APPENDIX E
EVALUATION OF HUMAN HEALTH EFFECTS OF OVERLAND TRANSPORTATION

E.1 INTRODUCTION

The overland transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose an additional risk due to the unique nature of the material itself. In order to permit a complete appraisal of the environmental impacts of the proposed action and alternatives, the human health risks associated with the overland transportation of plutonium residues and scrub alloy have been assessed.

This appendix provides an overview of the approach used to assess the human health risks that may result from the overland transportation. The appendix includes discussion of the scope of the assessment, analytical methods used for the risk assessment (i.e., computer models), important assessment assumptions, and determination of potential transportation routes. It also presents the results of the assessment. In addition, to aid in the understanding and interpretation of the results, specific areas of uncertainty are described, with an emphasis on how the uncertainties may affect comparisons of the alternatives.

The approach used in this appendix is modeled after that used in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a). That environmental impact statement (EIS) did not perform as detailed of analysis of the specific actions taken for plutonium residues and scrub alloys because of the breadth necessary to analyze the entire plutonium disposition program. Nevertheless, the fundamental assumptions used in this analysis are consistent with those used in that EIS, and the same computer codes and generic release and accident data are used.

The risk assessment results are presented in this appendix in terms of "per-shipment" risk factors, as well as for the total risks associated with each material. Per-shipment risk factors provide an estimate of the risk from a single plutonium residue or scrub alloy shipment between the Rocky Flats Environmental Technology Site (Rocky Flats) and the interim management sites. The total risks for a given alternative are found by multiplying the expected number of shipments by the appropriate per-shipment risk factors.

E.2 SCOPE OF ASSESSMENT

The scope of the overland transportation human health risk assessment, including the alternatives and options, transportation activities, potential radiological and nonradiological impacts, and transportation modes considered, is described below. Additional details of the assessment are provided in the remaining sections of the appendix.

- **Proposed Action and Alternatives—**The transportation risk assessment conducted for this EIS estimates the human health risks associated with the transportation of plutonium residues and scrub alloy for a number of management alternatives.

- **Transportation-Related Activities—**The transportation risk assessment is limited to estimating the human health risks incurred during the overland transportation for each alternative. The risks to workers or to the public during loading, unloading, and handling prior to or after shipment are not included in the overland transportation assessment, but are addressed in Appendix D of this EIS. Similarly, the transportation risk assessment does not address possible impacts from increased transportation levels on local traffic flow, noise levels, or infrastructure.

- **Radiological Impacts—**For each alternative, radiological risks (i.e., those risks that result from the radioactive nature of the plutonium residues and scrub alloy) are assessed for both incident-free (i.e., normal) and accident transportation conditions. The radiological risk associated with incident-free transportation conditions would result from the potential exposure of people to external radiation in the vicinity of a loaded shipment. The radiological risk from transportation accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways (i.e., exposure to contaminated ground or air, or ingestion of contaminated food).

  All radiologically-related impacts are calculated in terms of committed dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (NRC 1998a), which is the sum of the effective dose equivalent from external radiation exposure and the 50-year committed effective dose equivalent from internal radiation exposure. Radiation doses are presented in units of roentgen equivalent man (rem) for individuals and person-rem for collective populations. The impacts are further expressed as health risks in terms of latent cancer fatalities and cancer incidence in exposed populations. The health risk conversion factors (expected health effects per dose absorbed) were derived from *International Commission on Radiological Protection Publication 60* (ICRP 1991).

- **Nonradiological Impacts—**In addition to the radiological risks posed by overland transportation activities, vehicle-related risks are also assessed for nonradiological causes (i.e., related to the transport vehicles and not the radioactive cargo) for the same transportation routes. The nonradiological transportation risks are independent of the radioactive nature of the cargo and would be incurred for similar shipments of any commodity. The nonradiological risks are assessed for both incident-free and accident conditions. Nonradiological risks during incident-free transportation conditions would be caused by potential exposure to increased vehicle exhaust emissions. The nonradiological accident risk refers to the potential occurrence of transportation accidents that directly result in fatalities unrelated to the shipment cargo. State-specific transportation fatality rates are used in the assessment. Nonradiological risks are presented in terms of estimated fatalities.

- **Transportation Modes—**All shipments have been assumed to take place by truck transportation modes.

- **Receptors—**Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered are truck crew members involved in the actual overland transportation. The general public includes all persons who could be exposed to a shipment while it is moving or stopped en route. Potential risks are estimated for the collective populations of exposed people, as well as for the hypothetical maximally exposed individual. The collective population risk is a measure of the radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing various alternatives.

Two other DOE EISs cover transportation activities related to the disposition of plutonium residue and scrub alloy, but outside the scope of this EIS. The *Surplus Plutonium Disposition Draft EIS* covers the disposition of plutonium that may be separated from residues and scrub alloy (DOE 1998). The second

| EIS, the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental EIS* (DOE 1997), known as WIPP SEIS-II, includes the environmental impacts of shipping transuranic wastes to the Waste Isolation Pilot Plant (WIPP). Appendix E of the WIPP SEIS-II gives the impacts on a per shipment basis, of transportation from Rocky Flats, Los Alamos National Laboratory, and the Savannah River Site to WIPP.

E.3 PACKAGING AND REPRESENTATIVE SHIPMENT CONFIGURATIONS

Regulations that govern the transportation of radioactive materials are designed to protect the public from the potential loss or dispersal of radioactive materials as well as from routine radiation doses during transit. The primary regulatory approach to promote safety is through the specification of standards for the packaging of radioactive materials. Because packaging represents the primary barrier between the radioactive material being transported and radiation exposure to the public and the environment, packaging requirements are an important consideration for the transportation risk assessment. Regulatory packaging requirements are discussed briefly below and in Chapter 5. In addition, the representative packaging and shipment configurations assumed for this EIS are described.

E.3.1 Packaging Overview

Although several Federal and State organizations are involved in the regulation of radioactive waste transportation, primary regulatory responsibility resides with the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission. All transportation activities must take place in accordance with the applicable regulations of these agencies specified in 49 Code of Federal Regulations (CFR) Part 173 (DOT 1992a) and 10 CFR Part 71 (NRC 1998b).

Transportation packaging for small quantities of radioactive materials must be designed, constructed, and maintained to contain and shield their contents during normal transport conditions. For large quantities and for more highly radioactive material, such as spent nuclear fuel or plutonium, they must contain and shield their contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Another packaging option, Strong, Tight, is still available for some domestic shipments.

Excepted packagings are limited to transporting materials with extremely low levels of radioactivity. Industrial packagings are used to transport materials that, because of their low concentration of radioactive materials, present a limited hazard to the public and the environment. Type A packagings are designed to protect and retain their contents under normal transport conditions and must maintain sufficient shielding to limit radiation exposure to handling personnel. These packagings are used to transport radioactive materials with higher concentrations or amounts of radioactivity than excepted or industrial packagings. Strong, Tight packagings are used in the United States for shipment of certain materials with low levels of radioactivity, such as natural uranium and rubble from the decommissioning of nuclear reactors.

The transportation of highway-route controlled quantities of plutonium (more than a few grams, depending on activity level) requires the use of Type B packaging. In addition to meeting the standards for Type A packaging, Type B packaging must provide a high degree of assurance that even in severe accidents the integrity of the package will be maintained with essentially no loss of the radioactive contents or serious impairment of the shielding capability. Type B packaging must be shown by test or analysis to withstand a series of accident conditions specified in 10 CFR Part 71 (NRC 1998b). The conditions were developed to simulate severe accident conditions, including impact, puncture, fire, and water immersion.

Beyond meeting U.S. Department of Transportation standards showing it can withstand normal conditions of transport without loss or dispersal of its radioactive contents or allowance of significant radiation fields, a Type B packaging must meet the 10 CFR Part 71 requirements administered by the U.S. Nuclear Regulatory Commission (NRC 1998b). The complete sequence of conditions is listed below:

❒ **Free-Drop—**A 9-meter (m) (30-foot [ft]) free-drop onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage to the package is expected.

❒ **Puncture—**A 1-m (40-inch [in]) drop onto the upper end of a 15-centimeter (cm) (6-in) diameter solid, vertical, cylindrical, mild steel bar (at least 20 cm [8 in] long) mounted on an essentially unyielding, horizontal surface.

❒ **Thermal—**Exposure to a heat flux of no less than that of a thermal radiation environment of 800 degrees Celsius (°C) (1,475 degrees Fahrenheit [°F]) with an emissivity coefficient of at least 0.9 for a period of 30 minutes.

❒ **Water Immersion—**A separate, undamaged package specimen is subjected to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft) for no less than 8 hours.

Effective April 1, 1996, 10 CFR Part 71 has been revised to require an additional immersion condition in 200 m (660 ft) of water for Type B casks designed to contain material with activity levels greater than one million curies (Ci) (NRC 1998b). Containers used for shipping plutonium residue and scrub alloy will not necessarily be subject to this test because they will contain much less than one million curies. The packaging may also be required to withstand the crush condition if it is considered a light-weight, low-density package as most drum-type packages are. The crush test consists of dropping a 500-kilogram (kg) (100-pound [lb]) steel plate from 9 m (30 ft) onto the package, which is resting on an essentially unyielding surface.

Additional restrictions apply to package surface contamination levels, but these restrictions are not important for the transportation radiological risk assessment. For risk assessment purposes, it is important to note that all packaging of a given type is designed to meet the same performance criteria. Therefore, two different Type B designs would be expected to perform similarly during incident-free and accident transportation conditions. The specific containers selected, however, will determine the total number of shipments necessary to transport a given quantity of plutonium residue or scrub alloy.

External radiation from a package must be below specified limits that minimize the exposure of the handling personnel and general public. For these types of shipments, the external radiation dose rate during normal transportation conditions must be maintained below the following limits of 49 CFR Part 173 (DOT 1992a):

- 10 millirem per hour (mrem/hr) at any point 2 m (6.6 ft) from the vertical planes projected by the outer lateral surfaces of the transport vehicle (referred to as the regulatory limit throughout this document)

- 2 mrem/hr in any normally occupied position in the transport vehicle.

Plutonium residues and scrub alloy would be shipped from Rocky Flats to other sites for processing in Type B containers. The U.S. Department of Energy (DOE) uses several containers that meet the Type B specifications and which may be selected for these shipments. The 6M container has been used for transporting plutonium metal and is the packaging assumed in this EIS for shipment of those materials. Most likely, plutonium-bearing residues and scrub alloy would be shipped in containers such as the 9968, the 9975, and the 6M container. Other containers, such as TRUPACT, 9965 or 9972 through 9974 could be evaluated and used in place of the 6M, 9968, and 9975 containers. These containers are described in the following sections.

E.3.1.1 Type 6M Packaging

The original Department of Transportation 6M packaging (49 CFR 173.354) was Dow Chemical Corporation's Model 1518, a 38-liter (L) (10-gallon [gal]) container, approved by the U.S. Atomic Energy Commission (now DOE) in March 1967 and issued as U.S. Department of Transportation Special Permit 5000 the following month. The 6M packaging was issued in December 1968 to cover a variety of similar containers ranging in capacity from 38 to 417 L (10 to 110 gal). The 6M packaging is currently authorized by the Department of Transportation regulations for shipment of Type B quantities of radioactive materials (49 CFR 173, Subpart I).

In 1980, the U.S. Nuclear Regulatory Commission expressed concern about shipping plutonium in the 6M packaging. Because of changing specifications, secondary containment for plutonium was required (NRC 1998b). The U.S. Nuclear Regulatory Commission decided the 6M packaging was adequate as an overpack.

