



## FOREWORD

The Savannah River Site (SRS) is a major Department of Energy (DOE) installation. The past mission of the SRS was to produce nuclear materials that supported the defense, research, and medical programs of the United States.

In 1992 the Secretary of Energy directed the SRS to phase out defense-related chemical separations activities. As a result of shutdowns and reduced demand for nuclear materials, the SRS presently has a large inventory of in-process solutions, reactor fuel assemblies, and reactor targets. These materials, due to their form or to the condition in which they are maintained, could represent a concern for the public, worker health and safety, and the environment.

DOE published a Notice of Intent (NOI) to prepare this environmental impact statement (EIS) on March 17, 1994 (59 FR 12588). The purposes of DOE actions related to the inventory of nuclear materials at the SRS are to stabilize those materials that represent a health and safety concern for the public, workers, and the environment in the short term and to convert those materials required to support DOE programs to the desired products. DOE considers these actions to be necessary intermediate steps before it can make and implement long-term decisions on the disposition of these nuclear materials.

On June 21, 1994, DOE issued an NOI to prepare a "Programmatic Environmental Impact Statement for Storage and Disposition of Weapons-Usable Fissile Materials" (59 FR 31985). DOE anticipates that it will need as long as 10 years to begin the implementation of the decisions it makes as a result of that programmatic EIS. In the meantime, some of the materials at the SRS require continuing vigilance because of unstable configurations and uncertainties related to continued storage.

ThI for this EIS 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 May 31, 1994. During the scoping period, individuals, organizations, and government agencies submitted 80 comments that DOE considered applicable to the interim management of nuclear materials. In addition, DOE held scoping meetings in Savannah, Georgia; North Augusta, South Carolina; and Columbia, South Carolina, on May 12, 17, and 19, respectively.

Transcripts of public testimony, copies of scoping letters, scoping comments and DOE responses, and reference materials cited in this EIS are available for review in the DOE Public Reading Room at the University of South Carolina-Aiken Campus, Gregg-Graniteville Library, 2nd Floor, University Parkway, Aiken, South Carolina, (803) 648-6851, and at the Freedom of Information Reading Room, Room 1E-190, Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C., (202) 586-6020.

DOE has prepared this EIS in accordance with the NEPA regulations of the Council on Environmental Quality (40 CFR Parts 1500-1508) and DOE NEPA Implementing Procedures

(10 CFR Part 1021). This EIS identifies the methods used and the scientific and other sources of information consulted. In addition, it incorporates, physically or by reference, available results of ongoing studies. The organization of the EIS is as follows:

- Chapter 1 describes the purpose and need for interim nuclear material management activities. This chapter also identifies and categorizes the nuclear materials that this EIS addresses.
- Chapter 2 identifies the alternatives that DOE would use for the management of the nuclear material at the SRS.
- Chapter 3 describes the SRS environment as it relates to the alternatives discussed in Chapter 2.

- Chapter 4 assesses the environmental impacts of the alternatives under normal operation and accident conditions.
- Chapter 5 discusses the cumulative impacts of interim management actions in relation to impacts of past, present, and foreseeable future activities at the SRS.
- Chapter 6 assesses the short-term versus long-term resource commitments associated with reinstating activities in the F- and H-Canyons and support facilities.
- Chapter 7 identifies irreversible or irretrievable resource commitments.
- Chapter 8 discusses regulatory requirements, including applicable statutes and DOE Orders, and compliance with state and Federal regulations.
- Appendix A lists SRS nuclear materials in three categories: (1) Stable (material that DOE does not need for programmatic purposes and can safely store as it currently exists), (2) Programmatic (material that requires conversion due to programmatic need), and (3) Candidates for Stabilization (material that could require short-term stabilization).
- Appendix B is a summary of programmatic need for and use of plutonium-242. Because this information is classified under the provisions of the Atomic Energy Act, it is not included here; however, the DOE decisionmaker will have access to this information for use as a basis for decisions on the interim management of these nuclear materials.
- Appendix C describes facilities and processes that would be involved in the interim management of nuclear materials.
- Appendix D provides environmental impact data for normal operations related to the interim management of nuclear materials.
- Appendix E discusses accidents that could occur at SRS facilities during the interim management of nuclear materials.





# CHAPTER 1. PURPOSE AND NEED FOR ACTION

## 1.1 Introduction and Background

The U.S. Atomic Energy Commission (AEC), a predecessor agency of the Department of Energy (DOE), established the Savannah River Site (SRS) in the early 1950s. The SRS occupies an area of approximately 800 square kilometers (300 square miles) adjacent to the Savannah River, primarily in Aiken and Barnwell Counties in South Carolina. The Site is approximately 40 kilometers (25 miles) southeast of Augusta, Georgia, and 32 kilometers (20 miles) south of Aiken, South Carolina ([Figure 1-1](#)). [Figure 1-2](#) shows the locations of the principal SRS facilities, which began operation between 1951 and 1954.

The SRS mission for the past 40 years has been the production of special radioactive isotopes to support national programs. Primarily, this mission was the production of strategic isotopes (plutonium-239 and tritium) used in the development and production of nuclear weapons for national defense. The Site produced other special isotopes (e.g., californium-252, plutonium-238, americium-241) to support research in nuclear medicine, space exploration, and commercial applications. To produce the isotopes, DOE fabricated selected materials into metal targets and irradiated them in the SRS reactors. The targets and reactor fuel were dissolved in acid and the special isotopes were chemically separated and converted to a solid form, either an oxide powder or a metal. The oxide or metal was fabricated into a usable form at the SRS or at other DOE sites. The final form of the material depended on the application (nuclear weapon component, encapsulated medical source, power source, etc.). [Figure 1-3](#) shows the historic SRS production cycle.

Due to the large-scale chemical separation capabilities at the SRS, materials containing significant quantities of plutonium-239, uranium-235, and other special isotopes were shipped to the SRS for processing and recovery. The materials were in a wide variety of physical shapes and forms, including (1) small encapsulated plutonium sources returned from use by national laboratories and domestic universities; (2) cans or drums of scrap metals and oxides from weapon manufacturing operations at other DOE sites; (3) irradiated metal fuel rods, tubes, plates, or assemblies from experimental DOE reactors, university research reactors, and foreign research reactors; and (4) cans, bottles, or drums containing residues or samples used in laboratory experiments at other DOE sites. All the materials were stored until they could be dissolved and processed in the chemical separations facilities. The small sources, scrap metals, oxides, residues, and samples were typically stored in cans, bottles, or drums in safeguarded concrete vaults. The irradiated fuel and targets were stored underwater in metal racks or buckets. The offsite materials were typically processed in conjunction

[Figure 1-1.](#)

[Figure 1-2.](#)

[Figure 1-3.](#)

with the materials produced at the SRS. [Figure 1-4](#) shows the historic processing and recovery cycle for scrap materials received from off the SRS. [Figure 1-5](#) shows the historic reprocessing cycle for spent fuel received.

In March 1992, DOE suspended chemical reprocessing and recovery activities at the SRS to address a potential safety

concern regarding the survival of the F- and H-Canyon ventilation systems in the event of an earthquake. That concern was addressed. However, before the resumption of reprocessing, the Secretary of Energy directed that the SRS phase out defense-related chemical separations activities in these facilities (DOE 1992). World events in the late 1980s and early 1990s resulted in the end of the Cold War and a reduction in the demand for new material for nuclear weapons. DOE stopped operating the SRS reactors to produce strategic isotopes. DOE has not processed nuclear materials at the SRS chemical separations facilities to recover special isotopes since March 1992, with the exception of scrap materials containing plutonium-238. DOE continued the processing of plutonium-238 to support future National Aeronautics and Space Administration (NASA) exploratory space missions.

The cessation in processing operations resulted in a large inventory of nuclear materials caught in various stages of the historic production (fabrication, irradiation, reprocessing, and recovery) cycle. These materials include irradiated and unirradiated reactor fuel, targets, and components; solutions containing dissolved nuclear materials and recovered isotopes in stainless-steel tanks; and product and scrap forms of metals or oxides in containers (cans, drums, etc.) typically used for temporary storage or shipment offsite.

## 1.2 Purpose and Need for Action

With the end of the Cold War, the primary mission of the nuclear production facilities at the SRS has changed to the storage and management of nuclear materials until DOE can make and implement decisions on the ultimate disposition of the materials. DOE is evaluating various strategies for the long-term management of nuclear material. Section 1.6 describes these evaluations. DOE anticipates that it might need as long as 10 years to make and fully implement management decisions on all these materials. Until DOE can implement these decisions, the large inventory of nuclear materials at the SRS requires continued management.

Some of the methods of storage for these materials pose risks to the environment or the safety and health of SRS workers or the public because, at the time DOE suspended the production cycle, many nuclear materials were in a form or were stored in a manner that was acceptable for only a temporary period (e.g., 1 to 2 years). Thus, the continued storage of some of the materials poses risks. In some cases, the material's physical or chemical form poses the risks; in other cases, the material simply needs to be repackaged or moved to another location to ensure its safe storage. DOE needs to either eliminate (if possible) or reduce the risks posed by continued storage of these materials.

[Figure 1-4.](#)

[Figure 1-5.](#)

In addition, although the need for strategic isotopes has been greatly diminished by the end of the Cold War, some nuclear materials stored at the SRS contain special isotopes that support remaining DOE programs. These materials require additional processing or conversion to forms that are suitable for continued safe storage at the SRS and eventual use at other DOE sites.

The purpose of the actions described in this EIS is for DOE to manage the existing SRS nuclear materials in a safe and environmentally sound manner while supporting national requirements for an inventory of special isotopes. DOE must consider actions to repackage, relocate, or convert some materials at SRS to a form appropriate for safe interim storage or future use. While DOE expects some reductions in environmental impacts from normal operations if it takes such actions, its primary objectives are to (1) eliminate or reduce risks from accidents that could occur during continued storage of the nuclear materials, and (2) convert nuclear materials to forms that it can store safely.

## 1.3 Categories of Nuclear Materials

For the purposes of this EIS, DOE has organized the inventory of nuclear materials at the SRS into three categories:

- **Stable** - Materials that have physical and chemical forms that, combined with their storage configurations, do not currently pose an environmental, safety, or health concern and are not likely to pose a concern over the next 10 years.
- **Candidates for Stabilization** - Materials that pose an existing environmental, safety, or health concern or that might pose a concern during the next 10 years. The concern posed might be due to their physical condition, chemical composition, or the manner in which they are stored (e.g., packaging or storage environment).
- **Programmatic** - Materials that contain special isotopes that are needed to support DOE programs. In their current forms, these materials are not usable or suitable for continued interim storage. Some type of processing or conversion is required to alter the physical form or chemical composition of the material; otherwise, programmatic materials might be categorized as Candidates for Stabilization.

This EIS analyzes the impacts that could be associated with the management of nuclear materials related to past production activities and missions of the SRS. However, the scope of the EIS does not include two types of nuclear material currently in the SRS inventory -- tritium and plutonium-238. DOE did not include the recycling of existing inventories of tritium because this is an ongoing SRS program that the Department has addressed in an environmental assessment (DOE 1986). In addition, DOE will address future tritium activities in the Tritium Supply and Recycling Programmatic EIS (59 FR 54175). Similarly, the processing of plutonium-238 for NASA space missions (e.g., Cassini) is an ongoing SRS program that DOE addressed in an environmental assessment (DOE 1991). Further, DOE is preparing a separate environmental assessment for future plutonium-238 processing operations that might be required (DOE 1994a). This EIS on the Interim Management of Nuclear Materials does, however, include a small amount of plutonium-238 contained in scrap from previous operations.

The scope of this EIS does not include residual levels of nuclear materials contained in low-level, high-level, transuranic, and mixed types of radioactive waste. The SRS Waste Management EIS evaluates the impacts from operations required to manage these types of radioactive waste. There are residual levels of nuclear materials contained in production, processing, handling, or storage facilities scheduled for decontamination and decommissioning (D&D). These residual materials are not included within the scope of this EIS. DOE will prepare separate NEPA documentation to evaluate impacts from D&D activities for such facilities, as appropriate.

## 1.4 Categorization Methods

### 1.4.1 Stable materials and Candidates for Stabilization

DOE categorized Stable materials and Candidates for Stabilization as a result of several reviews. Within the past 18 months, DOE completed two nationwide reviews of how it stored nuclear materials at SRS and other sites:

- *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities* (November 1993) (DOE 1994b).
- *Plutonium Working Group Report on Environment, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage* (September 1994) (DOE 1994c).

The DOE Office of Environment, Safety and Health performed these reviews using teams of independent technical experts. Each report identified vulnerabilities associated with the continued storage of one or more nuclear materials at the SRS. The following sections summarize the scope of each review, the vulnerabilities identified with SRS materials, and the methods DOE used to categorize materials as Candidates for Stabilization or Stable.

#### 1.4.1.1 Spent Fuel Working Group Report

The scope of this assessment (DOE 1994b) was nationwide, involving 11 sites where DOE stores reactor irradiated nuclear materials (RINM) in basins, pools, canals, canyons, inactive reactors, warehouses, hot cells, vaults, wells, casks, and burial grounds. RINM consists of spent fuel (in any condition) and irradiated nuclear targets from production and research reactors. It does not include fuel in active reactors, waste products, and irradiated structural materials. The assessment defined vulnerabilities in nuclear facilities as conditions or weaknesses that might lead to radiation exposure to the public, unnecessary or increased exposure to workers, or release of radioactive materials to the environment. The vulnerabilities that involved SRS materials dealt with fuel and target materials in wet storage basins:

Corrosion of fuel and target materials in the water basins and its effects constitute the major ES&H (Environment, Safety, and Health) vulnerability at the SRS pertaining to stored RINM. Corrosion is occurring in K- and L-Reactor basins and it is becoming increasingly difficult to maintain the (cesium)-137 activity within the administrative limit. Continued corrosion will eventually impact the physical integrity of stored materials. Such an eventuality would impact criticality, personnel radiation exposure, and fuel retrievability and disposal. The mechanisms and consequences of the corrosion are being addressed by WSRC (Westinghouse Savannah River Company) and the levels of contamination are low, however, fissile material such as uranium, plutonium are being released to the basin water which constitutes an ES&H vulnerability. Left unmitigated, the long term consequences of this situation could be severe.

Based on the assessment conducted by the Working Group Assessment Team, the condition of the L-Reactor basin constitutes the greatest vulnerability as a consequence of the severity of the corrosion that is taking place, the quantity of stored material, and the level of the activity in the water. Next in degree of vulnerability is K-Reactor basin followed by P-Reactor basin, F-Canyon, H-Canyon, and RBOF (Receiving Basin for Offsite Fuel) in that order.

The following paragraphs discuss the SRS facilities affected by the assessment:

- L-Reactor Disassembly Basin - Delays and the subsequent suspension of processing at the SRS have resulted in fuel and target residence times in the reactor basin significantly greater than those originally anticipated. Reactor basins were originally intended only for interim storage, approximately 12 to 18 months. The basin contains approximately 13,000 irradiated Mark-31 targets, 500 Mark-22 assemblies, and 600 other targets. The Mark-31 targets contain plutonium-239 in the uranium-238 matrix, the Mark-22 fuel contains uranium-235 highly enriched uranium in a uranium/aluminum alloy, and the other targets contain primarily cobalt-60. This material (and most other material in the reactor basins) has been stored for 5 years or longer.
- The targets and fuel are aluminum-clad. The Mark-31 targets (sometimes referred to as "slugs" due to their short cylindrical shape) are stored in stainless-steel buckets in the basin. The Mark-22 fuel and the other targets are stored either vertically on stainless-steel hangers or horizontally in slotted aluminum racks. The fuel suspended on hangers is corroding severely at the aluminum-to-stainless-steel interface region where a galvanic couple has formed. Relatively little corrosion (i.e., pitting or general) is occurring on cladding removed from the end region. However, corrosion is occurring in localized regions where the aluminum-oxide protective coating has been damaged; DOE assumes that cladding penetrations have occurred based on studies on representative nonirradiated alloys.

This corrosion behavior observed on the Mark-31 targets stored in stainless-steel buckets is in sharp contrast to the behavior of the Mark-22 fuel. Extensive pitting corrosion has penetrated the cladding, and corrosion of the uranium target material is releasing uranium, plutonium, and fission products to the basin water. DOE recently placed the buckets in stainless-steel boxes with lids to help confine the corrosion products. Continued corrosion will accelerate the transport of fissile materials into the water; subsequent material deposition and concentration in sludge and structural and water treatment components will increase concerns about possible criticality. Efforts are in process to remove this sludge by vacuuming, but the rate of corrosion is likely to continue, and perhaps accelerate. The continued release of fission products to the basin and the subsequent cleanup will result in exposures to personnel.

- **K-Reactor Disassembly Basin** - This basin contains approximately 900 Mark-16 fuel assemblies, 200 Mark-31 targets, and 200 other targets. The fuel and targets are stored in the same manner as those in the L-Reactor basin. The physical condition of the materials is deteriorating in the same way. The vulnerabilities applicable to the storage situation in the L-Reactor basin are applicable to the K-Reactor basin. The primary difference between the two basins is that the K-Reactor basin contains fewer Mark-31 targets, which are the materials that have exhibited the most extreme evidence of corrosion and physical deterioration.
- **P-Reactor Disassembly Basin** - This basin contains approximately 500 Mark-22 fuel assemblies, 60 targets (slugs) used for the production of californium-252, and 9 Mark-42 assemblies used to produce plutonium-242. The fuel and targets are stored in the same manner as those in the L- and K-Reactor basins. The Mark-42 assemblies are stored in aluminum cans hung in a vertical position on stainless-steel hangers. "Although there is no evidence of corrosion on the surface of the fuel assemblies, the general corrosion of the components, including galvanic corrosion at the aluminum-stainless steel interfaces of the Mark-42 containers, aluminum tools, and the horizontal storage racks is judged to be the most severe in the P-Reactor basin" (DOE 1994b). The vulnerabilities applicable to the storage situation in the L- and K-Reactor basins are also applicable to the P-Reactor basin. The primary difference is P-Reactor materials have been in storage a much shorter time than those in the L- and K-Reactor basins. P-Reactor basin contains the smallest amount of fuel and does not contain Mark-31 targets.
- **F-Canyon Storage Basin** - This basin contains approximately 2,500 Mark-31 targets (or slugs) stored in buckets. "If observed corrosion continues unmitigated, increased releases of fissile and radioactive materials are probable." The targets are "remaining in a non-favorable environment for far longer than that envisioned or anticipated." The "corrosion of the slugs and resultant nuclear material release would not significantly impact ES&H while the fuel (targets) remains in the F-Canyon; however, retrievability and handling would be encumbered" (DOE 1994b).
- **H-Canyon Storage Basin** - This basin contains 13 fuel assemblies (Mark-16 and Mark-22) grouped in five bundles. No corrosion has been detected.
- **Receiving Basin for Offsite Fuels** - This basin contains approximately 1,500 irradiated fuel elements (assemblies, rods, tubes, cans, etc.). Aluminum-clad fuels in storage and the aluminum racks that have been in the basin for more than 30 years show no visible signs of corrosion.

Based on the extent of the vulnerabilities identified, DOE categorized the materials in the L-, K-, and P-Reactor Disassembly Basins as Candidates for Stabilization. DOE also categorized the fuel and target materials in the F- and H-Canyon storage basins as Candidates for Stabilization, primarily because they store the same type of targets and fuel as the reactor basins and the storage environment is similar (i.e., wet storage with limited chemistry control and leak detection). There has been no evidence of corrosion on the fuel stored in the Receiving Basin for Offsite Fuels, and corrosion concerns are not likely during the next 10 years. For these reasons, DOE categorized the materials in the receiving basin as Stable.

#### 1.4.1.2 Plutonium Working Group Report

The scope of the *Draft Plutonium Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Department's Plutonium Storage* (DOE 1994c) was nationwide, involving 166 facilities at 35 sites. The *Department of Energy Plutonium ES&H Vulnerability Assessment, Savannah River Site Assessment Team Report* (WSRC 1994) documented the SRS portion of the study. The working group report evaluated the storage of nearly all the plutonium that is not in intact nuclear weapons. It reviewed plutonium forms and packaging with the exception of residual plutonium from underground nuclear tests; plutonium in low-level, high-level, and transuranic wastes; and plutonium in very low residual levels in facilities undergoing decontamination and decommissioning. (DOE evaluated plutonium in spent fuel and irradiated targets in the spent fuel study described in Section 1.4.1.1.) This assessment included transuranic elements such as neptunium, americium, curium, and californium. It identified approximately 300 environmental, safety, and health vulnerabilities at 13 sites. The following paragraphs discuss the vulnerabilities that involved SRS materials.

**Solution Vulnerabilities.** F-Canyon has 14,000 liters (3,700 gallons) of americium and curium in solution in a stainless-steel tank. H-Canyon has 34,000 liters (6,000 gallons) of plutonium solution and 6,100 liters (1,600 gallons) of neptunium solution in four tanks. These solutions are unstable and corrosive and could breach their containers, resulting in releases of radioactive materials. Such releases could cause exposure of workers and the public and environmental contamination. Unanticipated high local plutonium concentrations in these tanks could also lead to criticality accidents. These tanks require continuous monitoring for corrosion, sampling for adjustment of solution chemistry, and periodic reagent additions to maintain liquid levels and prevent the formation of solids. The continued storage of these highly dispersible solutions creates significant vulnerabilities to workers and the environment. The assessment team determined that the potential for inadvertent criticality could be significant and a nuclear criticality could also result in releases from the building to the environment.

The tank of americium and curium solution is the largest single source of radioactivity in F-Canyon (approximately 220,000 curies). The solution has been in storage since 1983, and tank corrosion is a concern. The tank has internal cooling coils through which water circulates to remove heat generated by radioactive decay in the solution. The cooling coils were recently disconnected from the cooling water system to prevent the possibility of a leak that might cause a release of radioactive solution to the environment and exposure of the public. The solution itself is self-heating and remains at a temperature slightly less than 60°C (140°F), which causes a high rate of evaporation. Frequent adjustments for solution chemistry and volume are necessary. Tank contents are susceptible to spills and leaks and a major facility accident could disperse the contents over a wide area.

Due to the vulnerabilities identified, DOE categorized these solutions as Candidates for Stabilization.

**Metal, Oxide, and Scrap and Residue Vulnerabilities.** FB-Line and Building 235-F contain more than 400 packages of plutonium metal and metal alloys and about 2,400 packages of plutonium oxides and compounds. Materials and packaging properties that could lead to worker exposure are reactive or corrosive compounds; plastics that degrade due to radiolytic and thermal decomposition (80 percent of the packages contain plastic); metals that are subject to oxidation and subsequent expansion due to oxide formation; and unknown and uncharacterized materials and packaging (i.e., the chemical composition is not completely known). The more than 2,800 packages contain combinations or mixtures of the following materials:

- Plutonium-uranium oxides (including normal and enriched uranium), oxides mixed with transuranics including neptunium and americium, and scrap and residues such as incinerator ash and plutonium alloys are present in more than 500 packages that have not been fully characterized and have unknown packaging. This could lead to unsuspected reactions between materials and an eventual breach of packaging.
- Fuel-grade plutonium (a higher specific activity material containing as much as 18 percent plutonium-240 in addition to plutonium-239) is present in about 600 packages. This material generates heat, thereby accelerating the degradation of plastics and increasing the chances of packaging failure.
- Scrap and residues received from other DOE sites in more than 150 different forms, including incinerator ash, graphite, and chloride-bearing residues, are partly characterized; potentially reactive compounds such as plutonium nitride are present in more than 600 packages. These include most of the packages of oxides and



- scrap and residues and packages of fuel-grade plutonium.
- Scrap and residues from plutonium metal production present in 700 packages contain calcium metal and corrosive fluoride compounds that can react with moisture and air and undergo radiolysis.

Due to the vulnerabilities noted, DOE categorized the materials listed above as Candidates for Stabilization.

#### **1.4.1.3 Materials Not Included in the Spent Fuel and Plutonium Working Group Reviews**

The scope of the Spent Fuel and Plutonium Working Group Reviews did not encompass all nuclear materials stored at the SRS. For each material not previously evaluated by an independent review, DOE performed an assessment to determine if the material poses an environmental, safety, and health concern or could pose a concern over the next 10 years. The assessment was performed by technical personnel responsible for the management of the nuclear materials in their current storage locations. Independent technical experts reviewed the results of the assessment, which consisted of a series of questions to evaluate qualitatively the inherent physical stability of the material, the current and projected physical condition of its storage container, and the potential for release of the material to the environment.

Of the other evaluated materials not included in the Spent Fuel and Plutonium Working Group Reviews, only one poses an existing or potential concern. The SRS has approximately 228,000 liters (60,000 gallons) of highly enriched uranium (HEU) solutions stored in stainless-steel tanks inside and outside the H-Canyon. Because of the similarity of these solutions to those discussed above (i.e., they are radioactive and pose a criticality concern), DOE categorized these solutions as Candidates for Stabilization.

Although approximately 300,000 liters (78,000 gallons) of depleted uranium solutions are stored in stainless-steel tanks inside and outside F-Canyon and in the TNX Area, DOE categorized these materials as Stable. DOE did not consider these solutions to pose an environmental, safety, or health concern because they contain only trace quantities of fissile isotopes (uranium-235, plutonium-239, etc.) and represent a very low radiological hazard. DOE categorized as Stable all other nuclear materials within the scope of this EIS that are stored at the SRS; this included a wide variety of nuclear materials containing special isotopes used to support sitewide operations, such as laboratory samples used in experimental work and encapsulated sources used for the testing and calibration of equipment.

#### **1.4.2 Programmatic materials**

DOE categorized certain nuclear materials as Programmatic after consultations with national laboratories and other appropriate Federal agencies (e.g., NASA). These consultations identified plutonium-242, neptunium-237, americium, and curium (various isotopes) as necessary to support DOE programs and responsibilities.

At present, DOE uses plutonium-242 for research. In accordance with the Atomic Energy Act, specific details on the use of plutonium-242 are classified and restricted from unauthorized disclosure for the protection of national security. Appendix B (which is classified and therefore not included in this document) describes the need for and use of plutonium-242 for the DOE decisionmaker. The SRS has plutonium-242 solution stored in a stainless-steel tank in H-Canyon that requires processing and conversion to a form suitable for safe storage and subsequent use.

Neptunium is a target material irradiated in a nuclear reactor to produce plutonium-238. Plutonium-238 is a thermal power source for remote terrestrial and space applications where solar collectors or chemical batteries are not feasible. The SRS has the remaining domestic inventory of recovered neptunium-237, the bulk of which is in solutions stored in stainless-steel tanks in H-Canyon. These solutions contain neptunium-237 that was recovered from the processing of

irradiated highly enriched uranium fuels. In addition, the Site has a limited number of targets containing neptunium-237 that were designed for irradiation in the SRS reactors; with the shutdown of the reactors, these targets are no longer usable. To support the future production of plutonium-238, DOE must convert these materials to a form that it can store safely and use later to fabricate new targets.

The approximately 14,000 liters (3,700 liters) of solution stored in a single stainless-steel tank in F-Canyon represents a unique stockpile of americium and curium that DOE needs to support domestic and international research programs. DOE uses americium and curium isotopes in the production of californium-252, which is used as a neutron source for radiography and for nuclear medicine in the treatment of certain types of cancer. These isotopes are also used for research in basic chemistry, nuclear physics, and solid-state chemistry. The current inventory is stored in a single tank in F-Canyon and in unusable metal targets in the reactor disassembly basins. These forms require processing and conversion to produce a physical form that DOE can store safely for later use.

Table 1-1 summarizes the inventory of nuclear materials at the SRS in the Stable, Programmatic, and Candidate for Stabilizations categories of material. Appendix A contains a more detailed listing.

**Table 1-1. SRS nuclear materials.**

Description	Quantity	Location(s)
<b>Stable</b>		
Spent fuel	1,500 elements	Receiving Basin for Offsite Fuels
Unirradiated fuel, targets, reactor components, and scrap from fabrication operations	315,000 items	Buildings 305A, 313-M, 315-M, 320-M, 321-M, 322-M, and 341-M
Unirradiated fuel, targets, and reactor components	6,900 items	K- and L-Reactors
Unirradiated and irradiated reactor components and control rods	420 items	C-, K-, L-, and P-Reactors
Depleted uranium oxide	36,000 drums	R-Reactor, Buildings 221-1F, 221-12F, 221-21F, 221-22F, 707-R, 714-7N, 728-F, 730-F, and 772-7B
Depleted uranium solutions	300,000 liters (78,000 gallons)	F-Canyon, F-Area Outside Facilities, and TNX
Sources, standards, and samples	20,000 items	Sitewide
Laboratory materials used in research and development	260 items	Savannah River Technology Center
<b>Programmatic</b>		
Plutonium-242 solutions	13,000 liters (3,500 gallons)	H-Canyon

Americium and curium solutions	14,000 liters (3,800 gallons)	F-Canyon
Neptunium solutions and targets	6,100 liters (1,600 gallons) 9 targets	H-Canyon Building 321-M
<b>Candidates for Stabilization</b>		
Plutonium-239 solutions	34,000 liters (9,000 gallons)	H-Canyon
HEU solutions	228,000 liters (60,000 gallons)	H-Canyon and H-Area Outside Facilities
Plutonium vault materials	2,800 packages	FB-Line, HB-Line, Building 772-F, Building 235-F, and SRTC
Irradiated Mark-31 targets	16,000 slugs	K-Reactor, L-Reactor, and F-Canyon
Irradiated Mark-16 and Mark-22 fuels	1,900 assemblies	K-, L-, and P-Reactors and H-Canyon
Other irradiated targets	900 targets	K-, L-, and P-Reactors

[Figure 1-6](#) shows the relative mass of nuclear material in each category. As the figure reflects, the vast majority (more than 98 percent) of the stored mass of nuclear materials falls within the Stable category. The high percentage of stable material is heavily influenced by the fact that much of the material in the stable category is depleted uranium stored in approximately 36,000 drums and approximately 315,000 miscellaneous items left from the fabrication process for SRS reactor components (fuel, targets, etc.), which contain varying amounts of uranium.

[Figure 1-6.](#) Amount of nuclear material in each category.

## 1.5 Defense Nuclear Facilities Safety Board Review

The Defense Nuclear Facilities Safety Board (DNFSB) is an independent organization established by Congress to provide oversight of DOE. On May 26, 1994, the DNFSB transmitted Recommendation 94-1 to the Secretary of Energy (DNFSB 1994). In its recommendation, the Board stated:

The halt in production of nuclear weapons and materials to be used in nuclear weapons froze the manufacturing

pipeline in a state that, for safety reasons, should not be allowed to persist unremediated. The Board has concluded from observations and discussions with others that imminent hazards could arise within two to three years unless certain problems are corrected.

We are especially concerned about specific liquids and solids containing fissile materials and other radioactive substances in spent fuel storage pools, reactor basins, reprocessing canyons, processing lines, and various buildings once used for processing and weapons manufacture.

It is not clear at this juncture how fissile materials produced for defense purposes will eventually be dealt with long term. What is clear is that the extant fissile materials and related materials require treatment on an accelerated basis to convert them to forms more suitable for safe interim storage.

The DNFSB noted it was "especially concerned" about plutonium and transplutonium (americium, curium, etc.) solutions stored in tanks in F-Canyon and the deteriorating reactor fuel stored in the canyons and reactor basins. The DNFSB recommended "that an integrated program plan be formulated on high priority basis, to convert within two to three years the materials addressed in the specific recommendations below, to forms or conditions suitable for safe interim storage." The Board made the following specific recommendations relevant to nuclear materials stored at the SRS:

That preparations be expedited to process the dissolved plutonium and trans-plutonium isotopes in tanks in the F-Canyon at the Savannah River Site into forms safer for interim storage. The Board considers this problem to be especially urgent.

That preparations be expedited to repackage the plutonium metal that is in contact with, or in proximity to, plastic or to eliminate the associated existing hazard in any other way that is feasible and reliable. Storage of plutonium materials generated through this remediation process should be such that containers need not be opened again for additional treatment for a reasonably long time.

That preparations be expedited to process the deteriorating irradiated reactor fuel stored in basins at the Savannah River Site into a form suitable for safe interim storage until an option for ultimate disposition is selected.

In response to the Board's recommendation, DOE is developing an Integrated Program Plan to address each concern in parallel with this EIS. The Integrated Program Plan will contain detailed schedules and information on actions that DOE can take to alleviate the concerns raised by the DNFSB. This EIS evaluates the potential environmental impacts from actions that DOE is considering in response to SRS-related concerns raised by the Board.

## **1.6 Related National Environmental Policy Act Documents**

### **F-Canyon Plutonium Solutions Environmental Impact Statement**

On March 17, 1994, DOE published (59 FR 12588) its intention to prepare the Interim Management of Nuclear Materials EIS to assess the interim management of nuclear materials stored at the SRS. The original scope of this EIS included the plutonium solutions stored in the F-Canyon facility. In May 1994 the Manager of the Savannah River Operations Office recommended that the Assistant Secretary for Defense Programs seek alternative arrangements for compliance with the National Environmental Policy Act (NEPA) to allow stabilization of the plutonium solutions in F-Canyon and the Mark-31 targets stored in the L-Reactor Disassembly Basin. The recommendation was based on the determination that the material presents risks to workers, the public, and the environment in the form of radiation exposure from normal operations and potential accidents, which DOE could reduce by converting the material to a solid stable form. In June 1994 the DOE Office of Environment, Safety and Health performed an independent evaluation of the SRS request (DOE 1994d). That report characterized the following potential facility accidents to be

of serious concern: (1) the potential for inadvertent criticality due to precipitation of plutonium from the F-Canyon solutions, and (2) potential radiological releases to the environment due to leakage of plutonium solutions through vessel cooling coils. The report did not conclude that the Mark-31 targets would be a serious concern over the next 12 to 20 months. In light of this evaluation, DOE determined that the appropriate action would be to prepare a separate expedited EIS to evaluate management alternatives for the F-Canyon plutonium solutions. On August 23, 1994, DOE published in the *Federal Register* the notice of an amendment to announce the preparation of a separate EIS on these solutions. The Final EIS on F-Canyon Plutonium Solutions (DOE 1994e) became available on December 30, 1994. The Record of Decision was signed on February 1, 1995. The F-Canyon Plutonium Solutions EIS is relevant in the assessment of cumulative impacts that could occur at the SRS during the period examined by this Interim Management of Nuclear Materials EIS (see [Chapter 5](#)).

