the incident-free highway analysis was performed. Detailed information regarding the rail routes and population distributions along the transportation routes to the NTS, Hanford Reservation, U.S. Ecology, SRS, Chem Nuclear, and Envirocare was obtained from the INTERLINE 5.0 computer program, a computerized rail routing model (ORNL, 1992b). All other aspects of the analysis are the same as for the highway analysis.

C.6 Highway Accidents

C.6.1 Methodology

Risk analysis of potential accidents differs from calculations for incident-free transportation because the analyst must account for the probability of an accident occurring. In the incident-free scenario, some exposure is expected from radiation emitted from the casks. In the case of accidents, the probability of exposure is only an estimate of a hypothetical event. Probabilities are derived from published accident rates for truck and rail transportation modes.

The DOE has developed a method for analyzing the risks associated with the transportation of radioactive material that does not employ the use of specific accident scenarios. Transportation accident analysis presents a very different risk assessment problem than fixed site facility accident analysis, such as those for nuclear power plants, for which the concept of accident scenario analyses are appropriate. Transportation accidents can happen at any point along the transportation route and the specifics that would define a particular accident scenario (e.g., weather, velocity, traffic, location, interaction with other vehicles and pedestrians) must be modeled in a generic, stochastic fashion. RADTRAN 4 uses a model that employs an accident severity category approach for modeling severe accident environments rather than specific accident scenarios. Accident environments are modeled as a set of "accident severity categories" (see Appendix A.2). The full range of credible accident outcomes are encompassed by the accident severity categories: from "fender benders" to horrific, violent accidents that could subject the conveyances and cargos to extreme physical stresses (via crush or puncture forces), or extreme thermal stresses (via intense and prolonged fire), or a combination of both types of stresses. The mapping of the spectrum of all credible accident outcomes into a two-dimensional space defined by two accident parameters (physical force vs. thermal stress) is synonymous to the development of accident scenarios for risk assessment of fixed facilities (such as nuclear power plants or waste disposal sites). The severity categories include all accidents with a probability of occurrence of one in a million or greater for the entire campaign of truck or rail shipments, a figure well within the levels found acceptable by the EPA and other agencies (Hallenbeck, 1986).

The likelihood that any given accident would result in a particular accident environment is modeled by assigning conditional probabilities to each of the severity categories (NRC, 1977). Conditional probabilities are assigned to each category (see Appendix A). A conditional probability is defined as the probability that an accident, given that it occurs, would be of a certain severity. These conditional probabilities, when combined with specific accident frequency rates and the number of shipments in a campaign, establish an estimate of the frequency of the accident severity categories. These frequencies are then combined with the RADTRAN 4 accident consequence analysis to yield estimates of accident risk. For truck shipments, the accident frequency rates are based on accident statistics for Federal, State, and local road types for each State and for each population density regime (urban, rural, and suburban). For rail, accident frequency rates are based on national rail accident data for each population density regime. The appropriate accident frequencies for each segment of the transportation route (these segments are illustrated in Section 3.0) of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste is taken from the HIGHWAY 5.0 computer program (ORNL, 1992a) for truck shipments and the INTERLINE 5.0 (ORNL, 1992b) computer program for rail shipments.

The behavior of the packages and the radioactive materials during accident environments is modeled by assigning release fractions to each accident severity category (see Appendix A). Release fractions for shipments of multiple Type A packages, such as for 55-gal drums and 4'x4'x7' boxes modeled for the shipping campaigns of the proposed action, have been estimated by the DOE (Finley, 1988) for each of the eight accident severity categories used in this analysis. Release fractions represent a statement of belief regarding the quantity of radioactive material that would be released into the environment given an accident environment of a particular severity. These release fractions are combined with other accident analysis parameters (e.g., accident frequencies, accident severity category probabilities) to develop the expected release of radioactive material into the environment.

Atmospheric dispersion is usually the primary mechanism for dispersing any radioactive material that might be released in a severe accident. Weather conditions cannot be predicted far in advance with any certainty, and transportation analyses must consider the fact that weather may vary from one point on a route to another. Therefore, national average weather conditions are used for transportation by highway.

C.6.2 Waste Packaging Performance

The performance of the package in each accident severity category is accounted for in this analysis. "Type A" waste containers such as a 55-gal steel drum or a 4'x4'x7' steel box (DOT 7A) are intended to provide a safe, economic means for transporting relatively small quantities of radioactive wastes. These containers are expected to retain their integrity under the kinds of abuse considered "normal," or likely to occur during transport: falling from vehicles or being dropped from similar heights, being exposed to rain, being struck by a sharp object that may penetrate their surface, being positioned under other heavy containers. They must be designed to satisfy all of the requirements imposed on Strong, Tight Containers. They must also satisfy stringent additional dimensional, ambient environment, internal pressure, and containment specifications. It is assumed that Type A packages would fail to contain their contents in a severe accident, creating a potential pathway for the release of contents. The regulations therefore prescribe limits on the maximum amounts of radionuclides that can be transported in such packages. These limits ensure that in the event of a release, the consequences from external radiation or contamination are minimized or below recognized thresholds.

