49-3

"SRS Spent Nuclear
Fuel Management
Final EIS"

# DOE/EIS-0279: Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (March 2000)

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# COVER SHEET

**RESPONSIBLE AGENCY:** U.S. Department of Energy (DOE)

**TITLE:** Savannah River Site, Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279) EC

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**ABSTRACT:** The proposed DOE action considered in this environmental impact statement (EIS) is to implement appropriate processes for the safe and efficient management of spent nuclear fuel and targets at the Savannah River Site (SRS) in Aiken County, South Carolina, including placing these materials in forms suitable for ultimate disposition. Options to treat, package, and store this material are discussed. The material included in this EIS consists of approximately 68 metric tons heavy metal (MTHM) of spent nuclear fuel (20 MTHM of aluminum-based spent nuclear fuel at SRS, as much as 28 MTHM of aluminum-clad spent nuclear fuel from foreign and domestic research reactors to be shipped to SRS through 2035, and 20 MTHM of stainless-steel or zirconium-clad spent nuclear fuel and some Americium/Curium Targets stored at SRS. EC TC

Alternatives considered in this EIS encompass a range of new packaging, new processing, and conventional processing technologies, as well as the No Action Alternative. A preferred alternative is identified in which DOE would prepare about 97 percent by volume (about 60 percent by mass) of the aluminum-based fuel for disposition using a melt and dilute treatment process. The remaining 3 percent by volume (about 40 percent by mass) would be managed using chemical separation. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic, and cumulative impacts. EC EC

**PUBLIC INVOLVEMENT:** DOE issued the Draft Spent Nuclear Fuel Management EIS on December 24, 1998, and held a formal public comment period on the EIS through February 8, 1999. In preparing the Final EIS, DOE considered comments received via mail, fax, electronic mail, and transcribed comments made at public hearings held in Columbia, S.C. on January 28, 1999, and North Augusta, S.C. on February 2, 1999. Completion of the Final EIS has been delayed because DOE has performed additional analyses of the melt and dilute technology, discussed in Chapter 2 and Appendix G. Comments received and DOE's responses to those comments are found in Appendix G of the EIS. EC

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**Change Bars**

Changes from the Draft EIS are indicated in this Final EIS by vertical change bars in the margin. The bars are marked TC for technical changes, EC for editorial changes, or if the change was made in response to a public comment, the designated comment number is as listed in Appendix G of the EIS.

# Abbreviations for Measurements

| | |
|---|---|
| cfm | cubic feet per minute |
| cfs | cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second |
| cm | centimeter |
| gpm | gallons per minute |
| kg | kilogram |
| L | liter = 0.2642 gallon |
| lb | pound = 0.4536 kilogram |
| mg | milligram |
| μCi | microcurie |
| μg | microgram |
| pCi | picocurie |
| °C | degrees Celsius = 5/9 (degrees Fahrenheit – 32) |
| °F | degrees Fahrenheit = 32 + 9/5 (degrees Celsius) |

# Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation" rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., $10^n$, or the number 10 multiplied by itself "n" times; $10^{-n}$, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
0.049 is written $4.9 \times 10^{-2}$
1,490,000 or 1.49 million is written $1.49 \times 10^6$

A positive exponent indicates a number larger than or equal to one; a negative exponent indicates a number less than one. | EC

In some cases, a slightly different notation ("E-notation") is used, where "$\times$ 10" is replaced by "E" and the exponent is not superscripted. Using the above examples

$4{,}900 = 4.9 \times 10^3 = 4.9E{+}03$
$0.049 = 4.9 \times 10^{-2} = 4.9E{-}02$
$1{,}490{,}000 = 1.49 \times 10^6 = 1.49E{+}06$

## Metric Conversion Chart

| To convert into metric | | | To convert out of metric | | |
|---|---|---|---|---|---|
| **If you know** | **Multiply by** | **To get** | **If you know** | **Multiply by** | **To get** |
| **Length** | | | | | |
| inches | 2.54 | centimeters | centimeters | 0.3937 | inches |
| feet | 30.48 | centimeters | centimeters | 0.0328 | feet |
| feet | 0.3048 | meters | meters | 3.281 | feet |
| yards | 0.9144 | meters | meters | 1.0936 | yards |
| miles | 1.60934 | kilometers | kilometers | 0.6214 | miles |
| **Area** | | | | | |
| sq. inches | 6.4516 | Sq. centimeters | sq. centimeters | 0.155 | sq. inches |
| sq. feet | 0.092903 | sq. meters | sq. meters | 10.7639 | sq. feet |
| sq. yards | 0.8361 | sq. meters | sq. meters | 1.196 | sq. yards |
| acres | 0.0040469 | sq. kilometers | sq. kilometers | 247.1 | acres |
| sq. miles | 2.58999 | sq. kilometers | sq. kilometers | 0.3861 | sq. miles |
| **Volume** | | | | | |
| fluid ounces | 29.574 | milliliters | milliliters | 0.0338 | fluid ounces |
| gallons | 3.7854 | liters | liters | 0.26417 | gallons |
| cubic feet | 0.028317 | cubic meters | cubic meters | 35.315 | cubic feet |
| cubic yards | 0.76455 | cubic meters | cubic meters | 1.308 | cubic yards |
| **Weight** | | | | | |
| ounces | 28.3495 | grams | grams | 0.03527 | ounces |
| pounds | 0.4536 | kilograms | kilograms | 2.2046 | pounds |
| short tons | 0.90718 | metric tons | metric tons | 1.1023 | short tons |
| **Temperature** | | | | | |
| Fahrenheit | Subtract 32 then multiply by 5/9ths | Celsius | Celsius | Multiply by 9/5ths, then add 32 | Fahrenheit |

## 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 = $10^{3}$ |
| 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 = $10^{-12}$ |
| femto- | f | 0.000 000 000 000 001 = $10^{-15}$ |
| atto- | a | 0.000 000 000 000 000 001=$10^{-18}$ |

# SUMMARY

## S.1 Introduction

The management of spent nuclear fuel (SNF) has been an integral part of the mission of the Savannah River Site (SRS) for more than 40 years. Until the early 1990s, SNF management consisted primarily of short-term onsite storage followed by processing in the SRS chemical separation facilities to produce strategic nuclear materials.

> ***What is Spent Nuclear Fuel?***
>
> Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. When it is removed from a reactor, spent nuclear fuel contains some unused enriched uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. The fuel elements exist in many configurations. Generally, a fuel element is covered by a metal called cladding and is shaped into long rods, flat plates, or cylinders.

With the end of the Cold War, the U.S. Department of Energy (DOE) decided in April 1992 to phase out processing of SNF for the production of nuclear weapons materials. Therefore, the management strategy for this fuel has shifted from short-term storage and processing for the recovery of highly-enriched uranium and transuranic isotopes to stabilization, when necessary, and interim storage pending final disposition. Interim storage includes preparing SNF for disposal in any potential geologic repository.

In addition to the fuel already onsite, the SRS will receive SNF from foreign research reactors until 2009 and potentially could receive SNF from domestic research reactors until 2035. As a result, the safe and efficient management of SNF will continue to be an important SRS mission.

A key element in the decisionmaking process for SNF management is a thorough understanding of the environmental impacts that may result from the implementation of the proposed action. The National Environmental Policy Act of 1969 (NEPA), as amended, provides Federal decisionmakers with a process to use when considering potential environmental impacts of proposed actions.

> ***National Environmental Policy Act of 1969:*** An act that requires Federal agencies to consider in their decisionmaking process the potential environmental effects of proposed actions, and to analyze alternative approaches to meeting the need for agency action.
>
> ***Environmental Impact Statement:*** A detailed environmental analysis of any proposed major Federal action that could significantly affect the quality of the human environment. It is a tool to assist the decisionmakers; it describes the positive and negative environmental effects of the proposed action and alternatives.
>
> ***Alternatives:*** The range of reasonable alternative actions, that could be taken to meet the need for agency action.
>
> ***Record of Decision:*** A concise public statement of the Federal agency's decision. It discusses the decision, identifies the alternatives considered, including the environmentally preferable alternative, and indicates whether all practicable means to avoid or minimize environmental harm were adopted (and if not, why not).

Following this process, DOE announced, on December 31, 1996 in the *Federal Register* its intent to prepare an EIS (61 FR 69085) and to establish a public comment period on the scope of the EIS that lasted until March 3, 1997. DOE accepted all comments received, even those received beyond the closing date. A public scoping meeting was held in North Augusta, South Carolina on January 30, 1997. Forty-one mem-bers of the public attended the meeting with 22 presenting comments or asking questions. In

addition, during the scoping period DOE received letters, E-mails, and other written comments. Based upon these submittals and presentations, DOE identified 118 separate public comments which DOE divided into the following categories: TC

- Processing of Spent Nuclear Fuel
- Alternative Technologies
- Need for a Transfer and Storage Facility EC
- Reuse of Nuclear Material for the Generation of Electricity
- Waste Form/Road-Ready Condition/Repository/Yucca Mountain
- Socioeconomic Impacts
- Human (Occupational and Public) Health
- Chemistry of Spent Nuclear Fuel
- Privatization
- Waste Generation
- No-Action Alternative
- Out-of-Scope Comments

Utilizing input from the public scoping meeting and the NEPA process, DOE prepared a draft Environmental Impact Statement (EIS) for public comment. TC

A Notice of Availability of the Draft EIS appeared in the Federal Register on December 24, 1998. Public meetings to discuss and receive comments on the Draft EIS were held on Thursday, January 28, 1999 at the Holiday Inn Coliseum, Columbia, SC and on Tuesday, February 2, 1999 at the North Augusta Community Center, North Augusta, SC. The public comment period ended on February 8, 1999. In the public meetings 17 individuals commented on the draft EIS. During the 45-day comment period DOE also received 15 letters commenting on the Draft EIS. DOE also received seven letters commenting on the EIS after February 8, 1999, and the comments have been addressed in the final EIS. TC

For ease of discussing the comments in this Summary, DOE divided the comments into 12 major categories. The major points associated with the public comments and DOE's responses are summarized below.

**Processing**

Comments were received related to processing of SNF. These ranged from support of processing as a proven method for disposition of SNF to admonitions that the processing facilities (canyons) should be shut down immediately. A number of comments asked for clarification regarding the criteria used for determining when processing would be necessary for SNF currently in storage. Commentors also criticized the method by which DOE outlined the missions of the canyons, and several requested definite closure dates for the canyons. TC

Response: The canyons at SRS cannot be shut down immediately because DOE is utilizing these facilities to stabilize nuclear materials. In this EIS, DOE proposes to use the canyons to process a relatively small amount (about 3 percent by volume or 40% by weight) of the SNF under consideration to eliminate the potential for certain health and safety problems. The basis for selecting the SNF proposed for processing is discussed in Section 2.4.3.2 of the Final EIS. DOE estimates the processing time would be less than 6 months in F Canyon and about 1 year in H Canyon. The proposed processing operations are within the current canyon schedule planning basis. In other words, the proposed SNF processing activities would not extend the planned canyon operations. However, establishing closure dates for the SRS canyons is beyond the scope of this EIS.

**Alternatives**

Comments were received regarding alternatives to conventional processing of SNF. The comments ranged from support for alternatives to conventional processing to questions regarding the details of alternatives and their impacts. Commentors also questioned DOE's ability to develop a new technology to treat SNF in a timely manner.

Response: DOE evaluated a variety of technologies for managing aluminum-based SNF at the SRS. DOE considers that the range of technologies included in the EIS to be an appropriate reflection of the technologies available. DOE also considers the range of alternatives evaluated in the EIS to represent a reasonable set of the technology combinations that could have been evaluated. Public comments did not reveal an SNF management technology that DOE has not considered. The DOE has completed considerable research and development work for the proposed SNF alternative treatment technology (i.e., Melt and Dilute). DOE is committed to developing and demonstrating that technology for aluminum-based SNF as quickly as possible.

TC

**Waste Form**

Comments were received relating to the acceptability in any geologic repository of the SNF waste form that would be produced using a new (alternative) SNF treatment technology. The principal concern was that waste acceptance criteria for a geologic repository have not been established. In this regard, the concern was that alternative technologies for the disposition of SNF may produce a product that will not meet the final repository criteria.

Response: Waste acceptance criteria describe the physical, chemical, and thermal characteristics to which SNF and associated canisters must conform for emplacement in a geologic repository. DOE has assessed the waste forms the primary new SNF treatment technologies (Melt and Dilute, and Direct Disposal/Direct Co-Disposal) would generate against potential repository preliminary waste acceptance criteria. DOE concluded that waste forms from both technologies would meet the preliminary criteria. Section 2.2.1 of the Final EIS has been revised to discuss the issue in greater detail.

**Impacts**

Comments were received related to the calculation of impacts from the proposed actions. These comments ranged from expressions that specific impacts were negligible to comments that the impacts from past Site activities had been underestimated.

Response: The impact estimates in the Final EIS are based on data from Site operations or operating experience and the judgement of expert analysts. DOE believes that the analyses presented in the EIS are adequate for comparing SNF management alternatives.

**Openness/Independent Review**

Comments were received regarding independent reviews of the SNF treatment technologies and how they would be used in the decisionmaking process. The comments called for increased public involvement. Some comments also called for DOE to share technology development data, particularly regarding the requirements and performance of the off-gas system.

TC

Response: DOE believes that the EIS process provides adequate opportunities for public involvment. For example, DOE has invited public comment and input for this process during scoping meetings and during the public comment period for the Draft EIS. Information regarding technology development that is referenced in the Final EIS is available at the DOE Public Reading Room, University of South Carolina at Aiken, Gregg-Graniteville Library, University Parkway, Aiken, South Carolina and at the DOE Freedom of Information Reading Room (Room 1E-190), Forrestal Building, 1000 Independence Ave., Washington, D.C. Additionally, information regarding the development of the new SNF treatment technologies, including the off-gas system

that would be used to collect fission products that could evolve during operation of the Melt and Dilute process, may be requested from Randall Ponik, U.S. Department of Energy, P.O. Box A, Aiken, South Carolina 29802, (803) 557-3263 or via E-mail at randall.ponik@SRS.gov. DOE has also solicited comments on the Melt and Dilute process from outside the Department. Contributing institutions include the University of South Carolina, the U.S. Nuclear Regulatory Commission (NRC), and the National Academy of Sciences. Their reports are publicly available, including in the DOE reading rooms, or upon request.

**Cost**

Comments were received regarding the potential costs of SNF treatment alternatives. These comments primarily questioned whether all costs and credits had been considered. This included the credits for the separation and sale of usable enriched uranium to the commercial nuclear power industry. Comments also were made regarding the adequacy of funding for the implementation of SNF treatment alternatives.

TC

Response: DOE prepared a report on costs associated with aluminum-based SNF treatment technologies. DOE considered all appropriate factors to prepare the report. A discussion of uranium credits (i.e., cost recovery based on the sale of low-enriched uranium to the private sector) was included in the cost analysis. The results of the cost report are discussed in Section 2.6.5 of the EIS. DOE obtained an independent review of the cost report; the recommendations from the independent review were factored into the report.

A timeline has been established for the development, design and implementation of the melt and dilute facility. This timeline will be controlled through DOE's line item budget and procurement process pending completion of this NEPA process. The design and construction of a full-scale facility would need to be developed in the context of constrained, out-year budget targets, and funding for such a facility would need to be balanced against other priorities at SRS. DOE has developed a schedule that can be used as a baseline for near-term planning and budgeting purposes. The FY 2000 budget has been established and includes funding for design completion of the L-Area Experimental Facility (LEF). The LEF is a pilot test facility which will demonstrate the feasibility of the melt and dilute technology. LEF is scheduled to be constructed and placed online by the end of FY 2002.

**References**

Comments were received related to the references used in the preparation of the EIS. The comments generally suggested alternate sources of information for the EIS and suggested that both foreign and domestic SNF handling experience be included in the discussion.

Response: DOE considered these suggestions. Based on the reports cited by the commentors, DOE believes accurate and current information was used to prepare the Final EIS. The information is based on actual Site operations (e.g., handling foreign and domestic SNF) and conditions or on estimates of operational activities and conditions that would exist for new facilities. As a result, DOE believes that data and references used in preparing the EIS provide an adequate basis for estimating impacts and for comparing technologies and alternatives. Current regulatory requirements and information have been cited as applicable. TC

**Nonproliferation**

Comments were received regarding nonproliferation issues as they relate to the treatment and disposition of SNF. A number of commentors felt that nonproliferation was being overemphasized in relation to its importance. However, one commentor doubted the independence of DOE in the preparation of the nonproliferation study, and another commentor stated that DOE should take a worldwide leadership role in nonproliferation by treating SNF without separating potential weapons materials.

Response: DOE believes nonproliferation to be one of the factors that must be considered during the decision-making process. DOE conducted a nonproliferation study for SNF treatment technologies in conjunction with the preparation of the Draft EIS. The study concluded that all technologies considered in the Draft EIS were compatible with the nonproliferation goals of the United States but that separations technologies, such as Conventional Processing, had distinct disadvantages because fissile material would be separated. The study was reviewed by experts independent of DOE: Matthew Bunn, Belfor Center for Science and International Affairs, Harvard University; Frank von Hipple, Woodrow Wilson School of Public and International Affairs, Princeton University; George Bunn, Center for International Security and Cooperation, Institute for International Studies, Stanford University; Harold Bengelsdorf, Bengelsdorf, McGoldrick and Associates, LLC; and David Albright, Institute for Science and International Security. No problems were identified with the conclusions presented in the report.

TC

**Methodology**

Comments were received related to the methodologies used in the preparation of the EIS. These included both positive and negative comments on health issues and environmental justice. One of the commenters asked what environmental impact would result from the release of cesium into the atmosphere in the event that the filtration system does not capture all the cesium. Another commenter stated that DOE had minimized impacts in the Cumulative Impacts Chapter and only used a limited amount of available information regarding actual operating experience. The Environmental Protection Agency (EPA) commended DOE on its method of segregating spent fuel by type and then applying the appropriate treatment methodology as the best way to proceed.

Response: Impacts in the EIS are estimated from the best available information, including operational data whenever possible. When operations data do not exist, SRS relies on experience and information from similar facilities and the best judgement of technical experts.

**Purpose and Need**

Comments were received related to the stated purpose and need for agency action. The comments generally focused on long-term solutions to the problems SNF poses and noted that other nuclear materials that could be processed in SRS facilities should also be addressed.

Response: DOE proposes to manage SNF in such a way as to prepare aluminum-based SNF to meet the requirements for disposal in a geologic repository, and will make the SNF ready for offsite shipment. DOE is separately evaluating potential geologic disposal of high-level waste and spent nuclear fuel in the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada as discussed in Section 1.6 of the SNF Management EIS. DOE has addressed other nuclear materials that could be managed at the SRS as part of the cumulative impacts discussion in Chapter 5 of this EIS. The inventory of material was based on recent studies completed by DOE (see Chapter 5). TC

**Safety**

Comments were received related to general safety issues of the proposed actions. Most comments were related to concerns on whether or not facilities would be constructed and operated using stringent safety standards.

Response: DOE is committed to the protection of workers, the public, and the environment. All operations and facilities at SRS meet or exceed all applicable health protection and safety requirements. SNF treatment facilities and operations will meet or exceed all applicable requirements.

**Failure of Stored SNF Before Treatment**

Comments were received regarding the possibility that stored SNF could fail before proposed treatment facilities are available. The comments requested impact estimates for these potential failures.

Response: The preferred alternative in the Final EIS includes a discussion of the action that would be taken (processing in SRS canyons) should SNF fail while in storage pending implementation of a new treatment technology. Section 1.5 of the Final EIS includes a qualitative discussion of the types of health and safety issues (e.g., uncontrolled release of fission products into storage basin water) that would be created by the failure of the SNF that DOE believes presents certain vulnerabilities for continued storage.

TC In addition, a number of other comments were received that offered editorial suggestions, could not be easily categorized, or were deemed to be out of scope of this EIS. Comments received and DOE's responses to all comments are presented in Appendix G of the EIS.

EC After consideration of public comments, DOE prepared a Final EIS. Decisions on the management of SNF at SRS will be presented in a Record of Decision issued at least 30 days after the Notice of Availability of the Final EIS is published in the *Federal Register*. EC The Record of decision will be published in the *Federal Register*.

## S.2 Background

### S.2.1 HISTORIC MISSIONS

The U.S. Atomic Energy Commission, a DOE predecessor agency, established the SRS in the early 1950s for the production of special radioactive isotopes to support national programs. Historically, the primary Site mission was the production of strategic isotopes (plutonium-239 and tritium) for use in the development and production of nuclear weapons. The SRS produced other isotopes (e.g., californium-252, plutonium-238, americium-241) to support research in nuclear medicine, space exploration, and commercial applications. DOE produced these isotopes in the five SRS production reactors. After the material was produced at the SRS, it was shipped to other DOE sites for fabrication into desired forms.

### S.2.2 FUEL CYCLE

The material in the SRS reactors consisted of nuclear fuel and targets. The nuclear fuel was enriched uranium that was alloyed with aluminum and then clad with aluminum. The targets were either oxides or metallic forms of various isotopes such as neptunium-237 or uranium-238 that were clad with aluminum. Fuel and targets were fabricated at the SRS and placed in the reactors, and then the reactors operated to create the neutrons necessary to transmute the target material. After irradiation, the fuel and targets (collectively referred to as spent nuclear fuel) were removed from the reactors and placed in water-filled basins for short-term storage, about 12 to 18 months, before they were reprocessed in the SRS separations facilities.

During processing, SNF was chemically dissolved in F or H Canyon to recover the uranium or transuranic isotopes for future use. EC The remaining residue from the fuel, high-level radioactive waste consisting primarily of fission products and cladding in liquid form, was transferred to large steel tanks for storage. The high-level waste is currently being vitrified in the Defense Waste Processing Facility at the SRS to prepare it for placement in any potential geologic repository. EC TC

### S.2.3 CHANGING MISSIONS

In 1992, the Secretary of Energy directed that processing operations to produce strategic nuclear materials be phased out throughout the DOE complex. However, SNF and targets from previous production reactor irradiation cycles remained in storage at SRS spent nuclear fuel storage facilities.

In addition to nuclear material production missions, another mission for the SRS was (and continues to be) the receipt of SNF from DOE, domestic, and foreign research reactors. Historically, SNF from these reactors was stored in the Receiving Basin for Offsite Fuel at SRS. In the past, much of the research reactor SNF was reprocessed in the same manner as spent fuel from SRS production reactors. However, with the end of the Site's strategic nuclear materials production mission, SNF from research reactors has been accumulating in the Receiving Basin for Offsite Fuel and in the L-Reactor Disassembly Basin.

Some of the research reactor spent nuclear fuel sent to SRS was not aluminum based. Because DOE did not have the capability to reprocess that type of SNF at SRS, it was placed in wet storage at the Receiving Basin for Offsite Fuel, where it remains in storage.

By 1995 DOE was storing about 195 metric tons heavy metal (MTHM [metric tons heavy metal] – the mass of uranium in the fuel or targets, excluding cladding, alloy materials, and structural materials) – of aluminum-based SNF in the SRS reactor disassembly basins and the Receiving Basin for Offsite Fuel. DOE also was storing about 20 MTHM of non-aluminum-based SNF in the Receiving Basin for Offsite Fuel.

### S.2.4 STABILIZATION

DOE has taken action to stabilize about 175 MTHM of the 195 MTHM of aluminum-based SNF that was in storage at SRS in 1995. DOE decided to stabilize this material following completion of the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE/EIS-0220). The primary purpose of the actions described in that EIS was to correct or eliminate potential health and safety vulnerabilities related to some of the methods used to store nuclear materials (including SNF) at SRS. In that EIS, DOE identified the remaining 20 MTHM (out of 195 MTHM) of aluminum-based SNF at SRS as "stable" (i.e., the SNF likely could be safely stored for about 10 more years, pending decisions on final disposition). That 20 MTHM of aluminum-based SNF is included in this EIS.

### S.2.5 SPENT NUCLEAR FUEL CONSOLIDATION

In May 1995, DOE decided (60 FR 28680) under the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* to consolidate existing and newly generated SNF at three existing Departmental sites (including SRS) based on fuel type, pending future decisions on ultimate disposition. DOE designated the SRS as the site that would manage aluminum-based SNF. As a result, DOE will transfer 20 MTHM of non-aluminum-based SNF from the SRS to the Idaho National Engineering and Environmental Laboratory (INEEL) and DOE will transfer about 5 MTHM of aluminum-based SNF at the INEEL to the SRS. Additionally, the SRS could receive about 5 MTHM of aluminum-based SNF from domestic research reactors through 2035.

In May 1996, DOE announced a decision (61 FR 25092) under the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (Nonproliferation Policy and Spent Fuel EIS) to accept about 18 MTHM of aluminum-based SNF containing uranium of United States origin from foreign research reactors for management in the United States at the SRS. The receipt of foreign research reactor SNF at SRS is now underway and receipts are scheduled to be completed by 2009. The 18 MTHM of foreign research reactor SNF that could be received at SRS is included in the scope of this EIS. (Recent decisions by some foreign research reactor operators have reduced the quantity of SNF expected to be shipped to SRS from about 18 MTHM to about 14 MTHM; however, the 18 MTHM projection is used for analysis purposes in this EIS because foreign research reactor operators still have the option to ship to the United States.) Table S-1 summarizes

the amount of SNF to be managed at SRS that is considered in this EIS.

## S.3 Purpose and Need for Action

DOE anticipates disposing of most of its aluminum-based SNF inventory in a geologic repository after treatment or repackaging. However, DOE does not expect a geologic repository to be available until at least 2010 and shipments from DOE sites might not begin until about 2015. Until a repository is available, the Department needs to develop and implement a safe and efficient SNF management strategy that includes preparing aluminum-based SNF stored at SRS or expected to be shipped to SRS for disposition offsite. DOE is committed to avoiding indefinite storage at the SRS of this nuclear fuel in a form that is unsuitable for final disposition. Therefore, DOE needs to identify management technologies and facilities for storing and treating this SNF in preparation for final disposition.

**Table S-1.** Quantity of SNF discussed in this EIS.

| | |
|---|---|
| • Aluminum-based SNF stored at SRS | 20 MTHM |
| • Domestic and DOE aluminum-based research reactor SNF to be received at SRS | 10 MTHM |
| • Foreign Research Reactor aluminum-based SNF to be received at SRS | 18 MTHM |
| • Non-aluminum-based SNF at SRS (to be shipped to INEEL) | 20 MTHM |

## S.4 Scope

In this EIS, DOE is evaluating the treatment and storage of about 48 MTHM of aluminum-based SNF including impacts from the construction and operation of facilities (either new or modified existing facilities) that would be used to receive, store, treat, and package SNF in preparation for ultimate disposition. Onsite transportation impacts are considered; however, no impacts associated with transporting SNF to SRS are included, because these impacts have been covered in other EISs. The potential impacts of transporting SNF to a geologic repository are discussed for completeness but no decisions related to transporting SNF offsite will be made under this EIS. Transportation of SNF to a federal repository will be addressed in the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Notice of Availability of the Draft EIS published in 64 FR 44200, August 13 1999). The Yucca Mountain EIS is being prepared as part of the process to determine if the Yucca Mountain site is suitable as the site of the Nation's first geologic repository for SNF and high-level radioactive waste.

DOE also evaluates transferring 20 MTHM of non-aluminum-clad spent nuclear fuel currently stored in the Receiving Basin for Offsite Fuel at SRS to a new dry storage facility at SRS. This transfer would occur only if a dry storage facility were built as part of the implementation of a treatment technology to prepare aluminum-based spent nuclear fuel for disposition and if the dry storage facility became operational before the non-aluminum-clad fuel was transferred to the Idaho National Engineering and Environmental Laboratory. The transfer to dry storage would occur after the fuel had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities necessary to phase out the use of the Receiving Basin for Offsite Fuel by fiscal year 2007.

This EIS does not evaluate the impacts of managing the non-aluminum-clad fuel at INEEL or of transporting the fuel to INEEL. These impacts were documented in the SNF management programmatic EIS (PEIS) and were evaluated as part of the process DOE used to decide to consolidate the storage of non aluminum-clad spent nuclear fuel at the INEEL.

SRS is storing Mark-51 and other targets in the Receiving Basin for Offsite Fuel (RBOF) in the Site's H-Area. This EIS evaluates the impacts of

continuing to store the Mark-51 and other targets in RBOF, and evaluates an alternative of transferring them to dry storage to provide flexibility in material management operations.

DOE is evaluating potential uses for this material and the operations and facilities that would be necessary. The Mark-51 and other targets (described in Section 1.5 of this EIS) contain americium and curium isotopes that could be used to produce elements with higher atomic numbers such as californium-252. Californium-252 is used as a neutron source for radiography and in the treatment of certain types of cancer and for research in basic chemistry, nuclear physics, and solid-state chemistry. If DOE were to determine that a programmatic need for this material exists, the targets would continue to be stored at the SRS pending preparations to ship them to another DOE facility where isotope production capability currently exists or could be constructed. SRS does not have isotope production capability.

This EIS does not evaluate the impacts of utilizing target material for programmatic purposes such as production of californium. DOE would perform the appropriate National Environmental Policy Act review to evaluate the impacts of shipment of the targets to an isotope production facility and of construction (or modification) and operation of the production facility, should such such a programmatic purpose be identified.

TC

DOE is storing the Mark-18 targets in wet basins at the SRS. These targets are similar to the Mark-51 and other targets in that they contain americium and curium that could be used to produce elements with higher atomic numbers such as californium-252. They are different from the small (about two feet in length) Mark-51 and other targets because the Mark 18s are about 12 feet long and therefore have different requirements for storage, transportation and use. As is the case with the Mark-51 and other targets, DOE is not proposing any actions that would lead to programmatic use of the Mark-18 targets at this time. Because of their length, the Mark-18 targets would have to be reduced in size for use in production facilities at another DOE facility or transfer to

dry storage at the SRS. This EIS considers only continued wet storage of Mark-18 targets. However, the Interim Management of Nuclear Materials EIS (which is incorporated herein by reference) considered the alternative of processing the Mark-18 targets in the SRS canyons, should they present potential health and safety vulnerabilities. See Section 1.5 of this EIS for more information.

## S.5 Decisions to be Based on this EIS

DOE expects to make the following decisions on the management and preparation of SNF for storage and ultimate disposition.

- The appropriate treatment or packaging technologies to prepare aluminum-based SNF that is to be managed at SRS. EC
- Whether DOE should construct new facilities or use existing facilities to store and treat or package aluminum-based SNF that is expected to be managed at SRS. EC TC
- Whether DOE should repackage and dry-store stainless-steel and zirconium-clad SNF pending shipment to the Idaho National Engineering and Environmental Laboratory, EC
- Whether DOE should repackage and dry-store Mark-51s and other americium/curium targets in the event dry storage capability becomes available at SRS. TC

## S.6 Proposed Action

DOE's proposed action is to safely manage SNF that is currently located or expected to be received at SRS, including treating or packaging

TC aluminum-based fuel for possible offsite shipment and disposal in a geologic repository, and preparing non-aluminum-clad fuel and programmatic material (i.e., material that could be used in national programs) for dry storage or off-site shipment.

EC In the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (61 FR 25092, May 17, 1996), DOE stated the Department would embark on an accelerated program at SRS to identify, develop, and demonstrate one or more non-processing, cost-effective treatment or packaging technologies to prepare aluminum-based foreign research reactor spent nuclear fuel for ultimate disposition.

Based on that decision, DOE's strategy is to select a new non-chemical processing technology or a new packaging technology that would put aluminum-based foreign research reactor SNF into a form or container suitable for direct placement in a geologic repository. Treatment or conditioning of the fuel would ad-dress potential repository acceptance criteria or safety concerns. Implementing the new non-chemical processing treatment or packaging technology would allow DOE (TC) to manage the SNF in a road-ready condition at SRS in dry storage pending shipment to a geologic repository. (TC)

Because of the similarity of the material, DOE proposes to manage the other aluminum-alloy SNF that is the subject of this EIS (domestic research reactor and DOE reactor fuels) in the same manner as the foreign research reactor fuels.

EC In the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, DOE stated that, should it become apparent by the year 2000 that DOE will not be ready to implement a new SNF treatment technology, DOE would consider chemically processing foreign research reactor SNF in F Canyon. DOE committed that any decision to use conventional chemical processing would consider the results of a study (62 FR 20001, December, 1998) on the nonproliferation, cost, and timing issues associated with chemically processing the fuel. (EC) DOE stated that any highly enriched uranium separated during chemical processing would be blended down to low enriched uranium. (EC)

With the limited proposed processing, as discussed below, and the current nuclear material stabilization program at SRS, DOE expects the canyons will be utilized to their fullest extent over the next several years. DOE has greater confidence now in the feasibility and availability of new non-chemical processing technologies than at the time the Nonproliferation Policy and Spent Nuclear Fuel EIS's Record of Decision was issued. (EC) Therefore, except in the case of potential health and safety vulnerabilities as discussed below, the use of the canyons for processing research reactor fuel as a backup for new technology would not be as likely.

DOE has included chemical processing as a management alternative in this EIS. However, DOE's strategy and preference is to use non-chemical separations processes. DOE proposes to use chemical separation processes when a potential health or safety vulnerability exists for aluminum-based SNF that DOE considers should be alleviated before a non-chemical separations process is in operation. (EC)

The limited proposed canyon SNF processing is not expected to extend the operating schedules for these facilities beyond the current planning basis. (EC) Processing would eliminate potential health and safety problems that could occur prior to the availability of a new SNF treatment technology. In the event the new treatment process becomes available, the SNF with potential health and safety vulnerabilities could be processed using the new treatment technology.

DOE may decide, in the future, that the Higher Actinide Targets have no programmatic use. (TC) Therefore, DOE proposes to maintain the Mark-18's, Mark-51's, and other Higher Actinide Targets pending decisions on final disposition.

## S.7 Categories of Spent Nuclear Fuel

DOE has categorized SNF at SRS into six groups (A through F), based on such characteristics as fuel size, physical or chemical properties, or radionuclide inventories. Table S-2 lists the amounts of each fuel type SRS expects to manage.

TC The aluminum-based fuels currently stored at SRS include some fuels that were not originally aluminum-clad (EBR-II and Sodium Breeder Experimental Reactor Fuel). Additionally, the aluminum-based category consists of one element not yet received but due to be shipped to SRS (the Advanced Reactivity Measurement Facility Core Filter Block). Most of the fuels that were not originally aluminum-clad (but are included under this EIS's major category of aluminum-based fuel) have been declad and placed in aluminum cans. In their present form they can be processed at the SRS through the existing technologies on site. Other fuels at SRS which are non-aluminum-clad fuels cannot be processed in their existing form using the existing technologies and are categorized in this EIS as non-aluminum-based fuel. The Core Filter Block is included under the category of aluminum-based fuel since the most practical way of dealing with it (based on its unique configuration) is to process it utilizing the existing technology at SRS. TC

**Table S-2.** Spent nuclear fuel groups.

| | Fuel group | Volume (MTRE)[a] | Mass (MTHM)[b] | |
|---|---|---|---|---|
| A. | Uranium and Thorium Metal Fuels | 610 | 19 | EC |
| B. | Material Test Reactor-Like Fuels | 30,800 | 20 | |
| C. | HEU/LEU[c] Oxides and Silicides Requiring Resizing or Special Packaging | 470[d] | 8 | TC |
| D. | Loose Uranium Oxide in Cans | NA | 0.7 | |
| E. | Higher Actinide Targets | NA | <0.1 | |
| F. | Non-Aluminum-Clad Fuels[e] | 1,900 | 20.4 | TC |
| | Total | 33,780 | 68.2 | |

a. MTRE = Materials test reactor equivalent. An MTRE is a qualitative estimate of SNF volume that provides information on the amount of space needed for storage. An MTRE of Materials Test Reactor-Like Fuels would usually be one fuel assembly measuring about 3 inches by 3 inches by 2 feet long. TC
b. MTHM = Metric tons of heavy metal.
c. HEU = highly enriched uranium; LEU = low enriched uranium.
d. Fuel group also includes about 2,800 pins, pin bundles, and pin assemblies.
e. This fuel group will be shipped to Idaho National Engineering and Environmental Laboratory. It will not be treated at SRS. TC

> ***Categorization of SNF at the Savannah River Site***
> Group A: Uranium and Thorium Metal Fuels
> Group B: Materials Test Reactor-Like Fuels
> Group C: HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging
> Group D: Loose Uranium Oxide in Cans
> Group E: Higher Actinide Targets
> Group F: Non-Aluminum-Clad Fuels

<u>**Uranium and Thorium Metal Fuels (Group A)**</u>

This group consists of fuels from the Experimental Breeder Reactor-II and the Sodium Reactor Experiment, as well as a core filter block from the Advanced Reactivity Measurement Facility at INEEL (that is scheduled to be transferred to SRS). This group also includes unirradiated Mark-42 targets that were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and wet-stored in canisters in the Receiving Basin for Offsite Fuel at SRS. The declad fuel presents a potential health and safety vulnerability. These fuels have cores of reactive metals that were exposed when the fuel cladding was removed. Any contact of the reactive metal core with water would lead to relatively rapid oxidation of the core and disintegration of the fuel, resulting in the release of fission products and particulate fuel material to the water of the storage basin at SRS.

The unirradiated Mark-42 targets were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum. The plutonium oxide and aluminum were pressed together in the manufacturing process. As a result, the unirradiated targets could be less durable than uranium-aluminum alloy SNF because of the particulate nature of the plutonium oxide, but more durable (i.e., less reactive) than uranium metal SNF since the plutonium is already in oxide form. The potential for dispersion of material into storage basin water in the event of cladding failure could present a health and safety vulnerability.

The core filter block at INEEL is made of depleted uranium and corrosion resistant metal (i.e., stainless steel), and was used as a neutron "filter" for reactivity experiments. As a result, the filter was subject to relatively short (or low-power level) exposure times in the test reactor and is only slightly irradiated.

EC Material in this fuel group in its current form may not be acceptable for disposal in a reposi-
TC tory due to the reactive nature of uranium metal or the particulate nature of some of the material.

This group accounts for approximately 2 percent of the volume of aluminum-based fuel that DOE is likely to manage at SRS from now until 2035. Because the fuel in Group A is made of unalloyed metal (i.e., it contains little or no aluminum), it is more dense than most of the other spent fuel considered in this EIS. As a result, this small volume of fuel contains about 40 percent of the mass of heavy metal.

**Materials Test Reactor-Like Fuels (Group B)**

This group consists primarily of Materials Test Reactor fuels and other fuels of similar size and composition. Most research reactors – foreign and domestic – use Materials Test Reactor fuel. These fuels vary in uranium-235 content from just below 20 percent to about 93 percent. Approximately 70 percent of the Group B assemblies are highly enriched uranium (>20 percent uranium-235), and the remainder are low enriched uranium (<20 percent uranium-235). Group B accounts for approximately 97 percent of the volume of aluminum-based SNF that DOE will manage at SRS between now and 2035. DOE considers that there are no currently known health and safety vulnerabilities for this material that would preclude wet storage pending the operation of a new treatment technology.

Although some Group B fuels are stored at SRS in the Receiving Basin for Offsite Fuel or in L Reactor Disassembly Basin, at present most are at domestic universities, foreign research reactors, and DOE research facilities pending shipment to the Site.

**HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (Group C)**

Fuels in this group are similar in composition to Group B fuels in that they are aluminum-based, highly enriched uranium and low enriched uranium oxides and silicides, but their size or shape might preclude packaging them in the disposal canisters proposed for use in a repository without resizing or special packaging considerations. TC Some fuel in this group is smaller in diameter and longer than Group B fuels or is larger than Group B fuels in both diameter and length; it often comes in odd shapes such as a 1.5-foot by 3-foot (0.46-meter by 0.9-meter) cylinder or a sphere with a diameter of 29 inches (74 centimeters). EC DOE would have to disassemble or use other volume-reduction activities to place such fuels in a nominal 17-inch direct co-disposal

canister. At present, much of this fuel is at other DOE sites and in other countries but is scheduled to be received at SRS.

A small amount of this fuel (currently stored in 14 cans) presents a potential health and safety vulnerability. The fuel was cut apart for research purposes and could release fission products and particulate material to the water of the wet storage basin at SRS should the storage cans leak. Additionally, fuel in this condition may not be acceptable in a geologic repository because the fuel is no longer intact.

Together Group B and Group C fuels represent about 97 percent of the volume of all fuel to be treated at SRS.

**Loose Uranium Oxide in Cans (Group D):**

This group consists of loose uranium oxide with fission products distributed throughout the material. The only material in this fuel group currently stored at the SRS is 676 cans of Sterling Forest Oxide. The majority of the material (estimated at over 6,000 cans) has not yet been produced at foreign research reactors. Research reactors in Canada would be the greatest single source for future material and these reactor operators are among those that, as discussed in Section S.2.4, may not participate in the foreign research reactor SNF return program. DOE expects that the material in this fuel group would not be acceptable for placement in a geologic repository because it is not in a tightly bound metal or ceramic matrix (i.e., it is a powder). Additionally, the Sterling Forest Oxide fuel presents a potential health and safety vulnerability due to the dispersible nature of the material should a storage can fail.

**Higher Actinide Targets (Group E)**

This group contains irradiated and unirradiated target materials used to generate radionuclides with atomic numbers higher than that of uranium. The targets were aluminum-clad plutonium oxide that now contain significant quantities of americium and curium, which react under neutron irradiation to produce elements with still higher atomic numbers such as californium. All materials in this group are stored in the Receiving Basin for Offsite Fuel. Group E accounts for less than 1 percent of the volume of aluminum-based SNF DOE will manage at SRS.

The Higher Actinide Target fuel group consists of 60 Mark-51 targets, 114 other targets, and 65 Mark-18 targets. This material was evaluated in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials* (DOE/EIS-0220). Under the Record of Decision for the Final Environmental Impact Statement for Interim Management of Nuclear Materials (FR 65300, 12/19/95), DOE decided that the targets should remain in wet storage.

In this EIS, DOE evaluates the continued wet storage of the Mark-51 and other targets pending shipment offsite, or alternatively repackaging the Mark-51 and other targets to place them in a new dry storage facility so that the material could be transferred to dry storage if necessary to provide flexibility in spent fuel storage operations.

The Mark-18 targets are different from the Mark-51 and other targets in several ways. The most important distinction is that each Mark-18 target is one continuous piece about 12 feet long. The Mark-51 and other targets are about 2 feet long and could be handled, transported, and stored (including in a dry storage facility) in their current configuration. The 12-long Mark-18 targets would require size reduction for transportion or storage in a dry storage facility. The standard method to reduce the size of the Mark-18 targets would be to cut them up under water in an SRS wet storage basin. However, the condition of the Mark-18 targets presents a health and safety vulnerability for under water cutting because of the suspected brittle condition of the targets and the uncertainty of the region of the target assemblies that contains the target product (i.e., americium and curium) and fission products. The brittle condition is due to a very long irradiation cycle in a reactor at SRS. Cutting the targets using the existing Site capability could result in the uncontrolled release of radioactive material to the water

of the Receiving Basin for Offsite Fuel. For these reasons, a previous DOE assessment of this material (see Section 1.6.2 of this EIS) concluded that the Department should consider processing the Mark-18 targets in F Canyon. These alternatives are not included in this EIS because DOE performed that evaluation in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials*, incorporated herein by reference. Those alternatives included dissolving the targets in F Canyon and then vitrifying the americium and curium in a new F-Canyon vitrification facility, dissolving the targets in F Canyon and recovering the americium and curium as an oxide, and dissolving the targets and transferring the americium and curium to the high-level waste tanks at the SRS.

**Non-Aluminum-Clad Fuels (Group F):**

This group consists of fuel that is clad in materials other than aluminum. It includes stainless-steel and zirconium-clad fuel at SRS that DOE plans to transport to the Idaho National Engineering and Environmental Laboratory in accordance with decisions based on the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* (DOE/EIS-0203).

## S.8 Affected Environment

The SRS is in west-central South Carolina and occupies an area of approximately 300 square miles (approximately 800 square kilometers) adjacent to the Savannah River, primarily in Aiken and Barnwell Counties. The Site is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 20 miles (32 kilometers) south of Aiken, South Carolina. All alternatives described in this EIS, including the possible construction of new facilities to implement some of the alternatives, would occur within existing industrial areas at SRS.

## S.9 Technologies

### S.9.1 NEW SNF MANAGEMENT TECHNOLOGIES

DOE has identified six reasonable new technologies to be analyzed in this EIS that could be used to prepare SNF at SRS for disposition. Most of the New Packaging Technology options and the New Processing Technology options are technologies that DOE has not previously applied to the management of aluminum-based SNF for the purpose of ultimate disposition. DOE assigned the highest confidence of success and greatest technical suitability to options that have relatively simple approaches.

***Technology Options for Management of SNF at the Savannah River Site***

- New Packaging Technology
  1. Direct Disposal/Direct Co-Disposal
  2. Repackage and Prepare to Ship to Other DOE Sites
- New Processing Technology
  1. Melt and Dilute
  2. Mechanical Dilution
     -- Press and Dilute
     -- Chop and Dilute
  3. Vitrification
     -- Plasma Arc Treatment
     -- Glass Material Oxidation and Dissolution System
     -- Dissolve and Vitrify
  4. Electrometallurgical Treatment
- Conventional Processing Technology

#### S.9.1.1 New Packaging Technologies

Under the New Packaging Technology, two of the options, Direct Disposal and Direct Co-Disposal, are non-destructive methods to prepare and package aluminum-based SNF for placement in a geologic repository, while one technology option, Repackage and Prepare to Ship to Another DOE Site, is pertinent only to non-aluminum-clad SNF and higher actinide targets

that are scheduled to be or could be shipped off-site.

EC The Direct Disposal/Direct Co-Disposal process is relatively simple because the fuel would remain intact but be repackaged in a way that minimizes the possibility of criticality. Elaborate treatment processes and equipment would not be required. The dry storage method that would be used to store the fuel after repackaging is common for commercial SNF and is adaptable for aluminum-based SNF.

The Direct Disposal and Direct Co-Disposal technology options are discussed together in this EIS as Direct Disposal/Direct Co-Disposal. The only difference between the technologies is the diameter of the canister into which the SNF would be loaded. The Direct Disposal options would use a 24-inch diameter canister because this is the same size as the high-level waste canisters currently being produced at the SRS Defense Waste Processing Facility. The Direct Co-Disposal option would use a smaller diameter canister (17 inches) that could be placed in the void space at the center of high-level waste packages that will be assembled at the repository (i.e., a five-canister array of 24-inch diameter high-level waste canisters with one 17-inch diameter SNF canister placed in the center). In either case, the canisters would be stored at SRS and shipped from SRS in the same manner. In this EIS, Direct Disposal and Direct Co-Disposal are treated as the same technology and the final decision on canister diameter would be made during the engineering design phase of the project to implement the technology.

### S.9.1.2 New Processing Technologies

DOE has identified four technology options that could treat aluminum-based SNF. These are: (1) Melt and Dilute, (2) Mechanical Dilution, (3) Vitrification, and (4) Electrometallurgical Treatment.

L10-2 The Melt and Dilute technology is more complicated than Direct Disposal since it would destroy the fuel elements, but it is one of the simplest of the destructive treatments. Under this technology, SNF would be melted along with other materials to ensure a low enriched uranium-aluminum product. Most fission products would remain trapped within the product matrix, although some would be volatilized. The melt product would be sealed in corrosion-resistant canisters. DOE has substantial experience melting SNF on a small scale for research purposes and has not identified any reasons why a full-scale operation to melt aluminum-based SNF and dilute the highly-enriched uranium would not be achievable.

The Mechanical Dilution Technology would involve either the Press and Dilute or the Chop and Dilute options, which are similar. DOE has represented these two technologies for analysis as the Mechanical Dilution options. L10-2

In the Press and Dilute Technology, SNF would be crushed between layers of depleted uranium to produce a product with low overall enrichment. The product would be mixed with a neutron poison as necessary to prevent criticality. The final product would be sealed in special canisters.

In the Chop and Dilute Technology, SNF would be shredded and mixed with depleted uranium to produce a low enriched product. As in Press and Dilute, a neutron poison could be added as needed and the product sealed in special canisters.

Three SNF processing technologies, Plasma Arc Treatment, Glass Material Oxidation and Dissolution System, and Dissolve and Vitrify options all use processes that produce a product with properties similar to that produced at the Defense Waste Processing Facility at SRS. Therefore, DOE has represented these three as the Vitrification option.

In the Plasma Arc Treatment Technology, SNF would be melted by a high-temperature plasma torch in a furnace. The melted SNF would be mixed with a ceramic material to produce a glass-ceramic product. Depleted uranium would be included as necessary to reduce the enrichment L10-2

of the final product, which would be sealed in special canisters.

In the Glass Material Oxidation and Dissolution Technology, the SNF would be converted directly to borosilicate glass. Depleted uranium would be included as necessary to reduce the enrichment of the final product, which would be sealed in special canisters.

In the Dissolve and Vitrify Technology, SNF would be dissolved as in conventional processing, but the enriched uranium would not be extracted. Instead, the dissolved solution would be vitrified. Depleted uranium would be included as necessary to reduce the enrichment of the final product, which would be sealed in special canisters. DOE expects that the resulting waste form would be acceptable for disposal in a geologic repository.

DOE prepared the current waste acceptance criteria using information available to date. DOE considers the criteria to be conservative. As repository designs evolve and more information is available on waste form performance under relevant repository conditions, the acceptance criteria will change. DOE currently is characterizing conditions at the Yucca Mountain site in Nevada as a possible site for development of a geologic repository. If a decision were made to develop Yucca Mountain, DOE would submit a license application to the U. S. Nuclear Regulatory Commission (NRC). The acceptance criteria developed at that time would be the basis for waste acceptance specifications in the license application. These specifications likely would be available before the melt and dilute facility would be operational and before the canyons cease operating. Final waste specifications will not be available until after the NRC approves construction of a repository and authorizes a license for DOE to receive and store SNF and high-level radioactive waste, prior to the beginning of repository operations.

Electrometallurgical Treatment is an electrorefining process that would separate highly-enriched uranium from the aluminum and fission products in the SNF. In the Electrometallurgical Treatment Technology, the SNF would be melted into metal ingots. Processing of the ingots first would remove the aluminum from the material. Further processing would remove the uranium from the material. The remaining material would be oxidized and dissolved in glass and then sealed in special canisters. This is a process that DOE has been evaluating for the management of certain non-aluminum-based SNF at other DOE sites.

### S.9.1.3 <u>Technical Considerations in Selecting a New Technology Option for SNF Processing</u>

Part of DOE's proposed action is to prepare SNF to meet the requirements that the Department anticipates will apply to material to be disposed of in a geologic repository. Any technology that DOE implements must be able to provide a product that is compatible with such criteria. DOE must rely on reasonable assumptions about what the acceptance criteria would include when making decisions on SNF treatment technologies. DOE anticipates that eventually it will place its aluminum-based SNF inventory in a geologic repository after treatment or repackaging.

One of the technical risks in implementing any of the new SNF technology options is the uncertainty surrounding the acceptability of DOE SNF for placement in a geologic repository. While DOE has documented preliminary acceptance criteria in the Waste Acceptance System Requirements Document (Rev. 3, 1999), the acceptance criteria will become more detailed. Final acceptance criteria will not be available until after DOE were to receive authorization from NRC to receive and possess SNF and high-level waste, based on criteria that meet NRC requirements. DOE-SR is working closely with NRC (the Federal agency that would license the operation of a geologic repository) to ensure that the final product from the selected SNF treatment technology would be acceptable at a repository.

Recognizing that repository disposal is the ultimate endpoint for the melt and dilute waste form, DOE-SR signed in August 1997 a Memorandum

of Understanding with NRC for their review and feedback on the research effort that DOE-SR is conducting. DOE-SR has provided the NRC with several technical reports on the results obtained from the research effort. Based upon their initial review, NRC stated in a June 1998 letter that "both the direct co-disposal and melt-dilute options would be acceptable concepts for the disposal of aluminum-based research reactor SNF in the repository." Additionally, as research efforts yield new findings, DOE is providing the information to the NRC for their feedback and review.

EC

The EIS has been revised to discuss in greater detail the expected repository acceptance criteria and compare the treatment technology products to these criteria. This information is discussed in Section 2.2.1.

EC

### S.9.2 EXISTING SNF MANAGEMENT TECHNOLOGIES

TC

The Conventional Processing technology is the only existing SNF treatment technology available at SRS.

With this technology, DOE would process SNF in F or H Canyon directly from wet storage. The process would chemically dissolve the fuel and separate fission products from the uranium by solvent extraction. Conventional Processing would apply to all SNF, except most of the targets in the Higher Actinide Targets fuel group (specifically the Mark-51 and "other" targets) and the non-aluminum-clad fuels. Non-aluminum-clad targets would be shipped to INEEL as a result of previous decisions by DOE.

TC

The Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel described the possible use of F Canyon for SNF processing based on a preliminary concept to consolidate all processing operations in one canyon. Subsequent review has shown that consolidating highly enriched uranium spent fuel processing operations in F Canyon would not be practical due to criticality considerations and process capacity restrictions associated with the pluto-nium-uranium extraction system used in F Canyon. Thus, in this EIS, H Canyon is referenced in regard to chemically separating highly enriched uranium spent fuel.

TC

## S.10 Alternatives

***Alternatives Considered***

- Minimum Impact Alternative
- Direct Disposal Alternative
- Preferred Alternative
- Maximum Impact Alternative
- No-Action Alternative

Because of the differences in the characteristics of the SNF and the capabilities of the technologies, no single technology could be applied to all the SNF. Table S-3 lists the technologies appropriate for each of the six fuel groups.

Because of the many possible combinations of technologies and fuel groups (more than 700), DOE has chosen to evaluate a limited number of configurations (as alternatives). The alternatives illustrate the range of impacts that could occur from any configuration the decisionmakers might select. Table S-4 and the following paragraphs describe the five alternatives considered in this EIS. See Section S.11 for a detailed description of the preferred alternative.

EC

EC

- *Minimum Impact Alternative:* This alternative combines the technologies appropriate for each fuel group that DOE believes would result in the lowest overall impact.

- DOE recognizes that this alternative might not result in the lowest impact for each impact category (e.g., worker health and public health could be lowest, but radioactive waste generation could be higher) and that there are other reasonable technology

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**Table S-3.** Fuel groups and analyzed technology options.

| | New Packaging Technology | | New Processing Technology | | | | Conventional Processing Technology |
|---|---|---|---|---|---|---|---|
| Fuel group | 1. Prepare for Direct Co-disposal | 2. Repackage and Prepare to Ship[a] | 3. Melt and Dilute | 4. Mechanical Dilution | 5. Vitrification Technologies | 6. Electro-metallurgical Treatment | 7. Conventional Processing in Canyons |
| A. Uranium and Thorium Metal Fuels | Yes[b] | No | Yes[c] | No | Yes | Yes | Yes |
| B. Materials Test Reactor-Like Fuels | Yes | No | Yes | Yes | Yes | Yes | Yes |
| C. HEU/LEU[d] Oxides and Silicides Requiring Resizing or Special Packaging | Yes | No | Yes | Yes | Yes | Yes | Yes |
| D. Loose Uranium Oxide in Cans | No | No | Yes | No | Yes | Yes | Yes |
| E. Higher Actinide Targets | No | Yes[e] | No | No | No | No | No[f] |
| F. Non-Aluminum-Clad Fuels[g] | No | Yes | No | No | No | No | No |

a. This alternative describes repackaging for storage at SRS pending shipment offsite.
b. "Yes" indicates that the technology could be applied to the fuel group. "No" indicates that the technology should not be applied to the fuel group (see Sections S.9.1.3 and Tables 2-1 and 2-2 of the EIS).
c. Except for the core filter block that may be incompatible with the melt and dilute process.
d. HEU = highly enriched uranium; LEU = low enriched uranium.
e. The Mark-18 targets from Fuel Group E are not acceptable for repackaging as proposed in this EIS. See footnote f.
TC
f. This entry is with respect to the Proposed Action of this EIS. Conventional Processing with a follow-on treatment (e.g., vitrification, oxidation, or disposal) has been evaluated for the Mark-18 target material in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials* (DOE/EIS-0220).
g. In light of a previous decision by DOE to transfer this material to INEEL, only packaging for dry storage needs to be considered further.

**Table S-4.** Alternatives analyzed in this EIS.

| Fuel Group | No-Action Alternative | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|---|
| A. Uranium and Thorium Metal Fuels | Continued Wet Storage | Prepare for Direct Co-Disposal | Conventional Processing | Conventional Processing | Conventional Processing |
| B. Materials Test Reactor-like Fuels | Continued Wet Storage | Prepare for Direct Co-Disposal | Prepare for Direct Co-Disposal | Melt and Dilute | Conventional Processing |
| C. HEU/LEU Oxide and Silicides Requiring Resizing or Special Packaging | Continued Wet Storage | Prepare for Direct Co-Disposal | Prepare for Direct[a] Co-Disposal | Melt and Dilute[a] | Conventional Processing |
| D. Loose Uranium Oxide in Cans | Continued Wet Storage | Melt and Dilute | Melt and Dilute[b] | Melt and Dilute[b] | Conventional Processing |
| E. Higher Actinide Targets | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site[c] | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site[c] |
| F. Non-Aluminum-Clad Fuels | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site |

TC

a. Conventional processing would be the preferred technology for the failed or sectioned Oak Ridge Reactor fuel, High Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor fuel, and a Mark-14 target (i.e., <1 percent of the material in this fuel group).
b. Conventional processing is the preferred technology for the Sterling Forest Oxide fuel (i.e., about 10 percent of the material in this fuel group).
TC c. Mark-18 target assemblies (approximately 1 kilogram heavy metal) would undergo conventional processing.

configurations that would result in similar minimal impacts. DOE expects that the impacts of this combination would be representative of the lower bound of impacts from the Proposed Action. This scenario would utilize the New Packaging and New Processing Technologies.

The Uranium and Thorium Metal Fuels would be treated using the Direct Disposal/Direct Co-Disposal technology with more complicated treatment (i.e., hot-vacuum drying). DOE recognizes that there is technical uncertainty regarding the acceptability of this material (treated this way) in a repository because of the potential reactivity of the material; however, Direct Disposal/Direct Co-Disposal was postulated to represent minimum impacts based on the assumption that the waste form would be acceptable for disposal in a geologic repository. Materials Test Reactor-like Fuels and HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging would receive minimum treatment (i.e., cold-vacuum drying and canning or resizing) using the Direct Disposal/Direct Co-Disposal technology before being placed in dry storage. The loose uranium oxide in cans would be treated using the Melt and Dilute Technology. TC

DOE would continue to wet-store the Mark-51 and other Higher Actinide Targets at the SRS. DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the non-aluminum-clad fuel has not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage. To maintain operational flexibilty DOE could transfer the Mark-51 and other targets to dry storage. DOE would maintain the Mark-18 targets in wet storage pending disposition decisions due to potential health and safety concerns associated with the actions that would be required to repackage the Mark-18 target assemblies. TC

- *Direct Disposal Alternative*: This alternative combines the New Packaging and New Processing Technologies with Conventional Processing Technology. Materials Test Reactor-like Fuels and HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (except for the failed or sectioned fuel) would receive minimum treatment (i.e., cold-vacuum drying and canning) using the Direct Disposal/Direct Co-Disposal technology before being placed in dry storage.

All material in the Uranium and Thorium Metals Fuel group, the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans group, and the failed or sectioned fuel from the HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging group would be treated with Conventional Processing because this material presents potential health and safety concerns and probably would not be suitable for placement in a geologic repository. Melt and Dilute would be applied to the majority of the material in the Loose Uranium Oxide in Cans fuel group because that material could be received after a melt and dilute facility was available. EC TC

DOE would manage the Higher Actinide Targets and the non-aluminum-clad SNF as described in the Maximum Impact Alternative. TC

***DOE's Preferred Alternative:*** The alternative which DOE believes would best fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

*Preferred Alternative:* This alternative combines a New Packaging Technology option, a New Processing Technology option, and the Conventional Processing Technology option. Materials Test Reactor-like Fuels, most HEU/LEU Oxides and Silicides Re-

quiring Resizing or Special Repackaging, and most Loose Uranium Oxide in Cans would be stored and then treated using the Melt and Dilute technology option when that option became available. The Conventional Processing Technology option would be used for the Uranium and Thorium Metal Fuels, about 10 percent of the HEU/LEU Oxides and Silicides Requiring Resizing or Special Repackaging; and about 10 percent of the Loose Uranium Oxide in Cans because of the potential health and safety vulnerability of continuing wet storage of those fuels while awaiting the availability of Melt and Dilute technology.

DOE is not proposing any actions that would lead to the programmatic use of the Higher Actinide Targets. Therefore, DOE will maintain the Mark-18, Mark-51 and other targets in wet storage until decisions are made on final disposition.

- *Maximum Impact Alternative:* This alternative would provide Conventional Processing for all SNF except the Mark-51 and other" targets and the non-aluminum-clad fuels already selected for offsite shipment. This alternative provides the upper bound on range of impacts from potential configurations because the analyses presented are conservative in that they assume that the entire SNF inventory would be processed in the separations facilities, which would produce the greatest impacts of all the treatment options.

  DOE would manage the Mark-51 and other Higher Actinide Targets and the non-aluminum-clad SNF as described in the Minimum Impact Alternative. DOE would process the Mark-18 Higher Actinide Targets in F Canyon followed by vitrification of the americium and curium in the new F-Canyon Vitrification Facility as analyzed in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials*.

- *No-Action Alternative*: The implementing regulations of NEPA require the inclusion of a No-Action Alternative. Under this alternative, DOE would continue to store the SNF in the wet basins at SRS even though this would not meet the purpose and need for action. To maintain safe conditions, DOE would take necessary actions to ensure safe storage in the basins, such as consolidation of fuel and upgrades of systems to ensure good water quality. As determined by the Record of Decision for the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* (DOE/EIS-0203), DOE would transport the Non-aluminum Clad Fuels to the Idaho National Engineering and Environmental Laboratory.

## S.11 Preferred Alternative

DOE proposes to implement several technologies to manage spent nuclear fuel at SRS. These technologies are Melt and Dilute, Conventional Processing, and Repackage and Prepare to Ship. Each of these technologies would treat specific groups of spent nuclear fuel, as described below. The technology and fuel group combinations form DOE's Preferred Alternative in this EIS. Figure S-1 provides a flowchart for the preferred alternative.

**Melt And Dilute**

> Melt and Dilute is the preferred treatment for 97 percent by volume (60 percent by mass) of the aluminum-based SNF at the Savannah River Site.

DOE has identified the Melt and Dilute process as the preferred method of treating most (about 97 percent by volume or about 32,000 MTRE) of the aluminum-based SNF considered in this EIS. DOE will continue to pursue a research and development program leading to a demonstration of the technology in FY 2001 using full-size irradiated research reactor spent nuclear

fuel assemblies. With a successful demonstration of the technology, DOE expects to have ready a treatment facility to perform production melt and dilute operations in FY 2008. DOE will ensure the continued availability of SRS conventional processing facilities until it has successfully demonstrated implementation of the Melt and Dilute treatment technology.

The fuel proposed for the preferred Melt and Dilute technology includes the Material Test Reactor-like fuel, most of the Loose Uranium Oxide in Cans fuel, and most of the HEU/LEU Oxide and Silicide fuel. Exceptions are the uranium and thorium fuel, failed and sectioned oxide and silicide fuel, some loose uranium oxide in cans fuel, the Higher Actinide Targets, and non-aluminum-clad fuel.

The Melt and Dilute Technology would satisfy DOE's objective and preference, as stated in the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (60 FR 25091), to select a non-chemical separations-based technology to prepare aluminum-based SNF for placement in a geologic repository. Additionally, this new technology would provide significant waste reduction (of high-level, low-level, transuranic, etc.) in comparison to conventional chemical processing and is fully compatible with and supportive of the non-proliferation objectives of the United States. In the Melt and Dilute process, aluminum-based SNF would be melted and highly-enriched uranium would be diluted with depleted uranium to produce low-enriched uranium. No separation of fissile materials from fission products would occur.

The potential impacts (e.g., worker and public health, waste generation, socioeconomics, etc.) among the new non-separations based technologies were all very similar; however, the Melt and Dilute option was the most efficient in volume reduction and produced the fewest number of SNF canisters. In fact, Melt and Dilute would volume reduce the fuel by more than 3 to 1 over Direct Disposal/Direct Co-Disposal. The volume reduction is achieved because the melt and dilute process eliminates voids in the fuel elements and in the canisters and fuel baskets used in the Direct Disposal/Direct Co-Disposal technology. DOE considered Melt and Dilute to be among the most "proven" of the new non-separations-based technologies because DOE has extensive experience with fuel melting operations for research purposes.

The Melt and Dilute technology offers DOE the flexibility to engineer the final waste form to provide a high degree of confidence that the material would be acceptable for placement in a geologic repository. Major technical concerns such as fuel characterization, criticality control, and repository performance can be reduced or eliminated by tailoring the chemical and physical form of the final product to meet specific criteria. DOE expects the Melt and Dilute option would be relatively simple to implement and would be less expensive than other similar technology options, although the ongoing technology development initiative will determine the viability of this alternative. The major technical issue for implementing this technology would be the design of an off-gas ventilation system to capture volatilized fission products. Preliminary engineering studies indicate that the system could be designed using proven approaches for managing off-gases.

To implement the preferred alternative (Melt and Dilute technology), DOE would construct a melt and dilute facility in the existing 105-L building at SRS and build a dry-storage facility in L Area, near the 105-L building. DOE is proposing to use this facility to house the Melt and Dilute process for the following reasons: the existing structure can accommodate the process equipment and systems; the applicable portions of the structure will meet DOE requirements for resistance to natural hazards (e.g., earthquakes); the integral disassembly basin has sufficient capacity for all expected SNF receipts and the current Site inventory; using 105-L avoids creating a new radiologically controlled facility that would eventually require decontamination and decommissioning; and DOE has estimated the cost

EC savings versus a new facility to be about $70 million.

Using the Melt and Dilute technology, DOE would melt aluminum-based SNF and blend down any highly enriched uranium to low enriched uranium using depleted uranium that is currently stored at SRS. The material would be cast as ingots that would be loaded into stainless-steel canisters approximately 10 feet tall and 2 feet (or less) in diameter. The canisters would be
TC placed in dry storage pending shipment to a geologic repository.

TC

During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and
EC Dilute option is not viable. As a back-up to Melt and Dilute, DOE would continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would implement this option if Melt and Dilute were no longer feasible or preferred. Direct Co-Disposal has the potential to be the least complicated of the new technologies and DOE believes this option could be implemented in the same timeframe as the Melt and
EC Dilute option. However, DOE believes there is greater risk in attempting to demonstrate that aluminum-based SNF, packaged according to the Direct Co-Disposal option, would be acceptable
TC in a geologic repository. A comparison of the preferred (Melt and Dilute) and back-up (Direct Co-Disposal) technologies DOE proposes to use to manage most of the aluminum-based SNF at SRS is presented in Table S-5.

If DOE identifies any imminent health and safety concerns involving any aluminum-based SNF,
TC DOE could use F and H canyons to stabilize the material of concern prior to the melt and dilute facility becoming operational.

**Conventional Processing**

> Conventional Processing is the preferred treatment for 3 percent by volume (40 percent by mass) of aluminum-based SNF at the Savannah River Site.

DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this processing is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block).

The total amount proposed for conventional processing is a relatively small volume of aluminum-based SNF at the SRS (about 3 % by volume and 40 % by mass). This material includes the Experimental Breeder Reactor-II fuel, the Sodium Reactor Experiment fuel, the Mark-42 targets and the core filter block from the Uranium and Thorium Metal fuel group; the failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuels and a Mark-14 target from the HEU/LEU Oxides and TC Silicides fuel group; and the Sterling Forest Oxide (and any other powdered/oxide fuel that may be received at SRS while H Canyon is still in operation) from the Loose Uranium Oxide in Cans fuel group. Although it is possible that a new treatment technology, such as melt and dilute, could be applied to most of these materials, DOE considers timely alleviation of the potential health and safety vulnerabilities to be the most prudent course of action because it would stabilize materials whose forms or types pose a heightened vulnerability to releasing fission products in the basin. Nonetheless, if these materials have not been stabilized before a new treatment technology becomes available, that new technology (melt and dilute) may be used rather than conventional processing.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and stored in canisters in the Receiving Basin for Offsite Fuel. The declad fuels present a potential health and safety vulnerability. Should their existing storage containers leak, the metal fuel would corrode and release fission products to the water of the storage basin. Once the metal of the fuel is wetted, simply repackaging the fuel in a water-

**Table S-5.** Comparison of preferred and backup technologies for aluminum-SNF disposal.

| Technology | Advantages | Disadvantages |
|---|---|---|
| Preferred technology: Melt-Dilute Process | • U-235 enrichment readily adjusted by dilution with depleted uranium to meet non-proliferation policy and nuclear criticality constraints.<br>• Melting reduces the volume of the fuel (see Section A.2.1). DOE estimates about 400 canisters would be generated in comparison to about 1,400 canisters for Direct Co-Disposal.<br>• Homogenous melt product provides basis for predictable behavior in a geologic repository. | • Implementation requires high temperature operation of melter and offgas control equipment in shielded cells. |
| Backup technology: Direct Co-Disposal Process | • Process technically straightforward to implement. Shielded-cell handling procedures well developed.<br>• Meets non-proliferation policy criteria better than other technologies. | • Different SNF configurations, materials, and U-235 enrichments present packaging complexities.<br>• No adjustment of U-235 enrichment possible to meet criticality constraints in a geologic repository. May require the use of exotic nuclear poisons.<br>• No reduction in the volume of the fuel.<br>• Non-uniform SNF structures and compositions complicates documentation of fuel characteristics to meet repository waste acceptance criteria and to predict behavior in a repository. |

tight container would not arrest the corrosion and, in fact, could exacerbate storage concerns since potentially explosive hydrogen gas would continue to be generated inside the storage canister as the fuel continued to corrode. An instance of water intrusion and subsequent fuel corrosion has already occurred with one Experimental Breeder Reactor-II canister stored in the Receiving Basin for Offsite Fuel. Additionally, several problems have occurred with other uranium metal fuel in similar storage conditions at SRS (e.g., the Taiwan Research Reactor fuel with failed or missing cladding that was overpacked in canisters and stored in SRS wet basins). DOE addressed these situations by processing the failed or declad fuel in F Canyon to eliminate the health and safety vulnerability.

The failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuel, and a sectioned Mark-14 target from the HEU/LEU Oxides and Silicides fuel group also present potential health and safety vulnerabilities. The integrity of these fuels was destroyed for research purposes. Then the material was canned and placed in wet storage at SRS. A breach of or leak in the cans would expose the interior surfaces of the sectioned fuel to water, contaminating the water in the storage basin with

radioactivity, and accelerating the corrosion of the fuel.

the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group. Should a breach occur in the cladding on the Mark-42 targets or in the canisters of Sterling Forest Oxide fuel, the particulate nature of the nuclear material in the targets and the Sterling Forest Oxide fuel could lead to dispersion of radioactive material in the water of the Receiving Basin for Offsite Fuel. Therefore, DOE is proposing to take action now to avoid the possibility of urgent future actions, including expensive recovery actions that also would entail unnecessary radiation exposure to workers.

DOE proposes to process the Experimental Breeder Reactor-II fuel and the Mark-42 targets in F Canyon. That fuel contains plutonium, approximately 114 kg of which would be recovered as part of the normal F Canyon chemical separations process and then transferred to FB-Line for conversion to metal. The plutonium metal would be considered surplus to the nation's nuclear weapons program and would be placed in storage at the SRS pending disposition pursuant to the January 2000 Record of Decision (ROD) for the Surplus Plutonium Disposition Environmental Impact Statement (DOE 1999). The surplus plutonium would be immobilized using the can-in-canister process or fabricated into mixed-oxide (MOX) commercial power reactor fuel at the SRS. DOE has scheduled processing of the Experimental Breeder Reactor-II fuel and the Mark-42 targets in FY00.

DOE proposes to process the Sodium Reactor Experiment fuel, the failed or sectioned fuel from the HEU/LEU Oxides and Silicides fuel group, and the Sterling Forest Oxide fuel in H-Canyon where the highly enriched uranium would be blended down to low enriched uranium and stored pending potential sale as feed-stock for commercial nuclear fuel. DOE would begin processing operations in H Canyon in 2000 and could complete them in about 18 months.

A potential health and safety vulnerability also exists for the unirradiated Mark-42 targets from the Uranium and Thorium Metal fuel group and DOE also proposes to process the core filter block from the Uranium and Thorium Metals fuel group. The core filter block is made of depleted uranium but it contains corrosion-resistant metal (e.g., stainless-steel) that would be incompatible with the Melt and Dilute Technology for aluminum-based SNF. The core filter block could be processed in either F Canyon or H Canyon. In either case, the material would become feedstock to blend down highly enriched uranium from either conventional processing or melt and dilute operations.

The processing operations described above in both F and H Canyons would occur when the canyons were being operated to stabilize other nuclear material. It is the preference of the Department of Energy not to utilize conventional reprocessing for reasons other than safety and health. However, the core filter block is not compatible with the melt and dilute process for aluminum-based SNF. The benefit to develop a new process to accommodate this form(?) would be disproportionately small when compared to the cost (DOE 1998a). Consequently, the Department proposes an exception in this case.

**Repackaging**

> Repackaging and dry storage is the preferred alternative for non-aluminum-clad SNF (about 6 percent by volume and 30 percent by mass of all the fuel considered in this EIS). Mark-51 targets, and other targets would be managed using onsite storage pending disposition decisions.

DOE would continue to wet-store the non-aluminum clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. DOE could transfer the non-aluminum clad fuel to dry storage after the material had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of ac-

tivities to phase out operations in the Receiving Basin for Offsite Fuel by fiscal year 2007.

**Continued Wet Storage**

DOE is not proposing any actions that would lead to programmatic use of the Higher Actinide Targets. Therefore, the Mark-18, Mark-51 and other Higher Actinide Targets will be maintained in wet storage until decisions are made on their final disposition.

TC

## S.12 Comparisons of Environmental Impacts Among the Alternatives

**Operational Impacts**

Impacts from operations under all of the alternatives would have no effect on ecological resources, water resources, or cultural resources. The impacts from onsite transportation of SNF would be small under all alternatives.

EC

Processing the Mark-18 targets (about 1 kilogram of heavy metal) was previously analyzed in the *Final Environmental Impact Statement on Interim Management of Nuclear Materials* and, therefore, was not analyzed in this EIS. The impacts of processing this small amount of material are minor and would not significantly add to the impacts currently analyzed for the Maximum Impact Alternative in this EIS. For example, total radiological dose from the Preferred Alternative to the maximally exposed individual for the entire period of analysis would be 0.67 millirem. Processing the Mark-18 targets would result in a dose of 0.0035 millirem. These extremely small doses are unlikely to result in any health effects.

TC

Tables S-6 and S-7 list impacts for the five alternatives. The EIS identifies the following operational impacts with potential to be discriminators among the alternatives:

*Worker and public health impacts* – Estimated impacts are reported as latent cancer fatalities for the involved worker population, noninvolved worker, the maximally exposed member of the public, and offsite population (Table S-6). These impacts are summed over the period of analysis based on annual emissions and radiation doses.

EC

Involved worker doses are estimated under the assumption that no worker would receive more than the SRS administrative annual limit of 500 millirem from normal operations. The estimated latent cancer fatalities for the involved worker population for the entire period of analysis would be 0.28 for the Minimum Impact Alternative and 0.84 for the Maximum Impact Alternative.

TC
EC

***EIS Operational Impact Potential Discriminators***

- Worker and Public Health Impacts
- Nonradiological Air Impacts
- Waste Generation
- Utilities and Energy Consumption
- Accidents

The noninvolved worker highest estimated probability of a latent cancer fatality over the entire period of analysis would be $2.0\times10^{-9}$ for the Minimum Impact Alternative and $6.3\times10^{-7}$ for the Maximum Impact Alternative.

Table S-6 provides the incremental impact for health effects to the noninvolved worker, maximally exposed individual, and the offsite population above the current baseline for the operations of the wet storage basins at the SRS (the No-Action Alternative) over the entire period of analysis. Summing these baseline and incremental values is conservative because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

The estimated latent cancer fatality probability to the maximally exposed individual over the entire

**Table S-6.** Impact summary by combination strategy.

| | Parameter | No Action Alternative (baseline) | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|---|---|
| | **Health Effects for Entire Period of Analysis (1998-2035)** | | | | | |
| TC | Integrated latent cancer fatality probability for the noninvolved worker | $1.7\times10^{-6}$[a] | $2.0\times10^{-9}$ | $9.6\times10^{-9}$ | $6.1\times10^{-7}$ | $6.3\times10^{-7}$ |
| TC | Integrated latent cancer fatality probability for the maximally exposed member of the public | $3.1\times10^{-7}$[a] | $3.0\times10^{-10}$ | $3.6\times10^{-9}$ | $9.5\times10^{-8}$ | $3.4\times10^{-7}$ |
| | Integrated latent cancer fatalities for the worker population | 0.30 | 0.28 | 0.34 | 0.33 | 0.84 |
| | Integrated latent cancer fatalities for the general public | $1.1\times10^{-2}$[a] | $1.1\times10^{-5}$ | $3.8\times10^{-5}$ | $3.4\times10^{-3}$ | $4.4\times10^{-3}$ |
| | **Waste Generation for the Entire Period of Analysis (1998-2035)** | | | | | |
| TC | Liquid (cubic meters) | 2,300 | 660 | 1,200 | 1,050 | 10,500 |
| | High-level waste generated (equivalent DWPF[b] canisters) | 38 | 11 | 20 | 17 | 160 |
| | Transuranic waste generated (cubic meters) | 0 | 15 | 360 | 563 | 3,700 |
| | Hazardous and mixed low-level waste generated (cubic meters) | 76 | 25 | 46 | 103 | 267 |
| | Low-level waste generated (cubic meters) | 57,000 | 20,000 | 31,000 | 35,260 | 140,000 |
| | **Utilities and Energy for the entire period of analysis (1998-2035)** | | | | | |
| | Water consumption (millions of liters) | 1,100 | 660 | 1,400 | 1,186 | 8,000 |
| | Electricity consumption (megawatt-hours) | 46,000 | 27,000 | 81,000 | 116,000 | 600,000 |
| | Steam consumption (millions of kilograms) | 340 | 190 | 520 | 650 | 3,600 |
| | Diesel fuel consumption (thousands of liters) | 230 | 180 | 2,300 | 2,760 | 22,000 |
| EC | **SNF Disposal Canisters (1998-2035)** | 0 | ~1,400 | ~1,300 | 400 | 0[c] |

a. Reflects current reactor-area emissions (including two SNF wet basins) for the entire period of analysis.
b. DWPF = Defense Waste Processing Facility.

period of analysis would be $3.0\times10^{-10}$ for the Minimum Impact Alternative and $3.4\times10^{-7}$ for the Maximum Impact Alternative. The

c. The technology used in the Maximum Impact Alternative (i.e., Conventional Processing) would not produce any canisters of SNF.