As secondary containment was required, the U.S. Nuclear Regulatory Commission also wanted assurance that the Department of Transportation Specification 2R (Inside Containment Vessel) would meet the new leak rates specified in the International Atomic Energy Agency regulations (Kelly 1994).

General construction requirements for the 6M packaging may be found in 49 CFR 178.354, "Specification 6M; Metal Packaging," and for the 2R vessel in 49 CFR 178.360. Refer to **Figure E–1** for an example of a typical 6M and the 2R inner vessel or container.

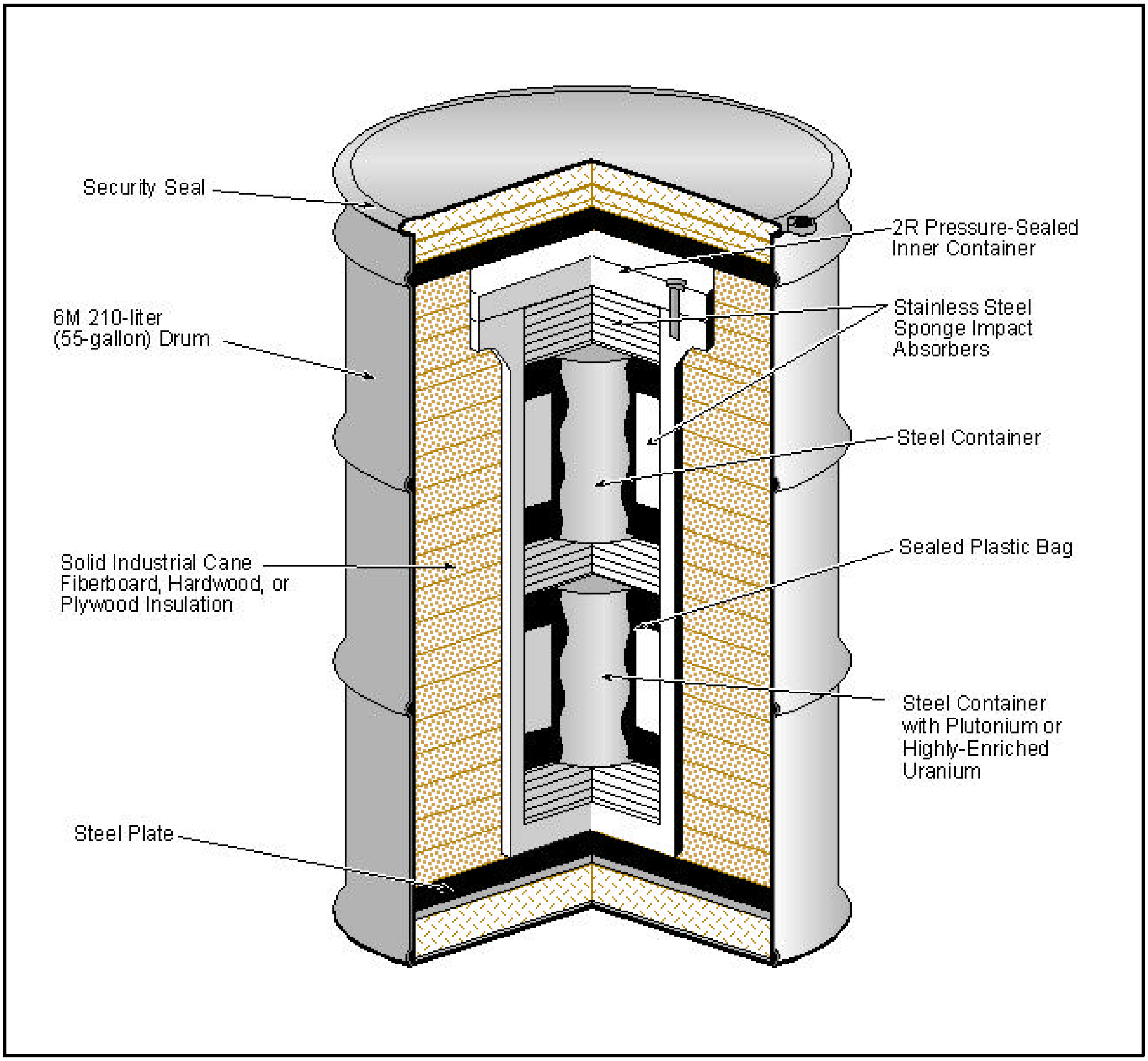

Figure E–1 Typical Assembly of 6M, Type B Packaging for Plutonium (Other than Pits)

In response to U.S. Nuclear Regulatory Commission concerns, the DOE and its contractors expended considerable effort to determine what role the 6M packaging should have for shipping DOE-owned plutonium. The three alternatives selected for evaluation were as follows:

- Improve the 6M procedures to resolve specific concerns raised by the U.S. Nuclear Regulatory Commission
- Procure and use packaging that is presently certified for shipment of plutonium
- Design and certify a new packaging to ship plutonium.

The first alternative was chosen. Technical reviews and safety assessments have been performed on 6M specification packaging, 2R inner container welds associated with 6M packaging, the types and quantities of radioactive material being shipped in 6M packaging, and future packaging to replace the 6M. In 1988, a DOE task force performed a technical review of the 6M packaging configuration. The review and subsequent documentation found that the 6M packaging configuration merits continued use (SNL 1988).

The task force that studied this subject recognized that the use of the 6M is authorized by current U.S. Department of Transportation regulations and recommended procedural improvements for its continued use. It was determined that the number of product can configurations and the number of 6M drum sizes should be reduced, and that the major shipping sites should coordinate an effort to minimize the number of can configurations and drum sizes used for shipment of plutonium.

In 1988, weld defects were found in the DT-14A packages fabricated by a particular manufacturer. Because the manufacturer was a major supplier of 2R inner containers, the integrity of 2R inner containers became a concern. In 1989, DOE Headquarters issued directives (Wade 1989) to all Defense Programs Operations Offices that future shipments of Type B radioactive material in the 6M packaging implement the applicable requirements as specified in the DOE task force's technical document (SNL 1988). The Container Weld Advisory Committee was formed in 1989 to develop recommendations and provide criteria for specific weld issues related to the 2R inner container. The Container Weld Advisory Committee recommended static force testing to ensure that the weld was strong enough to withstand the postulated hypothetical accident condition loadings. The leak testing was to ensure no leak paths existed in the weld. The safety enhancements developed will allow interim use of the 6M until a replacement container is available. As a result, 2R inner-containment vessels have had their bottom plate welds static force tested and leak tested. Additional requirements for Type B plutonium oxide shipments were also imposed, including an evaluation of the payload configuration against hypothetical accident conditions, load testing of the existing inner vessel (2R) welds, and DOE approval of the configuration. The purpose of the added requirements is to allow interim use of the 6M configuration until a replacement container is available (Kelly 1994).

❒ **Drum—**The outer shell is made of straight-sided steel, with welded body seams, and in accordance with Department of Transportation Specification 6C or 17C, with each length to contain 3 wedged or rolled rolling hoops as prescribed for either of these specifications. A removable head has one or more corrugations in the cover near the periphery. For a packaging exceeding 57 L (15 gal) volume, the head must be crowned (convex), not extending beyond the level of the chime, with a minimum convexity of 1 cm (3/8 in).

  Each drum has at least four 1.2-cm (0.5-in) diameter vents near the top, each covered with a weatherproof tape or fusible plug, or equivalent device. A layer of porous refractory fiber may be placed behind the pressure-relief vent holes.

  The outer drum closure is at least a 16-gauge bolt-type locking ring having at least a 5/16-in steel bolt for drum sizes not over 15 gal or a 12-gauge bolted ring with drop-forged lugs, one of which is threaded, and a 5/8-in steel bolt for drum sizes over 15 gal. Each bolt is provided with a lock nut or equivalent device.

  The closure device has means for the attachment of a tamper-proof lock wire and seal.

❒ **Insulation—**The inner containment vessel is fixed within the outer shell by solid centering media, with the sides of the inner vessel protected by at least 9.5 cm (3.75 in) of insulation media, and the ends with at least the thickness as prescribed in 49 CFR 178.104-3(a)(1). The centering media is usually machined discs and rings made of solid industrial can fiberboard having a density of at least 0.24 grams per cubic centimeter (15 lb per cubic foot) fitted such that the radial clearances between the fiberboard, inner vessel, and shell do not exceed 6 millimeters (1/4-in).

- **Shielding—**When necessary, shielding may be provided within the 2R containment vessel. Any radiation shielding material used must be placed within the inner containment vessel or must be protected in all directions by at least the thickness of the thermal insulating material.

- **Primary Containment Vessel—**The primary containment vessel is constructed to Department of Transportation Specification 2R (49 CFR 178.360). Each vessel is made of stainless steel, malleable iron, or brass, or other material having equivalent physical strength and fire resistance.

  The closure device is a screw-type cap or plug. The number of threads per inch must not be less than U.S. standard pipe threads and must have sufficient length of thread to engage at lease five threads when securely tightened. Pipe threads are luted with an appropriate nonhardening compound which must be capable of withstanding up to 149°C (300°F) without loss of efficiency. Tightening torque is adequate to maintain leak tightness with the specific luting compound.

- **Product Cans—**The following cans are authorized for Rocky Flats shipments (SNL 1988):

Material to be Packaged	***Can Dimensions***	***Descriptions***
Plutonium/ Aluminum/ Americium Alloy Button	Can (outer), 11.9-cm diameter (dia), 25.07-cm tall (4.7-in dia, 9.87-in tall)	Ellisco #110345, aluminum, with D-ring handle.
	Can (inner), 11.11-cm dia, 11.89-cm tall (4.375-in dia, 4.68-in tall)	Ellisco #113044, aluminum.
Plutonium Metal	Can (outer), 10.8-cm dia, 17.8-cm tall (4.25-in dia, 7-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.015-in) thick, ends are 0.03-cm (0.812-in) thick, no end profile.
	Can (inner), 10.31-cm dia, 14.12-cm tall (4.06-in dia, 5.56-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.012-in) thick, any end profile authorized.
Plutonium Oxide	Can (outer), 10.8-cm dia, 17.8-cm tall (4.25-in dia, 7-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.015-in) thick, ends are 0.03-cm (0.012-in.) thick, no end profile.
	Can (middle) 10.31-cm dia, 14.12-cm tall (4.06-in dia, 5.56-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.012-in) thick, any end profile authorized.
	Can (inner), 8.74-cm dia, 11.58-cm tall (3.44-in dia, 4.56-in tall)[c]	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body and ends are 0.025-cm (0.010-in) thick, any end profile authorized.

Material to be Packaged	*Can Dimensions*	*Descriptions*
Plutonium/ Aluminum/ Americium Alloy Button, Anode Heels, and Category 3 Metal	Can (outer), 11.43-cm dia, 12.4-cm tall (4.5-in dia, 4.88-in tall)	• Special order. Welded side seam body. • Unsealed end, round, open-top style lid, compound lined with Parexd compound 313 (38.5-40.5) or Parex exp compound AD 23118 LS, double-seamed closure. • Sealed end, no compound allowed, double-seamed, sealed with lead-free tin solder; 0.25 electrolytic tinplate all surfaces of can body and lids. • 0.038-cm (0.015-in) thick body, 0.03-cm (0.012-in) thick ends, no end profile.

- ❐ **Impact Absorbers—**Silicone sponge impact absorbers, made of medium-grade closed-cell silicone sponge rubber, are used.