Federal regulations require that all Type A packages used be certified by the appropriate agency. The DOE proposes to use only DOT-certified packagings for this proposed action. The certification process for a package design includes extensive documentation that the package can pass certain performance-based test criteria. Passing is defined as the package's ability to maintaining specified shielding and containment capabilities after being subjected to appropriate test conditions. Type A packages must be able to withstand test conditions that simulate the stress of normal, nonaccident conditions of transport. The test standards for Type A packages as established in Title 49 Code of Federal Regulations, Parts 173.463 through 173.469 (49 CFR 173.463 through 173.469) are as follows:

- water spray for one hour
- free-fall drop of the package onto a flat surface from a height of 1.2 m (4 ft), if the package weighs 11,000 pounds or less;
- compression five times the package's weight for 24 hours; and
- free-fall drop of a 5.9 kg-bar (13 lb-bar) on end onto the package from a height of 1 m (3.3 ft).

An NRC certificate is issued as evidence that a packaging and its contents meet applicable Federal regulations. The certificate is issued on the basis of a Safety Analysis Report (SAR) on the packaging design. Type B packaging must survive certain severe hypothetical accident conditions of impact, puncture, fire, and immersion. The tests are not intended to duplicate accident environments, but rather to produce damage equivalent to extreme accidents. The complete accident sequence is described 10 CFR 71.73 and is summarized here.

C.6.3 Test Sequence for Type B Packagings

The effects on a package of the tests may be evaluated either by subjecting a scale-model sample package to the test or by other methods acceptable to the NRC. The NRC Regulatory Guide 7.9 allows assessment of package performance by analysis, prototype testing, model testing, or comparison to a similar package. To be judged as surviving, the packaging must not exceed allowable releases defined in 10 CFR 71.51. The dose rate outside the packaging must not exceed 1 rem/hour at a distance of 1 meter (3.3 ft) from the packaging surface. The first three tests must be performed on the same package in this order: drop test; puncture test; and thermal test (with an immersion test following for fissile material packagings only).

The drop test consists of a 9-meter (30-foot) drop onto a flat, essentially unyielding, horizontal surface, striking the surface in the position for which maximum damage is expected. The puncture test consists of a 1-meter (40-inch) drop onto the upper end of a 15-centimeter (6-inch) solid, vertical, cylindrical bar of mild steel mounted on an essentially unyielding surface. The top of the bar must be horizontal and its edge rounded to a radius of not more than 6 millimeters (.25 inches). An essentially unyielding surface is one that absorbs very little of the energy of impact, which means that the energy of impact is absorbed almost entirely by the test object (cask). Unyielding surfaces are constructed of a monolithic concrete base, reinforced by Re-bar and covered with a plate of battleship armor.

In a thermal test, the packaging must be exposed for not less than 30 minutes to a heat flux not less than that of a radioactive environment of 800°C (1475°F) with an emissivity coefficient of at least 0.9. The surface absorptivity must be either the value that the package may be expected to possess if exposed to a fire, or 0.8, whichever is greater. When it might be significant, convective heat input must be included on the basis of still, ambient air. The packaging may not be artificially cooled after external heat input ceases, and any combustion of packaging materials must be allowed to proceed until it terminates naturally.

Fissile materials packaging for which water in-leakage has not been assumed for criticality analysis must be subjected to submersion under a head of water of at least 0.9 meters (3 feet) for not less than 8 hours and in the attitude for which the maximum leakage is expected. All packages must be subjected to a separate test in which an undamaged cask is submerged under a head of water of at least 15 meters (50 feet) for not less than 8 hours.

Although spent fuel casks have been involved in several accidents, their integrity has never been compromised. The regulatory tests are structured to place an upper bound on the kinds of damage seen in actual severe transportation accidents. Furthermore, after completion of this series of performance qualification tests, Type B packagings are further subjected to a post-accident, leak-rate performance test (10 CFR 71.51). In this test, no escape of radioactive material is allowed that exceeds an A2 amount within one week of testing. The A2 amount of an isotope is the maximum activity of that isotope in a potentially dispersible form that is allowed to be shipped in a Type A packaging, which is non-accident resistant. Safety Series No. 6 lists A2 values for all commonly transported isotopes.

The use of an essentially unyielding target makes the regulatory certification tests extremely demanding. Real targets are much more yielding. For example, a lead-shield steel cast was dropped 610 meters (2,000 feet) from a helicopter onto undisturbed soil (USNRC, 1977). Impact velocity was 396 kilometers per hour (235 miles per hour). The cast entered 2.4 meters (8 feet) into the hard soil but suffered no measurable deformation. An identical cask dropped 9 meters (30 feet) onto an essentially unyielding surface during regulatory testing suffered considerably more deformation (Yoshimura, 1978). More recent research has expanded the study of yielding targets (e.g., concrete surfaces) and their comparison with the regulatory surface.

C.6.4 Transportation Regulations - Overland Carriage

Overland shipments (by rail car or by truck) are regulated by a variety of DOT and NRC regulations dealing with packaging, notification, escorts, and communication. In addition, there are specific regulations for carriage by truck and carriage by rail.

