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# SUPPLEMENT ANALYSIS FOR THE U.S. DISPOSITION OF GAP MATERIAL – SPENT NUCLEAR FUEL

National Nuclear Security Administration

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# ACRONYMS

| | |
|---|---|
| BR-2 | Belgian Reactor 2 |
| CEQ | Council on Environmental Quality |
| CFR | *Code of Federal Regulations* |
| DoD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| EIS | environmental impact statement |
| FR | *Federal Register* |
| FRR | foreign research reactor |
| GTRI | Global Threat Reduction Initiative |
| HEU | highly enriched uranium |
| IAEA | International Atomic Energy Agency |
| INF Code | International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships |
| INL | Idaho National Laboratory |
| ISO | International Standards Organization |
| LCF | latent cancer fatality |
| LEU | low-enriched uranium |
| MAR | material at risk |
| MEI | maximally exposed individual |
| MTHM | metric tons of heavy metal |
| MTR | Materials Test Reactor |
| NEPA | National Environmental Policy Act |
| NNSA | National Nuclear Security Administration |
| NRU | National Research Universal (reactor) |
| NWS | Naval Weapons Station |
| ROD | Record of Decision |
| SA | Supplement Analysis |
| SNF | spent nuclear fuel |
| SEIS | supplemental environmental impact statement |
| SPEIS | supplemental programmatic environmental impact statement |
| SRS | Savannah River Site |
| TRIGA | Training, Research, Isotopes, General Atomics (reactor) |
| U.S. | United States |
| WMD | weapons of mass destruction |

## CONVERSIONS

| METRIC TO ENGLISH | | | ENGLISH TO METRIC | | |
|---|---|---|---|---|---|
| **Multiply** | **by** | **To get** | **Multiply** | **by** | **To get** |
| **Area** | | | | | |
| Square meters | 10.764 | Square feet | Square feet | 0.092903 | Square meters |
| Square kilometers | 247.1 | Acres | Acres | 0.0040469 | Square kilometers |
| Square kilometers | 0.3861 | Square miles | Square miles | 2.59 | Square kilometers |
| Hectares | 2.471 | Acres | Acres | 0.40469 | Hectares |
| **Concentration** | | | | | |
| Kilograms/square meter | 0.16667 | Tons/acre | Tons/acre | 0.5999 | Kilograms/square meter |
| Milligrams/liter | 1 [a] | Parts/million | Parts/million | 1 [a] | Milligrams/liter |
| Micrograms/liter | 1 [a] | Parts/billion | Parts/billion | 1 [a] | Micrograms/liter |
| Micrograms/cubic meter | 1 [a] | Parts/trillion | Parts/trillion | 1 [a] | Micrograms/cubic meter |
| **Density** | | | | | |
| Grams/cubic centimeter | 62.428 | Pounds/cubic feet | Pounds/cubic feet | 0.016018 | Grams/cubic centimeter |
| Grams/cubic meter | 0.0000624 | Pounds/cubic feet | Pounds/cubic feet | 16,025.6 | Grams/cubic meter |
| **Length** | | | | | |
| Centimeters | 0.3937 | Inches | Inches | 2.54 | Centimeters |
| Meters | 3.2808 | Feet | Feet | 0.3048 | Meters |
| Kilometers | 0.62137 | Miles | Miles | 1.6093 | Kilometers |
| **Temperature** | | | | | |
| *Absolute* | | | | | |
| Degrees C + 17.78 | 1.8 | Degrees F | Degrees F - 32 | 0.55556 | Degrees C |
| *Relative* | | | | | |
| Degrees C | 1.8 | Degrees F | Degrees F | 0.55556 | Degrees C |
| **Velocity/Rate** | | | | | |
| Cubic meters/second | 2118.9 | Cubic feet/minute | Cubic feet/minute | 0.00047195 | Cubic meters/second |
| Grams/second | 7.9366 | Pounds/hour | Pounds/hour | 0.126 | Grams/second |
| Meters/second | 2.237 | Miles/hour | Miles/hour | 0.44704 | Meters/second |
| **Volume** | | | | | |
| Liters | 0.26418 | Gallons | Gallons | 3.78533 | Liters |
| Liters | 0.035316 | Cubic feet | Cubic feet | 28.316 | Liters |
| Liters | 0.001308 | Cubic yards | Cubic yards | 764.54 | Liters |
| Cubic meters | 264.17 | Gallons | Gallons | 0.0037854 | Cubic meters |
| Cubic meters | 35.314 | Cubic feet | Cubic feet | 0.028317 | Cubic meters |
| Cubic meters | 1.3079 | Cubic yards | Cubic yards | 0.76456 | Cubic meters |
| Cubic meters | 0.0008107 | Acre-feet | Acre-feet | 1233.49 | Cubic meters |
| **Weight/Mass** | | | | | |
| Grams | 0.035274 | Ounces | Ounces | 28.35 | Grams |
| Kilograms | 2.2046 | Pounds | Pounds | 0.45359 | Kilograms |
| Kilograms | 0.0011023 | Tons (short) | Tons (short) | 907.18 | Kilograms |
| Metric tons | 1.1023 | Tons (short) | Tons (short) | 0.90718 | Metric tons |
| **ENGLISH TO ENGLISH** | | | | | |
| Acre-feet | 325,850.7 | Gallons | Gallons | 0.000003046 | Acre-feet |
| Acres | 43,560 | Square feet | Square feet | 0.000022957 | Acres |
| Square miles | 640 | Acres | Acres | 0.0015625 | Square miles |

**a. This conversion is only valid for concentrations of contaminants (or other materials) in water.**

## METRIC PREFIXES

| Prefix | Symbol | Multiplication factor |
|---|---|---|
| exa- | E | 1,000,000,000,000,000,000 = $10^{18}$ |
| peta- | P | 1,000,000,000,000,000 = $10^{15}$ |
| tera- | T | 1,000,000,000,000 = $10^{12}$ |
| giga- | G | 1,000,000,000 = $10^{9}$ |
| mega- | M | 1,000,000 = $10^{6}$ |
| kilo- | k | 1,000 = $10^{3}$ |
| deca- | D | 10 = $10^{1}$ |
| deci- | d | 0.1 = $10^{-1}$ |
| centi- | c | 0.01 = $10^{-2}$ |
| milli- | m | 0.001 = $10^{-3}$ |
| micro- | μ | 0.000 001 = $10^{-6}$ |
| nano- | n | 0.000 000 001 = $10^{-9}$ |
| pico- | p | 0.000 000 000 001 = $10^{-12}$ |

# Summary

The National Nuclear Security Administration's (NNSA's) Global Threat Reduction Initiative (GTRI) is a vital part of the U.S. national security strategy of preventing the acquisition of nuclear and radiological materials for use in weapons of mass destruction (WMD) and other acts of terrorism. The GTRI mission is to reduce the amount of and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. In support of nonproliferation goals, NNSA conducts a Foreign Research Reactor (FRR) Spent Nuclear Fuel (SNF) Acceptance Program that recovers FRR SNF from foreign countries. The fuel eligible for recovery under this program was manufactured from U.S.-origin highly enriched uranium (HEU) and comes from countries specifically identified in the Record of Decision (ROD) for the *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 its Supplement Analyses (SAs) (DOE 1998a, 1998b, 2004a).[1] Analysis in the *FRR SNF EIS* is based on the receipt of about 19.2 metric tons (21.1 tons) of heavy metal (MTHM) of FRR SNF; current projections, however, indicate that the program will recover about 6.9 MTHM (7.6 tons) of FRR SNF.

NNSA has identified a category of material currently in foreign countries that presents a potential threat to nonproliferation goals and may not have adequate safe and secure management options; it is referred to as Gap Material SNF consisting of SNF containing non-U.S.-origin HEU and SNF containing U.S.-origin HEU that was not addressed in the *FRR SNF EIS*. If no other reasonable pathways are identified to address U.S. national security interests, such as return to secure locations in the countries of origin or other commercial disposition options, NNSA proposes to transport up to 1 MTHM (1,000 kilograms or 1.1 tons) of Gap Material SNF to the United States in accordance with applicable U.S. and international requirements. Gap Material SNF from countries other than Canada would be transported by chartered ship to the Charleston Naval Weapons Station (NWS), Charleston, South Carolina, and then transferred to truck or rail car for shipment to the Savannah River Site (SRS), Aiken, South Carolina, for storage in L-Basin pending ultimate disposition. Gap Material SNF from Canada would enter the United States near Alexandria Bay, New York, and be transported by truck or rail to SRS.

Council on Environmental Quality (CEQ) regulations at Title 40, Section 1502.9(c), of the *Code of Federal Regulations* (40 CFR 1502.9[c]) require that Federal agencies prepare a supplemental environmental impact statement (EIS) when the agency makes substantial changes in the Proposed Action or there are significant new circumstances or information relevant to environmental concerns. U.S. Department of Energy (DOE) regulations at 10 CFR 1021.314(c) direct that when it is unclear whether a supplemental EIS is required, an SA be prepared to assist in making that determination. Under the proposed action analyzed in this SA, procedures currently in place for receiving FRR SNF into the United States under the FRR SNF Acceptance Program would be extended to Gap Material SNF. Acceptance of Gap Material SNF would be contingent on the material complying with the acceptance criteria for the SRS facility at which it would be received and managed. Additionally, NNSA, working closely with DOE, would identify an expected disposition pathway for Gap Material SNF prior to acceptance.

Acceptance of Gap Material SNF would not cause the total quantity of SNF projected to be received under the FRR SNF Acceptance Program to exceed the estimates in the *FRR SNF EIS*. Impacts for

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*[1] The original record of decision (ROD) following the FRR SNF EIS was issued on May 17, 1996 (61 Federal Register [FR] 25092). Revised RODs were issued on July 19, 2000 (65 FR 44767) and December 1, 2004 (69 FR 69901). In addition, the ROD was revised on July 25, 1996, and August 25, 2008 (61 FR 38720 and 73 FR 50004, respectively), to provide greater flexibility in the locations where DOE takes title to FRR SNF, and on April 13, 1999 (64 FR 18006), to clarify the fee policy.*

incident-free transport of Gap Material SNF from overseas to the United States would be low, with no latent cancer fatalities (LCFs) predicted for the ship's crew. Considering experience with past shipments of FRR SNF, transport of Gap Material SNF would not be expected to cause collective ship crew doses to exceed the levels estimated in the *FRR SNF EIS*. NNSA, however, would extend the mitigation action plan (DOE 1996d) in place for FRR SNF to Gap Material SNF to ensure that individual crew member doses are maintained as low as reasonably achievable and less than 100 millirem in a year.

There would be negligible environmental impacts at Charleston NWS. Taking into account the probability of a severe port accident involving a shipment of Gap Material SNF (a ship collision followed by a fire), the risk of an LCF in the population surrounding Charleston NWS is estimated to be exceedingly low ($2 \times 10^{-10}$).

Impacts for incident-free overland transport of Gap Material SNF from Charleston NWS to SRS, or from the Canadian border to SRS, would be low, with no LCFs predicted to the transport crews or members of the public. A severe transportation accident involving the largest shipment of SNF is estimated to have an LCF risk of up to $7 \times 10^{-9}$ to populations for a truck shipment from Charleston NWS to SRS, or an LCF risk of up to $7 \times 10^{-8}$ to populations for a truck shipment from Alexandria Bay, New York, to SRS.

Because a small amount of Gap Material SNF may be physically and radiologically different from the SNF specifically addressed in the *FRR SNF EIS*, this SA includes a simple screening tool based on the total radionuclide inventory of the SNF to compare the Gap Material SNF to the *FRR SNF EIS* transportation impact analysis. Additionally, for fuel that may not meet the screening value, a more detailed screening method for comparing Gap Material SNF to the SNF analyzed in the *FRR SNF EIS* is presented. Additional NEPA analysis would be performed for proposed shipments that do not pass the screening evaluations.

Although it is not possible to predict the occurrence or exact nature of an intentional destructive act, the *FRR SNF EIS* addressed possible acts. In the current analysis, the *FRR SNF EIS* analysis was adjusted for the population of the Charleston NWS area and updated to reflect a conservatively projected population growth to the year 2020 and an updated risk factor of 0.0006 LCFs per person-rem. An intentional destructive act at the Charleston NWS is estimated to result in a population dose of 26,000 person-rem with an associated likelihood of 16 LCFs.

The consequences of a potential intentional destructive act while shipping Gap Material SNF for disposal in a geologic repository are expected to be comparable to those analyzed by DOE for shipment of commercial pressurized water reactor fuel to the Yucca Mountain geologic repository in the *Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Supplemental Yucca Mountain EIS)* (DOE 2008b). DOE assumed the attack would occur (probability of 1) and under conditions that would reasonably maximize the consequences. Such an attack in a generic urban area was estimated to result in a population dose of 47,000 person-rem for a truck cask and 32,000 person-rem for a rail cask. These doses could result in 28 and 19 LCFs, respectively.

With acceptance of Gap Material SNF, the total quantity of SNF projected to be managed at SRS would not exceed the estimates in the *FRR SNF EIS*. Working closely with DOE, NNSA would ensure that any Gap Material SNF accepted under the FRR SNF Acceptance Program would be compliant with the Authorization Basis for L-Basin, and that sufficient storage capacity would be available. The availability of storage capacity at L-Basin will depend on considerations other than Gap Material SNF acceptance, such as the timing of the proposed exchange of SNF between SRS and Idaho National Laboratory, and DOE decisions about the use of H-Canyon to recover and down-blend HEU from existing stored SNF for reuse in commercial nuclear reactors. If storage capacity is insufficient, one option would be to expand storage capacity within L-Basin. Expansion of storage capacity would be preceded by appropriate NEPA analysis.

Subsequent disposition of Gap Material SNF would not be expected to cause impacts outside the envelope of impacts addressed in the *FRR SNF EIS*, the *Savannah River Site Spent Fuel Management Final Environmental Impact Statement* (*SRS SNF Management EIS*) (DOE/EIS-0279) (DOE 2000a), and the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (*Yucca Mountain EIS*) (DOE/EIS-0250) (DOE 2002) and its Supplemental EISs (DOE 2008b, 2008c). No cumulative impacts are expected beyond those analyzed in the aforementioned documents.

Transportation and receipt of the Gap Material SNF would result in environmental impacts in the range of those analyzed in the *FRR SNF EIS*. The inclusion of 1 MTHM (1.1 tons) of Gap Material SNF would not constitute a substantial change in the *FRR SNF EIS* Proposed Action relevant to environmental concerns. As indicated by the analysis in this SA, there are no significant new circumstances or information relevant to environmental concerns related to the Proposed Action or its impacts within the meaning of 40 CFR 1502.9(c) and 10 CFR 1021.314. Therefore, neither a supplement to the *FRR SNF EIS*, nor a new EIS, is required.

# 1.0 Introduction

*NNSA proposes expansion of current efforts under the GTRI FRR SNF Acceptance Program to allow limited quantities of SNF containing U.S.- and non-U.S.-origin HEU to be recovered from foreign countries and managed at DOE sites in the United States. This SA addresses the environmental impacts associated with the transport of this Gap Material SNF to and within the United States and its subsequent disposition.*

This SA presents information to support an NNSA determination of whether the recovery and management of Gap Material SNF would represent a substantial change relevant to environmental concerns evaluated in previously prepared DOE EISs, or whether there are significant new circumstances or information relevant to environmental concerns related to the proposed initiative. Gap Material addressed in this SA consists of SNF[2] from foreign research reactors containing HEU of U.S. and non-U.S. origin. The CEQ regulations at 40 CFR 1502.9(c) require that Federal agencies prepare a supplement to an EIS when the agency makes substantial changes in the Proposed Action or there are significant new circumstances or information relevant to environmental concerns. The DOE regulations at 10 CFR 1021.314(c) direct that when it is unclear whether a supplement to an EIS is required, an SA be prepared to assist in making that determination.

This SA is based primarily on the *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). This SA also considers evaluations in the *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (SRS SNF Management EIS)* (DOE/EIS-0279) (DOE 2000a), and the *Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS)* (DOE/EIS-0250) (DOE 2002) and its supplemental EISs (DOE 2008b, 2008c).

## 1.1 Background

The NNSA's GTRI is a vital part of the U.S. national security strategy of preventing the acquisition of nuclear and radiological materials for use in WMD and other acts of terrorism. The GTRI mission is to reduce and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. GTRI has the goals of: (1) converting reactors from using WMD-usable HEU to low-enriched uranium (LEU), (2) removing or disposing of WMD-usable excess nuclear and radiological materials, and (3) protecting at-risk WMD-usable nuclear and radiological materials from theft and sabotage.

In support of the GTRI mission, NNSA conducts an FRR SNF Acceptance Program that recovers FRR SNF from foreign countries. The fuel eligible for recovery under this program is made with U.S.-origin HEU and comes from countries specifically identified in previous NEPA documents (DOE 1996a, 1998b, 2004a). Upon delivery to the United States, the SNF is sent to either the SRS or the Idaho National Laboratory (INL) for storage pending ultimate disposition (see 61 *Federal Register* [FR] 25092, 65 FR 44767, and 69 FR 69901).