- ❐ **Contents of Package—**A list of the authorized contents of package, by Rocky Flats drawing number, follows:

Drawing Number	*Material to be Packaged*	*Maximum Material per 2R kg (lb)*	*Maximum Material per Inner Can kg (lb)*
33021-01	Plutonium/Aluminum/Americium Alloy Button	4.5 (9.92)	2.3 (5.07)
33021-02	Plutonium-Contaminated ^{235}Uranium	2.0 (4.41)	2.0 (4.41)
33021-03	Enriched Uranium or Plutonium Metal ^{238}Plutonium Metal	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33021-04	Plutonium Oxide ^{238}Plutonium Oxide	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33021-05	Plutonium Oxide ^{238}Plutonium Oxide	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33020-09	Plutonium/Aluminum/Americium Alloy Button, Anode Heels, and Category 3 Metal	4.5 (9.92)	2.3 (5.07)

E.3.1.2 Type 9975 Packaging

The 9975 type packagings consist of stainless steel containment vessels enclosed within cane fiberboard insulation within a steel drum. The packagings have a double containment assembly of a primary containment vessel with a secondary containment vessel. The 9975 type packagings is the last of a series of Type B containers designed to overcome the drawbacks of the 6M container. The other Type B packagings are 9965, 9968, 9972, and 9974. The 9975 type packaging has a lead shielding insert between the secondary containment vessel and the insulation. The steel drum defines the confinement boundary, and the containment vessels define the containment boundary (WSRC 1996).

The 9975 package assembly is shown in **Figure E–2**. Lead shielding is provided in the 9975 packaging. The 9975 packaging weighs 163 kg (360 lb). The 13-cm (5-in) extension to the 30-gal drum results in a drum that is 89 cm (35-in) high with a 132-L (35-gal) capacity. The containment vessels and the drum are all made of Type 304L stainless steel. The bolts are high-strength alloy steel and the shielding is lead. Containers 9965, 9968, and 9972 through 9974 are similarly constructed, and are technically capable of transporting plutonium-bearing material. The following paragraphs describe specific aspects of the packagings.

- **Drum—**The drum is fabricated as a 132-L (35-gal) removable-head drum. The drum is fabricated of 18–gauge Type 304L stainless steel. Four vent holes are drilled into the drum, approximately 90 degrees apart, just below the top curl and are covered with a Caplug (fusible plug).

  The plugging device prevents water or moisture from entering the drum through the vent holes under normal conditions of transport. In the event a fire occurs, the plug melts, allowing the drum to vent gases generated from the insulation to prevent rupture of the drum. A locking ring with lugs, installed with a high-strength steel bolt, secures the cover to the drum. The steel bolt threads into the lug and must be provided with a jam nut to prevent loosening during transit. A small hole is drilled through both lugs for insertion of a wire seal to function as a tamperproof device.

- **Insulation—**The insulation material that surrounds the containment vessels is cane fiberboard and is manufactured per American Society for Testing and Materials Specification C-208-72. The cane fiberboard insulation comes in sheets that are bonded together into top and bottom subassemblies with a water-based carpenter's glue. The insulation subassemblies are fitted to the drum so that the radial clearances between the insulation, the lead cylinder, and the drum do not exceed 0.635 cm (1/4 in). Placed over and glued to the top fiberboard subassembly is an air shield made of stainless steel. This thin-walled shield prevents possible smoldering of the top fiberboard layers when exposed to air in a fire. A length of sash chain welded to the top of the air shield serves as a handle for removing the top subassembly.

  A filler pad is required between the top insulation subassembly and the drum lid. The filler pad consists of a ceramic fiber blanket (Kaowool) encapsulated in stainless steel foil and heat sealed.

- **Shielding—**The radiation shielding configuration is a lead cylinder assembly that surrounds the primary containment vessel/secondary containment vessel double-containment assembly. The shielding assembly consists of an inside cylinder fabricated of lead, surrounding a stainless steel tubing weldment. The lid is made of aluminum. The lid has four equally spaced bolt holes near the edge for attachment to the cylinder body. The shielding assembly has no lead lid since the thickness of the stainless steel lids for the primary and secondary containment vessels provide sufficient shielding.

- **Bearing Plates—**Two aluminum bearing plates are added to the packaging to provide additional load-bearing surfaces against the cane fiberboard insulation.

- **Primary Containment Vessel—**The primary containment vessel is of a stainless steel pressure vessel designed in accordance with Section III of the *American Society of Mechanical Engineers Boiler and Pressure Vessel Code,* 1992 edition, with design conditions of 10.3 bar (150 lb per square in gauge [psig]) at 260°C (500°F) for normal conditions of transport and 20.6 bar (300 psig) at 260°C (500°F) for hypothetical accident conditions. By definition, the design conditions shall be higher than the pressures and temperatures that can be generated under normal or accident conditions of transport.

  The primary containment vessel is fabricated from 12.7-cm (5-in) Schedule 40, seamless, Type 304L stainless steel pipe and has a standard Schedule Type 304L stainless steel pipe cap at the blind end. Both vessel body joints are circumferential full penetration butt welds examined by radiographic and liquid

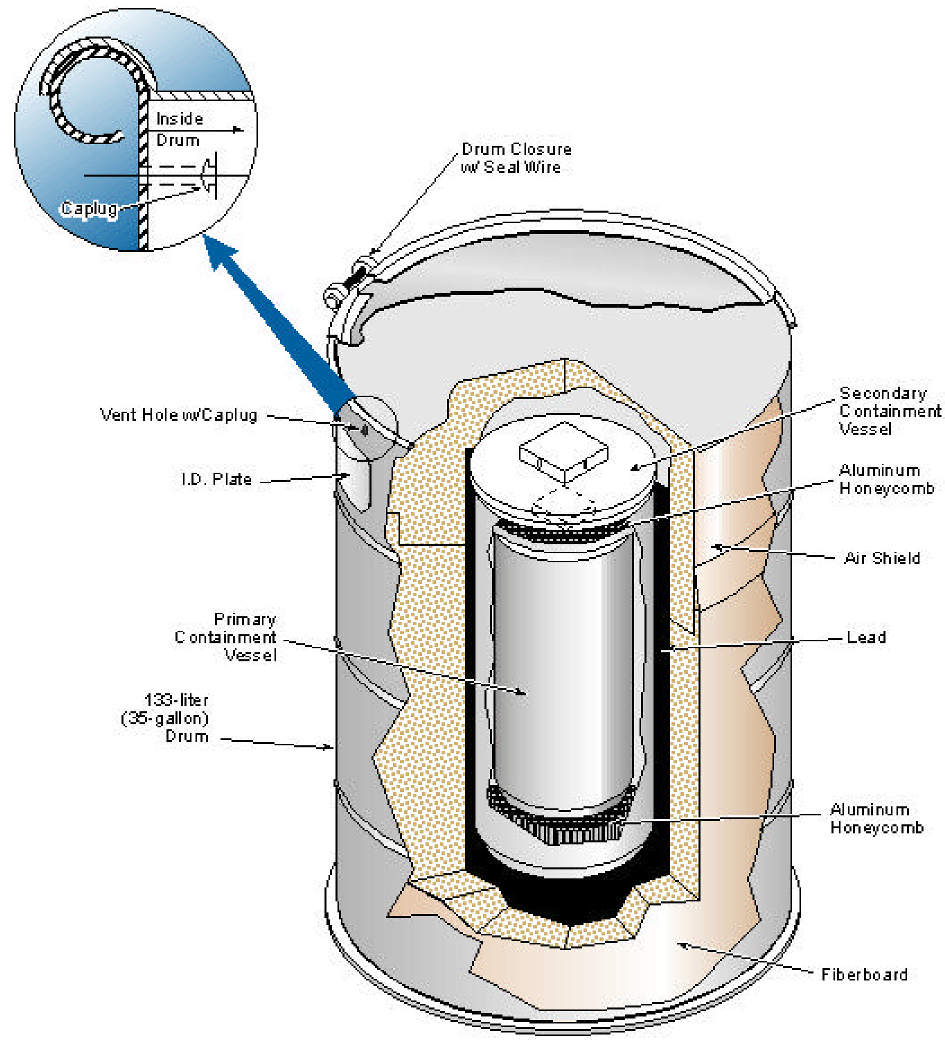

Figure E–2 Typical Assembly of Type 9975 Package

penetrant methods. These welds satisfy *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, Section III, Subsection NB, requirements.

A 10-cm (4-in), Schedule 40 pipe of the same material is welded to the convex side of the cap to form a skirt to vertically support the primary containment vessel. The skirt has two slots on the bottom surface (180 degrees apart) to engage a rectangular key to prevent vessel rotation.

The primary containment vessel closure is male-female cone joint with surfaces that have been machined to identical angles so that they mate with zero clearance. Two grooves for O-rings have been machined onto the face of the Type 304L stainless steel male cone. A leak test port is provided between the two O-ring grooves. A small rectangular groove is present on the face of the male cone between the two O-ring grooves. This is to ensure helium detection during leakage testing. Two Viton GLT fluoroelastomer O-rings (greased with high vacuum silicone grease) are placed in the grooves to form a leaktight seal. Zero clearance behind the two O-rings prevents extrusion and loss of sealing ability at design pressures and temperatures. The leak test port allows for simple leakage tests (pressure drop method) when opening a loaded containment vessel. When the leak test port is plugged (as in normal shipment), a redundant O-ring seal is formed. A snap-ring fits onto the male cone for use in unseating the cone during disassembly. The seal nut, which forces the male cone against the female cone, is threaded into the containment vessel body. Dissimilar materials were selected for the seal nut (Nitronic 60) and the containment vessel body (Type 304L stainless steel) to minimize galling.

- **Honeycomb Spacer—**An aluminum honeycomb spacer is inserted into the concave cavity of the primary containment vessel to provide a flat horizontal surface for the product cans.

- **Product Cans—**The uranium and plutonium metal and oxides are normally placed inside metal cans prior to removing the items from the glove box. Metal cans with organic food liners cannot be used. A rubber gasket material may be applied to the edge of the lid to ensure an hermetic is achieved. The lid is then mechanically crimped to the can wall. The cans are made from either tin-plated mild steel or aluminum.

  The can containing the radioactive material is then placed in a low-density polyethylene bag. The low-density polyethylene bag must meet American Society for Testing and Materials Specification D-4635. Sometimes a second or even a third can is used. More than one bag can also be used. The use of polyvinyl chloride tape is allowed to seal slip-lid cans. However, the package content is limited to 100 grams of polyethylene. No credit for containment is taken for the can assembly.

- **Secondary Containment Vessel—**The secondary containment vessel shown in Figure E–2 consists of a stainless steel pressure vessel that is designed in accordance with Section III of the *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, 1992 edition. The secondary containment vessel is fabricated from 15.2-cm (6-in) Schedule 40, seamless, Type 304L stainless steel pipe and has a standard Schedule Type 304L stainless steel pipe cap at the blind end. Both vessel body joints are circumferential full penetration butt welds examined by radiographic and liquid penetrant methods. These welds satisfy *American Society of Mechanical Engineers Boiler and Pressure Vessel Code* Section III, Subsection NB requirements.

  A 12.7-cm (5-in), Schedule 40 pipe of the same material is welded to the convex side of the cap to form a skirt to vertically support the secondary containment vessel. Like the primary containment vessel, the secondary containment vessel skirt has two slots on the bottom surface (180 degrees apart) to engage a rectangular key to prevent vessel rotation. The secondary containment vessel closure is identical to that used on the primary containment vessel except that the secondary containment vessel is 2.5 cm (1 in) larger in diameter.