When provisions are made to secure a package so that its position within the transport vehicle remains fixed during transport, with no loading or unloading between the beginning and end of transport, a package shipped overland in exclusive-use closed transport vehicles may not exceed the following radiation levels as provided in 49 CFR 173.441(b):

- 1,000 mrem/hr on the external package surface;

- 200 mrem/hr at any point on the outer surface of the vehicle;

- 10 mrem/hr at any point 2 meters (6.6 feet) from the vertical planes projected by the outer lateral surfaces of the vehicle; or, in the case of an open vehicle, at any point 2 meters from the vertical planes projected from the outer edges of the vehicle; and

- 2 mrem/hr in any normally occupied position in the vehicle. This provision, does not apply, however, to private motor carriers when the personnel are operating under the auspices of a radiation protection program and are wearing radiation-exposure monitoring devices.

The shipper of record must comply with the requirements of 10 CFR 71.5 and 73.37. Section 71.5 provides that all overland shipments must be in compliance with DOE and NRC regulations. These regulations provide for security of irradiated reactor fuel. General requirements include the following: provide notification to NRC in advance of each shipment; develop a shipping plan; provide escort instructions; establish a communication center to be staffed 24 hours a day; make arrangements with local law enforcement agencies along the route for their response; ensure that law enforcement agencies are not being used as escorts, ensure that the escorts are trained in accordance with 73.37 Appendix D; and ensure that escorts make notification calls every two hours to the communications center. Additional requirements include having two armed escorts within heavily populated areas (when not in heavily populated areas, only one escort is needed) with the capability of communicating with the communications center and local law enforcement agencies through a radiotelephone or other NRC-approved means of two-way voice communications.

The shipper of record, required by 49 CFR 173.22, provides physical security measures for spent fuel shipments equivalent to those of the NRC. The shipper and his agent will provide notification to State officials for unclassified spent fuel shipments.

C.6.5 Truck Carriage

For carriage by truck the carrier will use interstate highways or state-designated preferred routes for movements of radioactive wastes in conformity with the DOE rulemaking known as Docket HM-164. These regulations, found in 49 CFR 397.101, establish routing and driver training requirements for highway carriers of packages containing "highway-route-controlled quantities" of radioactive wastes. Spent fuel shipments constitute such quantities. DOT rules make those routes designated by appropriate State agencies enforceable by the Federal government according to DOT's own determination that such route designations, when accompanied by an adequate safety analysis, are likely to result in further reduction of radiological risk.

C.6.6 Rail Carriage

For carriage by rail car, each shipment by the railroad must comply with 49 CFR 174, in particular, 174 Subpart K, "Detailed Requirements for Radioactive Materials."

Accident Risks During Overland Transportation

The radiological accident risks from the shipping campaign described in Section 2.1.4 were calculated assuming that a specific population of people was exposed to a contaminated plume that might result from an accident. The number of persons potentially exposed varied by route segment and was based on the segment population density and downwind travel of the radioactive cloud (plume). In the event of a severe transportation accident and fire within an urban area, the radioactive cloud is assumed to travel over the urban area to a distance of 80 km (50 mi) of the accident site. In reality, the plume would be subject to prevailing winds and might disperse from populated areas. In addition, although the urban population is typically much greater than the population in surrounding outlying areas, the accident model treats the urban population density as constant over the 80 km (50 mi). Another conservative assumption incorporated into the risk assessment is that the entire population remains in the area for 24 hours and therefore is exposed to the greatest extent possible to radioactive waste deposited on the ground from the plume. In reality, individuals close to an accident would probably be evacuated in less than 24 hours.

C.7 Rail Accidents

Risk associated with rail shipments of radioactive waste is estimated based on the number of rail cars shipped, not train shipments. This is because accident data for rail are aggregated into rail car mileage statistics. Thus, for this assessment, a single rail shipment is defined as a shipment of LLW involving an individual rail car. If more than one rail car of SNL/NM LLW were to be attached to the same train, then the total number of rail cars carrying LLW associated with that train would determine the associated impacts. All other aspects of the rail accident methodology are the same as the highway accident methodology (Section 4 of the Environmental Assessment for Sandia National Laboratories/New Mexico Offsite Transportation of Low-Level Radioactive Waste).

C.8 Nonradiological Health Effects and Risks

A series of unit-risk factors (that is, risk per kilometer traveled) have been developed based on national statistics for accident-related deaths for highway and rail modes (Wilmot, 1983). These factors, shown in Table C.2, have been used to calculate the expected numbers of nonradiological fatalities associated with highway transportation of the SNL/NM LLW shipments to each of the options for the proposed action.

The nonradiological impacts were estimated only for a truck shipment campaign using 55-gal drums to package the waste. This establishes an upper bound on the potential nonradiological risks. If the 4'x4'x7' boxes were used to package the waste, then fewer shipments would be required than those with the use of drums. The primary non-radiological impact is death from mechanical causes in traffic accidents. Traffic accidents also may cause non-fatal injuries. In general, approximately 98 percent of traffic-related injuries in urban areas and 94 percent in rural areas are non-fatal. However, no estimate of the expected number of injuries was made in this analysis.