*Summary*
DOE/EIS-0279
March 2000

**Table S-7.** Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each alternative (percent of regulatory standard).

| No Action Alternative | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|
| 0.03 (nitrogen oxides) | 0.07 (ozone [as VOC]) | 1.2 (nitrogen oxides) | 1.1 (nitrogen oxides) | 3.6 (nitrogen oxides) |

VOC = volatile organic compound.

estimated offsite latent cancer fatalities would be $1.1\times10^{-5}$ for the Minimum Impact Alternative and $4.4\times10^{-3}$ for the Maximum Impact Alternative. The estimated latent cancer fatalities in the offsite population affected by SRS over the entire period of analysis would be much less than 1 for any alternative.

- *Nonradiological Air Quality* – Table S-7 presents the estimated maximum incremental concentration of the nonradiological air pollutant that would contribute the most to the deterioration of air quality at the SRS boundary for each alternative. As noted from Table S-7, the concentration of the nonradiological constituent contributing the highest fraction of the offsite air qualitystandard would range from 0.03 percent of the standard for the No-Action Alternative to 3.6 percent of the standard for the Maximum Impact Alternative. Under all alternatives, nonradiological air concentrations at the SRS boundary would be well below applicable standards.

- *Waste generation* – Wastes volumes were estimated over the period of analysis. The Maximum Impact Alternative would generate the greatest volume of waste, while the Minimum Impact Alternative would generate the least volume of waste (Table S-6). For wastes generated under all alternatives, DOE would use the surplus capacity in existing SRS waste management facilities to treat, store, dispose, or recycle the waste in accordance with applicable regulations.

- *Utilities and energy consumption* – The quantities of water, electricity, steam, and diesel fuel that would be required over the entire period of analysis were estimated (Table S-6).

  The Maximum Impact Alternative would require the most water, electricity, steam, and diesel fuel, while the Minimum Impact Alternative would require the least. For all alternatives, water and steam would be obtained from existing onsite sources and electricity and diesel fuel would be purchased from commercial sources. These commodities are readily available and the amounts required would not have an appreciable impact on available supplies or capacities.

- *Accidents* – DOE evaluated the impacts of potential accidents related to each of the alternatives. For each potential accident, the impacts were evaluated as radiation dose to the noninvolved worker, radiation dose to the offsite maximally exposed individual, collective radiation dose to the offsite population, and latent cancer fatalities to the offsite population. Table S-8 presents the results of this analysis. Table S-8 also indicates the estimated frequency of occurrence for each accident.

  The highest consequence accident postulated under the continued wet storage, direct co-disposal, and repackage and prepare to ship technologies is a seismic/high wind-induced criticality, which is estimated to result in 6.2 latent cancer fatalities in the offsite population. The highest consequence accident under conventional processing technology is a TC

coil and tube failure with an estimated offsite population impact of 39 latent cancer fatalities. The frequencies of these accidents are once in 2,000 to once in 26,000 years.

TC For the other new SNF technologies evaluated, the maximum consequence accident (earthquake induced spill with loss of ventilation) is associated with the melt and dilute process. This accident is estimated tooccur once in 200,000 years and to result in 10 latent cancer fatalities in the offsite population.

**Construction Impacts**

> Impacts of construction would be minor and short-lived.

Construction activities could affect four resources: surface water, air, ecological resources, and socioeconomics. However, because workers would build the facilities needed to carry out the proposed action in an area of the Site that is already industrialized, DOE expects little impact to these resources from construction activities.

In summary, none of the alternatives analyzed would result in undue adverse environmental effects. The preferred alternative is the alternative that DOE considers provides the greatest assurance of preparing the SNF for ultimate placement in a geologic repository by using a relatively simple new processing technology and a proven technology.

## S.13 Cumulative Impacts

L3-8 DOE evaluated the cumulative impacts of SNF management activities coupled with other past, present, and reasonably foreseeable future actions that could impact the SRS and its environs.

This cumulative impacts analysis included the impacts from SNF management, other related DOE NEPA actions, current SRS operations, and potential processing in the SRS canyons of other nuclear materials located at other DOE sites. DOE analyzed cumulative impacts for the following areas: (1) air resources, (2) water resources, (3) public and worker health, (4) waste generation, and (5) utilities and energy consumption. Table S-9 presents the results of the nonradiological air resources cumulative impact analysis. Table S-10 presents the results of the cumulative analysis for the other technical discipline areas. L3-8

## S.14 Other Factors

DOE evaluated other factors such as technical availability, nonproliferation and safeguards, labor availability and core competency, custodial care, and cost. These factors are discussed in Section 2.6 of the Final EIS.

Life-cycle costs (1998 billion of dollars) for each of the alternatives were estimated as follows:

- Minimum Impact Alternative 1.9
- Direct Disposal Alternative 1.9
- Preferred Alternative 2.0 EC
- Maximum Impact Alternative 2.0
- No Action Alternative 1.7

Life-cycle cost comparisons indicate that the No Action Alternative would be the least expensive. EC However, the cost of continued wet storage does not include costs of actions necessary to prepare SNF for ultimate disposition. The Direct Disposal Alternative and the Preferred Alternative (both using a renovated reactor building) have approximately the same life-cycle cost. Installation in a renovated reactor facility presents cost advantages of about $70 million compared to a TC new treatment facility.

**Table S-8.** Estimated maximum consequence accident for each technology.

| Option | Accident Frequency | Consequences: Noninvolved Worker (rem) | MEI (rem) | Offsite Population (person-rem) | Latent Cancer Fatalities |
|---|---|---|---|---|---|
| **Continued Wet Storage (No Action)[a]** | | | | | |
| RBOF (high wind-induced criticality) | Once in 26,000 years | 13 | 0.22 | 12,000 | 6.2 |
| L-Reactor basin (basin-water draindown) | Once in 500 years | 0.014 | 0.016 | (b) | (b) |
| **Direct Co-Disposal** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| **Repackage and Prepare to Ship** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| **Conventional Processing** | | | | | |
| Processing phase in F/H Canyons (coil and tube failure) | Once in 14,000 years | 13 | 1.3 | 78,000 | 39 |
| **Melt and Dilute** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Melt and dilute phase (earthquake-induced spill) | Once in 200,000 years | 30 | 0.5 | 21,000 | 10 |
| TC **Mechanical Dilution** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Mechanical dilution phase (criticality with loss of ventilation) | Once in 33,000 years | 0.71 | 0.074 | 3,000 | 1.5 |
| **Vitrification Technologies** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Vitrification phase (earthquake-induced release with loss of ventilation) | Once in 200,000 years | 0.10 | 0.0017 | 71 | 0.035 |
| **Electrometallurgical Treatment** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Electrometallurgical phase (earthquake induced spill with loss of ventilation) | Once in 200,000 years | 30 | 0.5 | 21,000 | 10 |

MEI = Maximally Exposed Individual.
RBOF = Receiving Basin for Offsite Fuels.

a. All alternatives would use RBOF and the L-Reactor Disassembly Basin; therefore, accidents in these facilities are possible for each technology.

b. Not available.

**Table S-9.** Estimated maximum cumulative ground-level concentrations of nonradiological pollutants (micrograms per cubic meter) at SRS boundary.

| Pollutant | Averaging time | SCDHEC ambient standard (μg/m³) | Cumulative concentration (μg/m³) | Percent of standard |
|---|---|---|---|---|
| Carbon monoxide | 1 hour | 40,000 | 10,093 | 25 |
| | 8 hours | 10,000 | 6,921 | 69 |
| Oxides of Nitrogen | Annual | 100 | 33.1 | 33 |
| Sulfur dioxide | 3 hours | 1,300 | 1,206 | 93 |
| | 24 hours | 365 | 351.7 | 96 |
| | Annual | 80 | 34.1 | 43 |
| Ozone | 1 hour | 235 | 1.8 | 1 |
| Lead | Max. quarter | 1.5 | 0.03 | 2 |
| Particulate matter (≤10 microns aerodynamic diameter) | 24 hours | 150 | 130.4 | 87 |
| | Annual | 50 | 25.1 | 50 |
| Total suspended particulates (μg/m³) | Annual | 75 | 67.1 | 89 |

**Table S-10.** Cumulative impacts.

EC
TC

| Parameter | Cumulative total |
|---|---|
| **Radiological Air Impacts** | |
| Annual MEI[a] Dose (rem) | $1.0\times10^{-4}$ |
| MEI LCF[b] Probability (unitless) | $5.1\times10^{-8}$ |
| Annual Population dose (person-rem) | 5.6 |
| Population LCFs (unitless) | $2.8\text{x}10^{-3}$ |
| **Radiological Water Impacts** | |
| Annual MEI Dose (rem) | $2.4\times10^{-4}$ |
| MEI LCF Probability (unitless) | $1.2\text{x}10^{-7}$ |
| Population dose (person-rem) | 2.6 |
| Population LCFs (unitless) | $1.3\times10^{-3}$ |
| **Worker and Public Health (Air and Water)** | |
| Annual Total MEI dose (rem) | $3.4\times10^{-4}$ |
| Total MEI LCF probability (unitless) | $1.7\times10^{-7}$ |
| Annual Total population dose (person-rem) | 8.2 |
| Total population LCFs (unitless) | 0.004 |
| Annual Collective worker dose (rem) | 859 |
| Collective worker LCFs (unitless) | 0.34 |
| **Waste Generation (Life-Cycle Waste)** | |
| High-level waste generation (cubic meters) | 94,681 |
| Low-level waste generation (cubic meters) | 430,401 |
| Hazardous/mixed waste generation (cubic meters) | 14,745 |
| Transuranic waste generation (cubic meters) | 18,532 |
| **Utilities and Energy** | |
| Annual electricity consumption (megawatt-hours) | $5.77\text{x}10^{5}$ |
| Water usage (liters) | $1.79\times10^{10}$ |

a. MEI = Maximally Exposed Individual.
b. LCF = Latent Cancer Fatality.

# COVER SHEET

**RESPONSIBLE AGENCY:** U.S. Department of Energy (DOE)

**TITLE:** Savannah River Site, Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279) EC

**CONTACT:** For additional information on this environmental impact statement, write or call:

Andrew R. Grainger, NEPA Compliance Officer
U.S. Department of Energy, Savannah River Operations Office, Building 742A, Room 183
Aiken, South Carolina 29802
Attention: Spent Nuclear Fuel Management EIS
Local and Nationwide Telephone: (800) 881-7292 Email: nepa@SRS.gov

The EIS is also available on the internet at: http://tis.eh.doe.gov/nepa/docs/docs.htm.

For general information on the process that DOE follows in complying with the National Environmental Policy Act, write or call: EC

Ms. Carol M. Borgstrom, Director, Office of NEPA Policy and Assistance, EH-42
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Telephone: (202) 586-4600, or leave a message at (800) 472-2756.

**ABSTRACT:** The proposed DOE action considered in this environmental impact statement (EIS) is to implement appropriate processes for the safe and efficient management of spent nuclear fuel and targets at the Savannah River Site (SRS) in Aiken County, South Carolina, including placing these materials in forms suitable for ultimate disposition. EC Options to treat, package, and store this material are discussed. The material included in this EIS consists of approximately 68 metric tons heavy metal (MTHM) of spent nuclear fuel (20 MTHM of aluminum-based spent nuclear fuel at SRS, as much as 28 MTHM of aluminum-clad spent nuclear fuel from foreign and domestic research reactors to be shipped to SRS through 2035, and 20 MTHM of stainless-steel or zirconium-clad spent nuclear fuel and some Americium/Curium Targets stored at SRS.

Alternatives considered in this EIS encompass a range of new packaging, new processing, and conventional processing technologies, as well as the No Action Alternative. A preferred alternative is identified in which DOE would prepare about 97 percent by volume (about 60 percent by mass) of the aluminum-based fuel for disposition using a melt and dilute treatment process. The remaining 3 percent by volume (about 40 percent by mass) would be managed using chemical separation. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic, and cumulative impacts.

**PUBLIC INVOLVEMENT:** DOE issued the Draft Spent Nuclear Fuel Management EIS on December 24, 1998, and held a formal public comment period on the EIS through February 8, 1999. In preparing the Final EIS, DOE considered comments received via mail, fax, electronic mail, and transcribed comments made at public hearings held in Columbia, S.C. on January 28, 1999, and North Augusta, S.C. on February 2, 1999. EC Completion of the Final EIS has been delayed because DOE has performed additional analyses of the melt and dilute technology, discussed in Chapter 2 and Appendix G. Comments received and DOE's responses to those comments are found in Appendix G of the EIS.

# FOREWORD

The U.S. Department of Energy (DOE) published a Notice of Intent (NOI) to prepare this environmental impact statement (EIS) on December 31, 1996 (61 FR 69085). As described EC in the NOI, DOE's proposal in general terms is to implement appropriate actions to manage safely and efficiently spent nuclear fuel (SNF) and targets that are currently located or expected to be received at the Savannah River Site (SRS), including placing these materials in forms suitable for disposition. This EIS assesses the potential environmental impacts associated with storing, treating, and packaging these materials, EC including onsite transportation activities.

The NOI requested public comments and suggestions for DOE to consider in its determination of the scope of the EIS, and announced a public scoping period that ended on March 3, 1997. DOE held a scoping meeting in North Augusta, South Carolina on January 30, 1997. During the scoping period, individuals, organizations, and government agencies submitted 118 comments that DOE considered applicable to the management of SNF at the SRS.

Transcripts of public testimony, copies of scoping letters, scoping comments and DOE responses to those comments, and reference materials cited in the EIS are available for review in the DOE Public Reading Room, University of South Carolina at Aiken, Gregg-Graniteville Library, University Parkway, Aiken, South Carolina.

A Notice of Availability for the Draft EIS appeared in the *Federal Register* on December 24, 1998. Public meetings to discuss and receive comments on the Draft EIS were held on Thursday, TC January 28, 1999 in Columbia, S.C. and on Tuesday, February 2, 1999 in North Augusta, S.C. The public comment period ended on February 8, 1999. Comments and DOE responses to comments are in Appendix G.

Changes from the Draft EIS are indicated in this Final EIS by vertical change bars in the margin. In cases where changes were made in response to comments, the comment number (as listed in Appendix G) is listed next to the vertical change bar. TC Many of the technical changes are the result of the availability of updated information since publication of the Draft EIS.

DOE has prepared this EIS in accordance with the National Environmental Policy Act (NEPA) regulations of the Council on Environmental Quality (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021). This EIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, it incorporates, directly or by reference, available results of ongoing studies. The organization of the EIS is as follows:

- Chapter 1 describes the purpose and need for SNF management at the SRS (i.e., to develop and implement a safe and efficient management strategy that includes preparing SNF for ultimate disposition), and describes the types of SNF to which the EIS applies.
- Chapter 2 identifies the alternatives that DOE is considering for management of SNF at the SRS.
- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives for construction activities, normal operations, and accidents.
- Chapter 5 discusses the cumulative impacts of SNF management actions in relation to

impacts of other past, present, and foreseeable future activities at the SRS.

- Chapter 6 identifies irreversible or irretrievable resource commitments.
- Chapter 7 discusses regulatory requirements, including applicable statutes, DOE Orders, and state and Federal regulations.
- Appendix A describes the technologies that DOE considered for implementing the SNF management alternatives described in Chapter 2.
- Appendix B describes previously identified facility vulnerabilities specific to SRS SNF management, their recommended corrective actions, and the current status of those corrective actions.
- Appendix C describes the SNF assigned to SRS for management and the categories into which DOE has grouped these fuels.
- Appendix D provides detailed descriptions of accidents that could occur at SRS facilities during the management of SNF.
- Appendix E describes assumed durations for each SNF management activity necessary to implement the alternatives described in Chapter 2.
- Appendix F lists estimated incremental nonradiological air concentrations attributable to SNF management activities.
- Appendix G describes public comments received on the Draft EIS and DOE responses. TC

## Change Bars

Changes from the Draft EIS are indicated in this Final EIS by vertical change bars in the margin. The bars are marked TC for technical changes, EC for editorial changes, or if the change was made in response to a public comment, the designated comment number is as listed in Appendix G of the EIS. EC

# ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

## Acronyms

| | |
|---|---|
| AAQS | ambient air quality standard |
| ALARA | as low as reasonably achievable |
| CFR | Code of Federal Regulations |
| CO | carbon monoxide |
| D&D | decontamination and decommissioning |
| DNFSB | Defense Nuclear Facilities Safety Board |
| DOE | U.S. Department of Energy |
| DWPF | Defense Waste Processing Facility |
| EIS | environmental impact statement |
| EPA | U.S. Environmental Protection Agency |
| ES&H | environment, safety and health |
| FR | Federal Register |
| GMODS | glass material oxidation and dissolution system |
| HEPA | high-efficiency particulate air [filter] |
| HEU | highly enriched uranium |
| HLW | high-level waste |
| IMNM | Interim Management of Nuclear Material |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| ISO | International Organization for Standardization |
| LCF | latent cancer fatality |
| LEU | low enriched uranium |
| MCL | maximum contaminant level |
| MEI | maximally exposed (offsite) individual |
| MTHM | metric tons of heavy metal |

| | |
|---|---|
| NAS | National Academy of Sciences |
| NCRP | National Council on Radiation Protection and Measurements |
| NESHAP | national emission standards for hazardous air pollutants |
| NIMS | nuclear incident monitoring system |
| $NO_X$ | nitrogen oxides |
| NPDES | national pollutant discharge elimination system |
| NRC | Nuclear Regulatory Commission |
| $O_3$ | ozone |
| OSHA | Occupational Safety and Health Administration |
| $PM_{10}$ | particulate matter less than 10 microns in diameter |
| RBOF | Receiving Basin for Offsite Fuel |
| RINM | reactor irradiated nuclear materials |
| ROD | Record of Decision |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SMDF | Saltstone Manufacturing and Disposal Facility |
| SNF | spent nuclear fuel |
| $SO_2$ | sulfur dioxide |
| SRI | Savannah River Natural Resources Management and Research Institute |
| SRS | Savannah River Site |
| TRIGA | Training Research Isotope general atomic [spent fuel] |
| TSP | total suspended particulates |
| TSS | total suspended solids |
| VLEU | very low enriched uranium |
| WSRC | Westinghouse Savannah River Company |

# Abbreviations for Measurements

| | |
|---|---|
| cfm | cubic feet per minute |
| cfs | cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second |
| cm | centimeter |
| gpm | gallons per minute |
| kg | kilogram |
| L | liter = 0.2642 gallon |
| lb | pound = 0.4536 kilogram |
| mg | milligram |
| μCi | microcurie |
| μg | microgram |
| pCi | picocurie |
| °C | degrees Celsius = 5/9 (degrees Fahrenheit – 32) |
| °F | degrees Fahrenheit = 32 + 9/5 (degrees Celsius) |

# Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation" rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., $10^n$, or the number 10 multiplied by itself "n" times; $10^{-n}$, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
0.049 is written $4.9 \times 10^{-2}$
1,490,000 or 1.49 million is written $1.49 \times 10^6$

A positive exponent indicates a number larger than or equal to one, a negative exponent indicates number less than one.

In some cases, a slightly different notation ("E-notation") is used, where "× 10" is replaced by "E" and the exponent is not superscripted. Using the above examples

$4{,}900 = 4.9 \times 10^3$ = 4.9E+03
$0.049 = 4.9 \times 10^{-2}$ = 4.9E-02
$1{,}490{,}000 = 1.49 \times 10^6$ = 1.49E+06

## Metric Conversion Chart

| To convert into metric | | | To convert out of metric | | |
|---|---|---|---|---|---|
| **If you know** | **Multiply by** | **To get** | **If you know** | **Multiply by** | **To get** |
| **Length** | | | | | |
| inches | 2.54 | centimeters | centimeters | 0.3937 | inches |
| feet | 30.48 | centimeters | centimeters | 0.0328 | feet |
| feet | 0.3048 | meters | meters | 3.281 | feet |
| yards | 0.9144 | meters | meters | 1.0936 | yards |
| miles | 1.60934 | kilometers | kilometers | 0.6214 | miles |
| **Area** | | | | | |
| sq. inches | 6.4516 | Sq. centimeters | sq. centimeters | 0.155 | sq. inches |
| sq. feet | 0.092903 | sq. meters | sq. meters | 10.7639 | sq. feet |
| sq. yards | 0.8361 | sq. meters | sq. meters | 1.196 | sq. yards |
| acres | 0.0040469 | sq. kilometers | sq. kilometers | 247.1 | acres |
| sq. miles | 2.58999 | sq. kilometers | sq. kilometers | 0.3861 | sq. miles |
| **Volume** | | | | | |
| fluid ounces | 29.574 | milliliters | milliliters | 0.0338 | fluid ounces |
| gallons | 3.7854 | liters | liters | 0.26417 | gallons |
| cubic feet | 0.028317 | cubic meters | cubic meters | 35.315 | cubic feet |
| cubic yards | 0.76455 | cubic meters | cubic meters | 1.308 | cubic yards |
| **Weight** | | | | | |
| ounces | 28.3495 | grams | grams | 0.03527 | ounces |
| pounds | 0.4536 | kilograms | kilograms | 2.2046 | pounds |
| short tons | 0.90718 | metric tons | metric tons | 1.1023 | short tons |
| **Temperature** | | | | | |
| Fahrenheit | Subtract 32 then multiply by 5/9ths | Celsius | celsius | Multiply by 9/5ths, then add 32 | Fahrenheit |

## 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 = $10^{3}$ |
| 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 = $10^{-12}$ |
| femto- | f | 0.000 000 000 000 001 = $10^{-15}$ |
| atto- | a | 0.000 000 000 000 000 001 = $10^{-18}$ |

# CHAPTER 1. INTRODUCTION

The management of spent nuclear fuel (SNF) has been an integral part of the mission of the Savannah River Site (SRS) for more than 40 years. Until the early 1990s, SNF management consisted primarily of short-term onsite storage and processing in the SRS chemical separation facilities to produce strategic nuclear materials.

With the end of the Cold War, the U.S. Department of Energy (DOE) decided to phase out processing of SNF for the production of nuclear weapons materials (DOE 1992). Therefore, the management strategy for this fuel has shifted from short-term storage and processing for the recovery of highly-enriched uranium and transuranic isotopes to stabilization, when necessary, and storage pending final disposition that includes preparing aluminum-based SNF for placement in any potential geologic repository. In addition to the fuel already onsite, the SRS will receive SNF from foreign research reactors until 2009 and from domestic research reactors until, potentially, 2035. As a result, the safe and efficient management of SNF will continue to be an important SRS mission.

This EIS evaluates the potential environmental impacts of DOE's proposed plans for managing SNF assigned to SRS.

## 1.1 Background

### 1.1.1 HISTORIC MISSIONS

The U.S. Atomic Energy Commission, a DOE predecessor agency, established the SRS in the early 1950s. The Site occupies an area of approximately 300 square miles (800 square kilometers) adjacent to the Savannah River, primarily in Aiken and Barnwell Counties in South Carolina. It is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 20 miles (32 kilometers) south of Aiken, South Carolina (Figure 1-1).

For the past 40 years the SRS mission has been the production of special radioactive isotopes to support national programs. Historically, the primary Site mission was the production of strategic isotopes (plutonium-239 and tritium) for use in the development and production of nuclear weapons. The SRS produced other isotopes (e.g., californium-252, plutonium-238, americium-241) to support research in nuclear medicine, space exploration, and commercial applications. DOE produced these isotopes in the five SRS production reactors. After the material was produced at the SRS, it was shipped to other DOE sites for fabrication into desired forms.

### 1.1.2 FUEL CYCLE

The material in the SRS reactors consisted of nuclear fuel and targets. The nuclear fuel was enriched uranium that was alloyed with aluminum and then clad with aluminum. The targets were either oxides or metallic forms of various isotopes such as neptunium-237 or uranium-238 that were clad with aluminum. Fuel and targets were fabricated at the SRS and placed in the reactors, and then the reactors operated to create the neutrons necessary to transmute the target material. For example, neptunium-237 targets were irradiated to produce plutonium-238, a material used by the National Aeronautics and Space Administration as a power source for deep space probes. After irradiation, the fuel and targets (collectively referred to as spent nuclear fuel) were removed from the reactors and placed in water-filled basins for short-term storage, about 12 to 18 months, before they were processed in the SRS separations facilities. Figure 1-2 shows the historic fuel and target cycle.

During processing, SNF was chemically dissolved in F or H Canyon to recover the uranium and transuranic isotopes. The recovered material was used in nuclear weapons programs or

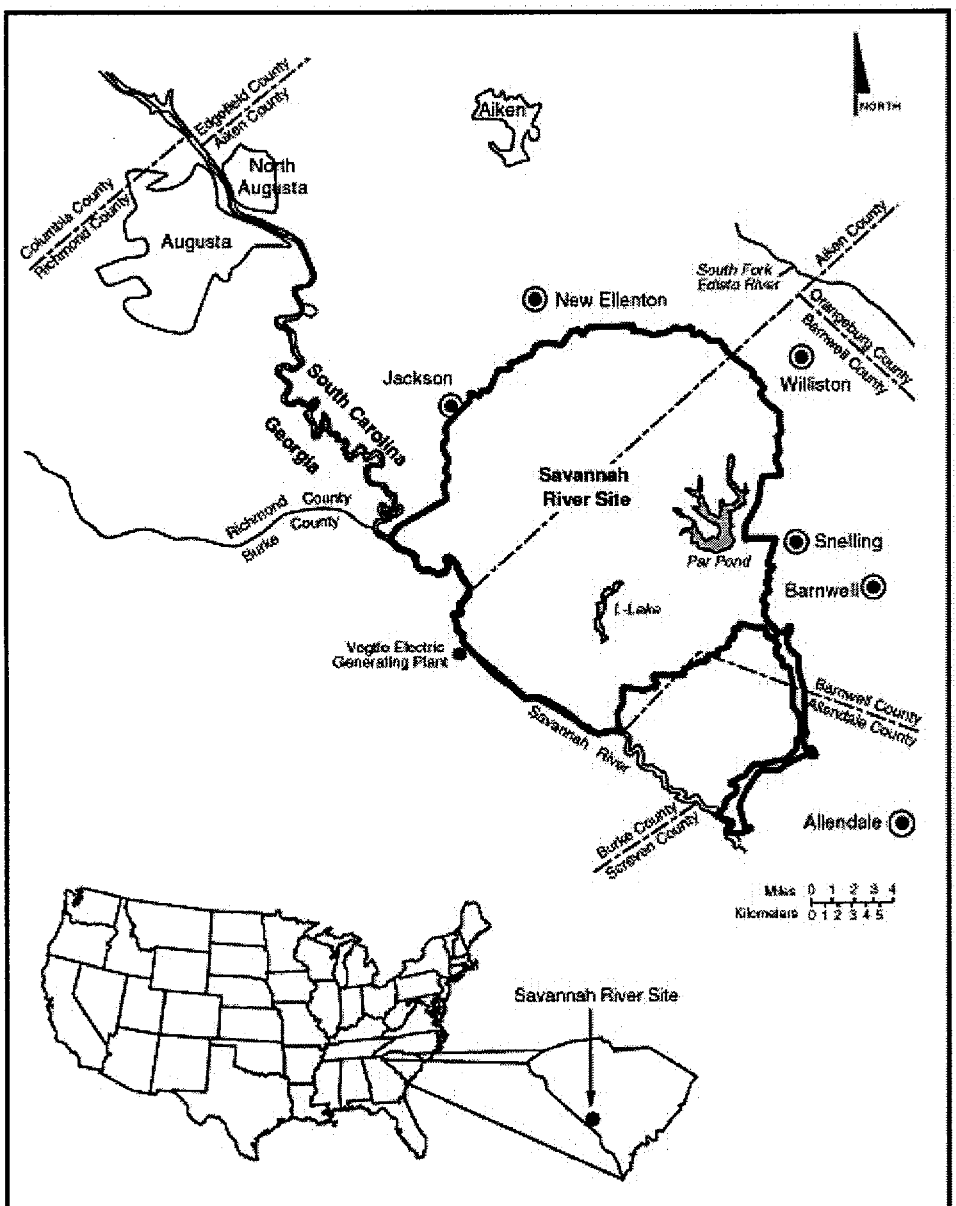


**Figure 1-1.** Location of the Savannah River Site.

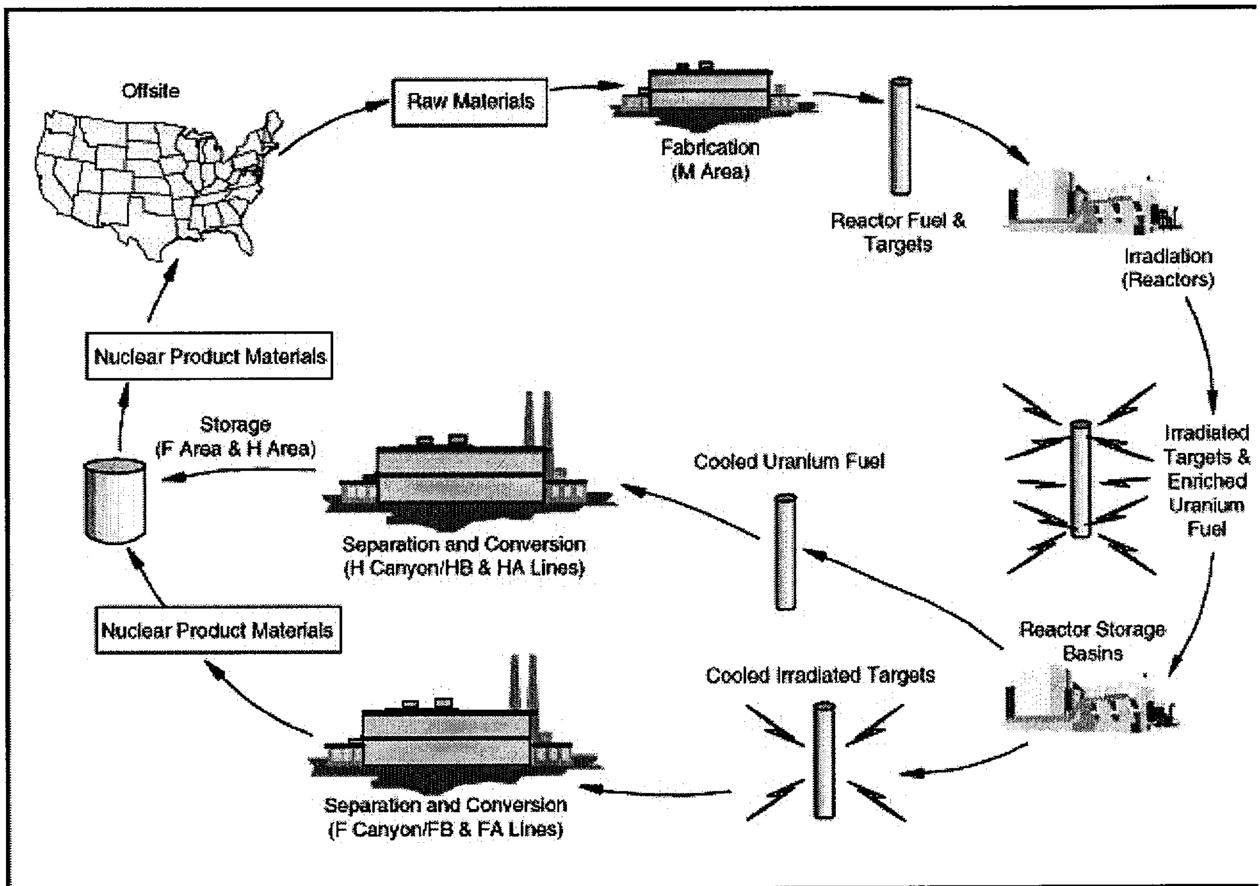


**Figure 1-2.** Historic nuclear materials production cycle at the Savannah River Site.

1-3

for commercial applications. The remaining residue from the fuel, high-level radioactive waste consisting primarily of fission products and cladding in liquid form, was transferred to large steel tanks for storage. The high-level waste is currently being vitrified in the Defense Waste Processing Facility at the SRS to prepare it for disposal in any potential geologic repository.

### 1.1.3 CHANGING MISSIONS

With the end of the Cold War there was a decreased need for the strategic nuclear material that was produced at the SRS. In 1992, the Secretary of Energy directed that processing operations be phased out throughout the DOE complex, effectively halting the SRS mission to produce strategic nuclear materials such as plutonium-239. However, SNF and targets from previous production reactor irradiation cycles remained in storage at K-, L-, C-, and P-Reactor Disassembly Basins. (Chapter 2 describes SRS SNF storage facilities.)

In addition to nuclear material production missions, another mission for the SRS was (and continues to be) the receipt of SNF from DOE, domestic, and foreign research reactors. These reactors were operated by DOE, universities, and research institutions for educational and research purposes and to produce isotopes for nuclear medicine. Historically, SNF from these reactors was stored in the Receiving Basin for Offsite Fuel at SRS. In the past, much of the research reactor SNF was processed in the same manner as spent fuel from SRS production reactors. However, with the end of the Site's strategic nuclear materials production mission, SNF from research reactors has been accumulating in the Receiving Basin for Offsite Fuel and in the L-Reactor Disassembly Basin.

Some of the research reactor spent nuclear fuel sent to SRS was not aluminum based. Because DOE did not have the capability to process that type of SNF at SRS, it was placed in wet storage at the Receiving Basin for Offsite Fuel, where it remains in storage.

By 1995 DOE was storing about 195 metric tons heavy metal (MTHM [metric tons heavy metal] – the mass of uranium in the fuel or targets, excluding cladding, alloy materials, and structural materials) – of aluminum-based SNF in the SRS reactor disassembly basins and the Receiving Basin for Offsite Fuel. DOE also was storing about 20 MTHM of non-aluminum-based SNF in the Receiving Basin for Offsite Fuel.

### 1.1.4 STABILIZATION

DOE has taken action to stabilize about 175 MTHM of the 195 MTHM of aluminum-based SNF that was in storage at SRS in 1995. DOE decided to stabilize this material following completion of the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE 1995a). The primary purpose of the actions described in that environmental impact statement (EIS) was to correct or eliminate potential health and safety vulnerabilities related to some of the methods used to store nuclear materials (including SNF) at SRS. The vulnerable SNF had been stored in wet storage basins with poor water quality. The poor water quality resulted in corrosion and failure of the cladding on the fuel and subsequent releases of radioactive fission products to the water of the storage basins. In 1996, SRS began stabilizing vulnerable aluminum-based uranium metal SNF in F Canyon. That work is complete. Vulnerable aluminum-based SNF still is being stabilized in H Canyon and that work is expected to continue through 2002. In the *Interim Management of Nuclear Materials EIS* (DOE 1995a), DOE identified 20 MTHM (out of 195 MTHM) of aluminum-based SNF at SRS that was "stable," i.e., that likely could be safely stored for about 10 more years, pending decisions on final disposition. That 20 MTHM of aluminum-based SNF is included in this EIS.

### 1.1.5 SPENT NUCLEAR FUEL CONSOLIDATION

In May 1995, DOE decided (60 FR 28680) under the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental*

*Restoration and Waste Management Programs Final Environmental Impact Statement* to consolidate existing and newly generated SNF at three existing Departmental sites based on the fuel type, pending future decisions on ultimate disposition. Specifically, DOE decided that existing Hanford production reactor fuel would remain at Hanford, aluminum-based SNF (excluding the aluminum-based SNF at Hanford) would be consolidated at SRS, and non-aluminum-based SNF would be consolidated at the Idaho National Engineering and Environmental Laboratory (INEEL). DOE stated that decisions on preparing the SNF for final disposition would be made under site-specific National Environmental Policy Act evaluations. As a result of DOE's decision to consolidate SNF storage, DOE will transfer 20 MTHM of non-aluminum-based SNF from SRS to INEEL and will transfer about 5 MTHM of aluminum-based SNF at INEEL to SRS. DOE estimates these transfers could begin about 2009 and may be completed by 2017. Thus, the non-aluminum-based SNF at SRS and the aluminum-based SNF from INEEL that will be transferred to the SRS are included in this EIS. Additionally, as a result of the consolidation decision DOE reached under the *Programmatic Spent Nuclear Fuel Management and Idaho mental Restoration and Waste Management Programs Environmental Impact Statement* (DOE 1995b), SRS could receive about 5 MTHM of aluminum-based SNF from domestic research reactors. Shipments from domestic research reactors could continue through 2035. Material expected to be received from domestic research reactors is included in this EIS.

In May 1996, DOE announced a decision (61 FR 25092) under the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (Nonproliferation Policy and Spent Fuel EIS) to accept about 18 MTHM of aluminum-based SNF containing uranium of United States origin from foreign research reactors for management in the United States at the SRS. The receipt of foreign research reactor SNF at SRS is now underway and receipts are scheduled to be completed by 2009. The 18 MTHM of foreign research reactor SNF that could be received at SRS is included in the scope of this EIS. (Recent decisions by some foreign research reactor operators have reduced the quantity of SNF expected to be shipped to SRS from about 18 MTHM to about 14 MTHM; however, the 18 MTHM projection is used for analysis purposes in this EIS because foreign research reactor operators still have the option to ship to the United States.)

### 1.1.6 PREPARATION FOR DISPOSITION

In summary, the total quantity of aluminum-based SNF at SRS that must be managed and prepared for disposition is as follows: 20 MTHM in existing SRS wet storage basins; about 10 MTHM to be received from INEEL and domestic research reactors; and about 18 MTHM to be received from foreign research reactors. Additionally, SRS must manage about 20 MTHM of non-aluminum-based SNF until it is transferred to INEEL.

## 1.2 Purpose and Need for Action

DOE anticipates placing most of its aluminum-based SNF inventory in a geologic repository after treatment or repackaging. However, DOE does not expect any geologic repository to be available until at least 2010 and shipments from DOE sites would not begin until about 2015. Until a repository is available, the Department intends to develop and implement a safe and efficient SNF management strategy that includes preparing aluminum-based SNF stored at SRS or expected to be shipped to SRS for disposition offsite. DOE is committed to avoiding indefinite storage at the SRS of this nuclear fuel in a form that is unsuitable for final disposition. Therefore, DOE needs to identify management technologies and facilities for storing and treating this SNF in preparation for final disposition.