NNSA has identified a category of material, called Gap Material SNF, that presents a potential threat to nonproliferation goals and may not have adequate safe and secure management options.[3] Gap Material

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[2] *Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation and whose constituents have not been separated.*

[3] *NNSA has also identified small quantities of separated weapons-usable plutonium in some foreign countries that may similarly present a potential threat to nonproliferation goals and may not have adequate safe and secure management options. Because this material is outside the scope of the analysis in the FRR SNF EIS, management options including transfer to the United States for safe and secure storage will be addressed in a separate NEPA analysis.*

SNF is currently in foreign countries and consists of SNF containing non-U.S.-origin HEU and SNF containing U.S.-origin HEU that was not previously addressed in the *FRR SNF EIS*. Gap Material SNF would be transported to the United States if its current management poses a threat to national security, is susceptible to use in an improvised nuclear device, presents a high risk or terrorist threat, and there is no other reasonable pathway (such as return to secure locations in the countries of origin or commercial disposition options) to assure security from theft or diversion. NNSA proposes to transport Gap Material SNF to the United States in accordance with applicable U.S. and international requirements. Gap Material SNF from most countries would be transported by chartered ship to the Charleston NWS, and then transferred to truck or rail car for shipment to SRS for storage pending ultimate disposition. Gap Material SNF from Canada would be transported overland (by truck or rail) to SRS.

A single ocean voyage may transport multiple casks of Gap Material SNF, which might be from more than one country. An ocean voyage shipping Gap Material SNF may also include packages containing materials covered under the existing FRR SNF Acceptance Program, including unirradiated enriched uranium or target material.[4] Any unirradiated enriched uranium included in a Gap Material shipment[5] would be sent to the Y-12 National Security Complex near Oak Ridge, Tennessee, unloaded, inspected, and transferred to a monitored storage location. The *Y-12 Site-Wide EIS* (DOE 2001) addresses overland transport to and management of unirradiated HEU at Y-12, and such activities are ongoing consistent with the decision announced in the ROD for that EIS (67 FR 11296).

## 1.2 Purpose and Need

Reducing the threat posed by the proliferation of nuclear weapons is a foremost goal of the United States. To continue to meet DOE's objective of reducing, and eventually eliminating, HEU from civil commerce worldwide, DOE needs to extend its FRR SNF Acceptance Policy to Gap Material SNF, which is not currently covered under the policy. This Gap Material SNF consists of up to 1 metric ton (1,000 kilograms or 1.1 tons) of heavy metal (MTHM) containing HEU that is either non-U.S.-origin or is of U.S.-origin but was not addressed previously in the *FRR SNF EIS*.

## 1.3 Related National Environmental Policy Act Documents

### 1.3.1 U.S. Policy for Acceptance of Foreign Research Reactor Spent Nuclear Fuel

The FRR SNF Acceptance Program has been in operation since 1996, and is being managed by NNSA as part of GTRI. Under the Acceptance Policy, the United States accepts target material and the following material containing uranium of U.S. origin (61 FR 25092):

- SNF from research reactors operating on LEU fuel or in the process of converting from HEU fuel to LEU fuel when the policy became effective (May 13, 1996);
- SNF from reactors operating on HEU fuel when the policy became effective, but that agree to convert to LEU fuel;
- HEU SNF from research reactors having lifetime cores, research reactors planning to shut down while the policy is in effect, and research reactors for which no suitable LEU fuel is available;

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[4] *A target is a tube, rod, or other form containing material that, on being irradiated in a nuclear reactor would produce a desired end product (e.g., molybdenum-99). The target material addressed in the FRR SNF EIS is the residual material following removal of the desired end product.*

[5] *A package (cask) of SNF would contain a much larger radionuclide inventory than a package of unirradiated enriched uranium. The transport packages would have higher radiation levels and the impacts of a release would be larger for SNF than for unirradiated enriched uranium.*

- SNF from research reactors that had already shut down before May 1996; and
- Unirradiated HEU or LEU fuel from eligible research reactors.

In the *FRR SNF EIS*, DOE and the Department of State considered the potential environmental impacts of the disposition of aluminum-based[6] and TRIGA[7] FRR SNF containing uranium enriched in the United States and target material. The *FRR SNF EIS* addressed U.S. receipt of 22,700 spent fuel elements from 41 countries, shipped in 837 transport casks. Environmental impacts addressed in the *FRR SNF EIS* included those from marine transport of FRR SNF from overseas points-of-origin to U.S. ports, overland transportation of FRR SNF from U.S. ports to SNF management sites, overland transportation of some FRR SNF from Canada, and management of FRR SNF at DOE sites until its ultimate disposition. Disposition alternatives evaluated in the *FRR SNF EIS* included disposal in a geologic repository and separation of HEU from FRR SNF or unirradiated fuel using chemical separations facilities at SRS and INL.[8] The separated HEU would be down-blended to LEU for use as fuel in commercial nuclear reactors and would ultimately be disposed of in a geologic repository. Overland transport of TRIGA FRR SNF from SRS to INL was also analyzed (DOE 1996a).

In a May 17, 1996, Record of Decision (ROD) based on the *FRR SNF EIS* (61 FR 25092), DOE announced that it was implementing the FRR SNF Acceptance Policy and would accept about 19.2 MTHM (21.1 tons) of FRR SNF (consisting of about 18.2 MTHM [20 tons] of aluminum-based SNF and about 1 MTHM [1.1 tons] of TRIGA fuel) and 0.6 MTHM (0.66 tons) of target material over a 13-year period. The United States would take title to the FRR SNF or target material after it had been unloaded from a ship at the U.S. port of entry, or at the continental border for shipments from Canada. Most SNF would be received from abroad through the Charleston NWS in South Carolina and the Concord NWS in California. Most of the target material and some SNF would be received overland from Canada. After a limited period of interim storage, the SNF would be treated and packaged as necessary to prepare it for transport to a final repository. In addition, DOE discussed four broad SNF management technologies in the ROD: wet storage, dry storage, chemical separation, and development of new treatment and/or packaging technologies to prepare the FRR SNF for disposal in a geologic repository. DOE announced that it would pursue technologies that would put the FRR SNF in a form or container that would be eligible for direct disposal in a geologic repository; but if a new treatment or packaging technologies were not available by the year 2000, DOE would consider chemical separation of some of the FRR SNF and blending down the recovered uranium to LEU.

Since May 1996, DOE/NNSA has prepared 3 other SAs of the *FRR SNF EIS* and has published announcements and revisions to the ROD in the *Federal Register*. The first SA (DOE/EIS-0218-SA1) determined that no further NEPA review was required for using a different route from Concord, California, to INL than the reference route evaluated in the *FRR SNF EIS* (DOE 1998a). A revised ROD was not issued following this SA.

The second SA (DOE/EIS-0218-SA-2) (DOE 1998b) examined the impacts of accepting FRR SNF under scenarios not specifically examined in the *FRR SNF EIS*: (1) accepting FRR SNF from research reactors not specifically mentioned in the *FRR SNF EIS*, but within the set of countries identified in the EIS; (2) accepting SNF from specific countries in quantities greater than those identified for that country, but within the overall numbers specified in the *FRR SNF EIS* and ROD; and (3) transporting more than 8 casks of SNF on a single ocean-going vessel. In the SA, DOE noted that all shipments had been made on chartered vessels having a single hold containing from 2 and 8 casks. DOE determined that the risks

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[6] *Aluminum-based fuel is aluminum-clad and has an active fuel region consisting of an alloy of uranium and aluminum or a dispersion of uranium-bearing compound (e.g., UAlx, $U_3O_8$, $U_3Si_2$, $U_3Si$) in aluminum (DOE 1996a).*

[7] *TRIGA refers to Training, Research, Isotopes, General Atomics. It is a pool-type reactor composed of uranium-zirconium-hydride fuel clad in stainless steel or Alloy 800. Originally designed to use HEU, newer designs can use LEU (GA 2008).*

[8] *Chemical separation of uranium from SNF is currently not being performed at INL.*

from a possible accident would not increase, regardless of the possible transport of up to 16 casks on a single vessel, because at most, only one cask could be breached during a severe accident. The SA concluded that accepting SNF under these scenarios would not constitute substantial changes or significant new circumstances or information relevant to environmental concerns (DOE 1998b). A revised ROD was published on July 19, 2000, to allow up to 16 casks of SNF on a single vessel transporting FRR SNF to the United States (65 FR 44767).

The third SA (DOE/EIS-0218-SA-3) (DOE 2004a) evaluated a proposal to extend the cutoff date for irradiation and return of a limited amount of FRR SNF (not to exceed the approximately 20 MTHM (22 tons) originally eligible) and to include SNF from the Replacement Research Reactor in Australia. DOE determined that extending the policy by up to 10 years (through May 12, 2019) and accepting an additional 96 elements from the Australian Replacement Research Reactor (compared to the 22,700 elements analyzed in the *FRR SNF EIS*), would not present a substantial change or significant new circumstances or information relevant to environmental concerns. The revised ROD was published on December 1, 2004 (69 FR 69901).

On July 25, 1996, and August 25, 2008, DOE revised the ROD to provide the FRR SNF Acceptance Program greater flexibility about the locations where DOE would take title to FRR SNF (61 FR 38720 and 73 FR 50004, respectively).[9] Also, on April 13, 1999, DOE announced a clarification to the fee policy in the event of a change in the economic status of the country from which the SNF would be shipped (64 FR 18006).

### 1.3.2 Additional NEPA Analyses

A number of options were considered and analyzed in the *FRR SNF EIS* for interim storage, treatment, and packaging of FRR SNF before its ultimate disposition. Although the May 17, 1996, ROD announced that FRR SNF would be transported ultimately to a geologic repository, DOE also announced that it would consider chemical separation of some of the FRR SNF and down-blending the recovered uranium to LEU (61 FR 25092). Additional NEPA analyses addressing the disposition of FRR SNF and other SNF include:

- *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (Programmatic SNF & INL EIS)*, issued in April 1995 (DOE/EIS-0203) (DOE 1995a).
- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (SRS SNF Management EIS)*, issued in March 2000 (DOE/EIS-0279) (DOE 2000a).
- *Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, (Yucca Mountain EIS)* (DOE/EIS-0250), issued in February 2002 (DOE 2002).
- *Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Supplemental Yucca Mountain EIS)* (DOE/EIS-0250F-S1), issued in June 2008 (DOE 2008b).
- *Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada – Nevada Rail Transportation Corridor (DOE/EIS-0250F-S2) and Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a*

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[9] *This change could allow the U.S. to take title to FRR SNF within a foreign country. In such instances, movement of FRR SNF from a nuclear facility to a port of departure for shipment to the United States would be performed in compliance with applicable laws and regulations.*

*Geologic Repository at Yucca Mountain, Nye County, Nevada (DOE/EIS-0369) (Rail Corridor SEIS and Rail Alignment EIS)*, issued in June 2008 (DOE 2008c).

Additional NEPA analyses have addressed shipment to and storage of unirradiated enriched uranium at the Y-12 National Security Complex (DOE 1995b, 1996b, 2001, 2006) and down-blending and dispositioning HEU (DOE 1996c, 2007a).

***Disposition of SNF***—Following the *Programmatic SNF & INL EIS* (DOE 1995a), on June 1, 1995, DOE announced its decision to regionalize management of SNF by fuel type at the Hanford Site, INL, and SRS; this decision included shipping aluminum-based fuel stored at INL to SRS, and non-aluminum-based fuel stored at SRS to INL (SRS-INL fuel exchange) (60 FR 28680). DOE also decided to manage about 1 MTHM (1.1 tons) of TRIGA FRR SNF at INL. After interim storage, the SNF would be treated and packaged at INL as necessary to prepare it for transport to a geologic repository for disposal. DOE also decided to manage about 18.2 MTHM (20 tons) of aluminum-based FRR SNF at SRS.

The *SRS SNF Management EIS* evaluated the potential environmental impacts associated with alternative technologies that could be used to prepare about 48 MTHM (53 tons) of aluminum-based SNF at SRS for disposition, including about 18.2 MTHM (20 tons) of FRR SNF (DOE 2000a). The *SRS SNF Management EIS* also evaluated the management of non-aluminum-based SNF, including TRIGA FRR SNF stored or expected to be stored at SRS and expected to be transferred to INL in accordance with the ROD (60 FR 28680) for the *Programmatic SNF & INL EIS* (DOE 1995a). In the August 7, 2000, ROD for the *SRS SNF Management EIS* (65 FR 48224), DOE announced its decision to manage about 60 percent (by mass) of the aluminum-based SNF (including all of the aluminum-based FRR SNF) using the melt and dilute technology to prepare the fuel for disposal in a geologic repository, to stabilize the remaining 40 percent of the aluminum-based SNF using conventional chemical separations processes, to continue to wet-store some material, and to ship about 20 MTHM (22 tons) of non-aluminum based SNF to INL. A treatment and storage facility would be constructed at L-Area in SRS to process the SNF and then store the processed SNF pending disposal. DOE has not implemented the decision in the ROD to use melt and dilute technology to manage SNF, and instead is contemplating the use of H-Canyon for separation and recovery of HEU contained in research reactor returns and certain other SNF. DOE would prepare additional NEPA analyses, as appropriate, before making a decision.

***Transport and Disposal of SNF and High-Level Radioactive Waste***—Geologic disposal of FRR SNF was analyzed in the *Yucca Mountain EIS* issued in February 2002 (DOE 2002). The EIS evaluates the potential environmental impacts associated with constructing, operating, and closing a repository and those associated with transporting materials to the Yucca Mountain geologic repository from various storage locations, including SRS and INL. In 2008, DOE issued the *Supplemental Yucca Mountain EIS* (DOE 2008b), which evaluates the potential environmental impacts from constructing, operating, and closing the repository under its current design and operational plans, and updates the analysis and potential environmental impacts of transporting SNF and high-level radioactive waste to the repository. In 2008, DOE also issued the *Rail Corridor SEIS and Rail Alignment EIS* (DOE 2008c), which evaluates the potential environmental impacts from constructing and operating a railroad for shipments of SNF and high-level radioactive waste from an existing rail line in Nevada to the repository.

***Shipment and Storage of Unirradiated Enriched Uranium***—The potential environmental impacts associated with storage of unirradiated enriched uranium are addressed in other NEPA documents including the *Environmental Assessment for the Proposed Interim Storage of Enriched Uranium Above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee (Y-12 Interim Storage EA)* (DOE/EA-0929) (DOE 1995b),[10] the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (*S&D PEIS)* (DOE/EIS-0229) (DOE 1996b), and the

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[10] *In addition to other HEU, the Y-12 Interim Storage EA addressed storage of up to 5 metric tons (5.5 tons) of foreign HEU, including U.S.- and non-U.S.-origin HEU (DOE 1995b).*

*Site-Wide Environmental Impact Statement for the Y-12 National Security Complex (Y-12 Site-Wide EIS)* (DOE/EIS-0309) (DOE 2001).[11] The *Y-12 Site-Wide EIS* also addressed the potential environmental impacts associated with overland transport of unirradiated enriched uranium to the Y-12 National Security Complex, and subsequent receipt, unloading, and transfer of the material into storage. A 2006 SA of the *Y-12 Site-Wide EIS* analyzed the potential environmental impacts of air and ocean transport of up to 5 metric tons (5.5 tons) of enriched uranium between foreign nations and the United States over a period of about 10 years (DOE/EIS-0309-SA-2) (DOE 2006). The SA concluded that there were no significant new circumstances or information relevant to environmental concerns and that neither a supplement to the *Y-12 Site-Wide EIS* nor a new EIS was needed.

***HEU Down-blend and Disposition***—The potential environmental impacts associated with DOE's program for HEU down-blending were addressed in the *Disposition of Surplus Highly Enriched Uranium Environmental Impact Statement* (*HEU Disposition EIS*) (DOE/EIS-0240) (DOE 1996c). DOE's current planned and proposed disposition path for 21 metric tons (23 tons) of surplus HEU is to process it in the H-Canyon facilities at SRS, blending the HEU to an LEU solution, and transferring the LEU solution to an end user for fabrication into commercial nuclear reactor fuel (DOE 2008a, SRS 2007). A portion of this surplus HEU is contained in DOE's current inventory or projected receipts of aluminum-clad SNF (DOE 2008a). The strategy for processing SNF through H-Canyon is currently under review to evaluate other disposition alternatives.

In the *Supplement Analysis for the Disposition of Surplus Highly Enriched Uranium* (DOE/EIS-0240-SA1), issued in October 2007 (DOE 2007a), DOE evaluated a proposal to implement new initiatives and modify elements of the existing surplus HEU disposition program. The proposed actions included: (1) supplying new end-users with LEU from surplus HEU (about 17.4 metric tons [19.2 tons]); (2) down-blending additional quantities of HEU (about 20 metric tons [22 tons]), including HEU from domestic and foreign research reactor SNF returns; and (3) establishing new disposition pathways for HEU discard material (about 18 metric tons [19.8 tons]). DOE proposed to directly dispose of the HEU discard material. About 15 metric tons (16.5 tons) of HEU SNF stored at INL would be disposed of in a geologic repository and about 3 metric tons (3.3 tons) of unirradiated HEU would be disposed of as low-level radioactive waste (DOE 2007a). An amended ROD has not been issued.

## 1.4 Proposed Action

DOE proposes to bring Gap Material SNF to the United States for management if the material poses a threat to national security, is susceptible for use in an improvised nuclear device, presents a high risk of terrorist threat, and has no other reasonable pathway to assure security from theft or diversion. DOE proposes to revise the FRR SNF Acceptance Program to include transport of Gap Material SNF from FRR locations to the United States if the material meets the above criteria and safely store Gap Material SNF at the DOE Savannah River Site in South Carolina pending ultimate disposition. Gap Material SNF consists of up to 1 MTHM (1,000 kilograms or 1.1 tons) of SNF containing either non-U.S.-origin HEU or U.S.-origin HEU that was not addressed in the *FRR SNF EIS*. The total amount of potentially eligible SNF under the FRR SNF Acceptance Program would remain unchanged from the 19.2 MTHM (21.1 tons) of SNF analyzed in the *FRR SNF EIS* and cited in the May 17, 1996 (61 FR 25092) ROD announcing the FRR SNF Acceptance Policy.