Health effects related to vehicle emissions from the truck shipments are estimated in terms of LCFs. Recovery rates for cancer are far more variable and dependent upon the location of the cancer. In part due to the large variation in relative incidence of non-fatal health effects, fatalities are the only measure of harm that allows direct comparison between radiological and nonradiological consequences. An estimate of consequences of incident-free transportation (latent cancer fatalities associated with release of pollutants by trucks in urban areas) are presented for completeness. These estimates include very large uncertainties. The incident-free estimates were calculated with published nonradiological risk factors (Rao, 1982) used in combination with the truck transportation distances associated with each LLW disposal option. The nonradiological impact estimates include the contribution from the return trip of the truck to SNL/NM.

C.9 Cumulative Impacts

Cumulative impacts are those that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (See 40 CFR §1508.7. [CEQ, 1978]). To calculate the cumulative radiological impact, maximum annual doses from the proposed action and from other projections for radioactive wastes transportation to the same facilities, along the same routes and during the same time as the proposed action, are added (see Table C.3). This approach neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the total cumulative dose (Ullrich, 1987; Miller, 1989).

The following discussion describes the results of the "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," NUREG-0170 (NRC, 1977).

Table C.3 Cumulative Impacts

NONRADIOLOGICAL UNIT FACTORS FOR TRUCK TRANSPORTATION			
	Rural	**Suburban**	**Urban**
Normal Nonoccupational (latent cancers/km)	---	---	1.0×10^{-7}
Accident Nonoccupational (fatalities/km)	5.3×10^{-8}	1.3×10^{-8}	7.5×10^{-9}
Occupational (fatalities/km)	1.5×10^{-8}	3.7×10^{-9}	2.1×10^{-9}

The proposed action is similar in many respects to that of other radioactive waste transportation that is taking place in the same locations and along similar routes. The transportation of radioactive wastes and shipments of spent nuclear fuel to support the fuel cycle, in particular, were assessed in NUREG-0170 (NRC, 1977). This Environmental Statement considered the risk of transporting various types of packages of radioactive waste along transportation corridors, such as the ones that would be used for the proposed action, and determined that the total annual incident-free and accident risk was minimal. Recent studies of radioactive waste shipments indicate that no substantial changes in the number of shipments or in their characteristics have occurred over the intervening years that would invalidate the general results of NUREG-0170 (Weiner, 1991). For individuals residing near principal transportation routes, NUREG-0170 estimated that the average annual individual dose from radioactive waste transportation activities was about 0.09 mrem. Recently it was estimated that a maximal exposed individual member of the public would not receive more than 0.14 mrem if exposed to the in-transit passage of all of the 1,611,443 radioactive materials packages shipped in the United States in a single year (Weiner, 1991). This is, of course, not a realistic scenario, but it does place an upper bound on the individual in-transit dose from other shipments.

It was also estimated that the individual in-transit dose for a person located 30 meters (98 ft) from an average route segment is only 0.00009 mrem (Mills, 1994). However, the number of radioactive waste shipments occurring annually in the vicinity of the NTS or Hanford could exceed the average radioactive waste traffic on the nation's roadways because of 1) the location of the U.S. Ecology commercial LLW repository within the Hanford boundary, and 2) the variety of shipments that enter and leave both the NTS and Hanford to support other DOE programs. NUREG-0170 used annual shipment levels for the United States as a whole to obtain maximally exposed individual dose estimates. The two classes of shipments considered that can be used to conservatively model traffic in the NTS and Hanford vicinity are spent fuel shipments (250 commercial reactor shipments) and secondary transport. Secondary transport is the shipment by light-duty vehicles of consignments of a large variety of packages (DOT Type A and small Type B packages) in cities and suburbs along secondary roadways and city streets. NUREG-0170 estimated that the dose to an individual living 30 m (98 ft) from a roadway over which all 250 spent fuel shipments passed would be 0.009 mrem and that no individual would receive more than an additional 0.009 mrem from secondary transport, which gives a total of 0.018 mrem from these sources. The maximum annual dose to a person exposed to local highway traffic in the vicinity of either the NTS or Hanford is unlikely to exceed 0.018 mrem. Therefore, the average annual individual dose remains valid for considering the cumulative impacts associated with the proposed action.

APPENDIX D

ACCIDENT RISK EXCEEDENCE PLOTS

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APPENDIX D:

D.1 Accident Risk Exceedence Plots

Figures D-1 through D-4 present a graphical illustration of intermediate RADTRAN 4 risk calculations. These figures show the expected frequency of exceeding specific levels of consequences. The figures contain graphs of expected number of accidents annually (accidents per year) versus the consequences (person-rem). The plots are generated by taking individual accident frequency/consequence pairs from the intermediate RADTRAN 4 risk calculations for each transportation route link. Thus, for a particular transportation route link, the appropriate rural, suburban, and urban accident frequency/consequence pairs will be plotted, and so on for each link along the route. The resulting plots yield a risk profile that illustrates how the likelihood of the occurrence or exceedence of specific levels of consequences becomes much less likely as the level of consequences increases. Also plotted on each graphs is the locus of constant risk that converts to a health effects risk of 1.0E-05 LCFs. This locus is presented a perspective on the risk profile against a constant standard.

