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ENVIRONMENTAL ASSESSMENT FOR GAP MATERIAL PLUTONIUM – TRANSPORT, RECEIPT, AND PROCESSING

National Nuclear Security Administration

U.S. Department of Energy
Washington, DC

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ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ARF	airborne release fraction
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CHAP	Consolidated Hazards Analysis Process
CH-TRU	contact-handled transuranic
CSSC	Container Surveillance and Storage Capability
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
EA	environmental assessment
EIS	environmental impact statement
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FRR	Foreign Research Reactor
FTE	full-time equivalent
GTRI	Global Threat Reduction Initiative
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HLW	high-level radioactive waste
IAEA	International Atomic Energy Agency
INF	Irradiated Nuclear Fuel
ISO	International Organization for Standardization
KAC	K-Area Complex
KAMS	K-Area Material Storage Facility
KIS	K-Area Interim Surveillance
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
LEU	low-enriched uranium
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
M3	Office of Material Management and Minimization
MEI	maximally exposed individual
MOX	mixed oxide
MPA_g	megapascals gauge
NMFS	National Marine Fisheries Service
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAT	Plutonium Air Transportable Package
PM_n	particulate matter less than or equal to *n* microns in aerodynamic diameter
psi	pounds per square inch

psig	pounds per square inch gauge
RADTRAN	Radioactive Material Transportation
RF	respirable fraction
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SNF	spent nuclear fuel
SRS	Savannah River Site
TRAGIS	Transportation Routing Analysis Geographic Information System
TRU	transuranic
TRUPACT	Transuranic Package Transporter
U.S.C.	*United States Code*
WIPP	Waste Isolation Pilot Plant
WMD	weapon of mass destruction

1.0 INTRODUCTION

The U.S. Department of Energy (DOE), National Nuclear Security Administration (NNSA), has prepared this *Environmental Assessment for Gap Material Plutonium – Transport, Receipt, and Processing* to evaluate the potential environmental impacts associated with transporting plutonium from foreign nations to the United States, storing the plutonium at the Savannah River Site (SRS) in South Carolina, and processing it for disposition. This action would be pursued only if it is determined that there is no other reasonable pathway to assure security of this plutonium from theft or diversion.

NNSA prepared this environmental assessment (EA) pursuant to (1) the National Environmental Policy Act (NEPA); (2) Council on Environmental Quality (CEQ) regulations at Title 40 of the *Code of Federal Regulations* (CFR), Parts 1500 through 1508 (40 CFR Parts 1500-1508); and (3) DOE implementing procedures at 10 CFR Part 1021. In accordance with 40 CFR 1508.9(a) and 10 CFR 1021.320(b), this EA provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) or to issue a Finding of No Significant Impact (FONSI).

1.1 Background

NNSA's Office of Material Management and Minimization (M3), formerly known as the Global Threat Reduction Initiative (GTRI), is a vital part of the U.S. national security strategy of preventing the acquisition of nuclear materials for use in weapons of mass destruction (WMDs) and other acts of terrorism. The M3 mission is to reduce vulnerable nuclear materials located primarily at civilian sites worldwide. M3's goals are to: (1) convert reactors from using WMD-usable highly enriched uranium (HEU) to using low-enriched uranium (LEU); (2) remove WMD-usable excess nuclear materials; and (3) dispose of WMD-usable nuclear materials.

M3 has identified a category of material, referred to as gap nuclear material, which is currently located in foreign countries and presents a potential threat to nonproliferation goals; the foreign countries where this gap nuclear material is located may not have adequately safe and secure management options. Gap material includes: (1) fresh, weapons-usable HEU that is not covered by M3's U.S.-origin or Russian-origin removal programs, (2) spent nuclear fuel (SNF) that was not originally addressed in the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (*FRR SNF EIS*) (DOE/EIS-0218) (DOE 1996a), and (3) separated weapons-usable plutonium (gap material plutonium).

NNSA evaluated the gap material SNF in an analysis (DOE 2009a) prepared to determine whether there was a need to supplement the *FRR SNF EIS* (DOE 1996a). NNSA determined that no additional NEPA analysis was necessary and issued a revised Record of Decision (ROD) (74 *Federal Register* [FR] 4173) allowing the gap material SNF to be brought to the United States as part of the Foreign Research Reactor (FRR) SNF Acceptance Program for safe storage pending disposition. This option will be employed if there is no other reasonable pathway for disposition of the gap material SNF.

For gap material plutonium, the subject of this EA, M3's first priority is to seek a foreign solution that does not involve bringing this material to the United States. M3 is working with other countries and commercial entities to identify options for disposition of the plutonium. Efforts will be made to facilitate the return of the plutonium to secure locations in the countries of origin or to transfer it to a foreign commercial facility for processing to a form that is not susceptible to use in a WMD. If no other reasonable pathways are identified to address U.S. national security interests, NNSA proposes to transport the plutonium to the United States in accordance with applicable U.S. and international requirements and manage it in accordance with NNSA plans and procedures for surplus U.S. plutonium. In the *Environmental Assessment for the U.S. Receipt and Storage of Gap Material – Plutonium and Finding of No Significant Impact* (*Gap Material Plutonium EA and FONSI*) (DOE/EA-1771) (DOE 2010a), NNSA determined that a limited quantity (100 kilograms [220 pounds]) of plutonium could be received from foreign countries for interim storage at SRS pending disposition. The current proposal addresses additional quantities of material that have subsequently been identified as gap material plutonium.

Disposition of these additional quantities of gap material plutonium would be accomplished in the same manner as disposition of U.S. surplus plutonium. NNSA is implementing actions to disposition surplus U.S. plutonium and other fissile materials to reduce the threat of nuclear weapons proliferation. Plutonium declared surplus to U.S. national security needs will be converted to proliferation-resistant forms. Pending disposition, NNSA will ensure safe, secure storage of the plutonium.

1.2 Purpose and Need

The purpose of M3's Gap Material Removal Program is to work worldwide to provide options for removing and eliminating weapons-usable nuclear materials. NNSA has identified weapons-usable gap material plutonium at facilities in foreign countries that poses a potential threat to national security, is susceptible to use in an improvised nuclear device, and presents a high risk of theft or diversion. The need for the Proposed Action is to ensure an appropriately secure option for management and disposition of gap material plutonium if it is determined that there is no other reasonable pathway to assure security from theft or diversion (DOE 2007a).

As President Obama stated in his speech in Prague in 2009, nuclear terrorism is the most immediate and extreme threat to global security. While there are now international efforts to secure vulnerable nuclear materials, break up black markets, and detect and intercept illicitly trafficked materials, weapons-usable gap plutonium could be used in such attacks. As tangible improvements in the security of nuclear materials are made, and stronger international institutions that support nuclear security are established, the storage of weapons-usable gap plutonium at SRS pending disposition, if a secure foreign solution is not identified, will reinforce the United States government's efforts to secure vulnerable materials as part of the country's national security interests.

1.3 Proposed Action

NNSA's first priority is to seek a foreign solution that does not involve bringing this material to the United States. If such a solution cannot be identified, NNSA proposes to receive weapons-usable plutonium from foreign countries and manage it at a DOE site in the United States. The Proposed Action is to transport up to 900 kilograms (1,984 pounds) of gap material plutonium by ship from countries in Europe, along the Pacific Rim, and in North America to a U.S. seaport of entry. From the port of entry, gap material plutonium would be transported by a specially designed transporter to SRS, where it would be placed in storage, processed as needed, and ultimately dispositioned along with surplus U.S. plutonium. Of the 900 kilograms (1,984 pounds) of gap material plutonium, it is currently projected that approximately 525 kilograms (1,157 pounds) would be in a form ready for disposition, and approximately 375 kilograms (827 pounds) would be in a form that requires stabilization. While the proportions may ultimately vary slightly, the total quantity of plutonium accepted by the program would not exceed 900 kilograms (1,984 pounds).

1.4 Scope

This EA evaluates the potential environmental impacts from transporting gap material plutonium across the global commons to the United States; transferring packages of gap material plutonium to transporters at the port of entry; transporting material overland to SRS; transferring packages from the transporters to storage; and decladding and stabilizing some of the plutonium. Storage and disposition of the 900 kilograms (1,984 pounds) of gap material plutonium have already been evaluated in the *Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (*SPD Supplemental EIS*) (DOE/EIS-0283-S2) (DOE 2015); therefore, these activities are not within the scope of this EA.

Sources of Additional Gap Material Plutonium

M3 has identified inventories of vulnerable plutonium and the countries in which the material is currently stored. The specific quantities that comprise the 900 kilograms (1,984 pounds) evaluated in this EA and their locations are sensitive and therefore are not included in this EA. M3's first priority is to seek foreign solutions that would secure disposition of the plutonium; therefore, some of the currently identified inventories may never be transported to the United States.

This EA analyzes the potential environmental impacts of movement of 900 kilograms (1,984 pounds) of plutonium in a dozen shipments from foreign countries to the United States (seven shipments from countries in Europe, two shipments from countries along the Pacific Rim, one shipment from North America, and two shipments from anywhere in the world). Detailed information used in the analysis is provided in Chapters 2 and 4.

Actions in the Global Commons

The scope of the analysis essentially begins when the conveyance for transporting the gap material plutonium to the United States enters the global commons.

Transport by Ship

This EA analyzes transportation of gap material plutonium by ship across the global commons to a U.S. seaport (the Joint Base Charleston-Weapons Station). Marine transport of gap material plutonium would be conducted using chartered, exclusive-use ships,[1] in compliance with international and national transportation standards.

Ground Transport to the Savannah River Site

This EA analyzes the ground transport of gap material plutonium in specially designed transporters from the Joint Base Charleston-Weapons Station to SRS. The analysis includes the potential impacts of transferring gap material plutonium from the ship to the transporters.

Receipt at the Savannah River Site

Activities at SRS to receive the plutonium would include unloading the packages of gap material plutonium, repackaging as needed to meet storage requirements, and moving the packages to a storage location.

Processing

Approximately 375 kilograms (827 pounds) of gap material plutonium would need to be processed at SRS before disposition. Processing operations would involve decladding, size reduction, and heating the plutonium for stabilization. After processing, material would be placed in a Model 9975 or 9977 container and transferred to the storage area (SRNS 2015).

Interim Storage and Disposition

Eventual disposition of gap material plutonium would be in accordance with decisions made for disposition of U.S. surplus plutonium. As discussed in Chapter 1, Section 1.5.2, of the *SPD Supplemental EIS* (DOE 2015), the 13.1 metric tons (14.4 tons) of surplus plutonium analyzed in the EIS included 0.9 metric tons (0.99 tons) of excess capacity to allow for the possibility that DOE may identify additional quantities of surplus plutonium that could be processed for disposition through the facilities and capabilities analyzed in the *SPD Supplemental EIS*. Therefore, the impacts from activities related to the

[1] *Exclusive-use ships operate as chartered vessels and are not used for the transport of any other cargo other than the plutonium (and potentially SNF) they are hired to transport.*

eventual disposition of the 900 kilograms (1,984 pounds) of plutonium analyzed in this EA have already been evaluated in the *SPD Supplemental EIS*, and no further NEPA evaluation is required for storage and disposition.

Activities Outside the Scope of this Environmental Assessment

NNSA works with its international partners on global nonproliferation issues to identify inventories of gap material plutonium. Once inventories are identified, NNSA works with the host country to develop a pathway for safe disposition of the plutonium. Consistent with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, the environmental impacts from actions to disposition plutonium in foreign countries are not within the scope of this EA.

To be accepted by SRS for eventual disposition, the plutonium must meet SRS acceptance criteria that are applicable at the time of plutonium shipment. It would be the responsibility of the personnel at the foreign facility to prepare and package the plutonium so it can be transported to and safely handled at SRS. The workers at the foreign facility would receive any necessary training prior to packaging, and the facility would submit their detailed loading procedures to SRS for review prior to shipping. The plutonium would meet the stabilization requirements of DOE-STD-3013, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials* (DOE 2012a), and be containerized and packaged to meet safe transport requirements and SRS acceptance criteria. Once prepared for shipment, it would be the responsibility of the entities managing the materials to arrange safe transport through the foreign countries to the seaports of departure in accordance with applicable regulations. Consistent with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, the environmental impacts from activities by non-U.S. entities in foreign countries are not within the scope of this EA.

1.5 Related NEPA Documentation

The proposed quantity of gap material plutonium addressed in this EA (0.9 metric tons [0.99 tons]) would be equivalent to 2 percent of the 47.1 metric tons (51.9 tons) of U.S. weapons-usable surplus plutonium currently managed by DOE (DOE 2015). NNSA expects to achieve disposition of gap material plutonium using the same technologies and processes that are contemplated for U.S. surplus plutonium. NEPA documents that support decisions related to the transportation, storage, processing, and disposition of U.S. surplus plutonium are discussed in the following sections.

1.5.1 Gap Material Plutonium

In the *Gap Material Plutonium EA and FONSI* (DOE 2010a), DOE assessed the potential environmental impacts of transporting 100 kilograms (220 pounds) of at-risk gap material plutonium from foreign locations to SRS for storage pending final disposition. The EA evaluated alternatives whereby transport of gap material plutonium to the United States would occur via chartered ocean vessel or by aircraft. Informed by this analysis, DOE determined that the transport and storage of the gap material plutonium would entail minor impacts and low risks. The EA addressed the impacts from transporting plutonium by ocean vessel to a U.S. seaport, unloading and transferring the plutonium to specially designed transporters, transporting the plutonium overland to SRS, and storing the plutonium pending its disposition. In the *Gap Material Plutonium EA and FONSI*, DOE determined that the impacts of implementing the proposed action were not significant.

1.5.2 Storage and Disposition of Surplus Plutonium

The *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (*S&D PEIS*) (DOE/EIS-0229) (DOE 1996b) evaluated the potential environmental impacts of providing safe and secure storage of U.S. weapons-usable fissile materials (plutonium and HEU), and of implementing a strategy to disposition surplus U.S. weapons-usable plutonium. In its January 21, 1997, ROD (62 FR 3014) and in subsequent amended RODs (67 FR 19432, 72 FR 51807), DOE announced its decision, among other things, to consolidate storage of non-pit plutonium at SRS.

The *Surplus Plutonium Disposition Final Environmental Impact Statement* (*SPD EIS*) (DOE/EIS-0283) (DOE 1999) tiered from the *S&D PEIS* and evaluated the potential environmental impacts associated with the disposition of 50 metric tons (55 tons) of surplus plutonium. The *SPD EIS* included consideration of different DOE sites and facilities to accomplish (1) plutonium pit disassembly and conversion, (2) plutonium conversion and immobilization using can-in-canister technology, and (3) mixed oxide (MOX) fuel fabrication. The *SPD EIS* also evaluated the potential environmental impacts of using MOX fuel in specific domestic commercial nuclear reactors.

In a January 11, 2000, ROD (65 FR 1608) that followed issuance of the *SPD EIS*, DOE announced its decision to immobilize 17 metric tons (19 tons) of surplus U.S. plutonium and to fabricate 33 metric tons (36 tons) into MOX fuel using disposition facilities to be built at SRS.

In 2002, DOE prepared the *Supplement Analysis for Storage of Surplus Plutonium Materials in the K-Area Material Storage Facility at the Savannah River Site* (DOE/EIS-0229-SA-2) (DOE 2002a). In this supplement analysis, DOE evaluated the potential for storage beyond 10 years at the K-Area Material Storage Facility (KAMS) (now known as the K-Area Material Storage Area) and concluded that potential impacts from the continued storage of surplus non-pit plutonium in KAMS for up to 50 years would not be substantially different from those addressed in the original analysis of storage in the Actinide Packaging and Storage Facility contained in the *S&D PEIS* (DOE 1996b). In a 2002 amended ROD (67 FR 19432) informed by this supplement analysis, DOE amended the *S&D PEIS* and *SPD EIS* RODs and, among other things, made the decisions to consolidate long-term storage at SRS of surplus non-pit plutonium stored separately at the Rocky Flats Environmental Technology Site (formerly the Rocky Flats Plant) and SRS and to authorize consolidated long-term storage in KAMS.

A supplement analysis of the *S&D PEIS* (DOE 1996b) and *SPD EIS* (DOE 1999), the *Supplement Analysis – Fabrication of Mixed Oxide Fuel Lead Assemblies in Europe* (*Lead Assemblies SA*) (DOE/EIS 0229-SA3) (DOE 2003b), evaluated the transport of approximately 150 kilograms (330 pounds) of plutonium from the United States to Europe for fabrication into MOX fuel lead assemblies and the return transport of the assemblies (plus scrap and archive material). This supplement analysis is relevant to this EA because it evaluated ground and ship transport of plutonium and included the Charleston Naval Weapons Station[2] as a port of departure and entry for the plutonium. NNSA determined that no additional NEPA analysis was required in order to proceed with shipment of plutonium to Europe, fabrication of MOX fuel assemblies, and return shipment of the MOX fuel assemblies.

In 2005, DOE prepared the *Environmental Assessment for the Safeguards and Security Upgrades for Storage of Plutonium Materials at the Savannah River Site* (DOE 2005a). DOE prepared the EA to evaluate installation and operation of the K-Area Container Surveillance and Storage Capability (CSSC) for non-pit plutonium surveillance and stabilization, deinventory of plutonium from F-Area for storage in K-Area, storage of plutonium in DOE-STD-3013 (DOE 2012a)-compliant containers, and installation of safeguards and security upgrades in K-Area and the Advanced Tactical Training Area. In the resulting FONSI, DOE determined that implementation of the Proposed Action was not expected to have a measurable impact on the human environment, so an EIS was not required (DOE 2005b). Since the initial FONSI on the EA was issued, DOE has issued a revised FONSI (DOE 2010b). In the revised FONSI, DOE explains that the features originally planned for CSSC have been replaced by the Stabilization and Packaging Project in the K-Area Complex (KAC). This project would provide the capability to comply with DOE-STD-3013 (DOE 2012a) requirements for stabilization and long-term storage of plutonium-bearing materials and would replace the compliance feature of CSSC.

Most of the surplus non-pit plutonium in storage at various DOE sites around the United States has been moved to SRS for consolidated long-term storage pending disposition, consistent with the 2002 amended

[2] *The Charleston Naval Weapons Station is now called the Joint Base Charleston-Weapons Station; see Chapter 3, Section 3.2.*

ROD (67 FR 19432); the *Supplement Analysis, Storage of Surplus Plutonium Materials at the Savannah River Site* (DOE/EIS-0229-SA-4) (DOE 2007b); and an amended ROD issued in 2007 (72 FR 51807) regarding surplus plutonium from the Hanford Site, Los Alamos National Laboratory (LANL), and Lawrence Livermore National Laboratory (LLNL).In an interim action determination approved in April 2013, DOE decided to expand plutonium storage into the Final Storage Area and Presentation Room of the SRS KAC (DOE 2013a). Modifications would require minor dismantlement and removal activities and a few physical enhancements, primarily for safeguards and security systems.

In the *SPD Supplemental EIS* (DOE 2015), DOE evaluated proposed actions to effect disposition of an additional 13.1 metric tons (14.4 tons) of surplus plutonium for which a disposition path had not been previously assigned. The DOE facilities proposed to store surplus plutonium and prepare it for disposition are located at SRS. The analyzed disposition pathways are can-in-canister immobilization with high-level radioactive waste (HLW); MOX fuel fabrication at the MOX Fuel Fabrication Facility and irradiation of the MOX fuel in U.S. commercial nuclear power reactors;[3] processing at H-Canyon/HB-Line for vitrification with HLW at the Defense Waste Processing Facility in S-Area; and processing at HB-Line for disposal as contact-handled transuranic (CH-TRU) waste at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

1.6 External Review

NNSA advised the States of Georgia and South Carolina of its intent to prepare an EA to evaluate the transportation, receipt, and processing of additional quantities of gap material plutonium. Copies of the draft EA were provided to the States of Georgia and South Carolina to provide them with information and to solicit their comments. Comments received from this review were considered during preparation of this final EA.

[3] *Gap plutonium would not meet MOX fuel fabrication acceptance criteria and, therefore, would not be considered for disposition via the MOX fuel disposition pathway.*

2.0 DESCRIPTION OF ALTERNATIVES

NNSA's first priority is to seek a foreign solution that does not involve bringing this material to the United States. If such a solution cannot be identified to assure security from theft or diversion, NNSA proposes to transport gap material plutonium to the United States for storage pending its disposition. The following sections describe: (1) an action alternative (Proposed Action), whereby the gap material plutonium would be transported to the United States to SRS for interim storage pending its disposition, and (2) a No Action Alternative, whereby the gap material plutonium would not be transported to the United States to SRS for interim storage and eventual disposition. Alternatives considered but dismissed from further evaluation are also identified. Potential impacts of the Proposed Action and No Action Alternative are presented in Chapter 4.

2.1 Proposed Action – Transport to and Management at the Savannah River Site

The Proposed Action is to transport up to 900 kilograms (1,984 pounds) of gap material plutonium from foreign countries to the United States for processing and eventual disposition. Plutonium transport would occur over approximately a 7-year period.

2.1.1 Shipment to the United States

Shipment of additional gap material plutonium to the United States would occur after (1) implementation of a contract or agreement between authorized representatives of the United States and the countries or nuclear facilities possessing the plutonium, (2) receipt of all data necessary to ensure safe handling and storage, and (3) satisfactory resolution of any identified issues. At the foreign sites, the plutonium would be stabilized to meet the requirements of DOE-STD-3013 (DOE 2012a) and placed into containers that are compatible with the requirements of the SRS storage facility. The containerized plutonium would be placed within packaging appropriate for the type and quantity of material, shipped to the United States,[4] and then to SRS, in compliance with requirements for safe transport of radioactive materials of the host country, the United States, and international organizations. These standards include the International Atomic Energy Agency (IAEA) Safety Standard Series Number SSR-6, *Regulations for the Safe Transport of Radioactive Material* (IAEA 2012), and 10 CFR Part 71, *Nuclear Regulatory Commission Regulations for Packaging and Transportation of Radioactive Materials*.

The mode of transport would be by chartered and exclusive-use ships, which would deliver the plutonium to the Joint Base Charleston-Weapons Station, South Carolina (**Figure 1**). The Joint Base Charleston-Weapons Station was selected for analysis in this EA because it was selected as a seaport for NNSA's FRR SNF Acceptance Program after an extensive analysis in the *FRR SNF EIS* (DOE 1996a). Its receipt of radioactive material has been analyzed in subsequent NEPA documents (e.g., DOE 2003b, 2006a, 2009a, 2010a). The Joint Base Charleston-Weapons Station has an ongoing working relationship with DOE, and the FRR SNF Acceptance Program is actively receiving shipments through this seaport. In addition, NNSA has successfully completed multiple shipments of gap material plutonium through the Joint Base Charleston-Weapons Station.