### 1.4.1 Locations and Characteristics of Gap Material Spent Nuclear Fuel

Countries currently identified as possessing Gap Material SNF are shown in **Table 1–1**. Characteristics, facilities, and vulnerability concerns for these materials are summarized in Attachment 1 (classified). With the exception of three countries, the countries currently identified as possessing Gap Material SNF

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[11] *Storage of any unirradiated enriched uranium received as part of the proposed action is covered by decisions reached from the Y-12 Interim Storage EA, S&D PEIS, and Y-12 Site-Wide EIS (60 FR 54068, 62 FR 3014, and 67 FR 11296, respectively).*

were included in the *FRR SNF EIS*. The currently identified material totals approximately 0.35 MTHM (350 kilograms or 770 pounds) of SNF. Because additional countries and nuclear facilities may be identified in the future, this SA addresses the potential transport and receipt of up to 1 MTHM (1,000 kilograms or 1.1 tons) of Gap Material SNF. This SA assumes that about 0.8 MTHM (800 kilograms or 1,760 pounds) would be shipped via ocean vessel in approximately 70 transport casks. This material would be fuel having a form acceptable for receipt and storage at SRS. All casks would be contained within standard International Standards Organization (ISO) containers for ocean transport. This SA also assumes that about 0.2 MTHM (200 kilograms or 440 pounds) would be shipped overland from Canada in approximately 50 transport casks. **Figure 1–1** shows transportation routing for Gap Material SNF. Incidental amounts of unirradiated HEU or SNF containing LEU could be accepted along with the SNF containing HEU – the environmental impacts of including those materials would be within those analyzed for the SNF under this SA.

**Table 1–1 Currently Identified Countries with Gap Material Spent Nuclear Fuel**

| *Country* | *Country Considered in the FRR SNF EIS?* | *Estimated Number of Transport Casks for Gap Material SNF* | *Country* | *Country Considered in the FRR SNF EIS?* | *Estimated Number of Transport Casks for Gap Material SNF* |
|---|---|---|---|---|---|
| Canada | Yes | 41 | Nigeria | No | 1 |
| Chile | Yes | 1 | Pakistan | Yes | 1 |
| Denmark | Yes | 1 | South Africa | Yes | 18 |
| Ghana | No | 1 | Syria | No | 1 |
| Iran | Yes | 1 | United Kingdom | Yes | 2 |
| Italy | Yes | 1 | Venezuela | Yes | 3 |
| Japan | Yes | 5 | | | |

*FRR SNF EIS* = *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (DOE 1996a), SNF = spent nuclear fuel.
Source: GTRI 2008.

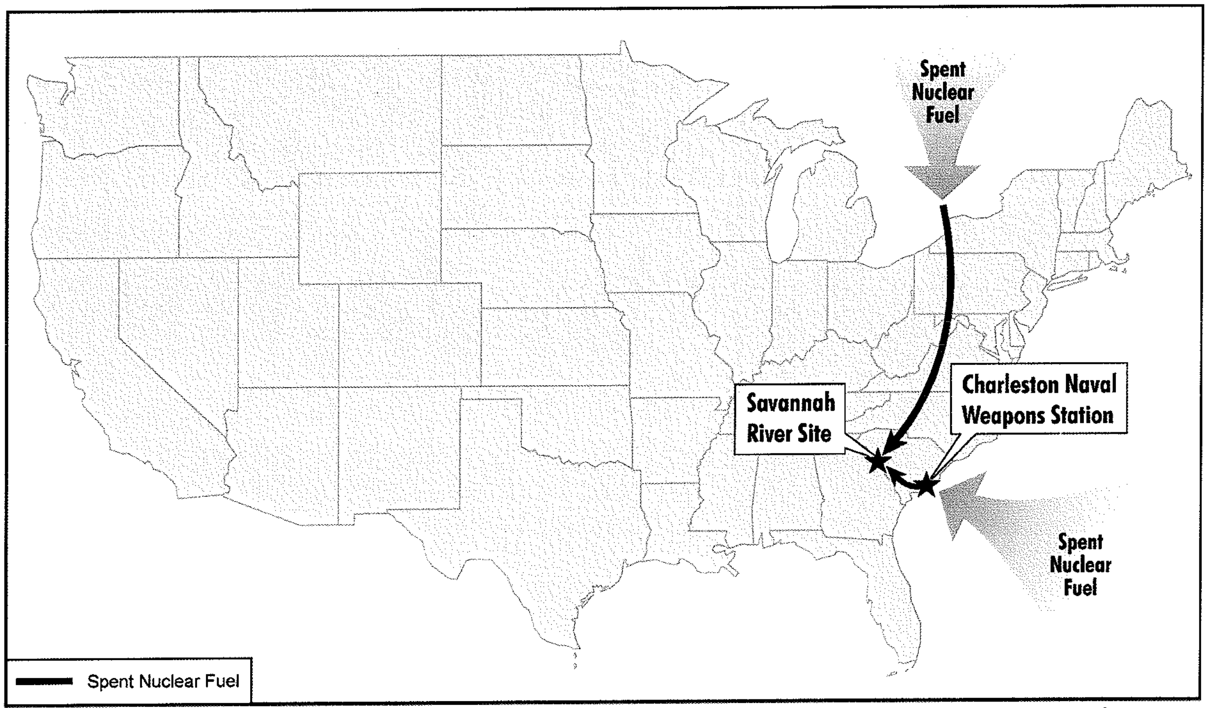

**Figure 1–1 Proposed Shipment of GTRI Gap Material Spent Nuclear Fuel to the United States**

The physical forms of the Gap Material SNF are expected to be generally consistent with the forms described in Appendix B, Section B.1.3, of the *FRR SNF EIS* (DOE 1996a). Gap Material SNF is expected to consist of aluminum-based fuel configured as plates, concentric tubes, pins, rods, annular designs, or other forms. Gap Material SNF may, however, include fuel of different designs than those described in Section B.1.3. Gap Material SNF may be accepted by the FRR SNF Acceptance Program provided that the fuel is compatible with the acceptance criteria for the SNF storage facility, and that sufficient storage capacity exists at the facility pending disposition.

**Table 1–2** summarizes the number of fuel elements, initial mass of uranium, and number of casks that were projected in the *FRR SNF EIS* (DOE 1996a); are currently projected by the FRR SNF Acceptance Program through May 2019 (GTRI 2008); and are estimated for Gap Material SNF. The number of fuel elements is uncertain, in part because there is a large variation in the designs (e.g., what constitutes a fuel assembly vs. a single element) and sizes of fuel elements. It was assumed that each cask from Canada would contain 2 fuel elements and that Miniature Neutron Source Reactor elements would be shipped and stored as complete core assemblies rather than individually. Therefore, a large number of casks shipping Gap Material SNF are projected to contain only a few fuel elements or assemblies per cask. Most of the remaining identified Gap Material SNF elements are projected to be similar to Materials Test Reactor (MTR) elements, which are larger in size and would be stored individually. Given these assumptions, receipt of Gap Material SNF would not be expected to cause the total receipt of SNF (including Gap Material SNF) to exceed the number of fuel elements, initial mass of uranium, or number of transport casks evaluated in the *FRR SNF EIS*.

Consistent with the *FRR SNF EIS*, the accident analysis for Gap Material SNF coming from overseas assumes a bounding inventory of radioactive material of 1.26 million total curies. This inventory is based on a cask containing 36 fuel elements of Belgian Reactor 2 (BR-2) fuel; the specific radionuclide inventory is included in the *FRR SNF EIS,* Appendix B (DOE 1996a).[12] Also consistent with the *FRR SNF EIS*, the accident analysis for a cask of Gap Material SNF coming from Canada is based on an inventory of 833,000 total curies; this represents a cask containing 24 fuel elements of Canadian National Research Universal (NRU) reactor fuel; the specific radionuclide inventory is also included in the *FRR SNF EIS,* Appendix B (DOE 1996a).

Gap Material SNF may have a different isotopic distribution than that assumed for the *FRR SNF EIS* analysis; however, an SNF shipment, regardless of type, uranium-235 loading, burnup, or cooling time that has no more than about 500,000 curies of fission products would be enveloped by the BR-2 or NRU accident analysis without further details on the specific isotopic content. This estimate is based on a quantitative comparison of the relative radioactive source terms and inhalation effective dose equivalent for the four types of SNF analyzed in the *FRR SNF EIS.* These fuel designs constitute a range of fuel and cladding materials, geometries, uranium-235 loading, burnup, and cooling times. In an analysis of FRR SNF casks received under the FRR SNF Acceptance Program from 1996 to 2004, the largest activity contained in these casks was 470,000 curies (DOE 2004a), while from August 2004 through September 2008, the largest cask activity in a sample of casks was about 711,000 curies (GTRI 2008). Additional analysis would be performed as needed for proposed shipments that would not be enveloped by the accident analysis.

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[12] *This SNF consists of 93 weight percent uranium-235 in a uranium-aluminum alloy clad with aluminum and assumed to have a 70 percent atomic burnup and a cooling time of 300 days for the purpose of determining fission product activity. The initial uranium-235 loading of each fuel element was 400 grams (or 14.4 kilograms (31.7 pounds) for 36 fuel elements) (DOE 1996a, IAEA 1989).*

## Table 1–2 Comparison of Number of Fuel Elements, Initial Mass of Uranium, and Number of Spent Nuclear Fuel Casks

| *Parameter* | *Ocean Transport to United States, Aluminum-Based SNF* | *Overland Transport from Canada to United States, Aluminum-Based SNF* | *Ocean Transport to United States, TRIGA SNF* | *Total* |
|---|---|---|---|---|
| **Fuel Elements** | | | | |
| Initially Projected for Acceptance in the *FRR SNF EIS* | 14,972 | 2,831 | 4,940 | 22,743 |
| Currently Projected for Acceptance by May 2019 | 9,085 | 140 | 4,315 | 13,540 |
| Gap Material SNF Fuel Elements | 2,000 [a, b] | 100 | 0 | 2,100 |
| Total Number of Fuel Elements if Proposed Action is Implemented | 11,085 | 240 | 4,315 | 15,640 |
| **Mass of Uranium (MTHM)** | | | | |
| Initially Projected for Acceptance in the *FRR SNF EIS* | 13.706 | 4.478 | 1.033 | 19.217 |
| Currently Projected for Acceptance by May 2019 | 5.985 | 0.028 | 0.842 | 6.855 |
| Gap Material SNF Uranium | 0.8 | 0.2 | 0 | 1.0 |
| Total Mass of Uranium if Proposed Action is Implemented | 6.785 | 0.228 | 0.842 | 7.855 |
| **Casks** | | | | |
| Initially Projected for Acceptance in *FRR SNF EIS* | 559 | 116 | 162 | 837 |
| Currently Projected for Acceptance by May 2019 | 318 | 5 | 137 | 460 |
| Gap Material SNF Casks | 70 | 50 | 0 | 120 |
| Total Number of Casks if Proposed Action is Implemented | 388 | 55 | 137 | 580 |

*FRR SNF EIS* = *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel*, MTHM = metric tons of heavy metal, SNF = spent nuclear fuel, TRIGA = Training, Research, Isotopes, General Atomic.

[a] A small quantity of this material may be unclad or clad in material different than aluminum.

[b] Assuming storage of Miniature Neutron Source Reactor fuel as a complete core assembly rather than individual elements.

Note: Totals may not precisely add because of rounding. To convert metric tons to tons, multiply by 1.1023.

Sources: DOE 1996a, GTRI 2008.

Gap Material SNF for which the following formula is true would be bounded by the *FRR SNF EIS* accident analysis:

$$F \sum A_i D_i RF_i < 1$$

*Where:*

**F** is a factor in units of rem/curie per sievert/becquerel per rem. For the BR-2 fuel, F is $2.02 \times 10^6$, obtained by dividing $3.7 \times 10^{12}$ (a factor to convert sieverts per becquerel to rem per curie) by $1.83 \times 10^6$ (the inhalation "effective dose equivalent" in units of rem from an accident involving the entire inventory of a fully-loaded cask containing BR-2 SNF). For NRU fuel, F is $1.37 \times 10^6$, obtained by dividing $3.7 \times 10^{12}$ (a factor to convert sieverts per becquerel to rem per curie) by $2.71 \times 10^6$ (the inhalation "effective dose equivalent" in units of rem from an accident involving the entire inventory of a fully-loaded cask containing NRU SNF). These factors are based on the most conservative inhalation retention factors from *Federal Guidance Report Number 11* (EPA 1988);

$\mathbf{A_i}$ is the quantity of the ith isotope in the shipment in units of curies; and

**$D_i$** is the effective dose equivalent dose conversion factor for the ith isotope in the shipment, for the inhalation pathway in units of sieverts per becquerel, as obtained from Table 2.1 of *Federal Guidance Report Number 11* (EPA 1988).

**$RF_i$** is the Release Fraction (unitless) for the ith isotope in the shipment as follows (DOE 1996a, Table D-21):

| | |
|---|---|
| Cobalt | 0.012 |
| Krypton | 0.1 |
| Tritium | 0.1 |
| Cesium | 0.00098 |
| Ruthenium | 0.000042 |
| Particulates | 0.00000005 |

Gap Material SNF could include unprocessed targets. Shipments of unprocessed targets would be acceptable provided that the potential accident impact hazard represented by the targets would be enveloped by the hazard represented by a shipment of the BR-2 or NRU fuel, as determined using the screening process described above.

### 1.4.2 Description of Transportation Activities and Storage at Department of Energy Sites

Acceptance of Gap Material SNF would occur in accordance with processes implemented to ensure compliance with DOE and international requirements. Shipments of Gap Material SNF would be made under the condition that the Gap Material SNF would comply with the acceptance criteria of the SRS facility receiving the Gap Material SNF (assumed to be L-Basin), and that sufficient storage capacity exists at SRS pending disposition of the material.

The process for Gap Material SNF acceptance would be the same as that for other FRR SNF. At least 180 days before the tentative shipping date, DOE would require a contract or agreement between DOE, representing the U.S. Government, and authorized representatives of the countries or nuclear facilities possessing the Gap Material SNF. This contract or agreement would provide for transfer of ownership of the Gap Material SNF to the U.S. Government. As addressed in the revisions to the original *FRR SNF EIS* ROD (see Section 1.3.1), the location where transfer of ownership would occur would be specified on a case-by-case basis in the individual contracts. A detailed description of the nuclear material would be submitted, including drawings, fuel dimensions and weights, its chemical form and cladding, the isotopic content, the fuel irradiation specifications, specific fuel element identification numbers, transport cask and internal basket data, and other information (DOE 2007b). Before shipment, teams of DOE or authorized contractor personnel would conduct site visits to perform detailed fuel examinations and facility and infrastructure assessments. Assuming satisfactory resolution of any identified issues and receipt of all required data, shipment of the SNF would be scheduled and coordinated as needed with other shipments of FRR SNF.[13]

Transport of Gap Material SNF would occur in accordance with applicable national and international requirements for safety and safeguards. Gap Material SNF would be placed in casks, Type B packaging that complies with U.S. and international standards for safe transport of radioactive materials. These standards include International Atomic Energy Agency (IAEA) Safety Standard Series Number TS-R-1, *Regulations for the Safe Transport of Radioactive Material* (IAEA 2005), and 10 CFR Part 71, *Nuclear Regulatory Commission Regulations for Packaging and Transportation of Radioactive Materials*.

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[13] *A similar program is in place for acceptance of unirradiated enriched uranium under the existing FRR SNF Acceptance Program, and this program would be extended to any Gap Material consisting of unirradiated enriched uranium.*

Type B packaging must be designed and tested to withstand the conditions of normal transport as well as accident conditions.[14]

A full cask can carry from 1 to over 100 SNF elements, depending on fuel element design, size, and cask capacity (DOE 1996a, GTRI 2008). Several different types of casks may be considered for Gap Material SNF, provided that the cask is certified for use both in the country of origin and the United States. Casks differ in terms of characteristics such as dimensions, weight, the type and quantity of SNF accommodated, the minimum fuel cooling time before shipment, the maximum activity, and the maximum uranium-235 content of each element. The selection of a particular cask would depend on the characteristics of the SNF to be shipped, the specific certification requirements for the cask, physical limitations at the SNF origin and receiving sites, availability, and other factors. Some Gap Material SNF could require removal of non-fuel-bearing sections before placement in casks, or development and certification of special internal structures, called baskets, that hold the SNF in place during shipment.

The shipping contractor and countries shipping Gap Material SNF would be responsible for arranging for transport packaging and casks, packaging and loading the Gap Material SNF into transport vehicles, complying with national safety and security requirements, coordinating with local and national officials, obtaining the necessary export approvals, making any needed transit arrangements with countries through whose territorial waters ships may pass, and other needed activities. DOE or contractor personnel may be present to inspect packaging or cask loading operations. Casks of Gap Material SNF would be secured for ocean transit within ISO containers.

At the port of departure, the ISO containers would be hoisted onto a chartered ship and safely secured in the ship's hold for transport to the United States (**Figure 1–2**). Shipment to the United States would occur in accordance with a security plan that would include a current threat assessment of the sea route and its alternatives. En route, the ship may stop at other ports to receive additional nuclear material. During the voyage, the cargo would be inspected to ensure that containers remain safely secured within the vessel.