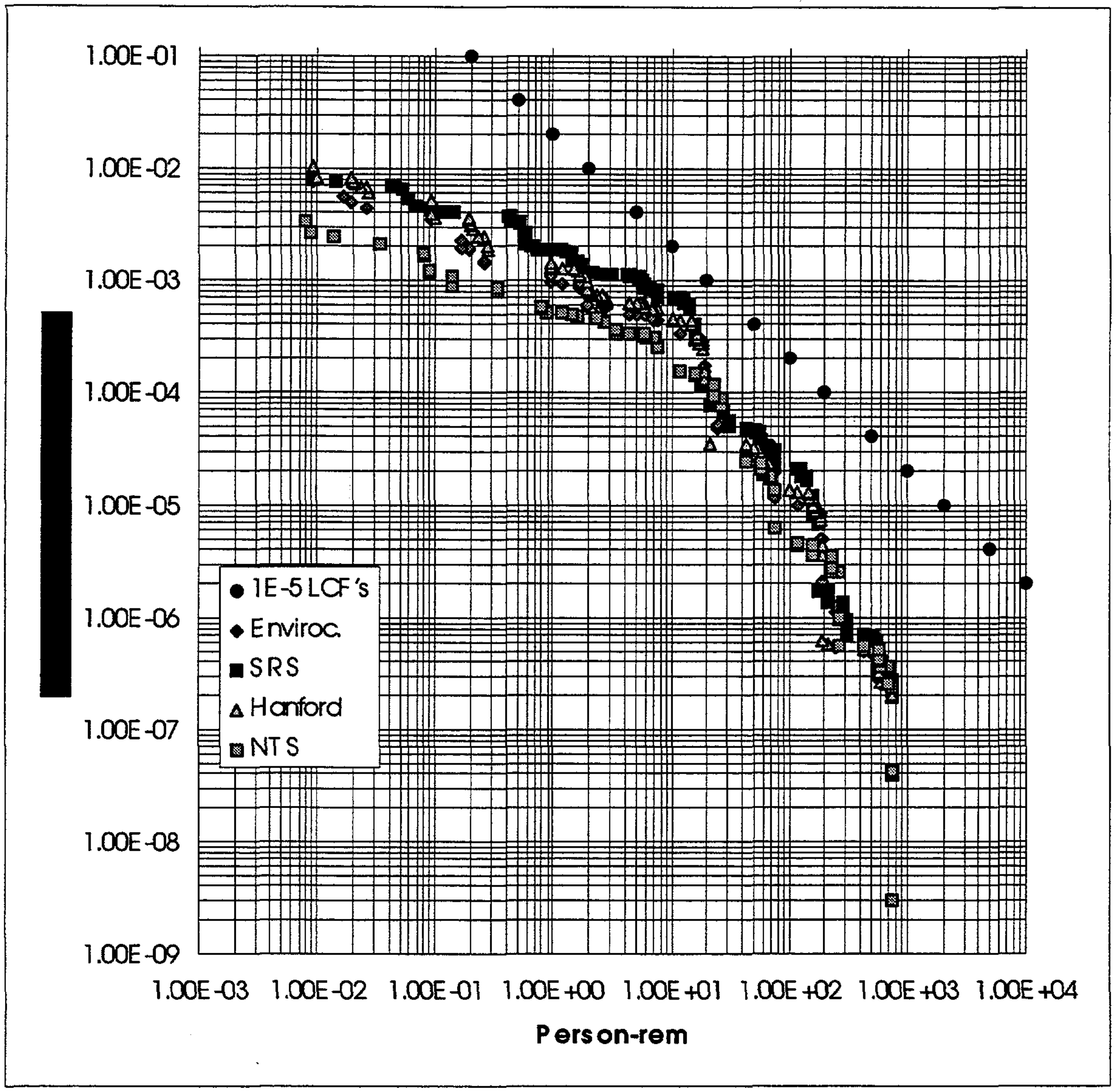

Figure D-1
Consequence Exceedence Graph For Truck Shipments of Average Waste Drums