### **Programmatic EIS for storage and Disposition of Weapons-Usable Fissile Materials**

As announced in the *Federal Register* on June 21, 1994 (59 FR 31985), DOE is preparing this Programmatic EIS to evaluate the long-term storage of weapons-usable fissile materials, primarily plutonium-239 and highly enriched uranium, and the disposition of such materials that the President has declared surplus to national defense needs. As described above, the SRS has a large inventory of plutonium-239, highly enriched uranium, and other weapons-usable fissile materials that DOE will include in the scope of the Programmatic EIS. The Programmatic EIS is, therefore, related because it evaluates alternatives for some of the materials discussed in this EIS. However, the implementation of decisions resulting from the Programmatic EIS could require 10 years or more to complete. Therefore, interim decisions on stabilization and storage alternatives for weapons-usable fissile materials are necessary until DOE can reach and implement those long-term decisions.

### **Environmental Assessment for the proposed interim storage of Enriched Uranium above the maximum historical storage level at the Y-12 plant**

The SRS has a large inventory of nuclear materials containing highly enriched uranium that could be consolidated for interim storage at the Y-12 Plant in Oak Ridge, Tennessee. These materials include a large portion of the approximately 315,000 items that remain from the fabrication of new (unirradiated) fuel for SRS reactors, approximately 228,000 liters (60,200 gallons) of highly enriched uranium solutions stored in stainless-steel tanks in H-Area, and irradiated fuel from both SRS and offsite reactors. Current SRS operations are recasting and consolidating the unirradiated fuel and leftover materials that contain highly enriched uranium into forms suitable for transport and storage at the Y-12 Plant. The conversion of the highly enriched uranium solutions into a highly enriched uranium oxide is one of the management alternatives evaluated in this EIS, as is the dissolution and reprocessing of irradiated SRS reactor fuel to recover highly enriched uranium. The Draft Environmental Assessment on Uranium Storage at the Y-12 Facility (DOE 1994f) includes the transport and storage of SRS highly enriched uranium materials. Therefore, the Y-12 Environmental Assessment is related to this EIS. The Final Environmental Assessment is in preparation.

### **Savannah River Site Waste Management EIS**

On April 6, 1994, DOE issued a Notice of Intent in the *Federal Register* (59 FR 16194) to prepare an SRS Waste Management EIS, which will provide a basis for selecting a sitewide strategic approach to managing present and future wastes generated at the Site. These wastes would be generated by several activities including ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The Draft SRS Waste Management EIS (DOE 1995), which became available on January 27, 1995, 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 technology for the treatment of mixed waste. All the alternatives evaluated in this Interim Management of Nuclear Materials EIS will result in the generation of waste (high-level, transuranic, mixed, etc.). Thus, the SRS Waste Management EIS is related to this EIS because it evaluates management alternatives for various types of waste that actions proposed in this EIS could generate. The SRS Waste Management EIS is also relevant in the assessment of cumulative impacts that could occur at the SRS during the period examined by this EIS (see [Chapter 5](#)). The Record of Decision for the SRS Waste Management EIS is scheduled for mid-1995.

## **Defense Waste Processing Facility (DWPF) Supplemental EIS**

On April 6, 1994, DOE issued a Notice of Intent in the *Federal Register* (59 FR 16499) to prepare a Supplemental EIS on the Defense Waste Processing Facility (DWPF) to examine the impacts of completing construction and operating the DWPF at the SRS. This supplement to an EIS that DOE issued in 1982 will assist the Department in deciding whether and how to proceed with the DWPF in light of changes to processes and facilities that have occurred since the issuance of the 1982 EIS. The Final EIS (DOE 1994g) was issued in November 25, 1994. The Record of Decision is scheduled for spring 1995.

One of the alternatives considered for the stabilization of materials in this Interim Management of Nuclear Materials EIS is vitrification using the Defense Waste Processing Facility. The selection of this alternative would depend on a DOE decision to complete construction and operate the DWPF. All the alternatives evaluated in this EIS would result in the generation of radioactive waste that DOE would have to handle or treat at facilities described in the SRS Waste Management EIS and the DWPF Supplemental EIS. Appendix D describes the estimated amounts of generated waste. The DWPF Supplemental EIS is also relevant in the assessment of cumulative impacts that could occur at the SRS during the period examined by this EIS. These impacts have been included in the cumulative impact evaluation discussed in [Chapter 5](#).

## **Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF and INEL EIS)**

DOE is preparing this EIS (DOE 1994h) in compliance with the 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 Draft EIS was published in June 1994. The Final EIS and the Record of Decision will be completed by April 30, 1995, and June 1, 1995, respectively. Volume 1 of this EIS analyzes at a programmatic level the potential environmental impacts over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of DOE-owned spent nuclear fuel. Volume I will be the basis for deciding, on a programmatic level, the sites at which DOE will manage the various types of DOE-owned spent fuel. The Programmatic Spent Fuel EIS is related to this Interim Management EIS because they both include alternatives for spent fuel currently stored in the SRS reactor disassembly basins and the Receiving Basin for Offsite Fuels. Volume I of the programmatic spent fuel EIS is also relevant in the assessment of cumulative impacts that could occur at the SRS during the period evaluated by this EIS. These impacts have been included in the cumulative impact evaluation discussed in [Chapter 5](#).

## **Proposed Policy for the Acceptance of Foreign Research Reactor Spent Nuclear Fuel EIS**

On October 21, 1993, DOE announced its intent to prepare this EIS (58 FR 54336), which analyzes the acceptance of spent nuclear fuel containing uranium originally enriched in the United States from foreign research reactors (FRR). This action would be in support of U.S. nonproliferation policy. The Draft EIS is scheduled for release in the spring of 1995. A Record of Decision is scheduled for the late summer of 1995. The EIS on foreign research reactor spent fuel is related to this Interim Management EIS because both include alternatives involving the current inventory of highly enriched uranium fuels stored at the Receiving Basin for Offsite Fuels and the reactor disassembly basins at the SRS.

## **Environmental Assessment for the Operation of the HB-Line Facility and Frame Waste Recovery Process for Production of Pu-238 Oxide at the Savannah River Site**

DOE released a draft of this environmental assessment (DOE 1994b) in September 1994. The draft document addresses future operation of the HB-Line facility and the Frame Waste Recovery process at the SRS. These facilities process plutonium-238 for energy sources in support of space, scientific, and terrestrial missions. The final environmental assessment is scheduled for completion in early 1995. The environmental assessment is related to this EIS because it includes the portion of the current SRS inventory of plutonium-238 that DOE considers usable to meet its programmatic needs. This EIS deals with management alternatives for unusable scrap materials that contain plutonium-238. The environmental assessment is also related because it evaluates proposed actions that could occur at the SRS during the same period evaluated in this EIS. For this reason, it is relevant in the assessment of potential cumulative impacts (see [Chapter 5](#)).

## 1.7 Relationship of Decisions

Many of the materials that are Candidates for Stabilization in this EIS are included in the scopes of Programmatic EISs that DOE is preparing (see [Section 1.6](#)). These materials include spent fuel and weapons-usable fissile materials such as plutonium-239 or highly enriched uranium. The actions (other than No Action) being considered in this EIS involve either changing the physical form of the nuclear materials or the manner in which they are stored. DOE believes that any actions taken as a result of this EIS would be interim actions (within the context of the National Environmental Policy Act) that are warranted for safety reasons independently of programs for long-term management or disposition.

For example, the programmatic EIS on spent nuclear fuel management evaluates alternatives for spent nuclear fuel stored at various DOE sites nationwide. The programmatic spent fuel EIS supports decisions regarding where spent nuclear fuel will be stored until final disposition decisions are made. The Mark-31 and Mark-16/22 aluminum-clad targets and fuel stored at SRS are included in the inventory addressed by the programmatic EIS (less than 10 percent of the amount of fuel considered in the programmatic spent nuclear fuel EIS). The Mark-31 targets and Mark-16/22 fuel are also evaluated for stabilization in this EIS. DOE believes stabilization decisions for safety reasons of the fuel and targets at SRS can be made independently and would not influence where DOE would manage spent nuclear fuel from a programmatic perspective.

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## CHAPTER 2. ALTERNATIVES

This chapter identifies the alternatives that DOE has evaluated for each material type and identifies DOE's preferred alternatives. [Table 2-1](#) lists the alternatives. Although most of the alternatives evaluated in this EIS would rely on the use of existing facilities at the SRS, some would require new or modified facilities. This chapter identifies such facilities for each alternative, if applicable. Appendix C contains detailed descriptions of the facilities and their operations.

DOE has identified three broad categories of materials (i.e., Stable, Programmatic, and Candidate for Stabilization). In general, DOE proposes to maintain Stable material in its current form, convert Programmatic material to a safe and storable form to meet future needs, and stabilize material that presents a safety concern if storage in its existing form continues. A number of steps (i.e., phases) are associated with the implementation of any alternative (other than the No-Action Alternative). The description of each alternative in this chapter includes a chart that shows the sequence and approximate duration of the steps needed to implement it; the heavier line on each chart indicates the critical time path for that alternative.

### 2.1 Stable Material

DOE has determined that the condition of most nuclear material at the SRS is not likely to present a safety concern over the next 10 years and that such material is stable and suitable for continued storage. [Table A-1](#) lists each Stable material and specifies the facility in which DOE has stored it.

Because Stable material is suitable for continued storage, no actions are necessary to meet the purpose and need for this EIS. Therefore, the preferred alternative for Stable material is Continuing Storage (No Action). Under this alternative, such material would be managed in its existing form to maintain the health and safety of workers and the public.

DOE would maintain facilities in good working condition and would continue to provide utilities (water, electricity, steam, compressed gas, etc.) and services (security, maintenance, fire protection, etc.) for each facility. Training activities would ensure that appropriate personnel maintained the skills necessary to operate the facilities and equipment.

DOE would relocate, repackage, or recan the material as necessary to maintain safety. Relocation would include the movement of material to consolidate storage, allow maintenance, or respond to a safety concern. Repackaging would include placing material from a damaged storage container in a new container or placing the damaged container in a larger container. DOE could perform repackaging before damage to a container occurred if analyses concluded that damage was likely. Recanning, which would primarily involve fuel and targets, would entail placing damaged or degraded fuel in metal containers, sealing the containers, and placing them in storage. Sampling, destructive and nondestructive examination, weighing, visual inspections, and similar activities would determine the physical and chemical condition of the material. Existing solutions would require chemical adjustments to maintain their required concentration limits and chemistry controls. In addition, DOE would continue ongoing programs for the consolidation of highly enriched uranium, including the recasting of uranium fuel into ingots.

## 2.2 Programmatic Material

DOE has determined that some of the nuclear material at the SRS is needed to meet current or future program missions. The following paragraphs indicate the missions for such materials, which [Appendix A](#) describes in more detail:

- Plutonium-242 (Pu-242), which DOE would use in the nuclear weapons stockpile stewardship program. This program assures the safety and reliability of the existing nuclear weapons stockpile and Pu-242 is an essential and increasingly important part of the stockpile stewardship program. DOE has placed the information on the use and need for Pu-242, which is classified, in [Appendix B](#). This appendix is available for review by the DOE decisionmaker.
- Americium-243 and curium-244, which DOE would maintain as a national asset to support research in nuclear medicine, nuclear chemistry, solid-state chemistry, and nuclear physics.
- Neptunium-237, which DOE would use in the production of plutonium-238 to provide a power source for remote terrestrial and space applications.

None of the programmatic material is in a form that DOE could use to meet its program missions. As a result, DOE has evaluated an alternative(s) for each material that would convert it to a stable and storable form for future use in DOE programs.

Almost all of the programmatic material exists in solution form ([see Table 1-1](#)). The plutonium-242, americium-243 and curium-244, and neptunium-237 solutions at the Savannah River Site present the same environmental, safety and health concerns as the Site's other plutonium solutions; however, due to the quantity of plutonium-242, and americium-243/curium-244 isotopes stored in solution, they do not present a criticality hazard. Therefore, there is a need to stabilize these solutions independent of the program need. Future DOE decisions will determine if these materials will actually be used. The Record of Decision following the completion of the Interim Management of Nuclear Materials EIS will only determine what, if any, stabilization actions will be taken for these special materials.

### 2.2.1 PLUTONIUM-242

The SRS plutonium-242 that could be used to meet programmatic needs is stored in an aqueous solution in one tank in H-Canyon. DOE has evaluated the following alternatives for the conversion of this plutonium-242 to a form that meets the programmatic need:

#### · Processing to Oxide.



DOE would convert existing forms of plutonium-242 to an oxide by operating H-Canyon and HB-Line (Figure 2-1 shows key facilities within H-Area, including the H-Can

yon building in the center; the figure also shows the Defense Waste Processing Facility in the adjoining S-Area). Chemical separation activities would be conducted in the canyon as necessary to separate the plutonium-242 from impurities and radioactive decay products in the solution to prepare the material for conversion to a solid in HB-Line. Separated material other than plutonium-242 would be transferred from H-Canyon to the high-level waste tanks via underground pipes. The entire inventory of plutonium-242 solution in H-Canyon would be transferred through pipes to HB-Line where it would be converted to an oxide. The oxide would be packaged in steel containers and stored in an SRS vault. The material would be monitored and inspected during this storage period but the containers would be

opened only to satisfy a concern about safety, material accountability, etc. When the proposed oxide packaging capability in FB-Line or the proposed Actinide Packaging Facility became available (see [Appendix C](#)), the existing inventory of material would be evaluated to determine if any action was required to ensure that the material met the DOE standard for storage of plutonium oxides (DOE 1994a). If actions were required, the material would be transferred to the packaging facility, heated, and repackaged.

### **Vitrification (F-Canyon).**



DOE would modify a portion of F-Canyon to add a vitrification capability. DOE would create the vitrification facility by modifying an area inside the hot canyon

(see [Appendix C](#)). This modified area - the F-Canyon Vitrification Facility - would take about 3-1/2 years to complete. Most of the waste generated from the modification operations would be low-level radioactive waste, which DOE would dispose of in existing SRS disposal facilities. After the facility became operational, DOE would transfer oxide from H-Canyon (produced as described above for the Processing to Oxide Alternative) to F-Area and vitrify it in the F-Canyon Vitrification Facility. DOE would store the canisters in F-Canyon or a shielded vault. As a variation, DOE could transfer the plutonium-242 solutions to F-Area using an appropriate shipping container (truck or rail). At present, however, DOE does not have the capability to make such transfers. The issues of container certification and availability must be resolved. In F-Area, the material could be moved into F-Canyon by using a transfer line in the F-Area Outside Facilities east of the canyon or by bringing the shipping container into the canyon and transferring the solution or targets to process vessels. Other transfer methods could be utilized, such as introducing the material through FB-Line. When the material was in the facility, it would be processed by chemical separation, if required, to ensure the purity of the plutonium-242. The material would be chemically adjusted as required to meet the specifications for introducing the plutonium to the vitrification process. The material would be directed through intrafacility piping to the vitrification facility where the plutonium would be combined with molten glass, poured into steel containers, cooled, and placed in storage in the canyon or a shielded vault. High-level waste generated during these operations would be transferred to the F-Area high-level waste tanks.

### **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the plutonium-242 solutions until the completion of technical feasibility studies. These studies would be necessary to determine the potential magnitude of the plutonium-242 contribution to saltstone radioactivity and assess whether the resulting saltstone radioactivity would exceed permitted limits. When the studies were complete, DOE would adjust the solution chemically as necessary for discharge to the waste tanks and eventually vitrify the material at the proposed Defense Waste Processing Facility.

- **Continuing Storage (No Action).** DOE would continue to store the plutonium-242 solution in the H-Canyon tank. The activities discussed for stable material ([Section 2.1](#)) would be applicable.

DOE has identified Processing to Oxide as the preferred alternative because the SRS currently has the capability to convert the material to an oxide, and because the oxide form would meet the programmatic need. DOE reviewed conversion of the material to metal but determined it to be unreasonable for detailed analysis in the EIS. Converting the material to a metal would still require either the production of an oxide in HB-Line and then the additional steps of transferring the material to FB-Line where it would be redissolved and converted to a metal, or the transportation of liquid plutonium-242 to FB-Line. DOE determined that producing an oxide and then dissolving it to produce metal would add unwarranted environmental impacts because the oxide form would meet the programmatic need. DOE did not select transferring the plutonium-242 solution to FB-Line for conversion to metal because DOE has not developed a method to hold the plutonium-242 during transportation. DOE evaluated but did not select the Processing and Storage for Vitrification (Defense Waste Processing Facility) alternative because implementing this alternative would make the material unavailable to meet the programmatic need. The material would not be available because once it was

discarded to the high-level waste tanks, it would be mixed with all other waste and diluted to the point that it would be unrecoverable. DOE evaluated but did not select the Vitrification

(F-Canyon) alternative because of the additional steps required to convert vitrified plutonium-242 to a form usable to meet the programmatic need. To make the plutonium-242 usable after vitrification, DOE would have to chemically dissolve the glass, separate the plutonium, and convert the plutonium solution to an oxide or metal.

## 2.2.2 AMERICIUM AND CURIUM

About 14,000 liters (3,800 gallons) of americium and curium solution are stored in a single tank in F-Canyon ([Figure 2-2](#) shows F-Area with the F-Canyon building in the center). Americium and curium are feed materials in the DOE National Heavy Metal and Advanced Neutron Source Program that produces heavier transuranium elements such as californium-252. Californium-252 has a wide variety of medical, commercial, and defense-related uses, which include cancer treatment and treatment research, neutron radiography for nondestructive testing of metal parts in aircraft, and the online assay of coal and cement as a quality control function.

DOE has determined that to be suitable for eventual programmatic use the material should be converted to a solid form that could be transported to and used by the Oak Ridge National Laboratory (the DOE user). DOE would have to convert the americium and curium solution in F-Canyon to a solid to meet these programmatic uses.

DOE has identified the following alternatives for evaluation in considering conversion of the americium and curium material to meet programmatic needs:

- **Vitrification (F-Canyon).**



DOE would continue to store the material in F-Canyon while undertaking studies, design work, and modification of a portion of the canyon to add a vitrification capability. DOE would create the vitrification facility by modifying an area inside the hot canyon (see [Appendix C](#)). This modified area - the F-Canyon Vitrification Facility - would take about 3-1/2 years to complete. Most of the waste generated from the modification operations would be low-level radioactive waste, which DOE would dispose of in existing SRS disposal facilities.

**[Figure 2-2.](#)** F-Area.

After the facility became operational, DOE would process the existing americium and curium solution to remove impurities and radioactive decay products and chemically adjust the material as necessary to meet vitrification process feed requirements. Then the material would be transferred to the vitrification facility. DOE would vitrify the material, pour it into stainless-steel canisters, seal the canisters, and place them in storage at the SRS. DOE expects it would take about 6 months to vitrify the americium and curium solutions, producing about 40 canisters. The radiation level would be very high, about 90 rem per hour at 1 meter (3.2 feet) from a canister. High-level waste generated from chemical processing operations would be transferred to the F-Area high-level waste tanks.

- **Processing to Oxide.**



DOE would continue to store the material in F-Canyon while undertaking studies, design work, and modification of a portion of the canyon to add the capability

to process americium and curium to oxide. These modifications would take about 3-1/2 years to complete. A

problem associated with oxide production is that the operation of the process would be limited to batches of 500 grams (17.6 ounces). Larger quantities would cause self-heating of the material to an extent that would impede the oxide conversion process. At this rate, it would take about 2-1/2 years to convert all the americium and curium to oxide even if DOE operated the conversion facility 24 hours a day, 7 days a week. This operation would yield about 250 cans of americium and curium oxide. Another problem is that the americium and curium oxide would emit very high levels of radiation. Each can of oxide could produce radiation levels as high as 30 rem per hour at 1 meter (3.2 feet). As a result, all loading and packaging operations (which are normally performed by hand) would have to be accomplished remotely. Designs for this remote operation would be complicated and would be the factor of greatest uncertainty associated with the implementation of this alternative. In addition, DOE has not yet been able to identify a suitable container (the cask into which it could load the oxide cans) for storage and eventual shipment.

After the facility became operational, DOE would process the existing americium and curium solution to remove impurities and radioactive decay products and chemically adjust the material as necessary to meet the oxide conversion process feed requirements. Then the solution would be transferred through pipes inside the canyon to the oxidation facility. The material would be converted to an oxide, sealed in containers, and placed in appropriate storage canisters. The material would be stored in F-Canyon or transferred to a heavily shielded vault for storage. High-level waste generated during processing would be sent to the F-Area high-level waste tanks via underground pipes.

### **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the americium and curium solutions until the completion of technical feasibility studies. These studies would be necessary to determine

the potential magnitude of the americium and curium contribution to saltstone radioactivity and assess whether the resulting saltstone radioactivity would exceed permitted limits. When the studies were complete, DOE would adjust the resulting solution chemically as necessary for discharge to the waste tanks and eventually vitrify the material at the proposed Defense Waste Processing Facility.

· **Continuing Storage (No Action).** DOE would continue to store the americium and curium solution in F-Canyon. The activities discussed for stable material ([Section 2.1](#)) would be applicable.

DOE has identified Vitrification (F-Canyon) as the preferred alternative to convert the americium and curium solution. The construction of facilities for vitrification and oxide production would have roughly the same cost and would require the same time for completion. The vitrified material, however, would be more stable, less dispersible, and less leachable than oxide. The vitrification process would also produce fewer containers, which would be more suitable for transportation and storage, than the oxide process. DOE also expects container loading and handling procedures for the vitrified material to be less complex than those for oxide. Finally, DOE would complete the vitrification alternative about 2 years before the oxide alternative due to the operational limitations associated with oxide production.

DOE evaluated but did not select the Processing and Storage for Vitrification (Defense Waste Processing Facility) alternative because implementing this alternative would make the material unavailable to meet the programmatic need. The material would not be available because once it was discarded to the high-level waste tanks, it would be mixed with all other waste and diluted to the point that it would be unrecoverable. In addition, the increased radiation levels expected to be generated by introducing this material to the high-level waste tanks could be reduced only by diluting the waste volume with an additional one million gallons of liquid waste.

### **2.2.3 NEPTUNIUM-237**



Approximately 6,100 liters (1,600 gallons) of neptunium-237 solution are currently stored in H-Canyon storage tanks. In addition, nine neptunium targets are stored in M-Area. Neptunium-237 is used in the production of plutonium-238, the principal use of which is in thermal power generators in applications where solar power or chemical batteries are not practical, such as exploratory spacecraft. DOE has identified the following alternatives for evaluation in considering conversion of the neptunium-237 in targets and solution to a form that could be used to meet programmatic needs:

- **Processing to Oxide.**



DOE would begin by transferring the nine targets from M-Area to H-Canyon and dissolving them. This material would be processed through the canyon and added to th

e existing neptunium solution. DOE would perform chemical separation operations as required to remove radioactive decay products and other chemicals that could interfere with the oxide conversion process. The resulting neptunium solution would be transferred to the HB-Line through intrafacility pipes and converted to neptunium oxide. The radioactive decay products and other material would be transferred through underground pipes to the high-level waste tanks. The oxide would be put in shielded containers and placed in storage in an F-Area vault. When the proposed Actinide Packaging Facility became available or the proposed FB-Line modifications for oxide packaging were completed (see [Appendix C](#)), any material that had not been used for programmatic purposes would be heated and repackaged if required to ensure long-term stability.

- **Vitrification (F-Canyon).**



DOE would continue to store the material in H-Canyon. During this time, DOE would complete the necessary technical evaluation to determine the feasibility of o

btaining a container that would enable the shipment of neptunium solutions across the SRS. In addition, DOE would undertake the studies, design work, and required equipment changes to provide the capability to vitrify neptunium-237 in F-Canyon (see [Appendix C](#)). Then DOE would transfer the neptunium-237 targets and solution to F-Canyon or FB-Line, using an appropriate shipping container (truck or rail). At present, DOE does not have the capability to make such transfers. The issues of container certification and availability must be resolved. In F-Area, the material could be moved into F-Canyon by using a transfer line in the F-Area Outside Facilities east of the canyon or by bringing the shipping container into the canyon and transferring the solution or targets to process vessels. Other transfer methods could be utilized, such as introducing the material through FB-Line. When the material was in the facility, it would be processed by chemical separation, if required, to ensure the purity of the neptunium-237. The material would be chemically adjusted as required to meet the specifications for introducing the neptunium to the vitrification process. The material would be directed through intrafacility piping to the vitrification facility where the neptunium would be combined with molten glass, poured into steel containers, cooled, and placed in storage in the canyon or a shielded vault. High-level waste generated during these operations would be transferred to the F-Area high-level waste tanks.

### **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the neptunium solutions until the completion of technical feasibility studies. These studies would be necessary to determine the pote

ntial magnitude of the neptunium contribution to saltstone radioactivity and assess whether the resulting saltstone radioactivity would exceed permitted limits. When the studies were complete, DOE would adjust the resulting solution chemically as necessary for discharge to the waste tanks and eventually vitrify the material at the proposed Defense Waste Processing Facility.

· **Continuing Storage (No Action).** DOE would continue to store the neptunium solution in H-Canyon and the targets in M-Area or another suitable storage facility on the Site. The no-action activities discussed for stable material ([Section 2.1](#)) would be applicable for the neptunium.

DOE has determined that the preferred alternative for neptunium-237 is Processing to Oxide because the existing technology for the production of plutonium-238 is based on the use of neptunium-237 targets, which use neptunium oxide as a raw material. Although the targets in M-Area are in an oxide form, they were fabricated originally to be irradiated in the SRS reactors and cannot be used anywhere else in their current form. The SRS reactors are no longer operating. Processing the targets would place the material in a form such that future users of the material (e.g., Oak Ridge National Laboratory) could fabricate the type of target required for their plutonium-238 production process. The Processing to Oxide Alternative would use existing SRS capabilities to produce a product that met programmatic needs. The Vitrification (*F-Canyon*) alternative was not selected because of unresolved technical issues concerning the shipment of neptunium in liquid form and because dissolution and chemical recovery operations would be required after vitrification to enable the use of the material to fabricate targets. DOE evaluated but did not select the Processing and Storage for Vitrification (Defense Waste Processing Facility) alternative because implementing this alternative would make the material unavailable to meet the programmatic need. The material would not be available because once it was discarded to the high-level waste tanks, it would be mixed with all other waste and diluted to the point that it would be unrecoverable.

## 2.3 Candidate Materials for Stabilization

DOE would stabilize a material if its physical form or storage configuration was a safety concern, or if it could become a safety concern within the next 10 years. DOE evaluated a range of alternative stabilization methods for each category of nuclear material, and used the following criteria to select the alternative stabilization methods for evaluation:

- The product of the proposed action should be stable over a reasonable period of time to prevent the need to restabilize the material.
- The stabilization method should involve a technology that would enable the initiation of stabilization actions as quickly as practical and within the period covered by this EIS.

After applying these criteria, DOE selected Processing to Metal, Processing to Oxide, Blending Down to Low Enriched Uranium, Processing and Storage for Vitrification (Defense Waste Processing Facility), Vitrification (F-Canyon), and Improving Storage as reasonable alternative stabilization methods for evaluation in addition to the No-Action Alternative.

DOE has identified a preferred alternative to stabilize the material in each category. Sections [2.4](#) and [2.5](#) summarize the results of the DOE evaluation, which concluded there were no significant differences in environmental impacts among the alternatives. DOE selected the preferred alternative in each material category that would achieve stabilization quickly, emphasizing the use of proven technology and existing facilities.

### 2.3.1 H-CANYON PLUTONIUM-239 SOLUTIONS

Approximately 34,000 liters (9,000 gallons) of plutonium nitrate solutions are stored in stainless-steel tanks in the H-Canyon facility. DOE has identified the following alternatives for management of these solutions:

## · **Processing to Oxide.**



DOE would process the plutonium-239 solution by operating H-Canyon as necessary to remove radioactive decay products and other impurities that would interfere with subsequent stabilization steps. No actions would occur to achieve a specific purity for the plutonium in the solution other than those necessary to operate the process. DOE would transfer the separated impurities to the H-Area high-level waste tanks, and would transfer the plutonium solution to the HB-Line for conversion to an oxide. DOE would place the oxide in storage containers, load the containers in shipping containers, and transport the material to F-Area for storage. In parallel with this effort, DOE would modify a portion of the existing FB-Line to provide the capability to package plutonium oxide in a manner that met the storage criteria the Department has established for plutonium oxides (DOE 1994a). A glovebox would be added to FB-Line to enable the oxide to be heated and packaged in a nonreactive atmosphere without the use of plastic wrapping material. After the completion of the FB-Line modifications, DOE would transfer the plutonium oxide to that facility, heat it to meet long-term storage criteria, package it, and transfer it to a storage vault in F-Area.

If it determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, DOE would begin work on the proposed Actinide Packaging Facility (see [Appendix C](#)); this would occur in parallel with plutonium conversion activities, but the facility would take about 8 years to complete and begin operations.

The Actinide Packaging Facility or the modifications to FB-Line would provide the capability to package plutonium oxide (or plutonium metal) to meet recent Departmental recommendations for the safe storage of plutonium metal and oxides (DOE 1994a). For plutonium oxides, the recommended packaging criterion is that the material be heated to achieve a condition where less than 0.5 percent of the weight of the material is lost by subsequent heating (over a specified time period) and that, following the heating step, the material is cooled and packaged for storage in a nonreactive atmosphere so the benefits of the heating step are retained. The purpose of these actions is to minimize the amount of gas generated within the container used to store the material because the gas has the potential to pressurize, and occasionally cause failure of, a storage container. Gas, normally oxygen and hydrogen, could be generated from the decomposition of water molecules by the radiation given off by the plutonium. The new heating and packaging steps would substantially reduce the amount of moisture in the plutonium oxide, thus reducing potential gas generation. For metal, the criterion is to package the material in a nonreactive atmosphere with no contaminants such as plastic wrapping. The existing B-Line facilities at the SRS (where packaging traditionally occurred) do not have the equipment required to accomplish these new steps.

## · **Processing and Storage for Vitrification (Defense Waste Processing Facility).**



DOE would continue to store the H-Canyon plutonium solution until ready to discharge it to the H-Area high-level waste tanks. The material would even

tually be vitrified at the proposed Defense Waste Processing Facility (DWPF).

The DWPF was designed to process 132.5 million liters (35 million gallons) of high-level waste (currently stored in F- and H-Area waste tanks) into a glass material encased in stainless-steel cylinders that would be suitable for disposal in a geologic repository. The first step for vitrifying the H-Canyon plutonium solutions would be to transfer the solutions to the high-level waste tanks, which will feed the DWPF. Before transfer, DOE would adjust the solutions to ensure the nuclear criticality safety of the material in the tanks. DOE has identified several concepts for such adjustments: diluting the solutions with water and chemicals to achieve very low fissile material concentrations, diluting the solutions with depleted uranium, or adding iron and manganese or other neutron poisons such as gadolinium (DOE 1994b). After transfer to the waste tanks, the material would be stored and eventually transferred to the DWPF for vitrification.



DOE would have to address many technical issues to demonstrate the feasibility of this stabilization method. For example, a detailed safety analysis would be performed to evaluate and develop controls to prevent an inadvertent nuclear criticality accident. This type of accident could occur if the fissile material, without adequate neutron poison, precipitated during or after the transfer to the waste tanks. A complete evaluation of the capability of the proposed Defense Waste Processing Facility to process fissile material-bearing high-level waste would be required because the original vitrification process was not designed to handle significant quantities of fissile material. In addition, DOE would have to review the availability of sufficient space in the waste tanks and incorporate impacts into established plans and schedules for consolidating and processing the material in the tanks and retiring older tanks from service. Because of these complex issues, DOE estimates it would need approximately 6 years to perform the technical studies, training, and qualification efforts necessary to ensure safe operations for the transfer of the solution for subsequent vitrification. Then DOE would need 3 years or more to transfer the solutions to the high-level waste tanks because of the availability of tank space and nuclear criticality concerns. The actual vitrification of fissile material solutions in the DWPF would not start within the 10-year period evaluated in this EIS. However, the annual impacts from the work associated with the vitrification process are presented in [Appendix D](#).

#### · **Vitrification (F-Canyon).**



DOE would complete the necessary technical evaluation to determine if it would be feasible to obtain a container suitable to enable the shipment of plutonium solutions across the SRS. At present, DOE does not have the capability to make such transfers. The issues of container certification and availability must be resolved. In addition, DOE would undertake the studies, design work, and equipment changes required to provide the capability to vitrify plutonium in F-Canyon (see [Appendix C](#)). Then DOE would transfer the H-Canyon plutonium solution to F-Canyon or FB-Line, using an appropriate shipping container (truck or rail). In F-Area, the material could be moved to F-Canyon by using a transfer line in the F-Area Outside Facilities east of the canyon or by bringing the shipping container into the canyon and transferring the solution to process vessels. Other transfer methods could be used, such as introducing the material through FB-Line. When the material was in the facility, it would be processed by chemical separation and chemically adjusted as required to meet the specifications for introducing the plutonium to the vitrification process. The material would be directed through intrafacility piping to the vitrification facility where the plutonium would be combined with molten glass, poured into stainless-steel canisters, cooled, and placed in storage in the canyon or a shielded vault. High-level waste generated during these operations would be transferred to the F-Area high-level waste tanks.

#### · **Processing to Metal.**



DOE would complete the necessary technical evaluation to determine the feasibility of obtaining a container that would enable the shipment of plutonium solutions across the SRS. At present, DOE does not have the capability to make such transfers. The issues of container certification and availability must be resolved. Then DOE would transfer the H-Canyon plutonium solution to F-Canyon or FB-Line, using an appropriate shipping container (truck or rail). In F-Area, the material could be moved into F-Canyon by using a transfer line in the F-Area Outside Facilities east of the canyon or by bringing the shipping container into the canyon and transferring the solution to process vessels. Other transfer methods could be used, such as introducing the material through FB-Line. When the material was in the facility it would be processed via chemical separation as required to meet the specifications for introducing the plutonium to FB-Line. No actions would occur to achieve a specific purity for this material other than those necessary to operate the process. The solution would be transferred through the FB-Line process equipment and converted to metal buttons. The buttons would be packaged and stored in an F-Area vault. Any high-level waste generated during this process would be transferred to the F-Area high-level waste tanks. In parallel with this effort, DOE would begin modifications to FB-Line to provide the capability to package plutonium metal in accordance with the Departmental plutonium storage standard (DOE 1994a). A glovebox would be added to the FB-Line facility to enable the material to be packaged in a nonreactive atmosphere without the use of plastic wrapping material. After the modifications, DOE would transfer the plutonium metal there and package it to meet DOE storage requirements for plutonium metal (i.e., the metal would be cleaned and repackaged in a nonreactive atmosphere and sealed in a container). The packaged

material would be placed in an F-Area vault.

If DOE determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, DOE would begin work on the proposed Actinide Packaging Facility; this would occur in parallel with plutonium conversion activities, but the facility would take about 8 years to complete and begin operations.

- **Continuing Storage (No Action).** DOE would continue to store the plutonium-239 solution in H-Canyon. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for this solution.