- **Impact Absorbers—**Aluminum honeycomb impact absorbers fit axially between the primary containment vessel and the secondary containment vessel. The top impact absorber has the shape of a ring. The bottom impact absorber is machined on the bottom face to fit the contour of the inside of the secondary containment vessel.

- **Operational Features—**The primary containment vessel and secondary containment vessel may be loaded by placing them in a support stand. A lifting tool, which attaches to the seal nut on the primary containment vessel or secondary containment vessel, may be used to lift the assembled containment vessel, by the cone seal nut, from the drum overpack.

  A vacuum lifting tool may be used for raising and lowering product cans into the primary containment vessel. A socket extension may be used with a commercial torque wrench to tighten the closure.

After the radioactive material is inserted and the containment vessel closure tightened to the prescribed torque, the containment closure is leak tested. The plug at the top of the leak test port is removed, the cavity between the two O-rings in the cone seal is pressurized, and any loss of pressure is recorded.

- **Contents of Packaging—**Type B radioactive material, in addition to fissile materials, may be shipped in these packagings. The requirement of 10 CFR 71.63, *Special Requirements for Plutonium Shipments*, states that solid plutonium in excess of 20 Ci must be provided with double containment for shipment, with the exception of reactor fuel elements, metal or metal alloy, or other plutonium solids that U.S. Nuclear Regulatory Commission determines should be exempt. Because the 9975 packagings provide double containment, they are also authorized for products of oxide, scrap, or powders in amounts that exceed 20 Ci.

  The radioactive material contents of the 9975 packages must be limited to meet the criticality and shielding requirements of 10 CFR Part 71. In addition, a maximum allowable decay heat load of 19 watts is established to ensure that the packages meet performance requirements.

- **Thermal Design—**These packagings have been designed to ensure that all safety-related internal components operate below regulatory thermal limits. The components of interest include the lead shield (shielding) and the primary containment vessel, secondary containment vessel, and vessel seals (containment). The thermal limits and design pressures of these components are presented in the *Safety Analysis Report—Packages 9965, 9968, 9972–75* (WSRC 1996).

  The thermal design features of the 9975 packagings include an air shield and a thermal blanket. The air shield, located at the drum top, is designed to minimize the potential for the fiberboard insulation to burn in a fire. Placement of a stainless steel cover on the upper portion of the fiberboard leaves an air gap between the cover and drum wall. The cover prevents fiberboard burning during a post-fire cooldown by prohibiting air flow into the fiberboard near the vent holes. The blanket is used as a filler material between the drum top and lid and is noncombustible. The fiberboard insulation consists of two main sections, each formed by stacking layers of fiberboard and gluing them together (from bottom to top). The sections are "stepped" to eliminate the possibility of a direct thermal shine path (i.e., radiant heat transfer path) from the drum wall to the lead shielding or the vessel wall after the 9.1-m (30-ft) free-drop test.

  The packagings employ a passive cooling and insulation system. Radioactive decay heat from the contents is radiated and conducted to the inner and outer product cans and to the walls of the primary containment vessel. In packagings with a double containment assembly, the heat is primarily transported radially by radiation and conduction across an air gap to the secondary containment vessel and across another air gap directly to the lead shield. The decay heat is primarily conducted radially through the insulation to the outer 132-L (35-gal) drum where it is radiated and convected to the ambient.

E.3.1.3 DOE Standard 3013 Storage and Transportation Container

Plutonium oxide produced from salt distillation, acid dissolution or water leach at Los Alamos National Laboratory will be loaded into packaging that meets the DOE-STD-3013-96, *Criteria for Safe Storage of Plutonium Metals and Oxides* (DOE 1996b) or equivalent. This package provides for safe storage of plutonium oxides for at least 50 years or until final disposition, and, serves as the primary containment vessel for shipping. DOE-STD-3013-96 specifies a design goal that the package could be shipped in qualified shipping containers without further reprocessing or repackaging.

| The 3013 primary containment vessel is designed for shipping, and would be compatible with a Type-B
| package, similar to the previously. No Type-B package has been specifically constructed or licensed for
| shipping DOE-STD-3013-96 primary containment vessels.

E.3.2 Shipment Overview

E.3.2.1 Safe Secure Transportation

Currently the Department anticipates that any transportation of the scrub alloy and those plutonium residues with the highest plutonium concentrations would definitely be required to be made through use of the Transportation Safeguards System and shipped using the Safe Secure Trailer System. Nevertheless, the Department is evaluating whether it would be possible to use commercial carriers for shipments of plutonium residues containing low concentrations of plutonium, and whether there would be any advantage to such shipments. The Safe Secure Trailer is a fundamental component of the Transportation Safeguards System. The Transportation Safeguards System is operated by the DOE Transportation Safeguards Division of the Albuquerque Operations Office for the DOE Headquarters Office of Defense Programs. Based on operational experience between FY84 and FY93, the mean probability of an accident requiring the tow-away of the safe secure trailer was 0.11 accidents per million km (0.066 accidents per million mi). By contrast, the rate for commercial trucking in 1989 was about 4.3 accidents per million km (2.7 accidents per million mi). Commercial trucking accident rates (Saricks and Kvitek 1994) were used in the human health effects analysis. Since established in 1975, the Transportation Safeguards Division has accumulated more than 145 million km (90 million mi) of over-the-road experience transporting DOE-owned cargo with no accidents resulting in a fatality or release of radioactive material.

The safe secure trailer is a specially designed component of an 18-wheel tractor-trailer vehicle. Although details of vehicle enhancements and some operational aspects are classified, key characteristics of the safe secure trailer system include the following:

- Enhanced structural characteristics and a highly reliable tie-down system to protect cargo from impact
- Heightened thermal resistance to protect the cargo in case of fire
- Various deterrents to prevent unauthorized removal of cargo
- An armored tractor component that provides courier protection against attack and contains advanced communications equipment
- Specially designed escort vehicles containing advanced communications and additional couriers
- 24-hour-a-day real-time communications to monitor the location and status of all safe, secure trailer shipments via DOE's Security Communication system
- Couriers who are armed Federal Officers and receive rigorous specialized training and who are closely monitored through DOE's Personnel Assurance Program
- Significantly more stringent maintenance standards than those for commercial transport equipment
- Conduct of periodic appraisals of the Transportation Safeguards System operations by Defense Programs to ensure compliance with DOE orders and management directives.,

E.3.3 Ground Transportation Route Selection Process

According to DOE guidelines, plutonium shipments must comply with both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation regulatory requirements. Commercial shipments are required by law to comply with both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation requirements. U.S. Nuclear Regulatory Commission regulations cover the packaging and transport of plutonium, whereas the U.S. Department of Transportation specifically regulates the carriers and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The highway routing of nuclear material is systematically determined according to U.S. Department of Transportation regulations 49 CFR 171-179 and 49 CFR 397 for commercial shipments. Specific routes cannot be publicly identified in advance for Transportation Safeguards Division shipments because they are classified to protect national security interests.

The U.S. Department of Transportation routing regulations require that shipment of a "highway route controlled quantity" of radioactive material be transported over a preferred highway network including interstate highways, with preference toward interstate system bypasses and beltways around cities, and State-designated preferred routes. A State or Tribe may designate a preferred route to replace or supplement the interstate highway system in accordance with U.S. Department of Transportation guidelines (DOT 1992b).

Carriers of highway route controlled quantities are required to use the preferred network unless moving from origin to the nearest interstate or from the interstate to the destination, when making necessary repair or rest stops, or when emergency conditions render the interstate unsafe or impassible. The primary criterion for selecting the preferred route for a shipment is travel time. Preferred routing takes into consideration accident rate, transit time population density, activities, time of day, and day of week.

The HIGHWAY computer code (Johnson et al. 1993) may be used for selecting highway routes in the United States. The HIGHWAY database is a computerized road atlas that currently describes about 386,400 km (240,000 mi) of roads. The Interstate System and all U.S. (US-designated) highways are completely described in the database. In addition, most of the principal State highways and many local and community roads are also identified. The code is updated periodically to reflect current road conditions and has been benchmarked against reported mileages and observations of commercial truck firms. Features in the HIGHWAY code allow the user to select routes that conform to the Department of Transportation regulations. Additionally, the HIGHWAY code contains data on the population densities along the routes. The distances and populations from the HIGHWAY code are part of the information used for the transportation impact analysis in this EIS.

E.4 Methods for Calculating Transportation Risks

The overland transportation risk assessment methodology are summarized in **Figure E–3**. After the EIS alternatives are identified and goals of the shipping campaign are understood, the first step is to collect data on material characteristics and accident parameters. Physical, radiological and packaging data were provided by the DOE sites. Accident parameters are largely based on the DOE-funded study of transportation accidents (Saricks and Kvitek 1994).

Representative routes that may be used for the shipment of plutonium residues and scrub alloy have been selected using the HIGHWAY code. These routes were selected for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport nuclear materials. Specific routes cannot be identified in advance because the routes would not be finalized until they had been reviewed and approved by U.S. Nuclear Regulatory Commission. The selection of the actual route would be responsive to environmental and other conditions that would be in effect or could be predicted at the time of shipment. Such conditions could include adverse weather conditions, road conditions, bridge closures, and local traffic problems. For security reasons, details about a route would not be publicized before the shipment.

The first analytic step in the ground transportation analysis was to determine the incident-free and accident risk factors, on a per-shipment basis, for transportation. Risk factors, as any risk estimate, are the product of the probability of exposure and the magnitude of the exposure. Accident risk factors were calculated for radiological and nonradiological traffic accidents. The probabilities, which are much lower than one, and the