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 INF Code classification of the ship, where an INF Class 1 vessel is certified to carry INF cargo having an aggregate activity less than 108,000 curies; an INF Class 2 vessel is certified to carry irradiated nuclear fuel or high-level radioactive waste having an aggregate radioactivity less than 54 million curies, and plutonium with an aggregate radioactivity less than 5.4 million curies; and an INF Class 3 vessel is certified to carry irradiated nuclear fuel, high-level radioactive waste, 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).

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[14] *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 subcriticality). There must be no substantial loss of function of the package even after being subject to a series of tests that are conducted sequentially. These tests simulate being dropped from 9.1 meters (30 feet) onto an unyielding surface; being crushed or punctured, being exposed to a high heat (a temperature of at least 800° C or 1,475°F), as from a fire, for 30 minutes; or immersion in water.*

Figure 1–2 Nuclear Material in an ISO Container Secured within the Hold of a Ship

Consistent with current practice for FRR SNF, the vessels used for marine transport of Gap Material SNF would meet the requirements of an INF Class 2 or 3 vessel, as appropriate. The choice of vessel would depend on factors such as the radionuclide inventory of the SNF, safety, security, availability, and cost. Security provisions (e.g., satellite tracking systems monitored continuously) would be incorporated on a graded basis depending on the category of the nuclear material carried, in accordance with IAEA's *Physical Protection of Nuclear Material and Nuclear Facilities* (INFCIRC/225/Rev.4) (IAEA 1999).[15] Operators of chartered ships specifically for shipment of radioactive materials, such as the INF Class 3 vessels operated by Pacific Nuclear Transport Limited,[16] would conduct activities in accordance with radiation protection principles. Technical and administrative controls would be imposed to limit radiation doses to crew members.[17] These controls may be less extensive for INF Class 2 chartered vessels.

At the port of entry, the necessary number of exclusive-use trucks would be parked at a secure location awaiting the arrival of the ocean vessel. (Alternatively, the necessary number of rail cars would be waiting at a secure railroad siding.) Upon arrival, the Gap Material SNF containers would be removed from the ship's hold. Workers would enter the hold, remove the tie-downs that secured the containers for the ocean voyage, attach rigging, remove the containers from the hold using a crane, and place the containers on the dock. At dockside, the rigging would be removed and the containers would be inspected. Containers holding casks of Gap Material SNF would be loaded and secured onto the transport vehicles (exclusive use trucks or rail cars). The transport vehicles would then proceed to the DOE site.

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[15] *Although the INF Code focuses on marine safety, the design and operational provisions imposed for INF ships would toughen them against the consequences from possible acts of terrorism or sabotage.*

[16] *These ships include features such as double hulls; collision damage resisting structures within the hull; twin engines, propellers, and rudders, and backup power generators in the bow and stern (PNTL 2005).*

[17] *A crew member of a chartered vessel may be considered a member of the public to which DOE dose limits in DOE Order 5400.5 would be applicable. This DOE Order limits the effective dose equivalent to a member of the public from exposures received from DOE activities to 100 millirem in a single year. Crew members considered to be radiation workers would have larger allowable dose limits (up to 5 rems in a single year). The mitigation measures implemented under the FRR SNF Acceptance Program would ensure that no crew member considered a member of the public would receive a dose exceeding 100 millirem in a year (see Section 2.2.1).*

At SRS, casks of Gap Material SNF would be removed from the ISO containers and inspected. The SNF would be removed from the casks and placed in secure storage configurations. Storage of SNF at SRS would be at L-Basin in L-Area (see Section 1.4.3.2).

Storage of aluminum-based SNF would continue pending disposition. Disposition could involve disposal in a geologic repository or inclusion in DOE's Enriched Uranium Disposition Project, in which HEU would be separated from the SNF, then blended down to LEU for use in commercial nuclear reactors. Such separation of the SNF would be subject to completion of appropriate NEPA review.

Any unirradiated enriched uranium included in a Gap Material shipment would be sent to the Y-12 National Security Complex, unloaded, inspected, and transferred to a monitored storage location. The *Y-12 Site-Wide EIS* addresses management of unirradiated HEU at Y-12 (DOE 2001).

### 1.4.3 Affected Environment

#### 1.4.3.1 Global Commons

As addressed in Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, global commons are natural assets outside the jurisdiction of any nation (e.g., the oceans or Antarctica). Transport of FRR SNF from overseas to the United States may affect the Atlantic, Pacific, and Indian 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 the 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 covers about 75 percent of the ocean bottom surface, and ranges in depth from about 3,000 to 6,000 meters (9,840 to 19,700 feet). 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 (DOE 1996a). Naturally occurring radionuclides are present in seawater and marine organisms at concentrations greater than in terrestrial ecosystems. Radionuclides have also been discharged into the oceans. In 1981, it was estimated that the total input of radionuclides from waste disposal and nuclear weapons testing approached 0.7 percent of the natural radioactivity present in the oceans. The inventory of natural radioactivity in the oceans is about $5 \times 10^{11}$ curies (DOE 2006).

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 being 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. Additional information about the world's oceans is provided in Section 3.1 of the *FRR SNF EIS* (DOE 1996a) and in other references (e.g., CIA 2008a, 2008b, 2008c).

#### 1.4.3.2 U.S. Sites Receiving Gap Material

***Charleston NWS***—Charleston, South Carolina, is a major East Coast U.S. seaport. The city is at the confluence of the Cooper and Ashley Rivers, about 11 kilometers (7 miles) inland from the Atlantic Ocean. The principal shipping terminals are along the west bank of the Cooper River, except for the Wando Terminal which is along the east bank of the Wando River about 20 kilometers (11 miles) from the Atlantic Ocean. Charleston NWS is on the west bank of the Cooper River, north of the city of North Charleston starting about 30 kilometers (19 miles) from the Atlantic Ocean (DOE 1996a).

Charleston NWS offers a secure site conducive to transferring Gap Material SNF from ships to trucks or rail cars. Charleston NWS routinely receives marine shipments of FRR SNF under the existing FRR SNF Acceptance Program. Charleston NWS encompasses over 6,900 hectares (17,000 acres) of land with 4,000 hectares (10,000 acres) of forest and wetlands, 26 kilometers (16 miles) of waterfront, 4 deep-water piers (including piers capable of loading trucks directly from ships), 61 kilometers (38 miles) of railroad and 470 kilometers (292 miles) of road. It provides ordnance storage capability and other material supply and support functions and employs over 11,000 personnel (CNIC 2009). Major interstate and Federal highways in the Charleston area are supplemented by interconnecting primary state highways.

The primary change to the affected environment relevant to the Gap Material SNF that would be received at Charleston NWS is the population living near the site. As with the SNF currently being received under the FRR SNF Acceptance Program, Gap Material SNF would be completely contained and use of the existing infrastructure and personnel would not involve impacts to air, water, biological, or cultural resources beyond those associated with normal operation of ships and port facilities. Because the size and shape of Charleston NWS remains essentially unchanged since 1996, the location of the public with respect to the piers at which vessels would be received and unloaded would be the same as that addressed in the *FRR SNF EIS*. Since publication of the *FRR SNF EIS*, however, the population in the area around the Charleston NWS has been growing and the projected increase to year 2020 is considered in this SA.

***Savannah River Site***—SRS is located in south-central South Carolina and occupies an area of approximately 80,300 hectares (198,400 acres) in Aiken, Barnwell, and Allendale Counties. The site is approximately 24 kilometers (15 miles) southeast of Augusta, Georgia, and 19 kilometers (12 miles) south of Aiken, South Carolina. The 7,700 hectares (19,000 acres) of developed SRS land includes 5 non-operational nuclear production reactors; 2 chemical separations facilities (of which H-Canyon is operational and F-Canyon is being deactivated); waste treatment, storage, and disposal facilities (including the F- and H-Tank Farms and the Defense Waste Processing Facility); and major supporting facilities. SRS also extracts tritium, and provides loading, unloading, and surveillance of tritium reservoirs. In 2002, SRS began extensive decommissioning activities. A major new facility, the Salt Waste Processing Facility, is under construction, and construction of the Mixed Oxide Fuel Fabrication Facility began in August 2007 (DOE 2008e). Additional information about the SRS affected environment is available in Section 4.8 of the *Complex Transformation Supplemental Programmatic Environmental Impacts Statement (Complex Transformation SPEIS)* (DOE/EIS-0236) (DOE 2008e). The projected increase in population in the SRS area to the year 2020 is considered in this SA.

SNF is stored at the former L-Reactor in L-Area. Most fuel is stored in a wet configuration in L-Basin, although a small quantity is stored dry. Racks and buckets are used to store a variety of fuels of different physical configurations. The current L-Basin storage capacity is about 15,500 fuel elements. The L-Basin storage capacity could be increased. If such a need were identified, DOE would prepare appropriate NEPA analysis prior to making a decision whether to proceed with a project to increase storage capacity.

# 2.0 Analysis and Discussion

This section presents the potential impacts of transporting 70 casks of Gap Material SNF by chartered ship over the global commons to Charleston NWS, the potential impacts of overland transport (truck or rail) of 70 casks of Gap Material SNF from Charleston NWS to SRS [18] and of up to 50 casks of Gap Material SNF from the Canadian border to SRS, and the potential impacts of receipt of Gap Material SNF on storage capacities at DOE sites; and addresses existing NEPA analyses for SNF storage and subsequent disposition of this material The analyses in this section rely principally on those presented in the *FRR SNF EIS* (DOE 1996a), as updated to reflect projected changes in population densities and DOE recommendations for risk analysis.

Consistent with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, this SA does not address impacts from packaging and transport from the foreign nuclear facility to the port of departure; transport through the territories of participating foreign countries; overland transport of Canadian SNF within Canada to the U.S.-Canadian border; and loading the Gap Material SNF onto ships at the ports of departure, or onto trucks or train cars within Canada. Countries shipping Gap Material SNF would be responsible for conducting appropriate environmental analyses for activities occurring within their borders.

## 2.1 Impacts to the Global Commons Under Incident-Free Transport

Acceptance of Gap Material SNF would not cause the total number of SNF casks to be received under the FRR SNF Acceptance Program to exceed the number estimated in the *FRR SNF EIS*. Therefore, accepting Gap Material SNF would not cause nonradiological impacts from the FRR SNF Acceptance Program to exceed those addressed in the *FRR SNF EIS*. Nonradiological impacts from shipping SNF under the FRR SNF Acceptance Program were judged in the *FRR SNF EIS* to be small. In addition, because there would be no release of radioactivity under incident-free transport, there would be no radiological impacts on the global commons, including impacts to marine biota or fisheries.

## 2.2 Human Health Impacts

### 2.2.1 Incident-Free Ship Transportation

The general public would not receive a radiation dose from incident-free transport of Gap Material SNF by ocean vessel; however, radiological impacts could be received by the crews of the ships carrying the Gap Material SNF during daily inspections of cargo and vessel features important to safety and seaworthiness, and during loading and off-loading the ISO containers. The radiological impact would depend on the number of inspections, which would depend upon the duration of the voyage.

The *FRR SNF EIS* considered the distance from 40 countries to an East Coast and a West Coast U.S. port. An average distance of 12,470 kilometers (6,735 nautical miles) was assumed to account for the use of either port. At an average speed of 15 knots, considering passage through canals, and assuming no intermediate port stops to pick up nonradioactive cargo, an average voyage length of 18 days was assumed for a chartered ship (DOE 1996a). These assumptions were updated for this SA.

The *FRR SNF EIS* analysis addressed two container-surface dose rates: (1) a dose rate equivalent to the regulatory limit for shipment (10 millirem per hour at 2 meters [6.6 feet] from the container surface); and (2) a dose rate one-tenth of the regulatory limit based on historical experience with shipping FRR SNF.

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[18] *Impacts addressed in this section for ship transport of Gap Material SNF to the United States would envelope those for ship transport of any Gap Material consisting of unirradiated enriched uranium. Impacts associated with overland transport of unirradiated enriched uranium to the Y-12 National Security Complex, and its subsequent handling and storage, are addressed in the Y-12 Site-Wide EIS (DOE 2001).*

Assuming the regulatory limit dose rate, the analysis concluded that the collective crew dose over the life of the FRR SNF Acceptance Program could be up to 75.4 person-rem, assuming all FRR SNF was shipped by chartered vessels. Assuming the same crews were used in all voyages and the surface radiation levels for all containers were at the regulatory limit, the analysis concluded that the annual dose to a maximally exposed individual (MEI) crew member could exceed 100 millirem (DOE 1996a). DOE therefore implemented mitigation measures as outlined in Section 4.2.1.5 of the *FRR SNF EIS* (DOE 1996a). DOE requires that its shipping contractor track each ship and crew involved in shipment of FRR SNF and includes a clause in its contract for shipping FRR SNF requiring that other crew members be used if any crew member approaches a 100-millirem dose in any year (DOE 1996d).

It was assumed for the *FRR SNF EIS* that a chartered vessel would contain up to 8 casks per voyage. The casks would be loaded 2 casks per hold, an assumption that could cause additional radiation exposure to the crew members because of the combination of radiation fields surrounding each of the casks (DOE 1996a). In the second SA to the *FRR SNF EIS*, DOE analyzed the impacts from shipping more than 8 casks per voyage, and concluded that the potential incident-free risk would be expected to remain essentially the same for the FRR SNF Acceptance Program, but could increase slightly on a per voyage basis. DOE also noted that experience had shown that the EIS estimates of doses during daily inspections of the cargo were very conservative (i.e., overestimated the dose) (DOE 1998b).

As of September 2008, 218 casks had been received at U.S. ports, well below the more than 700 projected in the *FRR SNF EIS*, and 3 casks had been shipped overland from Canada (GTRI 2008). In the 2004 SA (DOE/EIS-0218-SA-3), an analysis of FRR SNF casks received from 1996 through April 2004 showed that the average cask surface dose rate was about 40 times smaller than the regulatory limit, rather than 10 times smaller as hypothesized in the *FRR SNF EIS* (DOE 2004a). Additional FRR SNF casks have been received under the GTRI program from August 2004 through September 2008. An evaluation of data for these casks shows that the peak surface total (gamma and neutron) dose rate ranged from 0.02 to 65.5 millirem per hour, with an average peak surface total dose rate of 10.2 millirem per hour. The average cask surface dose rate was 4.1 millirem per hour,[19] which is a factor of about 17 smaller than the surface dose rate assumed for the *FRR SNF EIS* analysis.[20] The cask activities ranged from 0.31 to about 711,000 curies (GTRI 2008). Conversely, it has been determined that the average speed of transport vessels was closer to 12 rather than 15 knots (DOE 1998b), which would tend to increase crew doses because transit would take longer, and there would be more inspections en route. In addition, intermediate port stops may be needed for some chartered voyages to pick up SNF from multiple countries. For the 40 countries identified in the *FRR SNF EIS*, the average distance to an East Coast U.S. port would be about 11,220 kilometers (6,056 nautical miles) (DOE 1996a). Assuming an average vessel speed of 12 knots, 3 days spent in intermediate stops, and passage through canals, this average distance would correspond to a voyage length of about 25 days rather than the 18 days assumed in the *FRR SNF EIS*.

Given similar assumptions, the voyage length for a shipment of Gap Material SNF could range from 17 days for a shipment from a country in Western Europe to several weeks for a shipment from a more distant country such as Pakistan. In this SA, an upper-bound voyage length of 50 days was assumed, which represents the assumed voyage length from a distant country.[21] The average voyage length for the countries (other than Canada) identified in Table 1–1 would be about 25 days, assuming an average voyage length of 11,480 kilometers (6,200 nautical miles), an average speed of 12 knots, 3 days spent in

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[19] *Note that these measurements are for cask surfaces; they would be further reduced by distance and shielding because the casks would be shipped within larger ISO containers.*

[20] *Using the ZYLIND computer code, it was analytically determined that a radiation level of about 71 millirem per hour at contact on the cask surface would result in a dose rate at 2 meters(6.6 feet) from the cask surface of 10 millirem per hour (DOE 2004a).*

[21] *Thailand was selected as representative of a distant country. Travel time was rounded up from 49.2 days, assuming a travel distance of 24,389 kilometers (13,169 nautical miles) to an East Coast U.S. port (DOE 1996a), an average vessel speed of 12 knots, 3 days spent in intermediate stops, and a half-day traversing a canal.*

intermediate stops, and passage through canals for shipments from some countries. This compares with the average 25-day voyage length estimated above for the 40 countries analyzed in the *FRR SNF EIS*.

**Table 2–1** provides the total crew dose and risk assuming 70 casks are shipped in 9 voyages (8 voyages each with 8 casks and 1 voyage with 6 casks), for average voyage lengths of 25 and 50 days. Risks were determined using the currently recommended risk factor of 0.0006 LCFs per person-rem (DOE 2003b). Based on the currently identified countries possessing Gap Material SNF, most voyages would average about 25 days. A collective crew dose of 75.4 person-rem was estimated in the *FRR SNF EIS,* based on the regulatory limit. Historical data and FRR SNF Acceptance Program experience indicate that radiation doses at shipping container surfaces would more likely be 2.5 to 10 percent of the regulatory limit (DOE 1996a, DOE 2004a, GTRI 2008). Considering this, it is concluded that the collective crew dose for all FRR SNF shipments (the Gap Material SNF shipments plus with those expected under the current FRR SNF Acceptance Program) would be less than that analyzed in the *FRR SNF EIS*. This would be expected even if all Gap Material SNF shipments required voyages of 50 days.