DOE's preferred alternative is Processing to Oxide because it would rely the most on proven technology and processes and existing facilities, and because it would achieve the most important step of the stabilization process (i.e., conversion to a solid) 1 year sooner than any other alternative. The Vitrification (F-Canyon) and the Processing to Metal Alternatives were not selected because of the implementation time and unresolved technical issues associated with shipping plutonium in liquid form. DOE did not select the Processing for Storage and Vitrification (Defense Waste Processing Facility) Alternative because it could not begin the stabilization activity within the next 10 years and because of the technical uncertainties associated with processing significant quantities of fissile material through the DWPF.

DOE did not consider alternatives that would improve the methods of storing the solutions (beyond that of the No-Action Alternative) as reasonable because the material would not be in a stabilized form.

### 2.3.2 H-CANYON URANIUM SOLUTION

There are approximately 228,000 liters (60,000 gallons) of enriched uranium nitrate solutions in stainless-steel tanks both inside and outside the H-Canyon facility. DOE has identified the following alternatives for management of these solutions.

- **Blending Down to Low-Enriched Uranium.**



Before stabilizing the enriched uranium, DOE would process the solutions through H-Canyon to separate the enriched uranium from the other material in the solution (e.g., radioactive decay products normally present in irradiated fuel). The decay products would be highly radioactive and DOE would not be able to introduce it to the uranium processing equipment because of the hazard it would present to workers. DOE would transfer the radioactive decay products and other material to the H-Area high-level waste tanks. DOE would stabilize the highly enriched uranium solution (comprising approximately 60 percent uranium-235) by converting the material to uranium oxide.

The FA-Line is the only SRS facility designed to produce uranium oxide, but it was not designed to produce oxide from solutions of highly enriched uranium. To use the FA-Line, DOE would dilute the uranium-235 solution with existing depleted uranium oxide. DOE would accomplish this by dissolving the depleted uranium oxide in FA-Line. DOE would transport the depleted uranium solution to H-Canyon by truck and blend it with the enriched uranium solution to achieve a diluted solution of uranium-235. DOE would transport the mixture back to FA-Line by truck and convert it to low-enriched uranium oxide. The final product would be loaded into 208-liter (55-gallon) drums for storage. DOE would make minor modifications in F- and H-Areas to enable truck-trailer loading and unloading and to install a spare oxide dissolver at FA-Line. In addition, DOE would construct a storage facility with an area of approximately 186 square meters (2,000 square feet) on previously disturbed land in the industrialized F-Area to handle the drums of uranium oxide.

A variation of this alternative would be to transport the uranium solution from H-Area to F-Area by rail or truck using an appropriate shipping container. FA-Line would be used to dissolve depleted uranium oxide and blend it with the uranium solution from H-Area to achieve a low-enriched uranium solution. Blending operations could occur in F-Canyon process vessels or in F-Area Outside Facility tanks. The facility modifications and the storage facility described above would be required.

- **Processing to Oxide (Uranium Solidification Facility).**



DOE would continue to store the enriched uranium solution in H-Canyon while completing construction of the Uranium Solidification Facility in the canyon. After construction, DOE would use the H-Canyon process to remove radioactive decay products and other material from the solution and would transfer the solution to the Uranium Solidification Facility using intrafacility piping. DOE would process the solution to highly enriched uranium oxide, place the oxide in containers, and store the containers in a vault.

- **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the H-Canyon uranium solution until it was ready for transfer to the H-Area high-level waste tanks. Before the transfer, DOE would adjust the solution to ensure the safety of the material already in the tanks. The material would be vitrified at the proposed Defense Waste Processing Facility. Criticality concerns similar to those described in [Section 2.3.1](#) would exist for this alternative.

- **Continuing Storage (No Action).** DOE would continue to store the uranium solution in H-Canyon. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for this solution.

DOE's preferred alternative is Blending Down to Low-Enriched Uranium because it would achieve stabilization at least 2 years faster than any other alternative and would use existing facilities and equipment with only minor modifications. Construction of the new storage facility would not be critical to the completion of this alternative because DOE would store any drums of low enriched uranium oxide in other facilities on a temporary basis until it had completed the new storage facility. DOE did not select Processing to Oxide (Uranium Solidification Facility) because it would require the construction of a new facility, and stabilization could not occur until the completion of construction and the subsequent staffing, training, and readiness review activities. DOE did not select the Processing for Storage and Vitrification (Defense Waste Processing Facility) Alternative because it could not begin the stabilization activity within the next 10 years and because of the technical uncertainties associated with processing significant quantities of fissile material through the proposed Defense Waste Processing Facility.

DOE did not evaluate Processing to Metal in detail because this capability does not exist at the SRS (facilities would have to be modified or constructed); in addition, because the oxide form is stable, there would be no advantage to producing uranium metal. DOE did not evaluate Improving Storage because this method would be viable only for material already in solid form.

### 2.3.3 PLUTONIUM AND URANIUM STORED IN VAULTS

The material in this category is currently stored in about 3,000 containers, most of which are small cans in either the Building 235-F vault or the FB-Line vault. The material includes alloys, compounds, oxides, large metal pieces such as buttons and ingots, and metal fragments, and consists predominantly of plutonium-239 with some uranium-235.

DOE anticipates that the material would fall into one of two categories. The first would be material for which DOE could achieve stabilization by simply heating and repackaging to meet the long-term storage criteria (DOE 1994a). The material in this category would generally be lower in chemical contaminants and higher in the percentage of fissile material; examples include plutonium metal (such as buttons) and plutonium and uranium oxides, which are essentially in product form. The other category of material would require some type of processing action to achieve stabilization. The material in this category would be higher in chemical contaminants (such as reactive calcium and fluorides) and lower in the percent of fissile material; examples include plutonium compounds, metal fragments, and plutonium and uranium oxides that are residual material from past production activities. DOE believes about half of all the containers hold material that would require only heating and repackaging; the remaining material would require a stabilization activity that involves processing. DOE has identified Continuing Storage (No Action), Improving Storage, Processing and Storage for Vitrification in Defense Waste Processing Facility, Processing to Oxide, Processing to Metal, and Vitrification (F-Canyon) as alternatives for the management of this material.

#### · **Improving Storage.**



DOE would upgrade its container inspection capability by installing new equipment in an existing facility such as FB-Line; this would consist of installing digital radiography screening equipment and other assay equipment to assess the condition of the material and the containers. DOE would transfer the containers to the inspection area to determine the condition of the material. Material determined to require processing before repackaging would be returned to storage until processing activities could be initiated. Material determined to require only repackaging would be returned to storage until the repackaging facility was completed.

In parallel with these inspection activities, DOE would begin work to provide the capability to meet the Departmental plutonium storage standard (DOE 1994a) in FB-Line. A glovebox would be added to heat plutonium oxide and to package oxide and metal in a nonreactive atmosphere without the use of plastic wrapping material. After the modifications were completed, DOE would transfer the plutonium oxide there for packaging. The packaged material would be placed in a SRS vault. High-level waste from these processing operations would be sent to the F-Area high-level waste tanks.

If DOE determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, DOE would begin work on the proposed Actinide Packaging Facility. This would be accomplished in parallel with plutonium inspection and characterization activities, but the facility would take about 8 years to complete and begin operations. Any plutonium oxide that had not been packaged to meet the DOE plutonium storage criteria (DOE 1994a) would be transferred to the facility and repackaged.

#### · **Processing to Oxide.**



DOE would transfer potentially unstable oxide or metal from storage to HB-Line or H-Canyon. DOE would dissolve the material in one of the HB-Line or H-Canyon dissolvers and process it as required in the canyon to separate the plutonium from the uranium and other impurities that contributed to the stability concerns. The plutonium would be processed through HB-Line to produce an oxide, which would be placed in a vault for storage. No actions would occur to achieve a specific purity for this material other than those necessary to operate the process. The uranium would be diluted to low enrichment, converted to an oxide, and packaged as described for the H-Canyon Uranium Solutions (see [Section 2.3.2](#)). As a variation, the uranium could be chemically adjusted and transferred to the H-Area high-level waste tanks. The amount of fissile material involved in this transfer would be small, obviating the criticality concerns described for the Processing and Storage in the Defense Waste Processing Facility Alternative. In parallel with this effort, DOE would begin work to provide the capability to meet the Departmental plutonium storage standard (DOE 1994a) in FB-Line. A glovebox would be added or modified to heat and package the material in a nonreactive atmosphere without the use of plastic wrapping material. After the modifications, DOE would transfer the plutonium oxide there for packaging. The packaged material would be placed in an F-Area vault. High-level waste from these

processing operations would be sent to the H-Area high-level waste tanks.

If DOE determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, it would begin work on the proposed Actinide Packaging Facility. This would be accomplished in parallel with oxide conversion activities, but the facility would take about 8 years to complete, and begin operations. Any plutonium oxide that had not been packaged to meet the DOE plutonium storage criteria (DOE 1994a) would be transferred to the facility and repackaged.

### **Processing to Oxide.**



DOE would transfer potentially unstable oxide or metal from storage to F-Canyon or FB-Line, dissolve the material in one of the F-Canyon or FB-Line dissolvers, and process it as required in the canyon to separate the plutonium from the uranium and other impurities that contributed to the stability concerns. The plutonium would be processed through the FB-Line to produce plutonium metal, which would be packaged and placed in a vault for storage. No actions would occur to achieve a specific purity for this material other than those necessary to operate the process. The uranium would be processed to low enrichment by blending it with depleted uranium using FA-Line and F-Canyon process vessels or F-Area Outside Facilities tanks, as described for the H-Canyon Uranium Solutions (see [Section 2.3.2](#)). As a variation, the uranium could be chemically adjusted and transferred to the F-Area high-level waste tanks. The amount of fissile material involved in this transfer would be small, obviating the criticality concerns described for the Processing and Storage in the Defense Waste Processing Facility Alternative. In parallel with this effort, DOE would begin work to provide the capability to meet the Departmental plutonium storage standard (DOE 1994a) in FB-Line. A glovebox would be added or modified to package the material in a nonreactive atmosphere without the use of plastic wrapping material. After the modifications, DOE would transfer the plutonium metal there for packaging. The packaged material would be placed in an F-Area vault. High-level waste from these processing operations would be sent to the H-Area high-level waste tanks.

If DOE determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, it would begin work on the proposed Actinide Packaging Facility. This would be accomplished in parallel with plutonium conversion activities, but the facility would take about 8 years to complete, and begin operations. Any plutonium metal that had not been packaged to meet the DOE plutonium storage criteria (DOE 1994a) would be transferred to the facility and repackaged.

### **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would store the material until it was ready to transfer it to the F- or H-Area high-level waste tanks. In preparing the material for transfer to the waste tanks, DOE would move it to FB-Line or F-Canyon or to HB-Line or H-Canyon and dissolve it. DOE would adjust the solution to ensure the safety of the material in the waste tanks and then would transfer the material to the F- or H-Area high-level waste tanks. The material would be vitrified at the proposed Defense Waste Processing Facility. The difficulties associated with this alternative are the same as those described in [Section 2.3.1](#)

### **Vitrification (F-Canyon).**



DOE would store the potentially unstable oxide and metal until the proposed F-Canyon Vitrification Facility was available. Then the material would be transferred to F-Canyon or FB-Line and dissolved and processed in the canyon to separate the plutonium and uranium and other impurities. The plutonium would be chemically adjusted as required to achieve the feed specifications for vitrification and then vitrified. The resulting glass product in stainless-steel canisters would be stored in F-Canyon or a vault. The uranium would be processed to low enrichment by blending it with depleted uranium using FA-Line and F-Canyon process vessels or F-Area Outside Facilities tanks, as described



in [Section 2.3.2](#).

As a variation, the uranium could be chemically adjusted and transferred to the F-Area high-level waste tanks. The amount of fissile material involved in this transfer would be small, obviating the criticality concerns described for the Processing and Storage in the Defense Waste Processing Facility Alternative. Any high-level waste associated with this alternative would also be sent to the F-Area high-level waste tanks.

**Continuing Storage (No Action).** DOE would continue to store the plutonium solids in a vault. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for these solids.

DOE proposes Improving Storage and Processing to Metal as the preferred alternatives for stabilizing this material. As mentioned above, DOE believes that about half the containers hold material for which the Improving Storage Alternative would be applicable. The material in the remaining containers would be stabilized by the Processing to Metal Alternative. DOE would use the Processing to Metal Alternative because it would achieve stabilization about 18 months sooner than Vitrification (F-Canyon) and about 2 years more quickly than Processing to Oxide. In addition, the metal alternative would rely the most on the use of existing capability and technology. The alternative of vitrification in the Defense Waste Processing Facility was not selected because stabilization activity could not be initiated within the next 10 years (or more) due to the technical issues and the inventory of existing high-level waste that would have to be vitrified first.

## 2.3.4 MARK-31 TARGETS

Approximately 16,000 metal targets are stored in water-filled basins in K- and L-Areas and the F-Canyon. These aluminum-clad targets contain depleted uranium, plutonium-239, and fission products. DOE has identified the following reasonable alternatives for the interim management of these targets:

### Processing to Metal.



DOE would load the targets from the disassembly basins into large casks, load the casks on SRS rail cars, and transport them to F-Canyon, where it would load the targets in a dissolver tank and dissolve the targets. Then DOE would use the PUREX process to separate the plutonium solution from depleted uranium, fission products, and other impurities. DOE would process the depleted uranium to oxide in FA-Line and store it in F-Area, and would process the plutonium to metal in FB-Line. No actions would occur to achieve a specific purity for this material other than those necessary to operate the process. DOE would place the metal in containers and store the containers in a vault. In parallel with this effort, DOE would modify a portion of the existing FB-Line to provide the capability to package plutonium metal in a manner that met the storage criteria the Department has established for plutonium (DOE 1994a). A glovebox would be added to FB-Line to enable the metal to be packaged in a nonreactive atmosphere without the use of plastic wrapping material. On completing the modification to the FB-Line, DOE would repackage the material to meet the long-term storage criteria for plutonium metal.

If DOE determined that it could not modify the FB-Line to provide the proper packaging capability or the capability for future inspection and packaging maintenance, DOE would begin work on the proposed Actinide Packaging Facility; this would occur in parallel with plutonium conversion activities, but the facility would take about 8 years to complete and begin operations.

### Processing to Oxide.



DOE would load the targets from the disassembly basins into casks, load the casks on SRS rail cars, and transport them to F-Canyon, where it would load the targets in a dissolver tank and dissolve the targets. Then DOE would use the PUREX process to separate the plutonium solution from depleted uranium, fission products, and other impurities. DOE would modify the FB-Line to support conversion of the plutonium solutions to plutonium oxide and to package the material for storage. No actions would occur to achieve a specific purity for the material other than those necessary to operate the process. DOE would produce a material form and packaging configuration that met the DOE standard for long-term storage of plutonium oxide (DOE 1994a). DOE would process the depleted uranium to an oxide in FA-Line and store the material in F-Area. Any high-level waste from these processing activities would be transferred to the F-Area high-level waste tanks.

If the extent of the FB-Line modifications necessary to meet the DOE plutonium storage standard were economically or physically impractical (i.e., too expensive or not enough space for the equipment required), the Department would perform the stabilization effort in two phases. DOE would convert the material initially to an oxide form and package it in FB-Line. In parallel, DOE would construct the proposed Actinide Packaging Facility. The oxide initially produced would be stored in a vault until the new facility was available. DOE estimates the minimum required modifications to FB-Line would take about 3 years to complete. DOE expects the Actinide Packaging Facility would be available in approximately 8 years.

DOE considered two other variations of this alternative. DOE could dissolve the Mark-31 targets in H-Canyon and process the resulting plutonium solutions into an oxide in HB-Line. This variation would require modification of the HB-Line to provide the capability to package the resulting oxide in accordance with the DOE standard for long-term storage of plutonium. Approximately 3 years would be required to make the necessary modifications. However, even if DOE modified HB-Line, the volume of depleted uranium contained in the Mark-31 targets as compared to the capacity of H-Canyon to dissolve and process, would require the operation of H-Canyon for over 30 years.

As another variation, DOE could dissolve the Mark-31 targets in F-Canyon, transport the resulting plutonium solutions to H-Canyon, and convert the plutonium to an oxide using HB-Line. Approximately 1 year would be required to modify the H-Canyon and F-Canyon facilities to provide the capability to load and unload the solutions into a transport container. DOE does not currently have a container designed to transport liquid plutonium, but is exploring the availability of such a container internationally. As in the variation described above, approximately 3 years would be required to modify HB-Line to provide the capability to package the oxide in accordance with the DOE standard. It would take over 6 years to convert the solutions to an oxide in HB-Line, as opposed to approximately 1 year in a modified FB-Line with the same capability. Some of the necessary facility modifications and dissolution operations could take place in parallel. However, even if DOE can find or develop a container suitable for transport of the plutonium solutions, the total time required to convert and package the plutonium contained in the Mark-31 targets into an oxide using this variation would be over 9 years (as opposed to 4 years using a modified FB-Line). For the above reasons, DOE did not consider these two variations to be reasonable oxide alternatives and warrant detailed analysis.

#### · **Improving Storage.**

DOE would move all Mark-31 targets to the L-Reactor Disassembly Basin and continue to store them there while it constructed a new Dry Storage Facility. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for these targets during the time DOE was constructing the new facility.

#### · **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the Mark-31 targets until it was ready to transfer material to the high-level radioactive waste system. DOE would process the existing depleted uranium solutions in F-Canyon through the FA-Line to make room for processing the Mark-31 targets. The resulting depleted uranium oxide would be loaded in 208-liter (55-gallon) drums and placed in storage. In F-Canyon, DOE would dissolve the targets and then process the material to separate the plutonium from the depleted uranium. Then, rather than transferring the plutonium solution to FB-Line, DOE would poison, concentrate, and neutralize the solution and discharge the mixture to the F-Area high-level waste

tanks. DOE would vitrify the material at the proposed Defense Waste Processing Facility; the difficulties associated with this process would be the same as those described in [Section 2.3.1](#) for the H-Canyon plutonium solutions. The depleted uranium would be converted to an oxide in FA-Line, packaged, and placed in storage. The high-level waste generated during the chemical separation and chemical adjustment operations would be sent to the F-Area high-level waste tanks.

- **Vitrification (F-Canyon).**



DOE could use the proposed F-Canyon Vitrification Facility to vitrify the plutonium in the Mark-31 targets. DOE would continue to store the material until the new facility was available. Then the material would be transferred to F-Canyon and dissolved. The material would be processed to separate the depleted uranium from the plutonium, and the plutonium would be vitrified. The depleted uranium solution would be converted to depleted uranium oxide in FA-Line. Any high-level waste from these operations would be transferred to the F-Area high-level waste tanks.

- **Continuing Storage (No Action).** DOE would continue to store the Mark-31 targets in the water-filled basins. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for these targets.

DOE's preferred alternative is Processing to Metal. DOE anticipates that it would complete the stabilization activity in about 2-1/2 years, as opposed to 4 years for the Oxide Alternative and 4-1/2 years for the Vitrification (F-Canyon) Alternative. In addition, the Processing to Metal Alternative would rely the most on previously operated systems, equipment, and facilities. The Vitrification via the Defense Waste Processing Facility Alternative was not selected because stabilization activity could not be initiated within the next 10 years (or more) due to the technical issues and the inventory of existing high-level waste that would have to be vitrified first. The Dry Storage Facility required for the Improving Storage Alternative would not be available within 10 years.

As a precursor to the Processing to Metal, Processing to Oxide, Processing and Storage for Vitrification in the Defense Waste Processing Facility, and the Vitrification (F-Canyon) Alternatives, DOE could dissolve unirradiated depleted uranium targets (which would result in no fissile material or fission products) in the F-Canyon dissolvers as part of equipment testing and operator training evaluations.

### 2.3.5 MARK-16 AND -22 FUELS

Approximately 1,900 irradiated fuel assemblies are stored in water-filled basins in the K-, L- and P-Reactor areas and in the H-Canyon facility. The fuel tubes contain highly enriched uranium and are clad in aluminum. DOE has identified the following alternatives for management of these fuels:

- **Blending Down to Low-Enriched Uranium.**



DOE would load the fuel tubes from the disassembly basins into casks, transport the casks to H-Canyon, dissolve the fuels, and separate enriched uranium from fission products, neptunium, and the small quantities of plutonium normally found in the fuel. This would be accomplished using the normal H-Canyon process. The fission products and other impurities would be transferred to the H-Area high-level waste tanks. The enriched uranium would be blended with depleted uranium and stabilized, as described in [Section 2.3.2](#).

If DOE selected this alternative for the uranium solutions in H-Canyon and the Mark-16 and Mark-22 fuel, it would build only one storage facility, which would have an area of about 557 square meters (6,000 square feet).



As a variation to this alternative, DOE could transport the fuel to F-Canyon for processing. In this case, the blending operations would occur immediately after the fuel dissolving operations. Depleted uranium from FA-Line or from material already in the canyon would be added after the dissolution process. The resulting low-enriched uranium would be separated from the other material and radioactive decay products in the fuel and transferred to FA-Line for conversion to uranium oxide. The oxide would be stored in 208-liter (55-gallon) drums. The fission products and other materials would be transferred to the F-Area high-level waste tanks.

- **Processing to Oxide (Uranium Solidification Facility).**



DOE would continue to store the fuel while completing construction of the Uranium Solidification Facility in H-Canyon. After construction, DOE would process the fuel as described in [Section 2.3.2](#), transfer the resulting enriched uranium solution to the Uranium Solidification Facility, convert the uranium solution to an oxide, package the oxide, and place the containers in a vault for storage.

- **Improving Storage.**



While constructing the new Dry Storage Facility, DOE would manage the Mark-16 and -22 fuel as described in [Section 2.1](#) for no-action activities. Then DOE would transfer the fuel to the completed facility. DOE estimates that movement of the Mark-16 and -22 targets to the new facility would not begin for at least 10 years.

- **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the material in solid form until it could complete technical studies on the transfer of fissile solutions to the high-level waste tanks. When the studies were complete, DOE would move the material to H-Canyon and dissolve it, adjust the resulting solution to ensure the nuclear criticality safety of the material in the waste tanks, and vitrify the material at the proposed Defense Waste Processing Facility. The difficulties associated with this process would be the same as those described in [Section 2.3.1](#) for the H-Canyon plutonium solutions.

- **Continuing Storage (No Action).** DOE would continue to store the Mark-16 and -22 fuel in a water-filled basin. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for the fuel.

DOE's preferred alternative is Blending Down to Low-Enriched Uranium. DOE anticipates that it could complete this alternative about 2 years more quickly than Processing to Oxide (Uranium Solidification Facility), for which it would have to build the Uranium Solidification Facility. The Vitrification via the Defense Waste Processing Facility Alternative was not selected because stabilization activity could not be initiated within the next 10 years (or more) due to the technical issues and the inventory of existing high-level waste that would have to be vitrified first. In addition, DOE did not select the Improving Storage Alternative because it does not expect the Dry Storage Facility to be available within 10 years.

DOE did not evaluate Processing to Metal because this capability does not exist at the SRS and, because the oxide form of the material would be stable, there would be no advantage in developing the capability to produce uranium metal.

## 2.3.6 OTHER ALUMINUM-CLAD FUEL AND TARGETS

Approximately 900 metal fuel and target elements are stored in water-filled basins in the K-, L-, and P-Areas. These elements contain small amounts of fissile material; primarily they contain such materials as thorium, cobalt, and thulium. DOE has identified the following reasonable alternatives for management of these fuels and targets:

- **Processing and Storage for Vitrification in Defense Waste Processing Facility.**



DOE would continue to store the material in its current form until it could complete technical studies on the transfer of fissile solutions to the high-level waste tanks. DOE anticipates that these studies would be simpler than those for other material evaluated in this EIS because the fissile material content of these items is relatively low. When the studies were complete, DOE would move the material to a B-Line or canyon and dissolve it. DOE would adjust the resulting solution to ensure the safety of the material in the waste tanks from nuclear criticality. The material would be vitrified at the proposed Defense Waste Processing Facility.

- **Improving Storage.**



While constructing the new Dry Storage Facility, DOE would manage the fuel and targets as described in [Section 2.1](#) for no-action activities of Section 2.1. Then DOE would transfer the material to the new Dry Storage Facility, which would not be available for about 10 years.

- **Continuing Storage (No Action).** DOE would continue to store the fuel in a water-filled basin. The no-action activities described for stable material (see [Section 2.1](#)) would be applicable for this fuel.

DOE proposes Processing and Storage for Vitrification in the Defense Waste Processing Facility as the preferred alternative because the relatively small amount of fissile material in the fuel would reduce the criticality concerns associated with using this method. DOE did not evaluate in detail alternatives that involved chemical dissolution and separation because the amount of fissile material would be so low there would be very little to recover, and therefore, the net result would be the same as the Processing and Storage with Vitrification in the Defense Waste Processing Facility Alternatives (i.e., the material would be dissolved and discharged to the high-level waste tanks).

## 2.4 Comparison of Alternatives

DOE would select a management alternative for each category of nuclear material listed in [Table 2-1](#). This would result in the implementation of a specific combination of the alternatives described and analyzed in this EIS. Tables 2-2 through 2-11 compare the environmental impacts for each alternative by nuclear material type and summarize how each alternative compares to the others. Choosing No Action for the management of each nuclear material group is likely to result in the smallest impacts for the 10-year period. Taking action to stabilize materials would entail some increased exposure and risk compared to No Action during the 10-year period. However, over the long term, choosing No Action could result in greater impacts than those that would occur by

choosing another alternative. This is because choosing No Action would result in the need for greater management vigilance and consequent worker exposures and because of the increased possibility that continued changes in material chemistry could result in releases to the environment. Furthermore, DOE eventually would have to take some type of stabilization action, and the attendant risks and exposures from these actions would occur at that time.

## 2.5 Other Factors

The selection of scenarios for the stabilization of SRS nuclear materials depends in part on existing technology (or on technology that DOE could develop quickly), the capabilities of existing SRS facilities, and the extent to which the actions would support long-term storage objectives. Consistent with a comprehensive review of options for plutonium disposition, DOE will consider the technical, nonproliferation, environmental, budgetary, and economic aspects of each alternative in each scenario before it selects any alternative for implementation.

In addition to comparing scenarios against the environmental criteria listed in [Section 2.4](#), DOE has compared other factors related to the stabilization of nuclear materials. These factors are representative of issues addressed by the National Academy of Science in its study of the management and disposition of plutonium (NAS 1994), the Office of Technology Assessment plutonium study (OTA 1993), and comments received during the EIS scoping period.

### 2.5.1 NEW FACILITIES REQUIRED

This factor considers qualitative impacts on the number and size of new facilities required, and the probable long-term restoration requirements after their use. All alternatives for candidate plutonium materials for stabilization, except Continuing Storage (No Action), would involve constructing the proposed Actinide Packaging Facility or modifying an existing facility inside the F-Area fence. Therefore, only this construction differentiates between Continuing Storage and the other alternatives. Continuing Storage would be the most advantageous alternative for this factor.

Processing H-Canyon uranium solutions and Mark-16 and -22 fuels to oxide in FA-Line would involve the construction of a new small storage building for low enriched uranium inside the F-Area fence. Processing these materials to oxide in H-Area would involve completing construction of the Uranium Solidification Facility. Therefore, processing these materials to oxide would be less advantageous than other alternatives for this factor. In addition, because the F-Area construction would be less costly and time-consuming than completion of the Uranium Solidification Facility, this factor would differentiate between these alternatives.

Vitrification in F-Canyon would involve preparing the F-Canyon Vitrification Facility to add vitrification and bagless transfer capability. Processing plutonium to an oxide in FB-Line would involve modifying FB-Line from its current metal-producing configuration.

Finally, Improving Storage of Mark-31 targets, Mark-16 and -22 fuels, and other aluminum-clad fuel and targets would involve constructing a new Dry Storage Facility on an undeveloped site. This construction makes this the least advantageous alternative for these materials.

### 2.5.2 SECURITY AND NONPROLIFERATION

This factor relates to how well each alternative would support national security objectives and nonproliferation. This issue is being debated on the national and international levels, and consensus has yet to be reached. However, DOE has qualitatively evaluated the alternatives and compared them to one another.

All the alternatives would involve the use of facilities within controlled industrial areas of the SRS, which are supported and protected by an armed protective force. However, the solutions or stabilized forms of plutonium would have varying degrees of utility in potentially supporting or leading to the manufacture of a nuclear weapon.

The Processing and Storage for Vitrification in the Defense Waste Processing Facility Alternative would produce a material form that would be least attractive for use in producing a nuclear weapon. Therefore, it would represent the most advantageous alternative in this regard. The Processing to (plutonium) Metal Alternative would result in a chemical form that closely resembled that used in weapons production. The other alternatives evaluated would maintain or convert plutonium to forms that would require varying degrees of processing to produce a form suitable for weapons use. All the alternatives would involve the use of facilities inside controlled industrial areas of the SRS, which are supported and protected by an armed guard force.

DOE has committed to prohibit the use of plutonium-239 or weapons-usable highly enriched uranium separated or stabilized during the phaseout, shutdown, and cleanout of weapons complex facilities for nuclear explosive purposes (DOE 1994c).

### **2.5.3 IMPLEMENTATION SCHEDULE**

Of the stabilization alternatives, those chosen for the Preferred Alternatives Scenario could be implemented in the shortest period of time. Alternatives involving dry storage would add the longest lead time (10 years), and the Processing and Storage for Vitrification in the Defense Waste Processing Facility Alternative would add at least 9 years of preparation.

### **2.5.4 TECHNOLOGY AVAILABILITY AND TECHNICAL FEASIBILITY**

This factor relates to the extent that technology development would be required and its likelihood of success. Processing to Metal in F-Area and Processing to Oxide in H-Area represent the most technically proven of the stabilization alternatives; they would use existing technology and equipment. The Vitrification (F-Canyon) and Processing and Storage for Vitrification in the Defense Waste Processing Facility Alternatives appear to be technically feasible, but would require increasing amounts of technology development. Dry storage would involve the most technology development.

In general, the technical uncertainty would increase as the stabilized form differed from that historically produced. There would also be technical uncertainty about the continued storage of the plutonium solutions under the Continuing Storage Alternative as a result of radiation and chemically induced changes in the solution chemistry and form.

### **2.5.5 LABOR AVAILABILITY AND CORE COMPETENCY**

There would be differences between the level of personnel knowledge and training required for each alternative. In addition, there would be impacts from providing the needed level of training. In general, the Processing and Storage for Vitrification in the Defense Waste Processing Facility Alternative would require the most labor to implement (due to the combination of a long period of maintaining stored materials plus processing activity). The Continuing Storage

and Processing to (plutonium) Metal Alternatives would involve activities similar to those performed in the past; as a result, facility personnel would have existing training and qualification programs to maintain core competency. The Processing to (plutonium) Oxide, Vitrification, and Improving Storage Alternatives would require additional levels of training; the only impact anticipated from such additional training would be the incremental funding and time required.

### **2.5.6 AGING FACILITIES**

All the alternatives would involve the use of existing facilities, some of which have been in operation for more than 40 years (e.g., F-Canyon). The No-Action Alternative would require continued storage of the material in existing facilities and is, therefore, the least desirable or advantageous in this regard.

Although the Processing and Storage for Vitrification in the Defense Waste Processing Facility Alternative would eventually make use of the proposed DWPF, it would require maintenance of the solutions in F-Canyon for 6 to 9 years. In addition, it would involve the transfer of the plutonium solutions to the high-level waste tanks. Therefore, this alternative has only a slight advantage over the No-Action Alternative.

While the Processing to (plutonium) Metal Alternative would involve limited use of the F-Canyon and FB-Line for stabilization, it would involve continued storage of the metal in the FB-Line vault. Therefore, it represents some reliance on aging facilities, but also represents an advantage over the No-Action and Vitrification Alternatives.

The Processing to (plutonium) Oxide Alternative would involve limited use of the F-Canyon and FB-Line facilities. It could use a new or modified facility for conversion to a high-fired oxide and eventual storage. The use of a new facility would represent the minimum reliance on existing or aging facilities.

### **2.5.7 MINIMUM CUSTODIAL CARE**

The vitrification alternatives would eventually result in a stabilized form of material that would require a minimum of custodial care. However, continued custodial care of the materials would be required in canyons, vaults, or high-level waste tanks until vitrification had been accomplished. Continued Storage would involve maintaining candidate materials for stabilization (necessitating increasing surveillance, maintenance, and corrective actions) for the longest time and, therefore, can be considered the least advantageous alternative in this regard.

Other processing and improving storage alternatives would have varying levels of custodial care requirements. Stable materials would need less care than candidate materials for stabilization, so the preferred alternatives would involve less custodial care than other alternatives because they would stabilize the materials the earliest.

## **2.6 Other Activities for Reduction of Risk**

DOE identified several alternatives that it eliminated from detailed study because they increased environmental or other risks without commensurate benefits or because they would be inconsistent with National Environmental Policy Act requirements for interim actions. These include processing to include fission products, transporting material off the Site, and burial.

DOE considered the addition of fission products to increase the radioactivity of the stabilized form of the material (e.g., metal). Such an addition would make the material essentially "self-protecting" from theft or potential use in weapons because of high radiation levels. However, this method would result in increased exposures to personnel performing processing and handling operations (e.g., at FB-Line). DOE considers such increased exposures to personnel to be unwarranted and, therefore, did not consider this a reasonable alternative.

Offsite transportation and onsite burial could reduce SRS risks but are disposition alternatives that could limit the choices of alternatives in the ongoing "Programmatic Environmental Impact Statement for Storage and Disposition of Weapons-Usable Fissile Materials" (59 FR 31985). This would be contrary to National Environmental Policy Act requirements and, therefore, DOE did not consider this a reasonable alternative.

## REFERENCES

DOE (U.S. Department of Energy), 1994a, *DOE Standard: U.S. Department of Energy Criteria for Safe Storage of Plutonium Metals and Oxides*, DOE-STD-3013-94, Washington, D.C.

DOE (U.S. Department of Energy), 1994b, *Assessment of Interim Storage of Plutonium Solutions in F-Canyon and Mark-31 Targets in L-Basin at the Savannah River Site*, DOE EH-0397P/

SRS-FCAN-94-01, Office of Environment, Safety and Health, Washington, D.C.

DOE (U.S. Department of Energy), 1994c, "ACTION: Commitment To Prohibit the Use of Plutonium-239 and Highly Enriched Uranium Separated and/or Stabilized During Facility Phaseout, Shutdown and Cleanout Activities for Nuclear Explosive Purposes," memorandum to the Secretary of Energy from Assistant Secretary for Defense Programs and Assistant Secretary for Environmental Management, Washington, D.C., December 20.

NAS (National Academy of Sciences), 1994, *Management and Disposition of Excess Weapons Plutonium*, Committee on International Security and Arms Control, National Academy Press, Washington, D.C.

OTA (Office of Technology Assessment), 1993, *Dismantling the Bomb and Managing the Nuclear Materials*, Office of Technology Assessment, U.S. Congress, Washington, D.C.