[4] *Typically, the country shipping the plutonium would be responsible for arranging for transport packaging and loading the plutonium into transport vehicles; complying with safety and security requirements; coordinating with local and national officials; obtaining export approvals; and making any needed transit arrangements with countries through whose territorial waters transport ships may pass. Packages transported into or out of the United States via commercial carrier must be certified by a current U.S. Department of Transportation Competent Authority Certification Certificate.*

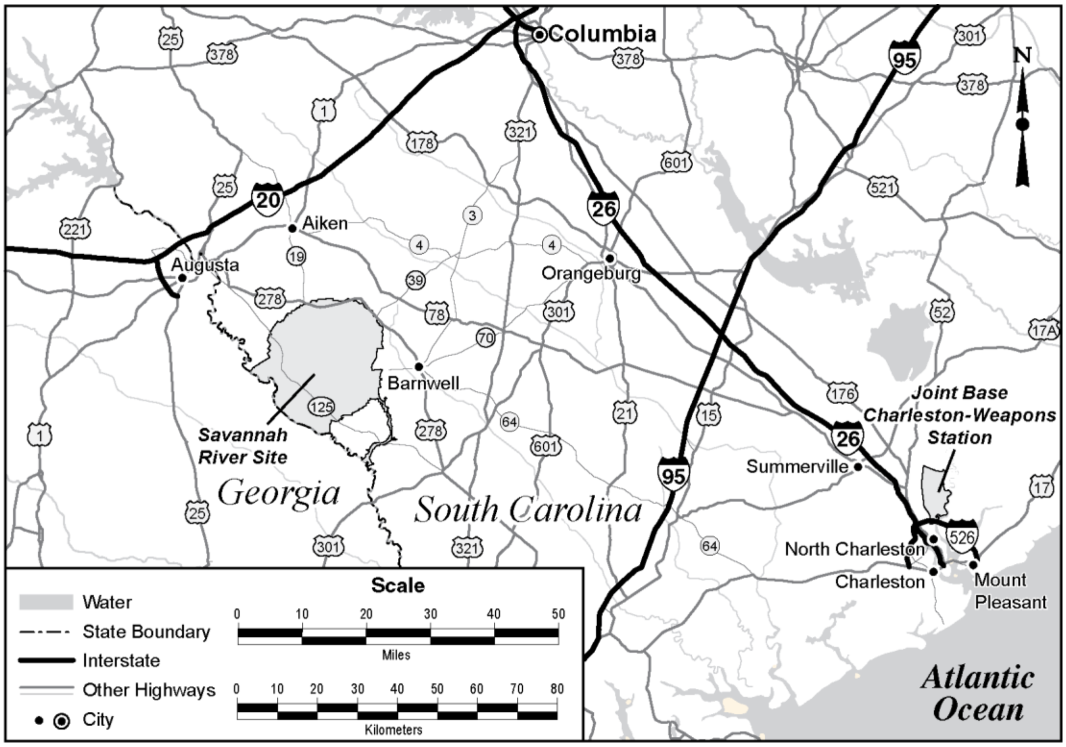

Figure 1. Locations of the Joint Base Charleston-Weapons Station and Savannah River Site

2.1.2 Overland Transport to SRS

Gap material plutonium received at the Joint Base Charleston-Weapons Station would be unloaded from the ship and transported to SRS (Figure 1) using transporters which are specially designed to prevent unauthorized removal of the cargo.

2.1.3 Plutonium Receipt, Processing, and Disposition

At SRS, the plutonium would be received, processed as needed, and safely and securely managed along with surplus U.S. plutonium. Eventual disposition of the gap material plutonium would occur along with surplus U.S. plutonium. In a variety of NEPA documents, most recently in the *SPD Supplemental EIS* (DOE 2015), DOE evaluated storage and several pathways for surplus plutonium disposition (see Section 1.5.2).

2.2 No Action Alternative

Under the No Action Alternative, additional gap material plutonium would not be transported to the United States for eventual disposition. This alternative could occur if a different disposition pathway is identified for all of the gap material plutonium that does not involve transport to the United States (for example, secure storage or disposal in another country). However, if a different disposition pathway is not identified, the No Action Alternative would not meet the objective of securing this plutonium and ensuring it is unavailable for use in WMDs.

2.3 Alternatives and Options Considered, but Dismissed from Further Evaluation

Additional alternatives and options that were considered for the transport, management, and eventual disposition of gap material plutonium are discussed in this section. These alternatives and options have been dismissed from detailed analysis for the reasons specified below.

2.3.1 Air Transport

Air transport was considered but not analyzed in detail because there is currently no specific package certified for the air transport of plutonium that can contain the types and quantities of plutonium to be transported under the Proposed Action. Although IAEA has established additional test requirements for packaging intended for air transport of plutonium, which it calls Type C packaging (IAEA 2012), the U.S. regulations for packages used for the air transport of plutonium in 10 CFR Part 71[5] impose more-rigorous testing requirements than those of IAEA. Therefore, it is possible for packaging to have a Certificate of Compliance for air transport of plutonium issued by another country for which a Certificate of Competent Authority allowing use in the United States would not be approved. A national security exemption to the 10 CFR Part 71 packaging requirements would be necessary to allow air transport of plutonium in packaging for which a Certificate of Compliance or Certificate of Competent Authority has not been issued.

The only packaging certified for air transport of plutonium in the United States is the Plutonium Air Transportable Package (PAT), Model PAT-1. Few Model PAT-1 packages are in service, and each can carry about 2 kilograms (4.4 pounds) of plutonium as an oxide. The quantity allowed per package is very small, and containers that can fit within Model PAT-1 packaging are not currently approved for storage at SRS. More importantly, the chemical forms of plutonium that may be transported within Model PAT-1 packaging would not encompass all of the chemical forms of plutonium to be transported under M3's gap material removal program. Air transport of small quantities of plutonium was previously analyzed in the *Gap Material Plutonium EA and FONSI* (DOE 2010a).

2.3.2 Rail Transport

Rail transport was not considered because rail is not currently part of the NNSA's plutonium transport capabilities. Specially designed transportation vehicles are routinely in use and provide safe, secure transport of nuclear material, with more flexibility than rail transport in terms of scheduling and routing.

2.3.3 Alternative Seaports of Entry

Seaports other than the Joint Base Charleston-Weapons Station were considered, but dismissed from detailed analysis after review of the *FRR SNF EIS* (DOE 1996a), the *Gap Material Plutonium EA and FONSI* (DOE 2010a), and identification of SRS as the storage and disposition location for surplus plutonium (65 FR 1608). Because SRS is located within a few hours driving time from the Atlantic Ocean, seaports on locations other than the Atlantic Ocean were considered less desirable because their use would require longer times for overland shipment of plutonium. Therefore, seaports other than those on the Atlantic Ocean were dismissed from consideration in this EA. In addition, seaports were dismissed from detailed analysis in this EA if they were not selected in the *FRR SNF EIS* for detailed analysis. After comparison with screening criteria and a list of desirable attributes, DOE selected for detailed analysis in the *FRR SNF EIS* the seaports located at the Military Ocean Terminal at Sunny Point and Wilmington, North Carolina; Jacksonville, Florida; Savannah, Georgia; and Portsmouth, Newport News, and Norfolk, Virginia. Although all these seaports could be candidates for acceptance of gap material plutonium, they were dismissed from analysis in this EA after consideration of attributes including: experience handling gap material plutonium and SNF; distance to SRS; distance from populated areas; and possession of a secure location for plutonium receipt, handling, and transfer (i.e., military seaports are secure locations because they can exclude members of the public from plutonium receipt and handling areas). The Joint Base Charleston-Weapons Station is the closest military seaport to SRS and has significant experience handling gap material plutonium and SNF; therefore, it was selected as the sole seaport for analysis in this EA.

[5] *The U.S. regulations do not use the designation of Type C package.*

2.3.4 Alternative Processing Locations in the United States

Consideration was given to alternative DOE processing locations that possess or have possessed plutonium, including LANL, LLNL, and the Pantex Plant. These alternative sites were dismissed from detailed analysis because DOE's programmatic objective is to consolidate surplus plutonium at SRS. Most of the surplus non-pit plutonium in storage at various DOE sites around the United States has been moved to SRS for consolidated long-term storage, consistent with the 2002 amended ROD (67 FR 19432); the *Supplement Analysis, Storage of Surplus Plutonium Materials at the Savannah River Site* (DOE/EIS-0229-SA-4) (DOE 2007b); and an amended ROD issued in 2007 (72 FR 51807). Based on current and planned capabilities, SRS is also the location at which the identified gap material plutonium would be processed for eventual disposition (65 FR 1608).

2.4 Description of the Proposed Action

2.4.1 Packaging and Shipments

Transportation of plutonium would be conducted in accordance with national and international requirements for safety and safeguards or, if determined to be in the interest of national security, in accordance with approved exceptions to those requirements. The packaging used for plutonium transport would need to be acceptable to both the host country and the United States, meaning that packaging for which a certificate of compliance has been issued in one country would have to be accepted by a competent authority of the other country. In general, individual countries' regulations conform to the IAEA *Regulations for the Safe Transport of Radioactive Material* (IAEA 2012), thereby facilitating acceptance of certified packaging by another country.

All plutonium would be shipped using Type B packaging. Type B packaging must be designed and tested to withstand both normal transport and accident conditions.[6] Two representative Type B packagings[7] were evaluated, resulting in a range of impacts. The Model 9975 packaging has been used in the United States for several years. Model 9977 packaging has been more recently developed. The designs of these two packagings provide a range of parameters that are used in the analysis, as well as a reasonable expectation that potential impacts would be within those presented in this EA.

Model 9975 packaging (**Figure 2**) includes an outside shell consisting of a stainless-steel 35-gallon (132.5-liter) drum with a flange at the top for fasteners. Model 9975 packaging can hold a single container, composed of nested inner and outer stainless steel containers, of plutonium that has been stabilized pursuant to the requirements of DOE-STD-3013 (DOE 2012a). One configuration housing welded containers meets DOE's standard for long-term plutonium storage (DOE 2012a). A second configuration housing non-welded containers is used for interim storage. Containers of plutonium are secured in the package within primary containment vessels and secondary containment vessels that are surrounded by lead shielding and insulating material. The current DOE Certificate of Compliance for the Model 9975 packaging limits it to 4.4 kilograms (9.7 pounds) of plutonium in metal or oxide form (5 kilograms [11 pounds], including impurities), provided the heat generated by the decay of the

[6] *Normal transport conditions, which may result in a package being subjected to heat, cold, vibration, changes in pressure, or other possible occurrences (e.g., being dropped, compressed under a weight, sprayed with water, or struck by objects), must not result in loss of function (e.g., containment, shielding, continuance of sub-criticality). With respect to accident conditions, there must be no substantial loss of function of the package after being subject to a series of tests that are conducted sequentially. These tests simulate being dropped from 30 feet (9.1 meters) onto an unyielding surface; being crushed or punctured; being exposed to a high heat (a temperature of at least 1,475 degrees Fahrenheit [800 degrees Celsius], as from a fire, for 30 minutes; and being immersed in water.*

[7] *In international and U.S. regulatory nomenclature, the term "package" means the packaging together with its radioactive contents as presented for transport. The term "packaging" means the assembly of components necessary to ensure compliance with packaging requirements. It may consist of one of more receptacles; absorbent materials; spacing structures; thermal insulation; radiation shielding; service equipment for filling, emptying, venting, and pressure relief; and devices for cooling or absorbing mechanical shocks.*

transported radionuclides does not exceed 19 watts (DOE 2014c). The Model 9975 packaging is approved for both interim and long-term plutonium storage at the SRS KAC. This package is also approved for plutonium transportation by the U.S. Department of Transportation (DOT 2013d).

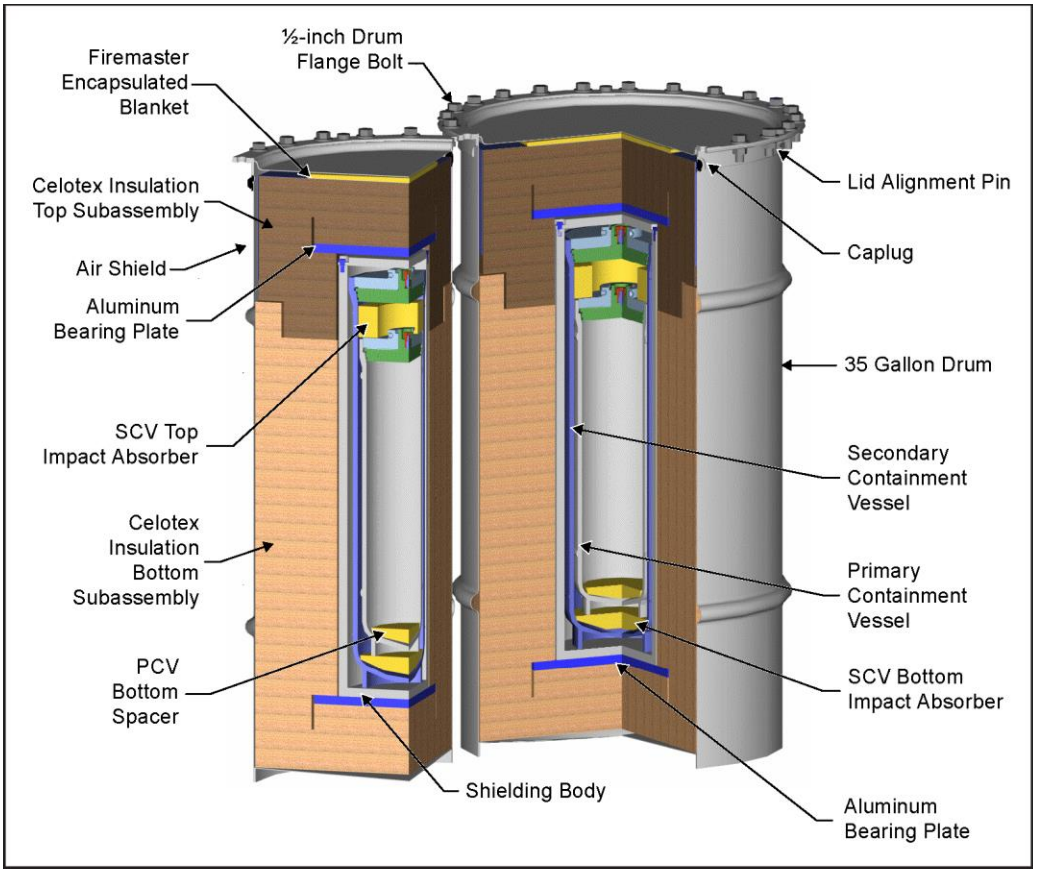

Figure 2. Model 9975 Shipping Package

The outside shell of a Model 9977 packaging (**Figure 3**) is also fabricated from a stainless-steel 35-gallon drum, although compared to a Model 9975 packaging, it lacks a flange at the top of the packaging and has a slightly smaller diameter. This package was originally developed as a replacement for the U.S. Department of Transportation 6M Specification Package; however, it was modified to accommodate two containers of plutonium stabilized in accordance with DOE-STD-3013 (DOE 2012a) within a single containment vessel. The principal modifications were to add an aluminum heat dissipation sleeve and a liner to the containment vessel to ensure criticality control. The current DOE Certificate of Compliance certifies the packaging for transport of up to 8.8 kilograms (19.4 pounds) of plutonium, not exceeding 10 kilograms (22 pounds) of plutonium oxide. The packaging limit for decay heat is 38 watts (19 watts for each container of plutonium)[8] (DOE 2012b). The current DOE Certificate of Compliance does not allow shipment by water of Model 9977 packaging containing two DOE-STD-3013 containers. Therefore, the DOE Certificate of Compliance would need to be modified to allow ocean transport of Gap Material Plutonium in Model 9977 containers. In addition, in order for the Model 9977 package to be used for plutonium transportation, it would need to be certified by the U.S. Department of Transportation. Although the Model 9977 packaging is not currently approved for plutonium transportation, analysis is included in this EA in the event this packaging (or other similar packaging) is approved in the future. The Model 9977 packaging is approved for interim and long-term plutonium storage at the SRS KAC.

[8] *The current heat limit at the SRS KAC for plutonium storage is 25 watts per package.*

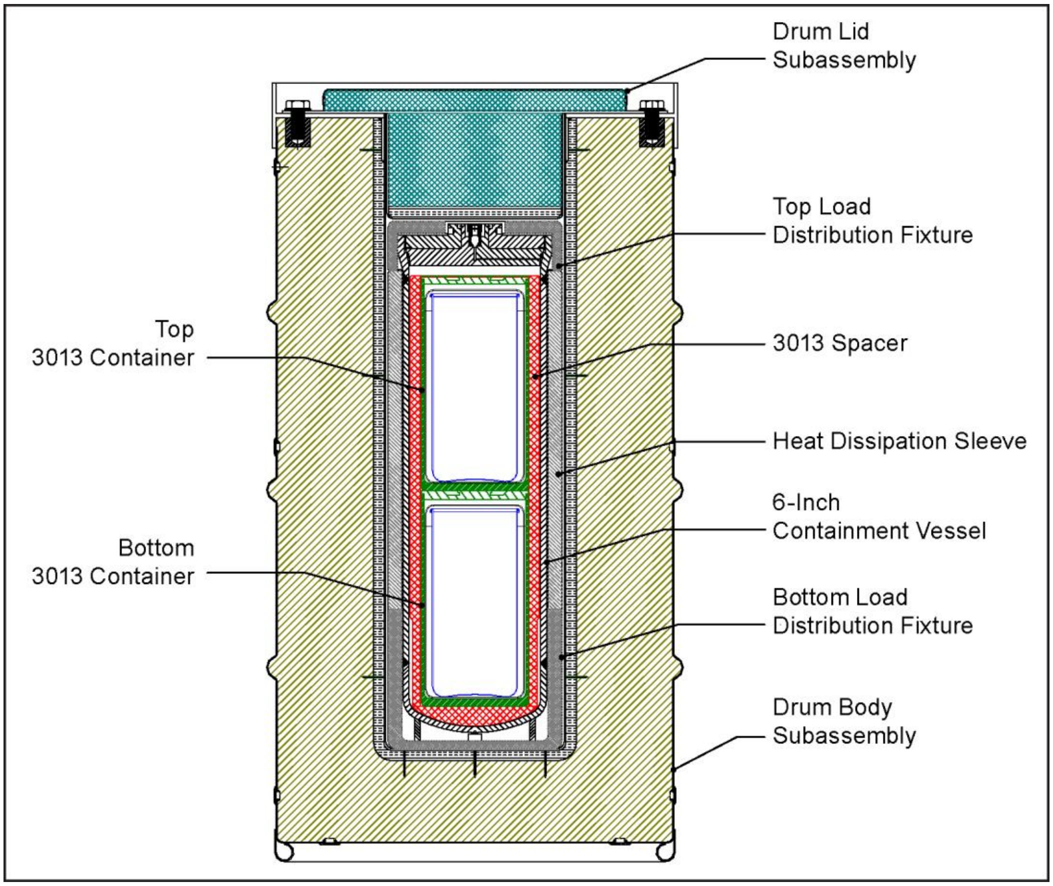

Figure 3. Model 9977 Shipping Package with Two DOE-STD-3013 Containers

The 900 kilograms (1,984 pounds) of plutonium evaluated in this EA would be transported from seven countries, with the quantity of plutonium transported from any single country ranging from a few kilograms to several hundred kilograms, and the number of packages from any single country ranging from 1 to over 100. This EA evaluates the potential impacts of three large (maximum expected) ocean shipments of up to 350 kilograms (770 pounds) each and nine smaller (representative) ocean shipments of up to 50 kilograms (110 pounds) each to the United States. Most shipments, however, would not contain the maximum quantity of plutonium evaluated under the shipment scenarios; no single shipment would exceed 350 kilograms (770 pounds), and the total quantity of plutonium from all countries would not exceed 900 kilograms (1,984 pounds).

2.4.2 Ship Transport

At least 180 days before the tentative shipping date for transporting gap material plutonium to the United States, NNSA would require a contract or agreement between NNSA, representing the U.S. Government, and authorized representatives of the countries or nuclear facilities possessing the plutonium. A detailed description of the nuclear material would be submitted, including drawings, dimensions and weights, chemical form, isotopic content, specific identification numbers, transport container and packaging data, and other information. Before shipment, teams of NNSA or authorized contractor personnel would conduct foreign site visits that would include representative material examinations and facility and infrastructure assessments. Assuming satisfactory resolution of any identified issues and receipt of all required data, shipment of the plutonium would be scheduled.

At the foreign sites, plutonium stabilized to meet the requirements of DOE-STD-3013 (DOE 2012a) would be placed into containers compatible with the requirements of the SRS storage facility. The containerized plutonium would be placed within packaging appropriate for the type and quantity of material. The packaged plutonium would be transported within the foreign countries to seaports of embarkation in compliance with local standards for safety and security. At the nuclear facility or seaport, the packages of plutonium would be securely mounted on pallets that would be secured within one or more International Organization for Standardization (ISO) shipping containers (ISO containers). Securing the packages on pallets facilitates transfer of the packages into and securing the packages within the ISO containers, removal of the packages from the ISO containers at the Joint Base Charleston-Weapons Station, and loading into specially designed transporters for shipment to SRS. The ISO containers would be hoisted onto the transport ship at the foreign port and stowed securely within the ship's hold (see **Figure 4**). NNSA or contractor personnel may be present to facilitate arrangements and inspect packaging and loading operations.

The number of packages placed within an ISO container may vary. Considering criticality safety requirements, the physical dimensions of the packages and their groupings on pallets, the typical dimensions of ISO containers and overland transport vehicles, and worker radiation protection, each ISO container would contain up to 25 Model 9975 or Model 9977 packages. Each maximum expected shipment would consist of three to five ISO containers, while each representative shipment would consist of one ISO container. Following these assumptions, a total of 18 ISO containers would be required if all of the plutonium were shipped in Model 9977 packaging; 24 ISO containers would be required if all of the plutonium were shipped in Model 9975 packaging.