**Table 2–1 Collective Crew Dose and Risk for Shipment of 70 Casks by Chartered Ship [a]**

| | *Average 25-Day Voyage* | | *Average 50-Day Voyage* | |
|---|---|---|---|---|
| ***Dose Basis*** | ***Dose (person-rem)*** | ***Risk (LCF) [b]*** | ***Dose (person-rem)*** | ***Risk (LCF) [b]*** |
| Regulatory Limit [c] | 8.9 | $5 \times 10^{-3}$ | 15 | $9 \times 10^{-3}$ |
| Historical [c] | 0.89 | $5 \times 10^{-4}$ | 1.5 | $9 \times 10^{-4}$ |
| 2004 Data [d] | 0.22 | $1 \times 10^{-4}$ | 0.37 | $2 \times 10^{-4}$ |

LCF = latent cancer fatality.

[a] Assuming 8 voyages each containing 8 casks and one voyage containing 6 casks.

[b] Risks were determined assuming a factor of 0.0006 LCFs per person-rem (DOE 2003b).

[c] As analyzed in the *FRR SNF EIS*, the regulatory dose rate was 10 millirem per hour at 2 meters (6.6 feet) from the container surface; a dose rate of 1 millirem per hour at 2 meters (6.6 feet) was based on historical data (DOE 1996a).

[d] A dose rate of 0.25 millirem per hour at 2 meters (6.6 feet) from the container surface is based on an analysis of data for casks received from 1996 to 2004 under the FRR SNF Acceptance Program (DOE 2004a).

There is a potential for some crew members to receive an annual dose exceeding 100 millirem. **Table 2–2** presents the estimated dose for several crew members for a single voyage containing 8 casks of SNF, for voyage lengths of 25 and 50 days. Because of the large number of casks that could be carried in a single voyage, some crew members could receive a dose exceeding 100 millirem if cask radiation surface levels were at the regulatory limit (10 millirem per hour at 2 meters [6.6 feet]). But based on historical data and FRR SNF Acceptance Program experience, individual doses would be less than 100 millirem.

The same crew member could be involved in multiple shipments per year. For perspective, the principal chartered shipper of SNF and other radioactive materials was contacted. This shipper travels primarily between Europe and Japan. Typically, a voyage with loaded cargo on board takes around 2 to 3 months. Although a crew member could theoretically be onboard for two round trips in a year (e.g., up to roughly 180 days), in practice this is very unlikely. The maximum exposure time is likely to be 4 to 5 months in a year (e.g., up to roughly 150 days), assuming radioactive cargo carried both to and from Japan. The maximum annual radiation dose to any crew member has never exceeded 100 millirem (PNTL 2008).

Surface dose rates on casks of Gap Material SNF and other future SNF may differ from surface dose rates on casks transported in the past. As discussed above, the average cask surface dose rates were larger for the sample of casks received from August 2004 through September 2008, than for the sample of casks received from 1996 to 2004. In neither case, however, did the average surface dose rate exceed the assumed values in the *FRR SNF EIS* (either dose rates at regulatory limits or at one-tenth of these dose rates). Nonetheless, the mitigation program outlined in the *FRR SNF EIS* would continue for Gap Material SNF.

**Table 2–2 Maximum Crew Doses and Risks for Transporting Eight Casks of Spent Nuclear Fuel via Chartered Vessel, Assuming a Single Sea Voyage of 25 or 50 Days**

| *Voyage Length* | *Maximum Dose (millirem) and LCF Risk* [a] *(in parentheses) for Individual Crew Members* | | | | |
|---|---|---|---|---|---|
| | ***Dose Basis*** | ***Chief Mate or Bosun*** | ***Mate on Watch*** | ***Seaman 1 or Seaman 2*** | ***Engineer*** |
| 25 Days | Regulatory Limit [b] | 300<br>($2 \times 10^{-4}$) | 40<br>($2 \times 10^{-5}$) | 72<br>($4 \times 10^{-5}$) | 230<br>($1 \times 10^{-4}$) |
| | Historical [c] | 30<br>($2 \times 10^{-5}$) | 4<br>($2 \times 10^{-6}$) | 7.2<br>($4 \times 10^{-6}$) | 23<br>($1 \times 10^{-5}$) |
| | 2004 Data [d] | 7.6<br>($5 \times 10^{-6}$) | 1<br>($6 \times 10^{-7}$) | 1.8<br>($1 \times 10^{-6}$) | 5.8<br>($3 \times 10^{-6}$) |
| 50 Days | Regulatory Limit [b] | 530<br>($3 \times 10^{-4}$) | 40<br>($2 \times 10^{-5}$) | 72<br>($4 \times 10^{-5}$) | 460<br>($3 \times 10^{-4}$) |
| | Historical [c] | 53<br>($3 \times 10^{-5}$) | 4<br>($2 \times 10^{-6}$) | 7.2<br>($4 \times 10^{-6}$) | 46<br>($3 \times 10^{-5}$) |
| | 2004 Data [d] | 13<br>($8 \times 10^{-6}$) | 1<br>($6 \times 10^{-7}$) | 1.8<br>($1 \times 10^{-6}$) | 12<br>($7 \times 10^{-6}$) |

LCF = latent cancer fatality.

[a] Risks were determined assuming a factor of 0.0006 LCFs per rem (DOE 2003b).

[b] The total may not equal the tabulated sum of the doses for individual crew members because of rounding.

[c] As analyzed in the *FRR SNF EIS,* the regulatory dose rate was 10 millirem per hour at 2 meters (6.6 feet) from the container surface; a dose rate of 1 millirem per hour at 2 meters (6.6 feet) was based on historical data (DOE 1996a).

[d] A dose rate of 0.25 millirem per hour at 2 meters (6.6 feet) from the container surface is based on an analysis of data for casks received from 1996 to 2004 under the FRR SNF Acceptance Program (DOE 2004a).

### 2.2.2 Incident-Free Port Operations

Port operations are expected to result in no radiation doses to members of the public. Charleston NWS is a secure military base and unauthorized personnel would be excluded from the vicinity of the operations of unloading and transferring casks to overland transport vehicles (trucks or rail cars). Radiation doses, however, could be received by port workers transferring the Gap Material SNF from the ships to the overland transport vehicles.

Containers of Gap Material SNF would be unloaded from ships and transferred to overland transport vehicles in the same manner as that for FRR SNF under the existing FRR SNF Acceptance Program. Appendix D of the *FRR SNF EIS* provides a description of port operations and potential radiation doses conservatively assumed to be received by workers involved in material handling at seaports (DOE 1996a) (see below). For chartered shipments, the analysis groups possible exposures into those for port handlers at the port of destination, port staging personnel, and inspectors.

**Table 2–3** summarizes the radiological doses and risks for receipt at Charleston NWS of 70 casks of Gap Material SNF, assuming all containerized casks emit radiation at the regulatory limit. Conservatively assuming all 70 casks would arrive in a single year, individual workers such as cargo inspectors would not receive doses exceeding 100 millirem in a year. And as noted, the average surface radiation levels from an analysis of SNF casks received from 1996 to 2004 was a factor of about 40 smaller than the regulatory limit (DOE 2004a), while the average surface radiation levels from an analysis of SNF casks received from August 2004 through September 2008 was a factor of about 17 smaller than the regulatory limit (GTRI 2008). In addition, cask unloading activities have taken an average of 20 minutes per container rather than the 65 minutes assumed in the *FRR SNF EIS*. Personnel involved in unloading operations at Charleston NWS are monitored by radiation safety technicians who ensure compliance with applicable requirements (DOE 2004a, GTRI 2008). To date, no dock worker has received measurable radiation exposure as a result of offloading FRR SNF program material (GTRI 2008). Radiological impacts to port personnel for receipt of Gap Material SNF would thus be enveloped by those for receipt of all FRR SNF as evaluated in the *FRR SNF EIS*.

**Table 2–3 Incident-Free Port Impacts for Receipt of 70 Casks from Chartered Ships [a,b]**

| | ***Chartered Ship*** | | | |
|---|---|---|---|---|
| | ***Maximally Exposed Worker*** | | ***Worker Population*** | |
| ***Risk Group*** | ***Dose (millirem)*** | ***Risk (LCF)*** [c] | ***Dose (person-rem)*** | ***Risk (LCF)*** [c] |
| Inspectors [d] | 91 | $5 \times 10^{-5}$ | 0.37 | $2 \times 10^{-4}$ |
| Port Handlers | 32 | $2 \times 10^{-5}$ | 0.11 | $6 \times 10^{-5}$ |
| Port Staging Personnel | 28 | $2 \times 10^{-5}$ | 0.32 | $2 \times 10^{-4}$ |
| Maximum [d] | 91 | $5 \times 10^{-5}$ | NA | NA |
| Total | NA | NA | 0.80 | $5 \times 10^{-4}$ |

LCF = latent cancer fatality, NA = not applicable.

[a] Container surface dose rates were assumed to be at the regulatory limit (10 millirem per hour at 2 meters [6.6 feet] from the container surface).

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

[c] LCF risks have been updated based on an assumed 0.0006 LCFs per rem or person-rem (DOE 2003b). The analysis in the *FRR SNF EIS* was based on the then-recommended 0.0004 LCFs per rem or person-rem for workers (DOE 1996a).

[d] Unloading operations would be under the direction of trained radiation technicians who would ensure that no individual received a radiation dose exceeding authorized limits.

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

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

### 2.2.3 Overland Transportation

The following analysis summarizes the impacts associated with transporting Gap Material SNF by truck or rail from Charleston NWS and Canada to SRS. This analysis was derived from the analysis in the *FRR SNF EIS*, which was performed using the RADTRAN Version 4 and RISKIND Version 1.11 computer codes, but incorporates an updated risk conversion factor and projected population growth to the year 2020 along representative transport routes. Since publication of the *FRR SNF EIS*, the RADTRAN code has been updated to Version 5 and the RISKIND code has been updated to Version 2.0. For incident-free analysis, because RADTRAN Version 5 contains a refined model of transportation stops, which reduced over-conservatisms (Neuhauser et al. 1997), use of RADTRAN Version 4 for incident-free analysis would be conservative.

For accident analysis, an internal comparison between RADTRAN Versions 4 and 5 by the developers of the codes indicated only small differences of 0.5 to 3.5 percent, both larger and smaller (Weiner 2008). Another assessment comparing the results of an accident analysis using Versions 4 and 5 of the RADTRAN code showed about a 6.7 percent difference, RADTRAN Version 5 results being higher (RWMA 2000). These examples indicate that the differences in accident dose from these two versions of the RADTRAN code are small, and well within the uncertainty of the modeling. Regarding the RISKIND code, a developer of the code has indicated that the primary difference between Versions 1.11 and 2.0 was the addition of a mapping function and that the results using the two versions of the code should be otherwise essentially the same (Biwer 2009).

***Incident-Free Transportation***—The *FRR SNF EIS* analyzed shipment of SNF from Charleston NWS to SRS and from Canada (near Alexandria Bay, New York) to SRS. Representative routes selected for risk assessment purposes are consistent with current routing practices, regulations, and guidelines, but may not necessarily be the actual routes used to transport FRR SNF (DOE 1996a). The *FRR SNF EIS* used 1990 census data to assess population doses and risks (DOE 1996a); the analysis for this SA incorporates a projected increase in population along representative transport routes between 1990 and 2020.

**Table 2–4** shows the collective crew and public doses and risks for incident-free transport of up to 70 containers of Gap Material SNF from Charleston NWS to SRS, and 50 containers of Gap Material SNF from Canada to SRS. In the current analysis, doses were estimated using per-shipment doses presented in the *FRR SNF EIS* adjusted for a projected increase in population along the representative transport routes between 1990 and 2020. Reported risks reflect the increase in the recommended dose-to-LCF factor for radiation workers and members of the public to 0.0006 LCFs per rem or person-rem (DOE 2003b). Considering Table 2–4, transporting Gap Material SNF would be unlikely to cause doses exceeding 100 millirem in a year to any individual member of the public. If the same transport crew members were to make multiple shipments of Gap Material SNF in a single year, some transport crew members might receive a dose exceeding 100 millirem in the absence of administrative controls. This would be no different than shipping any other FRR SNF, and is consistent with the conclusions in the *FRR SNF EIS.* Actual individual and population doses and risks would depend on the radiation dose rates at the surface of the Gap Material SNF transport cask, which are likely to be much smaller than the surface dose rates assumed for the analysis.

**Table 2–4 Incident-Free Radiation Dose and Latent Cancer Fatality Risk for Overland Transport of 120 Containers of Gap Material Spent Nuclear Fuel**

| | | | *Crew* [a] | | *Public* [b] | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | *Population* | | *MEI* [c] | |
| *Origin* | *Destination* | *Mode* | *Dose (person-rem)* | *Risk (LCF)* | *Dose (person-rem)* | *Risk (LCF)* | *Dose (millirem)* | *Risk (LCF)* |
| Charleston NWS [d] | SRS | Truck | 1.3 | $8 \times 10^{-4}$ | 4.2 | $3 \times 10^{-3}$ | $4.8 \times 10^{-2}$ | $3 \times 10^{-8}$ |
| | | Rail | 0.98 | $6 \times 10^{-4}$ | 0.66 | $4 \times 10^{-4}$ | | |
| Canada (at Alexandria Bay, New York) [d] | SRS | Truck | 5.2 | $3 \times 10^{-3}$ | 15 | $9 \times 10^{-3}$ | | |
| | | Rail | 1.7 | $1 \times 10^{-3}$ | 4.8 | $3 \times 10^{-3}$ | | |

LCF = latent cancer fatality, MEI = maximally exposed individual, NWS = Naval Weapons Station, SRS = Savannah River Site.

[a] Assumes a crew of 2 people for truck and 5 people for rail shipment.

[b] Public doses and risks incorporate a projected increase in en route populations from 1990 to 2020 of 34 percent for shipments from Alexandria Bay, New York, and 42 percent from Charleston NWS. The projected increases were extrapolated from increases in population from 1990 to 2000 along representative state and county transport routes (Census 2008b, 2008c, 2008d, 2008e, 2008f, 2008g).

[c] MEI impacts are calculated assuming exposure of a person who lives on an approach route to SRS who would be exposed to all 120 shipments, whether they originate from Charleston NWS or Canada.

[d] Assuming up to 70 containers transported from Charleston NWS to SRS, and up to 50 containers from Canada to SRS.

Note: Radiation dose was conservatively determined assuming a container surface dose rate of 10 millirem per hour at 2 meters (6.6 feet) from the container surface. The LCF risk was determined using a factor of 0.0006 LCFs per rem or person-rem (DOE 2003b).

***Accidents***—The *FRR SNF EIS* analyzed potential transportation accidents in two ways: an accident consequence assessment and an accident risk assessment. The accident consequence assessment answers the question, "What if a severe accident occurs?", and is intended to provide an estimate of the potential impact posed by a maximum reasonably foreseeable transportation accident. (For purposes of this analysis, an accident is considered reasonably foreseeable (credible) if its probability of occurrence is equal to or greater than $10^{-7}$ per year.) Because it is impossible to predict the exact location of a severe transportation accident, separate accident consequences were calculated for accidents occurring in representative rural, suburban, and urban population zones.

The accident risk assessment is a probabilistic analysis taking into account the probability of an accident along the transport route, and the possible releases to the environment caused by a spectrum of possible accident scenarios, from low-probability accidents having high consequences (large releases) to high-probability accidents (fender benders) that have low or no consequences (small or no releases). Potential accident damage to a cask is categorized according to the magnitude of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. The analysis sums the products of consequences and probabilities over all accident probabilities and severity categories to result in a probability-weighted value in terms of dose (person-rem) and risk (LCF) (DOE 1996a).

The results of the accident consequence assessment from the *FRR SNF EIS* are presented in **Table 2–5** for a maximum reasonably foreseeable accident involving an SNF shipment in an urban, suburban, and rural population zone. A maximum reasonably foreseeable accident is one for which the combination of mechanical and thermal forces lead to the largest releases from the accident (for example, a high-speed accident in which a cask impacts an unyielding surface and is then enveloped in fire). The assessment presented in this table is for neutral atmospheric conditions, which would result in the most likely consequences; and stable atmospheric conditions, which would represent a worst-case weather situation. As noted, doses and risks presented in this table are based on the assumption that a maximum reasonably foreseeable accident occurs – that is, there is no assumption regarding the probability of the accident. LCF risks for this table were updated from the *FRR SNF EIS* based on a risk conversion factor of 0.0006 LCF per rem or person-rem (DOE 2003b). Based on a maximum population dose of 120 person-rem, no LCFs would be expected in the population as a result of an accident, and the risk of an MEI developing an LCF would be small ($5 \times 10^{-6}$ or 1 chance in 200,000).