## CHAPTER 3. AFFECTED ENVIRONMENT

The activities described in this environmental impact statement would take place on the Savannah River Site. Most would take place in industrialized areas ([Figures 2-2](#)). The only exceptions would involve the interarea transport of nuclear materials or waste and the potential construction of a facility that would provide dry storage of spent fuel. The industrialized areas consist primarily of buildings, paved parking lots, and graveled areas. While some grassed areas occur around the administration buildings and vegetation is present along drainage ditches, most of these areas have little or no vegetation. As a consequence, these areas have minimal value as wildlife habitat. No aquatic habitat or wetlands occur in these areas, nor do threatened or endangered species. No SRS facilities have been nominated for inclusion in the National Register of Historic Places, and there are no plans for such nomination. Because the F- and H-Areas are industrial sites constructed during the 1950s, the presence of any important cultural resources remaining is unlikely.

DOE has identified an undeveloped host site for the potential construction of a Dry Storage Facility. This site is to the south and east of H-Area, adjacent to SRS Road E and close to an existing railroad line ([Figure 3-1](#)). DOE could connect this site to existing electricity, water, and steam networks with minimal additional construction.

The host site is representative of many areas on the SRS that could support stabilization activities. It is almost completely forested, for the most part with 5- to 40-year-old upland pine, for which the Savannah River Forest Station (which is operated by the U.S. Forest Service) conducts an active management program. The site contains suitable habitat for white-tailed deer and feral hogs as well as other species common to the mixed pine/hardwood forest of South Carolina. DOE would conduct a detailed analysis in accordance with the provisions of the National Environmental Policy Act before implementing any decisions on the construction of new facilities on an undeveloped site.

DOE would transport nuclear material or waste using existing SRS roads or railways. The primary SRS roadways (see [Figure 3-2](#)) are in good condition and are smooth and free from potholes. Railings along the roadways offer protection at appropriate locations from dropoffs or other hazards. In general, heavy traffic occurs in the early morning and late afternoon when workers commute to and from the Site. Railroads on the Site include both CSX and SRS track lines. The rails and crossties are in good condition, and the track lines are clear of vegetation and debris. The rail lines cross the surface waters, floodplains, and wetlands associated with Upper Three Runs Creek, Fourmile Branch, and Pen Branch. There is a Carolina Bay along the K-Line railway and an abandoned farm pond near the L-Line railway. A number of documents (Wike et al. 1993; Weiner and Smith 1981;

[Figure 3-1.](#)

[Figure 3-2.](#)

Bennett and McFarlane 1983; Gibbons, McCort, and Mayer 1986; Whicker 1988; Workman and McLeod 1990; and Cothran et al. 1991) provide detailed ecological information including habitat descriptions and animal species lists. Several monographs (Patrick, Cairns, and Roback 1967; Dahlberg and Scott 1971; Bennett and McFarlane 1983), the eight-volume comprehensive cooling water study (Du Pont 1987), and three EISs (DOE 1984, 1987, 1990) that evaluated operations of SRS production reactors describe the aquatic systems and biota of the SRS.

### 3.1 Geologic Setting and Seismicity



The Savannah River Site is on the Aiken Plateau of the Upper Atlantic Coastal Plain about 40 kilometers (25 miles) southeast of the Fall Line that separates the Atlantic Coastal Plain from the Piedmont ([Figure 3-3](#)). Most of the nuclear material storage areas considered in this EIS are on topographically high (upland) areas that are generally flat and lack any distinctive features. The range of local relief of these areas above nearby lowlands is from 12 meters (40 feet) in L-Area to about 60 meters (190 feet) in F-Area. Local relief above nearby lowlands reaches about 55 meters (180 feet) in M-Area, 50 meters (160 feet) in H-Area, 30 meters (90 feet) in K-Area, and 25 meters (80 feet) in P-Area. All storage areas are above the 100-year floodplain. The Final Environmental Impact Statement, Continued Operation of K-, L-, and P-Reactors, Savannah River Site, Aiken, South Carolina (DOE 1990) contains a complete description of the geologic setting and the stratigraphic sequences of the SRS. The Soil Survey of Savannah River Plant Area, Parts of Aiken, Barnwell, and Allendale Counties, South Carolina (USDA 1990) describes soil characteristics and erosion potential for the area.

### 3.1.1 SUBSURFACE FEATURES

Several fault systems occur off the Site northwest of the Fall Line (DOE 1990). A recent study of available geophysical evidence (Stephenson and Stieve 1992) identified six faults under the SRS: the Pen Branch, Steel Creek, Advanced Tactical Training Area (ATTA), Crackerneck, Ellenton, and Upper Three Runs Faults. [Figure 3-4](#) shows the locations of these faults. The closest of these to areas storing nuclear materials are the Steel Creek Fault, which passes through L-Area, and the Pen Branch Fault, which passes close to K-Area. The fault lines on [Figure 3-4](#) represent the projection of the faults to the ground surface; the actual faults do not reach the surface but stop several hundred feet below it. Based on information developed to date, none of the faults discussed in this section is "capable." A fault is capable if it has moved at or near the ground surface within the past 35,000 years or is associated with another fault that has moved in the past 35,000 years. (For a more detailed definition of a capable fault, see 10 CFR Part 100.)

[Figure 3-3. General location of the Savannah River Site and relationship to physiographic provinces of the eastern United States.](#)

[Figure 3-4. Savannah River Site, showing seismic fault lines and locations of onsite earthquakes.](#)

### 3.1.2 SEISMICITY

Two major earthquakes have occurred within 300 kilometers (186 miles) of the SRS. The first was the Charleston, South Carolina, earthquake of 1886, which had an estimated Richter scale magnitude of 6.8 and occurred approximately 145 kilometers (90 miles) from the Site. The SRS area experienced an estimated peak horizontal acceleration of 10 percent of gravity (0.10g) during this earthquake (URS/Blume 1982). The second major earthquake was the Union County, South Carolina, earthquake of 1913, which had an estimated Richter scale magnitude of 6.0 and occurred about 160 kilometers (99 miles) from the Site (Bollinger 1973). Because these earthquakes are not associated conclusively with a specific fault, researchers cannot determine the amount of displacement resulting from them.

In recent years, two earthquakes occurred inside the SRS boundary. On June 8, 1985, an earthquake with a local Richter scale magnitude of 2.6 and a focal depth of 0.96 kilometer (0.59 mile) occurred on the Site; its epicenter was west of C- and K-Areas. On August 5, 1988, an earthquake with a local Richter scale magnitude of 2.0 and a focal depth of 2.68 kilometers (1.66 miles) occurred on the Site; its epicenter was northeast of K-Area. Existing information



does not correlate the two earthquakes conclusively with the known faults on the Site. [Figure 3-4](#) shows the locations of the epicenters of these two earthquakes.

Outside the SRS boundary, a Richter scale magnitude 3.2 earthquake occurred on August 8, 1993, approximately 16 kilometers (10 miles) east of the City of Aiken near Coughton, South Carolina. Residents reported feeling this earthquake in Aiken, New Ellenton (immediately north of the SRS), and North Augusta [approximately 40 kilometers (25 miles) northwest of the SRS], and on the Site.

The accident analyses for this EIS evaluated a severe earthquake of a magnitude that would produce a peak ground acceleration of 0.2g, which is estimated to recur at an interval of about once every 5,000 years. The EIS analyzes earthquakes of this magnitude because this represents the SRS design-basis earthquake (i.e., new facilities would be designed to withstand an earthquake of this magnitude). The canyon structures were designed to resist a bomb blast impact against the exterior walls. The acceleration of the blast "front" from a nearby detonation would be many times the acceleration due to gravity (32 feet per second squared). For this reason, the structures would be highly damage-resistant to an earthquake with a horizontal ground acceleration of 0.20g or 20 percent of gravity at the structure base, although some materials probably would be released. Structures other than the canyons would also have some inherent resistance to seismic damage; however, these structures were assumed to fail. A precise translation of this acceleration to a Richter scale reading is not possible because the impact would be greatly affected by the type of soil in the area of the earthquake epicenter, the nearness of a shallow fault line, and attenuation of the shock wave in rock or other formations.

## 3.2 Water Resources

### 3.2.1 Surface-Water and GROUNDWATER FEATURES

Six tributaries of the Savannah River - Upper Three Runs Creek, Fourmile Branch, Beaver Dam Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek - drain almost all of the SRS ([Figure 3-5](#)). Surface waters in the vicinity of the F- and H-Areas flow into Upper Three Runs Creek and Fourmile Branch. Similarly, shallow groundwater in the vicinity recharges both Upper Three Runs Creek and Fourmile Branch.

The Savannah River, which forms the boundary between the States of Georgia and South Carolina, supplies potable water to several municipalities. Upstream from the SRS, the river supplies domestic and industrial water needs for Augusta, Georgia, and North Augusta, South Carolina. Approximately 203 river kilometers (126 river miles) downstream from the SRS, the river supplies domestic and industrial water needs for the Cherokee Hill Water Treatment Plant at Port Wentworth, Georgia, through intakes at river kilometer 47 (river mile 29), and for Beaufort and Jasper Counties in South Carolina through intakes at about river kilometer 63 (river mile 39.2).

Groundwater is a domestic, municipal, and industrial water source throughout the Upper Coastal Plain. Most municipal and industrial water supplies in Aiken County are from the deep aquifers. Domestic water supplies are primarily from the intermediate and shallow zone. In Barnwell and Allendale Counties, the intermediate zone and overlying units that thicken to the southeast supply some municipal users. At the SRS, most groundwater production is from the deep zone, with a few lower capacity wells pumping from the intermediate zone. Every major operating area at the SRS has groundwater wells; total groundwater production is from 34,000 to 45,000 cubic meters (9 to 12 million gallons) per day, similar to the volume pumped for industrial and municipal production within 16 kilometers (10 miles) of the Site (Arnett, Karapatakis, and Mamatey 1993).

Groundwater beneath the Site flows slowly toward SRS streams and swamps and into the Savannah River at rates

ranging from inches to several hundred feet per year. The depth to which the onsite streams cut into the soils controls the horizontal movement of groundwater. The valleys of the smaller perennial streams allow discharge from the shallow saturated geologic formations. The valleys of major tributaries of the Savannah River (e.g., Upper Three Runs Creek) drain formations of intermediate depth, and the valley of the Savannah River drains deep formations.

[Figure 3-5. Savannah River Site, showing 100-year floodplain and major stream systems.](#)

Groundwater flow is downward at some locations on the site, including A-, M-, L-, and P-Areas. In other areas, gradient and subsequent water pressure is upward from the lower to the upper sediments. This upward flow occurs, for example, in certain sections of F- and H-Areas and around K-Area. Horizontal groundwater flow occurs at the M-Area metallurgical laboratory (to the west-northwest in the shallow aquifer and subsequent flow to the south toward Upper Three Runs Creek in the intermediate aquifer), K-Area disassembly basin (toward Pen Branch and L-Lake), P-Area disassembly basin (toward Steel Creek), F-Canyon building (toward Upper Three Runs Creek and Fourmile Branch), and H-Canyon building (toward Upper Three Runs Creek and its tributaries).

### 3.2.2 Surface-Water and Groundwater Quality

In 1993, the major releases of radionuclides to surface waters were 12,700 curies of tritium, 0.477 curie of strontium-89 and -90, and 0.246 curie of cesium-137. The resulting doses to a downriver consumer of river water from all radionuclides released from the Site were less than 2 percent of the EPA and DOE standards for public water supplies (40 CFR Part 141 and DOE Order 5400.5, respectively) and less than 0.2 percent of the DOE dose standard from all pathways (DOE 5400.5). From a nonradiological perspective, there was no significant difference between upriver and downriver water quality parameters. Other than 72 instances of exceeding coliform (an indicator of the presence of human or animal fecal material) standards, analyses of streams, including the Savannah River, that can receive SRS discharges met the more stringent 1992 updated river classification of Freshwaters; that is, 99.9 percent of the analyses were in compliance with the SRS National Pollutant Discharge Elimination System permit. [Table 3-1](#) lists radioactive liquid releases by source for 1993.

Industrial solvents, metals, tritium, and other constituents used or generated on the Site have contaminated the shallow aquifers beneath 5 to 10 percent of the SRS. These aquifers are not used for SRS operations and drinking water; however, they do discharge to Site streams and eventually the Savannah River. [Figure 3-6](#) shows groundwater contamination on the Site (Arnett, Karapatakis, and Mamatey 1993). Most contaminated groundwater at the SRS flows beneath a few facilities; contaminants reflect the operations and chemical processes performed at those facilities. At F- and H-Areas, contaminants in the groundwater include tritium and other radionuclides, metals, nitrates, and chlorinated and volatile organics. At A- and M-Areas, contamination includes chlorinated volatile organics, radionuclides, metals, and nitrates. At the reactors (K-, L-, and P-Areas), tritium, other radionuclides, and lead are in the groundwater.

**Table 3-1. 1993 liquid releases by source (including direct and seepage basin migration releases).**

Radionuclide <sup>b</sup>	Half-life (years)	Reactors	Separations <sup>c</sup>	Reactor materials	Heavy water	SRTC/TNX	Total
H-3 (oxide)	12.3	2,290	9,880	-	499	0.129	12,700
Sr-89,90 <sup>d</sup>	29.1	0.187	0.241	-	$4.65 \times 10^{-2}$	$2.02 \times 10^{-3}$	0.477
I-129	$1.6 \times 10^7$	-	$2.20 \times 10^{-2}$	-	-	-	$2.20 \times 10^{-2}$

Cs-137	30.2	$1.29 \times 10^{-2}$	0.233	-	-	-	0.246
Pm-147	2.6	-	$7.03 \times 10^{-3}$	-	-	-	$7.03 \times 10^{-3}$
U-235,238	$4.5 \times 10^9$	-	$1.14 \times 10^{-5}$	-	-	-	$1.14 \times 10^{-5}$
Pu-239 <sup>e</sup>	24,000	$5.97 \times 10^{-4}$	$8.65 \times 10^{-3}$	$7.64 \times 10^{-5}$	-	$2.66 \times 10^{-4}$	$9.59 \times 10^{-3}$

<sup>a</sup>. Source: Arnett, Karapatakis, and Mamatey (1994).

<sup>b</sup>. H = hydrogen (H-3 = tritium), Sr = strontium, I = iodine, Cs = cesium, Pm = promethium, U = uranium, Pu = plutonium.

<sup>c</sup>. Includes F- and H-Area releases.

<sup>d</sup>. Includes unidentified beta-gamma.

<sup>e</sup>. Includes unidentified alpha.

Radioactive constituents (tritium, cesium-137, iodine-131, ruthenium-106, and strontium-89 and -90) above drinking water standards have occurred in F-Area monitoring wells. One well (FCA-9DR) showed activities considerably higher than others; strontium activities were especially notable, as much as 1,000 times over drinking water standards (Arnett, Karapatakis, and Mamatey 1994). Studies of flow directions, infiltration rates, and operating history indicate that this contamination is from an isolated incident that occurred more than 35 years ago (Reed 1993).

Contamination beneath the H-Canyon reflects the pervasiveness of tritium in the H-Area. The tritium is not directly from H-Canyon activities, but rather results from past use of the nearby H-Area seepage basins with subsequent transport beneath the canyon.

### 3.3 Air Resources

Based on SRS data collected from onsite meteorological towers for the 5-year period from 1987 to 1991, maximum wind direction frequencies are from the northeast and west-southwest and the average wind speed is 3.8 meters per second (8.5 miles per hour) (Shedrow 1993). The average annual temperature at the SRS is 17.8°C (64°F). The atmosphere in the SRS region is unstable approximately 56 percent of the time, neutral 23 percent of the time, and stable about 21 percent of the time (Shedrow 1993). In general, as the atmosphere becomes more unstable, atmospheric dispersion of airborne pollutants increases and ground-level pollutant concentrations decrease.

#### [Figure 3-6. Groundwater contamination at the Savannah River Site.](#)

##### 3.3.1 Severe Weather Conditions

The SRS area experiences an average of 55 thunderstorm days per year with 50 percent of these occurring in June, July, and August (Shedrow 1993). On an annual average, lightning flashes will strike six times per year on a square-

kilometer area (Hunter 1990). The highest windspeed recorded at Bush Field (Augusta, Georgia) between 1950 and 1990 was 100 kilometers (62 miles) per hour (NOAA 1990).

From 1954 to 1983, 37 reported tornadoes occurred in a 1-degree square of latitude and longitude that includes the SRS (WSRC 1993a). This frequency of occurrence is equivalent to an average of about one tornado per year. The estimated probability of a tornado striking a point on the SRS is 0.0000711 per year. This results in a "point-strike recurrence" interval of about once every 14,000 years (Bauer et al. 1989). Due to the size of the SRS, the occurrence of several individual strikes is unlikely. Since operations began at the SRS in 1953, nine tornadoes have been confirmed on or near the Site. Nothing more than light damage was reported, with the exception of a tornado in October 1989 that caused considerable damage to forest resources in an undeveloped southeastern sector of the SRS (Shedrow 1993).

From 1700 to 1992, 36 hurricanes occurred in South Carolina, resulting in an average frequency of about one hurricane every 8 years (WSRC 1993a). Because SRS is about 160 kilometers (100 miles) inland, the winds associated with hurricanes have usually diminished below hurricane force [i.e., equal to or greater than a sustained wind speed of 33.5 meters per second (75 miles per hour)] before reaching the SRS. Winds exceeding hurricane force have been observed only once at the SRS (Hurricane Gracie in 1959) (Shedrow 1993).

### 3.3.2 Radiological Air Quality

DOE provides detailed summaries of radiological releases to the atmosphere from SRS operations along with the resulting concentrations and doses in a series of annual environmental data reports. This section references several of these documents, which contain additional information. The information enables comparisons of current data with releases, concentrations, and doses associated with each alternative.

In the SRS region, airborne radionuclides originate from natural sources (i.e., terrestrial and cosmic), worldwide fallout, and Site operations. The SRS maintains a network of air monitoring stations on and around the Site to determine concentrations of radioactive particulates and aerosols in the air (Arnett, Karapatakis, and Mamatey 1994).

[Table 3-2](#) lists average and maximum nontritium atmospheric radionuclide concentrations at the SRS boundary and at background monitoring locations [160-kilometer (100-mile) radius] during 1993. Tritium is the only radionuclide of SRS origin detected routinely in offsite air samples above background (control) concentrations (Cummins, Martin, and Todd 1990, 1991; Arnett et al. 1992; Arnett, Karapatakis, and Mamatey 1993). [Table 3-3](#) lists average concentrations of tritium in the atmosphere, as measured at the boundary and offsite monitoring locations.

**Table 3-2. Radioactivity in air at the SRS boundary and at the 160-kilometer (100-mile) radius during 1993 (picocuries per cubic meter).**

Location	Gross alpha	Nonvolatile beta	Sr-89,90 <sup>b</sup>	Pu-238 <sup>b</sup>	Pu-239 <sup>b</sup>
Site boundary					
Average	0.0018	0.019	<0.000088	0.00000052	0.00000026
Maximum	0.0050	0.063	0.00027	0.0000048	0.0000021
Background (160-kilometer radius)					
Average	0.0020	0.020	<0.00027	0.00000070	<0.0000020
Maximum	0.0049	0.043	0.00058	0.0000059	0.0000044

<sup>a</sup>. Source: Arnett (1994).

<sup>b</sup>. Monthly composite.

**Table 3-3. Average atmospheric tritium concentrations around the Savannah River Site (picocuries per cubic meter).**

Location	1993	1992	1991
Site boundary	30	27	21
40-kilometer radius	9	11	11
160-kilometer radius	4.7	8.3	8.5

<sup>a</sup>. Source: Arnett, Karapatakis, and Mamatey (1994).

[Table 3-4](#) lists 1993 radionuclide releases from each major operational group of SRS facilities. All radiological impacts are within regulatory requirements.

### 3.3.3 Nonradiological Air Quality

The SRS is in the Augusta (Georgia) - Aiken (South Carolina) Interstate Air Quality Control Region (AQCR). This region, which is designated as a Class II area, is in compliance with National Ambient Air Quality Standards (NAAQS) for criteria pollutants. Class II is the initial designation of any area that is not considered a pristine area; pristine areas include national parks or national wilderness areas. The criteria pollutants include sulfur dioxide, nitrogen oxides (reported as nitrogen dioxide), particulate matter (less than or equal to 10 microns in diameter), carbon monoxide, ozone, and lead (40 CFR Part 50).

DOE utilized the comprehensive emissions inventory data for 1990, which is the most recent data available, to establish the baseline year for showing compliance with national and state air quality standards by calculating actual emission rates for existing sources. DOE based its calculated emission rates for the sources on process knowledge, source testing, material balance, and U.S. Environmental Protection Agency (EPA) Air Pollution Emission Factors (AP-42; EPA 1985). The inventory also included maximum potential emissions for sources permitted for construction through 1992.

DOE has performed atmospheric dispersion modeling for criteria and toxic air pollutants for actual emissions for the base year 1990 (plus potential emissions for sources permitted for construction), using the EPA Industrial Source Complex Short Term No. 2 Model. This model used data from the SRS meteorological tower for 1991 along with the 1990 emissions data to estimate maximum ground-level air pollutant concentrations at the SRS boundary. DOE added the incremental impacts associated with the alternatives evaluated in this EIS to the baseline concentrations to estimate total air quality impacts.

The South Carolina Department of Health and Environmental Control (SCDHEC) has air quality regulatory authority over the SRS and determines ambient air quality compliance based on air pollutant emissions and estimates of concentrations at the Site boundary based on atmospheric dispersion modeling. The SRS is in compliance with National Ambient Air Quality Standards for criteria pollutants and gaseous fluoride and with total suspended particulate standards, as required by SCDHEC Regulation R.61-62.5, Standard 2, "Ambient Air Quality Standards"

(AAQS). Table 3-5 lists these standards and the results of the atmospheric dispersion modeling for base year 1990.

The SRS is in compliance with SCDHEC Regulation R.61-62.5, Standard 8, "Toxic Air Pollutants," which regulates the emission of 257 toxic air pollutants (WSRC 1994a). DOE has identified emission sources for 139 of the 257 regulated air toxics; the modeled results indicate that the Site is in compliance with SCDHEC air quality standards. [Table 3-6](#) lists toxic air pollutants that are the same as those that the alternative actions described in this EIS would emit. Table 3-6 also compares maximum downwind concentrations at the Site boundary for base year 1990 to SCDHEC standards for toxic air pollutants.

**Table 3-5. Estimated ambient concentrations of criteria air pollutants from SRS sources.**

Pollutant <sup>c</sup>	Averaging time	Concentration (μ/nepa/dbgraphics/eishtml/eis-0220/m3) <sup>d</sup>	Most stringent AAQS <sup>e</sup> (national or state) (μ/nepa/dbgraphics/eishtml/eis-0220/m3)	Concentration as a percent of AAQS <sup>f</sup> (%)
SO <sub>2</sub>	Annual	10	80 <sup>g</sup>	12.5
	24-hour	185	365 <sup>g,h</sup>	50.7
	3-hour	634	1,300 <sup>g,h</sup>	48.8
NO <sub>x</sub>	Annual	4	100 <sup>g</sup>	4.0
CO	8-hour	23	10,000 <sup>g,h</sup>	0.2
	1-hour	180	40,000 <sup>g,h</sup>	0.5
Gaseous fluorides (as HF)	12-hour	0.62	3.7 <sup>f</sup>	16.8
	24-hour	0.31	2.9 <sup>f</sup>	10.7
	1-week	0.15	1.6 <sup>f</sup>	9.4
	1-month	0.03	0.8 <sup>f</sup>	3.8
PM <sub>10</sub>	Annual	3	50 <sup>g</sup>	6.0
	24-hour	56	150 <sup>g</sup>	0.4
O <sub>3</sub>	1-hour	NA <sup>i</sup>	235 <sup>g,h</sup>	NA
TSP	Annual geometric mean	11	75 <sup>f</sup>	14.7
Lead	Calendar quarter mean	0.0003	1.5 <sup>e</sup>	0.02

<sup>a</sup>. Source: WSRC (1994a).

<sup>b</sup>. The concentrations are the maximum values at the SRS boundary.

<sup>c</sup>. SO<sub>2</sub> = sulfur dioxide; NO<sub>x</sub> = nitrogen oxides; CO = carbon monoxide; PM<sub>10</sub> = particulate matter < 10mm in diameter; TSP = Total Suspended Particulates, O<sub>3</sub> = Ozone.

<sup>d</sup>. Based on actual emissions from all existing SRS sources plus maximum potential emissions for sources permitted for construction through December 1992.

- e. AAQS = Ambient Air Quality Standard.  
 f. Source: SCDHEC (1976).  
 g. Source: 40 CFR Part 50.  
 h. Concentration not to be exceeded more than once a year.  
 i. NA = Not available.

**Table 3-6. Estimated 24-hour average ambient concentrations at the SRS boundary - toxic air pollutants regulated by South Carolina from SRS sources.**

<b>Pollutant<sup>b</sup></b>	<b>Concentration (<math>\mu</math>/nepa/dbgraphics/eishtml/eis- 0220/m3)<sup>c</sup></b>	<b>Regulatory standard (<math>\mu</math>/nepa/dbgraphics/eishtml/eis- 0220/m3)</b>	<b>Concentration as a percent of standard (%)</b>
Benzene	31	150	20.70
Hexane	0.07	200	0.04
Nitric acid	6.70	125	5.40
Sodium hydroxide	0.01	20	0.05
Toluene	1.60	2,000	0.08
Xylene	3.80	4,350	0.09

- a. Source: WSRC (1994a).  
 b. Pollutants listed include air toxics of interest in relation to interim management of nuclear materials alternatives. ([Section 5.2](#) addresses the effects of all air toxics.)  
 c. Based on actual emissions from existing SRS sources plus maximum potential emissions for sources permitted for construction through December 1992.

## 3.4 Socioeconomics

This section discusses baseline socioeconomic conditions in a region of influence where approximately 90 percent of the SRS workforce lived in 1992. The SRS region of economic influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site (HNUS 1992) contains additional information on the economic and demographic characteristics of the six-county region.

### 3.4.1 Employment

Between 1980 and 1990, total employment in the six-county region increased from 139,504 to 199,161, an average



annual growth rate of approximately 5 percent. The unemployment rates for 1980 and 1990 were 7.3 percent and 4.7 percent, respectively (HNUS 1992). In 1995, regional employment will be approximately 242,000. Over the 10-year planning period, employment in the region will increase at a projected average rate of 1 percent per year, reaching approximately 264,000 by 2004 (HNUS 1994).

In Fiscal Year 1992, employment at the SRS was 23,351, approximately 10 percent of regional employment, with an associated payroll of more than \$1.1 billion. Due to planned budget reductions, Site employment could decline by as many as 4,200 jobs between 1995 and 1996 (Fiori 1995).

### 3.4.2 Population

Between 1980 and 1990, the population in the region of influence increased 13 percent, from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken County (28.4 percent), Columbia County (15.5 percent), or Richmond County (44.6 percent). In 1995, the population in the six-county region will be approximately 462,000. Over the 10-year planning period, the regional population will grow at a projected rate of 0.4 percent per year, reaching approximately 479,000 by 2004 (HNUS 1994). According to census data, in 1990 the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years (HNUS 1992).

### 3.4.3 Community Characteristics

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires that Federal agencies identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations; minority populations are hereafter referred to as people of color. DOE is in the process of developing official guidance on the implementation of the Executive Order. The guidance that DOE eventually develops might depart somewhat from the approach taken in this EIS for analysis of environmental justice issues. This approach is intended to identify the potential effects from onsite activities on individuals in the identified communities of people of color or low income. The following discussion describes the framework for analysis of environmental justice issues for the alternatives considered in this EIS.

The potential offsite health impacts would result from releases to the air and to Savannah River water downstream of the SRS. For air releases, standard population dose analyses are based on an 80-kilometer (50-mile) radius because expected dose levels beyond that distance would be negligible. For liquid releases, the region of interest includes areas along the river that draw drinking water from the river (Beaufort and Jasper Counties in South Carolina and Port Wentworth in Georgia). Combining these two areas, the analysis included data (U.S. Bureau of the Census 1990a,b) for populations in all census tracts that have at least 20 percent of their area in the 80-kilometer (50-mile) radius and all tracts from Beaufort and Jasper Counties in South Carolina and Effingham and Chatham Counties in Georgia, which are downstream of the Site. DOE used data from each census tract in this combined region to identify the racial composition of communities and the number of persons characterized by the U.S. Bureau of the Census as living in poverty. The combined region contains 247 census tracts, 99 in South Carolina and 148 in Georgia.

Tables [3-7](#) and [3-8](#) list racial and economic characteristics, respectively, of the population in the combined region. Table [3-7](#) indicates a total population of more than 993,000 in the area; of that population, approximately 618,000 (62.2 percent) are white. Within the population of people of color, approximately 94 percent are African American. The remainder of the population of people of color is made up of small percentages of Asian, Hispanic, and Native

American persons. [Figure 3-7](#) shows the distribution of people of color by census tract areas in the SRS region.

Executive Order 12898 does not define minority populations. One approach is to identify communities that contain a simple majority of people of color (greater than or equal to 50 percent of the total community population). A second approach, proposed by EPA for environmental justice purposes, defines communities of people of color as those that have higher-than-average (over the region of interest) percentages of minority persons (EPA 1994). [Figure 3-7](#) has two shading patterns to indicate census tracts where (1) people of color constitute 50 percent or more of the total population in the census tract, or (2) people of color constitute between 35 percent and 50 percent of the total population in the tract. For this analysis, DOE has adopted the second, more expansive, approach to identify people of color communities.

**Table 3-7. General racial characteristics of population in the SRS region of analysis.**

State	Total population	White	African American	Hispanic	Asian	Native American	Other	People of color	Percent people of color <sup>b</sup>
South Carolina	418,685	267,639	144,147	3,899	1,734	911	355	151,046	36.08%
Georgia	574,982	350,233	208,017	7,245	7,463	1,546	478	224,749	39.09%
Total	993,667	617,872	352,164	11,144	9,197	2,457	833	375,795	37.82%

<sup>a</sup>.Source: U.S. Bureau of the Census (1990a).

<sup>b</sup>.People of color population divided by total population.

**Table 3-8. General poverty characteristics of population in the SRS region of analysis.a**

Area	Total population	Persons living in poverty <sup>b</sup>	Percent living in poverty
South Carolina	418,685	72,345	17.28%
Georgia	574,982	96,672	16.81%
Total	993,667	169,017	17.01%

<sup>a</sup>.Source: U.S. Bureau of the Census (1990b).

<sup>b</sup>.Families with income less than the statistical poverty threshold, which in 1990 was 1989 income of \$8,076 for a family of two.

The combined region has 80 tracts (32.4 percent) where populations of people of color constitute 50 percent or more of the total population of the tract. In an additional 50 tracts (13.5 percent), people of color constitute between 35 and 50 percent of the population. These tracts are well distributed throughout the region, although there are more of them toward the south and in the immediate vicinities of Augusta and Savannah, Georgia.

Low-income communities are defined as those in which 25 percent or more of the population is characterized as living in poverty (EPA 1993). The U.S. Bureau of the Census defines persons in poverty as those whose income is less than a "statistical poverty threshold." This threshold is a weighted average based on family size and the age of the persons in the family. The baseline threshold for the 1990 census was a 1989 income of \$8,076 for a family of two.

### **Figure 3-7. Distribution of people of color by census tract in SRS region of analysis.**

Table 3-8 indicates that in the SRS region, more than 169,000 persons (17.0 percent of the total population) are characterized as living in poverty. In [Figure 3-8](#), shaded census tracts identify low-income communities. In the region, 72 tracts (29.1 percent) are identified as low-income communities. These tracts are distributed throughout the region of analysis, but primarily to the south and west of the SRS. As discussed in Chapter 4, no adverse health effects are likely to occur in any offsite community, including minority and low-income communities.

## **3.5 Public and Worker Health**

### **3.5.1 PUBLIC RADIOLOGICAL HEALTH**

The release of radioactivity to the environment from any nuclear facility is a sensitive issue for onsite workers and the public. Because there are many other sources of radiation in the human environment, evaluations of radioactive releases from nuclear facilities must consider all the ionizing radiation to which people are routinely exposed.

Public radiation exposure in the vicinity of the Site amounts to approximately 357 millirem per year, consisting of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; radiation from weapons test fallout; radiation from consumer and industrial products; and radiation from nuclear facilities. [Figure 3-9](#) shows the relative contributions of each source to people living in the vicinity of the Site. All radiation doses mentioned in this EIS are "effective dose equivalents"; internal exposures are reported as "committed effective dose equivalents."

Releases of radioactivity to the environment from the Site account for less than 0.1 percent of the total annual average environmental radiation dose to individuals within 80 kilometers (50 miles) of the Site. Natural background radiation contributes about 293 millirem per year or 82 percent of the annual dose of 357 millirem received by an average member of the population within 80 kilometers (50 miles) of the Site. Based on national averages, medical exposure accounts for an additional 14.8 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 3 percent of the total dose (NCRP 1987a).

Other nuclear facilities within 80 kilometers (50 miles) of the Site include a low-level waste burial site operated by Chem-Nuclear Systems, Inc., near the eastern SRS boundary, and the Georgia Power Company's Vogtle Electric Generating Plant, directly across the Savannah River from the Site. In addition, Carolina Metals, Inc., which is northwest of Boiling Springs in Barnwell County, processes

### **Figure 3-8. Low income census tracts in SRS region of analysis.**

### **Figure 3-9. Major sources of radiation exposure in the vicinity of Savannah River Site.**

Depleted uranium. The South Carolina Department of Health and Environmental Control Annual Report for 1992 on Nuclear Facility Monitoring (SCDHEC 1992) documents that the Chem-Nuclear and Carolina Metals facilities do not appear to influence radioactivity levels in the air, precipitation, groundwater, soil, vegetation, or external radiation, based on State measurements. Plant Vogtle began commercial operation in 1987; in 1991, releases from the plant produced a maximally exposed individual annual dose of 0.00017 rem at the plant boundary and a total population dose within an 80-kilometer (50-mile) radius of 0.057 person-rem (NRC 1994).

In 1993, releases of radioactive material to the environment from SRS operations resulted in a maximum Site boundary

individual dose from atmospheric releases of 0.11 millirem per year in the north-northwest sector around the Site, and a maximum dose from liquid releases of 0.14 millirem per year, for a maximum total annual dose at the Site boundary of 0.25 millirem. The maximum dose to downstream consumers of Savannah River water – 0.057 millirem per year – occurred to Port Wentworth public water supply users (Arnett 1994).