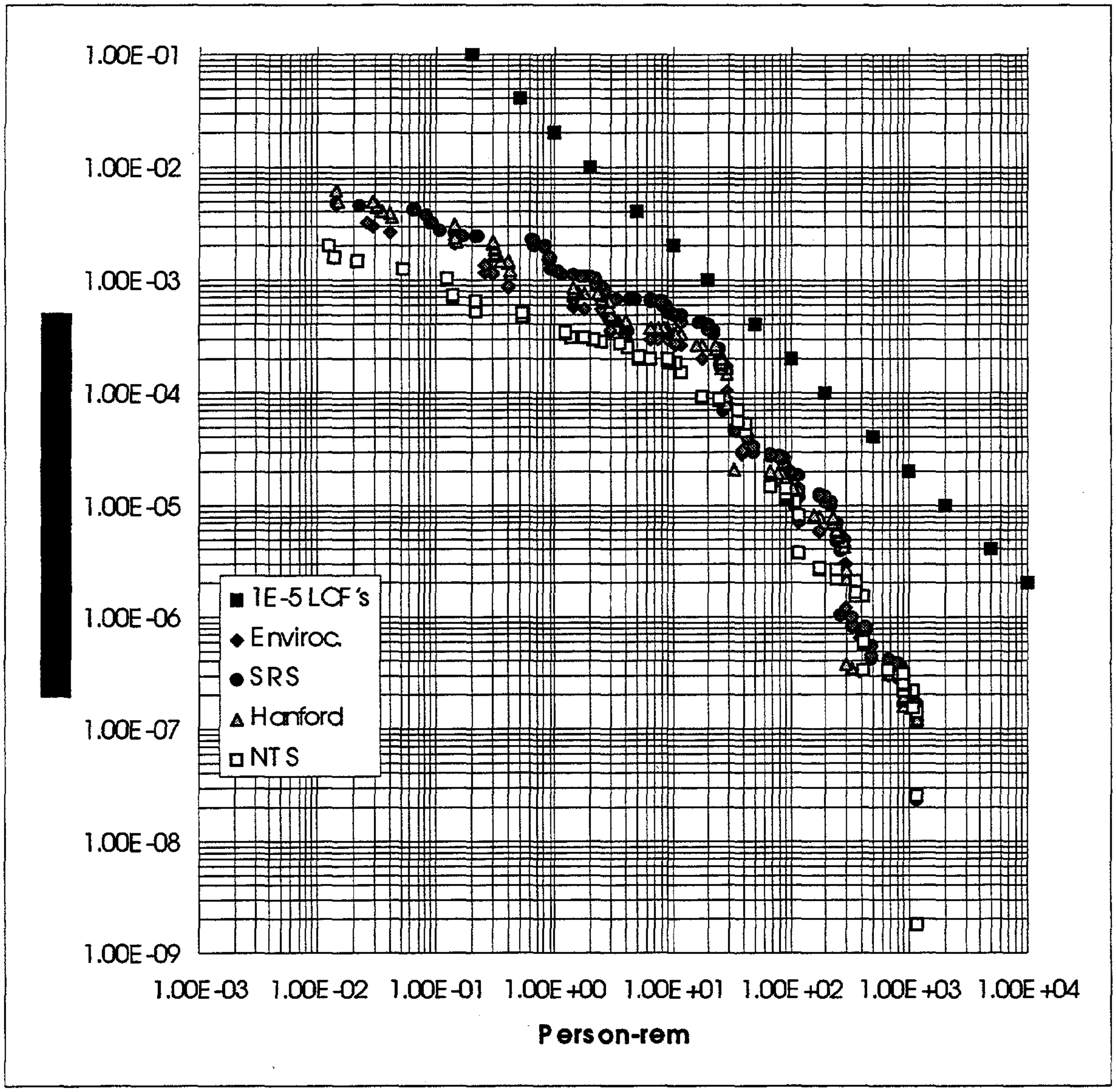

Figure D-2
Consequence Exceedence Graph For Truck Shipments of Average Waste Boxes