## 1.3 Scope

This EIS evaluates potential environmental impacts from managing SNF that currently is lo-

cated or expected to be located at SRS. The evaluation includes impacts from the construction and operation of facilities (either new or modified existing facilities) that would be used to receive, store, treat, and package SNF in preparation for ultimate disposition. Onsite transportation impacts are considered, however, no impacts associated with transporting SNF to SRS are included, because these impacts have been covered in other EISs. The potential impacts of transporting SNF to a geologic repository are discussed (in Chapter 4) for completeness but no decisions related to transporting SNF offsite will be made under this EIS. Transportation of SNF (and high-level waste) to a federal repository will be addressed in the EIS for a federal repository (see Section 1.6). The Yucca Mountain EIS is being prepared as part of the process to determine whether to recommend the Yucca Mountain site as the site of the Nation's first geologic repository for SNF and high-level radioactive waste.

In this EIS, DOE is evaluating the management of about 48 MTHM of aluminum-based SNF for treatment and storage (20 MTHM of aluminum-based SNF stored at SRS and about 28 MTHM of aluminum-based SNF from foreign and domestic research reactors that could be shipped to SRS until 2009 and from domestic research reactors that could be shipped to SRS until 2035).

DOE also evaluates transferring 20 MTHM of non-aluminum-clad spent nuclear fuel currently stored in the Receiving Basin for Offsite Fuel at SRS to a new dry storage facility at SRS. This transfer would occur only if a dry storage facility were built as part of the implementation of a new treatment technology to prepare aluminum-based spent nuclear fuel for disposition (potential technologies are discussed in Section 2.2) and if the dry storage facility became operational before the non-aluminum-clad fuel was transferred to the INEEL. The transfer to dry storage would occur after the fuel had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities necessary to phase out the use of the Receiving Basin for Offsite Fuel by fiscal year 2007.

This EIS does not evaluate the impacts of managing the non-aluminum-clad fuel at INEEL or of transporting the fuel to INEEL. These impacts were documented in the SNF programmatic EIS (PEIS) (DOE 1995b) and were evaluated as part of the process DOE used to decide to consolidate the storage of non aluminum-clad spent nuclear fuel at the INEEL.

SRS is storing Mark-51 and other targets in the Receiving Basin for Offsite Fuel (RBOF) in the Site's H-Area. This EIS evaluates the impacts of continuing to store the Mark-51 and other targets in RBOF, and evaluates an alternative of transferring them to dry storage to provide flexibility in material management operations.

DOE is evaluating potential uses for this material and the operations and facilities that would be necessary. The Mark-51 and other targets (described in Section 1.5 of this EIS) contain americium and curium isotopes that could be used to produce elements with higher atomic numbers such as californium-252. Californium-252 is used as a neutron source for radiography and in the treatment of certain types of cancer and for research in basic chemistry, nuclear physics, and solid-state chemistry. If DOE were to determine that a programmatic need for this material exists, the targets would continue to be stored at the SRS pending preparations to ship them to another DOE facility where isotope production capability currently exists or could be constructed and operated. SRS does not have isotope production capability.

This EIS does not evaluate the impacts of utilizing target material for programmatic purposes such as production of californium. DOE would perform the appropriate National Environmental Policy Act review to evaluate the impacts of shipment of the targets to an isotope production facility and of construction (or modification) and operation of the production facility, should such a programmatic purpose be identified.

DOE is storing the Mark-18 targets in wet basins at the SRS. These targets are similar to the Mark-51 and other targets in that they contain

americium and curium that could be used to produce elements with higher atomic numbers such as californium-252. They are different from the small (about two feet in length) Mark-51 and other targets because the Mark 18s are about 12 feet long and therefore have different requirements for storage, transportation and use. As is the case with the Mark-51 and other targets, DOE is not proposing any actions that would lead to programmatic use of the Mark-18 targets at this time. Because of their length, the Mark-18 targets would have to be reduced in size for use in production facilities at another DOE facility or transfer to dry storage at the SRS. This EIS considers only continued wet storage of Mark-18 targets. However, the Interim Management of Nuclear Materials EIS (which is incorporated herein by reference) considered the alternative of processing the Mark-18 targets in the SRS canyons, should they present potential health and safety vulnerabilities. See Section 1.5 of this EIS for more information.

TC

## 1.4 Decisions to be Based on this EIS

DOE expects to make the following decisions on the management and preparation of SNF for storage and ultimate disposition.

- The selection of the appropriate treatment or packaging technologies to prepare aluminum-based SNF that is to be managed at SRS. EC
- Whether DOE should construct new facilities or use existing facilities to store and treat, or package aluminum-based SNF that is expected to be managed at SRS. EC EC
- Whether DOE should repackage and dry-store stainless-steel and zirconium-clad SNF pending shipment to the Idaho National Engineering and Environmental Laboratory. EC
- Whether DOE should repackage and dry-store Mark-51s and other americium/curium targets in the event dry-storage capability becomes available at SRS. TC EC

## 1.5 Spent Nuclear Fuel Groups

This section introduces the basic terminology for describing SNF and provides more information on the approximately 68 MTHM of SNF subject to analysis in this EIS.

DOE has categorized the spent fuel considered in this EIS into six groups (Group A through Group F). The categorization is based on such characteristics as fuel size, physical or chemical properties, or radionuclide inventories. DOE grouped the fuel to distinguish how it could apply the management alternatives evaluated in the EIS (Section 2.2). Table 1-1 lists the fuel groups and the amount of fuel in each group. Appendix C provides more detailed information regarding fuel types, quantities, locations, radionuclide inventories, and curie content.

The aluminum-based fuels currently stored at SRS include some fuels that were not originally aluminum-clad (EBR-II and Sodium Breeder Experimental Reactor Fuel). Additionally, the aluminum-based category consists of one element not yet received but due to be shipped to SRS (the Advanced Reactivity Measurement Facility Core Filter Block). Most of the fuels that were not originally aluminum-clad (but are included under this EIS's major category of aluminum-based fuel) have been declad and placed in aluminum cans. In their present form they can be processed at the SRS through the existing technologies on site. Other fuels at SRS which are non-aluminum-clad fuels cannot be processed in their existing form using the existing technologies and are characterized in this EIS as non-aluminum-based fuel. The Core Filter Block is included under the category of TC

**Table 1-1.** Spent nuclear fuel groups.

| Fuel group | Volume (MTRE)[a] | Mass (MTHM)[b] |
|---|---|---|
| A. Uranium and Thorium Metal Fuels | 610 | 19 |
| B. Material Test Reactor-Like Fuels | 30,800 | 20 |
| C. HEU/LEU[c] Oxides and Silicides Requiring Resizing or Special Packaging | 470[d] | 8 |
| D. Loose Uranium Oxide in Cans | NA | 0.7 |
| E. Higher Actinide Targets | NA | <0.1 |
| F. Non-Aluminum-Clad Fuels[e] | 1,900 | 20.4 |
| Total | 33,780 | 68.2 |

NA = Not applicable
a. MTRE = Materials test reactor equivalent. An MTRE is a qualitative estimate of SNF volume that provides information on the amount of space needed for storage. An MTRE of Materials Test Reactor-Like Fuels would usually be one fuel assembly measuring about 3 inches by 3 inches by 2 feet long.
b. MTHM = Metric tons of heavy metal.
c. HEU = highly enriched uranium; LEU = low enriched uranium.
d. Fuel group also includes about 2,800 pins, pin bundles, and pin assemblies.
e. This fuel group will be shipped to Idaho National Engineering and Environmental Laboratory. It will not be treated at SRS.

EC TC TC EC TC

TC aluminum-based fuel since the most practical way of dealing with it (based on its unique configuration) is to process it utilizing the existing technology at SRS.

**Uranium and Thorium Metal Fuels (Group A):**

This group consists of fuels from the Experimental Breeder Reactor-II and the Sodium Reactor Experiment, as well as a core filter block from the Advanced Reactivity Measurement Facility at INEEL (that is scheduled to be transferred to SRS). This group also includes unirradiated Mark-42 targets that were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and stored in canisters in the Receiving Basin for Offsite Fuel. The declad fuel presents a potential health and safety vulnerability. These fuels have cores of reactive metals that were exposed when the fuel cladding was removed. Any contact of the reactive metal core with water would lead to relatively rapid oxidation of the core and disintegration of the fuel. Should the existing storage containers leak, the metal fuel would corrode and release fission products to the water of the storage basin. Once the metal of the fuel is wetted, simply repackaging the fuel in a watertight container would not arrest the corrosion and, in fact, could exacerbate storage concerns since potentially explosive hydrogen gas would continue to be generated inside the storage canister as the fuel continued to corrode. Water intrusion and subsequent fuel corrosion has already occurred with one Experimental Breeder Reactor-II canister stored in the Receiving Basin for Offsite Fuel. That material was processed in F Canyon to eliminate the problem. In the event that leaks were detected in any additional canisters prior to processing/treatment in accordance with decisions reached under this EIS, DOE would process those canisters in an SRS canyon facility. This management approach is consistent with the Records of Decision reached under the *Interim Management of Nuclear Materials Final Environmental Impact Statement* for other uranium metal SNF stored in the Receiving Basin for Offsite Fuel at the SRS. The *Interim Management of Nuclear Materials EIS* deferred decisions on the materials that did not pose

L2-5 EC

immediate health and safety vulnerabilities because they were considered to be stable for 10 years and DOE wanted to provide the public an opportunity to comment as part of the overall planning for SNF at SRS.

The unirradiated Mark-42 targets were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum. The plutonium oxide and aluminum were pressed together in the manufacturing process. As a result, the unirradiated targets are less durable than uranium-aluminum alloy SNF because of the particulate nature of the plutonium oxide but more durable (i.e., less reactive) than uranium metal SNF since the plutonium is already in oxide form. The unirradiated Mark-42 targets present a potential safety and health vulnerability in that should the cladding of these targets be breached, the plutonium oxide could migrate to the water of the storage basin.

The core filter block at INEEL is made of depleted uranium and was used as a neutron "filter" for reactivity experiments. As a result, the filter was subject to relatively short (or low-power level) exposure times in the test reactor and is only slightly irradiated. The core filter block contains cylindrical sleeves of various corrosion resistant metals at different diameters within the filter block.

EC DOE is unaware of any health or safety concerns related to the core filter block. The core filter block is a unique assembly in that it includes materials that would not be compatible with the melt and dilute process for aluminum-based
L2-14 SNF. Additionally, the core filter block is composed mainly of depleted uranium and has been exposed to relatively low power so it contains very little fissile material or fission products. Processing would not extend the time for planned canyon operations, would not generate recovered fissile material, and would produce only a few kilograms of depleted uranium.

EC There is uncertainty regarding the acceptability of the material in this fuel group in its current form into a repository due to the reactive nature of uranium metal or the particulate nature of some of the material. The oxidation or burning of the metal in the repository could cause damage and spread radioactive particles throughout the repository. Although somewhat less reactive than pure metals, the uranium and thorium metal fuels discussed in this EIS (Group A) would need special attention to mitigate their reactivity. EC

This group accounts for approximately 2.0 percent of the volume of aluminum-based fuel that DOE is likely to manage at the SRS from now until 2035. Because the fuel in Group A is made of unalloyed metal (i.e., it contains little or no aluminum), it is more dense than most of the other spent fuel considered in this EIS. As a result, this small volume of fuel contains about 40 percent of the mass of heavy metal.

**<u>Materials Test Reactor-Like Fuels (Group B):</u>**

This group consists primarily of Materials Test Reactor fuels and other fuels of similar size and composition. Most research reactors – foreign and domestic – use Materials Test Reactor fuel, which has a flat or curved plate design. Figure 1-3 shows a typical Materials Test Reactor fuel assembly. Although these fuels come in a variety of shapes and compositions, the active fuel region is typically about 2 feet (0.6 meter) long and the overall assembly is about 4 feet (1.2 meters) long. The cross-section of an assembly is approximately square, about 3 inches (8 centimeters) on a side.

These fuels vary in enrichment. Approximately TC 70 percent of the Group B assemblies are highly enriched uranium, and the remainder are low enriched uranium. They are uranium-aluminum, uranium oxide-aluminum, or uranium silicide-aluminum alloy; all types are clad with aluminum. Group B accounts for approximately 97 percent of the volume of aluminum-based SNF that DOE will manage at SRS between now and 2035. DOE considers that there are no currently known health and safety vulnerabilities for this material that would preclude wet storage pending the operation of a new treatment technology.

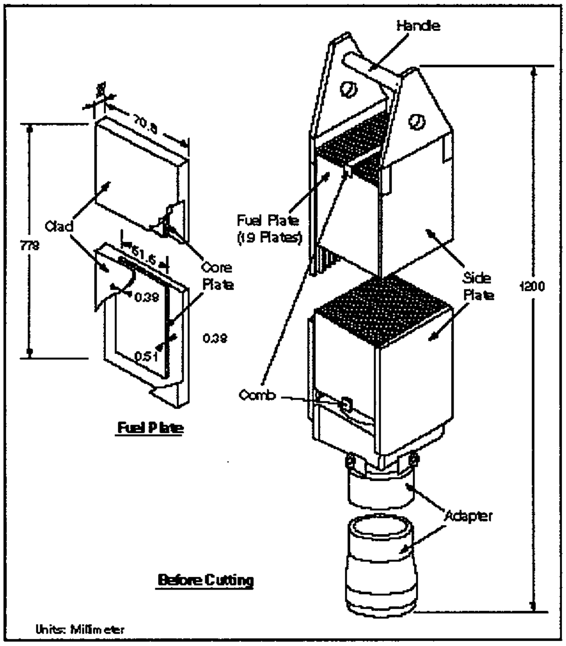


**Figure 1-3.** Typical Materials Test Reactor fuel assembly.

Although some Group B fuels are stored at SRS in the Receiving Basin for Offsite Fuel or in L Disassembly Basin, at present most are at domestic universities, foreign research reactors, and DOE research facilities pending shipment to the Site. All of the Group B fuels that are currently stored at SRS are "intact." The good condition of the cladding and the durability of the alloyed fuel at SRS provide a high degree of confidence that the fuel will not degrade during storage and that actions to correct potential health and safety vulnerabilities will not be necessary before treatment using the technology that DOE proposes to select under the record of decision from this EIS. DOE expects this will be true for most of the foreign and domestic research reactor SNF included in Group B that is yet to be shipped to SRS. However, if DOE determines that any of the Group B fuel presents a health and safety vulnerability, DOE would evaluate the situation and take appropriate action that could include canning the problem fuel or processing the fuel in one of the SRS canyon facilities. This management approach is consistent with the Record of Decision reached under the *Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.*

**<u>HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (Group C):</u>**

Fuels in this group are similar in composition to Group B fuels in that they are aluminum-based, highly enriched uranium (HEU) and low enriched uranium (LEU) oxides and silicides, but their size or shape might preclude packaging them in the disposal canisters proposed for use in a repository without resizing or special packaging considerations. | EC Some fuel in this group is smaller in diameter and longer than Group B fuels or is larger than Group B fuels in both diameter and length; it often comes in odd shapes such as a 1.5-foot by 3-foot (0.46-meter by 0.9-meter) cylinder or a sphere with a diameter of 29 | EC inches (74 centimeters). DOE would have to disassemble or use other volume-reduction activities to place such fuels in a nominal 17-inch direct co-disposal canister (see Section 2.2). At present, much of this fuel is at other DOE sites and in other countries but is scheduled to be received at SRS.

DOE expects that most of the fuel in this category is intact and would be managed as described above for Group B fuels. However, a small amount is not intact. That material consists of some fuel and one target that were cut or sectioned for research purposes. After the research was completed, the fuel and target pieces were canned in 14 cans and placed in wet storage. The origin and location of this material is discussed in Appendix C, Table C-3. The sectioned fuel and target present a potential health and safety vulnerability similar to that of the Group A fuel discussed previously. If a storage can were to leak, DOE would address the problem as described for the Group A fuel to prevent the release of fission products and particulate material to the water of a storage basin. Additionally, the current form of the fuel (i.e., failed) may not be acceptable in a repository because its integrity has been com- | EC promised.

Together Group B and Group C fuels represent 97 percent of all fuel to be managed at SRS, and 93 percent of the total fuel at SRS (including Group F fuels which will be shipped to Idaho National Engineering and Environmental Laboratory without treatment at SRS).

**<u>Loose Uranium Oxide in Cans (Group D):</u>**

This group consists of loose uranium oxide with fission products distributed through the material that has been stored in aluminum cans. This material, in its current particulate form, probably would not be acceptable for disposal in a repository because it is not in a tightly bound metal or ceramic matrix. Therefore, this group probably would require special packaging and/or treatment. Group D fuels also include targets in foreign countries that are liquid and that DOE expects would be converted to oxide prior to shipment to SRS. Only about 10 percent of the Group D fuel is in storage at SRS. The rest of the material has yet to be produced via foreign research reactor operations. Although eligible for shipment, most of this fuel is not part of the current shipping plan as projected by foreign research reactor operators.

The Group D fuel currently stored at SRS (676 cans of Sterling Forest Oxide fuel from the former medical isotope – production reactor; see Table C-4) presents a potential health and safety vulnerability similar to that of the Group A fuels. If a storage can leaked, DOE would address the problem as described for the Group A fuels to prevent the release of fission products and particulate matter to the water of an SRS storage basin. Group D comprises approximately 6 percent of the volume of the aluminum-based SNF that DOE could manage at SRS from now until 2035.

**<u>Higher Actinide Targets (Group E):</u>**

This group contains irradiated and unirradiated target materials used to generate radionuclides with atomic numbers higher than that of uranium. This material could be used to support such national programs as space exploration or medical research. The targets are aluminum-clad plutonium oxide that contain significant quantities of americium and curium, which react under neutron irradiation to produce elements with still higher atomic numbers such as californium. All materials in this group are stored in the Receiving Basin for Offsite Fuel. Group E accounts for less than 1 percent of the volume of aluminum-based SNF DOE could manage at SRS from now until 2035.

The Higher Actinide Target fuel group consists of 60 Mark-51 targets, 114 other targets, and 65 Mark-18 targets. This material was evaluated in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials,* (DOE/EIS-0220) and DOE decided the targets should remain in wet storage. In this EIS, DOE evaluates the continued wet storage of the Mark-51 and other targets pending shipment offsite. DOE also evaluates repackaging the Mark-51 and other targets to place them in a new dry storage facility so that the material could be transferred to dry storage if necessary to provide flexibility in spent fuel storage operations.

The Mark-18 targets are different from the Mark-51 and other targets in several ways. The most important distinction is that each Mark-18 target is one continuous piece about 12 feet long. The Mark-51 and other targets are about 2 feet long. The Mark-51 and other targets could be handled, transported and stored (including in a dry storage facility) in their current configuration. The 12-foot long Mark-18 targets would require size reduction for transport or storage in a dry storage facility. The standard method to reduce the size of the Mark-18 targets would be to cut them up under water in an SRS wet storage basin. The condition of the Mark-18 targets presents a health and safety vulnerability for under water cutting because of the suspected brittle condition of the targets and the uncertainty of the region of the target assemblies that contains the target product (i.e., americium and curium) and fission products. The brittle condition is due to a very long irradiation cycle in a reactor at the SRS. Cutting the targets using the existing site capability could result in the uncontrolled

release of radioactive material to the water of the Receiving Basin for Offsite Fuel. For these reasons, a previous DOE assessment of this material (see Section 1.6.2) concluded that the Department should consider processing the Mark-18 targets in F Canyon. Analysis of such alternatives are not included in this EIS because DOE performed that evaluation in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials*, which is incorporated herein by reference. Those alternatives included dissolving the targets in F-Canyon and then vitrifying the americium and curium in a new F-Canyon vitrification facility, dissolving the targets in F-Canyon and recovering the americium and curium as an oxide, and dissolving the targets and transferring the americium and curium to the high-level waste tanks at the SRS.

**Non-Aluminum-Clad Fuels (Group F):**

This group consists of the large variety of stainless-steel or zirconium-clad SNF at SRS that DOE plans to ship to INEEL in accordance with decisions DOE reached under the SNF PEIS (DOE 1995b).

### 1.5.1 COMPARISON OF SPENT NUCLEAR FUEL GROUPS

A comment was made regarding the differences between the fuel categories used in this EIS and the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (i.e., Yucca Mountain EIS). The Notice of Availability of the Yucca Mountain Draft EIS was published on August 13, 1999 (64 FR 44217) and analyzes the options being considered for siting of a repository for spent nuclear fuel and high level waste.

Table 1-2 shows the categories being used in both EISs. The Yucca Mountain categories and MTHM numbers encompass fuel and targets being managed by SRS in preparation for ultimate disposition. Should a repository be developed, that fuel and most targets would be shipped, in one form or another, to the repository for ultimate disposition. Category F fuel will be shipped from SRS to INEEL under the Record of Decision for the Final Programmatic Spent Nuclear Fuel and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs EIS. As such, INEEL will be responsible for determining the ultimate disposition of category F fuel. Therefore, the 20.4 MTHM of non-aluminum clad fuel is not included in the Yucca Mountain categories for SRS managed fuel.

Category A is made up of 17 MTHM EBR-II (matching Yucca Mountain EIS category 1) and 2 MTHM SRE ("Thorium" part). The SRE is contained within Yucca mountain category 16.

Material within groups B and C of the SRS SNF EIS are included in groups 5, 6, and 7 of the Yucca Mountain EIS. Material within groups D & E of the SNF EIS are included in group 16 of the Yucca Mountain EIS. The material is made up of foreign research reactor and domestic research reactor fuel and targets and other target material produced at SRS.

Excluding group F, there is a 4.0 MTHM difference between the totals calculated for the SNF EIS table (47.8 MTHM) and the Yucca Mountain table (43.8 MTHM). The differences are due to recent decisions by some foreign research reactor (FRR) operators which have reduced the quantity of SNF expected to be shipped to SRS. However, the SRS SNF EIS uses the larger projected number because those FRRs still have the option to ship to the United States.

**Table 1-2.** Comparison of Spent Nuclear Fuel Groups.

| NEPA document | | Fuel group | Mass (MTHM)[a] |
|---|---|---|---|
| Savannah River Site Spent Nuclear Fuel Management EIS (DOE/EIS-0279) | A | Uranium and Thorium Metal Fuels | 19 |
| | B | Material Test Reactor-Like Fuels | 20 |
| | C | HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging | 8<br>0.7 |
| | D | Loose Uranium Oxide | 0.1 |
| | E | Higher Actinide Targets | 20.4 |
| | F | Non-Aluminum-Clad Fuels | |
| Draft EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, NYE County, Nevada (DOE/EIS-0250D)[b] | 1 | Uranium Metal | 17 |
| | 5 | Uranium Oxide, Failed/ Declad/ Aluminum Clad | 3.2 |
| | 6 | Uranium-Aluminide | 8.7 |
| | 7 | Uranium-Silicide | 12 |
| | 16 | Miscellaneous | 2.9 |

TC

a. MTHM = Metric tons of heavy metal.
b. Includes only Savannah River Site Fuel

## 1.6 Relevant Documents

### 1.6.1 NATIONAL ENVIRONMENTAL POLICY ACT DOCUMENTS

***Final Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement***

DOE prepared this EIS (DOE 1995b) in compliance with a Court Order dated December 22, 1993, in the case of Public Service Company of Colorado v. Andrus, No. 91-0054-5-HLR (D. Idaho). The preferred alternative in the Final EIS, which DOE issued in April 1995, is Regionalization by Fuel Type. Volume 1 of this EIS analyzes at a programmatic level potential environmental impacts over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of DOE-owned SNF. Volume 1 supports programmatic decisions on sites at which DOE will manage various types of SNF.

In the Record of Decision, which selected the preferred alternative for implementation (60 FR 28680), DOE decided to manage its SNF by type (fuel cladding and matrix material) at the Hanford Site, the Idaho National Engineering and Environmental Laboratory, and the SRS. Section C.1.2 in Appendix C of this SRS SNF Management EIS discusses its relationship to the programmatic SNF EIS.

An amendment to the Record of Decision (61 FR 9441) reflects the October 16, 1995, Settlement Agreement between DOE, the State of Idaho, and the Department of the Navy by reducing the number of proposed spent fuel shipments to Idaho.

***Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor SNF***

This EIS (DOE 1996a) analyzes the management of foreign research reactor SNF that contains uranium originally produced or enriched in the United States. It also analyzes appropriate ways to manage such fuel received in the United States, amounts of fuel, shippers, periods of time over which DOE would manage the fuel, modes of transportation, and ownership of the fuel. In EC

its Record of Decision (61 FR 25091), DOE stated it would accept from 41 listed countries aluminum-based spent fuel, Training Research Isotope General Atomic (TRIGA) spent fuel, and target material containing uranium enriched in the United States. 12-5

EC Over the life of the foreign research reactor SNF acceptance program, DOE could accept approximately 19.2 MTHM of foreign research reactor SNF in as many as 22,700 separate elements and approximately 0.6 MTHM of target material. Most of the fuel will arrive through the Charleston Naval Weapons Station in South Carolina (about 80 percent), with a very limited amount arriving through the Concord Naval Weapons Station in California (about 5 percent). Most of the target material and some of the fuel (about 15 percent) will arrive overland from Canada. Shipments through Charleston began in September 1996 and those through Concord began in July 1998.

TC After a limited period of storage, DOE will process and package the fuel as necessary at the SRS and the Idaho National Engineering and Environmental Laboratory to prepare it for disposal in a geologic repository. Section C.1.2 in Appendix C explains the relationship of the Foreign Research Reactor SNF EIS to this EIS.

***Final Environmental Impact Statement Interim Management of Nuclear Materials***

This EIS (DOE 1995a) evaluates actions to stabilize SRS materials that represent environmental, safety, and health vulnerabilities in their current storage condition or that might represent a vulnerability within the next 10 years.

EC DOE has published four decisions under this EIS. In the first (60 FR 65300), DOE decided to process plutonium-242 solutions to oxide; vitrify americium and curium solutions to glass; blend highly-enriched uranium solutions down to low enrichment; process the plutonium in Mark-31 target slugs; process plutonium and uranium material in vaults to metal, oxide, or glass, if necessary; and process failed Taiwan Research Reactor SNF and a failed canister of Experimental Breeder Reactor-II SNF.

DOE decided that processing the EBR-II fuel in unbreached canisters was not immediately necessary. EBR-II fuel is declad and reactive, but only when it is in contact with water. The fuel inside a storage canister will not corrode as long as the canister retains its integrity. A monitoring and inspection program is in place that would detect any change in the integrity of the storage canisters. Any canisters that failed would be detected and the fuel then processed under the provisions of the Record of Decision to stabilize the material. This monitoring and inspection program applies as well to other fuel types in storage.

In the first supplement to the Record of Decision (61 FR 6633), DOE decided to stabilize Mark-16 and -22 fuels by processing them in the SRS canyons and blending the resulting highly enriched uranium down to low enriched uranium; and to stabilize "other aluminum-clad targets" by dissolving them in the canyons. DOE will transfer the resulting nuclear material from the targets to the SRS high-level waste tanks for vitrification in the Defense Waste Processing Facility.

The second supplement to the Record of Decision (61 FR 48474) contains decisions on vitrifying neptunium-237 solutions, and on the stabilization of plutonium-239 solutions by converting them to a metal using the F and H Canyons and FB-Line.

In the third supplement to the Record of Decision (62 FR 17790), DOE decided to use the F Canyon and FB-Line to stabilize the remaining Taiwan Research Reactor SNF in the Receiving Basin for Offsite Fuel. These actions are relevant to the cumulative impacts assessment in this EIS (see Chapter 5).

***Disposition of Surplus Highly Enriched Uranium Environmental Impact Statement***

DOE prepared this EIS (DOE 1996b) because of the need to reduce the threat of nuclear weapons proliferation worldwide in an environmentally TC

safe manner by reducing stockpiles of weapons-usable fissle materials, setting a non-proliferation example for other nations, and allowing peaceful, beneficial use of the material to the extent practical.

TC

In the Record of Decision (61 FR 40619), DOE stated it would implement a program that will gradually blend as much as 85 percent of the surplus highly enriched uranium to a uranium-235 enrichment level of approximately 4 percent, and will blend the remaining surplus highly enriched uranium down to an enrichment level of about 0.9 percent for disposal as low-level waste. This will occur over 15 to 20 years. DOE could use different technologies at four potential blending facilities, including SRS and the Oak Ridge Reservation. Blending down of highly-enriched uranium would affect SRS operations and waste generation. This activity is relevant to the assessment of cumulative impacts (see Chapter 5).

***Storage And Disposition Of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement***

DOE prepared this programmatic EIS (DOE 1996c) to evaluate a safe and secure strategy for the long-term storage of weapons-usable fissile materials, primarily plutonium-239 and highly enriched uranium, and the disposition of weapons-usable plutonium that was surplus to national defense needs. This EIS included the SRS inventory of plutonium-239, highly enriched uranium, and other weapons-usable materials.

The Record of Decision (62 FR 3014) specified that DOE will expand or upgrade SRS facilities (i.e., the Actinide Packaging and Storage Facility) to consolidate weapons-usable plutonium, and will move plutonium pits now stored at the Rocky Flats Environmental Technology Site in Colorado to the Pantex Plant in Texas and non-pit plutonium materials to SRS. DOE will ship the non-pit plutonium to SRS only if a subsequent decision calls for the immobilization of plutonium at the Site. The DOE disposition strategy enables the immobilization of surplus plutonium in glass or ceramic material for disposal in a geologic repository, and the burning of some surplus plutonium as mixed oxide fuel in domestic commercial reactors with subsequent disposal of the spent fuel in a geologic repository in accordance with the Nuclear Waste Policy Act.

TC

TC

DOE specified that it will determine the exact locations for disposition of these materials in site-specific EISs and in cost, technical, and nonproliferation studies. However, DOE has decided that it will locate a vitrification or immobilization facility (with a plutonium conversion facility) at either the Hanford Site in Washington or SRS, and that SRS is a candidate site for a potential mixed oxide fuel fabrication facility and a pit disassembly and conversion facility. The implementation of these decisions will require several years. The Programmatic Weapons-Usable Fissile Materials EIS is also relevant in the assessment of cumulative impacts that could occur at the SRS (see Chapter 5).

The Department issued an Amended Record of Decision (63 FR 43386) to the environmental impact statement, *Storage and Disposition of Weapons-Usable Fissile Materials*, on August 6, 1998. In order to support the early closure of the Rocky Flats Environmental Technology Site (RFETS) and the early deactivation of plutonium storage facilities at the Hanford Site, DOE modified, contingent upon the satisfaction of certain conditions, some of the decisions made in its Storage and Disposition ROD associated with surplus plutonium storage pending disposition. Namely, DOE will take steps that allow: (1) the accelerated shipment of all non-pit surplus weapons-usable plutonium from the RFETS (about 7 metric tons) to the SRS beginning in about 2000, in advance of completion of the Actinide Packaging and Storage Facility in 2001, and (2) relocation of all Hanford surplus weapons-usable plutonium (about 6.4 metric tons) to the SRS, between about 2002 and 2005, pending disposition. However, consistent with the Storage and Disposition PEIS ROD, DOE will only implement the movement of the RFETS and Hanford plutonium inventories to the SRS if the

SRS is selected as the immobilization disposition site. DOE is preparing the *Surplus Plutonium Disposition EIS*, draft issued July 1998, as part of the decision-making process for determining the immobilization site. The action described in this EIS is relevant in the assessment of cumulative impacts that could occur at SRS (see Chapter 5).

***Final Defense Waste Processing Facility Supplemental Environmental Impact Statement***

DOE prepared a Supplemental EIS to examine the impacts of completing construction and operating the Defense Waste Processing Facility at the SRS. This document (DOE 1994) assisted the Department in deciding whether and how to proceed with the Defense Waste Processing Facility project, given the changes to processes and facilities that had occurred since 1982, when it issued the original Defense Waste Processing Facility EIS. The Record of Decision (60 FR 18589) announced that DOE would complete the construction and startup testing of the Defense Waste Processing Facility, and would operate the facility using the In-Tank Precipitation process after the satisfactory completion of startup tests.

The alternatives evaluated in this EIS on the management of SNF could generate radioactive waste that DOE would have to handle or treat at facilities described in the Defense Waste Processing Facility Supplemental EIS and the SRS Waste Management EIS (see next paragraph). The Defense Waste Processing Facility Supplemental EIS is also relevant to the assessment of cumulative impacts (see Chapter 5) that could occur at SRS.

***Savannah River Site Waste Management Final Environmental Impact Statement***

DOE issued the SRS Waste Management EIS (DOE 1995c) to provide a basis for the selection of a sitewide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs.

The SRS Waste Management EIS includes the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area tank operations and waste removal, and construction and operation of a replacement high-level waste evaporator in the H-Area tank farm. In addition, it evaluates the Consolidated Incineration Facility for the treatment of mixed waste. The Record of Decision (60 FR 55249) stated that DOE will configure its waste management system according to the moderate treatment alternative described in the EIS. The SRS Waste Management EIS is relevant to this SNF Management EIS because it evaluates management alternatives for various types of waste that actions proposed in this EIS could generate. The Waste Management EIS is also relevant in the assessment of cumulative impacts that could occur at the SRS (see Chapter 5).

***Environmental Impact Statement for a Geologic Repository for the Disposal of SNF and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada***

On August 13, 1999, DOE announced the availability (64 FR 44200) of a draft environmental impact statement for a geologic repository at Yucca Mountain for the disposal of SNF and high-level radioactive waste, in accordance with the Nuclear Waste Policy Act of 1982. The DEIS evaluates site-specific environmental impacts from the construction, operation, and closure of the repository. It also evaluates reasonable alternatives for implementing such a proposal, and transportation-related impacts for shipments from across the United States. The DEIS also evaluates the consequences at SRS of continued SNF and high-level waste management assuming the repository is not constructed and operated. The repository decision will affect the ultimate disposal of SNF from SRS. The Final EIS is scheduled to be completed in Fiscal Year 2001.

***Treatment and Management of Sodium-Bonded Spent Nuclear Fuel Environmental Impact Statement***

DOE has published a draft environmental impact statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel (64 FR 8553 2/22/99). Alternatives to processing at the Idaho National Engineering and Environmental Laboratory (INEEL) include the use of the Plutonium-Uranium Extraction (PUREX) solvent extraction method currently in use at SRS and the melt and dilute technology that is being proposed under this EIS. The technologies would be applied to sodium-bonded spent nuclear fuel blanket assemblies, which are currently in storage at INEEL. L2-16 There is approximately 22.4 MTHM of Experimental Breeder Reactor-II (EBR-II) blanket fuel and 34.2 MTHM of Fermi-1 blanket fuel to be processed. This EIS includes cumulative impacts of sodium-bonded spent nuclear fuel processing at the SRS based on estimates from conventional processing of Fuel Group A. Fuel Group A is mostly EBR-II fuel (16.7 MTHM out of 19 MTHM) and therefore provides a good basis for estimating impacts from processing of similar material at SRS. DOE estimates that the impacts for conventional processing would be sufficiently representative of impacts from melt and dilute for the purpose of presenting cumulative impacts.

***Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site Final Environmental Impact Statement***

In August 1998, the Department issued the Final EIS (DOE 1998a). In this EIS DOE proposed to process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site (Rocky Flats) located near Golden, Colorado. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at that site. In their present forms, these materials cannot be disposed of or otherwise dispositioned because they contain plutonium in concentrations exceeding DOE safeguards termination requirements.

DOE has decided to ship approximately 7,450 pounds of sand, slag and crucible and plutonium fluoride residues (containing approximately 600 pounds of plutonium) and approximately 1,543 pounds of scrub alloy (containing L2-16 approximately 440 pounds of plutonium) to SRS where these materials will be stabilized in F Canyon by chemically separating the plutonium from the remaining materials in the residues and scrub alloy. The separated plutonium will be placed in safe and secure storage, along with a larger quantity of plutonium already in storage at the Savannah River Site, until DOE has completed the *Surplus Plutonium Disposition Environmental Impact Statement* and made final decisions on the disposition of the separated plutonium. Transuranic wastes generated during the chemical separations will be sent to the Waste Isolation Pilot Plant for disposal. Other wastes generated during the chemical separations operations will be disposed of in accordance with the Savannah River Site's normal procedures for disposing of such wastes. The actions will occur between 1998 and 2002.

***Final Environmental Impact Statement Accelerator Production of Tritium at Savannah River Site* (DOE, 1998b)** EC

DOE has proposed an accelerator design (using helium-3 target blanket material) and an alternate accelerator design (using lithium-6 target blanket material). If an accelerator is built, it would be located at SRS. In the Record of Decision DOE decided to use an existing commercial light-water reactor as the new tritium source. Therefore, the accelerator will not be built at SRS and impacts from construction and operation are not included in the cumulative impacts section of this EIS. TC

***Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site* (DOE 1998c)** EC EC

As stated in the Record of Decision (64 FR 26369; 5/14/99), DOE will construct and operate a Tritium Extraction Facility on SRS to provide the capability to extract tritium from commercial TC

light water reactor targets and targets of similar design. The purpose of the proposed action and alternatives evaluated in the EIS is to provide tritium extraction capability to support either accelerator or reactor production. The Tritium Extraction Facility EIS is relevant in the assessment of cumulative impacts that could occur at SRS (see Chapter 5).

EC ***Surplus Plutonium Disposition Final Environmental Impact Statement* (DOE 1999)**

This EIS analyzes the activities necessary to implement DOE's disposition strategy for surplus plutonium. Following completion of the EIS, SRS was selected (65.FR 1608) as the location for mixed oxide fuel fabrication and plutonium TC immobilization facilities that would be used for plutonium disposition, and for the plutonium pit (a component of nuclear weapons) disassembly and conversion facility. The projected impacts of these operations are incorporated in Chapter 5 of this EIS.

### 1.6.2 OTHER RELEVANT DOCUMENTS

In August 1997, DOE chartered the Nuclear Materials Processing Needs Assessment. The purpose of the assessment was to determine which, if any, additional nuclear materials within the Department of Energy complex may require use of the SRS chemical separations facilities (F or H canyon) for stabilization or preparation for disposition prior to canyon de-commissioning. L15-7 Chemical separations operations are occurring at SRS because DOE is using the canyons to stabilize nuclear materials that represent potential health and safety risks in their current storage configuration. The decisions to use processing capabilities have been documented in a number of Records of Decision, including those following the *F-Canyon Plutonium Solutions EIS*, the *Interim Management of Nuclear Materials EIS*, and the *Rocky Flats Plutonium Residues EIS*. These decisions are consistent with DOE's Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 94-1, wherein the Board recommended that DOE take steps, including use of the L15-7 processing facilities, to stabilize nuclear materials that represented health and safety risks.

The Processing Needs Assessment evaluated four material categories that could require the canyons EC for stabilization or disposition: spent nuclear TC fuel, plutonium-239, uranium, and other special isotopes. The results of the assessment are being reviewed by DOE management to identify needed EC follow-on actions.

Other materials under consideration for processing as SRS canyons include various components currently located at other DOE sites, including Oak Ridge, Rocky Flats, Los Alamos, and Hanford. These materials, which were identified during the Processing Needs Assessment, consist L2-16 of various plutonium and uranium components. If DOE were to process these materials in the SRS separations facilities, additional NEPA reviews would need to be performed. This material has been considered in the cumulative impacts presented in Chapter 5.