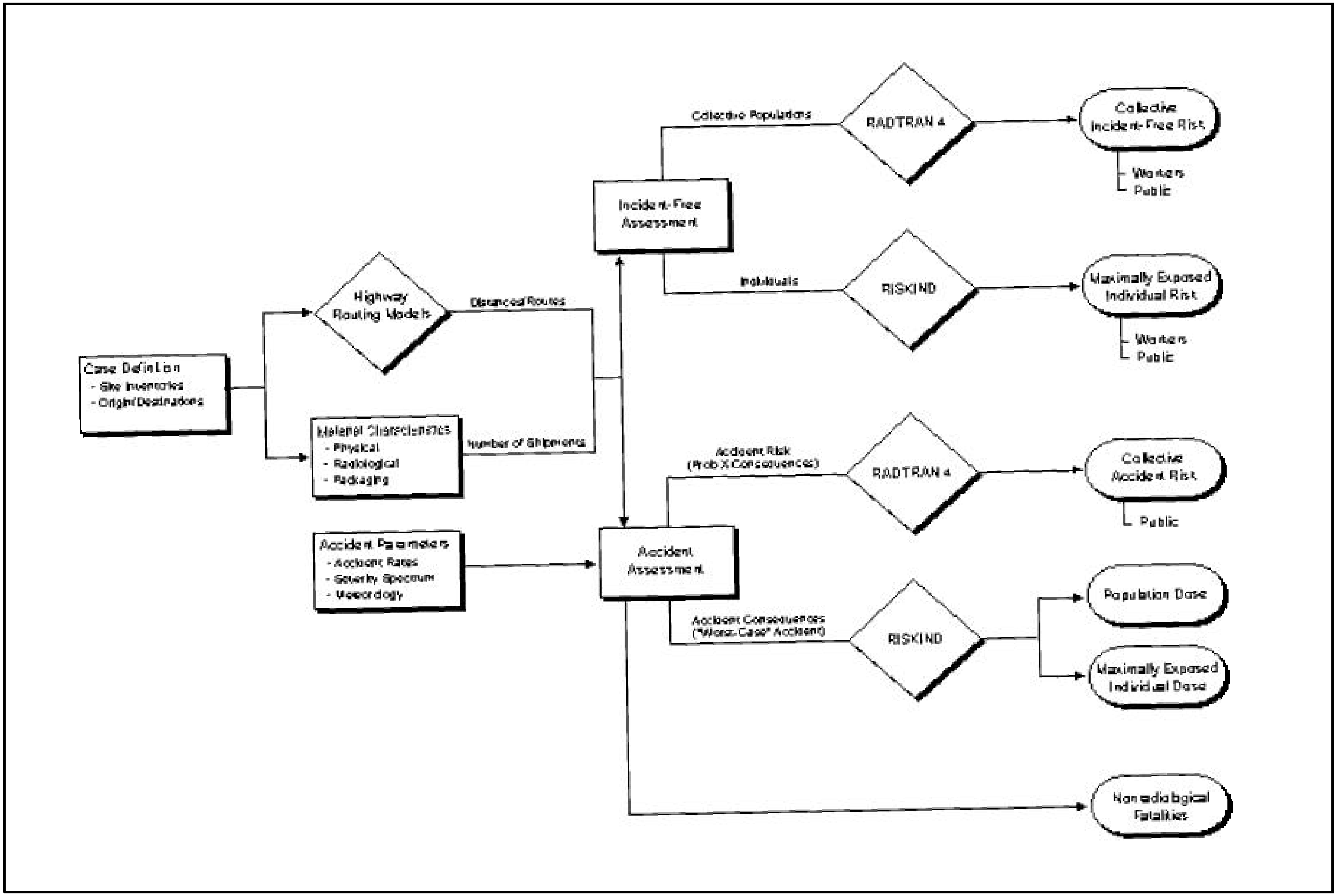

Figure E–3 Overland Transportation Risk Assessment

magnitudes of exposure were multiplied, yielding very low risk numbers. Incident-free risk factors were calculated for crew and public exposure to radiation emanating from the shipping container (cask) and public exposure to the chemical toxicity of the transportation vehicle exhaust. The probability of incident-free exposure is unity (one).

Radiological risk factors are expressed in units of rem. Later in the analysis, they will be multiplied by *International Commission on Radiation Protection Publication 60* (ICRP 1991) conversion factors and estimated number of shipments to give risk estimates in units of latent cancer fatalities. The vehicle emission risk factors are calculated in latent mortalities, and the vehicle accident risk factors are calculated in mortalities. The nonradiological risk factors will be multiplied by the number of shipments.

For each alternative, risks were assessed for both incident-free transportation and accident conditions. For the incident-free assessment, risks were calculated for both collective populations of potentially exposed individuals and for maximally exposed individuals. The accident assessment consists of two components: (1) a probabilistic accident risk assessment that considers the probabilities and consequences of a range of possible transportation accident environments, including low-probability accidents that have high consequences and high-probability accidents that have low consequences, and (2) an accident consequence assessment that considers only the consequences of the most severe transportation accidents postulated.

The RADTRAN 4 computer code (Neuhauser and Kanipe 1993) is used for incident-free and accident risk assessments to estimate the impacts on collective populations. RADTRAN 4 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge.

The RADTRAN 4 population risk calculations take into account both the consequences and probabilities of potential exposure events. The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing the various alternatives.

The RISKIND computer code (Yuan et al. 1995) is used to estimate the incident-free doses to maximally exposed individuals and for estimating impacts for the accident consequence assessment. The RISKIND computer code was developed for DOE's Office of Civilian Radioactive Waste Management to analyze the exposure of individuals during incident-free transportation. In addition, the RISKIND code was designed to allow a detailed assessment of the consequences to individuals and population subgroups from severe transportation accidents under various environmental settings.

The RISKIND calculations were conducted to supplement the collective risk results calculated with RADTRAN 4. Whereas the collective risk results provide a measure of the overall risks of each alternative, the RISKIND calculations are meant to address areas of specific concern to individuals and population subgroups. Essentially, the RISKIND analyses are meant to address "What if" questions, such as "What if I live next to a site access road?" or "What if an accident happens near my town?"

The DOE-developed Analysis of Dispersal Risk Occurring in Transportation was developed to provide probabilistic risk analysis of nuclear explosives, nuclear explosive components and other special nuclear material shipped in a safe, secure trailer (Clauss 1995).

Analysis of Dispersal Risk Occurring in Transportation is actually an integrated software tool for transportation risk assessment including:

- Analysis of Dispersal Risk Occurring in Transportation Analysis of Dispersal Risk Occurring in Transportation Analysis of Dispersal Risk Occurring in Transportation
- MELTER
- Explosive Release – Atmospheric Dispersal
- Latin Hypercube Sampling

These codes utilize an extensive set of data files including:

- Transportation Safeguards Division incident data
- commercial tractor semi-trailer accident data
- route data files
- meteorological data
- population data

Using these codes and data, an analysis that is specific to the material, packaging system, and route can be conducted. The most notable feature of Analysis of Dispersal Risk Occurring in Transportation is the event tree logic. The 17-question event tree describes scenarios by defining accident conditions, evaluating consequences and estimating unique sets of consequences for each end-state.

For this EIS, Analysis of Dispersal Risk Occurring in Transportation was used to analyze the shipment of scrub alloy in a 6M/2R package. This analysis provides a more realistic accident risk estimate for material shipped in a safe, secure trailer. A complete analysis of the 9975 container could be done with Analysis of Dispersal Risk Occurring in Transportation, but the thermal models for the 9975 container have not been created. Analysis of Dispersal Risk Occurring in Transportation is normally used for weapons components, and the 9975 container is not used for weapons components, so the input data and models have not been created.

E.5 PARAMETERS AND ASSUMPTIONS

The transportation risk assessment is designed to ensure—through uniform and judicious selection of models, data and assumptions—that relative comparisons of risk among the various alternatives are meaningful. The major input parameters and assumptions used in the transportation risk assessment are discussed below.

E.5.1 Material Inventory

For the purposes of analysis, the plutonium residues and scrub alloy have been characterized into the different materials show in **Table E–1**. Note that several materials will not be shipped and were not considered further in the transportation analyses. All materials would be shipped from Rocky Flats to the Savannah River Site, except the possible shipment of pyrochemical salt residues. These pyrochemical salt residues could be shipped to the Los Alamos National Laboratory site, as noted in Table E–1.

E.5.2 Shipment External Dose Rates

The dose and corresponding risk to populations and maximally exposed individuals during incident-free transportation conditions are directly proportional to the assumed shipment external dose rate. The Federal regulations for maximum allowable dose rates for exclusive-use shipments were presented in Section E.3.1.

The actual shipment dose rate is a complex function of the composition and configuration of shielding and containment used in the cask, the geometry of the loaded shipments, and characteristics of the material shipped. Rocky Flats has years of experience handling the materials listed in Table E–1 and has regularly made radiation level measurements while handling these materials. The maximum predicted dose, based on experience at DOE facilities, from individual packages, would yield a dose rate less than the Federal regulatory limit in every case. However, in order to ensure a conservative analysis, a dose rate equal to the regulatory limit was used in all risk analyses.

Table E–1 Summary of Material Shipping Requirements

Material	*Safe Secure Trailer Required* [a]	*Container*	*Number of Shipments*	*kg Pu per Shipment*	*Total Pu (kg)*
Shipments from Rocky Flats:					
Ash Residues					
Incinerator Ash and Firebrick Fines					
Purex	No	9975	116	8	900
MEO/Purex	No	9975	86	10	890
Pulverized Sand, Slag, and Crucibles	No	9975	26	5	129
Graphite Fines for MEO	No	9975	7	11	74
Inorganic Ash	Not Shipped				
Salt Residues					
Electrorefining & Molten Salt Extraction					
Salt Distillation at LANL - IDC 409	No	9975	6	39	235
Salt Distillation at LANL - All other IDCs	No	9975	44	13	569
Purex at SRS (following Scrub) - IDC 409	No	9975	7	33	228
Purex at SRS (following (Scrub) - All other IDCs	No	9975	15	37	553
Direct Oxide Reduction Salts					
Acid Dissolution or Water Leach at LANL - IDCs 365, 413, 417, & 427	No	9975	3	46	138
Acid Dissolution or Water Leach at LANL - All other IDCs	No	9975	10	5	51
Purex at SRS (following Scrub) - IDCs 365, 413, 417, & 427	No	9975	3	45	134
Purex at SRS (following Scrub) - All other IDCs	No	9975	1	49	49
Combustible Residues	Not shipped				
Plutonium Fluoride Residues	Yes	9975	7	20	141
Filter Media Residues	Not shipped				
Sludge Residues	Not shipped				
Glass Residues	Not shipped				
Graphite Residues (MEO)	No	9975	16	6	96
Inorganic (Metals and Others)	No	9975	4	19	18
Existing Scrub Alloy	Yes	6M	6	33	200

kg = kilogram Pu = plutonium MEO = mediated electrochemical oxidation LANL = Los Alamos National Laboratory
SRS = Savannah River Site
[a] Interpreted from DOE Order 5633.3B, "Control and Accountability of Nuclear Materials." However, DOE currently expects to use the Safe, Secure Trailer for added assurance.

E.5.3 Material Characterization Data

For the purpose of analysis, the isotopic mixtures for aged weapons grade plutonium and high americium salt were used (see Table D–28). The weapons grade plutonium contains five different plutonium isotopes, as well as a measurable quantity of americium, which is produced as plutonium decays. As the plutonium ages, the mixture changes.

E.5.4 Representative Routes and Population

Representative overland truck routes have been selected for the shipments to the Savannah River Site and to the Los Alamos National Laboratory. The routes were selected consistent with current routing practices and all applicable routing regulations and guidelines. However, the routes were determined for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport plutonium residues and scrub alloy in the future. Specific routes cannot be identified in advance. The representative routes are shown in **Figure E–4**.

Route characteristics that are important to the radiological risk assessment include the total shipment distance and the population distribution along the route. The specific route selected determines both the total potentially exposed population and the expected frequency of transportation-related accidents. Route characteristics are summarized in **Table E–2**. The exposed population includes all persons living within 800 m (0.5 mi) of each side of the road.

Table E–2 Summary of Route Distances and Population Distributions [a]

Parameter	*Rocky Flats to the Savannah River Site*	*Rocky Flats to Los Alamos National Laboratory*
Distance	2,616.7 km (1,625.0 mi)	733.8 km (456.0 mi)
Percentages in Zones		
Rural	78.2	83.5
Suburban	19.3	13.4
Urban	2.5	3.1
Average Persons per km^2 (mi^2)		
Rural	8.9/km^2 (23.1/mi^2)	4.5/km^2 (11.7/mi^2)
Suburban	358.4/km^2 (931.8/mi^2)	451.5/km^2 (1,169.4/mi^2)
Urban	2,239.7/km^2 (5,823.2/mi^2)	2,260.6/km^2 (5,854.91/mi^2)
Number of Affected Persons [b]	553,000	158,000

[a] Route characteristics were generated using the routing model HIGHWAY (Johnson et al. 1993).
[b] The affected population includes all persons within 800 m (0.5 mi) of the route.

E.5.5 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected cancer fatalities were taken from *International Commission on Radiation Protection Publication 60* (ICRP 1991): 0.0005 and 0.0004 fatal cancer cases per person-rem for members of the public and workers, respectively. Cancer fatalities and incidence occur during the lifetimes of the exposed populations and, thus, are called latent cancer fatalities.