In 1990 the population within 80 kilometers (50 miles) of the Site was approximately 620,100. The collective effective dose equivalent to that population in 1993 was 7.6 person-rem from atmospheric releases. The 1990 population of 65,000 people using water from the Cherokee Hill Water Treatment Plant near Port Wentworth, Georgia, and the Beaufort-Jasper Water Treatment Plant near Beaufort, South Carolina, received a collective dose equivalent of 1.5 person-rem (Arnett 1994). Population statistics indicate that cancer caused 23.5 percent of the deaths in the United States in 1990 (CDC 1993). If this percentage of deaths from cancer continues, 23.5 percent of the U.S. population will contract a fatal cancer from all causes. Thus, in the population of 620,100 within 80 kilometers (50 miles) of the site, 145,700 persons will be likely to contract fatal cancers from all causes. The total population dose from the SRS of 9.1 person-rem (i.e., 7.6 person-rem from atmospheric pathways plus 1.5 person-rem from water pathways) could result in 0.0046 additional latent cancer death expected in the same population (based on 0.0005 cancer death per person-rem).

### 3.5.2 PUBLIC NONRADIOLOGICAL HEALTH

The hazards associated with the alternatives described in this EIS include nonradiological chemicals. Exposure to nonradiological chemicals occurs in the form of air and water pollution. [Table 3-5](#) lists ambient air quality standards and concentrations for selected pollutants. These standards are designed to protect the public health and welfare. Because the concentrations listed in [Table 3-5](#) are lower than the standards, DOE does not expect adverse health impacts. [Section 3.2.2](#) discusses water quality in the vicinity of the SRS.

### 3.5.3 WORKER RADIOLOGICAL HEALTH

One of the major goals of the SRS Health Protection Program is to keep worker exposures to radiation and radioactive material as low as reasonably achievable (ALARA). An effective ALARA program must balance minimizing individual worker doses with minimizing the collective dose of all workers in a given group.

The purpose of an as-low-as-reasonably-achievable program is to minimize doses from both external and internal exposure. Such a program must evaluate both doses with the goal to minimize the total effective dose equivalent. ALARA evaluations must consider individual and collective doses to ensure the minimization of both. Using many workers to perform extremely small portions of a task would reduce the individual worker doses to very low levels. However, the frequent worker changes would make the work inefficient, with the result that the total dose received by all the workers would be significantly higher than if fewer workers received slightly higher individual doses.

SRS worker doses have typically been well below DOE worker exposure limits. DOE has set administrative exposure guidelines at a fraction of the exposure limits to help enforce doses that are as low as reasonably achievable. For example, the current DOE worker exposure limit is 5 rem per year, and the 1993 SRS administrative exposure guideline was 1.5 rem per year.

Table 3-9 lists the maximum and average individual doses and the SRS collective doses from 1988 to 1993.

**Table 3-9. SRS annual individual and collective radiation doses.**

Year	Individual dose (rem)		Site collective dose (person-rem)
	Maximum	Average <sup>b</sup>	
1988	2.040	0.070	864
1989	1.645	0.056	754
1990	1.470	0.056	661
1991	1.025	0.038	392
1992	1.360	0.049	316
1993	0.878	0.051	263

<sup>a</sup>. Sources: Du Pont (1989), Petty (1993), WSRC (1991, 1992, 1993b, 1994b).

<sup>b</sup>. The average dose includes only workers who received a measurable dose during the year.

Workers exposed to radiation have an additional risk of 0.04 percent per person-rem of contracting a fatal cancer (NCRP 1993). In 1993, 5,157 SRS workers received a measurable dose of radiation. Statistically, these workers should contract approximately 1,200 fatal cancers from all causes during their lifetimes; however, this cancer incidence rate depends on the age and sex distribution of the population. In 1993, this group received 263 person-rem and could experience as many as 0.1 additional cancer death due to their 1993 occupational radiation exposure. Continuing operation of SRS could result in as many as 0.1 additional cancer death for each year of operation, assuming future annual worker exposures continue at the 1993 level.

### 3.5.4 WORKER NONRADIOLOGICAL HEALTH AND SAFETY

Industrial hygiene and occupational health programs deal with all aspects of a worker's health and relationship with the work environment. The basic objective of an effective occupational health program is to protect employees against health hazards in their work environment. To evaluate these hazards, routine monitoring determines employee exposure levels to hazardous chemicals. Exposure limit values are the basis of most occupational health codes and standards. If an overexposure to a harmful agent does not exist, that agent generally does not create a health problem.

The Occupational Safety and Health Administration (OSHA) has established Permissible Exposure Limits (PELs) to regulate worker exposure to hazardous chemicals. These exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could receive repeated exposures day after day without adverse health effects.

Table 3-10 lists the estimated maximum annual concentrations of existing OSHA-regulated workplace pollutants modeled in and around the F- and H-Canyons. Virtually all nonradiological air pollutant emissions for each material evaluated in this EIS would be associated with these areas. These nonradiological concentrations are associated with the continued maintenance and storage of nuclear materials and, with the exception of nitric acid, carbon monoxide, sulfur dioxide, and nitrogen dioxide (as NO<sub>x</sub>), should not change from current levels. [Section 4.1.2](#) describes the incremental impacts for nitric acid, carbon monoxide, sulfur dioxide, and NO<sub>x</sub>. Estimated concentration levels for existing OSHA-regulated workplace pollutants are less than 1 percent of the OSHA Permissible Exposure Limits, with

the exception of benzene, which is 2 percent of the OSHA limit averaged over 8 hours.

DOE has established industrial hygiene and occupational health programs for the processes covered by this EIS and across the SRS to protect the health of workers from nonradiological hazards.

**Table 3-10. Estimated maximum annual concentrations (milligrams per cubic meter) of workplace pollutants regulated by the Occupational Safety and Health Administration.**

Pollutant	OSHA PEL <sup>b</sup>	Time period	Concentration
Carbon monoxide	55	8-hour	0.011
Nitrogen dioxide (as NO <sub>x</sub> )	9	Ceiling limit <sup>c</sup>	0.176
Total particulates	15	8-hour	0.004
Sulfur dioxide (as SO <sub>x</sub> )	13	8-hour	0.003
Benzene	16 3.25	Ceiling limit <sup>c</sup> 8-hour	0.230 0.066
Hexane	1,800	8-hour	0.066
Nitric acid	5	8-hour	0.013
Sodium hydroxide	2	8-hour	0.0008
Toluene	1,149 766	Ceiling limit <sup>c</sup> 8-hour	0.230 0.066
Xylene	440	8-hour	0.066

<sup>a</sup>. Estimated maximum annual impacts to workers in and around F- and H-Canyons (WSRC 1994a).

<sup>b</sup>. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL).

<sup>c</sup>. Ceiling limits are permissible exposure limits that a facility cannot exceed at any time.

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## CHAPTER 4. ENVIRONMENTAL IMPACTS

This analysis covers the 10-year period from 1995 to 2004. DOE chose this span because it represents the period that it might need to make and implement decisions on the ultimate disposition of the nuclear materials under consideration in this EIS. DOE used engineering studies to identify the activities that could be required to implement each alternative, the amount of time required for each step (or "phase") of the alternative, and the annual impacts estimated to occur during each phase. A number of assumptions were required to forecast or predict the environmental impacts that could occur during this period. To the extent practical, DOE used historic data to predict and estimate future impacts or trends. If an alternative would involve new facilities or processes, DOE extrapolated data from similar operations or facilities at the SRS.

Any delays associated with implementing alternatives to process programmatic materials or stabilize materials would result in impacts comparable to those of the No-Action Alternatives involving the continued storage of the materials in their present form and locations. Similarly, any delays during processing or stabilization operations would simply extend the period of impact at the same rate. For example, the generation of low-level radioactive waste in the form of protective clothing would result from personnel continuing their work in radiologically controlled areas.

This chapter and Appendixes [D](#) and [E](#) contain calculated or estimated impact data. The discussion of environmental factors might present data calculated to several decimal places. This does not imply that DOE predicts environmental consequences to that degree of precision. Rather, this assessment retained the number of decimal places in the calculated data to enable relative comparisons between the magnitudes of the impacts resulting from alternatives or combinations of alternatives. In some cases, the data are presented in this manner to illustrate that expected impacts would be small.

As described in [Chapter 2](#), DOE has grouped the nuclear materials into three general categories: (1) stable, (2) programmatic, and (3) candidates for stabilization. DOE evaluated the environmental impacts of a reasonable range of alternatives for processing or stabilizing the nine types of material (americium and curium, neptunium-237, H-Canyon uranium solutions, etc.) included in categories 2 and 3 and the impacts of continuing storage for the category 1 material. The result of this effort was the analysis of environmental impacts for 39 alternatives. [Appendix D](#) presents the annual impacts expected from each alternative, dependent upon the activities being performed. [Appendix E](#) presents the potential impacts from accidents.

The Council on Environmental Quality regulations suggest that the impacts of alternatives be presented in a comparative form to define sharply the issues and choices placed before the decisionmaker (40 CFR 1502.14). [Tables 2-2](#) through [2-11](#) were constructed to provide a direct comparison of the environmental impacts (over a 10-year period) between alternatives for each type of material.

DOE recognized that it would implement an alternative for each of the different material categories. The number of material categories and reasonable alternatives lead to large number of possible combinations (more than 200,000) which could be selected. Since presentation of such a large number of combinations is impractical, three scenarios are presented to illustrate the range of impacts as analyzed in Appendixes [D](#) and [E](#).

The three scenarios cover the entire spectrum of alternatives and illustrate the contrast between the least impactful scenario and most impactful scenario which might result. For each environmental factor, DOE summed the 10-year impacts from all the No-Action alternatives; the tables in this chapter present this information in the No-Action Scenario column. The No-Action Alternatives were found to have the lowest impact over the 10-year period of analysis. Similarly, DOE summed the 10-year impacts from all the preferred alternatives; the Preferred Alternatives Scenario. To illustrate the highest impact likely to occur, DOE summed the 10-year impacts from selected alternatives; the Comparative Alternatives Scenario. [Table 4-1](#) lists the alternatives that comprise the No-Action, Preferred Alternatives, and Comparative Alternatives Scenarios. As illustrated in the subsequent sections of this chapter, the variability of impacts across the range of alternatives represented by these three scenarios is relatively small. As a result, it is unnecessary to arbitrarily construct other scenarios in order to understand the cumulative effect of alternatives analyzed in this EIS. However, the reader should refer to [Chapter 2](#) and Appendixes [D](#) and [E](#) to examine the relative impacts of all alternatives for any particular material.

**No-Action Scenario** - The impacts projected for this alternative could occur if current storage practices continue over the 10-year period. There is, however, a degree of uncertainty associated with these projections for factors such as worker and population radiation exposure, which are dictated by the performance characteristics of the stored material. For example, the continued degradation of fuel or targets in the SRS reactor basins would result in the release of more fission products to the basin water, which in turn could result in higher worker radiation exposures. Experience with the long-term storage of degrading fuel or other potentially unstable material such as plutonium or americium and curium solutions is limited and makes the prediction of future effects difficult.

**Table 4-1. Composition of management scenarios.**

Material	No Action	Preferred Alternatives	Comparative Alternatives
Stable material	Continuing Storage	Continuing Storage	Continuing Storage
Plutonium-242	Continuing Storage	Processing to Oxide	Processing to Oxide
Americium and curium	Continuing Storage	Vitrification (F-Canyon)	Vitrification (F-Canyon)
Neptunium	Continuing Storage	Processing to Oxide	Processing to Oxide
H-Canyon plutonium-239 solutions	Continuing Storage	Processing to Oxide	Processing and Storage for Vitrification (DWPF) <sup>a</sup>
H-Canyon enriched uranium solutions	Continuing Storage	Blending Down to Low Enriched Uranium	Processing to Oxide (USF) <sup>b</sup>
Plutonium and uranium stored in vaults	Continuing Storage	Processing to Metal <sup>c</sup> Processing to Oxide <sup>c</sup> Improving Storage <sup>c</sup>	Vitrification (F-Canyon)
Plutonium and uranium stored in vaults (plutonium-238 scrap material)	Continuing Storage	Improving Storage	Processing to Oxide

Mark-31 targets	Continuing Storage	Processing to Metal	Previtrication stage
Mark-16 and -22 fuels	Continuing Storage	Blending Down to Low Enriched Uranium	Processing and Storage for Vitrification (DWPF)
Other aluminum-clad fuel and targets	Continuing Storage	Processing and Storage for Vitrification (DWPF)	Processing and Storage for Vitrification (DWPF)

<sup>a</sup>. DWPF = Defense Waste Processing Facility.

<sup>b</sup>. USF = Uranium Solidification Facility.

<sup>c</sup>. For the plutonium and uranium stored in vaults, there are three preferred alternatives. DOE will choose the appropriate alternative for a particular solid based on results of the material inspection. The analysis in this EIS presents the impacts from Processing to Metal (which would produce the greatest impacts of the three alternatives) as a conservative estimate of impacts.

- **Preferred Alternatives Scenario** - The impacts from this scenario would be the sum of the impacts from the preferred alternative for each type of material over the 10-year period (i.e., No-Action for stable material + Plutonium-242 to Oxide + Americium/Curium Vitrification + Neptunium-237 to Oxide + H-Canyon Plutonium Solutions to Oxide + etc.). These impacts are derived from data associated with similar previous or processing operations at the SRS.
- **Comparative Alternatives Scenario** - The impacts from this scenario would be the highest overall for the 10-year period for the environmental factors recognized in the Notice of Intent to prepare this EIS (59 FR 12588). These factors are worker and public health for both normal operations and accidents, and radioactive waste generation. DOE considered it appropriate to use these factors to identify the stabilization methods that would pose the greatest impacts based on estimated 10-year data. DOE evaluated the alternatives for each type of material to determine those that would result in the highest overall impact for the three environmental factors. Then DOE summed the impacts of the selected alternatives to determine the impacts represented in the Comparative Alternatives Scenario. In the case of four of the materials, as shown in [Table 4-1](#), the alternative with the highest impact for a material was the same as the preferred alternative, and in the case of six of the materials, the preferred alternatives presented a lower impact than the comparative alternative. In the case of stable materials, there is no difference in the impacts for any of the scenarios. DOE recognizes that the Comparative Alternatives Scenario might not result in maximum impacts for every environmental factor considered; for example, an alternative for a given material could maximize worker and public health impacts but not those from radioactive waste generation. However, DOE believes that its consideration of the stated environmental factors in the choice of the appropriate alternatives has resulted in a Comparative Alternatives Scenario that indicates the upper range of environmental impacts that could occur from the selection of any other combination of alternatives.

[Tables 2-2](#) through [2-11](#) are arranged by type of material (plutonium-242, americium and curium, neptunium-237, etc.). A review of the appropriate table can indicate the relative difference in impacts between alternatives for a particular type of material. The No-Action Scenario or a combination that consists predominantly of alternatives that would delay stabilization until near the end or after the 10-year period would result in the smallest estimated cumulative impact, because the analysis is limited to 10 years.

DOE would not realize the benefits of near-term stabilization (i.e., an annual reduction in radiation exposure to workers) without an initial increase in impacts caused by processing or repackaging the material. In some cases, a reduction in annual impacts would not occur until almost the end of the 10-year period. In general, the higher impacts reflected in the Preferred Alternatives and Comparative Alternatives Scenarios would be due to the fact that the near-term annual increases from stabilization activities would dominate the impacts summed over the 10-year period. The data in [Appendix D](#) indicates that the impacts from normal operations probably would be reduced after the implementation of many of the alternatives. [Appendix E](#) indicates a similar trend for the potential impacts from accidents before, during, and after the implementation of alternatives.

DOE considered a wide variety of subjects for evaluation to determine environmental impacts in this EIS. DOE conducted detailed evaluations of the following subjects:

- Health Effects from Normal Operations ([Section 4.1](#))
- Health Effects from Accidents ([Section 4.2](#) and [Appendix E](#))
- Transportation ([Section 4.3](#))
- Air Resources ([Section 4.4](#))
- Water Resources ([Section 4.5](#))
- Utilities ([Section 4.6](#))
- Waste Management ([Section 4.7](#))

Only one alternative (Improving Storage) would require the potential construction of a new facility outside the industrialized F- and H-Areas. This facility would be for the dry storage of a spent nuclear fuel (see [Appendix C](#)). The impacts associated with the construction of this new facility would result in the conversion of no more than 0.4 square kilometer (100 acres) of pine forest to industrial use. If DOE selected this activity, it would prepare separate NEPA documentation to address the potential impacts of construction and operation. In addition, several alternatives would require modifications to existing facilities. DOE would confine the modifications within the existing facility structure(s). For alternatives that would involve new facilities to package and store plutonium, uranium, and other materials, DOE would construct the facilities within F- or H-Area. The construction would be a warehouse or concrete vault-type structure near existing nuclear facilities in those areas. Because construction would be confined to previously disturbed and developed areas, DOE expects little or no environmental impacts in the following areas:

- Geologic Resources
- Ecological Resources
- Cultural Resources
- Aesthetics and Scenic Resources

DOE analyzed the potential impacts associated with the alternatives in this EIS in relation to these areas. Because the activities associated with each alternative would involve the use of existing facilities (except as noted above) within industrialized areas and the existing SRS transportation infrastructure (i.e., highways, railways), the analyses indicate that there would be little or no impact on the affected environment discussed in [Chapter 3](#). The amount of traffic would not change from current volumes, so there should be no change in the number of vehicle-wildlife collisions. DOE does not anticipate impacts to ecological resources, surface waters, or their associated wetlands because activities would be confined to developed areas. Because estimated radiological and nonradiological emissions would be small, impacts to ecological resources are not likely. The alternatives evaluated in this EIS would not affect endangered species because activities would not occur in areas such species inhabit.

Because construction projects would be limited to modifications of existing facilities or construction of warehouse or vault-type facilities (i.e., not complex major nuclear facilities), DOE could use the existing SRS workforce to support these projects. Similarly, DOE would use the existing SRS workforce to implement any of the alternatives considered. The resource requirements would be effectively the same for each. As a result, DOE does not estimate any socioeconomic impacts from actions proposed in this EIS.

## 4.1 Health Effects of Normal Operations

This section discusses the radiological and nonradiological health effects on the public and workers from all the alternatives during normal operations, which are planned activities associated with each alternative (e.g., sampling and maintenance). Health effects are represented as additional latent cancer fatalities that could occur in the general population around the SRS and in the population of workers that would be associated with the alternatives.

### 4.1.1 RADIOLOGICAL HEALTH EFFECTS

DOE expects minimal public and worker health impacts from the radiological consequences of managing SRS nuclear materials. The 10-year total effects would vary little between the Preferred Alternatives and the Comparative Alternatives Scenarios but, consistent with the discussion in the introduction to this chapter, the No-Action Scenario would have the smallest cumulative impacts. The greatest calculated impact to the public could be 0.20 additional cancer death in the population within 80 kilometers (50 miles) of the Site, compared to a predicted 145,700 deaths from cancer due to all causes (23.5 percent of population of 620,100; see [Section 3.5.1](#)). The greatest calculated impact to workers could be 0.51 additional cancer death, compared to 411 cancers expected from all causes. Table 4-2 summarizes the possible health effects from radiological doses for each management scenario.

DOE calculated health effects based on (1) the 10-year collective dose to the population around the Site (approximately 620,000 people); (2) the 10-year collective dose to all workers in the affected group; (3) the 10-year dose to the hypothetical maximally exposed individual in the public; and (4) the dose to the maximally exposed worker. The collective population doses include the dose from airborne releases ([Section 4.4](#)) and the dose resulting from the use of the Savannah River for drinking water, recreation, and as a source of food ([Section 4.5](#)). The estimated worker doses are based on past operating experience and the projected schedule for implementing the alternative actions (WSRC 1994a). For the case of the maximally exposed worker, DOE assumes that no worker would receive an annual dose greater than 0.8 rem for any alternative because the SRS uses 0.8 rem as an administrative limit for normal operations (i.e., personnel receiving an annual dose at that level are normally assigned other duties in nonradiation areas). From these radiological doses, DOE calculated estimates of latent cancer fatalities using the conversion factor of 0.0004 latent cancer fatality per rem for workers and 0.0005 latent cancer fatality per rem for the public (56 FR 23363). The value of the conversion factor for the public is greater than that for workers because the public consists of all age groups (including children), while the worker population consists only of adults. [Appendix D](#) provides annual radiological dose data for each phase applicable to each alternative for each material.

**Table 4-2. Estimated 10-year radiological health effects from normal operations.**

Subject	No Action	Preferred Alternatives	Comparative Alternatives
Public additional cancer deaths	0.0023	0.16	0.20
Worker additional cancer deaths	0.17	0.50	0.51
Probability of cancer death from MEI <sup>a</sup> dose	1 in 10 million	4 in 1 million	5 in 1 million
Probability of cancer death from worker maximum dose	3 in 1,000	3 in 1,000	3 in 1,000

<sup>a</sup>. MEI = Maximally exposed individual in the public.

Under the No-Action Scenario, the lifetime effect on the public could be 0.0023 additional cancer death in the population within 80 kilometers (50 miles) of the Site. The lifetime effect to SRS workers involved with the No-Action Scenario could be 0.17 additional cancer death resulting from exposure to radiation over the 10-year period. The effects on the maximally exposed individual and the maximally exposed worker are expressed not as a latent cancer fatality but as the additional lifetime probability of contracting a fatal cancer. For the maximally exposed member of the public, the additional or incremental probability of contracting a fatal cancer associated with the 10-year exposure to radiation would be 1 in 10 million. For the worker, the incremental probability would be 3 in 1,000.

As Table 4-3 indicates, both the Preferred Alternatives Scenario and the Comparative Alternatives Scenario would increase the risk to the public. The lifetime risk to the maximally exposed individual in the public from the 10-year exposure would increase to a maximum 5-in-1-million probability of contracting a fatal cancer. The incremental risk for the maximally exposed worker would remain unchanged because administrative controls would limit maximum annual worker exposure. [Tables 4-3 through 4-5](#) list 10-year dose data for all three scenarios, divided into the dose attributable to each applicable phase for each scenario.

**Table 4-3. Estimated 10-year doses from the No-Action Scenario.**

MEI <sup>c</sup> dose (rem)	Collective population dose <sup>d</sup> (person-rem)	Collective worker dose <sup>e</sup> (person-rem)	Number of workers per year
$2.8 \times 10^{-4}$	4.5	430	1,411 <sup>f</sup>

<sup>a</sup>. Combination of effects from all materials in the No-Action Scenario.

<sup>b</sup>. Values are rounded.

<sup>c</sup>. MEI = Maximally exposed individual; dose at the SRS boundary, including doses from atmospheric and liquid releases.

<sup>d</sup>. Dose to all people within 80 kilometers (50 miles) from atmospheric releases and to people using the Savannah River for drinking water, recreation, and as a source of food.

<sup>e</sup>. Dose to all workers involved with the specific operation.

<sup>f</sup>. Average number of radiation workers in the involved work groups for the years in which worker exposure occurred.

**Table 4-4. Estimated 10-year doses from the Preferred Alternatives Scenario.**

MEI <sup>c</sup> dose (rem)	Collective population dose <sup>d</sup> (person-rem)	Collective worker dose <sup>e</sup> (person-rem)	Number of workers per year
$2.8 \times 10^{-4}$	4.5	430	1,411 <sup>f</sup>

Phase	MEI <sup>b</sup> dose (rem)	Collective population dose <sup>c</sup> (person-rem)	Collective worker dose <sup>d</sup> (person-rem)	Number of workers per year
Existing storage	9.7×10 <sup>-5</sup>	2.15	202	1,409
Characterization	4.3×10 <sup>-6</sup>	0.17	195	159
Conversion	7.8×10 <sup>-3</sup>	310	605	3,801
Interim storage	2.1×10 <sup>-5</sup>	0.24	79	328
Additional conversion (if required)	3.5×10 <sup>-6</sup>	0.15	20	774
Packagin/nepa/dbgraphics/eishtml/eis-0220/repackaging	4.3×10 <sup>-9</sup>	0.00018	18	785
Post-stabilization storage	3.7×10 <sup>-8</sup>	0.0016	124	400
Totals <sup>e</sup>	7.9×10 <sup>-3</sup>	310	1,240	1,643 <sup>f</sup>

<sup>a</sup>. Combination of effects from all materials in the Preferred Alternatives Scenario (see [Table 4-1](#)).

<sup>b</sup>. MEI = Maximally exposed individual; dose at the SRS boundary, including doses from atmospheric and liquid releases.

<sup>c</sup>. Dose to all people within 80 kilometers (50 miles) from atmospheric releases and to people using the Savannah River for drinking water, recreation, and as a source of food.

<sup>d</sup>. Dose to all workers involved with the specific operation.

<sup>e</sup>. Totals are rounded.

<sup>f</sup>. Average number of radiation workers in the involved work groups for the years in which worker exposure occurred.

**Table 4-5. Estimated 10-year doses from the Comparative Alternatives Scenario.**

Phase	MEI <sup>b</sup> dose (rem)	Collective population dose <sup>c</sup> (person-rem)	Collective worker dose <sup>d</sup> (person-rem)	Number of workers per year
Existing storage	1.0×10 <sup>-4</sup>	2.3	230	1,409
Conversion	9.8×10 <sup>-3</sup>	394	851	3,765
Interim storage	1.9×10 <sup>-5</sup>	0.22	61	129
Additional conversion (if required)	1.3×10 <sup>-11</sup>	5.3×10 <sup>-7</sup>	94	4,662
Packagin/nepa/dbgraphics/eishtml/eis-0220/repackaging	2.4×10 <sup>-9</sup>	1.0×10 <sup>-4</sup>	10	471
Post-stabilization storage	1.9×10 <sup>-8</sup>	8.1×10 <sup>-4</sup>	65	256
Totals <sup>e</sup>	9.9×10 <sup>-3</sup>	400	1,278	1,748 <sup>f</sup>

<sup>a</sup>. Combination of effects from all materials in the Comparative Alternatives Scenario (see [Table 4-1](#)).

<sup>b</sup>. MEI = Maximally exposed individual; dose at the SRS boundary, including doses from atmospheric and liquid releases.

<sup>c</sup>. Dose to all people within 80 kilometers (50 miles) from atmospheric releases and to people using the Savannah River for drinking water, recreation, and as a source of food.

<sup>d</sup>. Dose to all workers involved with the specific operation.

<sup>e</sup>. Totals are rounded.

<sup>f</sup>. Average number of radiation workers in the involved work groups for the years in which worker exposure occurred.

#### 4.1.2 NONRADIOLOGICAL HEALTH EFFECTS

DOE evaluated the range of chemicals to which the public and workers would be exposed due to SRS nuclear material management activities, and expects minimal public and worker health impacts from nonradiological health effects. Sections [4.4](#) and [4.5](#) discuss the offsite chemical concentrations from air emissions and liquid discharges, respectively. DOE estimated the worker impacts using the EPA Industrial Source Complex Short Term No. 2 Model to calculate concentrations in and around work areas (WSRC 1994a,b,c) and compared them to the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) or ceiling limits for protecting worker health. All impacts are well below the limits.

OSHA limits (29 CFR Part 1910.1000) are time-weighted average concentrations that a facility cannot exceed during a prescribed duration of a 40-hour week. The facility cannot exceed OSHA ceiling concentrations during any part of the workday. These exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could be exposed day after day without adverse health effects. However, because of the wide variation in individual susceptibility, a small percentage of workers could experience discomfort from some substances at concentrations at or below the permissible limit. [Table 4-6](#) summarizes the results of this comparison. [Appendix D](#) provides the detailed material- and alternative-specific analysis.

**Table 4-6. Estimated maximum incremental onsite concentrations (milligrams per cubic meter) of nonradiological air pollutants regulated by the Occupational Safety and Health Administration.**

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Pollutant	Averaging Time	Scenario			
		OSHA PEL <sup>b</sup>	No Action	Preferred Alternatives	Comparative Alternatives
Carbon monoxide	8-hour	55	0.015	0.11	0.11
Nitrogen oxides	1-hour	9 <sup>c</sup>	0.11	0.80	0.78
Sulfur dioxide	8-hour	13	0.000022	0.00016	0.00016
Carbon dioxide	8-hour	9,000	0.000011	0.000078	0.000077
Nitric acid	8-hour	5	0.0042	0.042	0.038

<sup>a</sup>. Source: WSRC (1994a,b,c).

<sup>b</sup>. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL).

<sup>c</sup>. OSHA ceiling limit not to be exceeded at any time during the workday; modeled 1-hour concentrations are listed for comparison to ceiling limits.

**Table 4-7. Annular sector factors for local dose evaluations.**

Fraction of total population dose in sector <sup>b</sup>						Fraction of total population dose that is dose to average person in sector <sup>b</sup>				
Sector <sup>a</sup>	1 (8-16 km)	2 (16-32 km)	3 (32-48 km)	4 (48-64 km)	5 (64-80 km)	1 (8-16 km)	2 (16-32 km)	3 (32-48 km)	4 (48-64 km)	5 (64-80 km)
A (N)	3.09E-04	2.79E-02	2.70E-02	8.63E-03	1.49E-02	1.19E-05	5.25E-06	2.69E-06	1.70E-06	1.22E-06
B (NNE)	5.86E-05	5.75E-03	4.71E-03	6.50E-03	1.51E-02	9.77E-06	4.35E-06	2.28E-06	1.46E-06	1.05E-06
C (NE)	1.02E-05	1.35E-02	7.03E-03	8.33E-03	1.17E-02	1.02E-05	4.57E-06	2.40E-06	1.58E-06	1.15E-06
D (ENE)	2.76E-04	1.29E-02	9.56E-03	7.43E-03	4.15E-02	1.02E-05	4.12E-06	2.13E-06	1.39E-06	1.02E-06
E (E)	1.28E-03	2.21E-02	8.91E-03	9.67E-03	3.48E-03	8.27E-06	3.27E-06	1.68E-06	1.10E-06	8.02E-07
F (ESE)	2.55E-04	4.37E-03	2.79E-03	2.56E-03	2.24E-03	7.07E-06	2.81E-06	1.45E-06	9.44E-07	6.90E-07
G (SE)	1.29E-04	1.11E-03	6.78E-03	4.54E-03	4.25E-03	4.96E-06	2.02E-06	1.04E-06	6.79E-07	4.95E-07
H (SSE)	1.61E-04	6.63E-04	6.92E-04	8.10E-04	1.12E-03	4.04E-06	1.70E-06	9.00E-07	5.97E-07	4.40E-07
I (S)	2.25E-06	5.48E-04	7.24E-04	2.69E-03	9.34E-04	2.25E-06	9.83E-07	5.44E-07	3.71E-07	2.80E-07
J (SSW)	1.29E-05	2.42E-03	2.90E-03	4.11E-03	2.12E-03	6.46E-06	2.70E-06	1.45E-06	9.82E-07	7.22E-07
K (SW)	1.87E-04	4.17E-03	5.22E-03	4.06E-03	3.02E-03	1.10E-05	4.41E-06	2.33E-06	1.56E-06	1.14E-06
L (WSW)	5.18E-04	3.87E-03	1.32E-02	2.84E-03	5.31E-03	8.64E-06	3.50E-06	1.86E-06	1.24E-06	9.13E-07
M (W)	3.43E-04	8.52E-03	1.11E-02	7.51E-03	4.62E-03	6.24E-06	2.57E-06	1.40E-06	9.40E-07	6.82E-07
N (WNW)	2.89E-03	9.16E-03	1.57E-01	4.99E-02	8.33E-03	6.43E-06	2.74E-06	1.47E-06	9.92E-07	7.22E-07
O (NW)	2.23E-03	2.08E-02	1.57E-01	3.04E-02	2.48E-03	8.22E-06	3.52E-06	1.79E-06	1.14E-06	8.21E-07
P (NNW)	3.97E-03	8.47E-02	6.28E-02	9.74E-03	6.34E-03	1.09E-05	4.70E-06	2.31E-06	1.46E-06	1.04E-06

a. Sector letter is letter shown on Figure 4-1. Letters in parentheses after the sector letter indicate the compass direction of the sector.

b. km = kilometers; to convert to miles, multiply by 0.62137.

### 4.1.3 Environmental Justice Assessment

In general, traditional impact analyses have not examined the effects of emissions on the health of populations identified by race or economic status. This EIS examines whether communities of people of color or low income could be recipients of disproportionately high and adverse human health and environmental impacts. Even though DOE does not expect adverse health impacts from any of the alternatives, it analyzed reasonably foreseeable impacts to determine whether there are "disproportionately high and adverse human, health or environmental effects of these alternatives on minority populations or low-income population" (Executive Order 12898). Figures 3-7 and 3-8 show communities of people of color and low income by census tract. This section discusses predicted average radiation doses received by individuals in those communities and compares them to the predicted per capita doses that could be received in the other communities in the 80-kilometer (50-mile) region. This section also discusses impacts of doses that could be received in the downstream communities from liquid effluents from all alternatives, and also discusses potential impacts from nonradiological pollutants.

Figure 4-1 shows a wheel with 22.5-degree sectors and concentric rings from 16 to 80 kilometers (10 to 50 miles) at 16-kilometer (10-mile) intervals. A fraction of the total population dose was calculated for each sector (Table 4-7), the sector wheel was laid over the census tract map, and each tract was assigned to a sector. For this analysis, if a tract fell in more than one sector, it was assigned to the sector with the largest value.

Figure 4-1. Annular sectors around the Savannah River Site.

DOE analyzed the impacts by comparing the per capita dose received by each type of community to the other types of communities within a defined region. To eliminate the possibility that impacts to a low-population community close to the SRS with a high dose per person would be diluted and masked by including it with a high-population community farther from the SRS, the analysis made comparisons within a series of concentric circles, the radii of which increase in 16-kilometer (10-mile) increments.

To determine the radiation dose received per person in each type of community, the number of people in each tract was multiplied by that tract's dose value to obtain a total population dose for each tract. These population doses for each type of community were summed over each concentric circle and divided by the total community population to obtain a community per capita dose for each circular area. [Figure 4-2](#) shows these results for the Comparative Alternatives Scenario, which would be the maximum value alternative. Table 4-8 provides the supporting data.