Figure 4. ISO Containers Secured within the Hold of a Ship

The chartered ship would be certified to meet the requirements of the *International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships* (INF Code) (SOLAS 1999). The requirements differ depending on the ship's INF Code classification: an INF Class 1 vessel may carry irradiated nuclear fuel, HLW, or plutonium with an aggregate activity of less than 108,000 curies; an INF Class 2 vessel may carry irradiated nuclear fuel or HLW with an aggregate radioactivity of less than 54 million curies or plutonium with an aggregate radioactivity less than 5.4 million curies; and an INF Class 3 vessel may carry irradiated nuclear fuel, HLW, or plutonium with no restrictions on aggregate radioactivity. Design and operational requirements for the three INF ship classes are addressed in a graded manner; they include those for vessel stability after damage, fire protection, temperature control of cargo spaces, structural strength of deck areas and support arrangements, cargo securing arrangements, electrical supplies, radiological protection equipment, ship management, crew training, and emergency plans (WNTI 2007).

Prior to each shipment, a threat assessment would be conducted in accordance with a security plan developed for the specific shipment. If determined necessary, armed security personnel could be onboard the transport vessel or an escort ship.

Although members of the general public would not be exposed to radiation during loading activities or during transport across the global commons to the United States, some members of the ship crew could be exposed to external radiation. Radiation doses potentially experienced by the crew would depend on the travel time to the Joint Base Charleston-Weapons Station, the loading and placement of ISO containers within the ship's hold, any material or cargo present that could provide shielding after stowage, and crew activities during loading and transit.

For shipments from a European country, a transport time of 22 days was assumed, based on the distance to the furthest European port evaluated in the *FRR SNF EIS* (DOE 1996a) and an assumed average cruising speed of 12 knots, consistent with experience in shipping FRR SNF (DOE 1998). For shipments from locations other than North American or European countries, a transit time was determined that would envelop the time from anywhere in the world. This travel time (60 days) was determined by assuming an average cruising speed of 12 knots and travel from a representative Japanese port (the port of Kushiro on the Japanese island of Hokkaido). No shipments would travel through the Suez or Panama Canal. For shipments from a North American location, the assumed travel time is 10 days.

The number of crew members and their activities during loading operations reflect those addressed in the *FRR SNF EIS* (DOE 1996a). Ship crew members performing loading operations would be assisted by radiation protection personnel to reduce the potential for excessive radiation exposures.

While at sea, some of the crew members would enter the hold and be in the vicinity of the ISO containers to inspect the cargo and ensure it remains securely stowed (e.g., check the tightness of the cargo tie-downs). This activity would occur daily and represent the largest potential for radiation exposure to crew members. The radiation dose received by these crew members would depend on the levels of radiation emitted by the ISO containers, the number and placement of the ISO containers within the ship's hold (for shipments containing more than one ISO container), the inspection times, and the distance maintained from the ISO container during inspections. The external radiation rates for the ISO containers were assumed to be the regulatory limit of 10 millirem per hour at 2 meters (6.6 feet) for exclusive-use shipments; in reality, the dose rate is expected to be well below the regulatory limit. Because the vessel used for plutonium shipment will be exclusive-use, crew members performing the inspections would understand radiation safety principles, and unauthorized crew members would be excluded from the immediate area of the radioactive cargo.

Before entering the Joint Base Charleston-Weapons Station, a vessel carrying gap material plutonium would communicate with appropriate personnel at the seaport to coordinate port entry and docking activities. Measures would be taken to ensure safety and security during the passage through the port entrance channel and travel within port reaches or turning basins. A pilot may board the vessel to assist the passage to the designated wharf. Escort vessels or tugs may also assist the passage.

2.4.3 Ship to Truck Transfer at the Joint Base Charleston-Weapons Station

At the Joint Base Charleston-Weapons Station, one or more specially designed transporter would be staged to await the arrival of the ship. In accordance with the security plan, if necessary, additional security would be provided at the dock during transfer of the cargo from the ship to the transporter. Upon arrival of the ship, authorized workers, assisted by ship crew members, would enter the hold; remove the tie-downs securing the ISO containers for the ocean voyage; attach rigging; remove the ISO containers from the hold using a crane; and place the ISO containers in a secure area of the dock. On the dock, authorized personnel would open the ISO containers and, following a radiation survey, remove the tie-downs securing the packages within the ISO containers. The packages would be transferred to and secured within the transporter for transport to SRS. During incident-free transfer of plutonium to the transporter, authorized personnel performing or assisting in the transfer would be exposed to external radiation from the packages. Members of the public and other workers at the Joint Base Charleston-Weapons Station would be restricted from the vicinity of the unloading and transfer operations and, therefore, would not be exposed to radiation during incident-free unloading and package transfer activities.

2.4.4 Truck Transport from the Joint Base Charleston-Weapons Station to the Savannah River Site

Once the cargo received at the Joint Base Charleston-Weapons Station is loaded and secured in the transporter, it would be promptly transported to SRS. Because of the short travel distance between the Joint Base Charleston-Weapons Station and SRS, no refueling or rest stops are expected.

2.4.5 Receiving Gap Material Plutonium at the Savannah River Site

Plutonium delivered to SRS would be removed from the transporter, and material control and accountability measurements would be taken. The packages of plutonium would remain at approved locations pending disposition; most likely at the existing KAC (see Chapter 3, Section 3.4). Other approved locations within the KAC or elsewhere at SRS could also be used.

2.4.6 Processing Gap Material Plutonium at the Savannah River Site

Approximately 375 kilograms (827 pounds) of plutonium would need to be processed at SRS, pending final disposition. To perform this activity, a portion of the KAC[9] would be renovated, and a new glovebox would be installed. Renovation activities could include removal of:

- lighting distribution panels and fixtures,
- personnel and material movement doors and door assemblies,
- a pair of distillation towers, and
- piping, instrumentation, and equipment (SRNS 2015).

Modifications to the KAC would take approximately 3 years and involve approximately 80 full-time equivalents (FTEs) (SRNS 2015). Modifications could include:

- disturbance of approximately 0.25 acres (0.10 hectares) for installation of concrete pads required for the diesel generators, breathing air compressor, and gas bottle racks within the existing K-Area footprint;
- cutting access doors where required;
- installation of new reinforced concrete wall sections and new accesses for personnel;
- installation of a new glovebox with process equipment and containment ventilation provided by exhaust fans and high-efficiency particulate air (HEPA) filters;
- installation of a heating, ventilating, and air conditioning system;
- installation of services (e.g., public address, telephone, emergency and normal lighting, electrical power and miscellaneous monitoring and process control);

[9] *In addition to the K-Area Complex, the H-Canyon/HB-Line at SRS could be used to stabilize gap material plutonium.*

- installation of safeguards and security measures (e.g., security cameras and surveillance systems, etc.); and
- installation of fire suppression, detection, and alarm systems and fire barriers (SRNS 2015).

Processing operations could involve decladding, size reduction, and heating the plutonium for stabilization. The materials to be processed are in the form of small plates and rods.

It would take approximately 3 years to process the plutonium at an average rate of 125 kilograms per year. The new 2,700-square-foot (250-square-meter) capability would require approximately 16 additional FTEs to operate (SRNS 2015).

Processing would stabilize the plutonium, producing a form that meets Interim Safe Storage Criteria Program requirements (SRNS 2015) and prepares the material for final disposition. After processing, the material would be removed from the glovebox, placed in a Model 9975 or 9977 container, and transferred to the storage area.

2.4.7 Storage and Disposition of Gap Material Plutonium

Gap material plutonium would remain at SRS at one of the KAC locations, the K-Area Material Storage Area, illustrated in **Figure 5,** until it is dispositioned along with U.S. surplus plutonium As described in Section 1.4, storage and alternatives for disposition of U.S. surplus plutonium have been addressed by DOE, most recently in the *SPD Supplemental EIS* (DOE 2015).

Figure 5. Storage of Surplus Plutonium at the K-Area Complex

3.0 AFFECTED ENVIRONMENT

This chapter discusses the environments that may be affected by the Proposed Action (action alternative) described in Chapter 2. It includes descriptions of (1) the global commons that would be traversed by ships carrying gap material plutonium, (2) the seaport (the Joint Base Charleston-Weapons Station) at which such ships would dock, (3) representative overland transportation routes, and (4) SRS, the location in the United States where the gap material plutonium would await processing and disposition in interim storage.

3.1 Global Commons

The global commons includes the world’s oceans that would be traversed by transport ships. Historically, there are four named oceans: the Atlantic, Pacific, Indian, and Arctic. However, most countries—including the United States—now recognize the Southern (Antarctic) as the fifth ocean (NOS 2015). Ships containing gap material plutonium could traverse the Atlantic, Pacific, Indian, and Southern Oceans. The structural features of the world’s oceans can be divided into the shore, continental shelf, continental slope and rise, basin (or abyssal plain), and mid-oceanic ridges. The shore region is that portion of the land mass that has been modified by oceanic processes. Providing some of the richest fisheries known, the continental shelf extends seaward from the shore and is characterized by a gentle slope of about 1:500. At the end of the shelf, the steepness of the slope first increases to about 1:20 (the continental slope) and then reduces (the continental rise). The ocean basin constitutes about 75 percent of the ocean bottom and ranges in depth from about 9,840 to 19,700 feet (3,000 to 6,000 meters). The deepest areas of the ocean basins are the deep sea trenches, contrasted by the mid-oceanic ridges, which provide relatively high points on the ocean bottom (DOE 1996a).

Seawater within the oceans is a complex solution of minerals, salts, and elements. Naturally occurring radionuclides are present in seawater and marine organisms at concentrations greater than in terrestrial ecosystems (DOE 1996a). The inventory of natural radionuclides in the oceans is about 5×10^{11} curies. Radionuclides have also been released into the oceans from nuclear weapons testing, radioactive waste disposal, and accidents. It has been estimated that the total input of radionuclides from human activities represents somewhat less than 1 percent of the natural radioactive material present in the oceans (DOE 2006a). An earthquake and tsunami occurring in Japan on March 11, 2011, resulted in unprecedented radioactivity releases from the Fukushima Dai-ichi nuclear power plants to the Northwest Pacific Ocean; however, based on a study by the National Academy of Sciences, radiation risks due to these releases are below those generally considered harmful to marine animals and human consumers, and even below those from naturally occurring radionuclides (NAS 2012).

Biologically, the characteristics of ocean organisms dramatically change with depth, largely dependent on the decrease in the amount of light and changes in the wavelength of light penetrating to a given depth. Deep-sea bottom dwellers, or benthos, are highly diverse, with many taxonomic groups represented by more species than most shallow-water communities. Yet the number of individual organisms in a given area decreases in the deep seas and this, together with a tendency for the average size of the organisms to also decrease, results in a dramatic reduction in biomass on the deep ocean floor (DOE 2009a).

Pacific Ocean. The Pacific Ocean is the largest of the world's five oceans (followed by the Atlantic Ocean, Indian Ocean, Southern Ocean, and Arctic Ocean). With an area of 60.1 million square miles (155.6 million square kilometers) and a coastline of 84,297 miles (135,663 kilometers), the Pacific Ocean covers about 28 percent of the global surface; almost equal to the total land area of the world. Surface currents in the northern Pacific are dominated by a clockwise, warm-water gyre (broad circular system of currents) and in the southern Pacific by a counterclockwise, cool-water gyre. In the northern Pacific, sea ice forms in the Bering Sea and Sea of Okhotsk in winter; in the southern Pacific, sea ice from Antarctica reaches its northernmost extent (through the Southern Ocean, reaching to 55 degrees south latitude) in

October. The ocean floor in the eastern Pacific is dominated by the East Pacific Rise, while the western Pacific is dissected by deep trenches, including the Mariana Trench (35,839 feet [10,924 meters] deep), which is the world's deepest. Hazards of the Pacific Ocean include tropical cyclones (typhoons) in southeast and east Asia from May to December; tropical cyclones (hurricanes) south of Mexico from June to October; ships subject to icing in the north Pacific from October to May; and persistent fog in the northern Pacific from June to December. Sea ice can be a hazard to offshore structures, fishing, and navigation, however it is less hazardous than icebergs. The International Maritime Bureau reports the territorial and offshore waters in the South China Sea as high risk for piracy and armed robbery against ships. Endangered marine species include the dugong, sea lion, sea otter, seals, turtles, and whales (CIA 2015a).

Indian Ocean. The Indian Ocean is the third largest of the world's five oceans, with an area of 26.5 million square miles (68.6 million square kilometers) and a coastline of 41,337 miles (66,526 kilometers). Northeast monsoons typically occur from December to April, and southwest monsoons from June to October. Tropical cyclones occur during May to June and October to November in the northern Indian Ocean and January to February in the southern Indian Ocean. Surface currents in the southern Indian Ocean are dominated by a counterclockwise gyre. Low atmospheric pressure over southwest Asia from hot, rising, summer air results in the southwest monsoon and southwest-to-northeast winds and currents, while high pressure over northern Asia from cold, falling, winter air results in the northeast monsoon and northeast-to-southwest winds and currents. The Indian Ocean floor is dominated by the Mid-Indian Ocean Ridge and subdivided by the Southeast Indian Ocean Ridge, Southwest Indian Ocean Ridge, and Ninetyeast Ridge. The lowest point of the seafloor is the Java Trench, which has a depth of 23,812 feet (7,258 meters). Occasional icebergs pose a navigational hazard in southern reaches of the Indian Ocean. The International Maritime Bureau reports the territorial and offshore waters as high risk for piracy and armed robbery against ships, particularly in the Gulf of Aden, along the east coast of Africa, the Bay of Bengal, and the Strait of Malacca. Endangered marine species include the dugong, seals, turtles, and whales (CIA 2015b).

Southern Ocean. The Southern Ocean extends from the coast of Antarctica north to 60 degrees south latitude. As such, the Southern Ocean is the fourth largest of the world's five oceans with a total area of 7.8 million square miles (20.3 million square kilometers) and a coastline of 11,165 miles (17,968 kilometers). Cyclonic storms travel eastward around the continent and frequently are intense because of the temperature contrast between ice and open ocean. The ocean area from about latitude 40 south to the Antarctic Circle has the strongest average winds found anywhere on Earth. In winter, the ocean freezes outward to 65 degrees south latitude in the Pacific sector and 55 degrees south latitude in the Atlantic sector, lowering surface temperatures well below 32 degrees Fahrenheit (0 degrees Celsius). The Southern Ocean is 13,123 to 16,404 feet (4,000 to 5,000 meters) deep over most of its extent, with only limited areas of shallow water. The Antarctic continental shelf is generally narrow and unusually deep, its edge lying at depths of 1,312 to 2,625 feet (400 to 800 meters). The Antarctic Circumpolar Current (13,049 miles [21,000 kilometers] long) is the world’s largest ocean current and moves perpetually eastward; it transports 4,591 million cubic feet (130 million cubic meters) of water per second. The lowest point of the ocean floor is the southern end of the South Sandwich Trench at a depth of 23,737 feet (7,235 meters). Hazards of the Southern Ocean include icebergs with drafts up to several hundred feet; sea ice (generally 1.6 to 3.3 feet [0.5 to 1 meters] thick); high winds and large waves; and ship icing, especially during the period from May to October. The International Whaling Commission prohibits commercial whaling south of 40 degrees south (south of 60 degrees south between 50 degrees and 130 degrees west). The Convention on the Conservation of Antarctic Seals limits sealing; the now-protected fur seal population is making a strong comeback after severe overexploitation in the 18th and 19th centuries. The Convention on the Conservation of Antarctic Marine Living Resources regulates fishing (CIA 2015c).

Atlantic Ocean. The Atlantic Ocean is the second largest of the world's five oceans with an area of 29.7 million square miles (76.8 million square kilometers) and a coastline of 69,510 miles

(111,866 kilometers). Tropical cyclones (hurricanes) develop off the coast of Africa near Cabo Verde and move westward into the Caribbean Sea. Hurricanes can occur from May to December, but are most frequent from August to November. Currents in the Atlantic include a clockwise warm-water gyre in the northern Atlantic, and a counterclockwise warm-water gyre in the southern Atlantic. The ocean floor is dominated by the Mid-Atlantic Ridge, a rugged north-south centerline for the entire Atlantic basin. The lowest point in the Atlantic Ocean is the Milwaukee Deep in the Puerto Rico Trench at a depth of 28,231 feet (8,605 meters). Hazards of the Atlantic Ocean include icebergs, which are common in the Davis Strait, Denmark Strait, and northwestern Atlantic Ocean from February to August; ships subject to icing in extreme northern Atlantic from October to May; persistent fog from May to September; and hurricanes from May to December. The International Maritime Bureau reports the territorial and offshore waters in the Gulf of Guinea off West Africa as high risk for piracy and armed robbery against ships (CIA 2015d). Information regarding endangered species in the Atlantic Ocean is provided below.

The United States has jurisdiction over 125 endangered and threatened marine species, including 38 foreign species[10] (NOAA 2015a). Special consideration was given to the Atlantic Ocean for this EA because all ships that may transport gap material plutonium to the United States would traverse this body of water as they approach the Joint Base Charleston-Weapons Station. The Atlantic Ocean contains some of the world's most productive fisheries, located on the continental shelves and marine ridges. Herring, anchovy, sardine, cod, flounder, perch, and tuna are the most important commercial species (DOE 2003b). Marine species that live in the Atlantic Ocean and are on the Federal endangered species list include whale species (North Atlantic right [*Eubalaena glacialis*], fin [*Balaenoptera physalus*], humpback [*Megaptera novaeangliae*], sperm [*Physeter macrocephalus*], and blue [*Balaenoptera musculus*]); all six species of sea turtles (loggerhead [*Caretta caretta*], leatherback [*Dermochelys coriacea*], green [*Chelonia mydas*], hawksbill [*Eretmochelys imbricate*], Kemp's ridley [*Lepidochelys kempii*], and olive ridley [*Lepidochelys olivacea*]); and the West Indian manatee (*Trichechus manatus*). Most of these marine species have the potential to occur around the Joint Base Charleston-Weapons Station, the U.S. seaport evaluated in this EA; two have established critical habitats.[11]

Effective August 11, 2014, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service designated critical habitat for the loggerhead sea turtle within the Northwest Atlantic Ocean Distinct Population Segment and nesting beaches off the coast of North Carolina, South Carolina (including Charleston beaches), Georgia, Florida, Alabama, and Mississippi (79 FR 39855, 79 FR 39755). Mating season occurs in late March to early June, followed by nesting season between late April and early September. After about a 2-month incubation period, hatching occurs between late June and mid-November. The greatest threat to the loggerhead sea turtle is incidental capture during fishing (NOAA 2014).

The North Atlantic right whale is protected under the International Convention of the Regulation of Whaling, which was established to provide proper and effective conservation and development of all whale species. The North Atlantic right whale is also designated a "depleted" species under the Marine Mammal Protection Act. There are currently about 450 right whales in the North Atlantic; ship strikes and entanglement in fishing gear are the most common human cause of severe injury or death. NMFS designated critical habitat for the North Atlantic right whale in areas off the coasts of Massachusetts, Georgia, and Florida (59 FR 28805). On February 20, 2015, NMFS proposed to replace the designated

[10] *Foreign species refers to species that occur exclusively in foreign waters and the global commons. Under the Endangered Species Act, all endangered and threatened species are listed, regardless of where they are found.*

[11] *Critical habitat is identified as habitat essential to the conservation of an endangered or threatened species. Listed species and their habitat are protected under the Endangered Species Act, which forbids all actions that result in illegal "take" (Section 19; also Title 16, United Stated Code, Section 1531 [16 U.S.C. 1531]), including injury through habitat alteration or destruction. The Act also prohibits Federal actions that may result in adverse modification of habitat (16 U.S.C. 1536(a)). Critical habitat for the North Atlantic right whale and loggerhead sea turtle exists near Joint Base Charleston-Weapons Station.*

critical habitat areas with two larger areas (80 FR 9314). The proposed areas are: (1) off the coasts of Maine to Massachusetts and (2) off the southeast coast from part of North Carolina through part of Florida (including the entire coasts of Georgia and South Carolina). In the southeast coastal waters, calving occurs from December through March (NOAA 2015b).

The Maritime Safety Committee of the International Maritime Organization adopted a mandatory ship reporting system that became effective in 1999. This system requires ships to report whale sightings in the major shipping lanes from November 15 to April 15 off the southeast coast of the United States so as to include the calving season for the right whales in this area. The system operates throughout the year on the northeast coast, where the whales have been sighted year-round (IMO 1998). Consistent with the International Maritime Organization requirement, before entering an area routinely inhabited by right whales, the U.S. Coast Guard requires any ship exceeding 270 gross metric tons (300 tons) to contact the Mandatory Ship Reporting System operated by the U.S. Coast Guard and report its name, call sign, location, course, speed, destination, and route. This system reduces the likelihood of a ship striking a right whale by providing ships in the area with data on the most recent whale sightings and whale avoidance procedures (DOE 2006a). To further reduce the likelihood of ships colliding with right whales, on October 10, 2008, NMFS established regulations implementing speed restrictions for vessels. All vessels 65 feet (19.8 meters) or longer must travel at 10 knots or less in this area during calving season to reduce the threat of ship collisions (73 FR 60173). These regulations apply within designated areas off the east coast of the United States at certain times of the year; for the areas off the coasts of Georgia, North Carolina, and South Carolina, the restrictions apply from certain dates in November through certain dates in April (50 CFR 224.105).[12, 13]

A database for known large whale ship strikes worldwide was developed based on an initial public request for information from NMFS that includes records of ship strikes drawn from ship reports, marine mammal stranding reports, and NOAA Office of Law Enforcement reports. Following receipt of the initial set of data, additional ship strike records were sought through personal communications and a review of published literature on ship strikes. The purpose of collecting this data was to compile ship strike to large whale reports into a comprehensive database to demonstrate that collisions between whales and ships are a worldwide phenomenon. Ship strikes were reported as early as 1885 (Jensen and Silber 2004). As many as 292 large whale ship strikes were reported through 2002.[14] Between 1990 and 2002, the average number of large whale ship strikes reported per year was approximately 15. In this database, most ship strikes occurred in the North and Mid-Atlantic Ocean and most frequently on the U.S. east coast. The highest occurrence of ship strikes recorded from 1990 through 2002 impacted the humpback whale (45 reports) followed by the fin whale (44 reports), and the North Atlantic right whale (25 reports). Of the 292 reports, 68 percent were fatal; 16 percent resulted in injury to the mammal; and 16 percent were undetermined (Jensen and Silber 2004).

3.2 U.S. Seaport of Entry – Joint Base Charleston-Weapons Station

The Joint Base Charleston-Weapons Station, South Carolina, was evaluated in this EA as the seaport of entry to the United States. The locations of the Joint Base Charleston-Weapons Station and SRS are shown in Figure 1. The natural background radiation dose to an average individual in the population near

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[12] Regulations restricting ship speed in designated areas off the east coast do not apply to "U.S. vessels owned or operated by, or under contract to, the Federal Government."