E.5.6 Accident Involvement Rates

For the calculation of accident risks, vehicle accident and fatality rates are taken from data provided in other reports (Saricks and Kvitek 1994). Accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel in that same year. Therefore, the rate is a fractional value, with accident-involvement count as the numerator of the fraction and vehicular activity (total travel distance) as its denominator. Accident rates are generally determined for a multi-year period. For

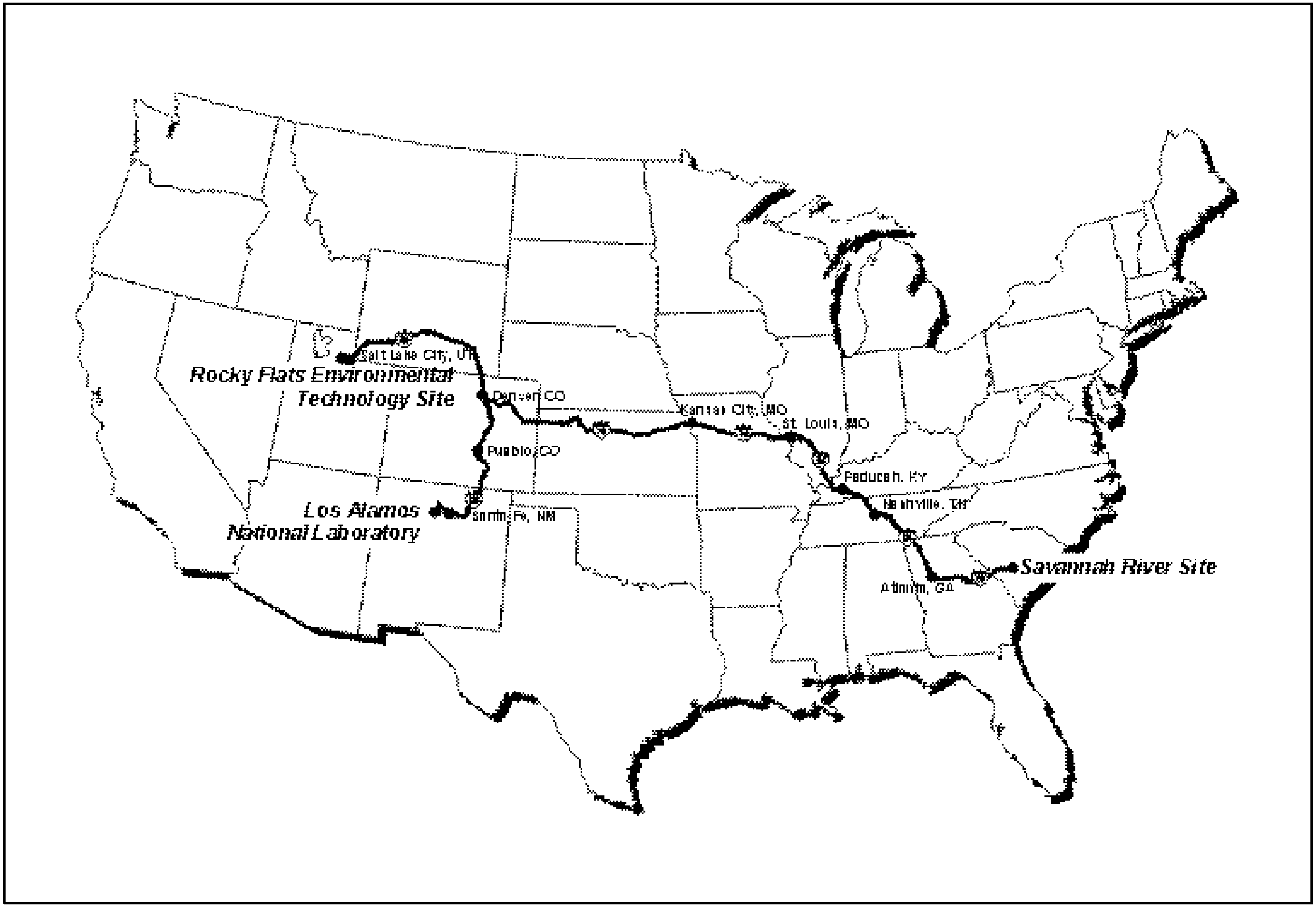

Figure E–4 Representative Routes

assessment purposes, the total number of expected accidents or fatalities is calculated by multiplying the total shipment distance for a specific case by the appropriate accident or fatality rate. For truck transportation, the rates presented are specifically for heavy combination trucks involved in interstate commerce (Saricks and Kvitek 1994). Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other. Heavy combination trucks are typically used for radioactive waste shipments. The truck accident rates are computed for each State based on statistics compiled by the Department of Transportation Office of Motor Carriers for 1986 to 1988. Saricks and Kvitek present accident involvement and fatality counts; estimated kilometers of travel by State; and the corresponding average accident involvement, fatality, and injury rates for the 3 years investigated. Fatalities are deaths (including crew members) attributable to the accident or that occurred at any time within 30 days thereafter.

E.5.7 Container Accident Response Characteristics and Release Fractions

The transportation accident model assigns accident probabilities to a set of accident categories. Eight accident-severity categories defined in the U.S. Nuclear Regulatory Commission's *Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170 (NRC 1977), were used. The least severe categories (Category I and II) represent low magnitudes of crush force, accident-impact velocity, fire duration, and/or puncture-impact speed. The most severe category (Category VIII) represents a large crush force, high accident-impact velocity, long fire duration, and a high puncture-impact speed. The fraction of material released and material aerosolized, and the fraction of that material that is respirable (particles smaller than 10 microns) was assigned based on the accident categories. Since all shipments will use the previously described Type B containers and the Safe Secure Trailer System, even severe accidents release, at the most, a portion of the material being transported.

E.6 RISK RESULTS

In this section, the risk assessment results are presented for the shipment materials and destinations being considered. The collective population risk results are presented in Section E.6.1, and the results are consolidated in Section E.6.2 so the different alternatives can be analyzed. Section E.6.3 describes the doses to the maximally exposed individuals.

E.6.1 Per-Shipment Risk Factors

Per-shipment risk factors have been calculated for the collective populations of exposed persons and for the crew for all anticipated routes and shipment configurations. The radiological risks are presented in doses per shipment for each unique route, material, and container combination. The radiological dose per shipment factors for incident-free transportation are presented in **Table E–3**. Doses are calculated for the crew, off-link public (i.e., people living along the route), on-link public (i.e., pedestrians and drivers along the route), and public at rest and fueling stops (i.e., stopped cars, buses and trucks, workers, and other bystanders). The radiological dose risk factors for accident transportation conditions are presented in **Table E–4**. The accident risk factors are called "dose risk" because the values incorporate the spectrum of accident severity probabilities and associated consequences.

The nonradiological risk factors are presented in fatalities per shipment in **Table E–5**. Separate risk factors are provided for fatalities resulting from hydrocarbon emissions (known to contain carcinogens) and transportation accidents (fatalities resulting from impact).

Table E–3 Incident-Free Radiological Doses per Shipment for All Material Types (Person-rem/Shipment) [a]

Origin	Destination	Crew	Public			
			Off-Link	On-Link	Stops	Total
Rocky Flats	Savannah River Site	0.155	0.00146	0.0112	0.0860	0.0987
Rocky Flats	Los Alamos National Laboratory	0.0415	0.000365	0.00293	0.0241	0.0274

[a] Incident-free risk factors are based on dose rates of 10 mrem per hour at 2 m from the vehicle.

Table E–4 Accident Radiological Dose Risk per Shipment for Each Material Type (Person-rem/Shipment)

Material	Shipments from Rocky Flats to:	
	Savannah River Site	Los Alamos National Laboratory
Ash Residues		
Incinerator Ash and Firebrick Fines		
Purex	0.000034	N/A
Mediated Electrochemical Oxidation/Purex	0.000046	N/A
Pulverized Sand, Slag, and Crucibles	0.000022	N/A
Graphite Fines for Mediated Electrochemical Oxidation	0.000047	N/A
Salt Residues		
Electrorefining & Molten Salt Extraction - IDC 409	0.000014	0.000029
Electrorefining & Molten Salt Extraction - All other IDCs	0.000016	0.000009
Direct Oxide Reduction Salts - IDCs 365, 413 & 427	0.000019	0.000033
Direct Oxide Reduction Salts - All other IDCs	0.000021	0.00004
Fluoride Residues	0.0009	N/A
Graphite Residues	0.000027	N/A
Inorganic Residues	0.000020	N/A
Scrub Alloy	0.000014	N/A

N/A = not applicable

Table E–5 Vehicle-Related (Nonradiological) Risk Factors per One-Way Shipment (Fatalities/Shipment)

Risk Factor	Shipments from Rocky Flats to:	
	Savannah River Site	Los Alamos National Laboratory
Vehicle Emissions	6.5×10^{-6}	2.3×10^{-6}
Vehicle Accident	0.000051	1.4×10^{-5}

E.6.2 Evaluation of Shipment Risks

Table E–6 shows the risks of transporting each of the plutonium residue and scrub alloy materials. The risks are calculated by multiplying the previously given per-shipment factors by the number of shipments and, in the case of the radiological doses, by the health risk conversion factors. Based on the results of the transportation risk analysis, it is unlikely that shipping plutonium residues and scrub alloy will result in a fatality.

Table E–6 Overland Transportation Risks for All Materials [a]

Material	Routine				Accidental
	Radiological		Nonradiological [b]		Radiological
	Crew	Public	Emissions	Traffic	
Ash Residues (to Savannah River Site)					
Incinerator Ash & Firebrick Fines					
Purex	0.0072	0.0057	0.00152	0.01181	2.0×10^{-6}
Mediated Electrochemical Oxidation/Purex	0.0053	0.0042	0.00113	0.00875	2.0×10^{-6}
Pulverized Sand, Slag & Crucibles	0.0016	0.0013	0.00034	0.00265	2.8×10^{-7}
Graphite Fines for Mediated Electrochemical Oxidation	0.0004	0.0003	0.00009	0.00071	1.6×10^{-7}
Salt Residues					
Electrofining & Molten Salt Extraction					
Salt Distillation at LANL - IDC 409	0.0001	0.0001	0.00003	0.00017	8.6×10^{-8}
Salt Distillation at LANL - All other IDCs	0.0007	0.0006	0.00020	0.00125	2.1×10^{-7}
Purex at SRS (following Scrub) - IDC 409	0.0004	0.0003	0.00009	0.00071	4.9×10^{-8}
Purex at SRS (following Scrub) - All other IDCs	0.0009	0.0007	0.00020	0.00153	1.2×10^{-7}
Direct Oxide Reduction Salts					
Acid Dissolution or Water Leach at LANL - IDCs 365, 413 & 427	0.00005	0.00004	0.00001	0.00009	5.0×10^{-8}
Acid Dissolution or Water Leach at LANL - All other IDCs	0.00017	0.00014	0.00005	0.00028	1.9×10^{-8}
Purex at SRS (following Scrub) - IDCs 365, 413, & 427	0.00019	0.00015	0.00004	0.00031	2.9×10^{-8}
Purex at SRS (following Scrub) - All other IDCs	0.00006	0.00005	0.00001	0.00010	1.1×10^{-8}
Fluoride Residues (to Savannah River Site)	0.0004	0.0003	0.00009	0.00071	3.1×10^{-6}
Graphite Residues (to Savannah River Site)	0.0010	0.0008	0.00021	0.00163	2.1×10^{-7}
Inorganic Residues (to Savannah River Site)	0.0002	0.0002	0.00005	0.00041	4.0×10^{-8}
Existing Scrub Alloy (to Savannah River Site)	0.0004	0.0003	0.00008	0.00061	4.3×10^{-8}

LANL = Los Alamos National Laboratory SRS = Savannah River Site

[a] All risks are expressed in latent cancer fatalities during the implementation of the policy, except for the Accidental-Traffic column, which represents a number of fatalities.