[Figure 4-2. Community impacts from Comparative Alternatives Scenario.](#)

**Table 4-8. Estimated per capita 10-year dose for identified communities in 80-kilometer (50-mile) region for the Comparative Alternatives Scenario.**

Distance	Low income		Persons of color			
	Less than 25 percent of population	Equal or more than 25 percent of population	Less than 35 percent of population	35 percent to 50 percent of population	Equal or more than 50 percent of population	All communities
0-16 km <sup>b</sup> (0-10 miles)	0.0044	0.0042	0.0040	0.0046	0.0040	0.0044
0-32 km (0-20 miles)	0.0021	0.0020	0.0019	0.0029	0.0016	0.0021
0-48 km (0-30 miles)	0.0011	0.0012	0.0012	0.0014	0.0009	0.0011
0-64 km (0-40 miles)	0.0009	0.0010	0.0009	0.0011	0.0008	0.0009
0-80 km (0-50 miles)	0.0008	0.0009	0.0009	0.0009	0.0007	0.0009

**Table 4-10. Maximum estimated annualized point estimate of increased risk of latent cancer fatalities.**

Preferred Alternatives Scenario		Comparative Alternatives Scenario							
Receptor group	No Action/ Continuing Storage	Conversion	Interim Storage	Additional Conversion (if required)	Post-Stabilization Storage	Conversion	Interim Storage	Additional Conversion (if required)	Post-Stabilization Storage
Mark-31 targets									
Population	3.7E-6	8.8E-2	1.1E-5	1.2E-4	2.5E-6	8.8E-2	1.1E-4	(a)	(a)
MEI	4.9E-9	1.5E-5	1.4E-9	2.0E-8	7.0E-10	1.5E-5	4.6E-8	(a)	(a)
Uninvolved worker	6.1E-9	2.6E-4	4.8E-8	3.6E-7	4.8E-8	2.6E-4	9.6E-7	(a)	(a)
Americium and curium solutions									
Population	4.3E-4	8.8E-2	(b)	(b)	(c)	8.8E-2	(b)	(b)	(c)
MEI	5.7E-8	1.5E-5	(b)	(b)	(c)	1.5E-5	(b)	(b)	(c)
Uninvolved worker	1.6E-6	2.6E-4	(b)	(b)	(c)	2.6E-4	(b)	(b)	(c)
H-Canyon uranium solutions									
Population	1.2E-3	1.1E-6	2.1E-6	(a)	(a)	2.1E-6	2.1E-6	(a)	(a)
MEI	9.6E-7	1.8E-10	1.5E-9	(a)	(a)	1.5E-9	1.5E-9	(a)	(a)
Uninvolved worker	1.3E-7	3.2E-9	1.5E-6	(a)	(a)	1.5E-6	1.5E-6	(a)	(a)
H-Canyon plutonium-239 solutions									
Population	2.6E-2	2.6E-2	1.1E-5	1.2E-4	2.5E-6	2.6E-2	1.1E-4	(a)	(a)
MEI	3.6E-6	3.6E-6	1.4E-9	2.0E-8	7.0E-10	3.6E-6	4.6E-8	(a)	(a)
Uninvolved worker	1.7E-5	1.7E-5	4.8E-8	3.6E-7	4.8E-8	1.7E-5	9.6E-7	(a)	(a)
H-Canyon neptunium solutions									
Population	2.6E-2	2.6E-2	1.1E-5	1.2E-4	2.5E-6	2.6E-2	1.1E-5	1.2E-4	2.5E-6
MEI	3.6E-6	3.6E-6	1.4E-9	2.0E-8	7.0E-10	3.6E-6	1.4E-9	2.0E-8	7.0E-10
Uninvolved worker	1.7E-5	1.7E-5	4.8E-8	3.6E-7	4.8E-8	1.7E-5	4.8E-8	3.6E-7	4.8E-8
H-Canyon plutonium-242 solutions									
Population	8.8E-2	8.8E-2	1.1E-5	(a)	(a)	8.8E-2	1.1E-5	(a)	(a)
MEI	1.5E-5	1.5E-5	1.4E-9	(a)	(a)	1.5E-5	1.4E-9	(a)	(a)
Uninvolved worker	2.6E-4	2.6E-4	4.8E-8	(a)	(a)	2.6E-4	4.8E-8	(a)	(a)
Preferred Alternatives Scenario		Comparative Alternatives Scenario							
Receptor group	No Action/ Continuing Storage	Conversion	Interim Storage	Additional Conversion	Post-Stabilization Storage	Conversion	Interim Storage	Additional Conversion	Post-Stabilization Storage

	Continuing Storage			(if required)			(if required)	
Mark-16 and -22 fuels								
Population	3.7E-6	2.6E-2	2.1E-6	(a)	(a)	2.6E-2	1.1E-4	(a) (a)
MEI	4.9E-9	3.6E-6	1.5E-9	(a)	(a)	3.6E-6	4.6E-8	(a) (a)
Uninvolved worker	6.1E-9	1.7E-5	1.5E-6	(a)	(a)	1.7E-5	9.6E-7	(a) (a)
Other aluminum-clad fuels								
Population	3.7E-6	2.6E-2	1.1E-4	(a)	(a)	2.6E-2	1.1E-4	(a) (a)
MEI	4.9E-9	3.6E-6	4.6E-8	(a)	(a)	3.6E-6	4.6E-8	(a) (a)
Uninvolved worker	6.1E-9	1.7E-5	9.6E-7	(a)	(a)	1.7E-5	9.6E-7	(a) (a)
Vault solids								
Population	6.1E-5	2.6E-2	1.1E-5	(a)	(a)	2.6E-2	1.1E-5	(a) (a)
MEI	1.0E-8	3.6E-6	1.4E-9	(a)	(a)	3.6E-6	1.4E-9	(a) (a)
Uninvolved worker	1.8E-7	1.7E-5	4.8E-8	(a)	(a)	1.7E-5	4.8E-8	(a) (a)
Plutonium-238d								
Population	1.1E-5	1.1E-5	2.5E-6	(a)	(a)	5.7E-2	1.1E-5	(a) (a)
MEI	1.4E-9	1.4E-9	7.0E-10	(a)	(a)	2.2E-6	1.4E-9	(a) (a)
Uninvolved worker	4.8E-8	4.8E-8	4.8E-8	(a)	(a)	1.9E-6	4.8E-8	(a) (a)

- a. Impacts from potential radiological accidents following completion of this alternative are beyond the timeframe of this EIS.
  - b. This phase is not applicable for this alternative.
  - c. No credible mechanism exists for measurable impacts for the storage of vitrified material; therefore, this impact would be approximately 0.
  - d. The impacts presented for vault solids do not include those from the special subcategory of solids representing plutonium-238 scrap. Appendix E tables provide the impacts for this subcategory.
- a. Total population dose = 400 person-rem.  
 b. km = kilometers.

As shown, the per capita dose is extremely small for each community type. This analysis indicates that atmospheric releases would not disproportionately affect communities of people of color (population equal to or greater than 35 percent of the total population) or low income (equal to or greater than 25 percent of the total population) in the 80-kilometer (50-mile) region.

Section 4.5 discusses predicted doses to the offsite maximally exposed individual and to the downstream population from exposure to water resources. Those doses reflect people using the Savannah River for drinking water, sports, and food (fish). Because the identified communities in the areas downstream from the SRS are well distributed, there would be no disproportionate impacts among people of color or low-income communities.

The distribution of carcinogenic and criteria pollutant emissions due to routine operations, and of criteria pollutants from construction activities, would be essentially identical to those presented for airborne radiological emissions because distribution pathways would be the same. As a result, people of color or low income communities would not be disproportionately affected by nonradiological emissions from any of the alternatives. Because nonradiological pollutant emissions would have only minimal impacts for any of the alternatives, and would not be disproportionately distributed among types of communities, there are no environmental justice concerns related to these pollutants for any of the alternatives.

## 4.2 Health Effects from Accidents

This section summarizes risks to members of the public and workers from potential facility accidents associated with the alternatives for management of the nuclear materials stored at the SRS. An accident is a series of unexpected or undesirable events leading to a release of radioactive or hazardous material within a facility or to the environment. All the alternatives discussed in this EIS have a potential for accidents.

Safety analyses for the SRS facilities that process and store nuclear materials identify and describe potential accidents. DOE used information from these analyses, along with information on inventories of hazardous chemicals or radioactive materials involved with each alternative, to estimate the potential impacts from such accidents. The accidents analyzed could be the result of external events (aircraft crashes, nearby explosions), internal events (equipment failures, human errors), or natural phenomena (earthquakes, tornadoes). DOE considered accidents (i.e., both high- and low-frequency events and large- and small-consequence events) that could result in the release of both radioactive and hazardous materials. In addition, DOE analyzed a reasonable spectrum of events that could result in a release of radioactive or hazardous materials. For radiological accidents, this section presents consequences in terms of the dose to an individual or the collective dose to a population. DOE has converted these potential doses to health effects in the form of latent cancer fatalities. For hazardous material releases, consequences are presented as chemical concentrations.

To estimate the doses that would result from radiological accidents, DOE established an initial baseline by assuming a release of 1 curie of each type of radionuclide from a point on the SRS that is representative of the location of the nuclear facilities. Mathematical models predicted the dose to an individual hypothetically located 640 meters (2,100 feet) from the point of release. The mathematical models account for such factors as the meteorological conditions at the time of the accident and the rate at which the accident would deposit radioactive material over the landscape (i.e., deposition rate). DOE used the distance of 640 meters (2,100 feet) to estimate the impacts to an uninvolved worker (i.e., a worker not in the immediate vicinity of an accident, but potentially in a nearby facility or work area that is directly in the path of a radioactive plume). Similarly, DOE used the model to estimate the dose to an individual hypothetically located at a point on the SRS boundary that is directly in the path of a radioactive plume; this simulates potential impacts to a maximally exposed member of the public. DOE calculated the collective dose to the offsite population for

individuals living within 80 kilometers (50 miles) of the Site who would be in the path of any release plume.

After developing the baseline information, DOE used the estimated amount of radioactive material released during each accident to calculate corresponding doses that could result to an uninvolved worker, maximally exposed offsite individual, and the offsite population. The estimated number of latent cancer fatalities were calculated using the radiological doses and conversion factors of 0.0005 latent cancer fatalities per person-rem and 0.0004 latent cancer fatalities per person-rem (0.0008 for projected doses above 20 rem) to determine health effects to the public or for workers, respectively. The conversion factor provides the estimated increase in fatal cancers over the next 50 years. As noted in [Chapter 3](#), the national cancer fatality rate is greater than 20 percent (i.e., there is about a one in five chance that the cause of a death was cancer). The increase in latent cancer fatalities reflected in this section would be in addition to the number from all other causes.

DOE multiplied the resulting accident consequences, in terms of latent cancer fatalities, by the estimated accident frequency to calculate the point estimate of accident risk. The annualized point estimate of risk is provided to enable the consideration of accidents that might not have the highest consequence but that might pose a greater risk due to a higher frequency.

An example of this concept is the No-Action Alternative accidents related to the H-Canyon plutonium solutions listed in [Table E-7](#). The inadvertent transfer from a processing vessel to the ground outside the H-Canyon building would result in the greatest consequence of 4.1 latent cancer fatalities per occurrence (Note: this number is in bold type in Table E-7). Because this accident is likely to occur only once in every 2,500 years [Table E-7 lists this frequency as 4.00E-04 (0.0004)], a time-weighted average of these consequences over the accident frequency time span (i.e., consequence times frequency) would result in an annualized point estimate of risk of 0.0017 latent cancer fatality per year. Although the unpropagated fire in a solution vessel would produce lower consequences of 1.3 latent cancer fatalities per occurrence, DOE estimates that this accident would occur once in every 45 years (a frequency of 0.0202), resulting in a higher point estimate of risk (0.026 latent cancer fatality per year). By factoring in the accident probability, DOE can compare the resulting risks.

This analysis discusses potential accident impacts to involved workers qualitatively; however, in the event of a criticality, the result could be prompt fatalities. For personnel other than workers who would be nearby, the impact would be delayed. The human health effect of concern is the delayed development of cancer (latent cancer) that proves fatal.

Tables [4-9](#) and [4-10](#) summarize the projected impacts of accidents on the population, maximally exposed offsite individual, and uninvolved worker. The No-Action, Preferred Alternatives, and

Comparative Alternatives Scenarios are listed for each material group. To facilitate comparison among the alternatives and among the varying phases of an alternative, two parameters (i.e., latent cancer fatalities and point estimate of risk) are listed for each material group. Actions such as characterizing materials and other monitoring are represented by accident analyses for the No-Action Alternative for each material group. Existing storage of material is part of each No-Action Alternative.

[Table 4-9](#) lists the estimated increases in latent cancer fatalities resulting from the calculated population dose of the maximum consequence accident. This projected increase in latent cancer fatalities is conservative and could result only if the postulated, yet highly unlikely, accident occurred during highly unfavorable meteorological conditions. The table lists the potential population impacts for the most affected sector of the 80-kilometer (50-mile) population (i.e., the northwest direction). An examination of the distribution of communities of low-income persons and people of color did not reveal high and disproportionate impacts from potential actions.

[Table 4-10](#) lists the point estimate of increased risk of latent cancer fatalities resulting from the calculated population dose for the accident that poses the greatest risk (i.e., the accident with the highest product when the population dose is multiplied by the accident frequency). This projected point estimate of increased risk considers the projected accident probability and, therefore, provides a more appropriate index of the hazard associated with each material and scenario.

According to the Environmental Protection Agency, the average annual cancer fatality risk to an individual is approximately 0.0019. Although the incremental risk to the maximally exposed individual from an accident would be well below this value, further stabilization actions could further reduce the risk. This reduction would be due to a twofold effect of stabilizing the particular material; in some cases the likelihood of an event that dispersed the same quantity of material would be smaller, and in others the physical form or packaging of the material after stabilization would be such that a large quantity could not be released. Solutions stored in locations not designed for long-term storage are examples of materials that would offer a dual benefit if solidified and packaged properly.

As indicated in the tables in this section and in [Appendix E](#), the risk and the number of postulated accidents for each material would decrease for most of the materials after the performance of the alternative actions.

DOE evaluated the impacts associated with hazardous or toxic chemicals for each entire facility that would be involved in the storage or stabilization of nuclear materials rather than attempting to attribute the hazardous chemicals to the specific nuclear material process or activity the chemical supports. The approach used in this EIS for determining hazardous chemical impacts is similar to that typically used in a facility hazard assessment. Each facility was assumed to contain its maximum chemical inventory, which in turn was assumed to be totally released to the environment without postulating accident scenarios or release mechanisms. The use of this approach provides results that are bounding to all alternatives and scenarios. [Appendix E](#) presents the hazardous chemical impacts associated with this bounding condition.

As with radiological accidents, impacts to a close-in worker from a chemical accident can be severe or life-threatening. Some instances (i.e., the total release of the hydrofluoric or nitric acid inventory) could exceed the chemical emergency response threshold values for uninvolved workers. These threshold values could be life-threatening if individuals were exposed for longer than 1 hour. However, because these individuals would be notified and evacuated within 1 hour of an inadvertent release, DOE does not expect any life-threatening or long-term effects. The projected maximum chemical concentration at the Site boundary could exceed the first emergency response level for nitric acid. The short-term health effects from this level of exposure would be irritation of the eyes and an objectionable odor. If DOE implemented the preferred alternative for each nuclear material, the need for chemicals to support storage or processing of these materials would diminish over the 10-year period covered by this EIS.

As stated in [Chapter 1](#), one of the primary objectives of DOE's proposed action is to eliminate or reduce the risks from potential accidents that could be associated with the continued storage of nuclear materials at the SRS. For example, a wide range of accidents could result in the release of radioactive material from solutions currently stored in stainless-steel tanks that contain a variety of radioisotopes (plutonium-239, americium-243, curium-244, uranium-235, etc.).

The tables in [Appendix E](#) list abnormal events and accidents that could result in releases of radioactive material during each phase of storage or conversion. The data from these tables were used to generate [Figure 4-3](#). The "Before" risk profiles on this figure indicate the range of evaluated accidents that could occur during the continued storage of nuclear material in its current form (i.e., the No-Action Alternative). The "After" risk profiles indicate the accidents that could occur after either the Preferred Alternatives or Comparative Alternatives Scenario stabilization actions were complete. Each individual data point represents an accident for one event involving one material group. Because certain facility accidents would be common for all materials, the figure shows some data points clustered so closely they appear to be a single point. If the figure shows the post-stabilization accidents either lower (reduction in consequences) or to the left (reduction in frequency) of the accidents that would occur before stabilization, the risk would be reduced.

The accidents discussed in this section would involve essentially the same nuclear materials, but stored in different forms. For example, after the conversion of solutions to a metal or oxide, the solutions would no longer exist and no accidents could result in a liquid release. The "Before" and "After" plots in [Figure 4-3](#) shows both the number

of accidents that could result in a release and the reduction of consequences from such accidents. This is an illustration of why DOE is proposing to convert these materials and the overall reductions in risk that DOE expects.

## 4.3 Traffic and Transportation

### 4.3.1 TRAFFIC

DOE analyzed impacts from each alternative to workers and members of the public from traffic activities. Road traffic related to facility operations would remain at or below current SRS levels because none of the alternatives would require the addition of employees to the SRS workforce. Rail traffic for the movement of spent fuel would increase less than 1 percent (HNUS 1994).

### 4.3.2 TRANSPORTATION

DOE used the RADTRAN (Neuhauser and Kanipe 1992) and AXAIR89Q (Hamby 1994) computer codes configured with applicable SRS demographic data and transportation accident rates (HNUS 1994) to model the transportation of radioactive materials for each alternative. The analysis was limited to onsite movements because no offsite transportation was included in the alternatives.

The analysis calculated transportation-related radiological health effects consistent with risk assessment recommendations issued by the National Research Council (NRC 1990), and the International Commission on Radiological Protection (ICRP 1977, 1991). DOE assumed that the recommended population-averaged, dose-to-risk conversion factors (0.0004 latent cancer fatality per rem for workers and 0.0005 latent cancer fatality per rem for the public) would apply in the

evaluation of individual risk, as discussed in [Section 4.1.1](#). Prerequisite modeling calculations defined five hypothetical human receptor groups:

- Uninvolved Worker - The SRS employee who is not assigned to the transportation activity but, as a casual observer along the normal transportation route, could receive radiation exposure from the normal transport shipment.
- Onsite Population - The collective SRS employee population not assigned to the transportation activity that could receive external or internal radiation exposure from normal and accident transport shipments.
- Involved Workers - The collective SRS employee population assigned to the transportation activity (i.e., transport crew and package handlers) that could receive external radiation exposure from normal transport shipments.
- Maximally Exposed Individual - The member of the public at the SRS boundary with the highest ground-level radioactive material concentration who could receive external or internal radiation exposure from accident transport shipments.
- Offsite Population - The collective members of the public in the meteorological sector most likely to experience radioactive material transport and dispersion phenomena resulting in the delivery of the maximum collective dose from accident transport shipments.

DOE considered both the probability and the consequences of vehicle (tractor-trailer, tractor-tanker, and train) accidents. The calculated probabilities reflect accident rate statistics, the probability for a given accident severity, and the total material-dependent distance traveled. The range of accident scenarios (severity categories based on impact as the result of an accident) resulting in reasonably foreseeable accident probabilities (greater than approximately 0.0000001) were selected for further analysis to determine the magnitude of accident consequences. The accident severity categories were typically medium to high probability events of low to medium severity.

The analysis defined reasonably foreseeable accident consequences by the identity and amount of radioactive material present at the applicable receptor locations (model limitations did not allow DOE to analyze the Uninvolved Worker and Involved Workers receptor groups) and determined the consequences on a radioactive material, category-specific basis. For most reasonably foreseeable accidents, the radiological consequences and projected additional health effects would be negligible because the transportation package is certified by the appropriate agency (DOE, the Department of Transportation, the Nuclear Regulatory Commission, or the International Atomic Energy Agency) for full containment of the radioactive material under the most severe reasonably foreseeable accident conditions. However, the DOE analysis showed some consequences for accidents that involved three material categories (fuels, targets, and uranium solutions). These postulated accidents could release some radioactive material because the transport package is not certified for full containment under the most severe accident conditions. The calculated range of nonzero consequences for the on- and offsite populations would be 0.05 to 3 person-rem and 0.002 to 0.2 person-rem, respectively. At such collective dose levels, additional latent cancer fatalities are unlikely. As expected, the transportation of uranium solutions would yield the greatest on- and offsite accident impacts.

Tables [4-11](#) and [4-12](#) list the results of analyses performed to estimate the transportation radiological impacts for each scenario. The impacts are quantified as increments of effective dose equivalent that are likely to be delivered or committed to five receptors during the indicated year. The listed impacts cover the truck and rail transport scenarios analyzed, and the normal transport, highest consequence, and lowest consequence accident. The analysis did not calculate offsite receptor doses for normal transport because they would be smaller than corresponding onsite doses.

Tables [4-11](#) and [4-12](#) also list estimated human health effects corresponding to transportation radiological impacts. The health effect analyzed is the excess latent cancer fatality (i.e., incremental addition to the natural cancer fatality incidence attributable to the transportation activity). These data support the expectation that the excess health effect incidence caused by 10-year normal transport activities under any alternative would be a small fraction of the incidence caused by other routine SRS activities.

DOE has evaluated the transportation impacts associated with the alternatives not discussed in this section; these impacts would be similar to those listed in Tables [4-11](#) and [4-12](#).

Tables [4-13](#) and [4-14](#) list the results of analyses performed to estimate the impacts and human health effects from the transportation of radiological waste. These analyses quantified the impacts listed in a manner similar to that for the radioactive material categories described above. The incident-free impacts would be greater for waste handling than for the materials listed in [Table 4-11](#) due to the large volume of waste to be shipped. In addition, impacts associated with accidents would be greater due primarily to a less robust shipping package and more easily dispersible matrix of the waste.

**Table 4-11. Estimated incident-free impacts by material and scenario from transportation of radioactive materials.**

Material	Receptor	Scenario		
		No Action	Preferred Alternatives	Comparative Alternatives
Plutonium-242	Uninvolved worker <sup>a</sup>	NT <sup>b</sup>	$1.41 \times 10^{-7}$	$1.41 \times 10^{-7}$
	Onsite population <sup>c</sup>	NT	$1.58 \times 10^{-4}$	$1.58 \times 10^{-4}$
	Involved workers <sup>c</sup>	NT	$1.94 \times 10^{-2}$	$1.94 \times 10^{-2}$
Americium and curium	Uninvolved worker	NT	NT	NT
	Onsite population	NT	NT	NT
	Involved workers	NT	NT	NT
Neptunium	Uninvolved worker	NT	$1.66 \times 10^{-5}$	$1.66 \times 10^{-5}$
	Onsite population	NT	$1.41 \times 10^{-2}$	$1.41 \times 10^{-2}$
	Involved workers	NT	1.38	1.38
H-Canyon plutonium-239 solutions	Uninvolved worker	NT	$5.46 \times 10^{-7}$	NT
	Onsite population	NT	$6.18 \times 10^{-4}$	NT
	Involved workers	NT	$7.47 \times 10^{-2}$	NT
H-Canyon enriched uranium solutions	Uninvolved worker	NT	$7.20 \times 10^{-6}$	NT
	Onsite population	NT	$9.55 \times 10^{-3}$	NT
	Involved workers	NT	$5.00 \times 10^{-2}$	NT
Vault solids	Uninvolved worker	NT	$3.45 \times 10^{-6}$	$3.45 \times 10^{-6}$
	Onsite population	NT	$3.90 \times 10^{-3}$	$3.90 \times 10^{-3}$
	Involved workers	NT	0.467	0.467
Plutonium-238	Uninvolved worker	$3.09 \times 10^{-8}$	NT	NT
	Onsite population	$3.48 \times 10^{-5}$	NT	NT
	Involved workers	$6.36 \times 10^{-3}$	NT	NT
Mark-31 targets	Uninvolved worker	NT	$1.49 \times 10^{-4}$	$1.49 \times 10^{-4}$
	Onsite population	NT	$1.27 \times 10^{-2}$	$1.27 \times 10^{-2}$
	Involved workers	NT	0.125	0.125
Mark-16 and -22 fuels	Uninvolved worker	NT	$5.71 \times 10^{-4}$	$5.31 \times 10^{-4}$
	Onsite population	NT	$9.80 \times 10^{-2}$	$4.54 \times 10^{-2}$
	Involved workers	NT	0.720	0.445
Other Aluminum-clad fuels and targets	Uninvolved worker	NT	$2.59 \times 10^{-5}$	$2.59 \times 10^{-5}$
	Onsite population	NT	$2.22 \times 10^{-3}$	$2.22 \times 10^{-3}$
	Involved workers	NT	$2.17 \times 10^{-2}$	$2.17 \times 10^{-2}$
<b>Total of all materials</b>	Uninvolved worker	$3.09 \times 10^{-8}$	$7.74 \times 10^{-4}$	$7.26 \times 10^{-4}$
	Onsite population	$3.48 \times 10^{-5}$	0.141	$7.86 \times 10^{-2}$
	Involved workers	$6.36 \times 10^{-3}$	2.86	2.46
Latent cancer fatalities	Uninvolved worker <sup>d</sup>	$1.24 \times 10^{-11}$	$3.10 \times 10^{-7}$	$2.91 \times 10^{-7}$



	Onsite population	1.39×10 <sup>-8</sup>	5.65×10 <sup>-5</sup>	3.14×10 <sup>-5</sup>
	Involved workers	2.54×10 <sup>-6</sup>	1.14×10 <sup>-3</sup>	9.85×10 <sup>-4</sup>

- a. Dose in rem.  
b. NT = No transportation of materials listed.  
c. Dose in person-rem.  
d. Additional probability of a latent cancer fatality.

Table 4-12. Estimated accident impacts and associated probabilities by material.

Material	Accident severity	Accident probability	Onsite population <sup>a</sup>	Offsite population <sup>a</sup>	Offsite MEI <sup>b</sup>
Plutonium-242	Low	3.59×10 <sup>-6</sup>	0	0	0
	Medium	2.35×10 <sup>-6</sup>	0	0	0
Americium and curium	Low	NT	NT	NT	NT
	Medium	NT	NT	NT	NT
Neptunium	Low	6.53×10 <sup>-5</sup>	0	0	0
	Medium	3.33×10 <sup>-5</sup>	0	0	0
H-Canyon plutonium-239 solutions	Low	5.02×10 <sup>-6</sup>	0	0	0
	Medium	2.56×10 <sup>-6</sup>	0	0	0
H-Canyon enriched uranium solutions	Low	5.02×10 <sup>-5</sup>	0	0	0
	Medium	2.56×10 <sup>-5</sup>	2.78	0.164	2.16×10 <sup>-5</sup>
Vault solids	Low	4.02×10 <sup>-5</sup>	0	0	0
	Medium	2.05×10 <sup>-5</sup>	0	0	0
Plutonium-238	Low	7.53×10 <sup>-6</sup>	0	0	0
	Medium	3.84×10 <sup>-6</sup>	0	0	0
Mark-31 targets	Low	8.26×10 <sup>-5</sup>	0	0	0
	Medium	5.50×10 <sup>-7</sup>	4.91×10 <sup>-2</sup>	2.23×10 <sup>-3</sup>	3.17×10 <sup>-4</sup>
Mark-16 and -22 fuels	Low	2.51×10 <sup>-4</sup>	0	0	0
	Medium	1.28×10 <sup>-4</sup>	2.78	0.164	2.16×10 <sup>-5</sup>
Other aluminum-clad fuels and targets	Low	3.59×10 <sup>-6</sup>	0	0	0
	Medium	2.35×10 <sup>-6</sup>	0	0	0
Material	Accident severity	Accident probability	Onsite population <sup>a</sup>	Offsite population <sup>a</sup>	Offsite MEI <sup>b</sup>
<b>Latent cancer fatalities as a result of transportation accidents</b>					
Plutonium-242	Low	3.59×10 <sup>-6</sup>	0	0	0
	Medium	2.35×10 <sup>-6</sup>	0	0	0
Americium and curium	Low	NT	NT	NT	NT
	Medium	NT	NT	NT	NT
Neptunium	Low	6.53×10 <sup>-5</sup>	0	0	0
	Medium	3.33×10 <sup>-5</sup>	0	0	0
H-Canyon plutonium-239 solutions	Low	5.02×10 <sup>-6</sup>	0	0	0
			-6		

	Medium	2.56×10	0	0	0
H-Canyon enriched uranium solutions	Low	5.02×10 <sup>-5</sup>	0	0	0
	Medium	2.56×10 <sup>-5</sup>	1.11×10 <sup>-3</sup>	8.21×10 <sup>-5</sup>	1.08×10 <sup>-8</sup>
Vault solids	Low	4.02×10 <sup>-5</sup>	0	0	0
	Medium	2.05×10 <sup>-5</sup>	0	0	0
Plutonium-238	Low	7.53×10 <sup>-6</sup>	0	0	0
	Medium	3.84×10 <sup>-6</sup>	0	0	0
Mark-31 targets	Low	8.26×10 <sup>-5</sup>	0	0	0
	Medium	5.50×10 <sup>-7</sup>	1.96×10 <sup>-5</sup>	1.12×10 <sup>-6</sup>	1.59×10 <sup>-7</sup>
Mark-16 and -22 fuels	Low	2.51×10 <sup>-4</sup>	0	0	0
	Medium	1.28×10 <sup>-4</sup>	1.11×10 <sup>-3</sup>	8.21×10 <sup>-5</sup>	1.08×10 <sup>-8</sup>
Other aluminum-clad fuels and targets	Low	3.59×10 <sup>-6</sup>	0	0	0
	Medium	2.35×10 <sup>-6</sup>	0	0	0

<sup>a</sup>. Dose in person-rem.

<sup>b</sup>. MEI = Maximally exposed individual; dose in rem.

<sup>c</sup>. NT = No transportation of materials listed.

**Table 4-13. Estimated incident-free impacts by waste type and scenario from transportation of radioactive materials.**

Waste type	Receptor	Scenario		
		No Action	Preferred Alternatives	Comparative Alternatives
DWPF <sup>a</sup>	Uninvolved worker <sup>b</sup>	NT <sup>c</sup>	NT	NT
	Involved workers <sup>d</sup>	NT	NT	NT
	Onsite population <sup>d</sup>	NT	NT	NT
Saltstone	Uninvolved worker	2.56×10 <sup>-5</sup>	6.18×10 <sup>-5</sup>	9.04×10 <sup>-5</sup>
	Involved workers	9.91	23.9	35.0
	Onsite population	4.96×10 <sup>-1</sup>	1.20	1.75
Transuranic waste	Uninvolved worker	1.25×10 <sup>-6</sup>	2.72×10 <sup>-6</sup>	2.57×10 <sup>-6</sup>
	Involved workers	0.460	0.998	0.943
	Onsite population	2.42×10 <sup>-2</sup>	5.25×10 <sup>-2</sup>	4.96×10 <sup>-2</sup>
Mixed waste	Uninvolved worker	1.97×10 <sup>-6</sup>	3.58×10 <sup>-6</sup>	3.94×10 <sup>-6</sup>
	Involved workers	1.48	2.70	2.97
	Onsite population	3.82×10 <sup>-2</sup>	6.94×10 <sup>-2</sup>	7.64×10 <sup>-2</sup>
Low-level waste	Uninvolved worker	1.06×10 <sup>-4</sup>	9.87×10 <sup>-5</sup>	1.06×10 <sup>-4</sup>
	Involved workers	83.4	77.5	83.4
	Onsite population	2.06	1.91	2.06
<b>Total dose from all waste types</b>	Uninvolved worker	1.35×10 <sup>-4</sup>	1.67×10 <sup>-4</sup>	2.03×10 <sup>-4</sup>
	Involved workers	95.3	1.05×10 <sup>2</sup>	1.22×10 <sup>2</sup>
	Onsite population	2.62	3.23	3.94
e	d	-8	-8	-8

<b>Latent cancer fatalities</b>	Uninvolved worker	$5.40 \times 10^{-2}$	$6.67 \times 10^{-2}$	$8.13 \times 10^{-2}$
	Involved workers	$3.81 \times 10^{-2}$	$4.20 \times 10^{-2}$	$4.89 \times 10^{-2}$
	Onsite population	$1.05 \times 10^{-3}$	$1.29 \times 10^{-3}$	$1.57 \times 10^{-3}$

<sup>a</sup>. DWPF = Defense Waste Processing Facility.

<sup>b</sup>. Uninvolved worker dose in rem.

<sup>c</sup>. NT = No transportation.

<sup>d</sup>. Involved workers and onsite population dose in person-rem.

<sup>e</sup>. Estimated number of latent cancer fatalities.

#### 4.4 Air Resources

This section discusses radiological and nonradiological offsite air quality impacts from normal operation for the three management scenarios evaluated in this EIS. The information in this section was one of the bases for the public health effects discussed in [Section 4.1](#) (which discusses the effects of onsite air impacts on workers).

[Appendix D](#) includes a detailed presentation of air impacts by material category or subcategory, alternative, and activities associated with each phase of the alternative.

**Table 4-14. Estimated accident impacts and associated probabilities by waste type.**

Waste type	Accident severity	Accident probability	Onsite population <sup>a</sup>	Offsite population <sup>a</sup>	Offsite MEI <sup>b</sup>
DWPF <sup>c</sup>	Low	NT <sup>d</sup>	NT	NT	NT
	Medium	NT	NT	NT	NT
Saltstone	Low	$7.15 \times 10^{-3}$	$5.01 \times 10^{-4}$	$1.10 \times 10^{-4}$	$6.72 \times 10^{-9}$
	Medium	$4.49 \times 10^{-3}$	$5.01 \times 10^{-2}$	$1.10 \times 10^{-2}$	$6.72 \times 10^{-7}$
Transuranic waste	Low	$5.59 \times 10^{-4}$	$4.61 \times 10^2$	40.5	$5.78 \times 10^{-3}$
	Medium	$2.15 \times 10^{-4}$	$4.61 \times 10^4$	$4.05 \times 10^3$	0.578
Mixed waste	Low	$1.45 \times 10^{-4}$	$1.37 \times 10^{-4}$	$1.36 \times 10^{-5}$	$1.94 \times 10^{-9}$
	Medium	$5.16 \times 10^{-5}$	$1.37 \times 10^{-2}$	$1.36 \times 10^{-3}$	$1.94 \times 10^{-7}$
Low-level waste	Low	$1.72 \times 10^{-2}$	$3.83 \times 10^{-4}$	$3.80 \times 10^{-5}$	$5.42 \times 10^{-9}$
	Medium	$3.29 \times 10^{-3}$	$3.83 \times 10^{-2}$	$3.80 \times 10^{-3}$	$5.42 \times 10^{-7}$
Waste type	Accident severity	Accident probability	Onsite population <sup>a</sup>	Offsite population <sup>a</sup>	Offsite MEI <sup>b</sup>
<b>Latent cancer fatalities<sup>e</sup></b>					
DWPF	Low	NT	NT	NT	NT
	Medium	NT	NT	NT	NT
Saltstone	Low	$7.15 \times 10^{-3}$	$2.00 \times 10^{-7}$	$5.52 \times 10^{-8}$	$3.36 \times 10^{-12}$
	Medium	$4.49 \times 10^{-3}$	$2.00 \times 10^{-5}$	$5.52 \times 10^{-6}$	$3.36 \times 10^{-10}$
Transuranic waste	Low	$5.59 \times 10^{-4}$	0.184	$2.02 \times 10^{-2}$	$2.89 \times 10^{-6}$
	Medium	$2.15 \times 10^{-4}$	18.4	2.02	$2.89 \times 10^{-4}$
Mixed waste	Low	$1.45 \times 10^{-4}$	$5.48 \times 10^{-8}$	$6.81 \times 10^{-9}$	$9.72 \times 10^{-13}$
	Medium	$5.16 \times 10^{-5}$	$5.48 \times 10^{-6}$	$6.81 \times 10^{-7}$	$9.72 \times 10^{-11}$
Low-level waste	Low	$1.72 \times 10^{-2}$	$1.53 \times 10^{-7}$	$1.90 \times 10^{-8}$	$2.71 \times 10^{-12}$
	Medium	$3.29 \times 10^{-3}$	$1.53 \times 10^{-5}$	$1.90 \times 10^{-6}$	$2.71 \times 10^{-10}$

<sup>a</sup>. Onsite and offsite population dose in person-rem.