[13] The section of the CFR limiting vessel speed in designated areas off the east coast during certain times of the year had a sunset clause of December 8, 2013. Effective December 6, 2013, NMFS removed the sunset clause, such that the speed restrictions will remain in force until circumstances warrant further changes (78 FR 73726).

[14] Many ship strikes go undetected or unreported due to strikes occurring in remote areas or struck whales drifting out to sea without detection; therefore, data may only represent a fraction of occurrences. The data reported illustrate the scope and magnitude of the threat of ship strikes to endangered large whale species. Also note that this data reflects ship strikes before any Federal vessel speed restrictions were implemented.

this port of entry was assumed to be the same as that to an average individual in the United States (approximately 311 millirem per year) (NCRP 2009).[15]

The Joint Base Charleston-Weapons Station is the section of Joint Base Charleston that was previously identified as the Charleston Naval Weapons Station. In October 2010, the Charleston Naval Weapons Station and Charleston Air Force Base were combined to become Joint Base Charleston, as recommended by the 2005 Base Closure and Realignment Commission, to optimize the delivery of installation support across the services (Military OneSource 2015). The Joint Base Charleston-Weapons Station is approximately 25 miles (40 kilometers) north of metropolitan Charleston. The principal shipping terminals at the Joint Base Charleston-Weapons Station are located along the west bank of the Cooper River, north of the city of North Charleston and about 19 miles (31 kilometers) upriver from the Atlantic Ocean. Charleston is the largest port city in South Carolina, and the greater Charleston area is a major seaport on the east coast of the United States. The Charleston area highway system includes Interstates 26 and 526 and U.S. Routes 17 and 52. Major interstate and Federal highways in the Charleston area are supplemented by interconnecting primary state highways that provide access to the Joint Base Charleston-Weapons Station (DOE 2009a). The region around Charleston and the Joint Base Charleston-Weapons Station is shown on **Figure 6**.

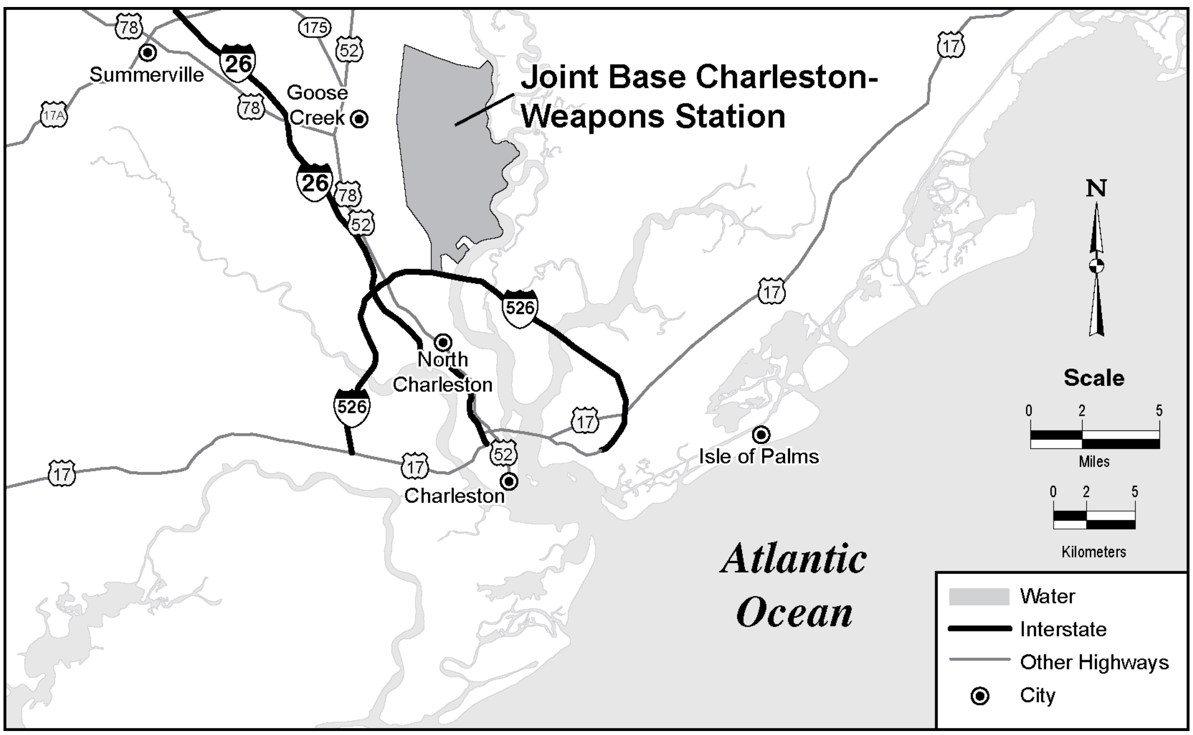

Figure 6. Region Around the Joint Base Charleston-Weapons Station

The Joint Base Charleston-Weapons Station encompasses over 17,000 acres (6,900 hectares) of land, including 10,000 acres (4,000 hectares) of forest and wetlands, 16 miles (26 kilometers) of waterfront, four deep-water piers (including piers capable of unloading transport containers directly from ships), 38 miles (61 kilometers) of railroad and 292 miles (470 kilometers) of road. The base provides ordnance

[15] The average American receives a total of approximately 620 millirem per year from all radiation sources, both natural and man-made, of which approximately 311 millirem per year are from natural sources. Radiation sources include (1) cosmic radiation, (2) terrestrial radiation, (3) internal radiation, (4) consumer products, (5) medical diagnosis and therapy, and (6) other sources (NCRP 2009).

storage capability and other material supply and support functions and has the ability to load and unload cargo directly between vehicles and ships (MARCOA Publishing, Inc. 2015).

According to the 2010 census, approximately 773,000 people lived within 50 miles (80 kilometers) of the docks at Joint Base Charleston-Weapons Station; approximately 737,000 people lived within 50 miles (80 kilometers) of the Charleston harbor, through which vessels pass to enter the Cooper River. The Joint Base Charleston-Weapons Station has a total of 1,017 family housing units located in two neighborhoods, MenRiv Park and Eastside. Approximately 11,500 military and contract employees, as well as 3,600 family members, live on the Joint Base Charleston-Weapons Station (MARCOA Publishing, Inc. 2015; Military OneSource 2015). The population in the area is growing, and the projected increase in the population to the year 2020 is considered in Chapter 4 of this EA. The natural background radiation dose to an average individual in the population near the Joint Base Charleston-Weapons Station was assumed to be the same as that to an average individual in the United States (approximately 311 millirem per year) (NCRP 2009).

The Joint Base Charleston-Weapons Station offers a secure site that is conducive to transferring gap material plutonium from ships to transport vehicles. In addition to the restricted access, there are secure parking areas where the specially designed transporters can be staged prior to driving to the wharf for cargo loading (DOE 2003b).

The Joint Base Charleston-Weapons Station supports M3 and routinely receives marine shipments of SNF. Since the program was established in 1996, over 60 SNF shipments have been received in the United States; most of these shipments were received at the Joint Base Charleston-Weapons Station (NNSA 2013). The SNF casks have been offloaded from ships to trucks or rail cars and transported to DOE facilities (DOE 2009a). In recent years, containers with gap material plutonium have also been received at the Joint Base Charleston-Weapons Station.

3.3 Overland Transportation Route

To assess incident-free and transportation accident impacts, route characteristics were determined for a representative overland shipping route to SRS from the Joint Base Charleston-Weapons Station, South Carolina.

The overland truck route would be selected consistent with current routing practices and applicable routing regulations and guidelines. The route used for risk assessment purposes is representative of the route that would be used to transport the gap material plutonium, but may not be the actual route taken. A specific route would be selected at the time of shipment, with consideration given to weather conditions, road and bridge conditions and closures, traffic, and security. The analyzed distance to SRS from the Joint Base Charleston-Weapons Station is 134 miles (216 kilometers). Route characteristics used in the analysis are given in Chapter 4, Section 4.3.

3.4 Storage, Processing, and Disposition Location – Savannah River Site

SRS. SRS is a DOE site located in southwestern South Carolina and occupies an area of 198,344 acres (80,268 hectares) in Aiken, Barnwell, and Allendale Counties (DOE 2015). It is bordered by the Savannah River to the southwest. The site is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 12 miles (19 kilometers) south of Aiken, South Carolina, the nearest major population centers. Based on the 2010 census, the population within 50 miles (80 kilometers) of SRS is about 781,060 (SRNS 2014). The population projected to year 2020 is discussed in Chapter 4 of this EA. The region around SRS is shown in Figure 1.

The 19,000 acres (7,700 hectares) of developed land (about 10 percent of the total land at SRS) includes five non-operational nuclear production reactors; two chemical separations facilities (H-Canyon, which is operational, and F-Canyon, which was deactivated in 2006); waste treatment, storage, and disposal facilities (including the F- and H-Area tank farms and the Defense Waste Processing Facility in S-Area);

and major supporting facilities. New facilities under construction include the Salt Waste Processing Facility in S-Area, the MOX Fuel Fabrication Facility in F-Area, and the Waste Solidification Building in F-Area (DOE 2011a). A program to decommission and demolish excess contaminated facilities is under way (SRNS 2014). A map of SRS is included as **Figure 7**.

K-Area is a 3,558-acre (1,440-hectare) area situated near the center of SRS, approximately 5.5 miles (8.9 kilometers) from the site boundary. The area is one of five SRS reactor areas that had the original mission of producing material for the U.S. nuclear weapons program; however, the K-Area production reactor was shut down in 1996 and subsequently deactivated. Structures and security at the KAC have been upgraded in recent years to convert it to a plutonium storage and surveillance facility which entails: the Material Storage Area for long-term storage; an area for interim storage,; and an area for the K-Area Interim Surveillance (KIS) Program (DOE 2015), which provides the capability for destructive and nondestructive examination of stored plutonium materials. The Material Storage Area is the principal SRS facility for long-term plutonium storage; to be placed into long-term storage, the plutonium must be stabilized and enclosed in welded containers, in compliance with DOE-STD-3013 (DOE 2012a), which are then placed in an approved Type B transportation package (e.g., Model 9975 packaging).

Another location in the KAC provides interim storage for plutonium. Plutonium stored in this area meets the stabilization requirements of DOE-STD-3013 (DOE 2012a), but is placed in containers intended for interim storage (the containers have a closure that does not require welding) that are then nested within approved Type B packages. This storage location contains multiple storage positions (DOE 2007c).

Within the existing storage locations, additional plutonium storage space has been developed in the KAC to enable acceptance and storage of plutonium from other DOE sites. Development of this space was implemented independently of the proposal to receive 900 kilograms (1,984 pounds) of gap material plutonium, but could provide another location at which the gap plutonium material could be stored if needed in the interim, pending disposition.

Physical Security. The SRS physical security protection strategy is based on a graded and layered approach supported by an armed guard force that is trained to deter, detect, and neutralize adversary activities and is backed by Federal, state, and local law enforcement agencies. SRS uses staffed and automated access-control systems to limit entry into areas and/or facilities to authorized individuals. Automated access-control systems include control booths, turnstiles, doors, and gates. Barriers, electronic surveillance systems, and intrusion detection systems form a comprehensive network of monitored alarms. Random patrols and visual observation are also used to deter and detect intrusions.

Roadways. Vehicular access to SRS is provided from South Carolina State Highways 19, 64, 125, 781, and U.S. Highway 278. The nearest interstate highway is Interstate 20, approximately 19 miles (31 kilometers) north-northwest of the site. Within SRS, there are approximately 130 miles (209 kilometers) of primary roads and 1,100 miles (1,800 kilometers) of secondary roads (DOE 2015).

Human Health. Radionuclides and hazardous chemicals can cause both cancer and noncancerous health effects. Releases of radionuclides and chemicals to the onsite and offsite environments from SRS operations are sources of potential exposures to SRS workers and to persons living in the vicinity of SRS. The radiological and chemical discharges to the air and water in 2013 from SRS operations resulted in minimal impacts to the offsite public and surrounding environment. The site's radioactive and chemical discharges to air and water were well below regulatory standards for environmental and public health protection, and the air and water quality met applicable requirements (SRNS 2014).

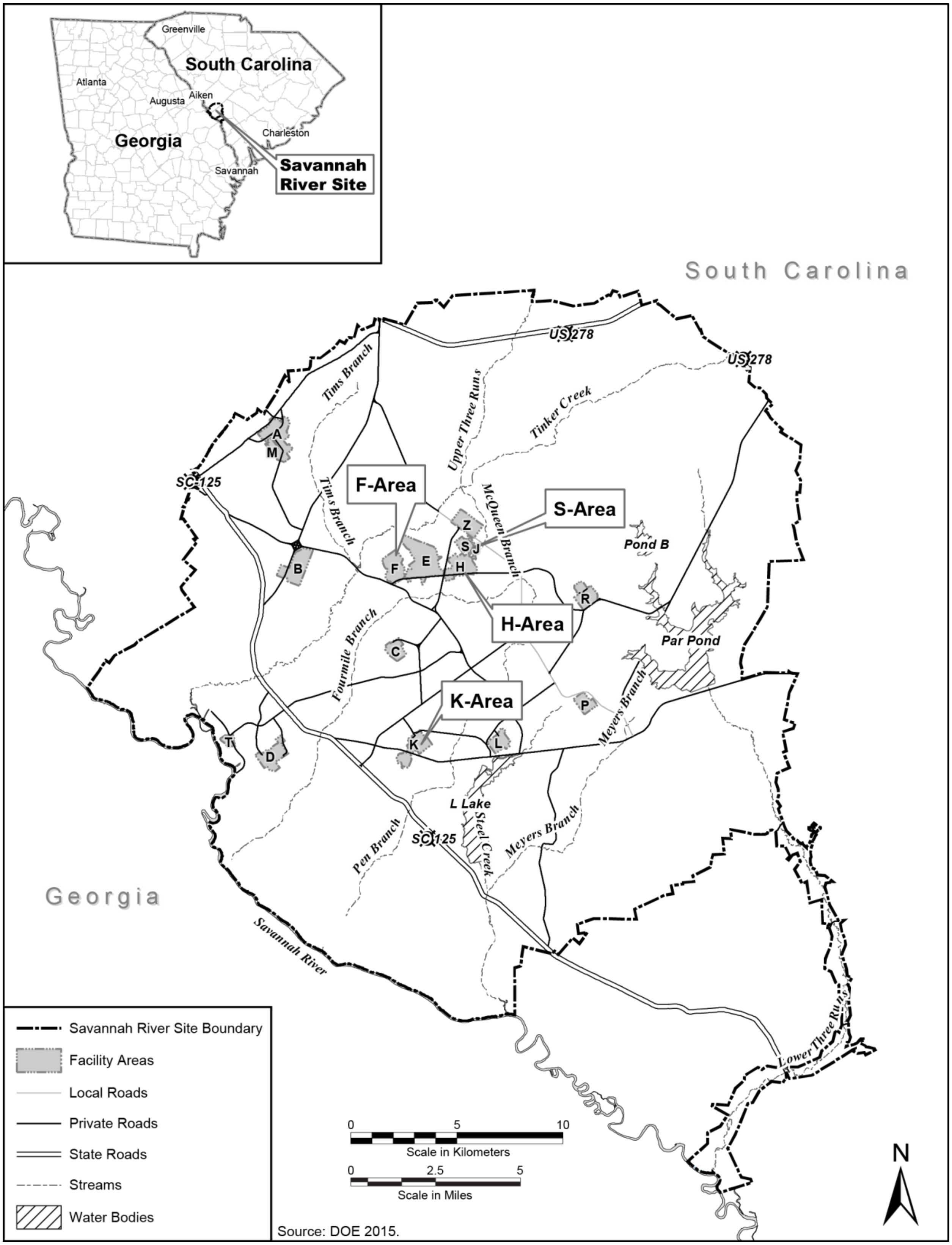

Figure 7. Savannah River Site

Radionuclides. Radiation doses to a hypothetical offsite member of the public (the maximally exposed individual [MEI]) and to the population residing within 50 miles (80 kilometers) of SRS are calculated annually. The radiation dose to the offsite MEI from SRS operations during 2013 was 0.10 millirem. Atmospheric releases contributed 0.05 millirem; drinking water contributed 0.02 millirem; and ingestion of fish contributed 0.03 millirem (SRNS 2014). For comparison, the average annual dose received by an individual in the United States (assumed to apply to the SRS vicinity and unrelated to SRS operations) is about 311 millirem from natural background radiation and about 620 millirem from all sources, including medical sources (NCRP 2009). The air pathway dose limit for exposure of the public from DOE operations is 10 millirem per year, while the public all-pathways dose standard for DOE operations is 100 millirem per year, with an additional requirement to reduce doses to members of the public to levels as low as reasonably achievable (ALARA) (DOE 2011b). The population within 50 miles (80 kilometers) of SRS received a collective dose of 3.4 person-rem from SRS operations in 2013; 2.2 person-rem resulted from atmospheric releases and 1.2 person-rem from liquid releases (not including irrigation pathways) (SRNS 2014).

SRS workers receive the same dose as the general public from background radiation, but also receive a dose from working in facilities with nuclear materials. SRS collected records for 5,833 individual workers in 2013, of which 1,471 workers received a measurable dose. In 2013, the average measurable dose to an SRS radiation worker was 60 millirem, which was within the DOE exposure limit and goal. The total workforce at SRS accrued a collective dose over this period of 88.5 person-rem (DOE 2014a). The DOE limit for radiological dose to an individual worker is 5 rem per year (10 CFR Part 835); however, DOE's goal is to maintain radiological exposures ALARA. DOE therefore calls for facility managers to establish an administrative control level below 2 rem per year (DOE 2009b); DOE contractors must make reasonable attempts to maintain worker doses below this level. Actions to maintain doses ALARA include worker training, assuring that protective equipment is worn, monitoring, and setting limits on the amount of time workers remain in specific radiation areas.

Hazardous chemicals. The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media, through which people may come in contact with hazardous chemicals (e.g., soil, surface water during swimming, or food through ingestion). Therefore, monitoring of air and water and other environmental media is performed for potential contaminants.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., from the National Emission Standards for Hazardous Air Pollutants and National Pollutant Discharge Elimination System [NPDES] permits) contribute to minimizing health impacts on the public. The effectiveness of these controls is verified through the use of environmental monitoring information and inspection of mitigation measures. Health impacts on the public may occur through inhalation of air containing hazardous chemicals released to the atmosphere during normal SRS operations. Risks to public health from other pathways, such as ingestion of contaminated drinking water or direct exposure, are lower than those from inhalation (DOE 2015).

The most substantial nonradiological air emissions at SRS include sulfur dioxide, carbon monoxide, oxides of nitrogen, particulate matter smaller than 10 micrometers (PM_{10}) and smaller than 2.5 micrometers ($PM_{2.5}$), volatile organic compounds, and toxic and hazardous air pollutants. A review of the calculated air emissions in 2013 for sources at SRS showed that concentration levels for each of the above pollutants were less than applicable standards or guidelines (SRNS 2014).

The South Carolina Department of Health and Environmental Control (SCDHEC) is the regulatory authority for the physical properties and concentrations of chemicals and metals in SRS effluents under the NPDES program. In 2013, SRS discharged water into onsite streams and the Savannah River under five NPDES permits: two for industrial wastewater, two for stormwater runoff, and one for general utility water. Applications of dewatered sludge and related sanitary wastewater treatment facility sampling are covered by a no-discharge land applications permit. The stormwater runoff permits require the implementation and maintenance of approved best management practices to assure that SRS stormwater discharges do not impair the water quality of receiving water resources. Industrial wastewater monitoring results are reported to SCDHEC through monthly discharge monitoring reports. Out of 3,914 samples collected in 2013, SRS had three NPDES permit limit exceptions. SRS received two Notices of Violation, one for an exceedance of total suspended solids limits and one for toxicity (SRNS 2014).

During normal operations, SRS workers may be exposed to hazardous materials by inhaling contaminants in the workplace atmosphere or by direct contact. The potential for health impacts varies among facilities and workers. Workers are protected from workplace hazards through appropriate training, protective equipment, monitoring, materials substitution, and engineering and management controls. They are also protected by adherence to the Occupational Safety and Health Administration Process Safety Management and workplace limits, as well as U.S. Environmental Protection Agency and state standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring reflecting the frequencies and quantities of chemicals used in the operational processes ensures these standards are not exceeded. DOE also requires that conditions in the workplace be as free as possible from recognized hazards that cause, or are likely to cause, illness or physical harm (DOE 2015).

4.0 ANALYSIS AND DISCUSSION

This chapter analyzes the environmental consequences of alternatives for transporting gap material plutonium from foreign countries to the United States, including impacts under incident-free and accident conditions from ship transport to a United States seaport (the Joint Base Charleston-Weapons Station), with subsequent ground transport to SRS. It also addresses impacts from receipt of gap material plutonium at SRS; gap material plutonium processing at SRS; plutonium storage and disposition at SRS; and intentional destructive acts, as well as cumulative impacts.

Consistent with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, this EA does not address impacts from activities involving gap material plutonium within the host countries. Countries shipping gap material plutonium would be responsible for complying with applicable laws and regulations associated with activities occurring within their borders.

Under the No Action Alternative, the 900 kilograms (1,984 pounds) of gap material plutonium would not be shipped to the United States and would not be processed or eventually dispositioned at SRS. Therefore, there would be no impacts to the global commons, at ports of entry into the United States, or at SRS from activities related to the 900 kilograms (1,984 pounds) of gap material plutonium.

Gap material plutonium could represent a range of characteristics with respect to the relative quantities of plutonium isotopes and americium. Primarily because of an increase in americium-241 over time that results from the radioactive decay of plutonium, 50-year-old plutonium would present the largest health risk and, therefore, was conservatively used for purposes of analysis in this EA. The radionuclide distribution and specific activities of the 50-year-old fuel-grade plutonium used for analysis are presented in **Table 1**.

Table 1. Assumed Composition of Gap Material Plutonium

Radionuclide	***Mass Fraction (grams per gram of plutonium)***	***Activity (curies per gram of plutonium)***
Plutonium-238	0.000697	0.0118
Plutonium-239	0.805	0.0499
Plutonium-240	0.185	0.0425
Plutonium-241	0.00149	0.148
Plutonium-242	0.00506	0.0000198
Total Plutonium	1.0	0.252
Americium-241	0.0322	0.110
Plutonium + Americium	1.032	0.362

Source: DOE 2005c. The mass fractions in the reference are for 30-year-old fuel-grade plutonium; for this table, the mass fractions were decayed to represent 50-year-old plutonium.