[b] These risks are associated with round-trip shipments.

E.6.3 Maximally Exposed Individuals

The risks to maximally exposed individuals under incident-free transportation conditions have been estimated for hypothetical exposure scenarios. The estimated dose to inspectors and the public is presented in **Table E–7** on a per-event basis (person-rem per event). Note that the potential exists for individual exposures if multiple exposure events occur. For instance, the dose to a person stuck in traffic next to a shipment for 30 minutes is calculated to be 11 mrem. If the exposure duration was longer, the dose would rise proportionally. In addition, a person working at a truck service station could receive a significant dose if trucks were to use the same stops repeatedly. The dose to a person fueling a truck could be as much as 1 mrem. Administrative controls could be instituted to control the location and duration of truck stops if multiple exposures were to happen routinely.

Table E–7 Estimated Dose to Maximally Exposed Individuals During Incident-Free Transportation Conditions [a, b]

Receptor		***Dose to maximally exposed individual***
Workers	Crew Member	0.1 rem/yr[c]
	Inspector	0.0029 rem/event
Public	Resident	4.0×10^{-7} rem/event
	Person in Traffic Congestion	0.011 rem/event
	Person at Service Station	0.001 rem/event

[a] The exposure scenario assumptions are described in Section E.6.3.
[b] Doses are calculated assuming that the shipment external dose rate is equal to the maximum expected dose 10 mrem/hr at 2 m (3.3 ft) from the package.
[c] Dose to truck drivers could exceed the legal limit of 100 mrem/yr in the absence of administrative controls.

The cumulative dose to a resident was calculated assuming all shipments passed his or her home. The cumulative doses assume that the resident is present for every shipment and is unshielded at a distance of 30 m (66 ft) from the route. Therefore, the cumulative dose is only a function of the number of shipments passing a particular point and is independent of the actual route being considered. The maximum dose to this resident, if all the material were to be shipped via this route, would be less than 0.1 mrem. The annual individual dose can be estimated by assuming that shipments would occur uniformly over a 15-year time period.

The estimated dose to crew members (truck drivers) is presented for a commercial crew. No credit is taken for the shielding associated with the tractor or trailer.

The accident consequence assessment is intended to provide an estimate of the maximum potential impacts posed by the most severe potential transportation accidents involving a shipment. The accident consequence results are presented in **Table E–8** for the maximum severity accidents. The population doses are for a uniform population density within an 80-km (50-mi) radius (Neuhauser and Kanipe 1993). The location of the maximally exposed individual is determined based on atmospheric conditions at the time of the accident and the buoyant characteristics of the released plume. The locations of maximum exposure would be 100 m (330 ft) and 90 m (300 ft) from the accident site for neutral (average) and stable conditions, respectively. The dose to the maximally exposed individual is independent of the location of the accident. In general, the dose to maximally exposed individuals for the most severe accidents would be less than 10 mrem. No acute or early fatalities would be expected from radiological causes.

The maximum foreseeable (frequency greater than 1×10^{-7} per year) offsite transportation accident involves a shipment of scrub alloy in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1 every 10 million years and could result in 1.1 person-rem and no fatalities. The probability of an accident occurring is at least 10 times smaller in either an urban area or under stable atmospheric conditions, and the consequences are less than 10 times greater.

Table E–8 Estimated Dose to Maximally Exposed Individuals and the Population During the Specific Accident Conditions [a, b]

Mode and Accident Location	*Neutral Conditions [c]*				*Stable Conditions [d]*			
	Population [e]		*Maximally Exposed Individual [f]*		*Population [e]*		*Maximally Exposed Individual [f]*	
	Dose (person-rem)	*Consequences (Cancer Fatalities)*	*Dose (rem)*	*Consequences (Probability of Cancer Fatality)*	*Dose (person-rem)*	*Consequences (Cancer Fatalities)*	*Dose (rem)*	*Consequences (Probability of Cancer Fatality)*
Truck								
Urban	9.9	0.005	0.021	0.000015	4.7	0.0023	0.0018	8.85×10^{-7}
Suburban	1.1	0.00055	0.021	0.000015	0.8	0.0004	0.0018	8.85×10^{-7}
Rural	0.04	0.00002	0.021	0.000015	0.02	0.000009	0.0018	8.85×10^{-7}

[a] The most severe accidents correspond to the NUREG-0170 accident severity category VIII (NRC 1977).
[b] Buoyant plume rise resulting from fire for a severe accident was included in the exposure model.
[c] Neutral weather conditions result in moderate dispersion and dilution of the release plume. Neutral conditions were taken to be Pasquill stability Class D with a wind speed of 4 meters per second (m/sec) (9 miles per hour [mph]). Neutral conditions occur approximately 50 percent of the time in the United States.
[d] Stable weather conditions result in minimal dispersion and dilution of the release plume and are thus unfavorable. Stable conditions were taken to be Pasquill stability Class F with a wind speed of 1 m/sec (2.2 mph). Stable conditions occur approximately one-third of the time in the United States.
[e] Populations extend at a uniform density to a radius of 80 km (50 mi) from the accident site. Population exposure pathways include acute inhalation, acute cloudshine, groundshine, resuspended inhalation, resuspended cloudshine, and ingestion of food, including initially contaminated food (rural only) (Yuan et al. 1995). No decontamination or mitigative actions are taken.
[f] The maximally exposed individual is assumed to be at the location of maximum exposure. The locations of maximum exposure would be 100 m (330 ft) and 90 m (300 ft) from the accident site under neutral and stable atmospheric conditions, respectively. Individual exposure pathways include acute inhalation, acute cloudshine, and groundshine during passage of the plume. No ingested dose is considered.

E.6.4 Analysis of Dispersal Risk Occurring in Transport Analysis

DOE analyzed the scrub alloy shipments to the Savannah River Site, and several selected shipments to Los Alamos National Laboratory using the Analysis of Dispersal Risk Occurring in Transport code. The purpose of this analysis was to show how much different the risk estimates would be if more credit were taken for the safe secure transport's inherent safety features. Note that the RADTRAN numbers in **Tables E–9** and **E–10** can be considered conservative for either safe secure or commercial transport. The Analysis of Dispersal Risk Occurring in Transport numbers are only conservative for safe secure transport.

Table E–9 Comparison of RADTRAN and Analysis of Dispersal Risk Occurring in Transport

Analysis of Dispersal Risk Occurring in Transport — Incident-free dose per shipment[1]					
Destination	*Workers*	*Public*			
		Off-road	*On-road*	*Stops*	*Total*
Savannah River Site	9.9×10^{-2}	4.2×10^{-3}	5.1×10^{-2}	2.8×10^{-2}	8.3×10^{-2}
Los Alamos National Laboratory	2.1×10^{-2}	1.3×10^{-3}	1.2×10^{-2}	6.0×10^{-3}	1.9×10^{-2}
RADTRAN — Incident-free dose per shipment[1]					
Savannah River Site	0.155	0.00146	0.0112	0.0860	0.0987
Los Alamos National Laboratory	0.0415	0.000365	0.00293	0.0241	0.0274

[1] Dose rate is assumed to be 10 mrem/hr at 2 meters.

Table E–10 Comparison of Accident "Risks" per Shipment

Code	*"Dose Risk" (person-rem) for Shipment to Savannah River Site*[1]	*Nonradiological Accidental Fatality Risk for Shipment to Savannah River Site*	*Nonradiological Accidental Fatality Risk for Shipment to Los Alamos National Laboratory*
ADROIT	1.0×10^{-7}	4.2×10^{-6}	1.1×10^{-6}
RADTRAN	1.4×10^{-5}	5.1×10^{-5}	3.7×10^{-6}

ADROIT = Analysis of Dispersal Risk Occurring in Transport
[1] Analysis of Dispersal Risk Occurring in Transport "dose-risk" computed using mean value for dose-health effects conversion factor (4.2×10^{-4} LCF/person-rem).

In Table E–9, the incident-free risk analysis results of RADTRAN and Analysis of Dispersal Risk Occurring in Transport are similar. The differences can be attributed to minor differences in the structure and definition of the models. However, as shown in Table E-10, the accident risk estimates of RADTRAN are much higher than those of Analysis of Dispersal Risk Occurring in Transport. This is because the RADTRAN analysis used commercial accident rates, and used standard commercial vehicle responses to accidents and fires. The Analysis of Dispersal Risk Occurring in Transport analysis took into account the extra capabilities of the safe, secure transports and the lower accident rate (Clauss 1994, Phillips 1994). Since the analytic approach of the two codes are different, input parameters cannot be directly compared.

E.6.5 Shipment of Transuranic Waste and Separated Plutonium

As described in Chapter 4, all processing of plutonium residues and scrub alloy generates transuranic waste and separated plutonium. The impacts of the transportation of transuranic waste and separated plutonium are covered in other EISs and are incorporated by reference into this EIS. However, for the convenience of the reader, the impacts related to material covered in this EIS (plutonium residues and scrub alloy) are summarized in the following sections.

E.6.5.1 Shipment of Transuranic Waste to the Waste Isolation Pilot Plant

The impacts of shipping this transuranic waste to WIPP are analyzed in the WIPP SEIS-II (DOE 1997). **Table E-11** shows the number of drums of transuranic waste generated from processing of plutonium residues and scrub alloy for the preferred alternative and Alternative 2. Using the fact that a truck shipment can carry three TRUPACT-II containers, and each TRUPACT-II container can carry 14 drums of transuranic waste, the number of shipments to WIPP is calculated and compared to the number of shipments analyzed in the WIPP SEIS-II (DOE 1997). As shown in Table E-11, the number of shipments to WIPP for material covered in this EIS are less than 20 percent of the total number of WIPP shipments from Rocky Flats, and less than 1 percent of the total number of WIPP shipments from the Savannah River Site and Los Alamos National Laboratory. Other alternatives considered in this EIS change the location of transuranic waste generated, and, to a lessor extent, the total amount of transuranic waste generated. Alternative 2 includes the disposition of scrub alloy through a calcination and vitrification process that was not envisioned at the time of the WIPP SEIS-II and, therefore, was not included in the WIPP SEIS-II. However, the impacts of transporting this material to WIPP can be estimated from information provided in Sections 4.11.1 and 4.15.2 of this EIS, and the WIPP SEIS-II, as shown in Table E-11.