<sup>b</sup>. MEI = Maximally exposed individual; dose in rem.

<sup>c</sup>. DWPF = Defense Waste Processing Facility.

<sup>d</sup>. NT = No transportation.

<sup>e</sup>. Estimated number of latent cancer fatalities.

#### 4.4.1 Radiological IMPACTS

The radiological impacts assessment indicates that the doses from total SRS airborne emissions for nuclear materials management would remain within the applicable dose standards for DOE facilities. DOE conducted an assessment to establish the actions it would perform during the treatment of the materials evaluated in this EIS to facilitate its prediction of the radiological doses associated with each scenario. The assessment reviewed past and current SRS actions, identified those that are the same as or similar to potential future treatment actions, and quantified the associated airborne releases. These actions made it possible to estimate the releases associated with each material and alternative over the 10-year period of interest. The releases were converted to doses using the MAXIGASP and includes a 0.073 person-rem contribution from water pathways ([Section 4.5](#)), would be less than 0.5 percent of the proposed 100-person-rem threshold for notification (proposed 10 CFR Part 834). The 100-person-rem value represents neither an acceptable nor unacceptable dose; it is simply a reporting limit that will help DOE concentrate its regulatory and oversight resources and respond, if necessary, in a timely manner.

Table 4-15 indicates that the No-Action Scenario would result in lower maximum annual and 10-year doses than the other two scenarios (discussed below) because fewer activities would release radioactivity to the environment under No Action. However, as shown in [Appendix D](#), the annual POPGASP computer codes (Simpkins 1994), which calculate the dose to a hypothetical maximally exposed individual at the SRS boundary and the collective dose to the population within an 80-kilometer (50-mile) radius, respectively. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1982) modules.

**Table 4-15. Estimated radiological doses from airborne releases of radioactivity associated with each management scenario.**

Receptor <sup>c</sup>	Scenario		
	No Action	Preferred Alternatives	Comparative Alternatives
MEI <sup>d</sup> (rem)			
Maximum annual <sup>e</sup>	0.0000084	0.0040	0.0043
10-year total	0.000084	0.0077	0.0097
Population <sup>f</sup> (person-rem)			
Maximum annual <sup>e</sup>	0.38	163	176
10-year total	3.8	310	400

<sup>a</sup>. Based on data in [Appendix D](#).

<sup>b</sup>. Composite of all materials processed under that scenario.

<sup>c</sup>. Atmospheric releases from total 1993 SRS operations produced a dose of 0.00011 rem to the maximally exposed member of the public and 7.6 person-rem to the regional population (Arnett, Karapatakis, and Mamatey 1994).

<sup>d</sup>. Maximally exposed offsite individual.

<sup>e</sup>. The analysis first determined the maximum annual dose for each material among the treatment phases, and then summed the maximum doses for all materials to obtain an upper bound dose value.

<sup>f</sup>. Population within 80 kilometers (50 miles) of the SRS (regional population).

Table 4-15 lists the doses from airborne releases of radioactivity associated with the continued maintenance and storage of the materials evaluated in this EIS (i.e., the No-Action Scenario). For this scenario the doses would remain constant over the 10-year period and within the 1993 totals from all SRS operations. The highest annual dose to the maximally exposed member of the public associated with the No-Action Scenario, 0.0000084 rem (0.0084 millirem), would be less than 0.1 percent of the 10-millirem DOE limit for sitewide airborne releases (DOE Order 5400.5). The highest annual population dose associated with the No-Action Scenario would be 0.45 person-rem; this dose, which doses from the other two scenarios would be two orders of magnitude less than those from the No-Action Scenario after all the material had been processed, stabilized, and stored. The materials that would contribute the highest doses under the No-Action Scenario would be stable materials, F-Canyon americium and curium solutions, and H-Canyon enriched uranium solutions. The major radionuclide contributors would be plutonium-239, uranium-235 and -238, and americium-241.

For the Preferred Alternatives Scenario, the materials that would contribute the highest doses during the 10-year period would be vault solids, Mark-16 and -22 fuels, and neptunium solutions. The major radionuclide contributors would be plutonium-238 and -239, uranium-235 and -238, and americium-241. Table 4-15 lists the incremental doses associated with this scenario. The highest annual incremental dose to the maximally exposed individual from airborne releases during the 10-year interim management period could be 0.0040 rem (4.0 millirem). This incremental individual dose would represent 40 percent of the 10-millirem sitewide limit. The highest annual incremental dose to the regional population from airborne releases would be 163 person-rem. The incremental dose to the population, including the 0.25-person-rem contribution from water pathways ([Section 4.5](#)) could exceed the proposed 100-person-rem reporting limit.

For the Comparative Alternatives Scenario, the materials that would contribute the highest doses would be vault solids, H-Canyon plutonium-239 solutions, and H-Canyon neptunium solutions. The major radionuclide contributors would be plutonium-238 and -239, uranium-235 and -238, and americium-241. Table 4-15 lists the incremental doses associated with this scenario. The highest annual incremental dose to the maximally exposed individual from airborne releases during the 10-year interim management period could be 0.0043 rem (4.3 millirem). This incremental individual dose would represent 43 percent of the 10-millirem limit. The highest annual incremental dose to the regional population from airborne releases during this 10-year period would be 176 person-rem. The incremental dose to the population, including the 0.62-person-rem contribution from water pathways ([Section 4.5](#)) could exceed the proposed 100-person-rem reporting limit. While this would not represent an unacceptable dose, the SRS would have to notify the appropriate DOE office.

#### 4.4.2 NONRADIOLOGICAL IMPACTS

DOE used the EPA Industrial Source Complex Short-Term No. 2 model to estimate nonradiological air pollutant concentrations. Emissions data were input to the model along with the meteorological data discussed in [Section 3.3.3](#). The model computed maximum boundary line concentrations at or beyond the SRS boundary.

Virtually all nonradiological air pollutant emissions for each material are associated with activities in F- and H-Areas. These emissions can be attributed to the F- and H-Area main stacks, diesel generators, and storage tanks. Emissions from the generators and storage tanks do not vary by material or treatment alternative, and thus are part of the facility baseline. These emissions, which are accounted for in [Section 3.3.3](#), are not included in the incremental modeling results presented in this section.

Table 4-16 lists the estimated maximum concentrations associated with each scenario evaluated in this EIS. As listed, the maximum concentrations for the No-Action Scenario would be approximately a factor of 10 lower than the maximum concentrations for the Preferred Alternatives and Comparative Alternatives Scenarios. The maximum concentrations for the Preferred Alternatives and Comparative Alternatives Scenarios would be approximately the same.

**Table 4-16. Estimated maximum incremental concentration (micrograms per cubic meter) of nonradiological air pollutants at the SRS boundary for each management scenario.**

Pollutant	Averaging Time	Scenario		
		No Action	Preferred Alternatives	Comparative Alternatives
Carbon monoxide	1-hour	9.6	68	67
	8-hour	2.3	16	16
Nitrogen oxides	Annual	0.19	1.3	1.3
Sulfur dioxide	3-hour	0.0056	0.040	0.039
	24-hour	0.0013	0.0089	0.0088
	Annual	0.000079	0.00056	0.00055
Gaseous fluorides (as HF)	12-hour	0.016	0.18	0.16
	24-hour	0.0086	0.095	0.084
	1-week	0.0034	0.037	0.033
	1-month	0.00095	0.010	0.0093
Nitric acid	24-hour	0.27	2.7	2.4
	Annual	0.018	0.18	0.16

<sup>a</sup>. Source: WSRC (1994 a,b,c).

To provide a comparison between the predicted concentrations and nonradiological air quality standards, DOE added the maximum concentrations for each scenario to the estimated sitewide (baseline) concentrations presented in [Section 3.3.3](#) and to (background) concentrations measured at various locations around the SRS. Table 4-17 lists the resulting total concentrations for each scenario and compares them to regulatory standards. As listed, all concentrations would be well below the standards. In addition, the incremental concentrations associated with each scenario (Table 4-16) would be a small part of the total concentrations listed in Table 4-17.

**Table 4-17. Estimated maximum total concentration (micrograms per cubic meter) of nonradiological air pollutants at the SRS boundary for each management scenario.<sup>a</sup>**

Pollutant	Averaging time	Regulatory standard	Scenario			Concentration standard (%)	Total concentration <sup>b</sup>	Concentration standard (%)	Total concentration <sup>b</sup>	Concentration standard (%)
			No Action	Preferred Alternatives	Comparative Alternatives					
Carbon monoxide	1-hour	40,000	180	NA <sup>c</sup>	180	0.45	250	0.62	250	0.62
	8-hour	10,000	23	NA	23	0.23	39	0.39	39	0.39
Nitrogen oxides	Annual	100	4.0	8	12	12	13	13	13	13
Sulfur dioxide	3-hour	1,300	630	34	660	51	660	51	660	51
	24-hour	365	190	17	210	57	210	57	210	57
	Annual	80	10	3	13	16	13	16	13	16
Gaseous fluorides	12-hour	3.7	0.62	NA	0.62	17	0.80	22	0.78	21
(as HF)	24-hour	2.9	0.31	NA	0.31	11	0.40	14	0.39	14
	1-week	1.6	0.15	NA	0.15	9.4	0.19	12	0.18	11
	1-month	0.8	0.03	NA	0.03	3.8	0.040	5.1	0.039	4.9

Nitric acid	24-hour	125	6.7	NA	6.7	5.4	9.4	7.5	9.1	7.3
	Annual	None	NA	NA	0.018	NA	0.18	NA	0.16	NA

<sup>a</sup> Sources: WSRC (1994a,b,c,d); SCDHEC (1992).

<sup>b</sup> For the Preferred and Comparative alternatives, total concentration would be the sum of the incremental concentration (from Table 4-16), the baseline concentration, and the background concentration. For the No-Action Scenario, the total concentration would be equal to the baseline concentration plus the background concentration.

## 4.5 Water Resources

This section describes the normal effects associated with the three management scenarios. This information was one of the bases for the health effects discussed in Section 4.1. DOE expects minimal impacts to either surface water or groundwater. In addition, the analysis concludes that water resource impacts would vary little among the scenarios.

Because normal operations would not involve releases to groundwater, DOE has limited this section to surface-water impacts. The major sources of liquid effluents from involved facilities would be process cooling water and steam condensate that could contain small quantities of radionuclides and chemicals. The exposure pathways considered are drinking water, fish ingestion, shoreline exposure, swimming, and boating. Usage factors for the maximally exposed individual are consistent with regularly published SRS environmental reports (e.g., Arnett, Karapatakis, and Mamatey 1994). As described below, DOE used a mathematical model to calculate the dose to the maximally exposed offsite individual and the collective dose to the offsite population.

DOE conducted an assessment to establish the actions it would perform during the treatment of the materials evaluated in this EIS. The assessment reviewed past and current actions at the SRS, identified those that are the same or similar to future alternatives, and quantified the associated liquid releases; this made it possible to estimate the releases associated with each material and alternative over the 10-year period of interest.

Calculations of radiological doses through water pathways based on these releases are supported by the use of LADTAP II, a computer code developed by the U.S. Nuclear Regulatory Commission to estimate radiation doses associated with normal reactor system liquid effluent releases to individuals, populations groups, and biota. LADTAP II uses the models in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (NRC 1977) to calculate doses received from water and fish ingestion and from recreational water activities.

Any radionuclide releases to surface water resulting from the alternative management scenarios would be to SRS streams that discharge to the Savannah River. Table 4-18 lists the maximum annual and total doses received from exposure to these materials over the 10-year period covered by this EIS. For the No-Action Scenario, the doses would remain constant over time. For the Preferred Alternatives and Comparative Alternatives Scenarios, the doses would increase by a factor of about four above those of the No-Action Scenario when processing of material was occurring and then, as shown in Appendix D, generally would decrease until, after all the material had been processed, stabilized, and stored, the annual doses would be at least 3 orders of magnitude less than those of the No-Action Scenario. As listed in Table 4-18, the dose for the Comparative Alternatives Scenario would be greater than those for the other scenarios.

**Table 4-18. Estimated radiological doses from surface-water pathway exposures.**

Dose <sup>a</sup>	Scenario		
	No Action	Preferred Alternatives	Comparative Alternatives
MEI <sup>b</sup> (rem)			
Maximum annual <sup>c</sup>	0.0000197	0.000070	0.00013
10-year total	0.000197	0.00020	0.00023
Population (person-rem)			
Maximum annual	0.073	0.25	0.62
10-year total	0.73	0.78	0.88

<sup>a</sup> Resulting from the use of Savannah River water between the SRS and the Atlantic Ocean.

<sup>b</sup> MEI = Maximally exposed individual.

<sup>c</sup> The analysis first determined the maximum annual dose for each material among the treatment phases, and then summed the maximum doses for all materials to obtain an upper bound dose value.

For all three scenarios, the ingestion of fish containing cesium-137 would contribute most of the exposure to both the maximally exposed individual and the population. Plutonium and uranium isotopes ingested with drinking water would be secondary contributors. The maximally exposed individual could receive annual doses from liquids as high as 14, 50, and 92 percent, respectively, of that from present liquid releases from the Site, which is itself a small fraction of the applicable Federal dose standard (Arnett, Karapatakis, and Mamatey 1994). The population doses from liquids could be as high as 5, 16, and 41 percent, respectively, of the dose from present SRS liquid releases. Section 4.4 discusses the regulatory aspects of the population dose from air and liquid pathways.

This assessment also compared chemical releases with applicable water quality standards. These standards are based on the preservation of aquatic biota populations, human health, and aesthetics (i.e., taste and odor). Figure 3-5 shows that none of the stabilization actions would occur within the 100-year floodplain. DOE would treat sanitary waste associated with personnel necessary to perform the selected treatment alternatives in existing sewage treatment plants; discharges from these plants (e.g., to L-Lake from L-Area, to Fourmile Branch from F-Area, to Fourmile Branch from H-Area) would continue to meet National Pollutant Discharge Elimination System permit limits.

Under the three scenarios, process cooling water treatment would result in releases of the following concentrations from F-Area to Upper Three Runs Creek:

--	--	--	--	--	--	--	--	--	--	--



- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• Nitrate - 40 micrograms per liter</li> <li>• Ammonia - 30 micrograms per liter</li> <li>• Manganese - 10 micrograms per liter</li> <li>• Uranium - 20 micrograms per liter</li> <li>• Lead - 6 micrograms per liter</li> </ul> | <ul style="list-style-type: none"> <li>• Nickel - 50 micrograms per liter</li> <li>• Chromium - 20 micrograms per liter</li> <li>• Aluminum - 200 micrograms per liter</li> <li>• Copper - 10 micrograms per liter</li> <li>• Zinc - 70 micrograms per liter</li> </ul> |
|---|---|

Similar or lower concentrations would be released from H-Area with the exception of those for nitrate and ammonia, which would be 100 and 500 micrograms per liter, respectively. Although proposed or final Federal drinking water standards do not apply to discharges, the SRS discharge concentrations would not exceed these standards (Arnett, Karapatakis, and Mamatey 1993). The discharges would also comply with South Carolina Water Quality Standards (SC 1994). In general, the release concentrations would be no greater than those measured in Upper Three Runs Creek and Fourmile Branch (Arnett 1993, 1994), with the exception of zinc and ammonia; however, zinc concentrations in the discharge would be two orders of magnitude less than South Carolina Water Quality Standards, which are based on the taste and odor of drinking water. Ammonia concentrations in the discharge (of which only H-Area releases would exceed stream concentrations) would be well within state standards. Lead, nickel, chromium, and copper were generally not detected in Upper Three Runs Creek and Fourmile Branch in 1993. The release concentrations of these metals would be no greater than those measured in 1992 and are well within state standards.

For the No-Action Scenario, the effluent discharge flow rate would be 5 percent of normal creek flow rates. For the Preferred Alternatives Scenario, an upper bound annual effluent discharge flow rate, calculated by assuming that all materials were processed in the same year, would be 170 percent of normal creek flow rates. The 10-year average flow rate for this scenario would be 35 percent of normal creek flow rates (decreasing to less than 1 percent after all the material had been processed and stored). Upper bound and 10-year average effluent flow rates for the Comparative Alternatives Scenario would be the same as and 25 percent higher, respectively, than those for the Preferred Alternatives Scenario; after all the material had been processed and stored, the flow rate for the Comparative Alternatives Scenario would be less than 1 percent of normal creek flow rates.

The liquid pathway dose, chemical releases, and effluent flow rates would initially be lower for the No-Action Scenario than for the Preferred Alternatives Scenario. However, as material processing was completed, the impacts to water resources would decrease until, after DOE had processed all the material, the impacts from the Preferred Alternatives Scenario would be at least an order of magnitude less than those of No Action. Comparative Alternatives Scenario impacts to water resources would generally be somewhat greater than those of the Preferred Alternatives Scenario.

#### 4.6 Utilities

DOE based its estimates of water, electricity, steam, and fuel annual consumption rates on past operational experience and the projected usage for each material and alternative. [Appendix D](#) presents annual impacts for the various phases of stabilization by material. DOE compared the 10-year cumulative consumption of utilities by scenario ([Table 4-19](#)) to the SRS utility capacities listed in [Table 4-20](#) to determine the potential for impacts. The existing SRS capacities and distribution systems would be adequate to support any of the alternatives; no new generation or treatment facilities would be necessary. Suitable groundwater from the deep aquifers at the Site is abundant and aquifer depletion is not a problem. Pumping from the deep aquifer to meet domestic, process, and other water uses has continued as needed since the early 1950s. This usage has not adversely affected water levels in the deep aquifer (Christensen and Gordon 1983).

**Table 4-19. Estimated utility consumption for the management scenarios.**

Utilities	Management Scenarios		
	10-year total	Preferred	Comparative
Water, ML <sup>b</sup>	38,400	36,400	39,600
Electricity, MW-hr <sup>c</sup>	1,259,300	1,140,400	1,400,600
Steam, Mkg <sup>d</sup>	5,900	4,900	6,500
Fuel, kL <sup>e</sup>	36,300	29,900	40,700

<sup>a</sup> Source: WSRC (1994a).

<sup>b</sup> Millions of liters; to convert liters to gallons, multiply by 0.26418.

<sup>c</sup> Millions of kilowatt-hours.

<sup>d</sup> Millions of kilograms; to convert kilograms to pounds, multiply by 2.2046.

<sup>e</sup> Thousands of liters.

DOE estimates that the smallest increase in demand for utilities during the 10-year period of interest would result from the Preferred Alternatives Scenario, and the greatest increase would result from the Comparative Alternatives Scenario.

#### 4.7 Waste Management

The SRS generates several different types of waste, including low-level waste, high-level waste, transuranic waste, and mixed waste. Low-level waste constitutes a

substantial portion of the generated

**Table 4-20. Current capacities and usage of utilities and energy at the Savannah River Site.**

<b>ELECTRICITY</b>	
Consumption	659,000 megawatt-hours per year
Load	75 megavolt-amperes
Peak Demand	130 megavolt-amperes
Capacity	340 megavolt-amperes
<b>WATER</b>	
Groundwater usage	11,920 billion liters (3,000 billion gallons) per year
Surface water usage (cooling)	75,700 billion liters (20,000 billion gallons) per year
<b>FUEL</b>	
Oil	28.4 million liters (7.5 million gallons) per year
Coal	208,655 metric tons (230,000 tons) per year
Gasoline	4.7 million liters per year
<b>WASTEWATER</b>	
Domestic capacity	3.97 million liters (1 million gallons) per day
Domestic load	1.89 million liters (500,000 gallons) per day
Industrial capacity <sup>b,c</sup>	1.64 million liters (400,000 gallons) per day
Industrial load	43,836 liters (12,000 gallons) per day

<sup>a</sup> Source: WSRC (1994a).

<sup>b</sup> F/H Effluent Treatment Facility only.

<sup>c</sup> Design capacity; permitted capacity is about 67 percent of this value.

waste and typically contains relatively small amounts of dispersed radioactive material. Compaction is often employed to reduce the volume of this type of waste and to minimize disposal space. High-level waste at the SRS is a liquid resulting from processing operations in the canyon facilities; DOE will treat this waste at the proposed Defense Waste Processing Facility (DWPF) and convert it to a solid glass material encapsulated in stainless-steel canisters. This EIS expresses the generation of high-level waste as both the volume of high-level liquid waste and "equivalent DWPF canisters," even though this facility will not produce canisters during the early portion of the 10-year time period covered by this EIS. The volumes of liquid waste reported in this section are the volumes as they leave the canyon, and do not reflect final volumes that would enter the waste tanks after concentration and evaporation. The use of equivalent DWPF canisters for measuring high-level waste provides a better comparison among alternatives because liquid waste can be diluted or concentrated such that the volume of liquid is not an accurate indicator of the actual waste content.

Table 4-21 lists estimated generation rates of Defense Waste Processing Facility canisters and other waste types for each alternative. These estimates are based on current and past SRS operations (WSRC 1994a). As listed in Table 4-21, DOE estimates that the smallest increase for all waste types over the 10-year period would occur if it implemented the No-Action Scenario. The largest increase in waste would result from implementing the Comparative Alternatives Scenario.

**Table 4-21. Estimated total waste generated over the 10-year time period by scenario.**

Waste type	Scenario		
	No-Action	Preferred Alternatives	Comparative Alternatives
High-level liquid waste (ML <sup>c</sup> )	8.7	26	39
Equivalent DWPF <sup>d</sup> canisters	200	300	500
Saltstone (cubic meters)	34,000	82,000	120,000
Transuranic waste (cubic meters)	830	1,800	1,700
Hazardous/mixed waste (cubic meters)	1,100	2,000	2,200
Low-level waste (cubic meters)	140,000	130,000	140,000

<sup>a</sup> Source: Based on data from WSRC (1994a).

<sup>b</sup> To convert cubic meters to cubic yards, multiply by 1.3079.

<sup>c</sup>

Millions of liters; to convert liters to gallons, multiply by 0.26418.

<sup>d</sup> DWPF = Defense Waste Processing Facility.

With the exception of Processing and Storing for Vitrification in the Defense Waste Processing Facility, the impact on SRS waste management capacities from implementing any of the alternatives would be minimal because the Site could accommodate all the waste generated with existing and planned radioactive waste storage and disposal facilities.

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## CHAPTER 5. CUMULATIVE IMPACTS

This chapter considers cumulative impacts, which include the impacts of existing offsite (non-DOE) industrial facilities and potential impacts of planned Savannah River Site facilities. Radiological impacts from the operation of the Vogtle Electric Generating Plant, a two-unit commercial nuclear powerplant approximately 16 kilometers (10 miles) southwest of the center of the SRS near Waynesboro, Georgia, are minimal, but DOE has factored them into the analysis. Radiological impacts of operation of the Chem-Nuclear Services facility, a commercial low-level waste disposal facility just east of the SRS, are so small that this assessment does not include them (SCDHEC 1992).

In addition to the interim management of nuclear materials, DOE has recently prepared other National Environmental Policy Act (NEPA) documentation relating to the Savannah River Site, including the following:

- Appendix C of the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (DOE 1994a)
- The SRS Defense Waste Processing Facility (DWPF) Supplemental EIS (DOE 1994b)
- The F-Canyon Plutonium Solutions Environmental Impact Statement (DOE 1994c)
- The SRS Waste Management EIS (DOE 1995)

To the extent that data from these impact assessments were available and relevant, DOE has included them in the cumulative impact analyses that follow.

DOE did not include a number of other facilities in this cumulative impact analysis because decisions on these facilities involve major unresolved DOE policy issues. Because of these unresolved issues, any attempt to analyze corresponding impacts would involve an unacceptable level of speculation and uncertainty. For example, this assessment does not consider DOE planning related to reconfiguring the nation's weapons complex, including a new source for tritium production. In addition, this assessment does not attempt to present quantitative impacts for other NEPA documents that DOE is preparing, including the Environmental Management Programmatic EIS, the Foreign Research Reactor Spent Nuclear Fuel EIS, or the Programmatic EIS for Disposition of Weapons-Usable Fissile Materials. If more complete or more definitive information becomes available before the preparation of the final version of this EIS, DOE will incorporate it.

DOE has analyzed cumulative impacts for public and worker health, air resources, water resources, waste generation, and utilities. The contributions of the Comparative Alternatives Scenario to the cumulative impacts of SRS operations on regional ecosystems and the Savannah River watershed (e.g., impacts on land use, surface water, and groundwater) were too small to characterize and are not included. Activities supporting the various management alternatives would take place inside secure fenced areas that were converted to industrial use more than 40 years ago. DOE anticipates no incremental impacts on ecological resources.

### 5.1 Public and Worker Health

[Table 5-1](#) summarizes the cumulative health effects of routine SRS operations. Current SRS project impacts are based on 1993 data. Other impacts resulting from proposed DOE actions are presented in the applicable environmental impact statement listed on page 5-1. This table lists, in addition to estimated radiological doses to the hypothetical maximally exposed individual and the offsite population, potential cancer fatalities for the public and workers due to exposure to radiation. These cumulative impacts could result in an additional latent cancer fatality risk of 0.0000011 per year to that individual and in a total of 0.04 additional cancer fatality per year to the 80-kilometer (50-mile) population from releases of radioactivity. The interim management of the nuclear materials evaluated in this EIS would account for about 50 percent of these health effects. The cumulative impact could result in an additional latent cancer fatality risk of 0.32 to the onsite workers; the interim management of nuclear materials would account for approximately 16 percent of this risk.

**Table 5-1. Estimated average annual cumulative radiological doses and resulting health effects to offsite population and facility workers.**

Activity	Maximally exposed individual				Total collective (to offsite population) <sup>b</sup>				Workers	
	Dose from airborne releases <sup>c</sup>	Dose from liquid releases <sup>c</sup>	Total dose <sup>c</sup>	Fatal cancer risk <sup>d</sup>	Dose from airborne releases <sup>e</sup>	Dose from liquid releases <sup>e</sup>	Total dose <sup>e</sup>	Latent cancer fatalities <sup>f</sup>	Dose <sup>e</sup>	Latent cancer fatalities <sup>f</sup>
Current SRS practices	0.00011	0.00014	0.00025	$1.3 \times 10^{-7}$	7.6	1.5	9.1	0.0046	263	0.11
Interim Management of Nuclear Materials <sup>g</sup>	0.00097	0.000024	0.00099	$5.0 \times 10^{-7}$	40	0.09	40	0.02	127	0.051
Stabilization of plutonium solutions	0.0000086	0.00000029	0.0000089	$4.5 \times 10^{-9}$	0.38	0.0037	0.38	0.00019	131	0.052
Waste Management	0.00024	$6.9 \times 10^{-7}$	0.00024	$1.2 \times 10^{-7}$	13	0.0068	13	0.0067	88	0.035
Defense Waste Processing Facility	0.0000010	NA <sup>h</sup>	0.0000010	$5.0 \times 10^{-10}$	0.07	NA	0.07	0.000035	118	0.047
Plant Vogtle	0.00000037	0.00017	0.00017	$8.5 \times 10^{-8}$	0.047	0.0097	0.057	0.000029	NA	NA
Spent nuclear fuel	0.0004	0.0001	0.0005	$2.5 \times 10^{-7}$	16.0	2.4	18.4	0.0092	79	0.032
Total	0.0017	0.00043	0.0022	$1.1 \times 10^{-6}$	77	4.0	81	0.04	806	0.32

<sup>a</sup> Sources: Arnett, Karapatakis, and Mamatey (1994); DOE (1994a,b,c; 1995); NRC (1994).

<sup>b</sup> Collective dose to the 80-kilometer population for atmospheric releases and to the downstream users of the Savannah River for liquid releases.

<sup>c</sup> Dose in rem.

<sup>d</sup> Probability of fatal cancer.

<sup>e</sup> Dose in person-rem.

<sup>f</sup> Incidence of excess fatal cancers.

<sup>g</sup> Average annual values from the Comparative Alternatives Scenario described in [Chapter 4](#).

<sup>h</sup> NA = not applicable.

Virtually all (more than 97 percent) of the total collective dose to the offsite population resulting from the interim management of nuclear materials would be from airborne sources. Similarly, more than 99 percent of the cumulative dose to the offsite population would be from airborne sources.

## 5.2 Air Resources

[Table 5-2](#) compares the cumulative concentrations of nonradiological air pollutants from the SRS, including those for the Comparative Alternatives Scenario, to Federal and state regulatory standards. The listed values are the maximum modeled concentrations that could occur at ground level at the Site boundary. The data demonstrate that total estimated concentrations of nonradiological air pollutants from the SRS, including those from the interim management of nuclear materials, would be well below the regulatory standards at the Site boundary.

**Table 5-2. Estimated maximum nonradiological cumulative ground-level concentrations of criteria and toxic pollutants (micrograms per cubic meter) at the SRS boundary.**

Pollutant	Averaging time	Regulatory standard	Baseline <sup>c</sup>	Cumulative concentration <sup>d</sup>
Carbon monoxide	1-hour	40,000	257.4 (0.66%)	324.4 (0.81%)
	8-hour	10,000	33.36 (0.33%)	49.4 (0.49%)
Nitrogen oxides	Annual	100	15.5 (15.5%)	16.8 (16.8%)
Sulfur dioxide	3-hour	1,300	641.5 (49%)	641.5 (49%)
	24-hour	365	186.0 (51%)	186.0 (51%)
	Annual	80	10.0 (13%)	10.0 (13%)
Gaseous fluorides	12-hour	3.7	1.06 (29%)	1.23 (33.1%)
	24-hour	2.9	0.43 (15%)	0.52 (17.9%)
	1-week	1.6	0.26 (16%)	0.30 (18.3%)
	1-month	0.8	0.05 (6%)	0.061 (7.6%)
Nitric acid	24-hour	125	5.66 (5%)	8.06 (6.4%)

<sup>a</sup> Sources: Hunter (1994); DOE (1994a).

<sup>b</sup> Numbers in parentheses indicate the percentage of the regulatory standard.

<sup>c</sup> All SRS sources including the Defense Waste Processing Facility, the Consolidated Incineration Facility, Spent Nuclear Fuel management, the stabilization of plutonium solutions in F-Canyon, and the SRS Waste Management EIS.

<sup>d</sup> Cumulative concentration includes the baseline concentration and the projected concentration from the Comparative Alternatives Scenario discussed in [Chapter 4](#).

DOE also evaluated the cumulative impacts of airborne radioactive releases in terms of dose to a maximally exposed individual at the SRS boundary. DOE has included the impacts of the two-unit Plant Vogtle in this cumulative total (NRC 1994). The radiological emissions from the operation of the Chem-Nuclear low-level waste disposal facility just east of the SRS are very low, and are not included (SCDHEC 1992). [Table 5-3](#) lists the results of this analysis, using 1993 emissions (1991 for Plant Vogtle) as the SRS baseline. The highest cumulative dose to the maximally exposed member of the public would be 0.0017 rem (or 1.7 millirem) per year, well below the regulatory standard of 10 millirem per year for the SRS (40 CFR Part 61). Summing the doses to maximally exposed individuals for the six actions or facilities listed in [Table 5-3](#) is an extremely conservative approach because it assumes that the maximally exposed individuals would occupy the same location over the same time period, which is a physical impossibility.

Adding the population doses from current and projected activities at the SRS, including stabilization of plutonium solutions, operation of the proposed Defense Waste Processing Facility, and management of spent nuclear fuel, would yield a total annual cumulative dose of 77 person-rem from airborne sources, 52 percent of which would be attributable to the interim management of nuclear materials. This translates into 0.04 latent cancer fatality per year in the population living within an 80-kilometer (50-mile) radius of the SRS. For comparison, 145,700 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

**Table 5-3. Estimated average annual cumulative radiological doses and resulting health effects to offsite population from airborne releases.**

	Offsite population



Activity	Maximally exposed individual		Total collective (to 80-kilometer population)	
	Dose <sup>b</sup>	Fatal cancer risk <sup>c</sup>	Dose <sup>d</sup>	Latent cancer fatalities <sup>e</sup>
Current SRS practices	$1.1 \times 10^{-4}$	$5.5 \times 10^{-8}$	7.6	$3.8 \times 10^{-3}$
Interim Management of Nuclear Materials <sup>f</sup>	$9.7 \times 10^{-4}$	$4.9 \times 10^{-7}$	40	$2.0 \times 10^{-2}$
Stabilization of F-Canyon plutonium solutions <sup>g</sup>	$8.6 \times 10^{-6}$	$4.3 \times 10^{-9}$	0.38	$1.9 \times 10^{-4}$
Waste Management	$2.4 \times 10^{-4}$	$1.2 \times 10^{-7}$	13	$6.5 \times 10^{-3}$
Defense Waste Processing Facility	$1.0 \times 10^{-6}$	$5.0 \times 10^{-10}$	0.07	$3.5 \times 10^{-5}$
Plant Vogtle	$3.7 \times 10^{-7}$	$1.9 \times 10^{-10}$	0.047	$2.4 \times 10^{-5}$
Programmatic SRS spent nuclear fuel	$4.0 \times 10^{-4}$	$2.0 \times 10^{-7}$	16.0	$8.0 \times 10^{-3}$
Total	$1.7 \times 10^{-3}$	$8.5 \times 10^{-7}$	77	$4.0 \times 10^{-2}$

<sup>a</sup> Sources: Arnett, Karapatakis, and Mamatey (1994); DOE (1994a,b,c; 1995); NRC (1994).

<sup>b</sup> Dose in rem.

<sup>c</sup> Probability of fatal cancer.

<sup>d</sup> Dose in person-rem.

<sup>e</sup> Incidence of excess fatal cancers.

<sup>f</sup> Average annual values from the Comparative Alternatives Scenario in [Chapter 4](#).

<sup>g</sup> Based on maximum annual releases.

Environmental restoration, decontamination and decommissioning, and waste management activities and facilities that DOE is assessing in the SRS Waste Management EIS (DOE 1995) would add variable but small increments to airborne emissions of radioactive and nonradioactive materials.