**Table 2–5 Potential Consequences of a Maximum Reasonably Foreseeable Transportation Accident Involving Spent Nuclear Fuel**

| ***Accident Population Zone*** | ***Neutral Conditions*** [a] | | | | ***Stable Conditions*** [b] | | | |
|---|---|---|---|---|---|---|---|---|
| | ***Population*** [c] | | ***MEI*** [d] | | ***Population*** [c] | | ***MEI*** [d] | |
| | ***Dose (person-rem)*** | ***Risk (LCF)*** [e] | ***Dose (millirem)*** | ***Risk (LCF)*** [e] | ***Dose (person-rem)*** | ***Risk (LCF)*** [e] | ***Dose (millirem)*** | ***Risk (LCF)*** [e] |
| **Truck and Rail** | | | | | | | | |
| Urban | 14 | $8 \times 10^{-3}$ | 2.4 | $1 \times 10^{-6}$ | 120 | $7 \times 10^{-2}$ | 7.9 | $5 \times 10^{-6}$ |
| Suburban | 2.7 | $2 \times 10^{-3}$ | | | 21 | $1 \times 10^{-2}$ | | |
| Rural | 0.15 | $9 \times 10^{-5}$ | | | 1.2 | $7 \times 10^{-4}$ | | |

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

[a] Neutral weather conditions are assumed to be Pasquill stability Class D with a wind speed of 4 meters per second (9 miles per hour).

[b] Stable weather conditions are assumed to be Pasquill stability Class F with a wind speed of 1 meter per second (2.2 miles per hour).

[c] Populations extend at a uniform population density to a radius of 80 kilometers (50 miles) from the accident site. Representative population densities are assumed for each accident population zone.

[d] The MEI is assumed to be at the location of maximum exposure, which would be 160 meters (528 feet) and 400 meters (1,320 feet) from the accident site under neutral and stable atmospheric conditions, respectively.

[e] LCF risk is based on the updated factor of 0.0006 LCFs per rem or person-rem (DOE 2003b).

Source: DOE 1996a (Table E–21).

The results of the accident risk assessment from the *FRR SNF EIS* are summarized in **Table 2–6** for a shipment of Belgian BR-2 SNF from Charleston NWS, South Carolina, to SRS, and a shipment of NRU SNF from Alexandria Bay, New York, to SRS. These shipments are considered bounding for FRR SNF (DOE 1996a). Unlike those presented in the previous table, the impacts in this table account for the probability of the accident occurring. The results incorporate the spectrum of accident severity probabilities and associated release fractions (DOE 1996a) and account for the projected increase in population from 1990 to 2020 along representative transport routes. LCF risks were updated from the *FRR SNF EIS* based on a risk conversion factor of 0.0006 LCF per rem or person-rem (DOE 2003b). No LCFs would be expected from shipping all Gap Material SNF by truck or rail.

**Table 2–7** summarizes the nonradiological risks per shipment due to transportation accidents (fatalities resulting from mechanical impact) for shipping Gap Material SNF. The risks reflect the projected increase in population along the transport routes between 1990 and 2020. No fatalities from mechanical impact would be expected from shipping all Gap Material SNF by truck or rail.

**Table 2–6 Population Doses and Risks from Transportation Accidents**

| *Origin* | *Destination* | *Fuel Type Assumed* | *Mode* | *Dose* [a] *(person-rem per shipment)* | *Risk* [a, b] *(LCF per shipment)* |
|---|---|---|---|---|---|
| Charleston NWS | SRS | BR-2 | Truck | $1.2 \times 10^{-5}$ | $7 \times 10^{-9}$ |
| | | | Rail | $1.3 \times 10^{-6}$ | $8 \times 10^{-10}$ |
| Canada (at Alexandria Bay, New York) | SRS | NRU | Truck | $1.2 \times 10^{-4}$ | $7 \times 10^{-8}$ |
| | | | Rail | $7.9 \times 10^{-5}$ | $5 \times 10^{-8}$ |

BR-2 = Belgian Reactor – 2, LCF = latent cancer fatality, NRU = National Research Universal (reactor), NWS = Naval Weapons Station, SRS = Savannah River Site.

[a] Public doses and risks account for the probability of an accident and incorporate a projected increase in en route populations from 1990 to 2020 of 34 percent for shipments from Alexandria Bay, New York, and 42 percent from Charleston NWS. The projected increases were extrapolated from increases in population from 1990 to 2000 along representative state and county transport routes (Census 2008b, 2008c, 2008d, 2008e, 2008f, 2008g).

[b] LCF risk is based on the updated factor of 0.0006 LCFs per rem or person-rem (DOE 2003b).

Source: DOE 1996a (Table E–9).

**Table 2–7 Nonradiological Accident Risks for Shipping Gap Material Spent Nuclear Fuel**

| *Origin* | *Destination* | *Mode* | *Fatality Risk per Shipment* [a] | *Number of Shipments* | *Fatality Risk from Multiple Shipments* [a] |
|---|---|---|---|---|---|
| Charleston NWS | SRS | Truck | $1.6 \times 10^{-5}$ | 70 | $1.6 \times 10^{-3}$ |
| | | Rail | $2.9 \times 10^{-7}$ | 70 | $2.9 \times 10^{-5}$ |
| Canada (at Alexandria Bay, New York) | SRS | Truck | $7.5 \times 10^{-5}$ | 50 | $5.0 \times 10^{-3}$ |
| | | Rail | $2.7 \times 10^{-6}$ | 50 | $1.8 \times 10^{-4}$ |

NWS = Naval Weapons Station, SRS = Savannah River Site.

[a] Per shipment risks are as reported in the *FRR SNF EIS*; fatality risks for multiple shipments incorporate a projected increase in en route populations from 1990 to 2020 of 34 percent for shipments from Alexandria Bay, New York, and 42 percent from Charleston NWS. The projected increases were extrapolated from increases in population from 1990 to 2000 along representative state and county transport routes (Census 2008b, 2008c, 2008d, 2008e, 2008f, 2008g).

Source: DOE 1996a (Table E–10).

### 2.2.4 U.S. Department of Energy Sites

***Gap Material Storage***—Gap Material SNF would be received and stored at the SRS L-Basin. Occupational and public health and safety impacts from receipt and handling of FRR SNF were analyzed in Section 4.2.4.1 of the *FRR SNF EIS* (DOE 1996a). Incident-free radiological impacts to the public were assessed assuming that there could be radiological emissions to the air during receipt and unloading of transport casks, and during the ensuing management period. For storage at L-Basin, the annual dose to the offsite MEI was projected to be 0.000073 millirem from receipt and unloading FRR SNF, while the annual dose to the 80-kilometer (50-mile) radius population was projected to be 0.0046 person-rem.[22] Updating these estimates to a conservative year 2020 maximum population (see Section 2.3.3), and using an updated risk factor of 0.0006 LCFs per rem or person-rem (DOE 2003b), the annual doses and risks from FRR SNF receipt and unloading would be about 0.000073 millirem ($4 \times 10^{-11}$ LCF risk) to the MEI and 0.0095 person-rem and no LCFs (calculated value of $6 \times 10^{-6}$) for the population. These doses and risks do not account for the reduced amount of FRR SNF currently projected to be received at SRS under the FRR Acceptance Program, which, including Gap Material SNF, amounts to about 39 percent of the mass of fuel projected in the *FRR SNF EIS* (see Table 1–2).

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[22] *Annual MEI and population doses from storage were estimated to be 0.00036 millirem and 0.022 person-rem, respectively, for all fuel stored in the facility. It was estimated that the FRR SNF contribution would be six orders of magnitude lower and is therefore insignificant (DOE 1996a).*

***Gap Material Disposition***—The *FRR SNF EIS* addressed the option of disposal of FRR SNF in a geologic repository as well as the option of processing FRR SNF at SRS to recover uranium-235 or other nuclear material (DOE 1996a). The *SRS SNF Management EIS* addressed alternative technologies, including the preferred melt and dilute technology, for management of FRR SNF and other SNF (DOE 2000a).

In the *FRR SNF EIS*, DOE determined that the acceptance of FRR SNF in a geologic repository would cause no impacts at DOE sites storing FRR SNF beyond those associated with storing and packaging the FRR SNF. If treatment would be necessary to convert the FRR SNF into a different form before disposal, the treatment would cause no greater impacts than those from chemically separating the same material (see below). Although the *FRR SNF EIS* did not analyze the environmental impacts of disposal of the FRR SNF at Yucca Mountain or alternative locations (DOE 1996a), worker and public health and safety impacts associated with overland transport and disposal of SNF in a geologic repository are addressed in the *Yucca Mountain EIS* (DOE 2002) and Supplemental EISs (DOE 2008b, 2008c).

Worker and public health and safety impacts associated with processing FRR SNF at the SRS H-Canyon are addressed in Section 4.3.6.6.4 of the *FRR SNF EIS* (DOE 1996a). This analysis addressed possible radiation doses to workers, to the offsite population residing within an 80-kilometer (50-mile) radius of the chemical separations facilities, and the offsite population that could be affected by surface-water emissions (DOE 1996a). The *FRR SNF EIS* projected that operation of the chemical separations facilities at SRS would result in an annual dose of 0.66 millirem to the MEI and 27 person-rem to the surrounding population because of releases to the air.[23] Updating doses for releases to the air pathway to a conservatively projected population for year 2020 (see Section 2.3.3), and assuming an updated risk factor of 0.0006 LCFs per rem or person-rem (DOE 2003b), the annual MEI dose would be 0.66 millirem with a corresponding risk of an LCF of $4 \times 10^{-7}$. The annual population dose would be 56 person-rem, which corresponds to no additional LCFs (a calculated value of 0.03). These doses and risks are small despite the conservatism of the analysis. As shown in Table 1–2, the total mass of aluminum-based FRR SNF currently projected to be received under the FRR SNF Acceptance Program, including Gap Material SNF, is projected to be about 39 percent of that estimated in the *FRR SNF EIS*.

The *SRS SNF Management EIS* evaluated the impacts from using alternative technologies to prepare 48 MTHM of aluminum-based SNF for disposition at SRS, including about 18.2 MTHM (20 tons) of aluminum-based FRR SNF (see Section S.12 of the EIS) (DOE 2000a). For analysis, the fuel was grouped into 6 groups of which FRR SNF (and other SNF) was included in Groups B (MTR-Like Fuel) and C (HEU/LEU Oxides and Silicides Requiring Resizing or Specialized Packaging). For combined Groups B and C, the EIS projected for the entire period of analysis (1998-2035) an MEI and surrounding population dose of 0.185 millirem and 6.84 person-rem, respectively (DOE 2000a). Assuming a risk conversion factor of 0.0006 LCF per rem or person-rem (DOE 2003b), these doses would result in risks of $1 \times 10^{-7}$ and 0.004 LCF, respectively. The melt and dilute technology was the method selected for preparation of the aluminum-based FRR SNF for disposal in a geologic repository (65 FR 48224).

DOE has not implemented the August 7, 2000, decision (65 FR 48224) to use melt and dilute technology to manage SNF, and is contemplating the use of H-Canyon for separation and recovery of HEU contained in FRR SNF and certain other SNF. DOE would prepare additional NEPA analyses, as appropriate, before making a decision.

Current projected receipts of SNF under the FRR SNF Acceptance Program, including Gap Material SNF, are smaller than the quantities evaluated in the *FRR SNF EIS*. Impacts from the disposition of Gap

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[23] *Annual doses to the MEI and population were projected to be a factor of 67 and 820 times smaller, respectively, for releases to the water pathway (DOE 1996a).*

Material SNF would be enveloped by those assessed in the *Yucca Mountain EIS* and its Supplemental EISs, the *FRR SNF EIS*, and the *SRS SNF Management EIS*.

## 2.3 Accidents Other than Overland Transportation Accidents

Fewer than 10 annual ocean voyages are expected for all Gap Material, representing less than 0.5 percent of the 2,046 commercial vessel calls at the port of Charleston[24] in 2005 (DOT 2006). Bounding analyses were performed in the *FRR SNF EIS* for severe port accidents involving Gap Material SNF (DOE 1996a), using the Methods for Estimation of Leakages and Consequences of Releases (MELCOR) Accident Consequences Code System (MACCS). Consequences (radiation dose and associated LCFs) and risks (chance of an LCF, including the probability that the accident would occur) were determined for the population within 80 kilometers (50 miles) of Charleston NWS.

### 2.3.1 Port Accidents

***Radiological Impacts***—The severe port accident for Charleston NWS would involve a collision with another ship severe enough to crush a cask, followed by a fire sufficient to oxidize the nuclear material. Since publication of the *FRR SNF EIS*, a report has been issued showing that there is no statistical difference in the frequencies of collisions between ships in high-, medium-, and low-traffic ports, and that the assumed probability of a severe accident in the *FRR SNF EIS* ($6 \times 10^{-10}$) is conservative (IAEA 2001).

Consequences and risks of port accidents at Charleston NWS for the transport of SNF have been revised from the original analyses (DOE 1996a) to account for a projected 105 percent change in the population in the Charleston area from 1990 to the year 2020, and an increase in the radiation dose-to-risk factor for members of the public. Factors affecting these impacts are listed in **Table 2–8**.

**Table 2–8 Charleston NWS Accident Consequence and Risk Adjustment Factors**

| *Radioactive Cargo* | *Population or Population Density (population dose) Change* | *Dose-to-Risk Factor Change* | *Population LCF Risk Change* |
|---|---|---|---|
| Spent Nuclear Fuel | +105 percent | +20 percent | +146 percent |

LCF = latent cancer fatality.

As in the *FRR SNF EIS*, the severe port accident consequences and risks determined for this SA are calculated for a fully-loaded cask containing BR-2 SNF; the consequences and risk of the severe port accident are based on failure of a single cask regardless of the number of casks on board. Results of the analysis are presented in **Table 2–9**. These results reflect the population increase indicated in Table 2–8 and a change in the dose-to-risk factor. Although there is a projected larger population than the analysis presented in the *FRR SNF EIS*, the accident consequence would nonetheless not be expected to cause an LCF to either the MEI (0.04 risk of an LCF) or the surrounding population (0.6 LCFs), and the MEI and population risks taking into account the probability of the accident would remain very small ($1 \times 10^{-14}$ and $2 \times 10^{-10}$ LCFs, respectively).[25] Assuming 9 total ocean shipments of Gap Material SNF (Section 2.2.1), the total risk to the MEI and surrounding population for all shipments of Gap Material SNF to the United States would be $9 \times 10^{-14}$ and $2 \times 10^{-9}$ LCFs, respectively, taking into account the probability of a severe accident occurring.

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[24] *To reach Charleston NWS, all ships must first traverse the Cooper River past the port of Charleston. The number of annual military vessel calls at Charleston NWS is classified.*

[25] *A previous SA to the FRR SNF EIS (DOE 1998b) indicated that the cask damage scenarios used in the FRR SNF EIS were over-conservative because a Type B SNF cask would be much stronger than the hull of a vessel. If there was a collision involving penetration of the hull of the vessel, an SNF cask would probably be pushed out the other side of the vessel before enough force could be brought to bear on the cask to breach it.*

Port accident consequences and risks are linearly related to the mass of radioactive material in the cask. For example, a cask with 10 percent of the assumed SNF mass of the BR-2 SNF would have 10 percent of the consequence and risk presented in Table 2–9.

**Table 2–9 Charleston NWS Per Shipment Accident Consequences and Risks**

| *Radioactive Cargo* | *MEI Dose (millirem)* | *MEI LCF Risk* [a] | *Population Dose* [b] *(person-rem)* | *Population LCF Risk* [a] |
|---|---|---|---|---|
| Spent Nuclear Fuel | 71 | $1 \times 10^{-14}$ | 980 | $2 \times 10^{-10}$ |

LCF = latent cancer fatality, MEI = maximally exposed individual, NWS = Naval Weapons Station.

[a] Population LCF risk is the risk that one LCF would occur in the total population, taking into account the probability of the accident occurring; MEI LCF risk is the risk of the MEI developing an LCF. Population or MEI LCF risk equals dose, in person-rem or rem, multiplied by a factor of 0.0006 LCFs per rem (DOE 2003b), and the per shipment accident probability of $3 \times 10^{-10}$.

[b] Based on 2020 population as projected from the increase in population in the area from 1990 to 2000 (Census 2008a, CensusScope 2008).

***Nonradiological Impacts***—Nonradiological risks of port operation were assessed using cask-handling information presented in the *FRR SNF EIS* and fatality accident frequency statistics based on Bureau of Labor Statistics as presented in the *Lead Assemblies SA* (DOE 2003a). Up to 4 longshoremen in the hold and 2 on the dock may be needed to move a cask from the ship's hold to the dock, and the time required for the movement may be up to 3 minutes (DOE 1996a). Using a fatality accident rate of 25 fatalities per 100,000 worker-years (DOE 2003a), the nonradiological fatality risk for unloading 1 container of Gap Material SNF would be $3.6 \times 10^{-8}$, while the nonradiological fatality risk for unloading 70 containers of Gap Material SNF would be $2.5 \times 10^{-6}$.[26]

### 2.3.2 Global Commons Accident

Transporting Gap Material SNF to the United States would not increase the number of ocean voyages over that analyzed in the *FRR SNF EIS*. Therefore, transport of Gap Material SNF would not cause an increase in impacts to crew members or the global commons beyond those estimated in the *FRR SNF EIS*. These voyages may be compared to the thousands of commercial[27] and military vessel trips crossing the oceans of the world each year. There would be nothing about shipments of Gap Material SNF that would engender more significant nonradiological risks for transport than those associated with transporting other cargo. Therefore, a few ships transporting Gap Material SNF would not present a significant nonradiological risk from possible accidents to either workers or the global commons.

***Accident Impacts to Ship Crew Members***—Radiological risks from an accident at sea would only result from an accident that would cause sufficient damage to Gap Material SNF casks to release some of the radioactive content. As discussed in Section 2.3.1 of this SA, for analytical purposes, it was conservatively assumed that an accident could result from a collision with another ship causing a severe fire, and assuming that the collision forces that could be imparted to the cask would not be relieved by the collapse of the ship's structure. (The probability of a collision between ships is smaller for ships at sea than for ships in congested areas such as port channels.) In this event, the assumed accident would cause immediate nonradiological risk and also threaten the seaworthiness of the vessel. Either situation would put the crew at far more immediate risk to life than would release of radioactive material.