The actual radionuclide distribution of gap material plutonium would be evaluated to ensure it would be compatible with the safety authorization bases for the transportation packages and SRS facilities that would receive and store the materials. The Model 9975 package is approved by the U.S. Department of Transportation for plutonium transportation, but the Model 9977 package is not yet approved. In order for the Model 9977 package to be used for plutonium transportation, it would need to be certified by the U.S. Department of Transportation.

The 900 kilograms (1,984 pounds) of plutonium evaluated in this EA were assumed to be transported from seven countries, with the quantity of plutonium transported from any single country ranging from a few to several hundred kilograms, and the number of packages from any single country ranging from 1 to over 100. For purposes of analysis, this EA evaluates the potential impacts associated with three maximum expected shipments of up to 350 kilograms (770 pounds) of plutonium and up to nine representative shipments of up to 50 kilograms (110 pounds) of plutonium.

In order to conservatively estimate the numbers of packages that would be needed to transport all of the gap material plutonium, individual packages of plutonium were assumed to contain less material than authorized. This assumption resulted in a larger number of packages and, therefore, a conservative estimate of the impacts of package transport under normal operations. The packaging to be used and the quantity of plutonium actually placed within a package would depend on operational factors such as the total quantity of shipped material, the isotopic distribution of the plutonium, and the presence of impurities. Depending on these operational factors, the quantity of plutonium shipped within a given package could range from levels less than half the authorized capacity to levels approaching the maximum capacity. Accordingly, the number of packages per maximum expected shipment could theoretically range from 80 to 160 Model 9975 packages filled to capacity or halfway, respectively, requiring four to seven ISO containers if only Model 9975 packages were used. Use of Model 9977 packages exclusively could result in shipment of 40 to 80 packages, requiring two to four ISO containers. However, it should be noted that neither the lower nor higher values in these ranges would likely represent any given shipment. Representative shipments, with a theoretical range between 12 and 23 packages, could fit within a single ISO container, regardless of the degree to which the packages are filled.

Consistent with previous analysis (DOE 2010a), it was assumed for purposes of analysis that the average plutonium content within a Model 9975 or 9977 package would be about 70 percent of authorized capacity. That is, each Model 9975 package would be loaded with about 3.1 kilograms (6.8 pounds) of plutonium, and each 9977 package would be loaded with about 6.2 kilograms (13.7 pounds) of plutonium. Given these assumptions, the maximum expected (350-kilogram [770-pound]) shipment using Model 9975 packaging would comprise up to 112 packages, which would require 5 ISO containers. The same shipment using Model 9977 packaging would comprise up to 56 packages, which would require 3 ISO containers. A representative (50-kilogram [110-pound]) shipment using Model 9975 packaging would comprise up to 16 packages, while the same shipment in Model 9977 packaging would comprise up to 8 packages.

Assuming all packages are filled to about 70 percent of authorized capacity, the maximum numbers of packages that would be transported in a single shipment are listed in **Table 2**; most shipments are likely to contain fewer packages than the maximum number shown. Shipment of all 900 kilograms (1,984 pounds) of gap material plutonium could require up to 291 Model 9975 packages or 146 Model 9977 packages. Individual shipments could consist of all Model 9975 packages, all Model 9977 packages, or a mix of Model 9975 and 9977 packages.

Table 2. Maximum Number of Packages for Single Gap Material Plutonium Shipments [a]

Shipment Scenario	*Shipping Packaging*	*Number of Packages*	*Number of Containers per Package [b]*
Maximum Expected Shipment (350 kilograms)	Model 9975	112	1
	Model 9977	56	2
Representative Shipment (50 kilograms)	Model 9975	16	1
	Model 9977	8	2

[a] Maximum number of packages projected in a single shipment, assuming packages are loaded to 70 percent of capacity.
[b] Refers to the number of containers containing plutonium stabilized in the accordance with the requirements of DOE-STD-3013 (DOE 2012a) within each transport package.

As discussed in Chapter 1, Section 1.5.2, of the *SPD Supplemental EIS* (DOE 2015), the 13.1 metric tons (14.4 tons) of surplus plutonium analyzed in the EIS included 0.9 metric tons (0.99 tons) of excess capacity to allow for the possibility that DOE may identify additional quantities of surplus plutonium that could be processed for disposition through the facilities and capabilities analyzed in the *SPD Supplemental EIS*. Therefore, the impacts from storage and disposition activities for the 900 kilograms (1,984 pounds) of gap material plutonium analyzed in this EA have already been evaluated in the *SPD Supplemental EIS*, and no further NEPA evaluation is required for storage and disposition.

4.1 Impacts on the Global Commons

4.1.1 Human Health Impacts from Ship Transport under Normal Operations

This section addresses incident-free human health impacts from shipping gap material plutonium across the global commons. The general public would not receive a radiation dose from incident-free transport of gap material plutonium by ocean vessel; however, radiological impacts would be experienced by the crews of the ships carrying the gap material plutonium from exposure to radiation during loading and off-loading the ISO containers and during daily inspections of cargo. The radiological impacts from cargo inspections would depend on the durations of the voyages. As discussed in Chapter 2, Section 2.4.3, a 10-day voyage was assumed for a shipment from North America, a 22-day voyage for a shipment from Europe, and a 60-day voyage for a shipment from countries located elsewhere in the world.

This EA analyzes three maximum expected and nine representative shipments of gap material plutonium to a United States seaport (the Joint Base Charleston-Weapons Station). This breakdown was selected in order to obtain a thorough analysis that covers a wide range of potential shipment scenarios. It should be noted that the quantity of gap material plutonium included in this analysis exceeds the total of 900 kilograms (1,984 pounds) proposed to be transported; however, shipment of more than 900 kilograms (1,984 pounds) is not proposed. Each of the maximum expected shipments analyzed in this EA would transport from three to five ISO containers, each containing up to 25 packages of plutonium, while each of the representative shipments would transport a single ISO container containing up to 16 packages of plutonium.

As addressed in Chapter 2, Section 2.4.2, operational procedures for loading and unloading ISO containers containing gap material plutonium, and for cargo inspections during transport, would be the same as those in the *FRR SNF EIS* (DOE 1996a) for ocean shipment of FRR SNF. Consistent with the *FRR SNF EIS*, the assumed crew duties are summarized in **Table 3**. As shown, a Chief Mate, Mate on Watch, Bosun, and two seamen were assumed to be exposed to radiation while loading the ISO containers onto the ship and unloading the ISO containers at the Joint Base Charleston-Weapons Station. Consistent with the *FRR SNF EIS*, when loading or unloading ISO containers for maximum expected shipments, the crew members were assumed to be exposed to other ISO containers in the ship's hold. Doses received by each crew member were assumed to be the same as those evaluated in the *FRR SNF EIS* because the same loading and unloading operations would be performed, and the radiation levels for the ISO containers were assumed to be the same.

Table 3. Assumed Crew Duties for Ocean Transport of Gap Material Plutonium

Crew Member	*Ship Loading Operations*	*Daily Cargo Inspections*	*Ship Unloading Operations*
Chief Mate	X	X	X
Mate on Watch	X		X
Bosun	X	X	X
Seaman (2)	X		X
Engineer		X	

The Chief Mate, Bosun, and Engineer were all assumed to participate in daily inspections of the cargo; each of these crew members was assumed to perform one cargo inspection per day during each assumed 8-hour shift (three inspections total per day). For maximum expected shipments, it was assumed that crew members performing inspections on one ISO container would be exposed to radiation from other stowed ISO containers, and that the stowed ISO containers would be separated by a minimum distance of 6 meters (20 feet), based on requirements (including criticality safety requirements) for safe transport of radioactive material (IAEA 2012). Each inspection was assumed to require 10 minutes.

The estimated doses per shipment to individual and all involved crew members are shown for three voyage lengths in **Table 4** for a single representative shipment, a single maximum expected shipment assuming three ISO containers per voyage and a single maximum expected shipment assuming five ISO containers per voyage. There is only a small difference in radiation dose for a representative shipment assuming use of 9975 or 9977 packaging. The maximum expected shipment using three ISO containers per voyage corresponds to use of all 9977 packaging, while the maximum expected shipment using five ISO containers per voyage corresponds to use of all 9975 packaging. It was assumed that there would be one maximum expected shipment from the Pacific Rim (60-day ocean transit) and two from Europe (22-day ocean transit). It was also assumed that there would be five representative shipments from Europe (22-day ocean transit), one from the Far East (60-day ocean transit), two from anywhere in the world (60-day ocean transit), and one from North America (10-day ocean transit). Given these assumptions, the total crew dose for 12 shipments of gap material plutonium would range from 2.8 to 4.1 person-rem, with no associated latent cancer fatalities (LCFs) (calculated value: 0.002).

Latent Cancer Fatalities

The most significant effects of radiation exposure are induced cancer fatalities, called latent cancer fatalities (LCFs) because the onset of cancer generally occurs many years after the radiation dose is received. In this EA, LCFs are used to measure the estimated risk due to radiation exposure and evaluate impacts. A factor of 0.0006 LCFs per rem or person-rem is used to calculate the risk associated with individual radiation doses; for acute individual doses above 20 rem, the risk factor is doubled (NCRP 1993). Other effects of exposure to low doses of radiation include mutagenic effects that can be passed to subsequent generations; the estimated risk from effects that can be inherited are about 3 to 4 percent of the nominal fatal cancer risk (Valentin 2007).

The results in Table 4 show that, for a single voyage with a single ISO container from either Europe or anywhere in the world, no crew member is expected to receive a dose exceeding 100 millirem in a single year. Given a long voyage containing two ISO containers of plutonium, however, doses to individual crew members could be larger than 100 millirem. Doses larger than 100 millirem could also be accrued by individual crew members, assuming a voyage involving three to five ISO containers. In addition, doses to individual crew members could be larger than 100 millirem a year if the same crew members were involved in multiple shipments in a single year, depending on the lengths of the voyages and the crew members' activities.

Dose rates at the surfaces of the ISO containers for actual shipments are expected to be smaller than those assumed for analysis (i.e., 10 millirem per hour at 2 meters [6.6 feet] from the ISO container surface for exclusive-use shipments).[16] It is difficult to quantify this reduction because of the possible variations in gap material plutonium composition, the quantities of plutonium per shipment, and the type and number of packages per shipment. Calculations performed as part of the *Gap Material Plutonium EA and FONSI* (DOE 2010a), however, indicate that, because of the shielding material included with Model 9975

[16] *Because the surface dose rate for all ISO containers was conservatively assumed to be at regulatory limits, the same surface dose rate was assumed for ISO containers in representative shipments as for ISO containers in maximum expected shipments. This is conservative because the ISO containers in representative shipments are expected to generally contain much less plutonium than the ISO containers in maximum expected shipments.*

packaging, the dose rate at 1 meter (3.3 feet) from a Model 9975 package filled with 50-year old reactor-grade plutonium could actually be less than 1 millirem per hour. Shielding calculations performed as part of certification of the Model 9977 package resulted in surface dose estimates that are less than half of those assumed for this EA (DOE 2012c).

Table 4. Per Shipment Crew Doses and Risks for Transporting Gap Material Plutonium via Chartered Vessel

Voyage Length	Maximum Dose (millirem) [a] and LCF Risk [b] (in parentheses)					
	Chief Mate	*Mate on Watch*	*Bosun*	*Seaman* [c]	*Engineer*	*Total*
Representative Shipment – 1 ISO Container per Voyage [d]						
10 Days	15 (9×10^{-6})	4.0 (2×10^{-6})	15 (9×10^{-6})	7.2 (4×10^{-6})	8.0 (2×10^{-6})	57 (3×10^{-5})
22 Days	25 (1×10^{-5})	4.0 (2×10^{-6})	25 (1×10^{-5})	7.2 (4×10^{-6})	18 (1×10^{-5})	86 (5×10^{-5})
60 Days	56 (3×10^{-5})	4.0 (2×10^{-6})	55 (3×10^{-5})	7.2 (4×10^{-6})	48 (3×10^{-5})	180 (1×10^{-4})
Maximum Shipment – 3 ISO Containers per Voyage						
22 Days	130 (8×10^{-5})	12 (7×10^{-6})	130 (8×10^{-5})	22 (1×10^{-5})	100 (6×10^{-5})	410 (2×10^{-4})
60 Days	300 (2×10^{-4})	12 (7×10^{-6})	300 (2×10^{-4})	22 (1×10^{-5})	280 (2×10^{-4})	950 (6×10^{-4})
Maximum Shipment – 5 ISO Containers per Voyage						
22 Days	220 (1×10^{-4})	20 (1×10^{-5})	220 (1×10^{-4})	36 (2×10^{-5})	180 (1×10^{-4})	710 (4×10^{-4})
60 Days	530 (3×10^{-4})	20 (1×10^{-5})	530 (3×10^{-4})	36 (2×10^{-5})	500 (3×10^{-4})	1,700 (1×10^{-3})

ISO = International Organization for Standardization, LCF = latent cancer fatality.

[a] Maximum doses were determined assuming that the radiation levels near the ISO containers correspond to regulatory limits (10 millirem per hour at 2 meters [6.6 feet] from the ISO container surface for exclusive-use shipments).

[b] Risks were determined assuming a factor of 0.0006 LCFs per rem and are presented using one significant figure (DOE 2003a).

[c] For each voyage, two seamen would receive radiation doses from the plutonium cargo; the doses presented are per seaman.

[d] Doses and risks are for the package (Model 9975 or 9977) resulting in the largest dose; there are negligible differences in doses between the two packages.

In addition, because the vessel used for plutonium shipment will be exclusive-use, ISO container loading and daily inspections would occur in accordance with radiation protection principles. For shipments containing multiple ISO containers, doses received by crew members performing at-sea inspections of ISO containers could be reduced by spacing the ISO containers apart from one another, consistent with the available stowage space on the ship, or by shielding with other cargo. (Shielding with other cargo would be difficult to predict and is conservatively not considered in this EA.) Whether shipments contain one or multiple ISO containers, radiation doses associated with at-sea inspections can be reduced by minimizing the amount of time required for inspections and by maintaining an appropriate distance from the ISO containers, consistent with inspection requirements.

Notwithstanding these caveats, it is conceivable, as indicated in Table 4, that some members of the crew that are not radiation workers could receive a radiation dose exceeding 100 millirem in a year. NNSA would extend the program described in the mitigation action plan for FRR SNF (DOE 1996c)[17] or implement a similar program for gap material plutonium shipments (see Section 4.9).

[17] Under the mitigation program applied to shipments of FRR SNF (DOE 1996c), NNSA requires that its shipping contractor obtain radiation surveys of FRR SNF casks before shipment, and use these data to ensure that the estimated dose to any crew member does not exceed 100 millirem per year. NNSA also maintains a database of the actual radiation surveys for each cask and shipment, and includes clauses in its shipping contracts to minimize the likelihood that any member of a ship's crew would be exposed to more than 100 millirem during a single year.

4.1.2 Human Health Impacts from Potential Shipping Accidents

There is a small probability of an accident involving a vessel containing gap material plutonium, and an even smaller probability that the accident would be severe enough to result in release of radioactive material (e.g., a collision with another ship that crushes packages of gap material plutonium, followed by a fire sufficient to release radioactive material as respirable particles to the atmosphere). The probability of a severe port accident that would result in the release of plutonium is 5×10^{-9} per ship arrival in port (DOE 1996a). The probability of this accident occurring in coastal waters or the open ocean is even lower (IAEA 2001). The probability is smaller than the probability that DOE considers for analysis of maximum reasonably foreseeable accidents (1×10^{-7}, or 1 chance in 10 million) (DOE 2002b); therefore, the consequences of this accident were not evaluated in this EA. This severe port accident was analyzed in previous NEPA documents addressing shipment of material under the GTRI program (e.g., DOE 1996a, 2006a, 2009a, 2010a).

4.1.3 Other Impacts from Ship Transport

Normal Shipping Operations

There would be no release of radioactive material under incident-free transport, meaning there would be no radiological impacts on the global commons, including impacts to marine biota and fisheries. There would be minimal nonradiological impacts, as discussed below.

Although there would be impacts such as emissions of nonradiological pollutants to the air from maritime vessels carrying gap material plutonium, the total number of shipments is not expected to exceed 12. For comparison, several thousand ocean vessels annually traverse the global commons. In 2011, 14,432 large ocean vessels made port calls in the South Atlantic Coastal Region (all ports from Alexandria, Virginia, to Miami, Florida) (DOT 2013a). During this year, there were 1,876 commercial vessel calls at the Port of Charleston, South Carolina (DOT 2013b), as well as 68 cruise ship departures from the Port of Charleston (DOT 2013c). Given the small number of gap material plutonium shipments (approximately 12 shipments over 7 years) compared to the large number of ocean vessels that annually traverse the global commons, shipment of gap material plutonium is not expected to appreciably add to global emissions of airborne pollutants. CEQ has issued draft guidance that recommends agencies consider 25,000 metric tons (27,558 tons) of carbon dioxide equivalent emissions on an annual basis as a reference point below which a quantitative analysis of climate change from greenhouse gas emissions is not required (CEQ 2014).

Under the most conservative scenario, in which all 12 shipments take place in the same year, approximately 78,000 metric tons (86,000 tons) of carbon dioxide equivalent (a greenhouse gas) would be emitted, assuming diesel fuel combustion associated with shipping across the global commons. While this amount would exceed the CEQ's reference point of 25,000 metric tons (27,558 tons) annually for quantitative analysis under NEPA, it would not represent a major impact. The amount of carbon dioxide equivalent emitted would represent less than 0.005 percent of the transportation sector's greenhouse gas emissions from fossil fuel combustion for the United States alone. Global transportation sector emissions are much, much higher, but are difficult to estimate because many countries do not keep accurate records. Furthermore, this scenario is unlikely; it is more likely that the shipments would be spread over the 7-year shipping period. In this case, annual greenhouse gas emissions would be approximately 11,000 metric tons (12,100 tons) of carbon dioxide equivalent. This level is below the CEQ's recommended reference point.

For similar reasons, there would be minimal impacts from discharge of pollutants to ocean waters. Discharges from ships transporting gap material plutonium (e.g., from pumping bilge water) would be no larger than discharges from ships transporting other cargo, and the number of shipments of gap material plutonium would be much smaller than the number of ocean vessels that annually traverse the global commons or call at the Port of Charleston, South Carolina. Discharge from ocean vessels in the Port of Charleston or in the Cooper River (the location of the Joint Base Charleston-Weapons Station) would be restricted in accordance with applicable laws and requirements.

Shipping Accidents

If an incident does occur (for example, a collision with another ship or foundering), environmental impacts could result; packages of gap material plutonium could rupture and be released into the ocean.[18] The response to, and potential impacts of, such an accident would be different, depending on the location and condition of the packages following the accident (DOE 1994, 2004). Packages that did not sink below about 660 feet (200 meters) could be located and recovered. Undamaged packages that sink deeper than about 660 feet (200 meters) could be breached by the pressure of the overlying water or by corrosion, which would release their contents.

If an accident results in release of radioactive material to the ocean, there would be potential impacts to marine life (see Section 4.1.2 for an analysis of potential impacts to humans). Potential impacts to marine life from an accident during transport of radioactive material over the global commons have been addressed in the *Environmental Assessment for the Proposed Interim Storage at the Y-12 Plant, Oak Ridge, Tennessee, of Highly Enriched Uranium Acquired from Kazakhstan by the United States* (DOE/EA-1006) (DOE 1994), the *Environmental Assessment for the Transportation of Highly Enriched Uranium from the Russian Federation to the Y-12 National Security Complex and Finding of No Significant Impact* (DOE/EA-1471) (DOE 2004), and the *FRR SNF EIS* (DOE 1996a). The first two analyses addressed accidents in which marine life was directly exposed to radioactive material released from sunken packages of HEU, while the *FRR SNF EIS* addressed accidents in which certain types of marine organisms were exposed to radioactive material released from sunken casks of FRR SNF. These three analyses concluded that some marine organisms directly exposed to radioactive material could receive large doses of radiation. Although the first two analyses concluded that some loss of marine life could occur, it was further concluded that, because of the large volumes of water involved, mixing mechanisms, existing background radiation levels, and radiation-resistance of aquatic biota, the radiological impact to marine life would be localized and minor (DOE 1994, 2004). The *FRR SNF EIS* noted the conservatism in its analysis and stated that doses to the analyzed marine organisms likely would be lower than those calculated. It also noted the low risk of impacts, considering the low probability of an accident that would result in a sunken and unrecovered cask of FRR SNF (DOE 1996a).

Plutonium is a heavy metal and both chemically and radiologically toxic, although the radiological toxicity far outweighs its chemical toxicity (Sutcliffe et al. 1995). Similar to the above analyses involving HEU and FRR SNF, it is expected that accidents involving the transport of gap material plutonium could expose marine organisms to radiation. It is similarly expected, however, that the radiological impact would be localized because of the large volumes of water involved and mixing mechanisms.

Ships containing gap material plutonium could strike and kill or injure endangered large whale species. All 12 ships containing gap material plutonium would pass through North Atlantic right whale (*Eubalaena glacialis*) critical habitat, a federally endangered species that is also protected internationally. Ships could strike and kill or injure the North Atlantic right whale while traversing their critical habitat. As addressed in Chapter 3, Section 3.1, there are Federal vessel speed restrictions and reporting requirements for certain vessels entering areas inhabited by right whales. Compliance with these restrictions and reporting requirements should reduce the probability of mortality or serious injury of the

[18] *For the 5-year period between 2010 and 2014, 22 large ship collisions were reported worldwide; approximately 5 per year (Allianz 2015). The frequency of serious ship collisions is estimated at 3.86 x 10^{-8} per nautical mile (IAEA 2001).*

North Atlantic right whale from ship strikes, and thus mitigate the potential impacts from ships carrying gap material plutonium.

There is also potential for a strike by a ship carrying gap material plutonium on an endangered species such as a loggerhead sea turtle or manatee; both species can be found in the vicinity of the Joint Base Charleston-Weapons Station. The impact on these species is expected to be minimal due to the small number of shipments and adherence to speed restrictions in port entrance channels. The greatest threat to the loggerhead sea turtle is from incidental capture during fishing and disturbance of nesting beaches, neither of which would result from activities conducted under the Proposed Action.

4.2 Impacts at the Seaport of Entry – The Joint Base Charleston-Weapons Station

4.2.1 Human Health Impacts under Normal Port Operations

Radiation doses at the seaport could be received by two groups of workers other than ship crews: (1) those involved in removing the ISO containers from the vessels and placing the ISO containers on the dock and (2) those involved in removing the packages from the ISO containers and transferring the packages to the transporters.[19] There would be no radiation doses received by members of the public from incident-free activities at the Joint Base Charleston-Weapons Station. Activities at the seaport would occur at a secure military base, and unauthorized personnel would be excluded from locations where the ISO containers would be removed from the vessel and the plutonium transferred from the ISO containers to the transporters (see Section 2.4.4).