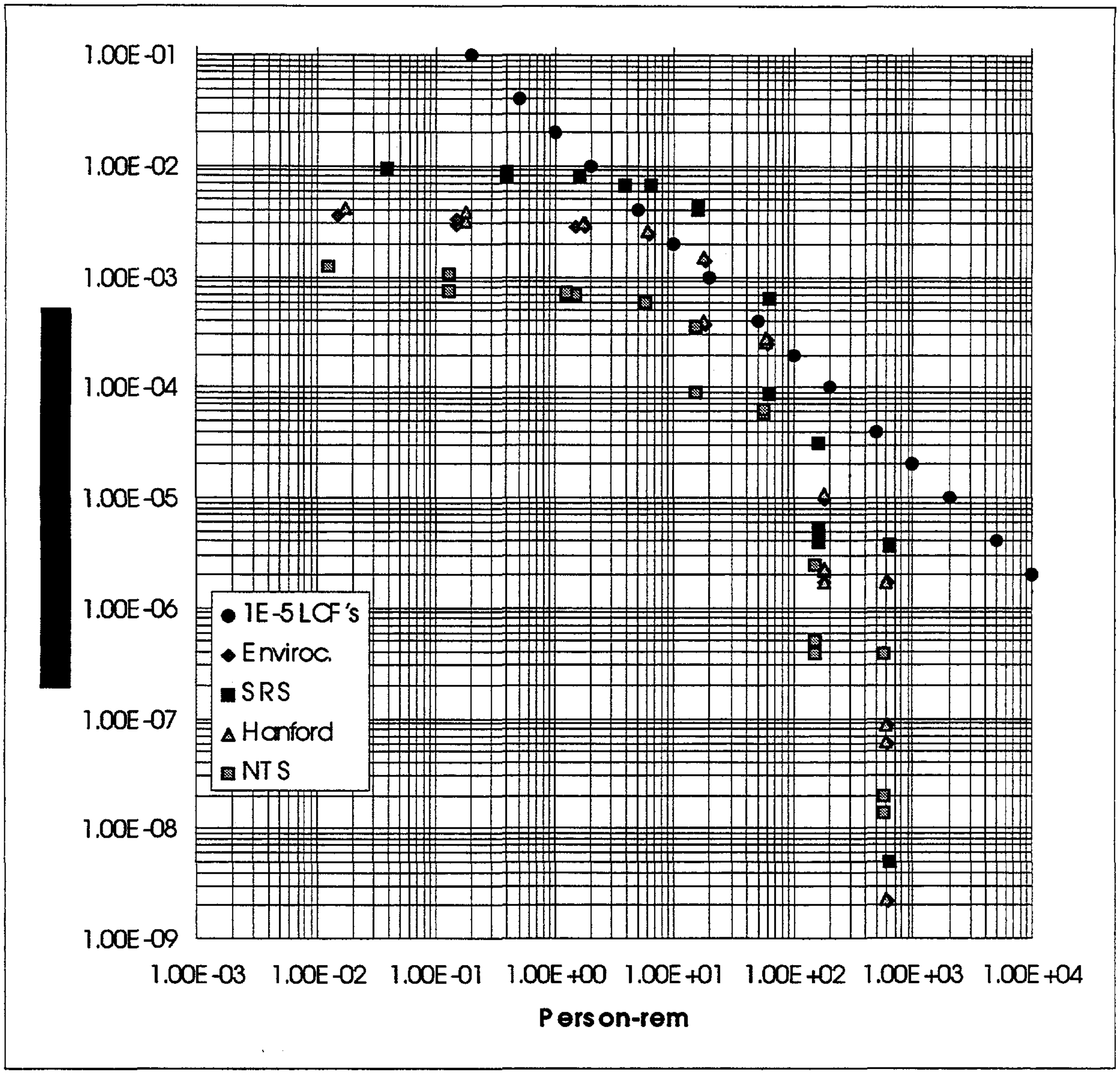

Figure D-3
Consequence Exceedence Graph For Rail Shipments of Average Waste Drums

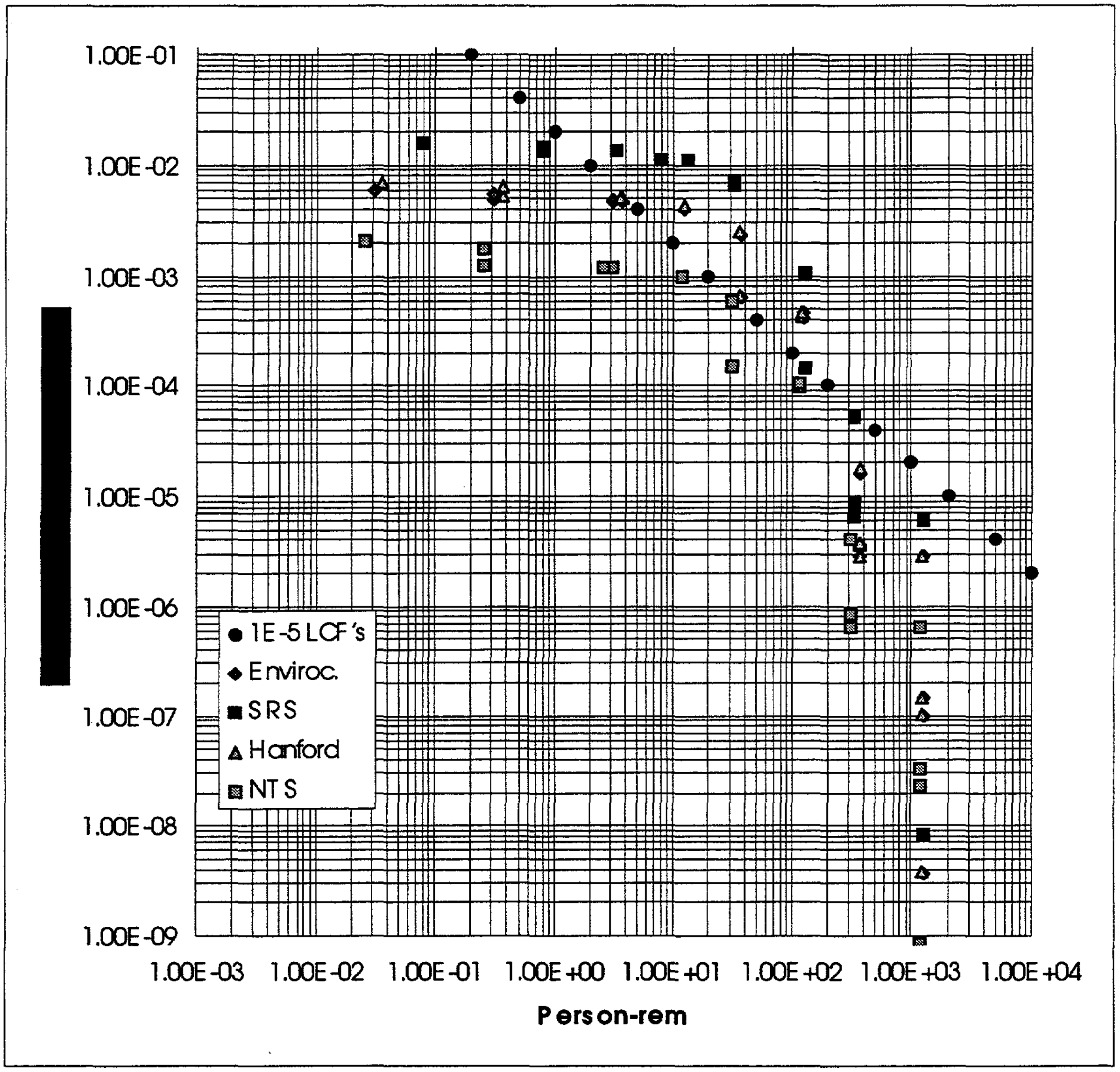

Figure D-4
Consequence Exceedence Graph For Rail Shipments of Average Waste Drums