Table E–11 Shipment Summary for Contact-Handled Transuranic Waste

	Plutonium Residues and Scrub Alloy EIS Preferred Alternative			***Impacts Attributable to Plutonium Residue and Scrub Alloy (person-rem)***		
				Incident Free[b]		
Waste Origin Site	***Number of Drums on Site***	***Number of Shipments to WIPP***	***WIPP SEIS-II Proposed Action -Number of Shipments to WIPP[a]***	***Worker***	***Public***	***Accident[c]***
Preferred Alternative						
Rocky Flats			2,485	5	33	3
- Stabilized Residue	17,600	420				
- Secondary Transuranic	2,300	55				
Savannah River Site	50	2	2,238	0.06	0.4	0.04
Los Alamos National Laboratory	900	22	5,009	0.1	0.9	0.03
Alternative 2						
Rocky Flats-Stabilized Scrub Alloy	2,748	66	0	1	5	0.4

[a] Taken from Table E-1 of the Waste Isolation Pilot Plant Disposal Phase Final Supplemental EIS (WIPP SEIS-II)(DOE 1997a)
[b] Calculated from the information in Table E-13 of the WIPP SEIS-II (DOE 1997a) multiplied by the number of shipments to WIPP related to plutonium residues and scrub alloy
[c] Calculated from the information in Tables E-1 and E-22 of WIPP SEIS-II (DOE 1997a) and the number of shipments to WIPP related to plutonium residues and scrub alloy

E.6.5.2 Separated Plutonium

The preferred alternative involves the separation of plutonium from the residues and scrub alloy at the Savannah River Site and at Los Alamos National Laboratory. This plutonium would become part of the surplus plutonium that was identified in the *Storage and Disposition of Weapons - Usable Fissile Materials Final Programmatic EIS* (DOE 1996a). Transportation impacts are analyzed in the *Surplus Plutonium Disposition Draft EIS* prepared by DOE's Office of Fissile Materials Disposition (DOE 1998). DOE estimates that less than 500 kg of plutonium will be separated at the Savannah River Site, and less than 150 kg of plutonium will be separated at the Los Alamos National Laboratory under the preferred alternative. This plutonium represents about one-third of the plutonium at the Savannah River Site and one-tenth of the plutonium at Los Alamos National Laboratory (DOE 1996a). This plutonium would be immobilized at either the Hanford Site or the Savannah River Site. Based on the *Surplus Plutonium Disposition Draft EIS* analyses, the maximum dose for transporting the separated plutonium to the crew and to the public would be less than one rem, and the maximum expected dose risk from accidents would be less than one millrem.

E.7 CONCLUSIONS AND LONG-TERM IMPACTS OF TRANSPORTATION

E.7.1 Conclusions

It is unlikely that transportation will cause an additional fatality. The nonradiological risks (air pollution and traffic accidents) are greater than the radiological risks.

E.7.2 Long-Term Impacts of Transportation

The *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995) analyzed the cumulative impacts of all transportation of radioactive materials, taking into account impacts from reasonably foreseeable actions that include transportation of radioactive material and general radioactive materials transportation that is not related to a particular action. The total worker and general population collective doses are summarized in **Table E–12**. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities) for the period of time 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was due to the general transportation of radioactive material. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The total number of latent cancer fatalities estimated to result from radioactive materials transportation over the period between 1943 and 2035 was 290. Over this same period of time (93 years), approximately 28 million people would die from cancer, based on 300,000 cancer fatalities per year (NRC 1977). It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010 percent of the total number of latent cancer fatalities.

Table E–12 Cumulative Transportation-Related Radiological Collective Doses and Latent Cancer Fatalities (1943 to 2035)

Category	*Collective Occupational Dose (person-rem)*	*Collective General Population Dose (person-rem)*
Shipment of Plutonium Residues and Scrub Alloy	< 100	< 100
Reasonably Foreseeable Actions		
Truck	11,000	50,000
Rail	820	1,700
General Transportation (1943–2035)	310,000	270,000
Total Collective Dose	320,000	320,000
Total latent cancer fatalities	130	160

Source: DOE 1995.

E.8 UNCERTAINTY AND CONSERVATISM IN ESTIMATED IMPACTS

The sequence of analyses performed to generate the estimates of radiological risk for the transportation includes: (1) determination of the inventory and characteristics, (2) estimation of shipment requirements, (3) determination of route characteristics, (4) calculation of radiation doses to exposed individuals (including estimation of environmental transport and uptake of radionuclides), and (5) estimation of health effects. Uncertainties are associated with each of these steps. Uncertainties exist in the way that the physical systems being analyzed are represented by the computational models, in the data required to exercise the models (due to measurement errors, sampling errors, natural variability, or unknowns simply caused by the future nature of the actions being analyzed), and in the calculations themselves (e.g., approximate algorithms used by the computers).

In principle, one can estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result; however, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions to be initiated at an unspecified time in the future. Instead, the risk analysis is designed to ensure, through uniform and judicious selection of scenarios, models, and input parameters, that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this design is accomplished by uniformly applying common input parameters and assumptions to each alternative. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives in a given measure of risk.

In the following sections, areas of uncertainty are discussed for the assessment steps enumerated above. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. The degree of reality conservatism of the assumption is addressed. Where practical, the parameters that most significantly affect the risk assessment results are identified.

E.8.1 Uncertainties in Plutonium Residue and Scrub Alloy Inventory and Characterization

The inventories and the physical and radiological characteristics are important input parameters to the transportation risk assessment. The potential amount of transportation for any alternative is determined primarily by the projected plutonium inventory and assumptions concerning shipment capacities. The physical and radiological characteristics are important in determining the amount of material released during accidents and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

The development of projected plutonium inventory and characterization data used to support the EIS is described in Appendix B. Uncertainties in the inventory and characterization will be reflected to some degree in the transportation risk results. If the inventory is overestimated (or underestimated), the resulting transportation risk estimates also will be overestimated (or underestimated) by roughly the same factor. However, the same inventory estimates are used to analyze the transportation impacts of each of the EIS alternatives. Therefore, for comparative purposes, the observed differences in transportation risks among alternatives are believed to represent unbiased, reasonably accurate estimates from current information in terms of relative risk comparisons.

E.8.2 Uncertainties in Containers, Shipment Capacities, and Number of Shipments

The amount of transportation required for each alternative is based in part on assumptions concerning the packaging characteristics and shipment capacities for commercial trucks and safe secure transports. Representative shipment capacities have been defined for assessment purposes based on probable future shipment capacities. In reality, the actual shipment capacities may differ from the predicted capacities, so that the projected number of shipments, and consequently the total transportation risk, would change. However, although the predicted transportation risks would increase or decrease accordingly, the relative differences in risks among alternatives would remain about the same. The maximum amount of material allowed in Type B containers is set by conservative safety analyses, such as WSRC 1996.

E.8.3 Uncertainties in Route Determination

Representative routes have been determined between all origin and destination sites considered in the EIS. The routes have been determined consistent with current guidelines, regulations, and practices, but may not be the actual routes that would be used in the future. In reality, the actual routes could differ from the representative ones in terms of distances and total population along the routes. Moreover, since plutonium residues and scrub alloy could be transported over an extended period of time starting at some time in the future, the highway infrastructures and the demographics along routes could change. These effects have not been accounted for in the transportation assessment; however, it is not anticipated that these changes would significantly affect relative comparisons of risk among the alternatives considered in the EIS. Specific routes cannot be identified in advance for the Transportation Safeguards Division shipments because the routes are classified to protect national security interests.

E.8.4 Uncertainties in the Calculation of Radiation Doses

The models used to calculate radiation doses from transportation activities introduce a further uncertainty in the risk assessment process. It is generally difficult to estimate the accuracy or absolute uncertainty of the risk assessment results. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, or any computer code of this type, is the scarcity of data for certain input parameters. Parameters describing the location of people, traffic flows, weather, vehicle speed, and operational practices and radiological effects are estimated from "typical" information. They cannot be calculated from observed conditions on a certain route.

Uncertainties associated with the computational models are minimized by using state-of-the-art computer codes that have undergone extensive review. Because there are numerous uncertainties that are recognized but difficult to quantify, assumptions are made at each step of the risk assessment process that are intended to produce conservative results (i.e., overestimate the calculated dose and radiological risk). Because parameters and assumptions are applied to all alternatives, this model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, the results may not represent risks in an absolute sense.

In order to understand the most important uncertainties and conservatism in the transportation risk assessment, the results for all cases were examined to identify the largest contributors to the collective population risk. The results of this examination are discussed briefly in the following paragraph.

For truck shipments, the largest contributors to the collective population dose, in decreasing order of importance, were found to be: (1) incident-free dose to members of the public at stops, (2) incident-free dose to transportation crew members, (3) incident-free dose to members of the public sharing the route (on-link dose), (4) incident-free dose to members of the public residing along the route (off-link dose), and (5) accident dose risk to members of the public. Approximately 80 percent of the estimated public dose was incurred at stops, 15 percent by the on-link population, and 5 percent by the off-link population. In general, the accident contribution to the total risk was negligible compared with the incident-free risks.

As shown above, incident-free transportation risks are the dominant component of the total transportation risk. The most important parameter in calculating incident-free doses is the shipment external dose rate (incident-free doses are directly proportional to the shipment external dose rate). For this assessment, it was assumed that all shipments would have an external dose rate at the regulatory limit of 10 mrem/hr at 2 m. In practice, the external dose rates would vary from shipment to shipment.

Finally, the single largest contributor to the collective population doses calculated with RADTRAN was found to be the dose to members of the public at truck stops. Currently, RADTRAN uses a simple point-source approximation for truck-stop exposures and assumes that the total stop time for a shipment is proportional to the shipment distance. The parameters used in the stop model were based on a survey of a very limited number of radioactive material shipments that examined a variety of shipment types in different areas of the country. It was assumed that stops occur as a function of distance, with a stop rate of 0.011 hour per km (0.018 hour per mi). It was further assumed that an average of 50 people at each stop are exposed at a distance of 20 m (66 ft). In RADTRAN, the population dose is directly proportional to the external shipment dose rate and the number of people exposed, and inversely proportional to the square of the distance. The stop rate assumed results in an hour of stop time per 100 km (62 mi) of travel.

Based upon the qualitative discussion with shippers, the parameter values used in the assessment appear to be conservative. However, data do not exist to quantitatively assess the degree of control, the location, frequency, and duration of truck stops. However, based on the regulatory requirements for continuous escort of the material (10 CFR Part 73) and the requirement for two drivers, it is clear that the trucks would be on the move much of the time until arrival at the destination. Therefore, the calculated impacts are extremely conservative. By using these conservative parameters, the calculations in this EIS are consistent with the RADTRAN default values.

Shielding of exposed populations is not considered. For all incident-free exposure scenarios, no credit has been taken for shielding of exposed individuals. In reality, shielding would be afforded by trucks and cars sharing the transport routes, rural topography, and the houses and buildings in which people reside. Incident-free exposure to external radiation could be reduced significantly depending on the type of shielding present. For residential houses, shielding factors (i.e., the ratio of shielded to unshielded exposure rates) have been estimated to range from 0.02 to 0.7, with a recommended value of 0.33. If shielding were to be considered for the maximally exposed resident living near a transport route, the calculated doses and risks would be reduced by approximately 70 percent. Similar levels of shielding may be provided to individuals exposed in vehicles. However, consideration of shielding does not significantly affect the overall incident-free risks to the general public.

Post-accident mitigative actions are not considered for dispersal accidents. For severe accidents involving the release and dispersal of radioactive materials in the environment, no post-accident mitigative actions, such as interdiction of crops or evacuation of the accident vicinity, have been considered in this risk assessment. In reality, mitigative actions would take place following an accident in accordance with U.S. Environmental Protection Agency (EPA) radiation protection guides for nuclear incidents (EPA 1991). The effects of mitigative actions on population accident doses are highly dependent upon the severity, location, and timing of the accident. For this risk assessment, ingestion doses are only calculated for accidents occurring in rural areas (the calculated ingestion doses, however, assumes all food grown on contaminated ground is consumed and is not limited to the rural population). Examination of the severe accident consequence assessment results has shown that ingestion of contaminated foodstuffs contributes on the order of 50 percent of the total population dose for rural accidents. Interdiction of foodstuffs would act to reduce, but not eliminate, this contribution.

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