Involved workers participating in transfer of the ISO containers from a ship to the dock at the Joint Base Charleston-Weapons Station were assumed to be the same types of workers as those evaluated in the *FRR SNF EIS* (DOE 1996a) for shipment of FRR SNF. It was assumed that the ISO containers unloaded from a ship would be transferred to a trailer at the dock, so the ISO container could be moved to a staging area away from the dock for transfer of the packages from the ISO containers to the transporters. These workers would include those responsible for inspection of the delivered cargo, transferring the cargo to the dock (cargo handlers), and moving the ISO containers to a staging area (staging personnel). The same radiation doses for transfer of a single ISO container were assumed for these workers as that evaluated in the *FRR SNF EIS* for receipt of FRR SNF, because the same basic port activities were assumed (inspection, unloading, and staging) for receipt of the gap material plutonium, and the same radiation levels were assumed for the ISO containers in this EA as that for FRR SNF in the *FRR SNF EIS*. Given these assumptions, doses and risks from shipping 18 to 24 ISO containers of gap material plutonium are presented in **Table 5**.[20] No worker is expected to receive a dose exceeding 100 millirem, even if all shipments were to occur in a single year. The total dose among all workers is projected to range from 0.20 to 0.26 person-rem, with no LCFs associated with these doses (calculated values: 0.0001 to 0.0002).

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[19] *Ship crew members were assumed to assist in removal of the ISO containers from the vessels; the doses and risks received by crew members from vessel unloading activities are included with the doses and risks presented in Section 4.2.1.*

[20] *Doses received by cargo handlers and staging personnel were based on the assumption that ISO container unloading activities would require 65 minutes per ISO container. Experience with the FRR SNF Acceptance Program suggests that the actual unloading time would be closer to 20 minutes per ISO container (DOE 2009a). The less time required to unload the ISO containers, the smaller the dose received by cargo handlers and other involved personnel.*

Table 5. Incident-Free Impacts for Unloading 18 to 24 ISO Containers of Gap Material Plutonium from Chartered Ships [a, b]

Risk Group [c]	Maximally Exposed Worker		Worker Population	
	Dose (millirem)	Risk (LCF) [d]	Dose (person-rem)	Risk (LCF) [d]
Inspectors (6)	23 to 31	1×10^{-5} to 2×10^{-5}	0.095 to 0.13	6×10^{-5} to 8×10^{-5}
Port Cargo Handlers (4)	8.3 to 11	5×10^{-6} to 7×10^{-6}	0.027 to 0.036	2×10^{-5}
Port Staging Personnel (5)	7.2 to 9.6	4×10^{-6} to 6×10^{-6}	0.083 to 0.11	5×10^{-5} to 7×10^{-5}
Maximum [e]	31	2×10^{-5}	NA	NA
Total	NA	NA	0.20 to 0.26	1×10^{-4} to 2×10^{-4}

LCF = latent cancer fatality; NA = not applicable.

[a] ISO container surface dose rates were assumed to be at the regulatory limit (10 millirem at 2 meters [6.6 feet] from the container surface for exclusive-use shipments).

[b] These results are based on the conservative assumption that each voyage carries more than one ISO container, resulting in larger doses to port personnel because of the combination of radiation fields surrounding each of the ISO containers.

[c] Numbers in parentheses are the assumed numbers of exposed personnel in each risk group.

[d] LCF risks are based on 0.0006 LCFs per rem or person-rem and are presented using one significant figure (DOE 2003a).

[e] The highest dose and risk among the risk groups.

Source: DOE 1996a for per-container radiation dose values.

Note: Totals may not equal the sums of table entries due to rounding.

Radiation doses to workers from transferring packages from ISO containers to transporters were estimated, assuming that workers would unseal and open the ISO containers, enter the ISO containers and remove tie-down straps, remove the packages and transfer them to the transporters, and secure the packages within the transporters. Because of their weight and the need to minimize radiation exposures, the packages were assumed to be transported on pallets, with the pallets transferred to the transporters using fork-lifts. The time required to transfer packages from a given ISO container will depend partially on the number of packages, which could range from 1 to 25, but was estimated to range from 1 to 2 hours.

Table 6 summarizes hourly radiation doses and risks to workers involved in package transfer operations, as well as total doses and risks, assuming it requires 2 hours to transfer the content of each ISO container to a transporter and the number of ISO containers ranges from 18 to 24. For this analysis, radiation doses to two groups of involved workers were estimated: (1) loaders who operate forklifts and are directly involved in transfer of the packages from the ISO container to the transporter and (2) guards (or other workers) who were assumed to be stationed at greater distances from the packages than loaders. Radiation doses for these workers were determined using the same methodology as that in the Radioactive Material Transportation (RADTRAN) 6.02 computer code (SNL 2013) for estimating radiation doses to transport vehicle crew and members of the public. It was assumed that the packages would be mounted on pallets on two-by-three arrays within the ISO containers, so that workers removing the packages from the ISO containers would be facing a row of containers three-packages wide. For loaders, dose rates in units of millirem per hour were determined for distances ranging from 1 to 5 meters (3.3 to 16 feet), and a total per-hour dose was determined assuming that the loader would spend no more time at one distance than another. The guards were assumed to be always located at a 10-meter (33-foot) distance from the packages. As in previous analyses (e.g., DOE 2010a), total doses were determined assuming two loaders and three guards.

Table 6. Doses and Risks from Transfer of Packages from ISO Containers to Transporters[a]

Hourly Doses (millirem per hour) and Risks (LCF per hour) for 1 ISO Container			***Total Doses (person-rem) and Risks (LCF) for 18 to 24 ISO Containers***		
Individual Loader	***Individual Guard***	***Total for All Workers***	***Loaders***	***Guards***	***Total***
6.9 (4×10^{-6})	0.38 (2×10^{-7})	15 (9×10^{-6})	0.50 to 0.66 (3×10^{-4} to 4×10^{-4})	0.040 to 0.055 (2×10^{-2} to 3×10^{-5})	0.54 to 0.72 (3×10^{-4} to 4×10^{-4})

ISO = International Organization for Standardization, LCF = latent cancer fatality.

[a] Doses were determined assuming package dose rates corresponding to regulatory limits for transportation (i.e., 10 millirem per hour at 2 meters [6.6 feet] from the package surface for exclusive-use shipments); risks were determined using a risk factor of 0.0006 LCF per rem or person-rem (DOE 2003a). Total doses and risks reflect the assumption of two loaders and three guards.

As shown in Table 6, the largest doses for any shipment would be received by workers transferring packages from ISO containers to transporters. Nonetheless, no LCFs are expected among any individual worker involved in transferring plutonium from a single ISO container, and no LCFs are expected among the population of workers involved in all plutonium transfer operations. It is possible, however, that the same individuals could be involved in multiple shipments in a single year and, in so doing, could receive individual radiation doses exceeding 100 millirem during that year. Therefore, to maintain worker doses within applicable standards and reduced to ALARA levels, NNSA would continue radiation protection procedures for the additional gap material plutonium addressed in this EA that were implemented after the previous analysis of gap material plutonium (DOE 2010a) and are routinely employed for ocean shipments of SNF (see Section 4.9). Personnel involved in unloading and package transfer operations at the seaport would be monitored by radiation safety technicians, who would ensure compliance with applicable requirements (DOE 2009a). As of 2008, no dock worker had received measurable radiation exposure from offloading FRR SNF Acceptance Program material (DOE 2009a).

4.2.2 Human Health Impacts from Potential Accidents Involving Port Operations

There is a small probability of an accident involving a vessel containing gap material plutonium, and an even smaller probability that the accident would be severe enough to result in release of radioactive material (e.g., a collision with another ship that crushes packages of gap material plutonium, followed by a fire sufficient to release radioactive material as respirable particles to the atmosphere). The probability of a severe port accident that would result in the release of plutonium is 5×10^{-9} per ship arrival in port (DOE 1996a). This is smaller than the probability that DOE considers for analysis of maximum reasonably foreseeable accidents (1×10^{-7}, or 1 chance in 10 million) (DOE 2002b); therefore, the consequences of this accident were not evaluated in this EA. This accident scenario was analyzed in previous NEPA documents addressing shipment of material under the GTRI program (e.g., DOE 1996a, 2006a, 2009a, 2010a).

Other accidents could also occur during ship unloading, ISO container staging, and transporter loading operations. It is conceivable that, for example, an ISO container could be dropped onto the dock while being unloaded from a ship, a pallet containing packages of plutonium could be dropped while being transferred using a forklift, or a package could be accidentally punctured by a forklift tine. Any potential human health risk to a worker from these hypothetical accidents would be associated with the physical forces of the accident and not from release of radioactive material. All plutonium would be shipped in Type B packages designed and constructed to meet hypothetical transport accident conditions (see Section 2.4.1) without release of the package contents. Package tests include being dropped from 30 feet (9.1 meters) onto an unyielding surface; being crushed or punctured; being exposed to high heat as from a fire; or being immersed in water. The construction of the packages would exceed the forces that could be imposed by these potential accident scenarios. Therefore, no releases of plutonium are expected from port handling accidents.

4.2.3 Other Impacts from Port Operations

Shipments of additional gap material plutonium would not affect the volume of ship traffic into or out of the Charleston, South Carolina, port area, meaning the shipments would have little effect on resource areas such as water quality, marine life, or socioeconomics. No more than 12 ocean voyages are expected for all gap material plutonium over a period of about 7 years. Even if all voyages occurred in a single year, 12 ocean voyages would represent less than 1 percent of the 1,944 large commercial vessel and cruise ship calls at the port of Charleston in 2011 (DOT 2013b, 2013c). [21]

Shipments of gap material plutonium would use existing infrastructure, with no need for construction or modification of Joint Base Charleston-Weapons Station facilities and no land disturbance that could potentially affect land use, biological resources, cultural resources, or geologic media. Under incident-free transport conditions, there would be no release of radioactive material to air or water. Nonradioactive waste would not be generated beyond that associated with normal operation of ships and port facilities. No pollutants, including greenhouse gases, would be discharged to the air beyond those normally released during ship and port operations. No water would be withdrawn from or discharged to surface water or groundwater beyond that authorized for normal operation of ships and port facilities. Shipments of gap material plutonium would not affect socioeconomic conditions at the seaport. Work would be accomplished using existing DOE, seaport, and contractor personnel.

Members of the public would be placed at no radiological risk during incident-free operations because a security perimeter would be established around the ship unloading and package transfer operations, and members of the public and unauthorized seaport personnel would be excluded from the perimeter. Because all members of the public would be thus protected from radiological risk, no disproportionately high and adverse radiological risks would occur among low-income and minority populations in the vicinity of the seaport.

4.3 Impacts from Overland Transport

4.3.1 Human Health Impacts from Incident-Free Overland Transportation

This section describes impacts to the general public and vehicle transport crews from incident-free ground transport of gap material plutonium under the Proposed Action. Under incident-free transport conditions, the hazard posed by gap material plutonium would primarily be external exposure to gamma radiation. The general public includes persons residing within 0.5 miles (800 meters) of the route(s), persons driving proximal to the transporters during transport, and persons at stops. The impacts were calculated for the transport of the gap material plutonium to SRS from the Joint Base Charleston-Weapons Station.

The radiological consequences of incident-free overland transportation were evaluated using the RADTRAN 6.02 computer code (SNL 2013) and the latest version of the Transportation Routing Analysis Geographic Information System (TRAGIS) (Johnson and Michelhaugh 2003) computer program operated by Oak Ridge National Laboratory. Several input assumptions (e.g., package dimensions, traffic densities, gamma/neutron ratios, vehicle dimensions, crew parameters, and shielding factors) were used by RADTRAN 6.02 to determine unit doses, which were then combined with population density data generated from TRAGIS to estimate receptor doses and associated health effects to individuals and the population along the route. The latest population density data available from TRAGIS are from the year 2010 census; this data was projected to 2020 to obtain population doses for 2020.

[21] *To reach the Joint Base Charleston-Weapons Station, all ships must travel up the Cooper River past the port of Charleston. The number of annual military vessel calls at the Joint Base Charleston-Weapons Station is classified.*

Conservative assumptions were made to bound the potential impacts to the general public and transport crews. The radiation exposure depends on the number, sizes, and stowage configuration of the transported packages and the package surface radiation levels. The maximum expected shipment (assumed to require one transporter) was assumed to contain 25 Model 9975 or Model 9977 packages. Radiation levels at 2 meters (6.6 feet) from the outside surfaces of the transporter were assumed to be at regulatory limits (10 millirem per hour) for exclusive-use shipments. The potential impacts derived from these assumptions for both the public and transport crew are conservative because the maximum number of packages per transporter may be less and actual radiation levels outside the packages would be less than those assumed.

Table 7 presents the doses and risks to transport crews and the general public from a single shipment of gap material plutonium. Doses to the general public are presented in terms of collective doses to the population, as well as doses to a hypothetical MEI. In all cases, the collective dose to members of the public includes doses experienced by individuals assumed to be in other vehicles sharing the road with the plutonium shipments, at stops (e.g., rest stops), and for persons living along the transport route. The MEI was assumed to be a member of the public who is always in a location alongside a road leading to SRS that is traveled by all shipments, regardless of shipment origin. For this reason, for a given shipment size and type of package, the dose to the MEI is independent of the specific transport route to SRS. Risks are presented assuming a dose-to-risk conversion factor of 0.0006 LCFs per rem or person-rem (DOE 2003a).

Table 7. Incident-Free Radiation Impacts from Ground Transport of One Shipment of Gap Material Plutonium to the Savannah River Site

			Public			
	Crew		*Population*		*MEI*	
Origin	*Dose (person-rem)*	*Risk (LCF)* [a]	*Dose (person-rem)*	*Risk (LCF)* [a]	*Dose (rem)* [b]	*Risk (LCF)* [b]
Shipment of Gap Material Plutonium in 25 Model 9975 Packages						
Joint Base Charleston-Weapons Station	0.0084	0 (5×10^{-6})	0.0057	0 (3×10^{-6})	9.1×10^{-7}	5×10^{-10}
Shipment of Gap Material Plutonium in 25 Model 9977 Packages						
Joint Base Charleston-Weapons Station	0.0084	0 (5×10^{-6})	0.0057	0 (3×10^{-6})	9.1×10^{-7}	5×10^{-10}

LCF = latent cancer fatality, MEI = maximally exposed individual.

a The reported value is the projected number of LCFs in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per rem or person-rem [DOE 2003a]) is shown in parentheses.

b The MEI shown represents a person in a car next to a transporter in a traffic jam for a half hour.

Note: Radiation dose is presented using two significant figures. LCF risks are presented using one significant figure.

Table 8 presents the doses and risks to transport crews and the general public for multiple shipments of gap material plutonium for each of the two packages assumed for this EA. Because transporters were assumed to be fully loaded and the Transport Index was assumed to be the maximum permissible for each type of package, the potential impacts listed in Table 8 are bounding. As indicated, the crew dose would not exceed 0.20 person-rem, and no LCFs would be associated with this dose (calculated value: 0.0001). The population dose would not exceed 0.14 person-rem, and no LCFs would be associated with this dose (calculated value: 8×10^{-5}). The MEI dose would not exceed 2.2×10^{-5} rem, and no LCFs would be associated with this dose (calculated value: 1×10^{-8}). Therefore, no fatalities are expected from incident-free transport of gap material plutonium.

Table 8. Total Incident-Free Radiation Impacts from Ground Transport of Gap Material Plutonium to the Savannah River Site

					Public			
		Number of Shipments	Crew		Population		MEI	
Origin	Packaging		Dose (person-rem)	Risk (LCF) [a]	Dose (person-rem)	Risk (LCF) [a]	Dose (rem)	Risk (LCF) [a]
Joint Base Charleston-Weapons Station	Model 9975	24	0.20	0 (1×10^{-4})	0.14	0 (8×10^{-5})	2.2×10^{-5}	1×10^{-8}
Joint Base Charleston-Weapons Station	Model 9977	18	0.15	0 (9×10^{-5})	0.10	0 (6×10^{-5})	1.6×10^{-5}	1×10^{-8}

LCF = latent cancer fatality, MEI = maximally exposed individual.

[a] The reported value is the projected number of LCFs in the population and is therefore presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per rem or person-rem [DOE 2003a]) is shown in parentheses.

[b] The MEI is a person living along the route and exposed to all shipments.

Note: Radiation dose is presented using two significant figures. LCF risks are presented using one significant figure.

4.3.2 Human Health Impacts from Potential Accidents during Overland Transportation

The potential for an accident during truck transport was evaluated using the RADTRAN (SNL 2013) and TRAGIS computer codes discussed above. The accident evaluation criteria established in NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977) identifies eight potential accident categories, with Category I being the least severe and most frequent and Category VIII being the most severe and least frequent. Only in the most severe accident case (Category VIII) would there be potential for a release of plutonium from a transporter transporting Type B packages. The probability of an accident for the analyzed transport routes was estimated based upon DOE transporter operational experience. Accident fatalities for transporters were estimated using the commercial truck transport "fatality per accident" ratios within each zone, based on data from studies of accident and fatality rates (Saricks and Tompkins 1999; UMTRI 2003).

An accident was assumed to cause the breach of one package in a transporter. Because the gap material plutonium chemical form could be metal or oxide, the source term for evaluating potential exposures was based on accidents involving a breach of a package containing oxide materials. This approach is conservative because oxide powder would be more dispersible than gap material plutonium in metal form. For the purpose of analysis, a release fraction of 0.1 for the most severe accidents (NRC 1977), an aerosolized fraction of 0.5, and a respirable fraction of 0.7 were assumed. Assuming the breached package contains maximum allowable plutonium, the resulting source term from an accident involving a transporter transporting Model 9975 packages would be 0.154 kilograms (0.340 pounds). Assuming the transporter is transporting Model 9977 packages and the same accident is postulated, the resulting source term could be up to twice as large, or 0.308 kilograms (0.679 pounds) of plutonium.

Estimated accident population doses, radiological risks in terms of LCFs, and risks in terms of traffic fatalities (nonradiological impacts) are presented in **Table 9**, assuming the accident occurs using Model 9975 or Model 9977 packages.[22] Doses and risks from use of Model 9977 packages were determined assuming the same isotopic distributions as those for Model 9975 packages, although each Model 9977 package was assumed to contain twice as much plutonium. Population doses presented are given as the sum of the doses determined for each accident category, multiplied by the probability of

[22] The chemical toxicity of plutonium is not addressed in the accident analysis because the radiological risks from an accident, assuming the accident causes a release of radioactive material, would far outweigh the chemical risks (Sutcliffe et al. 1995).

occurrence for that accident category. For all routes and using either Model 9975 or Model 9977 packages, the collective dose to the population would be less than 0.00058 person-rem, with no LCFs associated with this dose (calculated value: 3×10^{-7}). The probability of occurrence for a maximum reasonably foreseeable transportation accident was determined for any shipment to be less than the probability that DOE typically considers for analyses of maximum reasonably foreseeable accidents, which is 1×10^{-7} (1 chance in 10 million) per year (DOE 2002b).

Table 9. Transportation Accident Risks for Ground Transport of Gap Material Plutonium to the Savannah River Site

Origin	*Packaging*	*Number of Shipments*	*Collective Dose to Population (person-rem)* [a]	*Number of LCFs in Population*	*Nonradiological Traffic Fatalities*
Joint Base Charleston	Model 9975	24	0.00039	0 (2×10^{-7})	0 (1×10^{-4})
	Model 9977	18	0.00058	0 (3×10^{-7})	0 (9×10^{-5})

LCF = latent cancer fatality.
[a] This collective population dose (often called dose-risk) accounts for the probability and severity of accidents.
Note: Radiation dose is presented using two significant figures. LCF risks are presented using one significant figure.

For nonradiological traffic fatalities, the risk of a traffic fatality would be less than 0.0001; therefore, no traffic fatalities are expected. For all analyzed transport routes, nonradiological traffic fatality risk is a higher contributor to total accident risk than radiological risk.

4.3.3 Other Impacts from Transportation

Ground transport of gap material plutonium would use existing road and highway networks, without new construction or modification. Transportation-related impacts to land use; hydrology; biological resources and soils; cultural resources; socioeconomics; noise and vibration; utilities, energy, and materials; and waste management would be negligible. There would be no release of radioactive material to the air, but operation of the transport vehicles would result in exhaust emissions of nonradioactive pollutants such as greenhouse gases (e.g., carbon dioxide, water vapor) and other pollutants such as carbon monoxide and particulates. The few (up to 24) road shipments of gap material plutonium would be dwarfed by the volumes of all other traffic.

4.4 Impacts from Receipt of Gap Material Plutonium at the Savannah River Site

Gap material plutonium delivered to SRS would be received at the KAC, where the packages would be unloaded from the transporters and material control and accountability measurements would be taken. The packages[23] would be transferred on metal pallets to the designated interim storage location.

All activities involving gap material plutonium receipt would be conducted in accordance with established radiation safety procedures and standards. Administrative and technical controls would be implemented to ensure that radiation dose rates to workers would be monitored, maintained to levels within DOE standards and guidelines, and reduced to ALARA levels.

Accidents could occur during receipt of the gap material plutonium containers at SRS. As described in Section 4.2.2, all plutonium would be shipped in Type B packages designed and constructed to meet hypothetical transport accident conditions (see Section 2.4.1) without release of the package contents. Therefore, no releases of plutonium are expected from handling accidents.

[23] *Model 9975 and 9977 packages are both approved for storage of plutonium at the SRS KAC.*

Gap material and other surplus plutonium would remain at SRS until its eventual disposition. As addressed in Section 4.6, environmental impacts from storage and disposition of gap material plutonium have already been evaluated in the *SPD Supplemental EIS* (DOE 2015).

4.4.1 Impacts to Workers

Impacts to workers could result from receiving gap material plutonium and placing it into storage. Worker doses from receipt of gap material plutonium would be comparable to those of personnel at the seaport transferring the plutonium packages from the ISO containers to the transporters. From Table 6, the doses to a worker involved in plutonium receipt operations would range from 6.9 to 15 millirem per shipment (4×10^{-6} to 9×10^{-6} LCFs), assuming that receipt operations would require from 1 to 2 hours. Assuming five workers per shipment at SRS involved in package receipt activities, (i.e., two loaders removing the packages from the transporters plus three additional workers at greater distances from the packages than the loaders), receipt of 18 to 24 shipments of gap material plutonium, and two hours for each shipment, the total dose received from all shipments of gap material would range from 0.54 to 0.72 person-rem. No LCFs would be associated with these doses (calculated values: 0.0003 to 0.0004). Assuming that gap material plutonium is received over a 6-year period, the annual average dose to workers from receipt of gap material plutonium would be about 0.077 to 0.10 person-rem per year with an associated risk of a single LCF of 5×10^{-5} to 6×10^{-5}.