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GLOSSARY

Absorbed Dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.
Activity	See Radioactivity
Ci, μCi, nCi	Curie, microcurie, and nanocurie; special unit of radioactivity. One Ci is 3.7 x 10^{10} nuclear transformations per second. One μCi equals 10^{-6} Ci, while one nCi equals 10^{-9} Ci; 10 nCi/g equals one part per million.
Committed Effective	The sum of the committed dose equivalents to various tissues in the
Dose Equivalent	body, each multiplied by the appropriate weighting factor. It is expressed in units of rem (or sievert) (WHC, 1994).
Compaction	Reduction of waste volumes by hydraulic press, in the cases where such reduction would not itself cause a hazard.
Dose	The quantity of radiation absorbed, per unit mass, by the body or by any portion or the body (10 CFR 20.4[a]).
Dose Equivalent	The product of absorbed dose in tissue, a quality factor, and other modifying factors. Absorbed dose (expressed in units of rad) is the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. A quality factor is the principal modifying factor used to calculate the dose equivalent from the absorbed dose. Dose equivalent is expressed in units of rem.
Dose Rate	The radiation dose delivered per unit of time measured, for example, in rem per hour (Shleien, 1992).
Effects	Synonymous with impacts. Includes ecological, aesthetic, historic, cultural, economic, social, or health impacts, whether direct, indirect, or cumulative. Under NEPA, the effects of beneficial, as well as detrimental, actions must be considered (DOE, 1994b).
Gamma Rays	Electromagnetic radiation emitted in the process of unclear transition or radioactive decay.
General Public	The general populace; does not include radiation workers.
Generator	Any person, by site location, whose act or process produces hazardous waste identified or listed in 40 CFR 261 (RCRA, Sections 144.2; 146.3; 270.2).

Impacts	See Effects
Latent Cancer Fatality	A fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure.
Low-Level Waste	Waste that contains radioactivity and is not classified as high-level
(LLW)	waste, transuranic waste, or spent nuclear fuel, or by-product material. Test specimens of fissionable material irradiated for research and development may be regarded as LLW only if the concentration of transuranics is less than 100 nCi/gm.
Maximally Exposed Individual	An individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters.
Neutron Generator	A piece of equipment that enhances a nuclear chain reaction in a nuclear warhead through the electrical acceleration of ions onto a target of fissionable material.
Offsite	Anything, such as roads, buildings, streams, or people, located outside or beyond the restricted public access boundaries. Any site that is not onsite.
Person-rem	Unit of estimating dose from radiation exposure to a population. Equal to the average individual dose times the number of people in the population exposed.
Probability	The annual probability of occurrence of a single accident or event sequence.
Rad	The unit of absorbed dose equal to 100 ergs/gm (0.01 J/kg) in any medium.
Radioactivity	(1) The spontaneous nuclear decay of a material with a corresponding release of energy in the form of particles and/or electromagnetic radiation. (2) The property characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel) (DOE, 1994b).
Radioactive Waste	Solid, liquid, or gaseous materials of negligible economic value that contain radionuclides in excess of threshold quantities except for radioactive material from post-weapons test activities.
Release Fraction	The fraction of the total inventory of radioactive or hazardous particulate or vapor released to the atmosphere during an accident.
Quality Factor	The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor (QF).

rem — See Roentgen Equivalent Man.

Risk — A measure of the product of the probability and the consequences of an accident expressed in either qualitative or quantitative terms.

Roentgen Equivalent Man (rem) — (1) Unit used to express human biological doses as a result of exposure to various types of ionizing radiation. (2) Unit of radiation that charges atoms, equal to the amount that produces the same damage to humans as 1 roentgen of high-voltage x-rays. The relation of the rem to other dose units depends on the biological effect under consideration and on the conditions/type of irradiation (DOE, 1994b.).

Site — The land area that a facility occupies. The area of land owned or controlled by the DOE for the principal purpose of constructing and operating a facility and limited by the site boundary.

"Traffic Jam" Maximally Exposed Individual — An individual member of the public who is sharing the highway with the LLW conveyance during a traffic stoppage resulting in traffic jam conditions. The exposure to this individual is modeled with a 2-hour traffic stoppage with an exposure distance of 2 m (6.5 ft). This dose estimate is performed for a single truck shipment to establish an estimate of a potential dose resulting from a realistic traffic situation.

Transportation Index (TI) — A dimensionless number (rounded up to the nearest first decimal place) displayed on the label of a package to designate the degree of control to be exercised by the carrier during transportation (10 CFR 71.4). For this EA, the TI is the number expressing the maximum radiation level in millirem per hour to be measured at 1 meter (3.25 ft) from the external surface of the outermost package on a conveyance.

Waste Streams — Typical and average quantities of waste by category produced by a facility or an organization annually.

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