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TC

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# CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

This chapter describes the U.S. Department of Energy's (DOE) proposed action; that is, the management of spent nuclear fuel (SNF) at the Savannah River Site (SRS). Technical terms are defined in the Glossary.

## 2.1 Proposed Action

As described in Chapter 1, SRS will receive aluminum-based SNF from foreign research reactors, domestic research reactors, and other DOE sites. DOE will have to manage this fuel, in addition to some SNF already stored at the Site, in a manner that will protect human health and the environment. Additionally, DOE is committed to avoiding indefinite storage at SRS of SNF that is in a form unsuitable for final disposition. Therefore, DOE's proposed action is to safely manage SNF that is currently located or expected to be received at SRS, including treating or packaging aluminum-based SNF for possible offsite shipment and disposal in a geologic repository, and packaging non-aluminum clad fuel for on-site dry storage or offsite shipment.

In the Record of Decision (ROD) for the Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF (61 FR 25092), DOE stated that it would embark on an accelerated program at SRS to identify, develop, and demonstrate one or more non-chemical processing, cost effective treatment or packaging technologies to prepare aluminum-based foreign research reactor spent nuclear fuel for ultimate disposition.

Based on that decision, DOE's proposal is to select a new non-chemical processing technology that would put aluminum-based foreign research reactor SNF into a form or container suitable for direct placement in a geologic repository. Treatment or conditioning of the fuel would address potential repository acceptance criteria and potential safety concerns. Implementing the new non-chemical processing treatment or packaging technology would allow DOE to manage the SNF in a road-ready condition at SRS in dry storage pending shipment offsite.

Because of the similarity of the material, DOE proposes to manage the other aluminum-alloy SNF that is the subject of this EIS (domestic research reactor and DOE reactor fuels) in the same manner as the foreign research reactor fuels.

In the Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF Record of Decision, DOE stated that, should it become apparent by the year 2000 that DOE will not be ready to implement a new SNF treatment technology, DOE would consider chemically processing foreign research reactor SNF in F Canyon. The Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF Record of Decision described the possible use of F Canyon for SNF processing based on a preliminary concept to consolidate all processing operations in one canyon. Subsequent review has shown that consolidating highly enriched uranium spent fuel processing operations in F Canyon would not be practical due to criticality considerations and process capacity restrictions associated with the plutonium-uranium extraction system used in F Canyon. Thus, DOE is now proposing to use H Canyon to chemically separate highly enriched uranium spent fuel.

DOE also committed that any decision to use conventional chemical processing would consider the results of a study (62 FR 20001) on the nonproliferation, cost, and timing issues associated with chemically processing the fuel. DOE stated that any highly enriched uranium separated during chemical processing would be blended down to low enriched uranium.

DOE has included chemical processing as a management alternative in this EIS, although

DOE's preference is to use non-chemical operations processes. DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block).

The limited proposed canyon processing actions is not expected to extend the operating schedules for these facilities beyond the current planning basis. Processing would eliminate potential health and safety vulnerabilities that could occur prior to the availability of a new SNF treatment technology. In the event a new treatment process becomes available, the SNF with potential health and safety vulnerabilities could be processed using the new treatment technology.

Previous DOE management decisions on disposition of SNF are outlined in Section 1.1 and Appendix C, Section C.1.2. Relevant National Environmental Policy Act documents are discussed in Section 1.6.

## 2.2 Spent Nuclear Fuel Management Technology Options

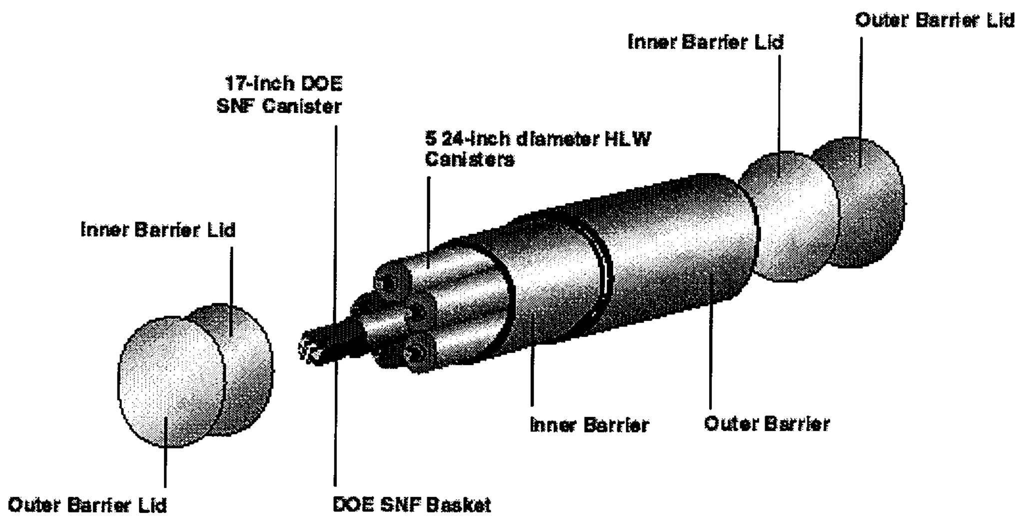
DOE has identified 11 potential treatment and packaging technology options in addition to conventional processing that could be used to prepare aluminum-based SNF at SRS for final disposition in a geologic repository. All of the technology options are discussed in Appendix A of this EIS.

Two of the options, Direct Disposal and Direct Co-Disposal, are non-destructive methods to prepare and package aluminum-based SNF for disposition in a geologic repository. Another technology option, Repackage and Prepare to Ship, is pertinent only to non-aluminum-clad SNF and programmatic material that would be shipped offsite. These three technology options are discussed under the New Packaging Technology options section (Section 2.2.3) of this EIS.

Nine of the technology options are potential processes for the treatment of aluminum-based SNF. These are Melt and Dilute, Press and Dilute, Chop and Dilute, Plasma Arc Treatment, Glass Material Oxidation and Dissolution System, Dissolve and Vitrify, Electrometallurgical Treatment, Can-in-Canister, and Chloride Volatility. DOE has consolidated seven of these processing technology options into four categories for analysis in this EIS. The Press and Dilute and the Chop and Dilute options are similar, so DOE has represented them for analysis as Mechanical Dilution. The Plasma Arc Treatment, the Glass Material Oxidation and Dissolution System, and the Dissolve and Vitrify options use processes that produce a product with properties similar to that produced at the Defense Waste Processing Facility (DWPF) at SRS. Therefore, DOE has represented these three as the Vitrification option. The Melt and Dilute and the Electrometallurgical Treatment options are analyzed separately. The new treatment options are discussed under the New Processing Technology section of this EIS (Section 2.2.4).

DOE considered the remaining two technology options but dismissed them from analysis in this EIS. With Chloride Volatility, SNF would react with chlorine gas at high temperatures to form volatile chlorides. The uranium, aluminum, fission products, and transuranics would be separated from each other by cooling and distillation. This technology is very immature

**Co-Disposal packaging – strategy for all options requiring shipment to the geologic repository**




Two alternatives, New Packaging Technology and New Processing Technology, would result in the dry storage of SNF in a road-ready condition. Under these alternatives, the fuel would be contained in stainless-steel canisters. At the repository the canisters would be loaded into a repository waste package with canisters of vitrified high-level waste. DOE expects five canisters of high-level waste would fit in a repository waste package, leaving room for one canister of SNF. This approach is termed Co-Disposal. It would enable repository disposal of SNF with no space requirements beyond those needed for the disposal of the high-level vitrified waste. The high radiation field of the vitrified high-level waste would provide safeguards protection against unauthorized diversion of the SNF for recovery of the enriched uranium.

The SNF canisters would be packaged for Co-Disposal with high-level vitrified waste canisters at the reposi-

in terms of actual development and testing and the potential for implementation in a timely manner is very uncertain. In addition, this method of chemical separation offers no advantage over conventional processing and DOE eliminated the option from further consideration.

The second technology option dismissed from analysis was Can-in-Canister, under which DOE would place SNF in a can (in an amount that would not pose criticality concerns), place the can in a stainless-steel canister, and fill the canister with vitrified high-level waste. This technology was originally developed as a means for disposing of immobilized plutonium. Because plutonium does not emit intense penetrating radiation, the high radiation field of the vitrified high-level waste would render the plutonium inaccessible. However, a more cost-effective and technologically viable way to protect the SNF with radiation fields is to employ the co-disposal concept. Should the Can-in-Canister method be used with aluminum SNF, the high temperature of the molten glass could melt the aluminum in the fuel, changing the geometry of the fuel matrix in an uncontrolled fashion. Therefore, this option could pose significant risks to human health and the environment, and for that reason was not considered a reasonable alternative. TC

The New Packaging Technology options and the New Processing Technology options consist of several technology options that DOE has not previously applied to the management of aluminum-based SNF for the purpose of ultimate disposition. As a result, DOE believes that the highest confidence of success and greatest technical suitability lies with options that have relatively sim- EC

ple approaches (i.e., Direct Disposal, Direct Co-Disposal, Melt and Dilute, and Press and Dilute).

### 2.2.1 REPOSITORY CONSIDERATIONS

As discussed in Section 2.1, part of DOE's proposed action is to prepare SNF to meet the requirements that the Department anticipates will be applicable to material to be placed in a geologic repository. Any technology that DOE implements must be able to provide a product that is compatible with such criteria. DOE must rely on reasonable assumptions about what the acceptance criteria would include when making decisions on SNF treatment technologies. As described in Chapter 1, DOE anticipates that eventually it will place its aluminum-based SNF inventory after treatment or repackaging in a geologic repository.

As the operator of any geologic repository for SNF, DOE would be responsible for developing acceptance criteria for the material that would be placed in the repository. However, the U.S. Nuclear Regulatory Commission (NRC) would be responsible for licensing the repository. Therefore, DOE is working closely with the NRC to develop acceptance criteria. DOE will provide the NRC with characterization data for material that would be prepared for disposal in a geologic repository. At this time, acceptance criteria need to be conservative because of uncertainties concerning any engineered or natural barriers at a repository. However, as repository and packaging designs evolve, the criteria will become more detailed. Fuel characterization data will need to be detailed enough to verify that each element or canister falls within the ultimate acceptance criteria. Such detail, however, is not currently available. Final acceptance criteria will not be available until after NRC issues its authorization, based on the successful demonstration of safe, long-term performance of the candidate repository in accordance with NRC regulations. Until such time, the preliminary acceptance criteria tend to be conservative to allow for uncertainties in performance of engineered or natural barriers and how such performance may impact public and worker health and safety, and material isolation.

DOE has performed preliminary evaluations of the expected SNF characteristics (DOE 1995a, 1996a). Those evaluations indicated that the SNF to be placed in the repository would have to meet requirements for the following characteristics:

**Packaging**

- Dimension and weight limits
- Material compatibility
- Thermal limits
- Internal gas pressure limits
- Labeling
- Handling ability
- Waste isolation

**Contents**

- Solid material – no particulates
- Noncombustible
- No free liquids
- No hazardous waste (as defined by the Resource Conservation and Recovery Act)

**Chemical reactivity**

- Not chemically reactive
- Nonpyrophoric
- Nonexplosive

**Nuclear material safeguards**

- Reduced uranium-235 enrichment
- Self-protecting radiation fields
- Tamper-proof seals

**Criticality control**

- Limits on nuclear reactivity by controlling amount of uranium and its enrichment (see Text Box on page 2-5)

## Proliferation and Criticality Concerns for SNF Disposal

Preparation of SNF for disposal in a geologic repository requires consideration of the risk of a disruptive nuclear criticality. Criticality risk is defined as the potential for a neutron-induced self-sustaining fission reaction like that which occurs in a nuclear reactor. Nuclear criticality in the SNF would be due to uranium enriched in the fissile nuclide uranium-235 with the remainder being principally non-fissile uranium-238. Characteristic enrichment levels in these fuels are designated as follows (DOE 1996b).

| | Percent uranium-235 |
|---|---|
| Highly enriched uranium (HEU) | >20-93 |
| Low enriched uranium (LEU) | >2-≤20 |
| Commercial power reactor fuel | <2-4 |
| Very low enriched uranium (VLEU) | ≤2 |
| Natural uranium (NU) | 0.72 |
| Depleted uranium (DU) | Typically 0.18 |

Concern for the enrichment level of the fuel arises from two considerations: (1) weapons material proliferation policy and (2) criticality control during storage, transportation, and repository disposal. The high-enriched uranium fuels are generally considered to present unacceptable proliferation risks, unless otherwise protected. Isotopic dilution of the high-enriched uranium fuels to 20 percent uranium-235 during treatment for repository disposal satisfies requirements for protection against this proliferation risk.

TC One approach to control the potential for a nuclear reaction during storage, transport, and repository disposal of the SNF (high-enriched uranium or low-enriched uranium) is addressed by incorporation of neutron-absorbing poison materials in the waste form or containers, by reduction of enrichment levels to the extent practical (2 to 20 percent), and by limiting the mass loading of fissile uranium-235 in the primary waste form canisters. Provisional limits for fissile mass loadings have been specified as follows (DOE 1996b):

| | Allowable fissile mass loading (kg U-235) per canister* |
|---|---|
| HEU | 14.4 |
| LEU | 43 |
| VLEU | 200 |

*Larger quantities of fissile U-235 in the canister are permitted at lower enrichment levels because of neutron escape or absorption in non-fissile material.

In accord with these specifications, the SNF processed for Direct Co-Disposal (with no dilution of highly enriched uranium) would require incorporation of neutron poisons in the waste canister and possibly smaller canisters to meet fissile mass loading limits. The processes under the New Processing Technology, which would achieve enrichment levels of 20 percent or less, would generate canisters within the low-enriched uranium fissile mass loading limits, but could require incorporation of poison materials for additional criticality

### Radiation

- Radiation field limits
- Canister surface contamination limits

L5-3 The preliminary acceptance criteria describe the physical, chemical, and thermal characteristics to which spent nuclear fuel, high-level waste, and associated disposable canisters must conform for emplacement in the repository. The preliminary criteria are organized into four categories:

- General/Descriptive
- Physical/Dimensional L5-3
- Chemical/Compatibility
- Thermal/Radiation/Pressure

*Disposability Assessment: Aluminum-Based Spent Nuclear Fuel Forms* (WSRC 1998a) provides a technical assessment of the Melt-and-Dilute and Prepare for Direct Disposal/Direct Co-Disposal technologies against these preliminary criteria. This assessment is based on results of several analytical and experimental –investigations at SRS, and criticality calculations. The Disposability Assessment concluded:

> Both Melt-Dilute and Direct [disposal] forms [for aluminum-alloy SNF] in disposable containers can meet the requirements of the Draft Standards for Spent Nuclear Fuel in Disposable Canisters. Completed analyses indicate that the Melt-Dilute form of eutectic composition (13.2 percent [uranium]) and containing less than 20 percent $^{235}$U [uranium-235] meets the requirements of the draft standards. Additional criticality analysis of the Melt-Dilute form and HLW [high-level waste] degraded within a waste package are needed for the disposability assessment and are being scheduled for FY00 and subsequent years as part of the development process for the full scale facility. The Melt-Dilute form is flexible in that additional dilution or the addition of neutron poisons to the Melt-Dilute product can be readily made, if necessary.
>
> L5-3 TC
>
> The Direct form in disposable canisters can meet all requirements of the Draft Standards. Criticality analyses have identified that neutron poison additions are needed to preclude criticality of degraded Al-SNF [aluminum based spent nuclear fuel] within a canister and of degraded Al-SNF and HLW within a waste package. A method is needed to incorporate neutron poisons into the canisters in the demonstration that reactivity of all possible configurations is within the acceptable limit. Several poison materials have been suggested and are being evaluated and tested for compatibility with the Al-SNF. These activities will continue throughout the development process for the full scale melt and dilute facility.
>
> EC

Based on the preliminary criteria and the conclusions in the Disposability Assessment, preliminary judgments can be made regarding the acceptability for disposal of the final waste forms produced under the other technologies evaluated in this EIS. Final disposal requirements will be specified by NRC; currently the final waste form produced under the Conventional Processing technology (borosilicate glass) is the best demonstrated available technology for treatment of high-level waste (55 FR 22520). Therefore, DOE has high confidence that this waste form would be acceptable for disposal in a geologic repository. The final waste form produced under the Vitrification technologies and Electrometallurgical Treatment technologies is similar to that produced under the Conventional Processing technology; thus, DOE also would have high confidence in the acceptability of their final products. For Vitrification technologies, criticality and nonproliferation concerns would need to be addressed by the dilution of the highly-enriched uranium to low-enriched uranium.

L5-3

The solid form with low enrichment that would be the product of mechanical dilution could be acceptable for storage in a geologic repository. However, this technology would not be as effective from a nuclear nonproliferation perspective as other treatments (such as Melt and Dilute) because of the potential to separate the pressed or chopped depleted uranium and SNF.

EC

Nuclear materials safeguards are one of the most important issues to be addressed for both onsite storage and transportation to a repository. Much of the aluminum-based SNF contains appreciable quantities of highly enriched uranium or plutonium. In addition to secure management, there are two basic methods for ensuring that these fissile materials have the proper safeguards: (1) reducing the uranium-235 enrichment or (2) making the fuel self-protecting. Reduced uranium-235 enrichment makes the fissile materials incapable of producing a nuclear explosion.

EC

EC

Reenrichment would require a massive commitment of resources not available to most nations. "Self-protecting" means the radiation fields around the fuel are sufficiently high that recovery of the fissile materials would be impossible without the considerable resources of facilities such as those at SRS.

Finally, the integrity of the fuel form that is stored after treatment pending shipment to a repository must be sufficient to ensure safe interim storage and to prevent degradation of design features that may be relied upon in the repository.

Because the melt and dilute waste form could eventually be disposed of in a geologic repository, DOE-SR signed in August 1997 a Memorandum of Understanding with the NRC for its review of the research effort that DOE-SR is conducting. DOE-SR has provided the NRC with several technical reports on the results obtained from the research effort. Based upon its initial review, the NRC in a June 1998 letter (Knapp 1998) stated that "both the direct co-disposal and melt-dilute options would be acceptable concepts for the disposal of aluminum-based research reactor SNF in the repository." Additionally, as research efforts yield new findings, DOE is providing the information to the NRC.

DOE would not implement a treatment technology option unless it has a high degree of confidence that the technology option would produce a final form that was compatible with what DOE believes the repository acceptance criteria will be. In order to ensure that the treatment technology DOE could select will produce a product that is likely to meet the acceptance criteria, DOE-SR is working with the NRC to obtain comments on the research and development work that DOE will perform to establish treatment technology specifications. To provide additional confidence in the suitability of new treatment technologies, DOE requested that the National Academy of Sciences (NAS) evaluate and provide recommendations regarding DOE's aluminum-based SNF disposition technical development program. Results of the NAS review are summarized in Section 2.6.1.

### 2.2.2 FACILITIES

Under the alternatives considered in this EIS, the Department could need a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility. A Transfer and Storage Facility for SNF would provide remote handling and heavy lifting capability, hot cells, and space to receive SNF shipments; place the SNF in interim storage as needed; open the shipping containers; sample and analyze the fuel; crop end fittings if necessary; vacuum-dry the SNF; repackage the fuel into storage canisters; and place the repackaged fuel in dry interim storage. Section 2.3.2.1 provides information on the Transfer and Storage Facility. A Transfer, Storage, and Treatment Facility would provide the capability to implement the options of the New Processing Technology. Section 2.3.2.2 provides more information on the Transfer, Storage, and Treatment Facility.

For all technologies, DOE would continue to use the Receiving Basin for Offsite Fuel and the L-Reactor Disassembly Basin for currently stored SNF and to receive and store incoming fuel. If DOE built the Transfer and Storage Facility, newly received fuel could go to that facility, and the inventory in the wet basins would gradually be moved to new dry storage. DOE intends to discontinue wet storage by 2009 (DOE could continue to use the L-Reactor Disassembly Basin for SNF receipt and unloading if Building 105-L was modified as a Transfer, Storage, and Treatment Facility [see Section 2.3.2]).

All currently stored SNF at the SRS is located in the Receiving Basin for Offsite Fuel or the L-Reactor Disassembly Basin (generically termed "wet basins" in this EIS). DOE initially would receive and store incoming fuel either in the L-Reactor Disassembly Basin or the Receiving Basin for Offsite Fuel and begin construction of a new Transfer and Storage or Transfer, Storage, and Treatment Facility. Fuel would be transported from wet storage basins to the new facility as prescribed to prepare the material for disposi-

tion. Radiological consequences of the on-site transportation of the spent nuclear fuel, under both incident-free and accident conditions are TC | projected in Section 4.1.1.7.

EC |

## 2.2.3 NEW PACKAGING TECHNOLOGY OPTIONS

In this section DOE describes technology options (Direct Disposal/Direct Co-Disposal) that could be used to prepare aluminum-based SNF for TC | placement in a geologic repository and a technology option (Repackaging and Prepare to Ship) that DOE could use to transfer non-aluminum-clad SNF and programmatic material to dry storage pending offsite shipment.

The Direct Disposal/Direct Co-Disposal technology has the advantage of being one of the simplest to implement because it would not require a Treatment Facility, nor would it entail many operational activities. However, several potential technical issues associated with the repository must be resolved. The acceptability of aluminum-based, highly-enriched uranium fuel in a geologic repository is uncertain because of criticality concerns. DOE proposes to address this matter by limiting the amount of uranium permitted in a canister of fuel and by adding a neutron poison. Hydrogen could be produced from radiolysis of bound water in the aluminum metal fuel; however, DOE could minimize hydrogen production by adequate drying and venting, if necessary. The level of SNF characterization and certification requirements is uncertain. DOE expects the operational history of the fuel and some statistical analysis, combined with an evaluation of the more important chemical and physical characteristics (e.g., original fissile material loading, post irradiation burn-up and radiation levels) should be sufficient to characterize the fuel. The need for more detailed characterization information, based on regulatory requirements that will be developed in the future, could require much more costly and time-consuming analysis for each fuel.

### 2.2.3.1 <u>Prepare for Direct Disposal/Direct Co-Disposal</u> | EC

In the Transfer and Storage Facility, the SNF would be cropped (cropping removes the end pieces of the assembly; see Glossary), vacuum dried, and placed in a stainless-steel canister with a neutron poison. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository. | TC Some of the uranium oxide and uranium silicide fuels could require cutting or other resizing to fit into the canisters. As an alternative, special packaging could be used for these oversized fuels.

From an SRS perspective, Direct Disposal and Direct Co-Disposal are identical except for a slight difference in number of canisters produced. The analyses in this EIS would apply equally to either technology. If DOE used canisters with a diameter of about 17 inches (43 centimeters), it could co-dispose (see text box on page 2-3 on the co-disposal concept) the canisters at the repository with vitrified high-level waste prepared in DWPF (Direct Co-Disposal). Otherwise, using 24-inch (61-centimeter) diameter canisters, DOE could dispose of the fuel between waste packages of commercial SNF (Direct Disposal).

Due to the nature and form of the SNF to be managed at SRS, DOE does not expect the Direct Disposal/Direct Co-Disposal technology option would be applicable to all the aluminum-based SNF considered in this EIS. Table 2-1 presents an explanation of the SNF that DOE considers appropriate for the Direct Disposal/ Direct Co-Disposal option.

Figure 2-1 shows the Direct Disposal/Direct Co-Disposal option. Appendix A provides a more complete discussion of Direct Disposal and Direct Co-Disposal.

#### 2.2.3.2 <u>Repackage and Prepare to Ship to Other DOE Sites</u>

This technology option would apply to two specific fuel groups, and this is the only option considered for these fuel groups.

- DOE has designated management responsibilities for the stainless-steel and zirconium-clad fuels (Group F) to the Idaho National Engineering and Environmental Laboratory (60 FR28680). DOE analyzed the environmental impacts of shipping these non-aluminum-clad fuels to the Idaho National Engineering and Environmental Laboratory in the Programmatic SNF EIS (DOE 1995b).

- The Higher Actinide Targets would be stored pending an evaluation of their disposition. Under the Repackaging and Prepare to Ship to Other DOE Sites technology option, DOE evaluates repackaging the Mark-51 and other targets to place them in a new dry storage facility in the event disposition decisions have not been made by the time an SRS dry storage facility is operational.

  DOE would not apply the Repackaging and Prepare to Ship option to the Mark-18 targets due to potential health and safety vulnerabilities as described in Section 1.5 of this EIS.

  In the Transfer and Storage Facility, the SNF and the Mark-51 and other targets could be cropped, vacuum dried, and placed in stainless-steel canisters, possibly with a neutron poison. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment offsite. Figure 2-2 shows the Repackage and Prepare to Ship option which would be implemented only in parallel with an alternative that required the construction of a Transfer and Storage Facility or Transfer, Storage, and Treatment Facility. A new facility would not be constructed solely to repackage non-aluminum-based fuels and the higher actinide targets.

### 2.2.4 NEW PROCESSING TECHNOLOGY OPTIONS

The New Processing Technology options would reduce the uncertainty associated with placing aluminum SNF in a geologic repository because criticality concerns would be reduced through the opportunity to adjust enrichment, add neutron absorbers, and better control geometry.

Under these technology options, DOE initially would receive and store incoming fuel either in the L-Reactor Disassembly Basin or the Receiving Basin for Offsite Fuel. DOE would construct and operate a Transfer, Storage, and Treatment Facility (Section 2.3.2.2) to receive later shipments, and would begin to transfer the fuel inventories in the existing storage pools to this facility. DOE could use the dry storage capacity of the facility to store SNF awaiting processing and to store the processed fuel form in a road-ready condition awaiting shipment to the geologic repository.

If a new facility was built, DOE would phaseout operation of the L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel by 2009. In the event that Building 105-L was modified to function as the Transfer, Storage, and Treatment Facility, SNF would continue to be received and unloaded in the L-Reactor Disassembly Basin, but long-term SNF storage in the basin and in the Receiving Basin for OffsiteFuel would be phased out. The Transfer, Storage, and Treatment Facility could be located in a new or existing facility in one of the reactor areas or in a new facility in F or H Area.

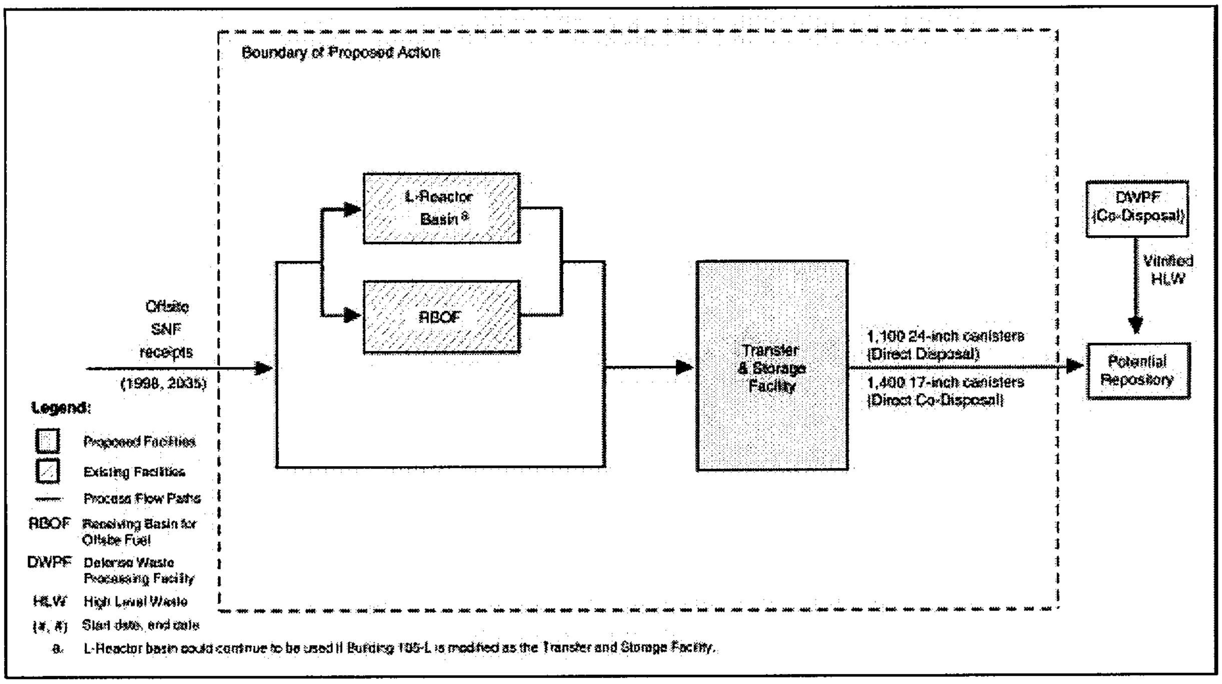
Each technology option that DOE could use in the Transfer, Storage, and Treatment Facility, except Electrometallurgical Treatment, would result in an SNF form that DOE would store in road-ready condition. The use of 17-inch (43-centimeter) diameter canisters would support the co-disposal concept; however, DOE could use other canister sizes. DOE assumed a 17-inch canister for purposes of estimating costs of each technology (see Section 2.6.5). The analyses in

this EIS would apply equally to other canister sizes.

**Table 2-1.** Applicability commentary of the New Packaging Technology options.

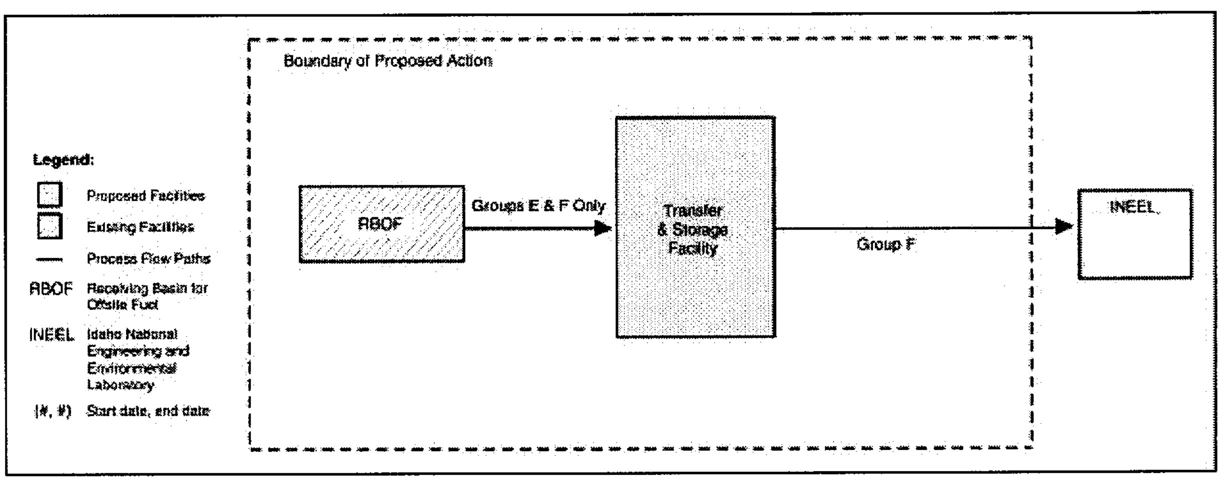
| | Fuel group | Prepare for Direct Disposal/Direct Co-Disposal | Repackage and Prepare to Ship to Other DOE Sites |
|---|---|---|---|
| | A. Uranium and Thorium Metal Fuels | **Applies** - These reactive metal fuels would require rigorous drying (hot vacuum drying) to ensure dehydriding and passivation of uranium metal for both short-term and repository storage. | **Does not apply** - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS. DOE would not ship aluminum-based SNF to another site for storage. |
| | B. Materials Test Reactor-Like Fuels | **Applies** - The fissile mass loading of the canisters would be limited because of criticality concerns. DOE and NRC[a] are discussing packaging restrictions which would eliminate the possibility of criticality. | **Does not apply** - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS. DOE would not ship aluminum-clad SNF to another site for storage. |
| | C. HEU/LEU[b] Oxides and Silicides Requiring Resizing | **Applies** - These fuels would not fit into the 17-inch (43-centimeter) diameter canister without resizing or special packaging. The highly enriched fuels present criticality concerns. The fissile mass loading of the canisters would be limited. | **Does not apply** - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS. |
| EC | D. Loose Uranium Oxide in Cans | **Does not apply** - Group D fuels are granular and might contain particulates. Current understanding of acceptance criteria for the geologic repository would rule out acceptance of particulate fuels. | **Does not apply** - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS and would ship non-aluminum fuel to INEEL. |
| EC | E. Higher Actinide Targets | **Does not apply** - This fuel group will be continually wet stored until DOE decides on their final disposition. | **Applies** - In the future, DOE might decide to ship these targets to another DOE site. Application of this technology to Group E fuels would include only the preparation for shipment, not the shipment itself. |
| | F. Non-Aluminum-Clad Fuels | **Does not apply** - The Record of Decision for the Programmatic SNF EIS designated INEEL[c] as the location for management of non-aluminum-clad SNF. SRS activities for Group F fuels are to prepare it for shipment to INEEL. | **Applies** - Under the Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b), DOE would ship non-aluminum-clad spent nuclear fuel to INEEL. DOE analyzed shipment from wet basins (DOE 1995b) which could occur under the No-Action Alternative. This technology would provide an additional action of repackaging and dry-storing Group F fuel before shipment. |

a. NRC = U.S. Nuclear Regulatory Commission.
b. HEU/LEU = Highly Enriched Uranium/Low Enriched Uranium.
c. INEEL = Idaho National Engineering and Environmental Laboratory.




TC

**Figure 2-1.** New Packaging Technology – Direct Disposal/Direct Co-Disposal.




TC

EC **Figure 2-2.** New Packaging Technology – Repackage and Prepare to Ship to Another DOE site.

Figures 2-3 and 2-4 show the New Processing Technology options. The following sections describe the new technology options; Appendix A describes them in more detail. Table 2-2 lists the applicability of the New Processing Technology to the fuel groups described in Chapter 1.

### 2.2.4.1 Melt and Dilute EC

Under the Melt and Dilute option, DOE would receive, unload, and crop the SNF in the Transfer, Storage, and Treatment Facility and either package the fuel in canisters for placement in dry storage pending treatment or send it directly to the treatment phase. The SNF would be melted and, if highly enriched, mixed with depleted ura-

nium and additional aluminum as necessary to produce a low-enriched uranium-aluminum melt. Neutron poison material also could be added if necessary. The low-enriched uranium product would be placed in corrosion-resistant canisters. The canisters, about 17-inch diameter by 120-inch length (43 by 305 centimeters), would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository.

Under this option, most of the fission products would remain in the uranium-aluminum melt; however, some would be volatilized. Dilution to low enrichment would address nuclear proliferation concerns relating to transport and disposal of fuels. Both the dilution and the poison addition would address criticality concerns. Other characteristics promoting acceptability of the final form for disposal in the geologic repository are discussed in Appendix A. | TC

Based on recent research and development work, preliminary conceptual design work, and considering aspects such as technical maturity, DOE considers Melt and Dilute to be the most viable of the technology options for implementation at SRS. DOE believes Melt and Dilute would entail the least technical risk because DOE has made substantial progress in the development of the melt and dilute process and ongoing work indicates full-scale operations that melt aluminum-based SNF and isotopically dilute the high-enriched uranium are achievable. A review by the National Academy of Sciences indicated that the Melt and Dilute process, as proposed by the SRS, should be achievable for aluminum-based SNF to be managed at SRS. | EC

| TC

During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and Dilute option is no longer viable. As a back-up to Melt and Dilute, DOE will continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would attempt to implement this option if Melt and Dilute were no longer feasible or preferable. Direct Co-Disposal has the potential to be the least complicated of the new technology options. However, there is uncertainty that aluminum-based SNF, packaged according to the Direct Co-Disposal option, would be acceptable in a geologic repository. A comparison of the preferred and backup technologies for aluminum-based nuclear fuel disposal is presented in Table 2-3. TC |

The DOE-SR and the NRC have established an agreement for the NRC to provide technical assistance in connection with the identification of potential issues relating to the placement of aluminum-based foreign and domestic research reactor spent nuclear fuel in a geologic repository. In a review of DOE's research and development work, the NRC staff indicated that both the Melt and Dilute and Direct Co-Disposal technologies would be acceptable concepts for the disposal of aluminum- based research reactor SNF in a repository (Knapp 1998). EC |

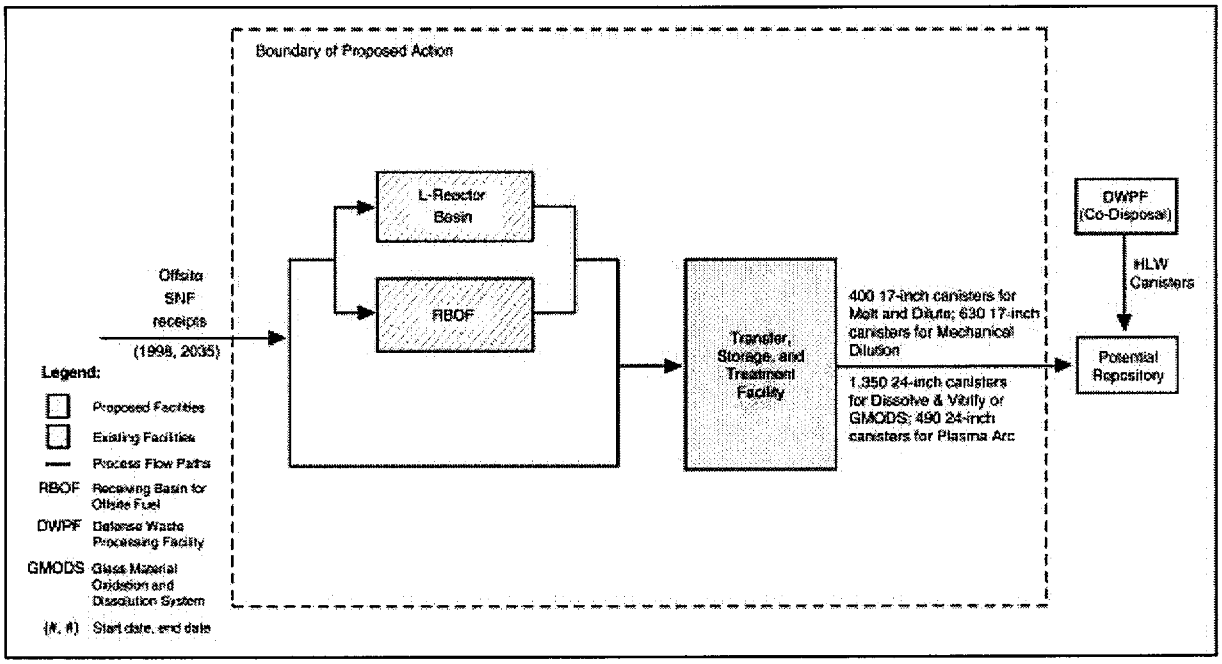
#### 2.2.4.2 Mechanical Dilution

EC |

For this option, DOE would use a mechanical process to consolidate the fuel and isotopically dilute the uranium-235. The process could be either Press and Dilute or Chop and Dilute (see Appendix A). The impact analyses in Chapter 4 are based on Press and Dilute because DOE believes those impacts would be representative of both technologies, which would have nearly identical process flows, facility requirements, and resulting fuel forms.