4.4.2 Impacts to the Non-Involved Workers and the Public

All gap material plutonium received at SRS would be contained within Type B packages, and there would be no releases to the environment during normal receiving activities. In addition, non-involved workers and the public would not be in direct proximity to the storage packages. H- and K-Areas are more than 5.5 miles (8.9 kilometers) from the SRS boundary. Therefore, there would be no radiological impacts to non-involved workers and the public from incident-free plutonium receipt.

4.4.3 Other Impacts from Receipt of Gap Material Plutonium at the Savannah River Site

Receipt of 900 kilograms (1,984 pounds) of gap material plutonium at SRS would occur using existing capabilities such as the KAC, which is already in operation for storage of surplus plutonium. Acceptance of gap material plutonium would cause little to no impacts to land use, biological resources, geological resources, utility use, air quality, noise, visual resources, or cultural resources above those previously evaluated for storage operations (e.g., DOE 2015). There would be no discharge to ground or surface waters beyond those required for operation of SRS and reported in annual environmental reports (e.g., SRNS 2014).

Because the proposed receipt of gap material plutonium would not increase public radiation doses, no disproportionately high and adverse radiological risks would occur among low-income and minority populations in the SRS vicinity.

Receipt of gap material plutonium at SRS would be contingent on having sufficient interim storage capacity. Available interim storage capacity would depend on the total number of packages of plutonium that may be received and stored from all sources, the schedule for disposition of the stored plutonium, and the development of additional space for plutonium storage.[24] Based on a 2007 supplement analysis (DOE 2007b), DOE determined that consolidated storage of surplus plutonium from DOE defense program laboratories at K-Area would not substantially change the potential environmental impacts analyzed in previous NEPA reviews (72 FR 51807) and has augmented the physical storage space at

[24] *The number of packages containing plutonium that may be stored at the SRS KAC is limited by facility safety analysis and technical safety requirements.*

K-Area as needed to meet storage requirements. M3 and DOE's Office of Environmental Management have a Memorandum of Agreement in place to ensure that sufficient storage space is available for the additional gap material plutonium.

4.5 Impacts from Processing of Gap Material Plutonium at the Savannah River Site[25]

Impacts on key resource areas (i.e., human health under normal operations, human health under potential accident conditions, transportation of wastes, and waste management) are discussed in Sections 4.5.1 through 4.5.3. The remaining resource areas are discussed in Section 4.5.4.

4.5.1 Human Health Impacts under Normal Operations

Workers. An estimated 30 workers could receive 30 millirem per person over the 3-year construction period, for a total worker dose of 0.9 person rem (SRNS 2015). No LCFs would be associated with this dose (calculated value: 0.005).

An estimated 72 workers would be exposed directly or indirectly through the handling and processing of material (SRNS 2015). Glovebox worker dose estimation assumed exposure as follows: 20 percent of throughput at 100 millirem per hour; 50 percent of throughput at 50 millirem per hour; and 30 percent of throughput at 25 millirem per hour. Operations associated with material container handling are baselined at 7.5 millirem per day. Support staff is baselined at 4 millirem per day. The total dose to the workers from operations was projected at 9.58 person-rem per year for 6 years, for a total of 57.5 person-rem over the life of the project.

Total annual worker doses and risks from plutonium receipt, storage, inspections, and destructive and nondestructive examinations were projected in the *SPD Supplemental EIS* to be about 34 person-rem per year and 0.02 LCF per year, respectively (DOE 2015). Processing of additional gap material plutonium was projected to raise the total annual worker doses by about 10 person-rem per year for 6 years, in addition to the 2 person-rem per year associated with receipt and inspections. Thus, the total worker dose could rise from 34 to 46 person-rem per year, with annual risks rising from 0.02 to 0.03 LCFs per year.

Public. In this process, approximately 375 kilograms (827 pounds) of plutonium would undergo thermal treatment in an inert atmosphere for stabilization. This activity is expected to operate over a 3-year period. For conservatism and to allow operational flexibility for the facility (i.e. multiple shifts), radionuclide emissions were determined assuming the material would be processed in 2 years. Other assumptions made in the calculation were: (1) the oven exhaust flow rate is 3 cubic feet (0.08 cubic meters) per minute and (2) the furnace is heated to 1,112 degrees Fahrenheit (600 degrees Celsius). The calculated radionuclide emissions (curies per year) from this process based upon the aforementioned assumptions (SRNS 2015) are:

- Pu-238 – 5.649×10^{-11}
- Pu-239 – 2.543×10^{-11}
- Pu-240 – 2.962×10^{-11}
- Pu-241 – 4.604×10^{-9}
- Pu-242 – 4.871×10^{-14}
- Am-241 – 1.038×10^{-6}

[25] *This section describes the impacts of gap material plutonium stabilization at the KAC. The H-Canyon/HB-Line (an existing nuclear facility) at SRS could also be used to stabilize gap material plutonium. Because the H-Canyon/HB-Line is further from the site boundary than the KAC and stabilization activities would be similar in design and operation to those at the KAC, the impacts of gap material plutonium stabilization at the H-Canyon/HB-Line are expected to be similar.*

Annual emissions and doses for material receipt, feed preparation, and stabilization have been evaluated previously in *NESHAP Evaluation of the Pu Vitrification Project in K Area Complex* (SRS 2008). The material evaluated in this calculation is similar to that in the proposed action. The potential Effective Dose Equivalent (millirem per year) without control devices (HEPA filter) for this project is 0.035 millirem per year. The calculated actual Effective Dose Equivalent (millirem per year) with filters (at an assumed efficiency of 99.9 percent) in place is 3.5×10^{-5} millirem per year (SRS 2008). Based on the dose factors in the previous NESHAP evaluation, the projected maximum individual doses from the projected radionuclide emissions for the Proposed Action would be 3×10^{-6} millirem per year or 1.8×10^{-9} LCFs.

4.5.2 Human Health Impacts under Potential Accident Conditions

Existing K-Area Accident Analyses

The impacts of potential K-Area accidents associated with the receipt, storage, processing (limited), and disposition of 13.1 metric tons (14.4 tons) of surplus plutonium were extensively addressed in the recent *SPD Supplemental EIS* (DOE 2015). In the *SPD Supplemental EIS*, DOE describes the environmental impacts of alternatives for disposition of surplus plutonium for which a disposition path is not assigned. In Appendix D, Section D.1.5.2.1, of the *SPD Supplemental EIS*, a range of potential accidents associated with the K-Area Material Storage Area and KIS activities are addressed. Accident scenarios for the K-Area Material Storage Area and KIS activities (DOE 2015, Appendix D, Table D–1) include the following:

- Design-basis accidents with consequences up to 0.16 rem to the MEI and no LCFs among the offsite population:
  - Fire in the K Area Material Storage Area vault producing DOE-STD-3013 (DOE 2012a) container rupture at 1,000 pounds per square inch gauge (psig)
  - Explosion (deflagration of a DOE-STD-3013 container during puncturing; container assumed to be at 700 psig)
  - Design-basis earthquake
- Beyond-design basis accidents (frequency of less than 1×10^{-6} per year) with consequences up to 9.1 rem to the MEI and 2 LCF among the offsite population:
  - Beyond-design-basis fire (unmitigated transuranic [TRU] waste drum fire)
  - Beyond-design-basis earthquake with fire (bounded by unmitigated pressurized DOE-STD-3013 container rupture due to an external fire and vault release [1,000 psig])

The unmitigated accidents were developed to determine the type of safety controls needed to prevent the accidents from happening and to reduce the potential consequences if the safety prevention systems failed. The postulated unmitigated accidents assumed bounding material inventories and bounding release mechanisms, with no credit taken for mitigation features such as building structure and filtration systems. With safety controls in place, the consequences of these bounding accidents would be substantially reduced by the building filtration systems, which would be designed to mitigate these accidents. A single HEPA filter with a leak path factor of 0.005 would prevent release to the environment of 99.995 percent of particulate contaminants.

Potential accident impacts associated with K-Area Material Storage Area and KIS are reported in Appendix D, Table D–10, of the *SPD Supplemental EIS*. Because only limited materials would be present at KIS and there are few sources of energy, the likelihood of a major accident is very remote. Most incidents would not involve much energy, and any spill would be confined to the glovebox, with no radiological impact. The bounding accident was found to be the long-burning “Fire in the KIS vault” that results in the heating up, overpressurization (to 1,000 psig), and ultimate rupture and high-pressure discharge of plutonium oxide from a DOE-STD-3013 (DOE 2012a) plutonium storage container. Because there are few sources of energy and limited potential for a long-burning fire to sufficiently pressurize a high-strength DOE-STD-3013 container to rupture, these events are considered to have a frequency range of 1×10^{-5} to 1×10^{-7} per year and be in the "extremely unlikely to beyond extremely unlikely" frequency category.

Receipt and Processing of Gap Material Plutonium in K-Area

It is anticipated that gap material plutonium stabilization will be conducted in the KAC. A seismic analysis will be performed during the conceptual phase of the project to determine the Performance Category and will be completed before major modifications begin or large procurements are placed.

The primary confinement strategy is the use of Model 9975 Type B shipping packages for protection from natural phenomena hazards and external initiated events. For confinement of material during processing, an active HEPA filtered ventilation system will be employed. The HEPA filtered ventilation system and its support systems will be designed to perform its intended safety functions under both normal and accident conditions and meet all commitments to the Defense Nuclear Facility Safety Board under Recommendation 2004-2 on *Active Confinement Systems* (DNFSB 2004).

Anticipated Future Safety Activities for Gap Material Plutonium Processing in K-Area

The existing *KAC Documented Safety Analysis* (WSRC-SA-2002-00005) includes storage and handling of plutonium metal and oxides. These activities are similar to those performed at other facilities at SRS. A Safety Design Strategy will be developed for the K-Area glovebox project, consistent with DOE-STD-1189, *Integration of Safety into the Design Process* (DOE 2008a).

The existing SRS Consolidated Hazards Analysis Process (CHAP) will be used to identify accident scenarios, assess consequences, and guide development of controls. Given that there are some differences between current glovebox operations and future glovebox operations, it is anticipated that existing accident scenarios will need to be updated and some new scenarios developed. These scenarios are expected to include fire, explosion, loss of confinement, and seismic events. The hazards and accident analysis process at SRS follows DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis* (DOE 2014b).

Each credible accident scenario, as identified in the SRS CHAP, will be individually evaluated to determine the unmitigated frequency of the accident and consequences for the facility worker, collocated worker, and the public. Accident parameters, including material at risk, release fraction, event duration, etc., may be unique to each scenario.

Based on the consequences relative to the DOE evaluation guidelines, controls are identified to prevent the event, mitigate the consequences, or both. This is an iterative process that is applied early in the design phase and refined throughout the process. Thus, it is premature to specify radiological consequences for credible accidents.

The SRS CHAP evaluation of chemical hazards and radiological accidents would be used to identify controls to prevent or mitigate the exposure of a worker to substantial concentrations of hazardous material. Given the types and quantities of the chemicals involved, it is not anticipated that an accident analysis involving chemicals as described by DOE-STD-3009 will be required.

Safety Activities Required for Gap Material Plutonium Processing in K-Area

A preliminary CHAP was conducted in January 2015 for the gap material plutonium project.[26] The purpose was to identify major hazards and risks that would require Safety Class and Safety Significant controls based on impacts to the collocated worker and public (MEI). These impacts could be substantial contributors to project cost and/or schedule. All major hazards associated with glovebox processing were identified and analyzed.

The preparers of the preliminary CHAP assumed that the consequences of potential accidents from the process would be bounded by a 1,000 pounds per square inch (psi) release of 4 kilograms (9 pounds) of plutonium oxide from the KIS bounding isotopic mix. Process accidents that would drive Safety Class and Safety Significant controls were identified as the following:

- room fire – mitigated by FM-200 fire suppression systems;
- glovebox fire – prevented through glovebox inerting; and
- furnace steam explosion – prevented through inherently safe furnace design.

For these events, active HEPA-filtered ventilation within the building exhaust system would reduce the potential radiological impacts outside of the building to low levels.

This accident was considered a bounding accident for all types of plutonium handling and processing accidents at SRS, including K- and H-Area accidents, and results from the increasing use of DOE-STD-3013 (DOE 2012a) plutonium storage containers at SRS. While these cans provide robust containment of plutonium oxide for long-term storage, they are not vented and, hence, could become pressurized in long-burning fires. If a pressurized can were to subsequently rupture, a high-pressure release of plutonium oxide would occur.

The gap material plutonium to be received at SRS is expected to be in strong but vented containers, not DOE-STD-3013 (DOE 2012a) containers. Because these containers are vented, the pressure that might build up before rupture and release of plutonium oxide, even in a very severe fire, would be less than would occur using a DOE-STD-3013 container. For the 1,000 psig release from a DOE-STD-3013 container, the *SPD Supplemental EIS* (DOE 2015, Table D-1) reported a combined airborne release factor (ARF) times the respirable fraction (RF) (ARF × RF) of 0.0284, or 2.84 percent of the container inventory being released and respirable immediately outside of the container. For vented containers under thermal stress, the recommended bounding values in *DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE-HDBK-3010-94) (DOE 2013b, page 4-7) are an airborne release fraction of 0.006 and a respirable fraction of 0.01 or a combined ARF × RF of 0.00006 or 0.006 percent of the contents. This is a factor of 473 lower than the 1,000 psig ARF × RF value. DOE-HDBK-3010-94 (page 4-8) also recommends a bounding ARF of 0.005 and an RF of 0.4 (ARF × RF = 0.002) for venting powders or for a confinement failure at pressures to 0.17 MPA_g (megapascals gauge) (~25 psig) or less. This is a factor of 14 less than the 1,000 psig case evaluated in the *SPD Supplemental EIS*. Thus, it would be reasonable to assume that the bounding release from a vented plutonium oxide storage container would be on the order of a factor of 10 lower than the 1,000 psig pressurized release evaluated in the *SPD Supplemental EIS* and other SRS safety documents.

Additional CHAPs are planned for conceptual and later phases of the project that will include evaluation of facility worker impacts. These will provide a completed and detailed analysis of hazards for the

[26] *Consolidated Hazards Analysis Process (CHAP) Summary, KAC Glovebox Project to Support, Budgetary Placeholder Estimate (SRS 2014).*

purpose of identifying a comprehensive engineered control set for protection of workers, as well as offsite impacts. Both conceptual and later design CHAPs are included in the project schedule.

Radiological Impacts of Accidents Involving Receipt and Processing of Gap Material Plutonium at the Savannah River Site

Based on the results of the January 2015 preliminary CHAP, it was assumed that the consequences of potential design-basis accidents from the gap material plutonium processing would be bounded by a 1,000 psi release of 4 kilograms (9 pounds) of plutonium oxide from the KIS bounding isotopic mix. This accident could be initiated by various extremely unlikely events (i.e., events with a probability in the 10^{-4} to 10^{-6} per year range), including room fires, glovebox fires, and a furnace steam explosion that would be prevented or mitigated by engineered design features and controls included in the processing design.

Impacts of this processing accident would be less than that for the similar bounding (highest impact) design-basis accident evaluated in the *SPD Supplemental EIS* (DOE 2015), the long-burning Fire in the KIS vault that results in the heating up, overpressurization (to 1,000 psig), and ultimate rupture and high-pressure discharge of plutonium oxide from a DOE-STD-3013 (DOE 2012a) plutonium storage container to the room and building, with an ultimate filtered release to the environment through the building ventilation system. In the *SPD Supplemental EIS*, the DOE-STD-3013 container was assumed to store 7 kilograms (15 pounds) of plutonium oxide from the KIS bounding isotopic mix, while the gap material plutonium container was assumed to store 4 kilograms (9 pounds) of plutonium oxide. The isotopic mixes were assumed to be similar and to maximize the potential radiological impacts of releases.

Appendix D, Table D–10, of the *SPD Supplemental EIS* (DOE 2015) indicates that an accident with fire in a KIS vault that ruptures a DOE-STD-3013 container (DOE 2012a) at 1,000 psig, would result in the dose-equivalent of 5.7 grams of plutonium-239 being released from the stack (after HEPA filtration), with a potential dose of 4.5 rem to a noninvolved worker within K-Area, a dose of 0.18 rem to an individual at the site boundary, and a dose to the population within 50 miles (80 kilometers) of the release point of 52 person-rem. For the noninvolved worker and individual at the site boundary, the probabilities of an LCF are 0.003 and 0.0001, respectively. Among the offsite population, no LCFs would be associated with these doses (calculated values: 0.03).

Gap Material Bounding Design-Basis Accident. For the receipt and processing of gap material plutonium, these impact estimates can be reduced because the amount of material at risk, according to the preliminary CHAP, is 4 kilograms (9 pounds) of plutonium oxide rather than the 7 kilograms (15 pounds) assumed in the *SPD Supplemental EIS* (DOE 2015). Therefore, the estimated impacts for the gap material plutonium are 4/7, or 57.1 percent, of the EIS estimates. Thus, estimated accident impacts from receipt and processing of gap material plutonium for the bounding (highest-impact) design-basis, HEPA-filtered accident at SRS, assuming material is released at high pressure from a DOE-STD-3013 (DOE 2012a)-like container are:

- 2.6 rem to a noninvolved worker within K-Area (LCF risk: 0.002),
- 0.10 rem to an individual at the site boundary (LCF risk: 0.0006), and
- 30 person-rem to the population within 50 miles (80 kilometers) of the release point (population LCFs 0 [0.02]).

If the material were in a strong but vented container, the container would be expected to rupture at a much lower pressure, and the fraction released from the container to the room or building would likely be at least a factor of 10 lower, based on the lower ARF × RF values from DOE-HDBK-3010-94 (DOE 2013b).

Appendix D, Table D–10, of the *SPD Supplemental EIS* (DOE 2015) also evaluated the beyond-design-basis earthquake with fire (bounded by unmitigated pressurized DOE-STD-3013 (DOE 2012a) container due to an external fire and vault release [1,000 psig]). The annual frequency of this accident is estimated to be in the "beyond extremely unlikely" range or less than 1×10^{-6} per year. In this accident, the building confinement and filtration system was assumed to fail with a building leak path factor of 0.25 for transport of the aerosolized plutonium through the building rubble. For the DOE-STD-3013 container storing 7 kilograms (15 pounds) of plutonium oxide, the release was estimated to have a plutonium-239 dose equivalent of 280 grams. For an accident involving 7 kilograms (15 pounds) of plutonium oxide, a potential dose of 310 rem to a noninvolved worker within K-Area, a dose of 9.1 rem to an individual at the site boundary, and a dose to the population within 50 miles (80 kilometers) of the release point of 2,500 person-rem. For the noninvolved worker and individual at the site boundary, the probabilities of an LCF are 0.4 and 0.005, respectively. Among the offsite population, 2 LCFs are expected.

Gap Material Bounding Beyond Design-Basis Accident (less than 1×10^{-6} per year): For the receipt and processing of gap material plutonium, these impact estimates can be reduced because the amount of material at risk, according to the preliminary CHAP, is 4 kilograms (9 pounds) of plutonium oxide rather than the 7 kilograms (15 pounds) assumed in the *SPD Supplemental EIS* (DOE 2015). Therefore, the estimated impacts for the gap material plutonium are 4/7, or 57.1 percent, of the EIS estimates. Thus, estimated gap material plutonium accident impacts from storage and process plutonium for the beyond-design-basis earthquake with fire bounding (highest-impact) accident at SRS, with an unfiltered release, assuming material is released at high pressure from a DOE Standard 3013-like container, are:

- 160 rem to a noninvolved worker within K-Area (LCF risk: 0.2),
- 5.2 rem to an individual at the site boundary (LCF risk: 0.003), and
- 1,430 person-rem to the population within 50 miles (80 kilometers) of the release point (population LCFs 1 [0.9]).

If the plutonium were in a strong but vented container, the container would be expected to rupture at a much lower pressure, and the fraction released from the container to the room or building would likely be at least a factor of 10 lower, based on the lower ARF × RF values from DOE-HDBK-3010-94 (DOE 2013b). As with the *SPD Supplemental EIS* (DOE 2015) accident, the annual frequency of this accident was estimated to be in the "beyond extremely unlikely" range or less than 1×10^{-6} per year.

4.5.3 Human Health Impacts from Transporting Wastes

The processing of gap material plutonium at SRS is expected to produce 5.3 cubic meters per year (185 cubic feet per year) of CH-TRU wastes. The generated TRU wastes would be packaged in 55-gallon (208 liters) drums for interim storage in E-area until shipment to WIPP. This waste is expected to be shipped using the Transuranic Package Transporter (TRUPACT) II waste package. The radiological characteristics of the CH-TRU waste would resemble the KIS Capability TRU wastes evaluated in the *SPD Supplemental EIS* (DOE 2015).

For the CH-TRU waste, the dose rate was assumed to be 4 millirem per hour at 1 meter (3.3 feet) (DOE 1997). The release fractions corresponding to the NUREG-0170 severity categories, as adapted in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, were used (DOE 1997, 2002b).

Table 10 presents the doses and risks to transport crews and the general public associated with a single shipment of CH-TRU waste to WIPP. **Table 11** presents the doses and risks to transport crews and the general public from multiple shipments of the CH-TRU wastes to WIPP.

Table 10. Incident-Free Radiation Impacts from Ground Transport of One Shipment of Contact-Handled Transuranic Waste to the Waste Isolation Pilot Plant

Origin – Destination	*Crew*		*Public*			
			Population		*MEI*	
	Dose (person-rem)	*Risk (LCF)* [a]	*Dose (person-rem)*	*Risk (LCF)* [a]	*Dose (rem)* [b]	*Risk (LCF)* [b]
SRS–WIPP	0.084	0 (5×10^{-5})	0.011	0 (7×10^{-6})	2.4×10^{-7}	1×10^{-10}

LCF = latent cancer fatality; MEI = maximally exposed individual; SRS = Savannah River Site; TRUPACT=Transuranic Package Transporter; WIPP = Waste Isolation Pilot Plant.

[a] The reported value is the projected number of LCFs in the population and is, therefore, presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per rem or person-rem [DOE 2003a]) is shown in parentheses.

[b] The MEI shown is representative of a person stuck in a car next to a truck transporting a TRUPACT II waste package in a traffic jam for a half hour.