Regarding nonradiological risks, there would be nothing inherent in shipping containers of Gap Material SNF that would raise more risks than would be involved in transporting other cargo. The only nonradiological risk that could arise from shipping Gap Material SNF would result from the hypothetical

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[26] *Charleston NWS has a robust industrial safety program, and to date, there have been no fatalities or injuries associated with unloading FRR SNF (Taylor 2008)*

[27] *In 2005, over 60,000 commercial vessels were registered worldwide (EMSA 2008). Over 35,000 of these vessels were over 500 metric tons (550 tons) in displacement.*

shifting of cargo within the vessel to the point of injuring crew members or jeopardizing the seaworthiness of the vessel. This risk, however, would be independent of the Gap Material SNF. There would be nothing about the physical characteristics of the Gap Material SNF that would present additional difficulties in safely securing the ISO containers for marine transport.

***Accident Impacts to the Global Commons***—Several studies were summarized in a 2001 IAEA report that evaluated the annual radiation dose to individuals assumed to consume large quantities of seafood contaminated from a severe accident that sinks a vessel, causing the submergence and release from casks containing radioactive material (IAEA 2001). These studies considered cask submergence to depths of 200 meters (660 feet), 2,500 meters (8,200 feet), and in the Western English Channel (IAEA 2001). (The maximum depth of the Western English Channel is about 180 meters (590 feet) [JNCC 2008].) Commercial nuclear power plant SNF, vitrified high-level radioactive waste, and plutonium were considered. The calculated MEI dose was in the range of $4.7 \times 10^{-7}$ to $8 \times 10^{-1}$ millirem per year (IAEA 2001), which represents between about $1 \times 10^{-7}$ and 0.2 percent of the normal annual background radiation dose of 360 millirem per year in the United States (DOE 2000b). The large range is due to differences between deep submergence and continental shelf submergence, along with differences in the radioactivity of each type of cargo that was evaluated in these studies (IAEA 2001).

Impacts to marine life from an accident during transport of radioactive material over the global commons would be similar to those discussed 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) and 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 2004b). These analyses concluded that there could be some loss of marine life directly exposed to radioactive material. Yet because of the large volumes of water involved, mixing mechanisms, existing background uranium concentrations, and radiation-resistance of aquatic biota, the radiological impact of an accident would be localized (DOE 2004b). Accidents involving the transport of Gap Material SNF could similarly impact directly exposed marine organisms.

It is possible that a ship containing Gap Material SNF could pass through an area routinely inhabited by the northern right whale (*Eubalaena glacialis*), a federally endangered species that is also protected internationally. There are currently about 300 right whales in the North Atlantic, with ship strikes accounting for about 50 percent of their known deaths. One identified habitat is off the coast of Massachusetts, and one is off the coasts of Florida and Georgia (66 FR 58066; November 20, 2001). The International Maritime Organization has adopted a mandatory ship reporting system that operates from November 15 to April 15 off the southeastern coast of the United States, and throughout the year on the northeastern coast (DOE 2003a). Before a ship exceeding 270 gross metric tons (300 gross tons) enters such an area, it must 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 contact information for data on the most recent whale sightings and avoidance procedures that could prevent a collision (DOE 2006). On October 10, 2008, the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, established regulations implementing speed restrictions for vessels having lengths equaling or exceeding 19.8 meters (65 feet) (73 FR 60173). These regulations apply within designated areas off the East Coast of the United States at certain times of the year. Compliance with these speed and reporting requirements would mitigate impacts from Gap Material SNF shipments.

### 2.3.3 Accidents at U.S. Department of Energy Sites

Accidents involving the receipt and storage of SNF at SRS were analyzed in the *FRR SNF EIS* (DOE 1996a). The bounding accidents analyzed included (a) a fuel element breach (i.e., cutting into the fuel region) or mechanical damage due to operator error, (b) an aircraft crash into the water pool facility, and (c) an accidental criticality. The largest risk to an MEI and the population within 80 kilometers (50 miles) of SRS [28] was determined to be from an accidental criticality at L-Basin with an assumed frequency of 0.0031 per year. This conservative estimate of frequency was based on a statistical evaluation; no accidental criticality event with SNF storage at SRS has actually occurred. The criticality event was assumed to involve $10^{19}$ fissions and to damage 10 BR-2 fuel elements. Radioactive fission products were assumed to be released into the air from the criticality event and from the damaged fuel. The annual risks to the MEI and 80-kilometer (50-mile) radius population were $2.6 \times 10^{-7}$ and 0.0047 LCFs, respectively, considering the probability of the accident occurring (DOE 1996a).

The largest increase in population from 1990 to 2000 in any of the 21 counties within an 80-kilometer (50-mile) radius of SRS was about 35.2 percent, in Columbia County, Georgia, while the average was about 16 percent (Census 2008b, 2008c, 2008d, 2008e).[29] Extrapolating the maximum population growth rate to 2020 (conservatively assuming all surrounding counties would have this growth rate), and using the currently recommended risk factor of 0.0006 LCFs per person-rem (DOE 2003b), the annual population risk from this accident would be less than 1 (0.01) LCF. Assuming a risk factor of 0.0006 LCFs per rem (DOE 2003b), the annual LCF risk to the MEI would be a factor of about 1.2 larger, or about $3 \times 10^{-7}$ (1 chance in 3.3 million).

The annual population risk estimate is about 2.5 times higher than the risk assessed in the *FRR SNF EIS*, principally because of the conservative projections of population increase in the area. Doses and risks to individuals in the population would not change and the individual risk of an LCF would increase by 20 percent due to the change in the dose-to-risk conversion factor. Considering the conservative nature of the analysis which would still result in an annual population risk of less than 1 LCF and an annual MEI risk of an LCF of much less than 1, the postulated increase in risk remains small.

As noted in Section 1.4.1 of this SA, Gap Material SNF may have a different isotopic distribution than that assumed for the *FRR SNF EIS* analysis; however, the constraint on radiological content recommended in Section 1.4.1 would ensure impacts of accidents would be within those analyzed in the *FRR SNF EIS*. DOE requires that shippers submit detailed information about the characteristics of the FRR SNF before it is shipped that demonstrates that the FRR SNF meets acceptance criteria for SNF storage facilities (see Section 1.4.2 of this SA). These safety procedures would be in effect for Gap Material SNF as well.

## 2.4 Intentional Destructive Acts

One of the goals of the GTRI program is to remove from foreign countries radioactive material that represents potential targets for diversion or terrorist actions and place the material in more secure and protected locations, an action that would significantly reduce health and safety risks to members of the public. The following discussion focuses on the transport of Gap Material SNF to and within the United States, and the management of Gap Material SNF at a DOE site.

In the aftermath of the September 11, 2001, attacks, DOE/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 the Charleston NWS and SRS involve a dynamic process of enhancement to meet threats; these safeguards will continue to evolve as threats change. It is not possible to predict whether intentional attacks would occur at the sites addressed in this SA, or the nature or types of such attacks.

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[28] *The MEI and population doses calculated for the assumed criticality accident at L-Basin were factors of 40 and 32, respectively, larger than the doses calculated for the aircraft crash accident, and factors of 18,000 and 21,000, respectively, larger than the doses calculated for the fuel element breach accident (DOE 1996a).*

[29] *Columbia County, Georgia, increased from a population of 66,031 in 1990 to 89,287 in 2000 (Census 2008c, 2008e).*

Nevertheless, DOE/NNSA and DoD, as appropriate, have re-evaluated security scenarios involving malevolent, terrorist, or intentional destructive acts at SRS and the Charleston NWS 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 form the basis for maintaining, updating, and testing site security to preclude and mitigate any postulated terrorist actions (Brooks 2004, DHS 2006, PL 2002:107-295, 33 CFR Part 165, and 33 CFR Part 334).

Each site's 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 local, state, and Federal law enforcement agencies. The sites use both staffed and automated access-control systems to limit entry into areas and/or facilities to authorized individuals. Automated access-control systems use control booths, turnstiles, doors, and gates. Escorting requirements provide access controls for visitors. 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.

There is also a potential for intentional destructive acts, such as terrorist attacks, during transport. The safety features of the transport casks that provide containment, shielding, and thermal protection would also protect against sabotage. The fuel is in a solid form, which would tend to reduce dispersion of radioactive material beyond the immediate vicinity of the cask, even if an event were to result in a breach of the cask. Transportation activities would incorporate existing physical safeguards aimed at protecting the public from harm, including enhanced security for transport of SNF containing HEU, and enhanced monitoring and coordination of all transport to minimize the possibility of sabotage and facilitate recovery of shipments that could come under control of unauthorized persons. Ocean shipments would occur in accordance with a security plan that would include a threat assessment of the proposed route and its alternatives.

### Intentional Destructive Act on the Global Commons

Maritime areas where acts of terrorism or piracy are more likely could be avoided or ships passing thorough these areas could be provided with additional security as necessary. About 80 percent of all acts of piracy, for example, take place in the territorial waters of states; and in 2007, the locations having the most incidents of piracy included waters near Indonesia, Nigeria, and Somalia (Petretto 2008). If an intentional destructive act were to occur at sea, impacts would primarily be to the onboard personnel. Impacts could range from fatalities associated with an explosion or drowning to lesser impacts of radiation exposure if the vessel were to survive. Radiological impacts to people on land would be bounded by the analysis of an intentional destructive act in a port as discussed below.

### Intentional Destructive Act in Port

Although it is not possible to predict the occurrence of sabotage or terrorism events, or the exact nature of such events if they were to occur, the *FRR SNF EIS* examined three scenarios that would result in the types of consequences that could result from such acts involving FRR SNF (DOE 1996a): two involving explosive damage to shipping casks and one of hijacking a shipping cask. None of these scenarios would lead to a criticality accident because the contents of the casks are configured to avoid criticalities.

***Explosive Damage to a Shipping Cask***—In one of these scenarios, the cask would be full of highly irradiated SNF and as a result of the blast, the fuel elements were assumed to be spread on the ground, producing the highest possible direct dose rate. Based on the results of this hypothetical, conservative analysis, an evacuation distance of about 900 meters (3,000 feet) would be sufficient to maintain a dose rate of less than 10 millirem per hour. This *FRR SNF EIS* analysis would be equally valid for the materials evaluated in this SA.

A second scenario assumes explosive penetration of a cask and damage of SNF inside the cask. It was assumed that the blast causes the release of all of the noble gases and one percent of the solid SNF as airborne aerosols. Using the MACCS computer code, the consequences of this event were determined for the most populous port considered in the *FRR SNF EIS,* which was Elizabeth, New Jersey, having an 80-kilometer (50-mile) radius population of 16 million people. A population dose of 208,000 person-rem with no acute fatalities or short-term adverse health effects was estimated. The MACCS results projected 91 LCFs among the population, with an average individual lifetime radiation dose of about 200 millirem among the one to two million people who would be exposed (because this is an acute event, it was assumed that atmospheric conditions would cause impacts in mostly one direction, affecting people within a 45-degree angle sector) (DOE 1996a).

The *FRR SNF EIS* analysis was adjusted to reflect the conditions evaluated in this SA. The 80-kilometer (50-mile) population around Charleston NWS in South Carolina has been projected to be approximately 1 million people as of 2020. The population dose for this scenario would be about 26,000 person-rem. Applying the current risk factor of 0.0006 LCFs per person-rem, approximately 16 LCFs could be expected. The explosion itself would likely produce fatalities, injuries and property damage in the vicinity of the cask.

***Hijacking a Shipping Cask***—The *FRR SNF EIS* considered the scenario of a theft of an SNF cask, although this occurrence is considered to be very unlikely due to the security measures that would be in place. In addition, the large size and weight of the cask (20 to 30 metric tons [22 to 33 tons]) and the inherent radioactivity of the SNF would deter most hijackers. The cask could not be opened by hijackers without great personal risk due to large radiation exposures. As discussed in the *FRR SNF EIS*, hijackers would not be able to alter the fuel configuration inside the cask to make it critical or have time or resources to change the moderating material to achieve criticality. If the hijackers were to remove the unshielded SNF, the resulting consequences to the public would be the same or less severe than other scenarios (intentional destructive acts or accidents).

### Intentional Destructive Act during Overland Transport

An intentional destructive act during overland transportation could occur, either en route to SRS or to an ultimate disposition site such as a geologic repository. The impacts discussed above for an attack occurring at the Charleston NWS provide a reasonable representation of impacts of an attack using explosives on a cask en route to SRS. The release of material would be the same as that analyzed above, and because the analysis is based on the urban area around Charleston NWS with an assumed population of 1 million people, it provides a reasonable representation of impacts in an urban area and bounds impacts for suburban and rural areas of the route.

Because materials being considered for transport under this SA would be limited to comparable or less total radioactivity than those analyzed in the *FRR SNF EIS* (see Section 1.4.1 of this SA), the corresponding impacts resulting from such events would be comparable or smaller.

Two options for dispositioning Gap Material SNF are disposal of some or all of the SNF at the planned Yucca Mountain geologic repository, or processing some or all of the SNF to recover and down-blend HEU for use in commercial nuclear reactors. In the latter case it is expected that the Yucca Mountain geologic repository would be the eventual destination of the SNF from the commercial nuclear reactors. For either case, it is expected that the potential impacts from a possible intentional destructive act during shipment of Gap Material SNF to the repository would be comparable to those analyzed by DOE for shipment of SNF to the repository (DOE 2002, 2008b). DOE noted that the occurrence of events of sabotage or terrorism, and the exact location and consequences of such events if they were to occur, was inherently uncertain – the possibilities were infinite (DOE 2008b). DOE evaluated possible events and determined a high-consequence scenario could involve a shipment of commercial, pressurized water reactor SNF in which an intentional destructive attack causes penetration of a truck or rail cask containing the SNF and damage to the fuel. DOE assumed the attack would occur and under conditions that would reasonably maximize the consequences. Based on the attack occurring in an urban area with an 80-kilometer (50-mile) radius population of 13 million, the population dose was estimated to be 47,000 person-rem for a truck cask and 32,000 person-rem for a rail cask. The corresponding number of LCFs that could be expected in the exposed population would be 28 and 19, respectively. The dose to an MEI was estimated to be 43 rem (an increased risk of an LCF of 0.026) for a truck cask and 27 rem (increased risk of an LCF of 0.016) for a rail cask (DOE 2008b).

## 2.5 Additional Impacts

### Charleston NWS

Shipments of Gap Material SNF would use existing infrastructure at Charleston NWS. There would be no construction or modification of seaport facilities, and there would be 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. There would be no release of nonradiological pollutants to air or water, nor would radioactive or nonradioactive waste be generated beyond that associated with normal operation of ships and port facilities. 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 SNF would not affect socioeconomic conditions at Charleston NWS. Work would be accomplished using existing personnel.

Members of the public would be placed at no radiological risk during normal operations because of the distance that would be maintained between the Gap Material SNF and members of the public. Radiological risk to members of the public would also be small in the event of a severe accident. In the unlikely event of a major ship accident in a shipping channel or at Charleston NWS, the radiological risk to the population would be bounded by the analysis in Section 2.3.1 which updated risks determined in the *FRR SNF EIS* to the projected population in 2020. Because risks to all members of the public from normal operations and accidents are small, risks to low-income and minority populations would also be small. Therefore, no disproportionately high and adverse radiological risks would be expected to occur in low-income and minority populations.

Nonradiological impacts from normal operations would be no larger for a shipment of Gap Material SNF than those for a shipment of other cargo. Similarly, nonradiological impacts from an accident involving a shipment of Gap Material SNF would be no larger than any accident involving a shipment of other cargo. A vessel containing Gap Material SNF would be one of many vessels making port calls to the Charleston, South Carolina, area. No disproportionately high and adverse nonradiological risks to low-income and minority populations would result.

### U.S. Department of Energy Sites – Receipt and Storage

The L-Basin at SRS has long been in operation for storage of numerous types of SNF. The *FRR SNF EIS* assessed radiation doses and risks that could result from receipt and unloading of FRR SNF and continued storage of all fuel, including FRR SNF, in the storage facility. Doses and risks from these activities were updated for this SA in Section 2.2.4. Regarding other resource areas, it is expected that receipt of Gap Material SNF at SRS would result in no additional impacts on land use, biological resources, geological resources, utility use, air quality, noise, visual resources, or cultural resources beyond those previously analyzed for operation of L-Basin. Radiological and nonradiological impacts to workers would be maintained within applicable requirements using technical and administrative controls. There would be no additional ground or surface water withdrawals or discharges beyond those previously analyzed or authorized for storage facility operation. Nor would there be need for additional storage facility personnel. Because the projected doses and risks to the MEI and population from receipt and storage of FRR SNF are very small, doses and risks to low-income and minority populations would also be small, and therefore not significant and disproportionate. Therefore, no disproportionately high and adverse radiological risks would be expected to occur in low-income and minority populations. Nonetheless, there could be limitations on the types and quantities of Gap Material SNF that could be stored at L-Basin as discussed below.