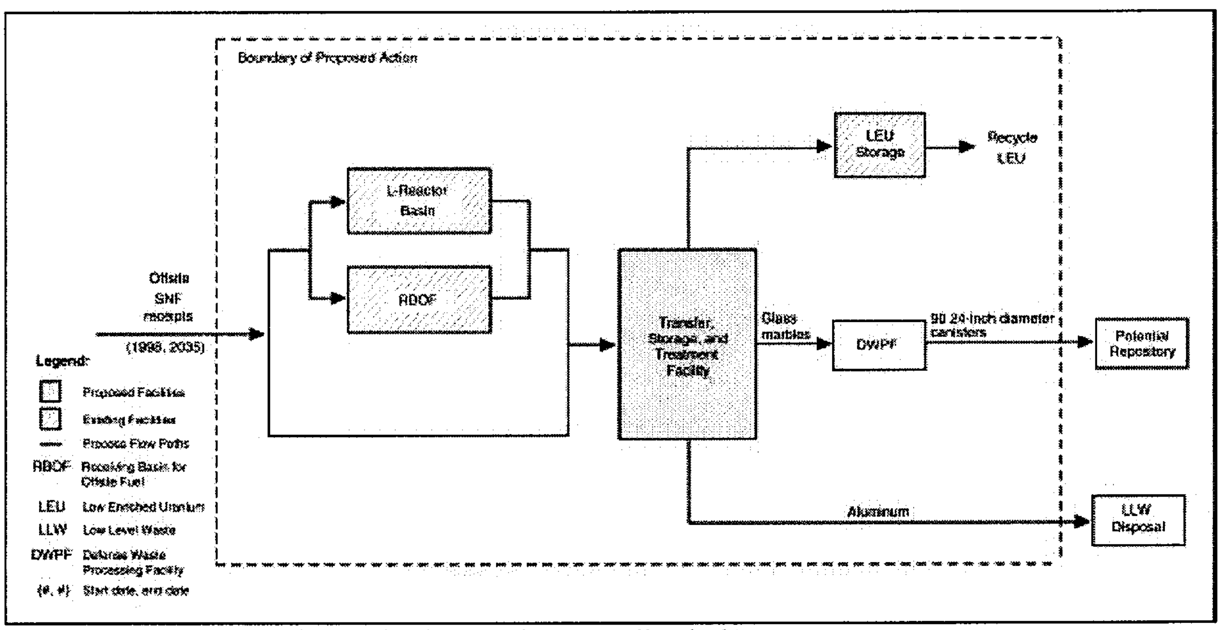
DOE would crop and cold-vacuum-dry SNF in the Transfer, Storage, and Treatment Facility and either place the fuel in canisters for dry storage pending treatment or send the fuel directly to the treatment phase for volume reduction and dilution. The Press and Dilute method would flatten fuel assemblies and press them into a laminate between layers of depleted uranium to produce packages with a low overall enrichment. The Chop and Dilute method would shred the fuel and mix it with depleted uranium. Regardless of the dilution method, DOE would package the product in 17- by 120-inch (43- by 305-centimeter) canisters. The package could contain a nuclear poi-

son (in either the laminate or the container) to reduce the




TC
EC

**Figure 2-3.** New Processing Technology - Melt and Dilute, Mechanical Dilution, Vitrification Technologies.




TC
EC

**Figure 2-4.** New Processing Technology – Electrometallurgical Treatment.

**Table 2-2.** Applicability of New Processing Technology options.

| Fuel Group | Melt and Dilute | Mechanical Dilution | Vitrification Technologies | Electrometallurgical Treatment |
|---|---|---|---|---|
| A. Uranium and Thorium Metal Fuels | **Applies** | **Does not apply** - Mechanical treatment would not address chemical reactivity issue. | **Applies** | **Applies** |
| B. Materials Test Reactor-Like Fuels | **Applies** | **Applies** | **Applies** | **Applies** |
| C. HEU/LEU[a] Oxides and Silicides Requiring Resizing | **Applies** | **Applies** | **Applies** | **Applies** |
| D. Loose Uranium Oxide in Cans | **Applies** | **Does not apply** - These fuels are granular and might contain particulates. This technology would leave Group D fuels as particulates. Current understanding of repository acceptance criteria is that particulate fuels would not be accepted without special treatment. | **Applies** | **Applies** |
| E. Higher Actinide Targets | This fuel group will be continually wet stored until DOE decides on their final disposition. | This fuel group will be continually wet stored until DOE decides on their final disposition. | This fuel group will be continually wet stored until DOE decides on their final disposition. | This fuel group will be continually wet stored until DOE decides on their final disposition. |
| F. Non-Aluminum-Clad Fuels | **Does not apply** - Record of Decision for Programmatic SNF EIS[b] designated INEEL[c] as location for non-aluminum SNF management. | **Does not apply** - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management. | **Does not apply** - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management. | **Does not apply** - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management. |

EC

EC

a. HEU/LEU = highly enriched uranium/low enriched uranium.
b. DOE (1995b).
c. INEEL = Idaho National Engineering and Environmental Laboratory.

**Table 2-3.** Comparison of preferred and backup technologies for aluminum-SNF disposal.

| Technology | Advantages | Disadvantages |
|---|---|---|
| **Preferred technology: Melt-Dilute Process** | • U-235 enrichment readily adjusted by dilution with depleted uranium to meet proliferation policy and nuclear criticality constraints.<br>• Melting reduces the volume of the fuel (see Section A.2.1). DOE estimates about 400 canisters would be generated, in comparison to about 1,400 canisters for Direct Co-Disposal.<br>• Homogenous melt product provides basis for predictable behavior in geologic repository. | • Implementation requires high temperature operation of melter and offgas control equipment in shielded cell. TC |
| **Backup technology: Direct Co-Disposal Process** TC | • Process technically straightforward to implement. Shielded-cell handling procedures well developed.<br>• Meets non-proliferation policy criteria better than other alternatives. | • Different SNF configurations, materials, and U-235 enrichments present packaging complexities.<br>• No adjustment of U-235 enrichment possible to meet criticality constraints in a geologic repository. May require the use of exotic nuclear poisons. TC<br>• No reduction in the volume of the fuel.<br>• Non-uniform SNF structures and compositions complicates documentation of fuel characteristics to meet repository waste acceptance criteria and to predict behavior in a geologic repository. TC |

potential for criticality. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository. TC

The fission products would remain with the uranium-aluminum alloy, making their release difficult. However, mechanical dilution would not be as effective from a nuclear nonproliferation viewpoint as other treatments (such as Melt and Dilute) because of the potential to separate the pressed or chopped depleted uranium and SNF. The dilution process and the addition of a neutron poison would decrease criticality potential. The solid form with low enrichment could be acceptable at the geologic repository. Although hydrogen generation in the canister would be possible due to the radiolysis of bound water, DOE could minimize hydrogen buildup by eliminating water from the canisters (e.g., by vacuum drying).

### 2.2.4.3 Vitrification Technologies EC

DOE could use one of three vitrification technologies: (1) Dissolve and Vitrify, (2) Glass Material Oxidation Dissolution System, or (3) Plasma Arc Treatment. In the vitrification options, the SNF would be converted to oxide and dissolved in molten glass to form a vitrified product. These options have the advantage of producing a vitrified waste form similar to that used for the disposal of high-level waste. Therefore, they should qualify for acceptance at a geologic repository. The final form would contain fission products, and criticality and nonproliferation concerns would be addressed by the dilution of enriched uranium. TC

For these options, DOE would crop and cold-vacuum-dry SNF in the Transfer, Storage, and Treatment Facility and either place the fuel in canisters for dry storage pending treatment or send it immediately for treatment. The resulting glass or ceramic would be poured into 24- by

120-inch (61- by 305-centimeter) canisters and placed in dry storage. The use of 24-inch diameter canisters would enable disposal like vitrified high-level waste.

These are advanced technologies. As such, they introduce more technical and schedule risk than the other options in this alternative. This EIS analyzes the impacts of the Dissolve and Vitrify option as representative of all three because DOE believes that the impacts among the three would be similar. The following paragraphs describe the three vitrification technologies; Appendix A provides more information.

**Dissolve and Vitrify**

The Dissolve and Vitrify treatment is similar to conventional processing except there would be no recovery of enriched uranium. The SNF would be cropped and charged to an electrolytic dissolver. The electrolyte solution would be nitric acid saturated with boric acid. If necessary, depleted uranium would be added to produce low-enriched uranium. The entire solution, including uranium and fission products, would be vitrified. The process would operate in a batch mode to ensure criticality control.

This EIS analyzes performing the Dissolve and Vitrify option in the Transfer, Storage, and Treatment Facility; however, DOE could modify one of the canyons to perform the process. DOE is not considering vitrification of this material in DWPF because that process is not designed to accommodate more than trace quantities of fissile material without major modifications that would be impractical and incompatible with DWPF operations, schedules, and mission.

**Glass Material Oxidation and Dissolution System**

The Glass Material Oxidation and Dissolution System would convert SNF directly to borosilicate glass using a batch process. The final form would address criticality concerns by diluting the uranium-235 with depleted uranium and by using boron oxide as a dissolving agent (boron is a neutron poison).

The process would use lead dioxide to oxidize the metals in the SNF so they would be soluble in glass. The resulting lead metal would be recovered and oxidized for reuse. The product of the process would be glass marbles that a second stage of melting could consolidate into logs. The process would occur in the new Transfer, Storage, and Treatment Facility.

**Plasma Arc Treatment**

The Plasma Arc Treatment technology would use a plasma torch to melt and oxidize the SNF in a rotating furnace. The fuel would be fed into the process with minimal sizing or pretreatment. The plasma torch would heat the fuel to temperatures as high as 2,900°F (1,600°C). The rotation of the furnace and the pressure of the torch would mix the melted fuel. A ceramic binder such as contaminated soil would be added to the mixture to form a glass-ceramic. Depleted uranium could be added to the process to produce low-enriched uranium. When the melting and oxidation is complete, the furnace rotation would slow and the molten fuel would flow by gravity into molds. The process would be conducted in the Transfer, Storage, and Treatment Facility, which would be equipped to capture volatile and semivolatile off-gasses.

#### 2.2.4.4 Electrometallurgical Treatment | EC

Under the Electrometallurgical Treatment option, DOE would crop and cold-vacuum-dry the SNF in the Transfer, Storage, and Treatment Facility, can it, and either place it in dry storage pending treatment or send it immediately to the treatment phase, which would shred and melt it into metal ingots. An ingot would be placed in an electrorefiner, where most of the metal in the SNF (aluminum) would be removed as a low-level waste stream. The remaining metal would be placed in a second electrorefiner where the uranium would be removed. If necessary, the uranium would be fed to a melter where depleted uranium would be added to produce low-enriched uranium. The

uranium could be sold as recycled uranium for manufacture into commercial nuclear fuel. The remainder of the fuel materials would be oxidized in a furnace and dissolved in glass which would be poured into 24- by 120-inch (61- by 305-centimeter) canisters and placed into dry storage.

This option has the advantage of potentially recycling the enriched uranium. Criticality concerns would be addressed by the isotope dilution of the highly enriched uranium, eliminating the issue of SNF acceptance at a geologic repository. DOE has been developing the electrometallurgical treatment process for certain non-aluminum-based SNF.

Figure 2-4 shows the Electrometallurgical Treatment technology. Appendix A provides a more complete discussion of the technology.

### 2.2.5 CONVENTIONAL PROCESSING TECHNOLOGY

In this technology, DOE would process SNF in the F or H Area Canyon directly from wet storage. The Record of Decision for the Final EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (61 FR 25091) stated that fuel would be processed in F Canyon. Because F Canyon is scheduled to be shut down before all the fuel could be processed, and because F Canyon is not suitable for highly-enriched uranium processing without modifications, H Canyon also would be used. The process would chemically dissolve the fuel and separate fission products from the uranium by solvent extraction. The uranium would be blended with depleted uranium, as necessary, to bring the enrichment down to about 5 percent or less. The wastes from solvent extraction would contain the highly radioactive fission products, thorium, and possibly some uranium. This high-level waste would be separated into high- and low-activity fractions, which would be converted to glass (vitrified) in DWPF and to a cementitious low-level solid in the Saltstone Manufacturing and Disposal Facility, respectively. Recovered uranium could be sold to a commercial producer of nuclear fuel. DOE would dispose of the vitrified waste in a geologic repository and the saltstone in onsite vaults.

For Conventional Processing, DOE would use several existing SRS facilities:

- The L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel for interim storage of the SNF before processing
- The F and H Canyons and related facilities for processing
- The high-level waste tank farms, DWPF, and Saltstone Manufacturing and Disposal Facility for high-level waste disposition

DOE expects that the Experimental Breeder Reactor-II fuel and the Mark-42 targets would be processed in F Canyon. The operation would result in the separation of plutonium that would be converted to metal in FB-Line and then placed in storage at SRS pending disposition in accordance with decisions reached under the *Surplus Plutonium Storage and Disposition EIS* currently being prepared by DOE. This material would not be used in any military application. All other processing operations would be conducted in H Canyon. Processing operations in H Canyon would continue if all fuel were to be processed until the aluminum-based SNF inventory was eliminated and the SNF receipt rate was low in about 2009 (i.e., receipts would be about 150 Materials Test Reactor-like elements per year and 12 High Flux Isotope Reactor assemblies per year). In parallel with processing operations, DOE could construct a Transfer, Storage, and Treatment Facility to receive and treat new SNF after processing operations cease. Because of the small volume of SNF to be processed in this facility, its dry storage capacity would be much less than required for other technologies.

Conventional Processing would be applicable to all fuel groups except most of the higher actinide targets (specifically the Mark-51 and "other" targets) and the non-aluminum-clad fuels. Con-

ventional Processing would apply to the Mark-18s in the Higher Actinide Targets fuel group. The Record of Decision for the Programmatic SNF EIS (DOE 1995b) designated the Idaho National Engineering and Environmental Laboratory as the location for management of non-aluminum-clad SNF. The SRS would store these fuels pending shipment to the Idaho National Engineering and Environmental Laboratory.

The resulting low-enriched uranium would not be suitable for use in weapons and any plutonium separated from the Experimental Breeder Reactor-II fuel or Mark-42 targets would be part of the plutonium considered surplus to the nuclear weapons program that will be dispositioned through decisions reached under the plutonium disposition EIS. Repository acceptance criteria should not be an issue because the vitrified high-level waste would be the same as the vitrified waste DOE is currently producing at SRS, and DOE has a high level of confidence that vitrified waste will meet the repository acceptance criteria. This option would add to the inventory of waste stored at SRS. However, sufficient storage and DWPF capacity exist to accommodate the added volume.

Figure 2-5 shows the Conventional Processing option. Appendix A provides more information on the technology.

## 2.3 Spent Nuclear Fuel Management Facilities

The implementation of the proposed action would require the construction of a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility and the use of several existing facilities, depending on the alternative selected. Table 2-4 lists the facilities required for the technologies. The following sections describe the existing and new facilities.

### 2.3.1 EXISTING FACILITIES

The existing SRS facilities that DOE would need for the proposed action are the L-Reactor Facility, the Receiving Basin for Offsite Fuel, and the F and H Canyons. Figure 2-6 shows the locations of these facilities. Appendix B provides information on the status of identified vulnerabilities at these facilities.

#### 2.3.1.1 L-Reactor Facility

**Facility Description**

The Federal Government built L Reactor in the early 1950s to produce nuclear materials for national defense. In 1988 DOE shut the reactor down for safety upgrades, and has not restarted it. In 1993 the Department ended the reactor's materials production mission. The current mission of this facility is to store reactor components and other radioactive materials in the disassembly basin, receive and store foreign and domestic research reactor fuel in the disassembly basin, decontaminate shipping casks in the stack area, store contaminated moderator in tanks or drums, and compact low-level waste in a compactor. DOE maintains the structures, systems, and components necessary to perform these missions, but has deenergized, drained, or otherwise deactivated many others.

In addition to the support systems, L Reactor has three principal areas that could be important to the proposed action – the disassembly basin, the L-Reactor building, and the stack area. Figure 2-7 shows L-Reactor and indicates the locations of these areas.

The disassembly basin, which would be the principal structure supporting the SNF storage mission, is a large concrete basin containing approximately 3.4 million gallons (13,000 cubic meters) of water varying in depth from 17 to 50 feet (5.2 to 15 meters). DOE has upgraded the basin to improve water control and monitoring, including continuously operating deionizers to improve water chemistry, makeup water deionizers, and a water level monitoring system. In addition, DOE has added storage racks to accommodate anticipated fuel receipts. The disassembly basin contains a transfer bay with one water-filled pit and heavy lifting equipment to transfer shipping casks to the basin.

The L-Reactor building has space potentially suitable for installation of facilities for treatment of SNF (see Section 2.3.2.2). The space includes the process room and crane maintenance area. The process room, a shielded area situated

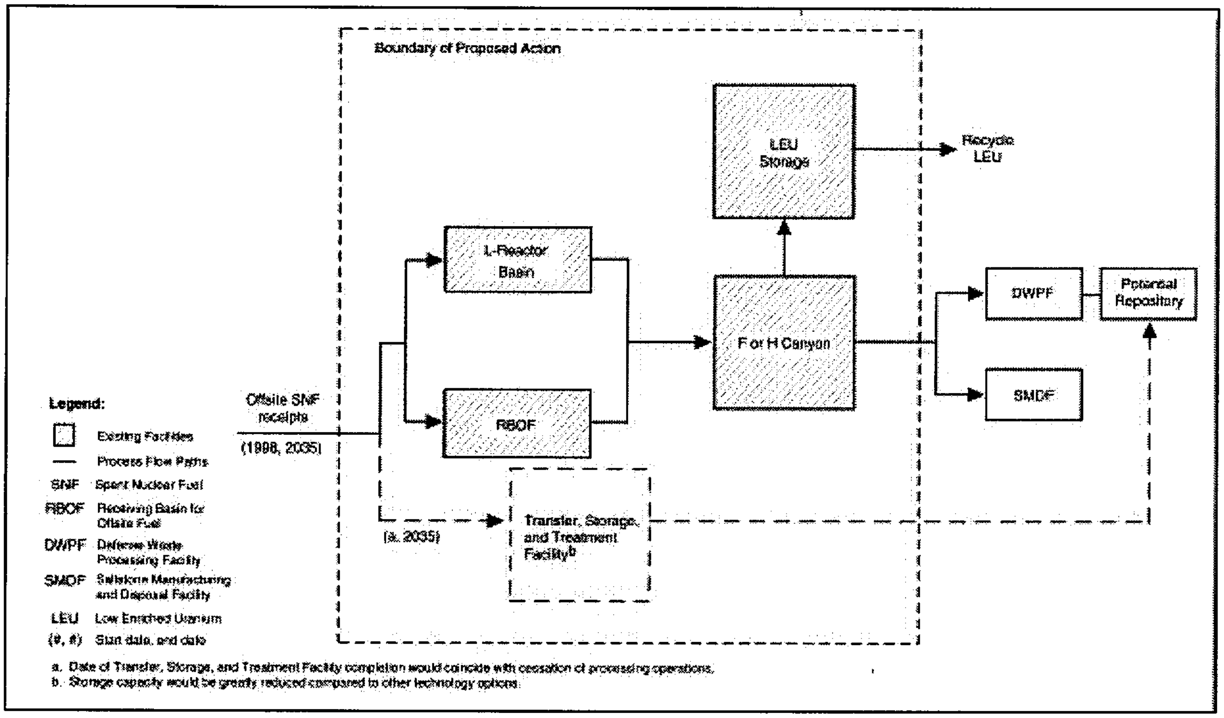



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**Figure 2-5.** Conventional Processing.

**Table 2-4.** Facilities needed for SNF technologies.

| Technology | Receiving Basin for Offsite Fuel | L-Reactor Facility | F or H Canyon | Transfer and Storage Facility | Melt and Dilute Treatment Facility | Mechanical Dilution Treatment Facility | Vitrification Facility | Electrometallurgical Treatment Facility | Renovated Reactor Facility |
|---|---|---|---|---|---|---|---|---|---|
| 1. Prepare for Direct Disposal/Direct Co-Disposal | ✓ | ✓ | | ✓ | | | | | ✓ |
| 2. Repackage and Prepare to Ship[a] | ✓ | ✓[b] | | ✓ | | | | | ✓ |
| 3. Melt and Dilute | ✓ | ✓ | | ✓ | ✓ | | | | ✓ |
| 4. Mechanical Dilution | ✓ | ✓ | | ✓ | | ✓ | | | ✓ |
| 5. Vitrification Technologies | ✓ | ✓ | | ✓ | | | ✓ | | ✓ |
| 6. Electrometallurgical Treatment | ✓ | ✓ | | ✓ | | | | ✓ | ✓ |
| 7. Conventional Processing | ✓ | ✓ | ✓ | ✓ | ✓[c] | | | | |
| 8. Continued Wet Storage | ✓ | ✓ | | | | | | | |

a. To another DOE site.
b. Needed only if a Transfer, Storage, and Treatment Facility were implemented in a reactor facility.
c. Once conventional processing is terminated, the remaining SNF would require treatment using one of the new technologies. A Melt and Dilute Treatment Facility is included as part of Conventional Processing as a reference follow-on treatment

above the reactor tank, formerly provided access to the reactor by means of a charge and discharge machine for handling reactor fuel assemblies. The area is serviced by an overhead crane. Fuel assemblies were transferred from the L-Reactor Disassembly Basin to the process room by way of an interconnecting water canal. The crane maintenance area, connected to the process room by a shielded crane wash area, allowed hands-on maintenance of the fuel assembly transfer systems.

DOE uses the L-Reactor stack area to unload shipping casks from their International Organization for Standardization (ISO) containers and to decontaminate empty shipping casks. The decontamination hut has a sump pump, spray equipment, a ventilation system, and deionizers.

In 1993 DOE performed a vulnerability assessment of its SNF facilities and identified several vulnerabilities related to the disassembly basins (DOE 1993). The Defense Nuclear Facilities Safety Board reported other vulnerabilities (DNFSB 1994; Burnfield 1995; Conway 1996), including the lack of adequate water chemistry control, which resulted in the corrosion of stored SNF and some cladding failure. The corroding fuel resulted in a buildup of radionuclides in the water and in the sludge at the bottom of the basins. Another vulnerability was the lack of an adequate leak detection capability. Since the vulnerability assessments, DOE has completed the corrective actions. One of the more significant upgrades is the installation of deionizers for maintaining water quality; maintenance of water chemistry is important to minimize corrosion. Appendix B describes these vulnerabilities and corrective action plans in greater detail.

**Facility Operations**

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DOE would receive SNF in shipping casks designed to meet SNF cask design criteria (10 CFR 71). If the cask was too large for the L-Reactor Disassembly Basin or if other operational restrictions (such as a maintenance out-age) occurred, DOE would transport the cask to the Receiving Basin for Offsite Fuel in H Area, remove the fuel and place it in a smaller cask, and transfer it to L Reactor. The smaller casks would be moved to the transfer bay of the disassembly basin.

SNF is unloaded from the casks underwater. The procedure is as follows: the casks are vented, filled with water, and submerged in the transfer bay. The purged air is cleaned by high-efficiency particulate air filters before being discharged to the atmosphere. The casks are opened and the fuel elements placed in a bucket for examination. If the fuel cannot be identified or is inconsistent with the documentation provided by the reactor operator, it is isolated until the discrepancy is resolved.

The SNF is moved to the storage area of the disassembly basin through a transfer canal. The cask lid is replaced and the cask is drained, washed, and decontaminated. Decontamination water is sent to the disassembly basin.

### 2.3.1.2 Receiving Basin for Offsite Fuel

**Facility Description**

The Receiving Basin for Offsite Fuel, located in H Area, has provided storage for irradiated SNF since 1964. It has an unloading basin, two storage basins, a repackaging basin, a disassembly basin, and an inspection basin, all underwater. Fuel is handled or stored under at least 4 feet (1.2 meters) of water to provide shielding against radiation. The reinforced-concrete basins are below grade. They have either chemical coatings or stainless-steel linings for ease of decontamination. The storage lattice in the basins consist of rows of racks of aluminum I-beams. Gratings, guide plates, and spacers between the racks separate individual storage positions and provide the spacing required for criticality safety. EC

In addition to the water-filled basins, the Receiving Basin for Offsite Fuel has a receiving bay, dry cask inspection pit, control room, office areas, equipment storage areas, and concrete cells that contain tanks for water decontamination (deionization) and temporary storage of

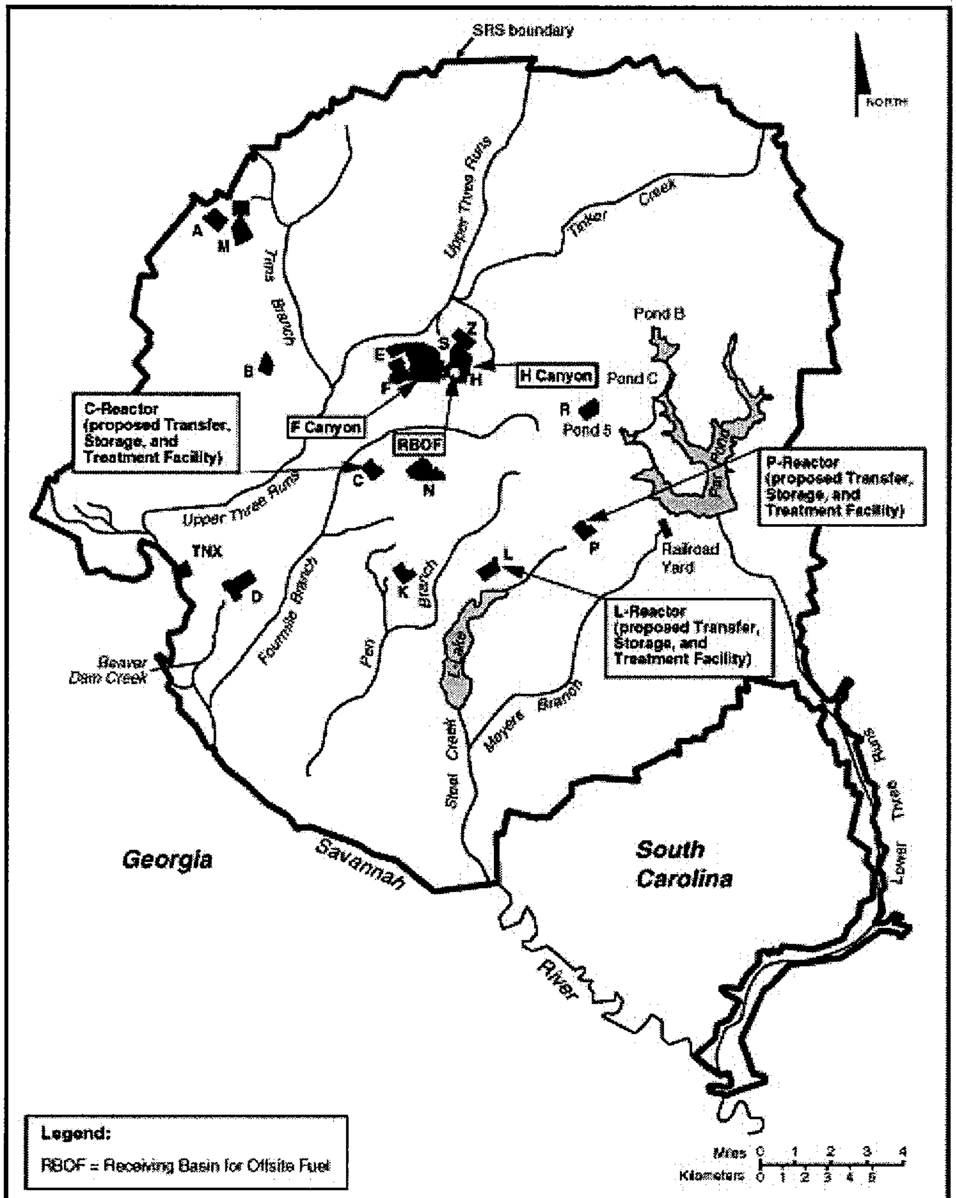


Figure 2-6. SRS map indicating locations of facilities needed for Proposed Action.

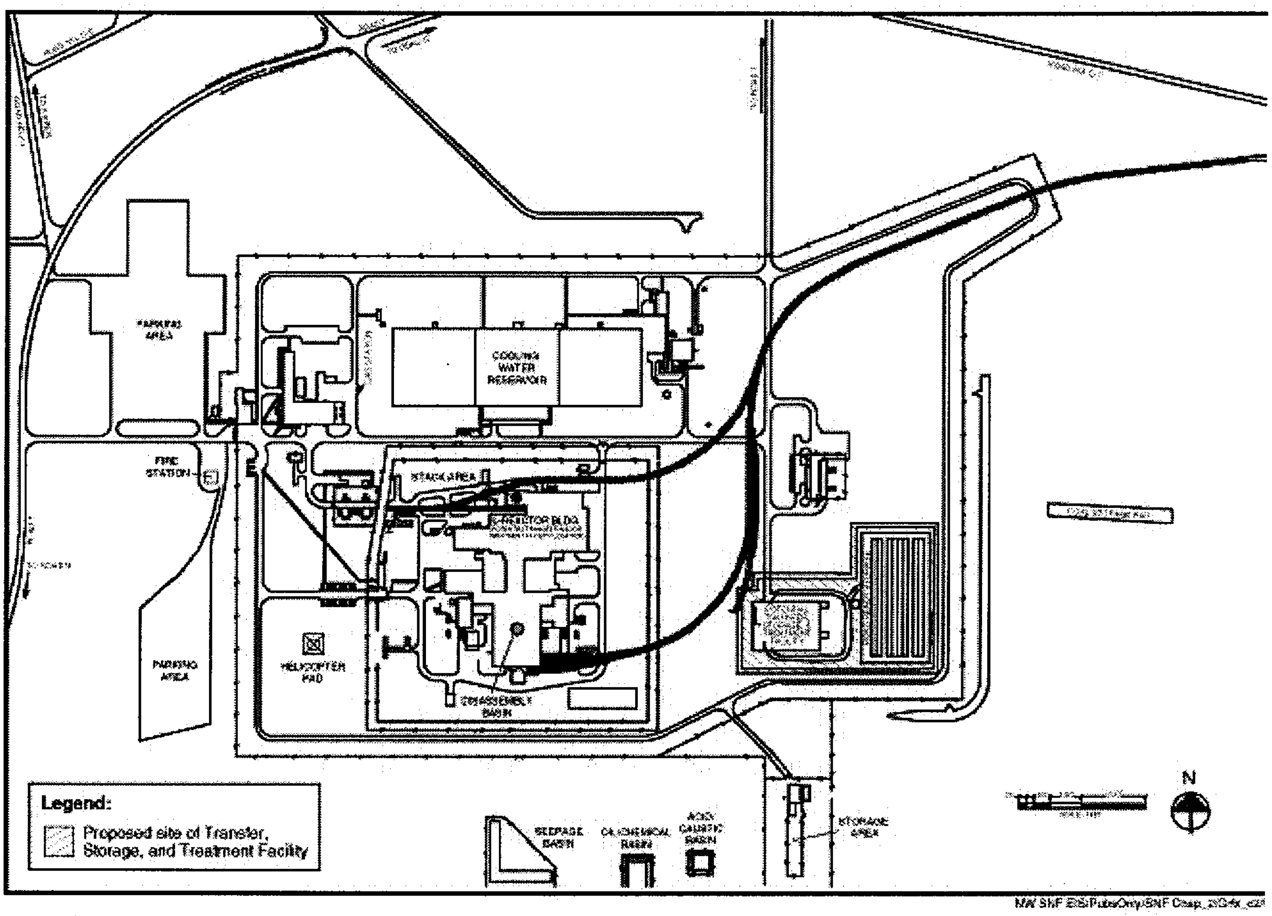


Figure 2-7. Plan view of the L-Reactor facility.

radioactive liquid waste. The facility has a 100-ton (91-metric-ton) bridge crane that travels on rails approximately 31 feet (9 meters) above grade. The crane has two 50-ton (45-metric-ton) hoists and two 3-ton (2.7-metric-ton) hoists. The crane travels over the cask receiving, unloading, and fuel storage areas.

The DOE vulnerability assessment (DOE 1993) and inspections performed by the Defense Nuclear Facilities Safety Board (Burnfield 1995; Conway 1996) identified vulnerabilities related to the Receiving Basin for Offsite Fuel. These vulnerabilities primarily involved the seismic qualification of the building, the lack of adequate leak detection, and the spacing of vertically stored fuel assemblies (a criticality concern). Appendix B describes these vulnerabilities and their corrective actions (which have all been completed).

**Facility Operations**

The receiving bay on the north side of the Receiving Basin for Offsite Fuel receives shipping casks containing irradiated fuel delivered by truck or rail. Radiological surveys of the casks determine external radiation and surface contamination levels. The cask is vented after cleaning and filled with water that is sampled to detect contamination, which would indicate damaged or failed fuel. The cask lid bolts are loosened and the cask transferred to the cask basin using the 100-ton (91-metric-ton) overhead crane. The cask is lowered into the basin until the top of the lid is approximately 3 feet (1 meter) above the water surface and the lid bolts are removed. The cask is lowered to the bottom of the basin and the lid removed. Fuel elements are removed from the cask and placed in transfer buckets, cans, or bundles, depending on the fuel design. The bucket, can, or bundle is placed in a storage rack and the process repeated until all fuel had been unloaded from the cask.

The Receiving Basin for Offsite Fuel has separate basins to segregate and can damaged or failed fuel, disassemble fuel components by mechanical means (e.g., cutting), or perform inspection and measurement. The basin water circulates through a filter and a deionizer for purification and clarification. DOE replaces the filters and deionizers periodically, depending on radioactivity or impurity levels in the water.

### 2.3.1.3 F and H Canyons

**Facility Description**

Two SRS facilities – F and H Canyons – could chemically separate uranium from fission products in SNF. The canyon facilities are nearly identical and use similar radiochemical processes for the separation and recovery of plutonium, neptunium, and uranium isotopes. Historically, F Canyon recovered plutonium-239 and uranium-238 from irradiated natural or depleted uranium, and H Canyon recovered pluto-nium-238, neptunium-237, and uranium-235 from irradiated reactor fuels and targets.

The canyons buildings are reinforced-concrete structures, 835 feet (254 meters) long by 122 feet (37 meters) wide by 66 feet (20 meters) high. They house the large equipment (tanks, process vessels, evaporators, etc.) used in the chemical separations processes.

Each canyon facility contains two canyons, the hot canyon and the warm canyon. The two canyons are parallel and separated by a center section, which has four floors. The center section contains office space, the control room for facility operations, chemical feed systems, and support equipment such as ventilation fans. Processing operations involving high radiation levels (dissolution, fission product separation, and high-level radioactive waste evaporation) occur in the hot canyon, which has thick concrete walls to shield people outside and in the center section from radiation. The final steps of the chemical separations process, which generally involve lower radiation levels, occur in the warm canyon. The F and H Canyons are designed to prevent the release of airborne radioactivity. The ventilation systems maintain a negative air pressure with respect to outside pressure. The ventilation discharges are filtered by high-efficiency particulate air filters and sand filters that remove

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more than 99.9 percent of the particulate radioactivity. Figure 2-8 shows a cutaway view of a canyon building. Figure 2-9 is an aerial photograph of H Canyon and the surrounding area.

DOE and the Defense Nuclear Facilities Safety Board have identified environmental, safety, and health vulnerabilities at the F and H Canyons (DOE 1993; DNFSB 1994). These vulnerabilities relate to the seismic qualification of the buildings and the continued storage of in-process nuclear materials. DOE has verified the seismic qualification of the canyons. In accor-dance with the various Records of Decision for the Interim Management of Nuclear Materials EIS (DOE 1995a), DOE is stabilizing selected materials of concern identified by the Defense Nuclear Facilities Safety Board.

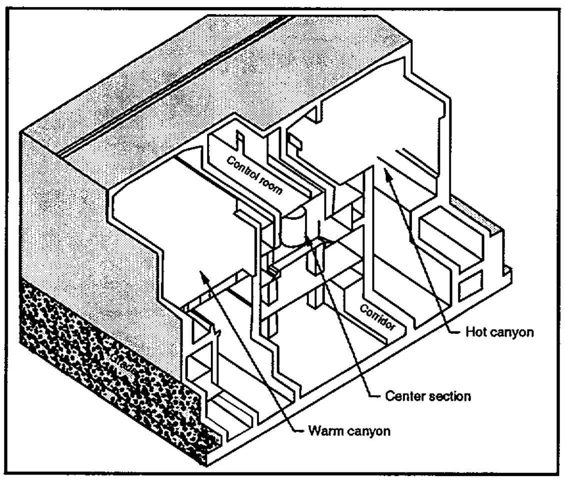


**Figure 2-8.** Canyon building sections.

__Facility Operations__

The SNF would arrive by rail in a shielded shipping cask from either the Receiving Basin for Offsite Fuel or the L-Reactor Disassembly Basin. The fuel would be unloaded and placed in an interim storage pool by a remotely operated crane. At the appropriate time, the fuel would be placed in the dissolver and dissolved by nitric acid. If the processing was performed in F Canyon, the acid solution would be blended down with depleted uranium. However, because H Canyon is designed to handle enriched uranium, the blending to low enriched uranium in H Canyon could occur at virtually any point in the processing operation. In either case, the uranium would be blended to about 5 percent uranium-235.

The resulting acid solution would be chemically processed using clarification and solvent extraction to produce a relatively pure and concentrated stream of uranyl nitrate, which would be stored in tanks awaiting disposition including selling it to commercial reactor fuel users/ manufacturers. Building ventilation discharge would be filtered (including sand filters) to remove at least 99.9 percent of the particulate radioactivity.

### 2.3.2 Proposed Facilities

DOE could construct new facilities or modify existing ones to accomplish the Proposed Action, depending on the alternative selected.

#### 2.3.2.1 __Transfer and Storage Facility__

A Transfer and Storage Facility would provide remote handling and heavy lifting capability, hot cells, and space to receive SNF shipments. This facility would place SNF in interim storage as needed, open the shipping containers, sample and analyze the fuel, crop end fittings if necessary, vacuum-dry the SNF, repackage the fuel in storage canisters, and place the repackaged fuel in interim storage. DOE would use this facility to perform the functions listed in Table 2-5 without the use of water-filled storage pools; however, DOE could choose to provide the capability to receive incoming SNF in a wet basin. This small wet basin, if used, would be for receipt only - not storage. Figure 2-10 shows this facility.