Note: Radiation dose is presented using two significant figures. LCF risks are presented using one significant figure.

Table 11. Total Incident-Free Radiation Impacts from Ground Transport of Contact-Handled Transuranic Waste to the Waste Isolation Pilot Plant

Origin-Destination	*Packaging*	*Number of Shipments*	*Crew*		*Public*			
					Population		*MEI*	
			Dose (person-rem)	*Risk (LCF)* [a]	*Dose (person-rem)*	*Risk (LCF)* [a]	*Dose (rem)*	*Risk (LCF)* [a]
SRS-WIPP	TRUPACTII	3	0.25	0 (2×10^{-4})	0.03	0 (2×10^{-5})	7.1×10^{-7}	4×10^{-10}

LCF = latent cancer fatality, MEI = maximally exposed individual; SRS = Savannah River Site; TRUPACT = Transuranic Package Transporter; WIPP = Waste Isolation Pilot Plant.

[a] The reported value is the projected number of LCFs in the population and is, therefore, presented as a whole number. When the reported value is zero, the result calculated by multiplying the collective dose to the population by the risk factor (0.0006 LCFs per rem or person-rem [DOE 2003a]) is shown in parentheses.

[b] The MEI is a person living along the route and exposed to all shipments.

Note: Radiation dose is presented using two significant figures. LCF risks are presented using one significant figure.

Table 12 presents the estimated accident population doses, radiological risks in terms of LCFs, and risks in terms of traffic fatalities (nonradiological impacts) from transport of CH-TRU wastes to WIPP. Overall, the dose estimates in Tables 10 through 12 show that the collective dose to the population from incident-free transportation would be 0.03 person-rem, with no LCFs associated with this dose (calculated value: 2×10^{-5}). Under accident conditions, the calculated dose and LCF would be very small. In addition, the probability of occurrence for a maximum reasonably foreseeable transportation accident was determined for any shipment to be less than the probability that DOE typically considers for analyses of maximum reasonably foreseeable accidents, which is 1×10^{-7} (1 chance in 10 million) per year (DOE 2002b).

Table 12. Transportation Accident Risks for Shipments of Contact-Handled Transuranic Wastes to Waste Isolation Pilot Plant

Origin-Destination	*Packaging*	*Number of Shipments*	*Collective Dose to Population (person-rem)* [a]	*Number of LCFs in Population*	*Nonradiological Traffic Fatalities*
SRS-WIPP	TRUPACTII	3	5.8×10^{-13}	0 (3×10^{-16})	0 (8×10^{-4})

LCF = latent cancer fatality; SRS = Savannah River Site; TRUPACT = Transuranic Package Transporter; WIPP = Waste Isolation Pilot Plant.

[a] This collective population dose (often called dose-risk) accounts for the probability and severity of accidents.

Note: Radiation dose is presented using two significant figures. LCF risks are presented using 1 significant figure.

4.5.4 Impacts from Waste Management

Construction and operation of the capability to process the plutonium would generate waste, as summarized in **Table 13**.

Waste would be managed according to existing procedures. TRU waste would be packaged for disposal and interim storage pending its disposition at WIPP. Low-level radioactive waste (LLW) would be disposed of at E-Area at SRS. Liquid and solid hazardous waste would be shipped off site to a permitted facility for treatment and disposal, while solid nonhazardous waste would be disposed of at the Three Rivers Regional Landfill or the SRS Construction and Demolition Landfill. The minimal quantities of liquid nonhazardous waste that would be generated during construction (mostly to support concrete-cutting operations) would be disposed of using the SRS Central Sanitary Wastewater Treatment System.

Table 13. Waste from Construction and Operation of a Gap Material Plutonium Processing Capability

Waste	Construction (cubic meters)	Operation	
		Annual Generation (cubic meters per year)	Total Generation (cubic meters)
Contact-handled transuranic waste		5.2	16
Low-level radioactive waste	35 [a]	4.0	12
Solid hazardous waste	4.5 [b]	0.4	1.3 [d]
Liquid hazardous waste	6 [c]	–	–
Solid nonhazardous waste	1	26	76
Liquid nonhazardous waste	Minimal	–	–

[a] Consists mostly of steel and concrete.
[b] Includes lead and other hazardous solids plus polychlorinated biphenyls and asbestos.
[c] Includes hazardous and toxic liquids such as polychlorinated biphenyls.
[d] Generally consists of universal waste such as batteries.
Source: SRNS 2015; McAlhany 2015.

4.5.5 Other Impacts from Processing Activities at the Savannah River Site

Impacts on other resource areas are discussed in this section. Activities would occur within the industrialized areas of SRS; undisturbed land would not be disturbed; and there would be no discharges to surface water or groundwater. Therefore, no impacts on geology and soils, water resources, ecological resources, and cultural resources are expected. The potential incremental impacts on the remaining resource areas (i.e., air quality, noise, infrastructure, socioeconomics, and environmental justice) are presented in **Table 14**.

4.6 Impacts from Storage and Disposition of Gap Material Plutonium at SRS

As discussed in Chapter 1, Section 1.5.2, of the *SPD Supplemental EIS* (DOE 2015), the 13.1 metric tons (14.4 tons) of surplus plutonium analyzed in the *SPD Supplemental EIS* includes 0.9 metric tons (0.99 tons) of excess capacity to allow for the possibility that DOE may identify additional quantities of surplus plutonium that could be processed for disposition through the facilities and capabilities analyzed in the *SPD Supplemental EIS*. Therefore, the impacts from storage and disposition activities for the 900 kilograms (1,984 pounds) of plutonium analyzed in this EA have already been evaluated in the *SPD Supplemental EIS*, and no further NEPA evaluation is required.

Table 14. Summary of Other Resources Impacts from Modification and Operation of a Gap Material Plutonium Processing Capability at the Savannah River Site

Resource Area	*Impact Indicator*	*Summary of Impacts*
Air Quality	**Modification** Short-term emissions from construction equipment use	Emissions from K-Area would be very small and would originate over 5.5 miles (8.9 kilometers) from the site boundary. Concentrations at the SRS site boundary would not exceed air quality standards.
	Operation Criteria and Hazardous/Toxic Air Pollutants from Oxidation* Aluminum fluoride: 1.5×10^{-05} metric tons per year Nickel/nickel oxide: 3.1×10^{-13} kilograms per year Beryllium/beryllium oxide: 2.0×10^{-13} kilograms per year] * Results taken from Plutonium Preparation Project. The values shown are higher than what is expected from the proposed gap material plutonium stabilization capability. Criteria and Hazardous/Toxic Air Pollutants from operation of one 300-kilowatt emergency diesel generator for 100 hours. Nitrogen oxides: 0.62 metric tons per year Sulfur oxides: 0.041 metric tons per year Carbon monoxide: 0.13 metric tons per year $PM_{2.5}$: 0.044 metric tons per year PM_{10}: 0.044 metric tons per year Aldehydes: 8.4 kilograms per year	
Noise	**Modification** Noise Sources: Power tools and construction equipment Distance from Site Boundary: 5.5 miles	Noise is not expected to result in increased annoyance to the public.
	Operation Noise Sources: Diesel generator and air compressor Distance from Site Boundary: 5.5 miles	
Infrastructure	**Modification** Electricity: Portable generators Potable Water: 25,000 gallons per year Gasoline: 2,500 gallons per year Diesel Fuel: 1,500 gallons per year	Electricity use for K-Area would increase 5 percent. Use of utilities is not expected to exceed historical use with the addition of plutonium processing. Utility usage would remain well within available capacities.
	Operation Electricity: 550 megawatt hours Domestic Water: 175,00 gallons per year Sanitary Water: 160,000 gallons per year	
Socioeconomics	**Modification** Additional FTEs: 80 Duration: 3 years	Employment would have minimal impacts on housing, community services, and traffic.
	Operation Additional FTEs: 17 Duration: 3 years	
Environmental Justice	**Modification** Minimal impacts to human health, air quality, and water resources	Because there would be little or no impact to human health and air quality, no disproportionately high and adverse effects on minority or low-income populations are expected.
	Operation Minimal impacts to human health, air quality, and water resources	

FTE = full-time equivalent; $PM_{2.5}$ = particulate matter less than or equal to 2.5 micrometers; PM_{10}= particulate matter less than or equal to 10 micrometers; SRS = Savannah River Site.
To convert gallons to liters, multiply by 3.785; kilograms to pounds, multiply by 2.2046; metric tons to tons, multiply by 1.1023; miles to kilometers, multiply by 1.6093.

4.7 Intentional Destructive Acts

One of the goals of M3 is to remove weapons-usable nuclear material that represents potential targets for diversion or terrorist actions from foreign countries and to place the material in more-secure and protected locations. The following discussion relates to the transport of gap material plutonium to and within the United States and the management of gap material plutonium at SRS.

4.7.1 Intentional Destructive Acts on the Global Commons

Maritime areas where acts of terrorism or piracy are more likely would be avoided, or ships passing thorough these areas would be provided with additional security as necessary. About 80 percent of all acts of piracy, for example, take place in the territorial waters of sovereign nations. In 2007, the locations with the most incidents of piracy included waters near Indonesia, Nigeria, and Somalia (Petretto 2008). If an intentional destructive act were to occur at sea, potential impacts would primarily be to onboard personnel. Potential impacts could range from fatalities associated with an explosion or drowning to lesser impacts of radiation exposure to untrained or uninformed personnel in the immediate vicinity of the transportation packages containing plutonium. Potential radiological impacts to people in the proximity of this accident would be similar to the analysis of intentional destructive acts during overland transport, as discussed in Section 4.7.2.

4.7.2 Intentional Destructive Acts in the United States

In accordance with DOE NEPA guidance (DOE 2006b), an analysis was performed in a classified appendix to the *Gap Material Plutonium EA and FONSI* (DOE 2010a) to consider the potential impacts of intentional destructive acts for activities related to plutonium transport. A range of scenarios involving the release of plutonium was evaluated in that EA. Each scenario involves an action by intruders during the transportation of packages within the United States. The analysis of intentional destructive acts performed for the *Gap Material Plutonium EA and FONSI* is applicable to the Proposed Action in this EA and is therefore incorporated by reference.

4.7.3 Mitigation of Intentional Destructive Acts

The likelihood of an intentional destructive act associated with transport of gap material plutonium is minimized by the security measures that would be taken to reduce knowledge of and access to the shipments. In the aftermath of the September 11, 2001, attacks, DOE (and NNSA), the U.S. Department of Defense (DOD), and the U.S. Department of Homeland Security implemented measures to minimize the risk and consequences of potential terrorist attacks on DOE and DOD facilities, as well as U.S. ports. Safeguards applied to protecting facilities containing nuclear material involve a dynamic process of enhancement as needed to meet threats; these safeguards will continue to evolve as threats change. DOE/NNSA, and DOD continually re-evaluate security scenarios involving intentional destructive acts to assess potential vulnerabilities and identify improvements to security procedures and response measures. Security at these facilities is a critical priority for both DOE/NNSA and DOD, which continue to identify and implement measures to deter attacks and defend against them. DOE/NNSA and DOD maintain a system of regulations, orders, programs, guidance, and training that forms the basis for maintaining, updating, and testing site security to preclude and mitigate any postulated terrorist actions (Brooks 2004; DHS 2006; PL 2002, 33 CFR Part 165, and 33 CFR Part 334). The SRS physical security protection strategy is described in Section 2.4.8.

4.8 Cumulative Impacts

CEQ regulations (40 CFR Parts 1500-1508) define cumulative impacts as effects on the environment that result from implementing the Proposed Action or any of its alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions (40 CFR 1508.7). The cumulative impacts of an action can be viewed as the total impacts on a resource, ecosystem, or human community of that action and all other activities affecting that resource irrespective of the source. This analysis of cumulative impacts emphasizes public health and safety impacts associated with transport of gap material plutonium and its subsequent disposition.

Transport to U.S. Seaports. Each year, there are several million worldwide shipments of radioactive materials using trucks, trains, ocean vessels, aircraft, and other conveyances, including large numbers of shipments across the global commons. Shipments of gap material plutonium to the Unites States would represent only a fraction of these worldwide shipments.

Collective radiation doses and risks to crews and populations for incident-free transport of 900 kilograms (1,984 pounds) of gap material plutonium from foreign countries to United Sates seaports are summarized in **Table 15**. This table also lists the doses and risks to ship crews and dock workers from shipment of: (1) 100 kilograms (220 pounds) of gap material plutonium by ocean vessel, as evaluated in the 2010 *Gap Material Plutonium EA and FONSI* (DOE 2010a); (2) 5 metric tons (5.5 tons) of HEU by ocean vessel, as evaluated in the 2006 *Supplement Analysis for the Air and Ocean Transport of Enriched Uranium between Foreign Countries and the United States* (DOE 2006a); and (3) shipment of FRR SNF by ocean vessel under the FRR SNF Acceptance Program. Some personnel could be exposed to radiation from shipments of gap material plutonium, as well as from shipment of FRR SNF or HEU in unirradiated nuclear fuel. Doses thus received as part of gap material shipments would be mitigated, as discussed in Section 4.9.

Table 15. Cumulative Radiation Doses and Risks for Incident-Free Marine Transport of Gap Material Plutonium to United States Seaports

Risk Receptor (scenario)	*Radiation Dose (person-rem)*	*Risk (LCF)* [a]
Ship crew, 900 kilograms of gap material plutonium (Proposed Action) [b, c]	2.8 to 4.1	2×10^{-3}
Dock handlers, 900 kilograms of gap material plutonium (Proposed Action) [b, c]	0.20 to 0.26	1×10^{-4} to 2×10^{-4}
Ship crew, 100 kilograms of gap material plutonium [b, c, d]	1.4	8×10^{-4}
Dock handlers, 100 kilograms of gap material plutonium [b, c, d]	0.67	4×10^{-4}
Ship crew, 5,000 kilograms of unirradiated HEU [f]	0.030	2×10^{-5}
Dock handlers, 5,000 kilograms of unirradiated HEU [f]	0.13	8×10^{-5}
Ship crew, FRR SNF [e]	75.4	5×10^{-2}
Dock handlers, FRR SNF [e]	8.2	5×10^{-3}
Totals	**89 to 90**	$\mathbf{5 \times 10^{-2}}$

FRR = foreign research reactor, HEU = highly enriched uranium, LCF = latent cancer fatality, SNF = spent nuclear fuel.

[a] Risks were determined using a dose-to-risk factor of 0.0006 LCFs per person-rem and are presented using one significant figure (DOE 2003a).

[b] Conservatively assumes a surface radiation dose at International Organization for Standardization container or package array surfaces of 10 millirem per hour at 2 meters (6.6 feet) for exclusive-use shipments.

[c] Assumes 12 shipments of gap material plutonium by chartered vessel.

[d] The 2010 *Environmental Assessment for the U.S. Receipt and Storage of Gap Material – Plutonium and Finding of No Significant Impact* (DOE/EA-1771) (DOE 2010a) addressed shipment of 100 kilograms (220 pounds) of gap material plutonium to the United States under a ship transport alternative and an aircraft transport alternative. Only the ship transport alternative is included here because the aircraft transport alternative has not been implemented.

[e] Assumes a radiation dose of 10 millirem per hour at 2 meters (6.6 feet) for exclusive-use shipments, including shipment of gap material SNF (DOE 2009a), and updating the dose-to-LCF factor from that assumed in the *FRR SNF EIS* (DOE 1996a) to 0.0006 LCFs per person-rem (DOE 2003a).

[f] The option of shipping the same 5,000 kilograms (11,023 pounds) of unirradiated HEU by military cargo or commercial aircraft was also assessed. Air shipment of all unirradiated HEU was projected to result in a collective dose to air crew members of up to 1.1 person-rem and a collective dose to ground cargo workers of up to 0.51 person-rem. The corresponding risks were 0.0007 LCF and 0.0003 LCF, respectively (DOE 2006a).

Note: Totals may not add due to rounding. To convert kilograms to pounds, multiply by 2.2046.

Transport of Gap Material Plutonium from Joint Base Charleston-Weapons Station to SRS. Under the Proposed Action, gap material plutonium received at the U.S. port of entry (the Joint Base Charleston-Weapons Station) would be loaded into transporters, transported to SRS, and placed into storage. Overland transport of gap material plutonium would represent only a small fraction of all overland shipments of radioactive materials over U.S. highways. As shown in Tables 6 and 8, workers loading plutonium into transporters could receive up to 0.72 person-rem, while the total dose to transporter crews and members of the public from transporting the gap material plutonium to SRS would range up to 0.34 person-rem. DOE evaluated the transport and management of 47.1 metric tons (51.9 tons) of surplus plutonium in the *SPD Supplemental EIS* (DOE 2015). The maximum dose from loading and transporting the gap material plutonium represents 0.09 to 0.3 percent of the cumulative doses to transport crews and members of the public from dispositioning 47.1 metric tons (51.9 tons) of surplus plutonium as evaluated in the *SPD Supplemental EIS* (380 to 1,230 person-rem), and 0.0001 percent of the cumulative doses to transport crews and members of the public from all shipments of radioactive material up to 2073 (857,000 person-rem) (DOE 2015).

Receipt and Handling of Gap Material Plutonium at SRS. As stated in Section 4.4.1, receipt and handling of gap material plutonium at SRS would not add substantially to radiation doses experienced by SRS radiation workers. Because no additional radiation doses are expected among members of the public in the SRS vicinity due to receipt and handling activities, there would be no additional cumulative impacts to members of the public. Similarly, because receipt and handling of gap material plutonium would cause little to no additional impacts to land use, biological resources, geological resources, utility use, air quality, noise, visual resources, ground and surface water, or cultural resources there would be no additional cumulative impacts on these resource areas.

Waste Management. **Table 16** lists cumulative volumes of LLW, hazardous waste, and solid nonhazardous wastes that would be generated at SRS. Cumulative waste volumes from existing site activities are projected over 30 to 35 years, a period of time that exceeds the projected period of construction and operation of the activities evaluated in this EA.

Table 16. Cumulative Waste Generation

Activity		*Low-level Radioactive Waste*	*Solid Hazardous Waste*	*Solid Nonhazardous Waste*
Existing site activities (30 years)		390,000	720	2,310,000
ER/D&D; 35-Year Forecast (DOE 2002c:5-11)		61,600	3,100	0
HLW Salt Processing Facility (DOE 2001: 4-36)		920	43	7,670
Tank closure (DOE 2002c:4-25)		1,284	43	428
Biomass cogeneration and heating (DOE 2008b:36) (30 years)		0	0	447,000
GTCC LLW facilities (DOE 2011c:5-89)		250	440	780,000
GTCC LLW disposal at SRS (DOE 2011c:1-9)		12,000	0	0
Surplus Plutonium Disposition (DOE 2015: 4-130)		10,000 to 34,000	7 to 7,000	13,000 to 43,000
Subtotal – Baseline Plus Other Actions		**476,054 to 500,054**	**4,353 to 11,346**	**3,558,098 to 3,588,098**
Environmental Assessment for Gap Material Plutonium – Transport, Receipt, and Processing	Construction	35	4.5	1.0
	Operations	12	1.3	76
	Total	47	6	77
Total		476,101 to 500,101	4,359 to 11,352	3,558,175 to 3,588,175

ER/D&D = environmental restoration and decontamination and demolition; GTCC = greater than Class C; HLW = high-level radioactive waste; LLW = low-level radioactive waste.
Source: German Fuel projections, DOE 2001, 2002c, 2008a, 2011c, 2015.

As indicated in Table 16, the small quantities of LLW, hazardous waste, and solid nonhazardous wastes that would be generated would represent only tiny fractions of the wastes that could be generated at SRS from other activities. Consistent with current operations, LLW would be sent to E-Area for disposal; hazardous waste would be shipped off site for management at a permitted facility; and nonhazardous waste would be disposed of at the Three Rivers Regional Landfill or the SRS Construction and Demolition Landfill.

The projected activities involving gap material plutonium would also generate small quantities of CH-TRU waste, which would be stored in the interim until it can be disposed of at WIPP. This CH-TRU waste would represent only a fraction of the TRU waste expected to be generated from SRS activities. To address the cumulative impacts of disposal of this waste at WIPP, the quantity of CH-TRU waste generated from processing gap material plutonium was compared against the unsubscribed WIPP capacity for CH-TRU waste disposal. The WIPP Land Withdrawal Act establishes a total WIPP capacity for TRU waste disposal of 175,600 cubic meters (6.2 million cubic feet), as well as restrictions on disposal of remote-handled TRU waste. Based on these statutory limitations and agreements between DOE and the State of New Mexico and considering past and projected disposals of TRU waste from across the complex, an unsubscribed disposal capacity of 24,700 cubic meters (872,000 cubic feet) of CH-TRU waste was estimated (DOE 2015). The projected quantity of CH-TRU waste generated from gap material plutonium processing evaluated in this EA would represent about 0.06 percent of this unsubscribed capacity.

4.9 Mitigation

NNSA would take actions to mitigate potential impacts associated with the Proposed Action. As discussed in Chapter 3, Section 3.1, the NMFS has established regulations to reduce the likelihood of ships colliding with right whales along the Atlantic Coast. All vessels 65 feet (19.8 meters) or longer must travel at 10 knots or less in certain locations along the east coast of the United States at certain times of the year (i.e., calving season, which occurs from December through March) (NOAA 2015b). Although the regulations do not apply to U.S. vessels owned or operated by, or under contract to, the Federal Government, M3 would voluntarily abide by these regulations as long as doing so did not pose a security threat.

As indicated in Table 4, it is conceivable that some members of the crew that are not radiation workers could receive a radiation dose exceeding 100 millirem in a year. To mitigate potential radiation impacts to workers, NNSA would extend the program described in the mitigation action plan for FRR SNF (DOE 1996c) or implement a similar program for gap material plutonium shipments. Under the mitigation program applied to shipments of FRR SNF, NNSA requires its shipping contractor to obtain radiation surveys of FRR SNF casks before shipment and to use these data to ensure the estimated dose to any crew member does not exceed 100 millirem per year. NNSA also maintains a database of the actual radiation surveys for each cask and shipment and includes clauses in its shipping contracts to minimize the likelihood that any member of a ship's crew would be exposed to more than 100 millirem during a single year.

Chapter 4, Section 4.2.2, discusses a hypothetical severe accident of a collision in or near a seaport involving a ship transporting gap material plutonium. The probability of occurrence of the postulated port accident is smaller than the probability that DOE typically considers for analysis of maximum reasonably foreseeable accidents (1×10^{-7}, or 1 chance in 10 million) (DOE 2002b). Nonetheless, to further reduce the risk, NNSA would require its contractor to enter port during times of minimal port traffic.

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