Working closely with DOE, NNSA would ensure that any Gap Material SNF accepted under the FRR SNF Acceptance Program would be compliant with the Authorization Basis for L-Basin, and that sufficient storage capacity would be available. Flexibility exists in the physical characteristics of the fuel that may be stored at L-Basin, although the inventory in a shipment cannot exceed the bounding inventory used to establish the Authorization Basis. In addition, L-Basin is limited to receipt of DOE Category II nuclear material. Acceptance of any SNF having an inventory exceeding the bounding inventory, or of DOE Category I nuclear material, would require a change to the Authorization Basis. Such a change would require time and resources, including those required for security modifications to meet DOE Category I requirements and for any required NEPA analysis. The effect of receipt of Gap Material SNF on the security category status of L-Basin would be assessed before the SNF would be accepted in the United States.

The availability of storage capacity for Gap Material SNF at L-Basin would depend on actual receipts of all SNF projected to be stored at L-Basin and disposition of stored material. The current L-Basin storage capacity is about 15,500 fuel elements. In the past, detailed plans to increase the storage capacity to about 18,500 elements were made as part of an L-Area Storage Rack project, although the project was not implemented because of lack of an immediate need. Installed storage capacity is sufficient for the current remaining number of SNF assemblies projected to be shipped under the FRR and domestic research reactor programs. Additional storage capacity could be needed, however, depending on the timing of DOE actions that would increase or decrease the amount of fuel in storage at L-Basin. Additional storage capacity would be needed if, before reaching its current storage limit, L-Basin were to receive Gap Material SNF and aluminum-based fuel currently stored at INL, and there was no processing of aluminum-based SNF through H-Canyon to recover HEU for down-blending and reuse. One option would be to install additional storage capacity. A decision to expand storage capacity would be preceded by appropriate NEPA analysis.

**U.S. Department of Energy Sites – Disposition**

Principal options for dispositioning some or all Gap Material SNF are: (1) processing the SNF to recover and down-blend HEU for use in commercial nuclear reactors with subsequent disposal in the Yucca Mountain geologic repository; (2) treating the SNF using melt and dilute technology before disposal in the Yucca Mountain geologic repository; and (3) direct disposal into the Yucca Mountain geologic repository.

Processing Gap Material SNF at SRS to recover HEU for down-blending would use existing facilities at SRS, while a separate facility would be constructed at SRS to implement the melt and dilute technology alternative. The environmental impacts of processing FRR SNF at SRS were addressed in the *FRR SNF EIS* (DOE 1996a), while the environmental impacts of treating FRR SNF using the melt and dilute technology were addressed in the *SRS SNF Management EIS* (DOE 2000a). Potential human health impacts from FRR SNF processing or implementation of the melt and dilute technology are summarized in Section 2.2.4 of this SA.

The conclusions regarding other environmental resource areas would be similar to those described in the previous section for FRR SNF receipt and storage. Radiological and nonradiological impacts to workers would be maintained within applicable requirements using technical and administrative controls. Because the total quantity of FRR SNF to be dispositioned would be smaller than that addressed in the *FRR SNF EIS* and *SRS SNF Management EIS*, there would be no additional impacts on land use, biological resources, geological resources, water resources, utility use, air quality, noise, visual resources, and cultural resources beyond those previously analyzed.

Regarding disposal at the planned Yucca Mountain geologic repository, the waste inventory used in the *Yucca Mountain EIS* (DOE 2002) for the Total System Performance Assessment includes the projected radionuclide and chemical inventory from commercial and DOE high-level radioactive waste, commercial SNF, and 11 categories of DOE SNF (reduced from the 16 categories originally considered). At least 92 percent of the inventory of the principal radionuclides of concern (cesium-137, technetium-99, neptunium-237, plutonium-238, and plutonium-239) was in commercial SNF (DOE 2002). The 11 categories of DOE SNF were meant to bound or represent the characteristics of about 250 varieties of DOE SNF, and include the general types of fuel considered in the *FRR SNF EIS* and this SA – e.g., uranium-silicide and uranium-aluminum alloy fuel with aluminum cladding, TRIGA fuel, and various miscellaneous fuel compounds with or without aluminum or other cladding. For its supplemental EIS (DOE 2008b), DOE revised the waste inventory, considering five basic fuel forms: commercial SNF, mixed-oxide fuel and plutonium ceramic (plutonium disposition waste), high-level radioactive waste, DOE SNF, and naval SNF. DOE SNF was organized into 34 groups based on the fuel compound, fuel enrichment, and the fuel cladding material and condition; these 34 groups represented only 3 percent of the mass of nuclear material in the waste inventory (90 percent comprised commercial SNF and high-level radioactive waste). The groups include the general types of fuel considered in the *FRR SNF EIS* and this SA. For both the *Yucca Mountain EIS* and *Supplemental Yucca Mountain EIS*, the contribution of FRR SNF to the DOE SNF inventory was based on projections in a repository EIS data call (DOE 1997). The mass of nuclear material in the aluminum-based FRR SNF cited in these projections was over twice as large as the 7.013 MTHM (7.730 tons) currently projected for the FRR SNF Acceptance Program, including Gap Material SNF (see Table 1–2). The *Yucca Mountain EIS* and its supplemental EISs were submitted to the U.S. Nuclear Regulatory Commission with the Yucca Mountain license application (DOE 2008d).

The physical characteristics of most Gap Material SNF are expected to be similar to the fuels specifically addressed in Appendix B of the *FRR SNF EIS* (e.g., MTR fuel). Some fuel may be physically dissimilar (e.g., unclad). Nonetheless, the physical characteristics of all Gap Material SNF are expected to be covered under the DOE SNF groupings addressed in the *Yucca Mountain EIS* and *Supplemental Yucca Mountain EIS*. The total mass of Gap Material SNF considered in this SA represents about 0.01 percent of that projected for the Yucca Mountain waste inventory. Based on this and the above analysis, acceptance of Gap Material SNF would not significantly affect the analyses in the Yucca Mountain NEPA documents or license application, nor affect the conclusions expressed in those documents.

## 2.6 Cumulative Impacts

The CEQ regulations (40 CFR 1500-1508) define cumulative impacts as the 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). Thus, the cumulative impacts of an action can be viewed as the total impact on a resource, ecosystem, or human community of that action and all other activities affecting that resource irrespective of the source. This analysis for cumulative impacts emphasizes public health and safety impacts associated with transport of Gap Material SNF and its subsequent disposition.

A cumulative impacts analysis for SRS was recently presented in the *Complex Transformation SPEIS* (DOE 2008e). Receipt and storage of SNF is an ongoing activity at SRS. Acceptance of Gap Material SNF would not cause the SNF that may be received and stored to exceed the quantities described in the *FRR SNF EIS* ROD (61 FR 25092). No cumulative impacts beyond those presented in the *Complex Transformation SPEIS* are expected. If disposition of SNF is delayed, the storage of SNF in L-Basin may require additional storage racks. Previous additions of storage racks in L-Basin have been undertaken consistent with the categorical exclusion provisions of the DOE NEPA Regulations (10 CFR 1021.410(b), Appendix B, Sections B1.3 and B2.5). Categorical exclusions are categories of actions that do not individually or cumulatively have a significant effect on the human environment. The possible addition of storage racks in L-Basin would not be expected to contribute appreciably to cumulative impacts.

Under the GTRI program, it is reasonably conceivable that NNSA would seek to return a small quantity (100 kilograms [220 pounds]) of separated plutonium to the United States. This plutonium is currently in foreign countries and would be transported to a DOE management site (likely SRS) by plane, ship, or truck. An environmental review of the impacts of transport and management of this material has not been completed. Although, no information on the environmental impacts of this specific proposal are available, DOE has evaluated the transport and management of 50 metric tons (55 tons) of surplus plutonium in the *Surplus Plutonium Disposition Final Environmental Impact Statement (SPD EIS)* (DOE/EIS-0283) (DOE 1999). In the RODs for the *SPD EIS* (65 FR 1608; 67 FR 19432; 68 FR 20134) DOE selected SRS as the location for new facilities to disposition up to 34 metric tons (37 tons) of surplus plutonium. Therefore, transportation and management of an additional 100 kilograms (220 pounds) of plutonium, less than 0.3 percent of the plutonium evaluated in the *SPD EIS*, would not appreciably contribute to cumulative impacts.

Disposal of FRR SNF in high-level radioactive waste canisters was addressed in the *Yucca Mountain EIS* (DOE 2002) and Supplemental EISs (DOE 2008b, 2008c). Disposal of Gap Material SNF at the Yucca Mountain geologic repository would not significantly affect the waste inventory used to perform the analyses in these documents. Therefore, the evaluation of cumulative impacts in the *Yucca Mountain EIS* and its Supplemental EISs would remain valid.

# 3.0 Conclusions

An SA is a DOE document used to determine whether an existing EIS should be supplemented or a new EIS prepared (10 CFR 1021.314). This SA analyzes the potential environmental impacts of transportation and subsequent management and disposition of up to 1 MTHM (1,000 kilograms or 1.1 tons) of SNF containing non-U.S.-origin HEU and SNF containing U.S.-origin HEU that was not identified in the *FRR SNF EIS* (DOE 1996a). It is assumed that shipment of Gap Material SNF would be made in accordance with all international and U.S. requirements for safe transport of nuclear materials. Acceptance of Gap Material SNF would occur under the condition that Gap Material complies with the acceptance criteria for the SRS facility receiving and storing the Gap Material SNF (assumed to be L-Basin), and that sufficient storage capacity exists at the facility pending disposition of the material. Doses and risks for transporting Gap Material SNF from foreign countries to SRS are summarized in **Table 3–1**.

**Table 3–1 Summary of Radiation Doses and Risks for Transporting Gap Material Spent Nuclear Fuel to the Savannah River Site**

| *Receptor (Scenario)* | *Radiation Dose (person-rem, unless noted otherwise)* | *LCF Risk* [a] |
|---|---|---|
| **Ocean Transport** | | |
| Ship crew (70 casks, normal operations) [b, c] | 15 | $9 \times 10^{-3}$ |
| **Port Operations** | | |
| Port handlers (unloading normal operations – 70 casks) [b] | 0.80 | $5 \times 10^{-4}$ |
| Population (accident, per shipment) [d, e] | 980 | $2 \times 10^{-10}$ |
| MEI (accident, per shipment) [e] | 71 millirem | $1 \times 10^{-14}$ |
| **Overland Transport** | | |
| Truck crew (70 casks, incident free – Charleston NWS to SRS) [b] | 1.3 | $8 \times 10^{-4}$ |
| Truck crew (50 casks, incident free – Canada to SRS) [b] | 5.2 | $3 \times 10^{-3}$ |
| Population (70 casks, incident free – Charleston NWS to SRS) [b, d] | 4.2 | $3 \times 10^{-3}$ |
| Population (50 casks, incident free – Canada to SRS) [b, d] | 15 | $9 \times 10^{-3}$ |
| MEI (incident free) [f] | $4.8 \times 10^{-2}$ millirem | $3 \times 10^{-8}$ |
| Population (accident, per shipment) [e] | (g) | $7 \times 10^{-8}$ |

LCF = latent cancer fatality, MEI = maximally exposed individual, NWS = Naval Weapons Station, SRS = Savannah River Site.

[a] Risk is calculated using a risk factor of 0.0006 LCFs per rem or person-rem.

[b] Assuming radiation dose at the regulatory limit of 10 millirem per hour at 2 meters (6.6 feet) from the container surface.

[c] Assuming a chartered vessel and voyage lengths of 50 days for all shipments.

[d] Doses and risks are based on populations extrapolated to 2020.

[e] Risk includes the probability of occurrence.

[f] Impact to the MEI assumes exposure to all shipments.

[g] The transportation accident considers a combination of several accident severities and frequencies. The dose, adjusted for accident severity and frequency, is $1.2 \times 10^{-4}$ person-rem assuming truck shipment of NRU fuel from Canada.

***Incident-Free Transport***—Acceptance of Gap Material SNF would not change the total quantity of FRR SNF projected to be received under the FRR SNF Acceptance Program beyond that estimated in the *FRR SNF EIS*. Acceptance of Gap Material SNF would not cause collective ship crew doses to exceed the estimates in the *FRR SNF EIS* for all SNF to be received under the FRR SNF Acceptance Program. It is possible, however, that in some circumstances some crew members might receive a dose exceeding 100 millirem in a year absent administrative controls. Therefore, the mitigation plan already in place for FRR SNF would continue for Gap Material SNF.

Receipt and offloading Gap Material SNF at Charleston NWS would not increase the total number of SNF transport casks to be received at a U.S. port beyond that analyzed in the *FRR SNF EIS*. The collective dose to port workers would therefore not exceed the conservative estimates in the

*FRR SNF EIS.* Based on analysis, experience with past receipts of FRR SNF, and radiation protection controls in place at Charleston NWS, no port worker is expected to receive an annual dose exceeding 100 millirem in a year.

Incident-free overland transport of Gap Material SNF to SRS from Canada and Charleston NWS was assessed, and no LCFs to transport crews or members of the public are expected. In the event that the same transport crew members were to make multiple shipments of Gap Material SNF in a single year, it is possible, although unlikely, that these crew members might receive an annual dose exceeding 100 millirem, absent administrative controls. Therefore, the mitigation plan already in place for FRR SNF would continue for Gap Material SNF.

***Accidents***—A severe port accident involving the largest shipment of SNF considered in the *FRR SNF EIS* is estimated to have a consequence of 980 person-rem to the population within an 80-kilometer (50-mile) radius of Charleston NWS. The risk of a single LCF occurring in the population, taking into account the probability of the accident, is $2 \times 10^{-10}$ (1 in 5 billion). Taking into account the probability of the severe overland transport accident occurring, the risk of a single LCF occurring in the population would be $7 \times 10^{-9}$ (1 in 140 million) for a truck shipment from Charleston NWS to SRS or $7 \times 10^{-8}$ (1 in 14 million) for a truck shipment from Alexandria Bay, New York, to SRS. The affected population in the vicinity of Charleston NWS was extrapolated to year 2020 for this assessment, as were the affected populations along representative overland transport routes to SRS.

***Intentional Destructive Acts***—An intentional destructive act involving use of a shaped charge could have a large impact on the public. The *FRR SNF EIS* considered such an act and estimated that in a port with a high population, the result could be a population dose of 208,000 person-rem with an associated 91 LCFs. In the current analysis, those results were adjusted for the Charleston NWS area and updated to reflect a conservatively projected population growth to the year 2020 and a risk factor of 0.0006 LCFs per person-rem. An intentional destructive act at the Charleston NWS is estimated to result in a population dose of 26,000 person-rem with an associated likelihood of 16 LCFs. Analysis of an intentional destructive act on the truck and rail casks to be used for transporting a broad array of SNF to the Yucca Mountain geologic repository was evaluated in the *Supplemental Yucca Mountain EIS* (DOE 2008b). Such an event in a generic urban area was estimated to result in a population dose of up to 47,000 person-rem for the truck cask and 32,000 person-rem for a rail cask. These doses could result in 28 and 19 LCFs, respectively.

***Additional Impacts***—Transport of Gap Material SNF to the United States would result in negligible environmental impacts at Charleston NWS. Ships transporting Gap Material SNF would represent only a small fraction of the ships annually entering the Charleston, South Carolina, port area.

Receipt and storage of Gap Material SNF at SRS is not expected to result in environmental impacts beyond those assessed in the *FRR SNF EIS.* However, there may be restrictions on the type and quantity of Gap Material SNF that could be accepted at L-Basin at SRS, because of conflicts with the Authorization Basis for operation of L-Basin, or because of possible capacity limitations. It is assumed that acceptance of Gap Material SNF would be conditional on case-specific resolution of any identified concerns.

The total quantity of FRR SNF to be managed at DOE sites would not change, but some Gap Material SNF may have different physical and radiological characteristics than those analyzed in the *FRR SNF EIS.* Processing the identified Gap Material SNF through H-Canyon would not be expected to cause impacts outside the envelope of impacts addressed in the *FRR SNF EIS* and *SRS SNF Management EIS;* nor would disposal of identified Gap Material SNF in the Yucca Mountain geologic repository cause impacts outside the envelope of impacts addressed in the *Yucca Mountain EIS* and its Supplemental EISs.

***Cumulative Impacts***—No additional cumulative impacts have been identified beyond the impacts described in the *Complex Transformation SPEIS,* and the *Yucca Mountain EIS* and its Supplemental EISs.

# 4.0 Determination

In compliance with DOE NEPA regulations, 10 CFR 1021.3 14(c), DOE/NNSA has examined the circumstances relevant to the Proposed Action to expand the FRR SNF Acceptance Program to include FRR SNF containing non-U.S.-origin HEU and FRR SNF containing U.S.-origin HEU not previously considered. This Gap Material SNF could be transported to the United States and placed in storage at SRS facilities pending its disposition. The examination was performed to determine whether the Proposed Action in this SA would result in a substantial change relevant to the environmental impacts reported in the *FRR SNF EIS* (DOE 1996a), or if there are significant new circumstances or information relevant to environmental concerns related to the Proposed Action. Implementation of the Proposed Action would be expected to result in environmental impacts in the range of those analyzed in the *FRR SNF EIS*. The inclusion of Gap Material SNF in the FRR SNF Acceptance Program would not constitute a substantial change in the Proposed Action evaluated in the *FRR SNF EIS*. There are no significant new circumstances or information relevant to environmental concerns related to the Proposed Action or its impacts within the meaning of 40 CFR 1502.9*(C)* and 10 CFR 1021.314. Therefore, neither a supplement to the *FRR SNF EIS* nor a new EIS is required.

Issued in Washington, DC, on this 13 day of January 2009.

P D'Agostino

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Administrator
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