The dry storage segment of the facility would provide lag storage for SNF waiting for preconditioning or treatment, road-ready storage for fuel packaged for shipment to a geologic repository, TC
and temporary storage for empty canisters and loaded and unloaded transportation casks. The size of the storage facility would depend on how DOE decided to implement the Proposed Action. For example, if DOE

**Figure 2-9.** H Canyon and surrounding area (view toward northeast).

**Table 2-5.** Transfer and Storage Facility functions.

| Function | Description |
|---|---|
| Receiving/shipping | Receive casks, unload SNF, load casks, and prepare loaded and unloaded casks for shipment |
| Characterization | Inspect SNF for storage, conditioning, and disposition (e.g., visual inspection, gamma spectrometry, and calorimetry) |
| Conditioning | Crop end fittings or binding pins; activity would not breach cladding or modify the fuel matrix |
| Packaging | Place SNF in appropriate cans and canisters (e.g., vacuum drying, filling with inert gas) and packaging for road-ready storage or direct transport |
| Stability/verification testing | Provide analytical capabilities to perform sampling and analysis to verify conformance to repository waste acceptance criteria |
| Treatment Facility Interface | Provide interfaces necessary to accommodate various treatment technologies |
| Storage | Provide dry road-ready storage using modular design and construction |

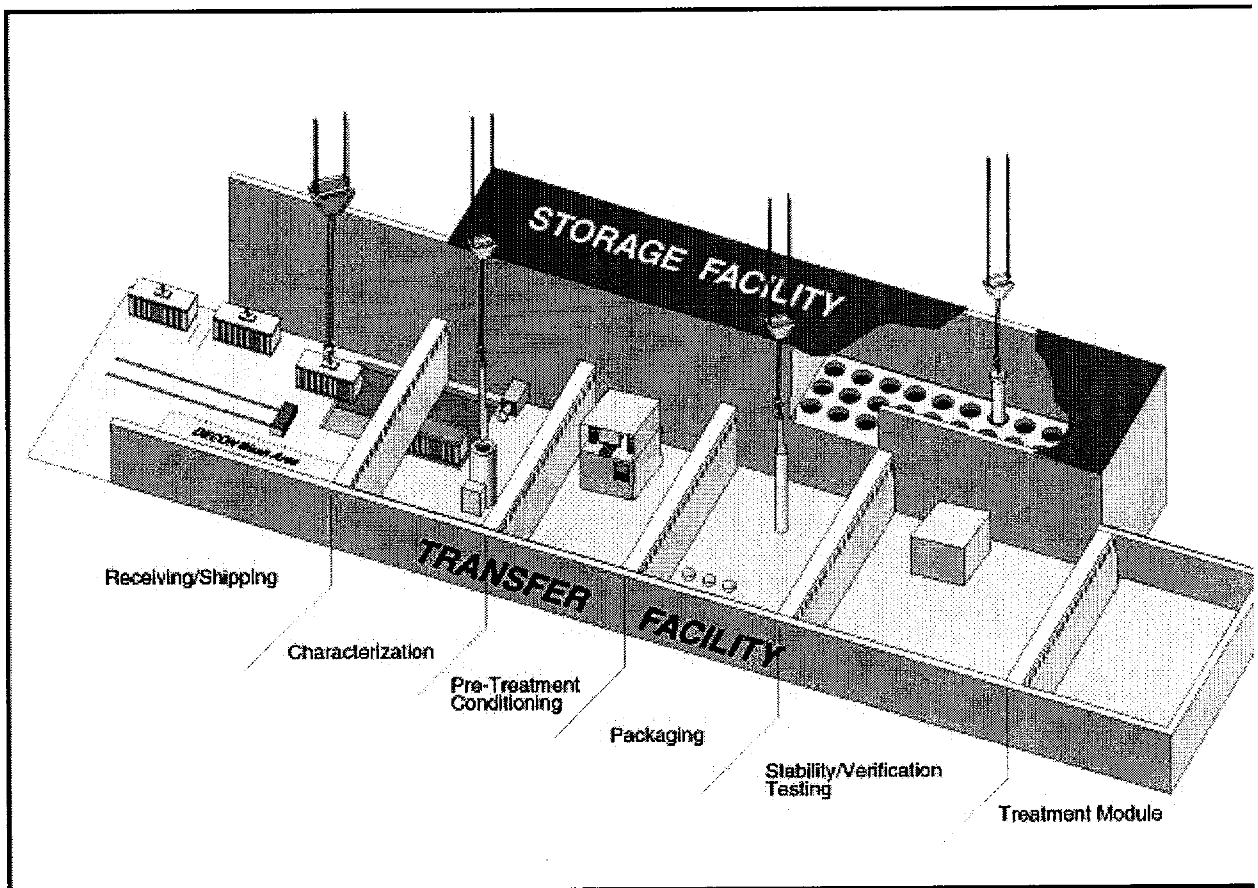


Figure 2-10. Schematic cut-a-way of the Transfer, Storage, and Treatment Facility.

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selected Electrometallurgical Treatment as a new processing technology, the storage component of the facility would only need to provide lag storage for fuel awaiting treatment; no road-ready storage would be necessary because waste produced from the Electrometallurgical Treatment would be sent to DWPF. Table 2-6 lists the number of road-ready canisters DOE would need to store for each technology. In each case, the number of canisters for the treatment technologies is less than that for the Direct Co-Disposal technology. The size of the transfer operations component of the facility would be independent of any new technology selected. In the event Conventional Processing is implemented, the size of the Transfer and Storage Facility would be reduced by about 30 to 60 percent.

The storage segment probably would have one of the three generic designs shown in Figure 2-11. Regarding the environmental impacts of constructing and operating a dry storage facility, the *Foreign Research Reactor Spent Nuclear Fuel EIS* (DOE 1996c) concluded, "There are significant differences between these technologies in terms of construction, operations and maintenance costs and various design details. However, these differences do not result in any important variations in environmental impacts and consequences."

The modular dry storage vault design is a self-contained concrete structure that would provide storage for hundreds of SNF assemblies. The vault would contain a charge and discharge bay with an SNF-handling machine above a floor containing steel tubes to house the removable fuel canisters. The bay would be shielded from the stored fuel by the thick concrete floor and shield plugs inserted at the top of the steel storage tubes. Large labyrinth air supply ducts and discharge chimneys would permit natural convection cooling of the fuel storage tubes to dissipate decay heat. The perimeter concrete walls would provide shielding.

**Table 2-6.** Road-ready storage capacities.

| Technology | Number of co-disposal canisters (17-inch diameter) |
|---|---|
| Prepare for Direct Co-Disposal/Direct Disposal | 1,400[a] |
| Repackage and Prepare to Ship | 0 |
| Melt and Dilute | 400 |
| Mechanical Dilution | 630 |
| Vitrification Technologies | 1,350[b] |
| Electrometallurgical Treatment | 0[c] |
| Conventional Processing | 0[d] |
| Continued Wet Storage | 0 |

a. Direct Disposal in 24-inch diameter canisters would require 1,100 canisters.
b. Vitrification Technologies would produce 24-inch diameter canisters. The value reported is for Dissolve and Vitrify and Glass Material Oxidation and Dissolution System. Plasma Arc Treatment would produce 490 24-inch diameter canisters.
c. Electrometallurgical treatment would produce about 90 high-level waste canisters to be stored in the Glass Waste Storage Building of the Defense Waste Processing Facility.
d. Conventional Processing would result in storage of about 150 high-level waste canisters in the Glass Waste Storage Building of the Defense Waste Processing Facility.

**Figure 2-11.** Typical spent nuclear fuel dry storage facilities.

A dry concrete storage cask, either vertical cask-on-pad or a horizontal concrete module, would perform a similar function, but would not be in a vault. The cask would provide the shielding. A dedicated truck and trailer would transport the fuel containers from the transfer area of the facility to the dry storage area. A ram (for horizontal modules) or a crane (for vertical modules) would insert the fuel package into the storage cask. Appendix F of the *Foreign Research Reactor Spent Nuclear Fuel EIS* (DOE 1996c) contains more information on dry storage facility designs.

DOE used a formal site selection process (Wike et al. 1996) to identify and evaluate potential sites for the construction of the Transfer and Storage Facility. Among the siting criteria were engineering and operational parameters; infrastructure support; human health, environmental, and ecological impacts; regulatory criteria; and land use planning. The process identified five potential sites, two of which received substantially higher scores than the others. These sites are the east side of L Area inside the facility fence, and the southeast side of C Area inside the facility fence. DOE has determined that these two sites are preferred and has completed some geotechnical evaluations on them. Figures 2-7 and 2-12, respectively, show these locations. DOE has considered these two sites in the analyses in this EIS. The transfer functions performed by a Transfer and Storage Facility could also be located in a renovated reactor building. Storage facilities would be as described above.

#### 2.3.2.2 Transfer, Storage, and Treatment Facility

DOE could build a new Transfer, Storage, and Treatment Facility in the locations previously described for the Transfer and Storage Facility. Alternatively, the facility could be located in a new facility in F or H Area (Figures 2-13 and 2-14) to take advantage of existing services and infrastructure in these areas. DOE would construct this facility only if it selected a technology that required it. The facility would be similar to the Transfer and Storage Facility described in Section 2.3.2.1, but with the addition of SNF treatment capability as described in the following paragraphs. The operations performed in the facility would depend on the treatment technology DOE selected, and could include Melt and Dilute, Mechanical Dilution, Vitrification Technologies, or Electrometallurgical Treatment.

The facility design would address criticality issues during normal operations and under conditions of extreme natural phenomena. The facility would contain hot cells, remote handling equipment for the fuel and canisters, processing equipment such as melters (depending on the technology option selected), waste handling and treatment capability, canister decontamination capability, and infrastructure needed for radiological protection operations (e.g., monitoring equipment and protective clothing change rooms). Treatment and handling operations would be performed in facility areas especially designed to prevent the release of airborne radioactivity. For example, the ventilation system would maintain a negative air pressure with respect to outside pressure. The ventilation discharge would be filtered to remove at least 99.9 percent of the particulate radioactivity.

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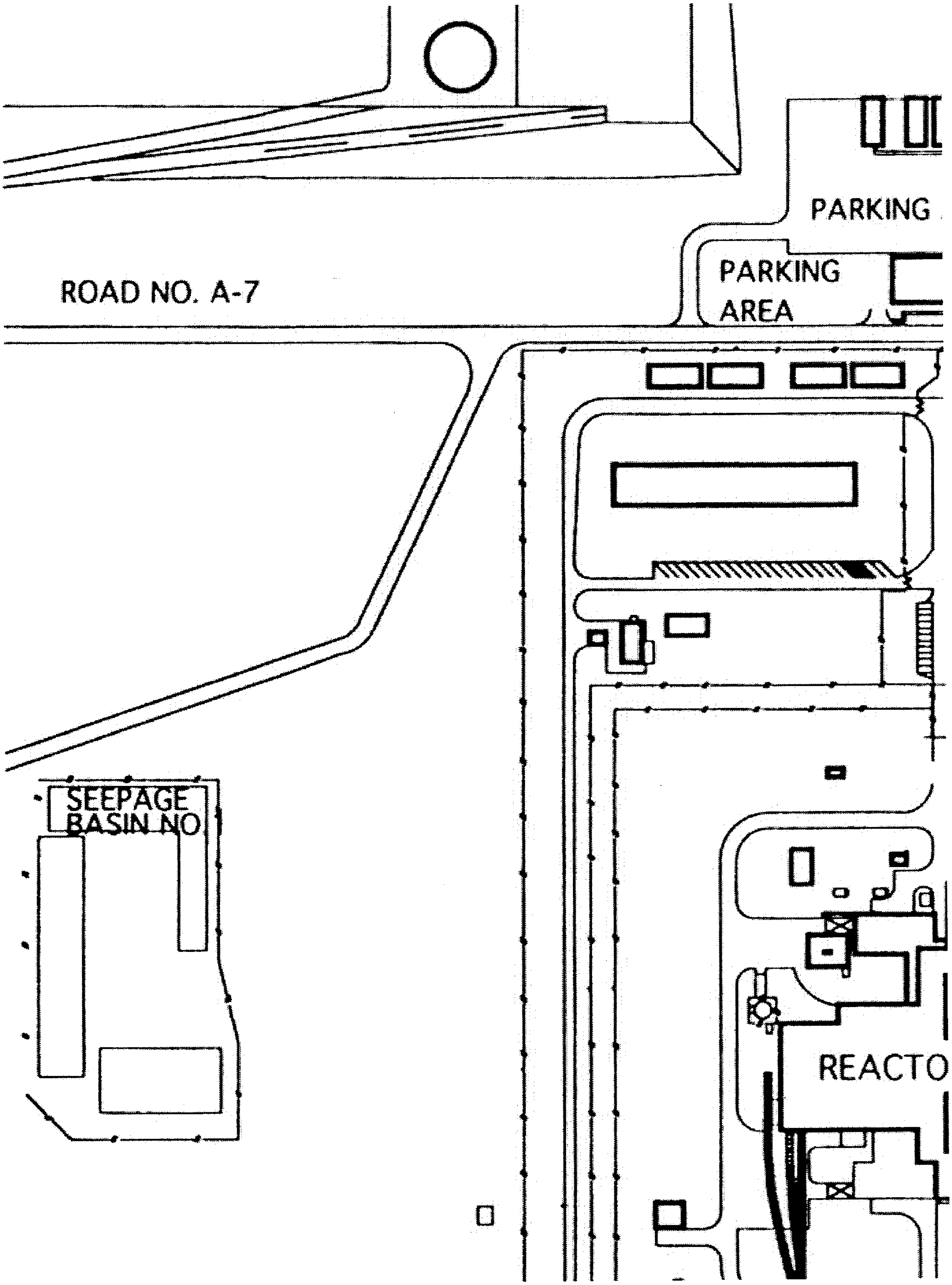
DOE also is considering performing SNF treatments in a renovated reactor facility. In this EIS, DOE has evaluated modifying Building 105-L, and DOE considers this evaluation representative of other reactor area facilities. The processes for transfer and treatment would be located within the L-Reactor building (Figure 2-7), supported by capabilities in the existing structure and adjacent L-Area enclosure. The treatment facilities would be operated in close conjunction with the underwater storage of the SNF in the L-Reactor Disassembly Basin, converting the SNF to the final waste form for dry storage in a Storage Facility as described in Section 2.3.2.1.

**Figure 2-12.** Plan view of C-Reactor facility.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SEEPAGE
BASIN NO
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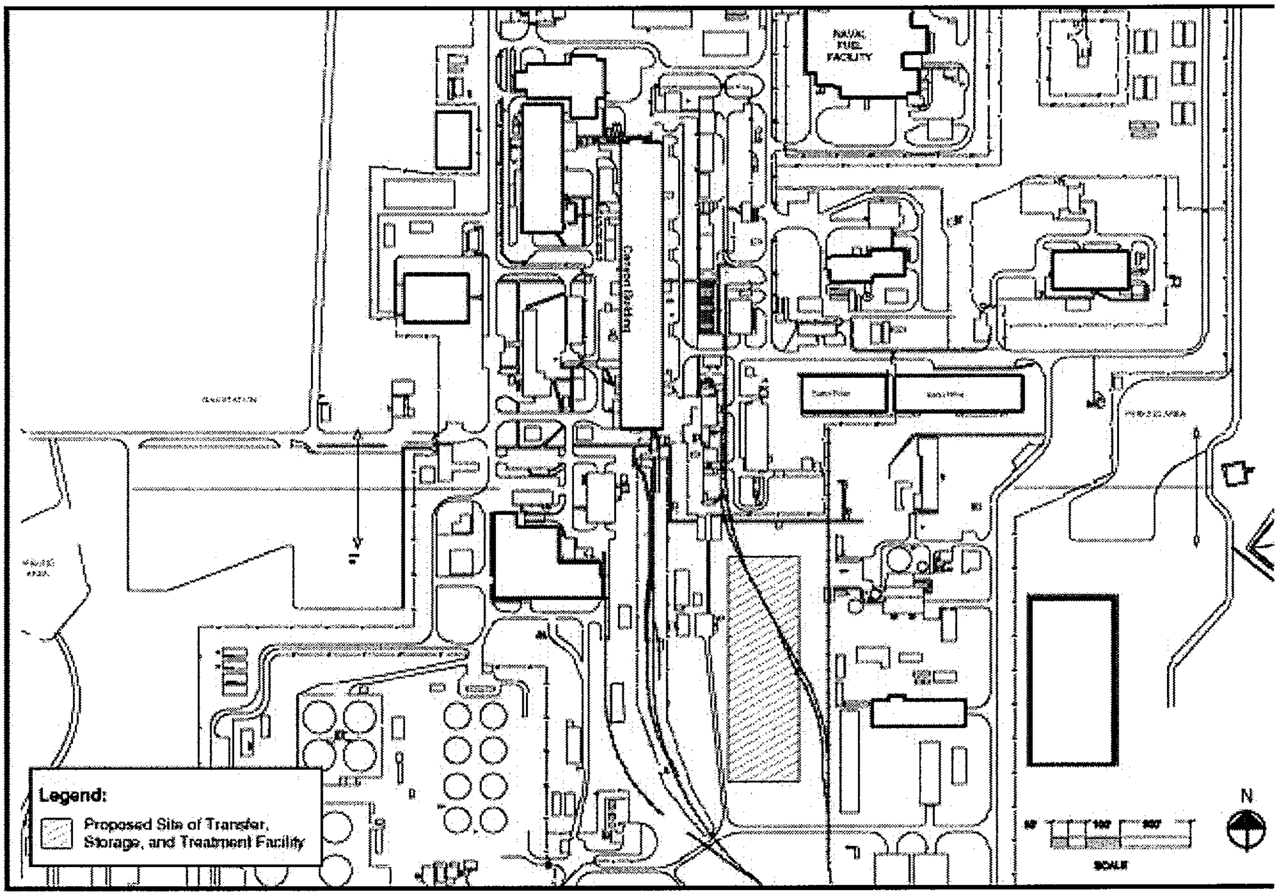


**Figure 2-13.** Potential Transfer, Storage, and Treatment Facility location in F Area.

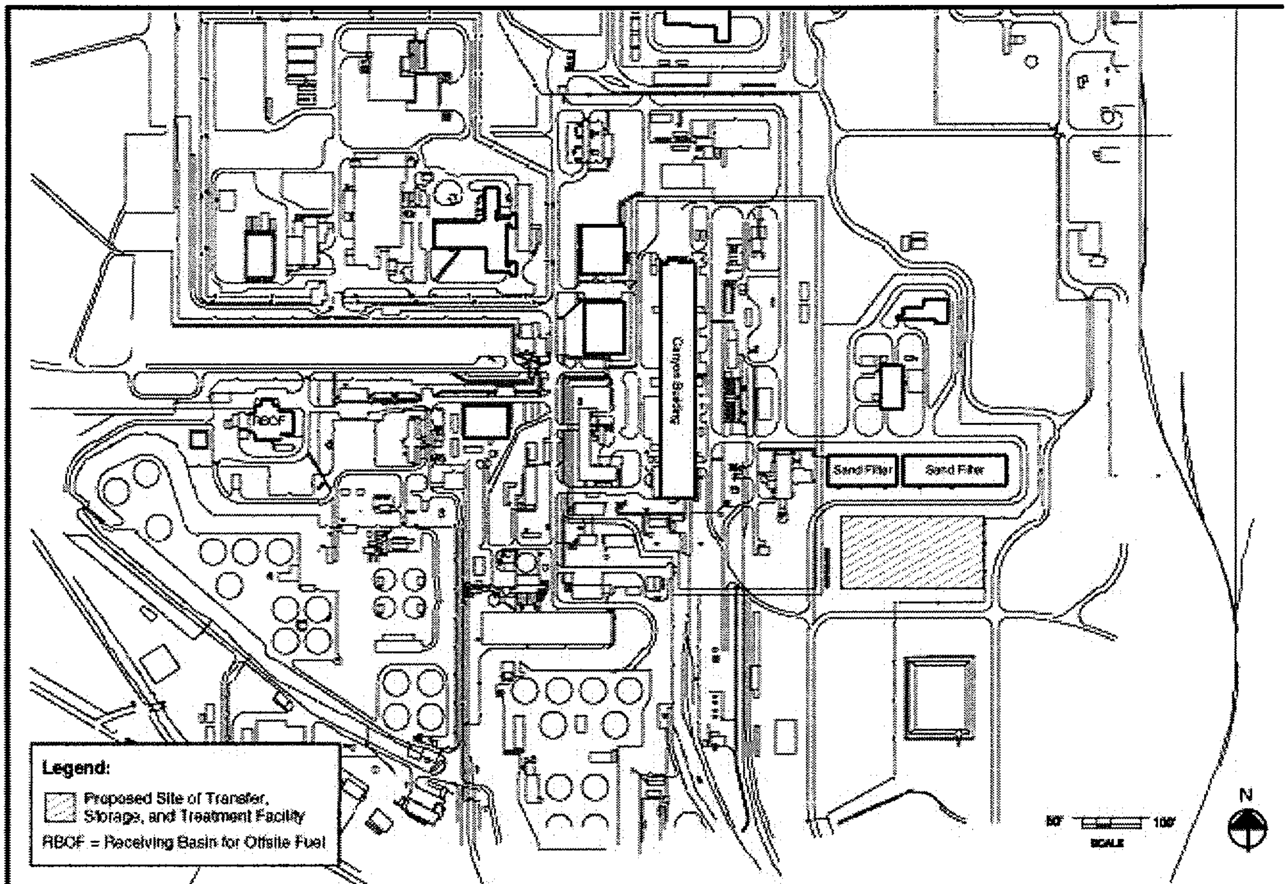


**Figure 2-14.** Potential Transfer, Storage, and Treatment Facility location in H Area.

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**Table 2-7.** Fuel groups and technology options that could be applied to meet the purpose and need. For each fuel group, the technologies that would produce the lowest and highest impacts have been identified.

| Fuel group | 1. Prepare for Direct Co-Disposal | 2. Repackage and Prepare to Ship[a] | 3. Melt and Dilute | 4. Mechanical Dilution | 5. Vitrification Technologies | 6. Electro-metallurgical Treatment | 7. Conventional Processing |
|---|---|---|---|---|---|---|---|
| A. Uranium and Thorium Metal Fuels | Yes[b], LB[c] | No | Yes | No | Yes | Yes | Yes, UB[d] |
| B. Materials Test Reactor-Like Fuels | Yes, LB | No | Yes | Yes | Yes | Yes | Yes, UB |
| C. HEU/LEU[e] Oxides and Silicides Requiring Resizing or Special Packaging | Yes, LB | No | Yes | Yes | Yes | Yes | Yes, UB |
| D. Loose Uranium Oxide in Cans | No | No | Yes, LB | No | Yes | Yes | Yes, UB |
| E. Higher Actinide Targets[f] | NA | Yes, LB/UB | NA | NA | NA | NA | NA |
| F. Non-Aluminum Clad Fuels[f] | NA | Yes, LB/UB | NA | NA | NA | NA | NA |

a. This alternative describes repackaging for storage at SRS pending shipment offsite.
b. "Yes" indicates that the technology can be applied to the fuel group. "No" indicates that the technology cannot be applied to the fuel group.
c. LB = lower bound of impacts.
d. UB = upper bound of impacts.
e. HEU = highly enriched uranium; LEU = low enriched uranium.
TC f. NA = not applicable; not decided in this EIS. Higher actinide targets would be stored until DOE determined their disposition and non-aluminum clad fuel is scheduled to be shipped to Idaho National Engineering and Environmental Laboratory for treatment. Only the impacts of storing these materials are considered in this EIS.

## 2.4 Alternatives Evaluated

As indicated in Sections 2.2.1 through 2.2.3, none of the technologies is likely to be applicable to all the fuel groups. Table 2-7 lists the technology options DOE believes are applicable to the fuel groups discussed in this EIS. DOE probably would implement a combination of options to accomplish SNF management at SRS. Many (more than 700) technology-fuel group configurations can be created using the information in Table 2-7. Tables 2-1 and 2-2 summarize the basis for the applicability of the New Packaging options and the New Processing Technology options. Conventional Processing could be applied to any fuel group except the non-aluminum-clad fuels and the higher actinide targets. Although the No-Action Alternative could be applied to all fuel groups, it would not meet the purpose and need for action.

Taking into consideration the technology options available to the various fuel groups and decisions previously made about managing certain types of SNF, DOE developed five alternatives to analyze in this EIS. DOE has chosen to present impacts from the No Action Alternative, the Preferred Alternative, the Direct Disposal Alternative, and the Maximum- and Minimum-Impact Alternatives described below to illustrate the range of impacts that could occur from any configuration the decisionmakers might select (Table 2-8). These configurations are representative of the range of those DOE could select to accomplish the proposed action and are expected to include the upper and lower bounds of potential impacts. The No Action Alternative represents the impact from current operations.

DOE recognizes that a combination of technology options might not result in the lowest or highest impact for all evaluated technical parameters (e.g., for a particular configuration, worker health and public health impacts could be lowest, but radioactive waste generation could be highest) and that there are other reasonable alternative configurations that would result in similar minimal or substantial impacts. Impacts resulting in human health effects and environmental pollution received greater weight than those resulting in the consumption of natural resources or waste disposal space. In addition, impacts to the general public received greater weight than those to SRS workers. Similarly, impacts that would occur immediately (e.g., operation of new and existing processing facilities) received greater weight than impacts that are not expected but could occur in the distant future.

### 2.4.1 MINIMUM IMPACT ALTERNATIVE

This alternative consists of the fuel groups and technologies that DOE believes would result in the lowest overall impact. The identification of the minimum impact (and environmentally preferred) alternative required both quantitative and qualitative analyses. The first step tabulated the analytical parameters (e.g., volume of high-level waste, air concentrations) and the minimum-impact technology for each parameter for each fuel group. The selected analysis parameters often resulted in a combination of high and low impacts for a particular fuel group. Therefore, the second step required a qualitative examination of trends in combinations that would provide overall minimum impacts.

DOE believes that the range of impacts from other reasonable choices of the minimum-impact alternative would be small. Therefore, DOE expects that the impacts of this alternative would be representative of the lower bound of impacts from the Proposed Action.

The minimum impact alternative would include New Packaging and New Processing Technologies options. Material Test Reactor-like fuels and highly enriched uranium/low enriched uranium (HEU/LEU) oxides and silicides would be treated using the Direct Disposal/Direct Co-Disposal option and placed in the Transfer and Storage Facility with a minimum of treatment (e.g., cold-vacuum drying and canning). The uranium and thorium metal fuels would be treated using the Direct Disposal/Direct Co-Disposal option but more rigorous treatment (i.e., hot-vacuum drying) would be required.

**Table 2-8.** Alternatives analyzed in this EIS.

| Fuel Group | No-Action Alternative | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|---|
| A. Uranium and Thorium Metal Fuels | Continued Wet Storage | Prepare for Direct Co-Disposal | Conventional Processing | Conventional Processing | Conventional Processing |
| B. Materials Test Reactor-like Fuels | Continued Wet Storage | Prepare for Direct Co-Disposal | Prepare for Direct Co-Disposal | Melt and Dilute | Conventional Processing |
| C. HEU/LEU Oxide and Silicides Requiring Resizing or Special Packaging | Continued Wet Storage | Prepare for Direct Co-Disposal | Prepare for Direct[a] Co-Disposal | Melt and Dilute[a] | Conventional Processing |
| D. Loose Uranium Oxide in Cans | Continued Wet Storage | Melt and Dilute | Melt and Dilute[b] | Melt and Dilute[b] | Conventional Processing |
| E. Higher Actinide Targets | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site[c] | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site[c] |
| F. Non-Aluminum-Clad Fuels | Continued Wet Storage | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site | Repackage and Prepare to Ship to Another DOE Site |

TC

a. Conventional processing would be the preferred technology for the failed or sectioned Oak Ridge Reactor fuel, High Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor fuel, and a Mark-14 target.
b. Conventional processing is the preferred technology for the Sterling Forest Oxide fuel.
c. Conventional processing is the applicable technology for the Mark-18 target assemblies (approximately 1 kilogram heavy metal), under these two alternatives.

TC

(DOE notes there is a high degree of technical uncertainty regarding the acceptability of this material in a repository; however, Direct Co-Disposal was postulated to represent minimum impacts.)

TC DOE would continue to wet store the Mark-51 and other Higher Actinide Targets at the SRS. Additionally, DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the non-aluminum clad fuel have not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage. TC To maintain operational flexibility, DOE could transfer the Mark-51 and other targets to dry storage. DOE would maintain the Mark-18 targets in wet storage pending disposition decisions due to potential health and safety concerns associated with the actions that would be required to repackage the Mark-18 target assemblies.

TC While in wet storage, if fuel began to deteriorate, resulting in imminent environmental, safety, and health vulnerabilities, DOE would use the canyons, if they were operating, to stabilize the vulnerable materials.

TC The loose uranium oxide in cans would not be contained in a tightly bound matrix and, therefore, may not be acceptable for placement in a geologic repository. Therefore, the Melt and Dilute technology would be used to treat these fuels.

### 2.4.2 MAXIMUM IMPACT ALTERNATIVE

This alternative provides the upper bound on the range of impacts from potential configurations. It would provide conventional processing for all SNF except the higher actinide targets and the non-aluminum-clad fuels selected for offsite shipment.

DOE expects that the Experimental Breeder Reactor-II and Mark-42 targets from the uranium and thorium metal fuels group would be processed in F Canyon. All other processing operations would be conducted in H Canyon. Processing operations in H Canyon would continue until the aluminum-based SNF inventory was eliminated and the SNF receipt rate was low (i.e., about 150 Materials Test Reactor-like elements per year and 12 High Flux Isotope Reactor assemblies per year; approximately 2009). In parallel with processing operations, DOE could construct a Transfer, Storage, and Treatment Facility with treatment capability to receive and treat new SNF after processing operations cease. Once the Transfer, Storage, and Treatment Facility was completed, processing in the canyons would be phased out.

Analyses of the maximum impact alternative are conservative in that they assume that the entire SNF inventory would be processed in the canyons, which would produce the greatest impacts of all the treatment options. No credit is taken for discontinuing use of the canyons and processing some of the inventory in a new treatment facility.

Although this EIS proposes only to continue to store Mark-18 targets, DOE has included the impacts of processing the Mark-18 targets in the Maximum Impact Alternative. The analysis of impacts is taken from the Final Environmental Impact Statement for Interim Management of Nuclear Materials. The 12-foot long Mark-18 targets would require size reduction for transport or storage in a dry storage facility. The standard method to reduce the size of the Mark-18 targets would be to cut them up under water in an SRS storage basin. The condition of the Mark-18 targets presents a health and safety vulnerability for under water cutting because of the suspected brittle condition of the targets and the uncertainty concerning which portion of the target assemblies contains the americium and curium product and fission products. Because of these concerns a previous DOE assessment (see Section 1.6.2) concluded that the Department should consider processing the Mark-18 targets. Although that TC

alternative was not chosen, and the Mark-18 targets are still stored in the Receiving Basin for Offsite Fuel, the analysis was performed and is incorporated as part of the Maximum Impact Alternative in this EIS. Processing the Mark-18 targets would not extend the operating time for the SRS canyons.

Until the Mark-51 and other Higher Actinide Targets are transferred to another site for use, DOE would continue to wet-store the material at the SRS. Additionally, DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the Mark-51 and "other" targets and non-aluminum clad fuel have not been transferred offsite by the time a dry storage facility is in operation at the SRS, DOE could repackage the targets and the fuel and transfer the material to dry storage. DOE would transfer the targets and non-aluminum clad fuel to dry storage after the material had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities to phase out operations in the Receiving Basin for Offsite Fuel by 2007.

### 2.4.3 PREFERRED ALTERNATIVE

Under the preferred alternative, DOE would implement several of the technologies identified in Section 2.2 to manage spent nuclear fuel at SRS. These technologies are Melt and Dilute, Conventional Processing, and Repackage and Prepare to Ship. Each of these technologies would treat specific groups of spent nuclear fuel, as described below. The technology and fuel group combinations form DOE's Preferred Alternative in this EIS. The configuration of this preferred alternative is identified in Table 2-9. Figure 2-15 provides a flowchart for the Preferred Alternative.

#### 2.4.3.1 Melt And Dilute

DOE has identified the Melt and Dilute process as the preferred method of treating most (about 97 percent by volume or about 32,000 MTRE) of the aluminum-based SNF considered in this EIS. DOE will continue to pursue a research and development program leading to a demonstration of the technology in FY 2001 using full-size irradiated research reactor spent nuclear fuel assemblies. With a successful demonstration of the technology, DOE expects to have ready a treatment facility to perform production melt and dilute operations in FY 2008. DOE will ensure the continued availability of SRS conventional processing facilities until we have successfully demonstrated implementation of the Melt and Dilute treatment technology.

The fuel proposed for the preferred Melt and Dilute technology includes the Material Test Reactor-like fuel, most of the Loose Uranium Oxide in Cans fuel, and most of the HEU/LEU Oxide and Silicide fuel. Exceptions are the failed and sectioned Oxide and Silicide fuel, about 10 percent of the Loose Uranium Oxide in Cans fuel as described in Section 2.4.3.2, and the Higher Actinide Targets and Non-Aluminum-Clad fuel that would be repackaged and prepared to ship as discussed in Section 2.4.3.3. The Melt and Dilute Technology satisfies DOE's objective and preference, as stated in the Record of Decision for the Nonproliferation Policy and Spent Nuclear Fuel EIS (60 FR 25091), to select a non-chemical separations-based technology to prepare aluminum-based SNF for placement in a geologic repository. Additionally, this new technology provides significant waste reduction (of high-level, low-level, transuranic, etc.) in comparison to conventional chemical processing and is fully compatible with and supportive of the nonproliferation objectives of the United States.

The potential impacts (e.g., worker and public health, waste generation, socioeconomics, etc.) among the new non-separations based technologies were all very similar; however, the Melt and Dilute option was the most efficient in volume reduction and produced the fewest number of SNF canisters. In fact, Melt and Dilute would increase volume reduction by more than 3 to 1 over Direct Disposal/Direct Co-Disposal. The volume reduction is achieved because the melt and dilute process eliminates voids in the fuel elements and in the canisters and fuel

**Table 2-9.** The fuel group technology configurations that compose the preferred alternative.

| Fuel group | 1. Prepare for Direct Co-Disposal | 2. Repackage and Prepare to Ship[a] | 3. Melt and Dilute | 4. Mechanical Dilution | 5. Vitrification Technologies | 6. Electro-metallurgical Treatment | 7. Conventional Processing |
|---|---|---|---|---|---|---|---|
| A. Uranium and Thorium Metal Fuels | – | – | – | – | – | – | Preferred |
| B. Materials Test Reactor-Like Fuels | – | – | Preferred | – | – | – | – |
| EC C. HEU/LEU[b] Oxides and Silicides Requiring Resizing or Special Packaging | – | – | Preferred | – | – | – | Preferred[c] |
| TC D. Loose Uranium Oxide in Cans | – | – | Preferred | – | – | – | Preferred[d] |
| E. Higher Actinide Targets[e] | – | | – | – | – | – | – |
| F. Non-Aluminum Clad Fuels | – | Preferred | – | – | – | – | – |

a. This alternative describes shipment to a DOE site other than SRS, not to a geologic repository.
EC b. HEU = highly enriched uranium; LEU = low enriched uranium.
c. For failed or sectioned Oak Ridge Reactor fuel, High-Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor Fuel, and a Mark-14 target (i.e., <1 percent of material in this fuel group).
TC d. For Sterling Forest Oxide fuel (i.e., about 10 percent of the material in this fuel group).
e. The preferred alternative is to maintain fuel Group E in continued wet storage until a decision is made on final disposition.

Figure 2-15. Preferred Alternative Management Flow-Path.

baskets used in the Direct Disposal/Direct Co-Disposal technology. DOE considered Melt and Dilute to be among the most "proven" of the new non-separations-based technologies because DOE has made extensive progress in the development of the melt and dilute process.

The Melt and Dilute technology offers DOE the flexibility to engineer the final waste form to provide a high degree of confidence the material would be acceptable for placement in a geologic repository. Major technical concerns such as fuel characterization, criticality control, and repository performance can be reduced or eliminated by tailoring the chemical and physical form of the final product to meet specific criteria. DOE expects the Melt and Dilute option would be relatively simple to implement and would be less expensive than other similar technology options, although the ongoing technology development initiative will determine the viability of this alternative. The major technical issue for implementing this technology would be the design of an off-gas system to capture volatilized fission products. Preliminary engineering studies indicate that the system could be designed using proven approaches for managing off-gases. TC

To implement the preferred alternative (Melt and Dilute technology), DOE would construct a melt and dilute facility in the existing 105-L building at SRS and build a dry-storage facility in L Area, near the 105-L building. DOE is proposing to use an existing facility to house the Melt and Dilute process because the existing structure can accommodate the process equipment and systems; the applicable portions of the structure will meet DOE requirements for resistance to natural hazards (e.g., earthquakes); the integral disassembly basin has sufficient capacity for all expected SNF receipts and the current Site inventory; using 105-L avoids the creation of a new radiologically controlled facility that would eventually require decontamination and decommissioning; and DOE has estimated the cost savings versus a new facility to be about $70 million. EC

Using the Melt and Dilute technology, DOE would melt aluminum-based SNF and blend down any highly enriched uranium to low enriched uranium using depleted uranium that is currently stored at SRS. The material would be cast as ingots that would be loaded into stainless-steel canisters approximately 10 feet tall and 2 feet (or less) in diameter. The canisters would be placed in dry storage pending shipment to a geologic repository. TC

During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and Dilute option is no longer viable. As a back-up to Melt and Dilute, DOE would continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would implement this option if Melt and Dilute were no longer feasible or preferred. Direct Co-Disposal has the potential to be the least complicated of the new technologies and DOE believes this option could be implemented in the same timeframe as could the Melt and Dilute option. However, DOE believed there is greater risk in attempting to demonstrate that aluminum-based SNF, packaged according to the Direct Co-Disposal option, would be acceptable in a geologic repository. A comparison of the preferred (Melt and Dilute) and back-up (Direct Co-Disposal) technologies DOE proposes to use to manage most of the aluminum-based SNF at SRS is presented in Table 2-3. TC EC

If DOE identifies any imminent health and safety concerns involving any aluminum-based SNF, DOE could use F and H Canyons to stabilize the material of concern prior to the melt and dilute facility becoming operational. TC

#### 2.4.3.2 Conventional Processing

DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this processing is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block). TC

The total amount proposed for conventional processing is a relatively small volume of aluminum-based SNF at the SRS (about 3 % by volume and 40 % by mass). This material includes the Experimental Breeder Reactor-II fuel, the Sodium Reactor Experiment fuel, the Mark-42 targets and the core filter block from the Uranium and Thorium Metal fuel group; the failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuels and a Mark-14 target from the HEU/LEU Oxides and Silicides fuel group; and the Sterling Forest Oxide (and any other powdered/oxide fuel that may be received at SRS while H Canyon is still in operation) from the Loose Uranium Oxide in Cans fuel group. Although it is possible that a new treatment technology, such as melt and dilute, could be applied to most of these materials, DOE considers timely alleviation of the potential
TC health and safety vulnerabilities to be the most prudent course of action because it would stabilize materials whose forms or types pose a heightened vulnerability to releasing fission products in the basin. Nonetheless, if these materials have not been stabilized before a new treatment technology becomes available, that new technology (melt and dilute) may be used rather than conventional processing.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and stored in canisters in the Receiving Basin for Offsite Fuel. The declad fuels present a potential health and safety vulnerability. Should their existing storage containers leak, the metal fuel would corrode and release fission products to the water of the storage basin. Once the metal of the fuel is wetted, simply repackaging the fuel in a water-tight container would not arrest the corrosion and, in fact, could exacerbate storage concerns since potentially explosive hydrogen gas would continue to be generated inside the storage canister as the fuel continued to corrode. An instance of water intrusion and subsequent fuel corrosion has already occurred with one Experimental Breeder Reactor-II canister stored in the Receiving Basin for Offsite Fuel. Additionally, several problems have occurred with other uranium metal fuel in similar storage conditions at SRS (e.g., the Taiwan Research Reactor fuel with failed or missing cladding that was overpacked in canisters and stored in SRS wet basins). DOE addressed these situations by processing the failed or declad fuel in F Canyon to eliminate the health and safety vulnerability.

The failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuel, and a sectioned Mark-14 target from the HEU/LEU Oxides and Silicides fuel group also present potential health and safety vulnerabilities. The integrity of these fuels was destroyed for research purposes. Then the material was canned and placed in wet storage at SRS. A breach of or leak in the cans would expose the interior surfaces of the sectioned fuel to water, contaminating the water in the storage basin with TC
radioactivity, and accelerating the corrosion of the fuel.

A potential health and safety vulnerability also exists for the unirradiated Mark-42 targets from the Uranium and Thorium Metal fuel group and the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group. Should a breach occur in the cladding on the Mark-42 targets or in the canisters of Sterling Forest Oxide fuel, the particulate nature of the nuclear material in the targets and the Sterling Forest Oxide fuel could lead to dispersion of radioactive material in the water of the Receiving Basin for Offsite Fuel. Therefore, DOE is proposing to take action now to avoid the possibility of urgent future actions, including expensive recovery actions that also would entail unnecessary radiation exposure to workers.

DOE proposes to process the Experimental Breeder Reactor-II fuel and the Mark-42 targets in F Canyon. That fuel contains plutonium, approximately 114 kg of which would be recovered as part of the normal F Canyon chemical separations process and then transferred to FB-Line for conversion to metal. The plutonium metal would be considered surplus to the nation's nuclear

weapons program and would be placed in storage at the SRS pending disposition pursuant to the January 2000 Record of Decision (ROD) for the Surplus Plutonium Disposition Environmental Impact Statement (DOE 1999). The surplus plutonium would be immobilized using the can-in-canister process or fabricated into mixed-oxide (MOX) commercial power reactor fuel at the SRS. DOE has scheduled processing of the Experimental Breeder Reactor-II fuel and the Mark-42 targets in FY00.

DOE proposes to process the Sodium Reactor Experiment fuel, the failed or sectioned fuel from the HEU/LEU Oxides and Silicides fuel group, and the Sterling Forest Oxide fuel in H-Canyon where the highly enriched uranium would be blended down to low enriched uranium and stored pending potential sale as feed-stock for commercial nuclear fuel. DOE would begin processing operations in H Canyon in 2000 and could complete them in about 18 months.

TC

DOE also proposes to process the core filter block from the Uranium and Thorium Metals fuel group. The core filter block is made of depleted uranium but it contains corrosion-resistant metal (e.g., stainless-steel) that would be incompatible with the Melt and Dilute Technology for aluminum-based SNF. The core filter block could be processed in either F Canyon or H Canyon. In either case, the material would become feedstock to blend down highly enriched uranium from either conventional processing or melt and dilute operations.

The processing operations described above in both F and H Canyons would occur when the canyons were being operated to stabilize other nuclear material. It is the preference of the Department of Energy not to utilize conventional reprocessing for reasons other than safety and health. However, the core filter block is not compatible with the melt and dilute process for aluminum-based SNF. The benefit to develop a new process to accommodate this form would be disproportionately small when compared to the cost (DOE 1998a). Consequently, the Department proposes an exception in this case.

#### 2.4.3.3 <u>Repackaging</u>

DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event that the non-aluminum-clad fuel has not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage. TC

#### 2.4.3.4 <u>Continued Wet Storage</u>

DOE is not proposing any actions that would lead to the programmatic use of the higher actinide targets. Therefore, under the preferred alternative the Mark-18, Mark-51 and other higher actinide targets would be maintained in wet-storage until decisions are made on their final disposition.

### 2.4.4 DIRECT DISPOSAL ALTERNATIVE

This alternative combines the New Packaging and the New Processing Technologies with the Conventional Processing Technology. Materials Test Reactor-like fuels and HEU/LEU Oxides and Silicides (except the failed and sectioned fuels) would be treated using the Direct Disposal/Direct Co-Disposal technology and placed in the Transfer and Storage Facility with a minimum of treatment (e.g., cold-vacuum drying and canning).

DOE would manage the Higher Actinide Targets and the non-aluminum based SNF as described in the Maximum Impact Alternative. TC

The uranium fuel and thorium metal fuel, Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group, and failed and sectioned fuel from the HEU/LEU Oxides and Silicides fuel group would be treated using chemical separations processes under the Conventional Processing Alternative to alleviate the potential

health and safety vulnerabilities discussed in Section 2.4.3.2 and because this material probably would not be suitable for placement in a geologic repository if treated with the Direct Disposal/Co-Disposal option. Most of the material in the Loose Uranium Oxide in Cans fuel group would be treated using Melt and Dilute since that material could be received after a melt and dilute facility was available.

### 2.4.5 NO-ACTION ALTERNATIVE: CONTINUED WET STORAGE

Under the No-Action Alternative, DOE would consolidate existing inventories of SNF at SRS in the L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel, and would store incoming SNF shipments in those basins. Maintenance, monitoring, and normal basin operations (as described in Section 2.3.1) would continue. DOE would be able to meet its commitments to receive SNF from domestic, foreign, and university research reactors and from the Idaho National Engineering and Environmental Laboratory. However, DOE would not meet the commitment made in the Record of Decision (61 FR 25092) for the Final EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (DOE 1996c) to manage its SNF in a road-ready condition for ultimate shipment to the geologic repository. DOE could ship non-aluminum-clad fuels to the Idaho National Engineering and Environmental Laboratory in accordance with the Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE resulting in increased environmental, safety, and health vulnerabilities. DOE would use the F or 1995b). Over the potentially 40 years of continued wet storage, some fuel could deteriorate, H Canyon facilities if they were operating for other reasons to stabilize any SNF that presented an environmental, safety, or health vulnerability. Figure 2-16 shows the No-Action Alternative.

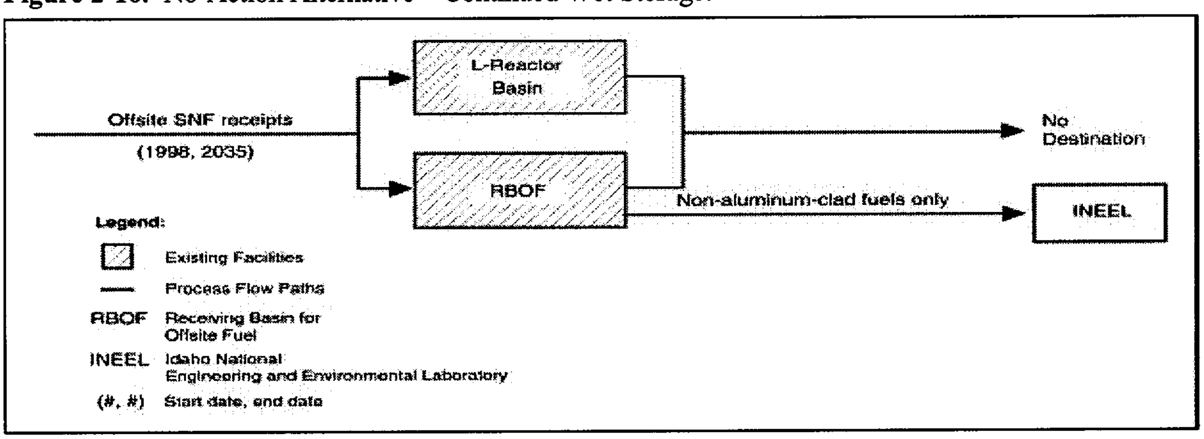
EC

DOE analyzed the impacts of transporting aluminum-based spent nuclear fuel to the Savannah River Site in the Nonproliferation Policy and Spent Nuclear Fuel EIS (DOE 1996c) and the programmatic SNF EIS (DOE 1995b). These documents concluded that the potential human health impacts from transportation of this fuel to SRS were low.

EC

**Figure 2-16.** No-Action Alternative – Continued Wet Storage.

TC



The No-Action Alternative would be applicable to all fuel groups; however, non-aluminum-clad fuels would remain in wet storage at SRS only until DOE shipped them to the Idaho National Engineering and Environmental Laboratory in accordance with the Programmatic SNF EIS Record of Decision.

### 2.4.6 ALTERNATIVES NOT ANALYZED IN DETAIL

DOE considered dry storing aluminum-based SNF (with no treatment or packaging) as a possible alternative for evaluation in this EIS. The first step for dry storing aluminum-based SNF would be accomplished by constructing a dry transfer facility. Fuel would be removed from wet storage in transfer casks, transported to the dry transfer facility, and removed from the transfer cask. Then the fuel would be placed in dry storage without any characterization, repackaging, or treatment that would be done under the New Packaging Technology alternative or New Processing Technology alternative. DOE decided not to evaluate this alternative because it would not meet the purpose and need for agency action (i.e., it would not prepare SNF for placement in a geologic repository). In order to prepare fuel for disposition, DOE would still have to implement the New Packaging Technology, New Processing Technology, or Conventional Processing alternatives, and dry storage is already analyzed as a component of these alternatives as applicable.

DOE considered a variation to the Chemical Processing Technology option where the dissolved Experimental Breeder Reactor-II fuel would be transferred to the high-level waste tanks at the SRS for subsequent vitrification in the Defense Waste Processing Facility. DOE evaluated this action under the *Interim Management of Nuclear Materials Final Environmental Impact Statement* (DOE 1995c) for material that is very similar to the Experimental Breeder Reactor-II fuel (i.e., Mark-31 targets and Taiwan Research Reactor SNF). In that EIS, DOE concluded that the process of transferring more than trace quantities of fissile material to the high-level waste tanks with subsequent vitrification was technically very complex and that it would take at least 6 years to develop the process. DOE noted that the Department would have to develop a process that would render fissile materials incapable of producing a nuclear criticality, regardless of the location or amount accumulated in various equipment or tanks. DOE postulated that this could be accomplished by the addition of a chemical or other material to serve as a nuclear "poison," which would minimize the potential for a criticality. However, the nuclear poison would have to be designed to accompany the fissile material throughout the process or different poisons would have to be used at different process steps (evaporation, concentration, precipitation, and ultimately vitrification). For these reasons, DOE does not consider this technology/fuel option reasonable for analysis in this EIS. Instead, DOE has analyzed the Dissolve and Vitrify option in the EIS, which would accomplish the same purpose as transferring the dissolved Experimental Breeder Reactor-II fuels to the high-level waste tanks for vitrification in the Defense Waste Processing Facility.

## 2.5 Comparison of Environmental Impacts Among Alternatives

Chapter 4 presents the predicted operational impacts, potential accident impacts, and construction impacts for each technology option and alternative. This organization enables the evaluation of recurring impacts (i.e., impacts from normal operations) independent of the infrequent impacts of accidents and the one-time impacts of construction.

As discussed in Section 1.3, DOE believes the amount of foreign research reactor SNF to be received in the U.S. could decrease from about 18 metric tons heavy metal (MTHM) to about 14 MTHM (or less). Therefore, the actual amount of aluminum-based material could be less than the 48 MTHM evaluated in this EIS. The only effect would be a small reduction of environmental impacts described in this EIS. DOE does not believe a reduction of this magnitude would materially affect the impacts associated

with normal operations involving Material Test Reactor-like fuels (Fuel Group B) and the reduction would occur across all alternatives. However, where it is applicable, DOE has included EC information in the impact tables for normal operations that provide an example of how the reduced Fuel Group B impact data could be calculated.

The potential reduction in foreign research reactor SNF receipts would have no effect on the accident impact data that are presented in the EIS because none of the postulated accidents could affect all the fuel at once. Processing related accidents would affect only the "batch" of fuel that was involved in the process operation and accidents that could affect stored fuel, such as an earthquake, would be unlikely to involve all the fuel in the storage facility.

Impacts from normal operations under all of the alternatives would have little if any effect on ecological resources, water resources, or cultural resources. The impacts from incident-free onsite transportation of SNF would be minimal under all alternatives.

Processing the Mark-18 targets (about 1 kilogram of heavy metal) was previously analyzed in the *Final Environmental Impact Statement on Interim Management of Nuclear* TC *Materials* and, therefore, was not analyzed in this EIS. The impacts of processing this small amount of material are minor and would not significantly affect the impacts analyzed for the Maximum Impact Alternative in this EIS. For example, total radiological dose from the Preferred Alternative to the maximally exposed individual for the entire period of analysis would be 0.67 millirem. Processing the Mark-18 targets would result in a dose of 0.0035 millirem.

Table 2-10 lists impacts for the five selected alternatives. The EIS identifies the following operational impacts with the potential to discriminate among the alternatives:

- *Worker and public health impacts* – Estimated impacts are reported as latent cancer fatalities for the involved worker population, noninvolved worker, the maximally exposed member of the public, and offsite population. These impacts are summed over the period of analysis based on annual emissions and radiation doses.

Involved worker doses assume that no worker would receive more than the SRS administrative annual limit of 700 millirem. Based on this, the estimated latent cancer fatalities for the involved worker population for the entire period of analysis would range from 0.28 for the Minimum Impact Alternative to 0.84 for the Maximum Impact Alternative.

The values in Table 2-10 for health effects to the noninvolved worker, maximally exposed individual, and the offsite population for the No-Action Alternative represent current reactor-area emissions (including two SNF wet basins) for the entire period of analysis. The values for the other alternatives would be incremental above these baseline values. Summing these baseline and incremental values would be conservative, however, because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

The noninvolved worker highest estimated probability of a latent cancer fatality over the entire period of analysis would range from $2.0\times10^{-9}$ for the Minimum Impact Alternative to $6.3\times10^{-7}$ for the Maximum Impact Alternative.

The estimated latent cancer fatality probability to the maximally exposed individual over the entire period of analysis would range from $3.0\times10^{-10}$ (Minimum Impact Alternative) to $3.4\times10^{-7}$ (Maximum Impact Alternative). The estimated latent cancer fatalities in the offsite population affected by SRS over the entire period of analysis would be much less than 1 for any alternative. These estimated offsite latent cancer

**Table 2-10.** Impact summary by alternative.

| Parameter | No Action Alternative (baseline) | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|---|
| **Health Effects for the Entire Period of Analysis (1998-2035)** | | | | | |
| Latent cancer fatality probability for the noninvolved worker | $1.7\times10^{-6}$[a] | $2.0\times10^{-9}$ | $9.6\times10^{-9}$ | $6.1\times10^{-7}$ | $6.3\times10^{-7}$ |
| Latent cancer fatality probability for the maximally exposed member of the public | $3.1\times10^{-7}$[a] | $3.0\times10^{-10}$ | $3.6\times10^{-9}$ | $9.5\times10^{-8}$ | $3.4\times10^{-7}$ |
| Latent cancer fatalities for the worker population | 0.30 | 0.28 | 0.34 | 0.33 | 0.84 |
| Latent cancer fatalities for the general public | $1.1\times10^{-2}$[a] | $1.1\times10^{-5}$ | $3.8\times10^{-5}$ | $3.4\times10^{-3}$ | $4.4\times10^{-3}$ |
| **Waste Generation Required for the Entire Period of Analysis (1998-2035)** | | | | | |
| Liquid (cubic meters) | 2,300 | 660 | 1,200 | 1,050 | 10,500 |
| High-level waste generated (equivalent DWPF[b] canisters) | 38 | 11 | 20 | 17 | 160 |
| Transuranic waste generated (cubic meters) | 0 | 15 | 360 | 563 | 3,700 |
| Hazardous and mixed low-level waste generated (cubic meters) | 76 | 25 | 46 | 103 | 267 |
| Low-level waste generated (cubic meters) | 57,000 | 20,000 | 31,000 | 35,260 | 140,000 |
| **Utilities and Energy Required for the Entire Period of Analysis (1998-2035)** | | | | | |
| Water consumption(millions of liters) | 1,100 | 660 | 1,400 | 1,186 | 8,000 |
| Electricity consumption (megawatt-hours) | 46,000 | 27,000 | 81,000 | 116,000 | 600,000 |
| Steam consumption (millions of kilograms) | 340 | 190 | 520 | 650 | 3,600 |
| Diesel fuel consumption (thousands of liters) | 230 | 180 | 2,300 | 2,760 | 22,000 |
| **Road-ready Repository canisters (1998-2035)** | 0 | ~1,400 | ~1,300 | ~400 | 0[c] |

a. Reflects current reactor-area emissions (including two SNF wet basins) for the entire period of analysis.
b. DWPF = Defense Waste Processing Facility.

c. The technology used in the Maximum Impact Alternative (i.e., Conventional Processing) would produce only high-level waste.

**Table 2-11.** Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each fuel group and technology (percent of regulatory standard).

| | Technology | | | | | | |
|---|---|---|---|---|---|---|---|
| Fuel group | 1. Prepare for Direct Co-Disposal | 2. Repackage and Prepare to Ship[a] | 3. Melt and Dilute | 4. Mechanical Dilution | 5. Vitrification Technologies | 6. Electro-metallurgical Treatment | 7. Conventional Processing |
| A. Uranium and Thorium Metal Fuels | 0.02 (ozone [as VOC]) | NA | 0.03 (ozone [as VOC]) | No | 1.1 (nitrogen oxides) | 0.03 (ozone [as VOC]) | 1.1 (nitrogen oxides) |
| B. Materials Test Reactor-Like Fuels | 0.03 (ozone [as VOC]) | NA | 0.05 (ozone [as VOC]) | 0.03 (ozone [as VOC]) | 1.7 (nitrogen oxides) | 0.05 (ozone [as VOC]) | 1.7 (nitrogen oxides) |
| C. HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging | 0.01 (ozone [as VOC]) | NA | 0.02 (ozone [as VOC]) | 0.01 (ozone [as VOC]) | 0.55 (nitrogen oxides) | 0.02 (ozone [as VOC]) | 0.55 (nitrogen oxides) |
| D. Loose Uranium Oxide in Cans | NA | NA | <0.004 (ozone [as VOC]) | NA | 0.06 (nitrogen oxides) | <0.002 (ozone [as VOC]) | 0.06 (nitrogen oxides) |
| E. Higher Actinide Targets | NA | <0.004 (ozone [as VOC]) | NA | NA | NA | NA | NA |
| F. Non-Aluminum-Clad Fuels | NA | NA | NA | NA | NA | NA | NA |

NA = Technology is not applicable to this fuel type.
VOC = volatile organic compound.

**Table 2-12.** Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each alternative (percent of regulatory standard).

| No Action Alternative | Minimum Impact Alternative | Direct Disposal Alternative | Preferred Alternative | Maximum Impact Alternative |
|---|---|---|---|---|
| 0.03 (nitrogen oxides) | 0.07 (ozone [as VOC]) | 1.2 (nitrogen oxides) | 1.1 (nitrogen oxides) | 3.6 (nitrogen oxides) |

VOC = volatile organic compound.

fatalities would range from $1.1 \times 10^{-5}$ to $4.4 \times 10^{-3}$.

- *Nonradiological Air Quality* – Table 2-11 presents the estimated maximum incremental concentrations of the nonradiological air pollutants that would contribute the most to the deterioration of air quality at the SRS boundary. Concentrations are presented for each technology fuel group concentration. The incremental concentrations would not affect human health. Table 2-12 presents the estimated maximum incremental concentration of the nonradiological air pollutant that would contribute the most to the deterioration of air quality at the SRS boundary for each alternative. As noted from Table 2-12, the concentration of the nonradiological constituent contributing the highest fraction of the offsite air quality standard would range from 0.03 percent of the standard for the No-Action Alternative to 3.6 percent of the standard for the Maximum Impact Alternative. Under all alternatives, nonradiological air concentrations of the SRS boundary would be well below applicable standards.

- *Waste generation* – Wastes volumes were estimated over the period of analysis. The Maximum Impact Alternative would generate the greatest volume of high-level waste, while the Minimum Impact Alternative would generate the least volume of high-level waste. For wastes generated under all alternatives, DOE would use the surplus capacity in existing SRS waste management facilities to treat, store, dispose, or recycle the waste in accordance with applicable regulations.

- *Utilities and energy consumption* – The quantities of water, electricity, steam, and diesel fuel that would be required over the entire period of analysis were estimated.

The Maximum Impact Alternative would require the most water, electricity, steam, and diesel fuel, while the Minimum Impact Alternative would require the least. For all alternatives, water and steam would be obtained from existing onsite sources and electricity and diesel fuel would be purchased from commercial sources. These commodities are readily available and the amounts required would not have an appreciable impact on available supplies on capacities.

*Accidents* – DOE evaluated the impacts of potential facility accidents related to each of the alternatives. For each potential accident, the impacts were evaluated as radiation dose to the noninvolved worker, radiation dose to the offsite maximally exposed individual, collective radiation dose to the offsite population, and latent cancer fatalities to the offsite population. Table 2-13 presents the results of this analysis. Table 2-13 also indicates the estimated frequency of occurrence for each accident.

The highest consequence accident postulated under the continued wet storage, direct co-disposal, and repackage and prepare to ship technologies is a seismic/high wind-induced criticality, which is estimated to TC

**Table 2-13.** Estimated maximum consequence accident for each technology.

| Option | Accident Frequency | Consequences: Noninvolved Worker (rem) | MEI (rem) | Offsite Population (person-rem) | Latent Cancer Fatalities |
|---|---|---|---|---|---|
| **Continued Wet Storage (No Action)**[a] | | | | | |
| RBOF (high wind-induced criticality) | Once in 26,000 years | 13 | 0.22 | 12,000 | 6.2 |
| L-Reactor basin (basin-water draindown) | Once in 500 years | 0.014 | 0.016 | (b) | (b) |
| **Direct Co-Disposal** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| **Repackage and Prepare to Ship** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| **Conventional Processing** | | | | | |
| Processing phase in F/H Canyons (coil and tube failure) | Once in 14,000 years | 13 | 1.3 | 78,000 | 39 |
| **Melt and Dilute** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Melt and dilute phase (earthquake induced spill with loss of ventilation) | Once in 200,000 years | 30 | 0.5 | 21,000 | 10 |
| TC **Mechanical Dilution** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Mechanical dilution phase (criticality with loss of ventilation) | Once in 33,000 years | 0.71 | 0.074 | 3,000 | 1.5 |
| **Vitrification Technologies** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Vitrification phase (earthquake-induced release with loss of ventilation) | Once in 200,000 years | 0.10 | 0.0017 | 71 | 0.035 |
| **Electrometallurgical Treatment** | | | | | |
| Dry Storage phase (earthquake-induced criticality) | Once in 2,000 years | 13 | 0.22 | 12,000 | 6.2 |
| Electrometallurgical phase (metal melter earthquake induced spill with loss of ventilation) | Once in 200,000 years | 30 | 0.5 | 21,000 | 10 |

MEI = Maximally Exposed Individual.
RBOF = Receiving Basin for Offsite Fuels.
a. All alternatives would use RBOF and the L-Reactor Disassembly Basin; therefore, accidents in these facilities are possible for each technology.
b. Not available.

result in 6.2 latent cancer fatalities in the offsite population. The highest consequence accident under conventional processing technology is a coil and tube failure with an estimated offsite population impact of 39 latent cancer fatalities. The frequencies of these accidents are once in 2,000 to once in 26,000 years.

TC

For the other new SNF technologies evaluated, the maximum consequence accident (earthquake induced spill with loss of ventilation) is associated with the melt and dilute process. This accident is estimated to occur once in 200,000 years and to result in 10 latent cancer fatalities in the offsite population.

Construction activities could affect four parameters: surface-water quality, air quality, ecological resources, and socioeconomics. However, because current SRS construction workers would build the facilities in an existing industrialized area of the Site, DOE expects little impact from construction activities.

## 2.6 Other Decisionmaking Factors

### 2.6.1 TECHNOLOGY AVAILABILITY AND TECHNICAL FEASIBILITY

The New Packaging and New Processing Technology Alternatives would rely on technologies that have not been applied to the management of aluminum-based SNF for ultimate disposition. Therefore, DOE conducted a feasibility study of the non-processing technologies and documented the study in a report prepared by a Research Reactor Task Team in its Office of Spent Fuel Management (DOE 1996b).

The Research Reactor Task Team examined a wide range of technical issues involved in achieving safe and cost-effective disposal of aluminum-based SNF under DOE jurisdiction. The Team identified and evaluated issues on technical grounds to arrive at a recommendedcourse of action that could lead to the implementation of a non-processing SNF management technology by 2000. The team considered three specific areas of investigation to be key: (1) repository and waste form considerations; (2) SNF receipt, handling, and storage provisions; and (3) treatment technologies (the same technologies this EIS considers). The team assigned the highest confidence of success and greatest technical suitability to technologies that would have relatively simple L3-3
approaches (i.e., Direct Disposal, Direct Co-Disposal, Melt and Dilute, and Press and Dilute). The Conventional Processing option would have the least technical uncertainty because it would rely largely on a technology that is proven for aluminum-based SNF. The No-Action Alternative would involve the greatest technical uncertainty in the area of potential fuel degradation, as a result of continued long-term wet storage in SRS basins. The non-processing technologies with the greatest technical uncertainties would be the more complicated technologies such as vitrification.

In response to a DOE request, the National Academy of Sciences evaluated and provided recommendations for DOE's aluminum-based SNF disposition technical program (NAS 1998). The NAS report was prepared by a Principal Investigator assisted by a panel of expert consultants in fields of nuclear criticality control, proliferation policy, costs and schedules, corrosion and metallurgy, processing and remote handling, and regulatory waste acceptance.

The panel reviewed the DOE program for developing a strategy for treatment of aluminum-based SNF in preparation for interim storage and final disposal, with emphasis on the following objectives:

- Evaluation of the set of technologies proposed by DOE for aluminum-based SNF treatment, with suggestions of other applicable technologies
- Examination of waste package performance criteria developed by DOE to meet the anticipated waste acceptance criteria for storage, transportation, and repository disposal

- Assessment of projected costs and schedule for implementation of the aluminum-based SNF technologies

The NAS report generally endorsed the projected DOE spent fuel disposition scenarios under development. The NAS recommendations for systems approach and phased strategy were incorporated by DOE into the EIS as follows:

Two systems analyses were completed for the primary new technologies being considered by DOE (Melt and Dilute and Direct Disposal/Direct Co-Disposal). A variety of attributes were evaluated, including cost, criticality concerns, public safety, worker safety, environmental concerns, nonproliferation, versatility, maintainability, and repository volume. One analysis was performed by Westinghouse Savannah River Company (WSRC 1998b), and a second independent multi-attribute decision analysis was completed by Sandia National Laboratory (SNL 1998). In both studies, Melt and Dilute had the least uncertainty.

DOE has recognized the advantages of applying a phased strategy for implementation of the melt and dilute process and continues to integrate its development and installation with other site program priorities and schedules in mind. The NAS concern regarding technology selection being driven by post-2015 SNF receipts is mitigated by the plan to design a facility with minimal-sized processing capabilities, which will be able to treat the current inventory of spent nuclear fuels within a reasonable timeframe, yet not be operationally burdensome when fuel receipts are reduced to minimal amounts.

The phased strategy was accommodated by provisions of backup treatments for appropriate fuel types should the projected preferred treatments not be successfully implemented within required time constraints. For example, the Direct Disposal/Direct Co-disposal technology is included as a backup technology for Melt and Dilute technology.

In summary conclusions, the NAS noted the complexity of the aluminum-based SNF disposal program including factors such as: the timely provision of initial storage capacity for the fuel at SRS; the selection, development, and implementation of one or more treatment options to qualify the fuel for possible repository disposal; and the interim storage required until the repository, yet-to-be designed, licensed, or constructed, can accept it. The Academy noted that an SNF disposition program requires a systems approach for optimization of the many interacting factors required for successful implementation. The NAS recommended that aluminum-based SNF treatment decisions be made using a phased strategy in which critical decisions are made as the information needed for sound choices becomes available, recognizing the trade-offs between information acquisition and costs of delayed decisions.

The NAS panel identified a number of specific findings with recommendations as described in their report (NAS 1998).

Specific observations of the panel included the following:

- DOE has identified a reasonably complete set of aluminum-based SNF treatment options, resulting in selection of the Direct Co-Disposal and Melt and Dilute technologies for further development.

- The selection of a preferred treatment alternative must take into account uncertainties in repository Waste Acceptance Criteria that could, for example, disqualify highly enriched uranium waste forms such as produced by the Direct Co-Disposal technology.

- Both the Direct Disposal/Direct Co-Disposal and Melt and Dilute technologies apparently can be implemented to produce acceptable waste forms. The high-temperature Melt and Dilute treatment is technically more demanding than the relatively straight-forward Direct Disposal/ Direct Co-Disposal treatment and presents potential problems in ra-

dioactive off-gas control, but the basic operations have been demonstrated in other programs. Suitability of other technology options, such as the Electrometallurgical Treatment, is less assured because of the additional development work needed.

| EC

- More careful consideration of the conventional processing option is needed, because it is a well-demonstrated technology, its costs and risks are known, the necessary facilities are in current operations, and the high-level waste form is likely acceptable in the repository.
- DOE has established a working relationship with DOE-Yucca Mountain and plans to continue this relationship to ensure timely identification of repository waste form criteria and waste characterization requirements.
- Other waste form criteria, including interim-storage criteria, appear reasonable and complete, except for transportation requirements. The panel recommended DOE review shipping requirements before finalization of canister/shipping cask design for the waste forms.
- Work under way by DOE-SR appears properly focused and appropriate to the above requirements. However, a single treatment option may not be suitable for all types of aluminum-clad SNF and the program should maintain flexibility in technology selection to accommodate this variability.
- Major cost factors are accounted for in the cost projections, but schedule projections appear ambitious, and schedule delays could affect the cost projections. Projected costs are, however, not a major discriminator of the various treatments and treatment selection can proceed based on current projections.

The DOE-SR and the Nuclear Regulatory Commission (NRC) have established an agreement for the NRC to provide technical assistance in connection with the identification of potential issues relating to the placement of aluminum-based foreign and domestic research reactor spent nuclear fuel in a geologic repository. In a recent review of DOE's research and development work, the NRC staff indicated that both the Melt and Dilute and Direct Co-Disposal technologies would be acceptable concepts for the disposal of aluminum-based research reactor SNF in a repository (Knapp 1998).

### 2.6.2 NONPROLIFERATION, SAFEGUARDS AND SECURITY

On May 13, 1996, the United States established a new 10-year policy to accept and manage foreign research reactor spent nuclear fuel containing uranium enriched in the United States (61 FR 25091). The goal of this policy is to reduce civilian commerce in weapons-usable highly enriched uranium, thereby reducing the risk of nuclear weapons proliferation, as called for in President William Clinton's September 27, 1993, Nonproliferation and Export Control Policy.

Two key disposition options under consideration for managing SNF in this EIS include conventional processing and new treatment and packaging technologies. The Record of Decision for managing foreign research reactor SNF specified that, while evaluating the processing option, "DOE will commission or conduct an independent study of the nonproliferation and other (e.g., cost and timing) implications of chemical separation of spent nuclear fuel from foreign research reactors." DOE's Office of Arms Control and Nonproliferation conducted the study. To receive a copy, contact DOE at 1-800-881-7292.

The study addresses the nonproliferation implications the Department considered in determining how to manage aluminum-based SNF at the Savannah River Site, including how to place these materials in forms suitable for ultimate disposition (DOE 1998a). Because the same technology options are being considered for the foreign research reactor and the other aluminum-based spent nuclear fuels, the report addresses the nonproliferation implications of managing all the Savannah River Site aluminum-based SNF.

The nonproliferation assessment evaluates the extent to which each technology option supports the United States nonproliferation goals, which are summarized below.

- To reduce the risk of nuclear proliferation and for other considerations, the United States neither encourages the civil use of plutonium nor engages in plutonium processing for either nuclear power or nuclear explosive purposes. In addition, the United States works actively with other nations to reduce global stocks of excess weapons-usable material; separated plutonium and highly enriched uranium. Under this policy, the United States honors its commitments to cooperate with civilian nuclear programs that involve the processing and recycling of plutonium in Western Europe and Japan. In all such cases, however, the United States seeks to ensure that the International Atomic Energy Agency (IAEA) has the resources needed to implement its vital safeguards responsibilities, and works to strengthen the IAEA's ability to detect clandestine nuclear activities. The United States seeks to eliminate where possible the accumulation of stockpiles of highly enriched uranium or plutonium, and to ensure that where these materials already exist they are subject to the highest standards of safety, security, and international accountability. The United States also actively opposes, as do other supplier nations, the introduction of processing and plutonium recycling activities in regions of proliferation concern.

- The United States also seeks to minimize the adverse environmental, safety, and health impacts of its management of nuclear materials and activities. This goal includes minimizing the generation of radioactive wastes and ensuring that waste materials are put into forms that can be disposed of safely.

To evaluate the extent to which the technology options support the United States' nonproliferation policy goals, the nonproliferation study evaluated the technology options using technical and policy factors, as explained below.

Technical factors include the degree to which a particular technology would:

- Help ensure that the weapons-usable nuclear material in the spent nuclear fuel could not be stolen or diverted during the process. This includes an assessment of the attractiveness to diversion of materials in process and the ease of providing institutional and inherent security features.

- Facilitate cost-effective international verification and transparency.

- Result in converting the spent nuclear fuel into a form from which retrieval of the material for weapons use would be difficult and unlikely, thus modestly reducing the total stockpile of material readily usable in nuclear weapons.

Policy factors include the degree to which a particular technology would:

- Be consistent with United States policy related to processing and nonproliferation.

- Avoid encouraging other countries to engage in the processing of spent nuclear fuel, or undermining United States efforts to limit the spread of processing technology and activities, particularly to regions of proliferation concern.

- Support United States efforts to convert United States and foreign research reactors to low enriched fuels, and avoid creating technical, economic, or political obstacles to implementing the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program.

- Help demonstrate that any treatment of these spent nuclear fuels will definitely not represent the production by the United States of additional materials for use in nuclear weapons.

- Support negotiation of a nondiscriminatory global fissile material cutoff treaty.

There are several options for the effective management of the aluminum-based SNF at SRS.

With respect to nonproliferation, the report concluded the following:

- All of the options could reliably discourage any theft or diversion of the material, but some are superior to others.
- All of the options could provide for some form of international safeguarding by the International Atomic Energy Agency (IAEA). The options vary in terms of cost and ease of application.
- All of the options would result in forms from which recovery of the material for use in weapons would be highly unlikely, although the Direct Disposal/Direct Co-Disposal Option would not blend down the residual highly enriched uranium and low enriched uranium, and the conventional processing option would recover plutonium metal that would be managed as surplus.
- All of the options would be consistent with United States nonproliferation policy, and would allow for verification approaches that would be acceptable to the United States if implemented in other countries.
- The electrometallurgical treatment and the conventional processing, by appearing to endorse these technologies, could conceivably encourage processing in other countries.
- All of the options have the potential to support fully United States efforts to reduce the civil use of highly enriched uranium, including the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program.
- None of these options would appear to be prejudicial to the ability of the United States to submit to international safeguards or monitoring under a nondiscriminatory fissile material cutoff treaty. However, the processing option involves the use of old facilities at the Savannah River Site not specifically designed to facilitate the application of international safeguards. An effective safeguarding regime would likely be difficult due to cost and safety retrofitting concerns (DOE 1998a).
- The Office of Arms Control and Nonproliferation fully supports the active pursuit of a new treatment technology for the aluminum-based spent nuclear fuel, and views the melt and dilute recommendation as a favorable technology in light of nonproliferation concerns.

### 2.6.3 LABOR AVAILABILITY AND CORE COMPETENCY

Each alternative and associated technologies would require different levels of personnel knowledge and training. In addition, providing the needed level of training would result in impacts, primarily in the area of personnel resources. In general, the New Packaging options probably would be the least labor-intensive. The Conventional Processing option or a combination of options that included conventional processing would be the most labor-intensive to implement on an annual basis.

Operations required for the Conventional Processing technology would occur in parallel with other canyon nuclear stabilization programs. As a result, no excess personnel would be available in the event the vulnerable SNF was not processed. Because the canyons already would be operating to process materials not considered in this EIS, there also would be no actual cost savings that could be transferred to another activity. L2-12

The Conventional Processing technology option and No-Action Alternative would require the least amount of training because the SRS workforce has a great deal of experience in these technologies and there are existing training and qualification programs to maintain core compe-

tency. The New Processing Technology options such as Vitrification Technologies or Electrometallurgical Treatment probably would require the greatest training effort because they would involve new and complex operations.

### 2.6.4 MINIMUM CUSTODIAL CARE

The New Packaging Technology and New Processing Technology options would create a form of material that required the least amount of custodial care before shipment off the Site. However, safeguards and security requirements would still be maintained. Conventional processing would require care of the vitrified waste similar in level-of-effort to the custodial care of the New Packaging and New Processing Technology option. In addition, it also would require care of the high-level waste until it was vitrified and any blended-down fissile material until they were delivered for disposition.

### 2.6.5 COST

To determine the potential cost of integrating various combinations of alternatives, DOE has estimated life-cycle costs for the alternatives and for the new technology options described in this EIS and for conventional processing. The cost report was prepared, in part, to satisfy the Department's commitment to study the implications of chemically separating SNF (see Section 2.6.2). The planning level costs have an uncertainty of +50 percent to -30 percent. These estimates, which are listed in Table 2-14, include both operating and capital (i.e., construction) costs (DOE 1998b).

DOE estimated the costs for the alternatives discussed in this EIS using the technology option cost information from the cost study. The cost estimates for the alternatives are presented in Table 2-15.

Comparison of the projected life cycle costs for the alternatives indicate the following:

- The life-cycle costs range from a low of $1.7 billion for No Action to a high of $2.0 billion for the Maximum Impact Alternative. However, the continued wet storage cost does not include actions necessary to prepare SNF for ultimate disposition.
- The Direct Disposal Alternative ($1.9 billion) and the Preferred Alternative ($2.0 billion) (both using a renovated reactor building) have approximately the same life-cycle cost, with installation in a renovated reactor facility presenting cost advantages of about $200 million compared to a new treatment facility. EC
- The cost of processing the SNF proposed in the Preferred Alternative would be incremental to the cost of operating the canyons for other reasons and very small when compared to the canyon overall operating cost. L4-15

**Table 2-14.** Life-cycle costs for aluminum-clad fuel technologies (1998 millions of dollars)[a].

**Table 2-15.** Life-cycle costs (1998 billions of dollars) for each alternative.[a]

| Minimum Impact | Direct Disposal | Preferred Alternative | Maximum Impact | No Action |
|---|---|---|---|---|
| 1.9[b] | 1.9 | 2.0[c] | 2.0 | 1.7 |

EC

a. Source: DOE (1998b).
b. Includes less than $30 million to install Melt and Dilute capability for Fuel Group D.
c. Includes about $6 million as direct and indirect cost of operating canyons for SNF processing during 1999-2001 while the material stabilization program is underway in response to Defense Nuclear Facility Safety Board Recommendation 94-1.

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