### 5.3 Water Resources

[Table 5-4](#) summarizes the estimated cumulative radiological doses to human receptors from exposure to waterborne sources downstream from the Savannah River Site. Liquid effluents from the Site could contain small quantities of radionuclides that are released to SRS streams that are tributaries of the Savannah River. Exposure pathways considered in this analysis included drinking water, fish ingestion, shoreline exposure, swimming, and boating. The ingestion of fish containing cesium-137 would contribute most of the exposure to both the maximally exposed individual and the offsite population. Plutonium and uranium isotopes ingested with drinking water would be secondary contributors.

**Table 5-4. Estimated average annual cumulative radiological doses and resulting health effects to offsite population from liquid releases.**

	Offsite population			
	Maximally exposed individual		Total collective (to downstream users of the Savannah River)	
	Dose <sup>b</sup>	Fatal cancer	Dose <sup>d</sup>	Latent cancer fatalities <sup>e</sup>

Activity		risk <sup>c</sup>		
Current SRS practices	$1.4 \times 10^{-4}$	$7.0 \times 10^{-8}$	1.5	$7.5 \times 10^{-4}$
Interim Management of Nuclear Materials <sup>f</sup>	$2.4 \times 10^{-5}$	$1.2 \times 10^{-8}$	0.09	$4.5 \times 10^{-5}$
Stabilization of F-Canyon plutonium solutions	$2.9 \times 10^{-7}$	$1.5 \times 10^{-10}$	0.0037	$1.9 \times 10^{-6}$
Waste Management	$6.9 \times 10^{-7}$	$3.5 \times 10^{-10}$	0.0068	$3.4 \times 10^{-6}$
Defense Waste Processing Facility	NA <sup>g</sup>	NA	NA	NA
Plant Vogtle	$1.7 \times 10^{-4}$	$8.5 \times 10^{-8}$	0.0097	$4.9 \times 10^{-6}$
Programmatic SRS spent nuclear fuel	$1.0 \times 10^{-4}$	$5.0 \times 10^{-8}$	2.4	$1.2 \times 10^{-3}$
Total	$4.3 \times 10^{-4}$	$2.2 \times 10^{-7}$	4.0	$2.0 \times 10^{-3}$

<sup>a</sup> Sources: Arnett, Karapatakis, and Mamatey (1994); DOE (1994a,b,c; 1995); NRC (1994).

<sup>b</sup> Dose in rem.

<sup>c</sup> Probability of fatal cancer.

<sup>d</sup> Dose in person-rem.

<sup>e</sup> Incidence of increase fatal cancers.

<sup>f</sup> Average annual values from the Comparative Alternatives Scenario in [Chapter 4](#).

<sup>g</sup> NA = not applicable.

The highest cumulative dose to the maximally exposed member of the public from liquid releases would be 0.00043 rem (or 0.43 millirem) per year, well below the regulatory standard of 4 millirem per year (40 CFR Part 141). Adding the population doses from current and projected activities at the SRS, including the stabilization of plutonium solutions, operation of the proposed Defense Waste Processing Facility, and management of spent nuclear fuel, would yield a total annual cumulative dose of 4.0 person-rem from liquid sources, approximately 2 percent of which would be attributable to the interim management of nuclear materials. This translates into 0.002 latent cancer fatality per year in the population living within an 80-kilometer (50-mile) radius of the SRS. For comparison, 145,700 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

## 5.4 Waste Generation

[Table 5-5](#) lists cumulative volumes of high-level radioactive waste, low-level waste, saltstone, transuranic waste, and hazardous and mixed wastes generated by the SRS. The values for current SRS operations are based on the SRS 30-year waste forecast (WSRC 1994), the SRS Waste Management EIS (DOE 1995), Appendix C to the *Draft Programmatic Spent Nuclear Fuel Management EIS* (DOE 1994a), and the F-Canyon Plutonium Solutions EIS (DOE 1994c).

**Table 5-5. Estimated cumulative waste generation from SRS operations.**

	Volume generated (cubic meters) <sup>a,b</sup>

Waste type	Current SRS operations <sup>c</sup>	Interim Management of Nuclear Materials	Cumulative total
High-level	2,045	3,900	5,945
Low-level	18,400	14,000	32,000
Saltstone	53,000	12,000	65,000
Transuranic	720	170	890
Mixed/hazardous	2,300	220	2,500

<sup>a</sup> Average annual values based on waste forecast from 1995 to 2004.

<sup>b</sup> To convert cubic meters to cubic yards, multiply by 1.3079.

<sup>c</sup> Includes proposed Defense Waste Processing Facility, Spent Nuclear Fuel management (low-level waste, high-level waste, and transuranic waste only), Stabilization of Plutonium Solutions in F-Canyon, including decontamination necessary to support facility modifications.

## 5.5 Utilities and Energy

[Table 5-6](#) lists the cumulative consumption of electricity and water (surface water and groundwater) by the Comparative Alternatives Scenario along with activities associated with the stabilization of plutonium solutions, the Defense Waste Processing Facility, the management of spent nuclear fuel, and current SRS operations. The SRS Waste Management EIS (DOE 1995) does not present estimates of electricity or water usage for the facilities considered in that EIS. As noted in [Table 5-6](#), the interim management of the nuclear materials evaluated in this EIS would account for approximately 13.6 percent of the electricity usage and 0.004 percent of the water usage.

**Table 5-6. Estimated average annual cumulative utility consumption.<sup>a</sup>**

Activity	Electricity Consumption (megawatt-hours)	Water usage <sup>b</sup> (liters)
Current SRS usage	659,000	$8.76 \times 10^{13}$
Interim management of nuclear materials <sup>c</sup>	140,100	$4.00 \times 10^9$
Stabilization of F-Canyon plutonium solutions	21,974	$1.19 \times 10^9$
Waste management	NR <sup>d</sup>	NR
Defense Waste Processing Facility	32,000	$9.12 \times 10^7$
Programmatic SRS spent nuclear fuel	110,400	$3.79 \times 10^8$
Total	963,374	$8.76 \times 10^{13}$

<sup>a</sup> Sources: Arnett, Karapatakis, and Mamatey (1994); DOE (1994a,b,c; 1995); NRC (1994).

<sup>b</sup> Includes both groundwater and surface-water usage.

<sup>c</sup> Based on Comparative Alternatives Scenario described in [Chapter 4](#).

<sup>d</sup> NR = not reported.

## REFERENCES

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## CHAPTER 6. SHORT-TERM USE VERSUS LONG-TERM RESOURCE COMMITMENTS

This section addresses the relationship between short-term uses of the environment and the maintenance of its long-term productivity.

Reinstating activities at the F- and H-Canyons and support facilities to accommodate the management of nuclear materials would result in the short-term resource uses described in [Chapter 4](#). However, these activities would not be likely to compromise environmental resources beyond the duration of management activities. As a result of normal operations, short-term use of the atmosphere as a receptor for emissions would have an incremental minimal effect on long-term global atmospheric conditions. DOE anticipates no increase in long-term resource commitments (e.g., electricity consumption).





## CHAPTER 7. IRREVERSIBLE OR IRRETRIEVABLE RESOURCE COMMITMENTS

Irreversible and irretrievable commitments of resources that could occur with the implementation of any of the alternatives to manage nuclear materials currently stored at the Savannah River Site fall into the categories of materials and energy. To a large extent the physical plant and facilities required to implement the alternatives being considered already exist in the F- and H-Areas, so the resources typically required to construct new buildings and establish new engineering processes would be relatively small. The exceptions to this would be modifications to produce the F-Canyon Vitrification Facility and the construction of a new Dry Storage Facility and an Actinide Packaging Facility. If necessary, the construction of such new facilities outside existing industrialized areas would require less than an estimated 0.4 square kilometer (100 acres) of onsite land.

### 7.1 Materials

The construction of the Actinide Processing Facility would require about 4,620 cubic meters (6,040 cubic yards) of concrete and about 1,775 metric tons (1,960 tons) of steel. The construction of the Dry Storage Facility would require about 17,950 cubic meters (23,520 cubic yards) of concrete and about 6,910 metric tons (7,600 tons) of steel.

Chemicals such as nitric acid and tributyl phosphate would be committed for the various alternative processes. The required chemicals and materials are readily available. Strategic and critical materials (e.g., beryllium, cadmium, cobalt) would not be required in quantities that would seriously reduce the national or world supply.

Existing facilities that DOE would use for management activities would have contaminated areas and equipment that would be unusable for recycling. This would include such materials as masonry, piping, metal structures and objects, flooring, and plastics.

### 7.2 Energy

All the alternatives would require power to operate the F- and H-Area buildings and the various process activities conducted in them. Steam would be used for applications such as evaporators and off-gas reactors. The fuel used to create electricity for the facilities would be purchased from commercial utilities. Small amounts of diesel fuel would also be used.

Cumulative electric consumption rates have been estimated for the 10-year period from 1995 through 2004. The electric use estimate for the No-Action Scenario would be 1,260,000 million kilowatt-hours, 1,140,000 million kilowatt-hours for the Preferred Alternatives Scenario, and 1,401,000 million kilowatt-hours for the Comparative Alternatives Scenario.







## CHAPTER 8. LAWS AND REQUIREMENTS

This chapter identifies and summarizes major laws, regulations, executive orders, and DOE Orders that might apply to the scenarios discussed in this EIS.

### 8.1 Federal Statutes and Regulations

#### National Environmental Policy Act

The National Environmental Policy Act (NEPA) establishes a national policy promoting awareness of the environmental consequences of the activity of humans on the environment and promotes a consideration of environmental impacts during the planning and decisionmaking stages of a project. NEPA requires all agencies of the Federal Government to prepare a detailed statement on the environmental effects of proposed major Federal actions that could significantly affect the quality of the human environment.

DOE prepared this environmental impact statement (EIS) in accordance with the Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of NEPA (40 CFR Parts 1500 through 1508) and DOE's NEPA Implementing Procedures (10 CFR Part 1021). The EIS discusses reasonable alternatives and their potential environmental consequences.

#### Atomic Energy Act

The Atomic Energy Act of 1954 authorizes DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under its jurisdiction. Through DOE Orders, regulations, and guidelines, the Department has established these environmental, health, and safety standards to ensure safe operations of its facilities.

#### Clean Air Act

The Clean Air Act is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Act requires each Federal agency with jurisdiction over any property or facility that might result in the discharge of air pollutants to comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety from any known or anticipated adverse effects of a regulated pollutant (42 USC Section 7409). The Act also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC Section 7411) and requires specific emission increases to be evaluated to prevent a significant deterioration in air quality (42 USC Section 7470).

Hazardous air pollutants, including radionuclides, are regulated separately (42 USC Section 7412). Air emissions are regulated by EPA through regulations codified at 40 CFR Parts 50 through 99. However, EPA has delegated primary authority to the South Carolina Department of Health and Environmental Control (SCDHEC) for all of the Act's regulatory provisions except DOE radionuclide emissions (40 CFR Part 61 Subpart H). Under the authority of the

South Carolina Pollution Act, SCDHEC has established the State's air pollution control program (R.61-62).

Airborne emissions would be associated with each of the scenarios, and these emissions would be subject to regulation under the Clean Air Act.

### **Clean Water Act**

The Clean Water Act was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Act requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements.

In addition to setting water quality standards for the Nation's waterways, the Act supplies guidelines and limitations for effluent discharges from point-source discharges and provides authority for EPA to implement the National Pollutant Discharge Elimination System (NPDES) permitting program. EPA has overall responsibility (40 CFR Part 122), but has delegated primary enforcement authority to SCDHEC for facilities in South Carolina. Under the South Carolina Pollution Control Act, SCDHEC enforces a wastewater treatment system permitting program (R.61-67).

### **Resource Conservation and Recovery Act**

The treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments of 1984, and the Federal Facility Compliance Act of 1992. Pursuant to Section 3006 of RCRA, any state that seeks to administer and enforce a hazardous waste program may apply for EPA authorization of its program. The EPA regulations implementing RCRA are at 40 CFR Parts 260 through 280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements. The regulations imposed on a generator or a treatment, storage, or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, or disposed of. The method of treatment, storage, and disposal also impacts the extent and complexity of the requirements.

Historically, DOE chemically reprocessed reactor targets and spent fuel to recover valuable products and fissionable materials. As such, the recovered material was not a solid waste under RCRA. World events have resulted in significant changes in DOE direction and operations. With these changes, the DOE focus has changed from reprocessing and recovery of materials to storage and ultimate disposition. In particular, DOE announced in April 1992 that it intended to phase out reprocessing. This, in turn, has created uncertainty with regard to the regulatory status of these materials in relation to RCRA.

DOE has initiated discussions with environmental regulators on the potential applicability of RCRA to the materials discussed in this EIS. Further discussions with the regulators might be necessary to develop a path forward to meet any RCRA requirements that could apply to the alternatives analyzed in this EIS.

### **Emergency Planning and Community Right-to-Know Act of 1986**

Under Subtitle A of this Act, Federal facilities provide various information (such as inventories of specific chemicals used or stored and releases that occur from these sites) to the State Emergency Response Commission and the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988. In addition, DOE requires compliance with Title III as a matter of Departmental policy. The requirements for this Act were promulgated by EPA in 40 CFR Parts 350 through 372. The SRS submits hazardous chemical inventory reports to the South Carolina Department of Health and Environmental Control. The chemical inventory could change depending on the alternative(s) DOE implemented; however, subsequent reports would reflect any change to the inventory.

### **SAFE DRINKING WATER ACT**

The primary objective of the Safe Drinking Water Act is to protect the quality of public water supplies and all sources of drinking water. The South Carolina Department of Health and Environmental Control has primary enforcement responsibility through the State Safe Drinking Water Act. SCDHEC administration and enforcement consist of construction permits, preliminary site inspections, final construction inspections, monthly sampling of drinking water, and regular operations and maintenance inspections of water supplies and facilities such as those at the SRS (R.61-58).

### **American Indian Religious Freedom Act, Archaeological Resources Protection Act, National Historic Preservation Act, and Native American Graves Protection and Repatriation Act**

The American Indian Religious Freedom Act, Archaeological Resources Protection Act, National Historic Preservation Act, and Native American Graves Protection and Repatriation Act require Federal agencies to consider the impacts that their actions could have on archaeological, historic, and cultural resources. DOE has determined that implementation of the activities associated with any alternative considered would not directly affect these resources.

### **Anadromous Fish Conservation Act, Bald and Golden Eagle Protection Act, Endangered Species Act, Fish and Wildlife Coordination Act, and Migratory Bird Treaty Act**

The Anadromous Fish Conservation Act, Bald and Golden Eagle Protection Act, Endangered Species Act, Fish and Wildlife Coordination Act, and Migratory Bird Treaty Act require Federal agencies to consider the impacts that their actions could have on biological resources. Biological resources would not be affected by the activities associated with the alternatives considered in this EIS.

## **8.2 Executive Orders**

### **Executive Order 12088, "Federal Compliance with Pollution Control Standards"**

This order directs Federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act.

### **executive order 12856, "federal compliance with right-to-know laws and pollution prevention requirements"**

This order directs Federal agencies to comply with the Emergency Planning and Community Right-to-Know Act of 1986 and with the Pollution Prevention Act of 1990.

### **Executive Order 11514, "National Environmental Policy Act"**

This order directs Federal agencies to monitor and control their activities continually to protect and enhance the quality of the environment. It also directs Federal agencies to develop procedures to ensure the fullest practicable provision of timely public information and understanding of the Federal plans and programs with environmental impact to obtain the views of interested parties. DOE has issued regulations (10 CFR Part 1021) and DOE Order 5440.1E for compliance with this Executive Order.

### **Executive Order 11988, "Floodplain Management"**

This order directs Federal agencies to establish procedures to ensure the consideration of potential effects of flood hazards and floodplain management for any action undertaken in a floodplain and the avoidance of floodplain impacts to the extent practicable. DOE has determined that implementation of or any alternative considered would not directly affect a floodplain.

### **Executive Order 11990, "Protection of Wetlands"**

This order directs governmental agencies to avoid, to the extent practicable, any short- and long-term adverse impacts on wetlands if there is a practicable alternative. DOE has determined that any alternative considered would not directly affect a wetland.

### **Executive Order 12898, "Environmental Justice"**

This order directs Federal agencies to achieve environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. The order creates an Interagency Working Group on Environmental Justice and directs each Federal agency to develop strategies within prescribed time limits to identify and address environmental justice concerns. The order further directs each Federal agency to collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative or judicial action and to make such information publicly available.

## **8.3 Department of Energy Regulations and Orders**

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE orders. The DOE regulations are generally found in Title 10 of the Code of Federal Regulations. These regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For this EIS, relevant regulations include 10 CFR Part 835, Occupational Radiation Protection; 10 CFR Part 1021, Compliance with the National Environmental Policy Act; and 10 CFR Part 1022, Compliance with Floodplains/Wetlands Environmental Review Requirements. DOE Orders generally set forth policies and the programs and internal procedures for implementing those policies. Applicable Orders pertaining to the activities associated with the alternatives discussed in this EIS include:

- DOE Order 5440.1E, "National Environmental Policy Act Compliance Program" (November 10, 1992). This Order establishes authorities and responsibilities of DOE officials and sets forth internal procedures for implementing the NEPA.
- DOE Order 5480.1B, "Environment, Safety and Health Program for Department of Energy Operations" (September 23, 1986). This Order establishes the Environment, Safety and Health Program for DOE operations.
- DOE Order 5480.31, "Startup and Restart of Nuclear Facilities" (September 15, 1993). This Order establishes the actions to be taken in the startup or restart of nuclear facilities.





## APPENDIX A. LIST OF NUCLEAR MATERIALS AT THE SAVANNAH RIVER SITE

DOE has evaluated the nuclear materials stored at the Savannah River Site and grouped them into three general categories: (1) Stable, (2) Programmatic, and (3) Candidates for Stabilization. Table A-1 lists the materials grouped in these categories, briefly describes each material, the storage management activities associated with it, and its storage location.

**Table A-1. Savannah River Site nuclear materials.**

Description and Storage Management Activities	Location
<b>STABLE MATERIAL</b>	
<b>Spent nuclear fuels stored in RBOF</b> - Approximately 1,500 uranium-plutonium fuel elements from a number of reactors around the world, clad with aluminum, stainless-steel, zirconium, hastaloy, or nichrome. Purity of the water in RBOFa prevents fuel corrosion. RBOF has the capability to inspect fuel, and assess its condition, overpack damaged fuel, and maintain water purity and quality:	
Bundle of enriched uranium-plutonium rods, stainless-steel-clad, from Westinghouse	RBOF
Bundles of enriched uranium fuel, aluminum-clad, from French Research Reactor	RBOF
Bundles of irradiated enriched uranium fuel, aluminum-clad, from Oak Ridge	RBOF
Bundles of irradiated enriched uranium fuel, aluminum-clad, from Sterling Forest reactor	RBOF
Bundles of Japanese Materials Test Reactor enriched uranium fuel, aluminum-clad	RBOF
Depleted uranium-plutonium mixed oxide fuel, zirconium- and stainless-steel-clad, from Battelle	RBOF
Electric Power Research Institute test fuel, zirconium-clad	RBOF
Enriched uranium and thorium elements, zirconium-clad, from heavy water Components Test Reactor	RBOF
Enriched uranium oxide tubes, zirconium-clad, from the heavy water components test reactor	RBOF
Enriched uranium-plutonium from Argonne	RBOF
Enriched uranium-plutonium from Battelle	RBOF
Enriched uranium-plutonium from Vallecitos	RBOF
Enriched uranium-plutonium fuel, stainless-steel-clad, from Argonne	RBOF
Enriched uranium-plutonium fuel, stainless-steel-clad, from Oak Ridge	RBOF
Enriched uranium-plutonium fuel, zirconium-clad, from Battelle	RBOF



Enriched uranium-plutonium fuel, zirconium-clad, from Vallecitos	RBOF
Enriched uranium-plutonium fuel, zirconium-clad, from Vallecitos boiling water reactor	RBOF
Enriched uranium-plutonium-thorium fuel, stainless-steel-clad, from Dresden	RBOF
Enriched uranium-thorium fuel, stainless-steel-clad, from Elk River	RBOF
Enriched uranium-thorium fuel, stainless-steel-clad, from sodium reactor experiment	RBOF
Experimental Boiling Water Reactor fuel, uranium with zirconium-cladding	RBOF
Experimental Boiling Water Reactor enriched uranium plates, stainless-steel-clad	RBOF
Experimental Boiling Water Reactor fuel, zirconium-clad, from Argonne	RBOF
Experimental Breeder Reactor II targets	RBOF

**Table A-1.** (continued).

<b>Description and Storage Management Activities</b>	<b>Location</b>
Irradiated depleted uranium from Canadian deuterium reactor and heavy water components test reactor	RBOF
Irradiated depleted uranium-plutonium Shippingport-fuel, zirconium-clad, from Battelle	RBOF
Irradiated enriched uranium from Argonne	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from French Reactor Hot Flux reactor	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from Massachusetts Institute of Technology reactor	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from Oak Ridge	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from Rhode Island Nuclear Service	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from Sterling Forest reactor	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from University of Michigan reactor	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from University of Missouri reactor	RBOF
Irradiated enriched uranium fuel, aluminum-clad, from University of Virginia reactor	RBOF
Irradiated enriched uranium fuel, nichrome-clad, from Idaho Chemical Processing Plant	RBOF
Irradiated enriched uranium fuel, stainless-steel-clad, from mobile low-power reactor (Idaho)	RBOF
Irradiated enriched uranium fuel, zirconium- and stainless-steel-clad, from Savannah River Laboratory Light Water Reactor	RBOF
Irradiated enriched uranium fuel, zirconium-clad, from special power excursion reactor test	RBOF
Irradiated enriched uranium pins, hastalloy-clad, from Gas Cooled Reactor Experiment - Idaho	RBOF

Irradiated enriched uranium Robinson Reactor fuel, zirconium-clad in a stainless-steel casing	RBOF
Irradiated enriched uranium, Zircaloy-clad, Mark-5 special-purpose reactor fuel	RBOF
Irradiated enriched uranium, zirconium-clad	RBOF
Irradiated enriched uranium-plutonium fuel, stainless-steel-clad, in cans from General Atomics sodium reactor	RBOF
Irradiated enriched uranium-zirconium alloy, zirconium-clad	RBOF
Irradiated Mark-31 slugs (depleted uranium, plutonium, neptunium)	RBOF
Irradiated natural uranium-plutonium rods and depleted uranium-plutonium from Taiwanese Research Reactor	RBOF
Irradiated natural uranium-plutonium rods from Taiwanese Research Reactor	RBOF
Mark-16 bundle (enriched uranium, neptunium, and plutonium)	RBOF
Mark-16 powder metallurgical assembly bundle (enriched uranium, neptunium, plutonium-238)	RBOF
Mark-18 targets	RBOF
Reject unirradiated Mark-42s from 321-M Building	RBOF
Uranium oxide scrap, stainless-steel-clad, from Babcock & Wilcox	RBOF
Uranium oxide tube, zirconium-clad, from Canadian deuterium reactor	RBOF
Uranium oxide tubes, zirconium-clad, from the heavy water components test reactor	RBOF
Uranium-plutonium mixed oxide fuel, stainless-steel-clad, from Idaho National Engineering Laboratory Experimental Breeder Reactor II	RBOF

**Table A-1.** (continued).

Description and Storage Management Activities	Location
<b>Research and development material</b> - About 260 nuclear materials, used in routine laboratory research and development activities. When not in use these materials are packaged in cans, bottles, or sample carriers and stored in laboratory hoods, gloveboxes, or cells to provide the necessary containment and storage safety:	
Americium-241 oxide scrap from Savannah River Laboratory test work	SRTC <sup>b</sup>
Americium, curium, plutonium-238 solution	SRTC
Depleted uranium metal	SRTC
Depleted uranium metal rods for hydride development	SRTC
Depleted uranium nitrate crystals	SRTC
Depleted uranium oxide and ring sections from tubes	SRTC

Depleted uranium oxide-aluminum powder compacted	SRTC
Depleted uranium scrap	SRTC
Depleted uranium slurry	SRTC
Enriched uranium floor sweepings	SRTC
Liquid samples from Old FB-Line ductwork (americium, curium, and plutonium-238)	SRTC
Liquid samples from Old HB-Line ductwork	SRTC
Mark-16 enriched uranium oxide powder metallurgy tube	SRTC
Natural uranium gel sphere samples	SRTC
Neptunium solution samples	SRTC
Plutonium oxide and anode heel residues	SRTC
Thorium oxide	SRTC
Unirradiated natural uranium	Building 772-F
Unirradiated normal uranium for research and development	SRTC
Uranium-233 oxide from Oak Ridge	Building 772-F
Uranyl nitrate solution sample	SRTC

Table A-1. (continued).

Description and Storage Management Activities	Location
<b>Reactor materials in reactor areas</b> - Approximately 420 unirradiated control rods, spargers, and targets and irradiated control rods stored in reactor disassembly basins. Construction materials are lithium-aluminum alloy clad with aluminum, and cadmium clad with aluminum. Corrosion of these materials is likely to be minimal during the next 10 years. Reactor basin water chemistry is being improved to minimize the corrosion of the targets. <sup>c</sup>	
Irradiated cadmium control rods	C-, K-, L-, P- Reactor Disassembly Basins
Lithium-aluminum control rods, spargers, and targets	K-, L-, P- Reactor Disassembly Basins
<b>Securely stored actinides</b> - Two thorium oxide spheres in Building 235-F that DOE used as production guides for startup of the Plutonium Fuel Fabrication Facility in 1977; four containers of neptunium scrap in HB-Line.	Building 235, HB-Line
<b>Description and Storage Management Activities</b>	

**Uranium solutions in F-Canyon** - Approximately 276,000 liters (73,000 gallons) of depleted uranium solution in two stainless-steel tanks in F-Canyon, seven stainless-steel tanks in A-Line, and one stainless-steel TNX tank truck. Actions during storage include monitoring concentration, specific gravity of the solution, acidity of solutions, and other properties (as required), and adding chemicals as needed to maintain chemical balances:

Depleted uranium solution - TNX Tank Truck	F-Area Outside Facility
Depleted uranium solutions	F-Canyon, F-Area Outside Facility
<b>Unirradiated uranium in M-Area</b> - More than 315,000 items consisting of uranium and lithium residues from fabrication of fuel and targets for the reactors (mostly unirradiated Mark-31 targets in various stages of fabrication). Uranium varies from depleted to fully enriched uranium. Lithium stocks are lithium metal or as lithium-aluminum alloy. These materials are stored dry and routinely monitored and inventoried. If corrective actions are needed, the material would be repackaged:	
Aluminum-enriched uranium alloy, aluminum-clad slugs from Savannah River Site Nuclear Test Gauge	Building 321-M
Bare Mark-25A cores and bare Mark-25B cores	Building 313-M
Canned Mark-31 slugs	Building 305-A
Canned Mark-31 slugs, depleted uranium, nickel-plated and aluminum-clad	Building 313-M
Depleted uranium Mark-31 scrap, no cladding (reject cores)	Building 313-M
Depleted uranium sludge	Building 322-M
Depleted uranium sludge	Building 341-1M
Enriched lithium metal in cans	Building 320-M
Enriched uranium grinding residues from Building 321-M	Building 321-M
Enriched uranium oxide in filter cake	Building 313-M
Enriched uranium slugs, aluminum-clad, from Building 321-M Nuclear Test Gauge	Building 321-M
Enriched uranium-aluminum alloy Mark-16 and Mark-22 tubes, scrap, standards	Building 321-M
Enriched uranium-aluminum floor sweepings	Building 322-M
Lithium-aluminum alloy control rods and sparger slugs	Building 315-M
Lithium-aluminum alloy in castings, billets, and cores	Building 315-M
Lithium-aluminum control rods, spargers, and targets	Building 315-M
Mark-15B canned slugs	Building 313-M
Mark-22 fuel tubes, enriched uranium with aluminum cladding	Building 321-M

Mark-25 depleted uranium dummy core	Building 313-M
Mark-31 depleted uranium fuel with aluminum cladding	Building 313-M
Natural lithium metal in cans	Building 320-M
Unclad normal uranium metal fuel pins	Building 313-M
Unirradiated Mark-15A cores	Building 305-A
Unirradiated Mark-16B assemblies, spares for reactor charge	Building 321-M
Uranium-aluminum fuel tube ring section	Building 322-M
Uranium-aluminum grinding fines from fuel tube grinding	Building 322-M

**Table A-1.** (continued).

Description and Storage Management Activities	Location
<b>Securely stored nuclear materials in reactor areas</b> - Approximately 6,900 items stored dry in reactor assembly areas. Materials are unirradiated and consist of various reactor components. Included are control rods, spargers, and targets consisting of lithium-aluminum alloy clad in aluminum. Also included are aluminum-clad enriched uranium-aluminum fuel tubes. These materials are routinely monitored and inventoried. If corrective actions are needed, the material would be repackaged:	
Lithium-aluminum control rods, spargers, and targets	K- and L-Reactor Assembly
Unirradiated contaminated lithium aluminum targets	K- and L-Reactor Assembly
Unirradiated Mark-16B assemblies, spares for reactor charge	L-Reactor Assembly
Unirradiated Mark-22 assemblies with lithium target tubes	K-Reactor Assembly
Unirradiated Mark-22 fuel assemblies (enriched uranium)	L-Reactor Assembly
<b>Depleted uranium oxide</b> - Approximately 36,000 208-liter (55-gallon) drums containing approximately 20 metric tonse of uranium. The uranium-235 concentration is mostly below naturally occurring uranium. These drums of uranium oxide are stored in buildings to keep them out of the weather. These materials are routinely monitored and inventoried.	R-Reactor Assembly, Buildings 221-21F, 221-22F, 704-R, 714-7N, 728-F, 730-F, 772-7B
<b>Uranyl nitrate solution in TNX</b> - Two stainless-steel tanks outside the TNX facility contain approximately 17,400 liters (4,600 gallons) of depleted uranium nitrate solution. The tanks are in a diked Radiation Control Area designed to contain any leakage, and are routinely monitored and inventoried.	TNX
<b>Sources, standards, and samples</b> - SRS uses sources and standards in its many monitoring and analytical functions. Most of these sources and standards contain a small amount of nuclear material. DOE estimates that more than 20,000 sources and standards are in use.	Sitewide
<b>Programmatic materials</b>	

<b>Plutonium-242</b>	
Solution - Approximately 13,200 liters (3,500 gallons) of nitrate solution high in plutonium-242, stored in a single stainless-steel tank. Compensatory actions during storage include monitoring concentration, specific gravity of the solution, acidity of solutions, and other properties (as required), and adding chemicals to maintain chemical balance as needed.	H-Canyon
<b>Americium and Curium</b>	
Solution - Approximately 14,000 liters (3,800 gallons) of americium-243 and curium-244 nitrate solutions are stored in a single stainless-steel tank. Compensatory actions during storage include monitoring concentration, specific gravity of the solution, acidity of solutions, and other properties (as required), and adding chemicals to maintain chemical balance as needed.	F-Canyon
<b>Neptunium-237</b>	
Solutions - Approximately 6,100 liters (1,600 gallons) of neptunium nitrate solutions stored in two stainless-steel tanks. Neptunium solution from H-Frames and recycled neptunium solution from Mark-16 and Mark-22 processing.	H-Canyon
Targets - Nine Mark-53 unirradiated neptunium-aluminum alloy targets clad with aluminum, stored dry in borated storage racks. Routinely monitored and inventoried.	Building 321-M
<b>Candidate materials for stabilization</b>	
<b>H-Canyon plutonium-239 solutions</b> - Approximately 34,000 liters (9,000 gallons) of plutonium nitrate solutions stored in two stainless-steel tanks. Compensatory actions during storage include monitoring concentration, specific gravity of the solution, acidity of solutions, and other properties (as required), and adjusting chemical balance as needed.	H-Canyon

Table A-1. (continued).

<b>Description and Storage Management Activities</b>	<b>Location</b>
<b>H-Canyon enriched uranium solutions</b> - Approximately 228,000 liters (60,000 gallons) of enriched uranium (approximately 60 percent uranium-235) nitrate solution. Solution is in two canyon tanks and five outside tanks. All tanks are stainless-steel and outside tanks are in concrete dikes large enough to contain the solution volume of the largest single tank. Compensatory actions during storage include monitoring concentration, specific gravity of the solution, acidity of solutions, and other properties (as required), and adjusting chemical balance as needed.	H-Canyon, H-Area Outside Facilities
<b>Plutonium and uranium stored in vaults</b> - Approximately 3,000 packages of material. The material contains alloys, compounds, oxides, large metal pieces such as buttons and ingots, and metal fragments, and consists predominantly of plutonium-239 with some uranium-235. In addition, some scrap predominately plutonium-238 material is stored in various locations.	
Low-uranium plutonium solids - Approximately 1,600 packages of plutonium-bearing solids containing low enough concentrations of uranium-235 to be processable in F-Area. Material is packaged in a metal can in a plastic bag in another metal pail or can (can/ba/nepa/dbgraphics/eishtml/eis-0220/can configuration), stored in a vault or glovebox. During storage, packages are monitored for evidence of internal pressurization or corrosion. These include evidence of bulging, weight gain, or package degradation. If conditions change, package could be radiographed to better define condition of the interior packaging. If monitoring indicates packaging failure (or imminent failure), material would be repackaged or over-packed, as needed.	

<i>Fissile plutonium solids</i> - Approximately 1,000 packages containing more than 100 grams (3.5 ounces) of fissile material in a container. They include alloys, metals, compounds, oxides, and large metal pieces (e.g., buttons and ingots) of plutonium-239 with minimal other actinide impurities other than americium-241, the decay daughter of plutonium-239:	
Depleted uranium-plutonium alloy from Argonne	Building 235-F
Depleted uranium-plutonium alloy from Zero Power Plutonium Reactor	Building 235-F
High-fired plutonium oxides from Rocky Flats	Building 235-F
Impure plutonium metal from Livermore	Building 235-F
Mixed plutonium-uranium oxide from Oak Ridge	Building 235-F
Natural uranium compounds from Battelle and Argonne	FB-Line
Natural uranium-plutonium alloy from Argonne	Building 235-F
Plutonium finished product	FB-Line
Plutonium metal	Building 235-F
Plutonium metal (Category 3) from Hanford	FB-Line
Plutonium metal	FB-Line
Plutonium metal from Argonne	FB-Line
Plutonium metal from Livermore	Building 235-F
Plutonium metal from Los Alamos	FB-Line
Plutonium oxide from Argonne	FB-Line
Plutonium oxide from Hanford	FB-Line
Plutonium oxide from Livermore	FB-Line
Plutonium oxide from Nuclear Fuel Services	FB-Line
Plutonium oxide from Rocky Flats	FB-Line
Plutonium-americium oxide	FB-Line
Plutonium-americium oxides from Rockwell	FB-Line
Plutonium-bearing alloy from Hanford	FB-Line



Plutonium-depleted uranium alloy from Argonne	FB-Line
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**Table A-1.** (continued).

Description and Storage Management Activities	Location
Plutonium-depleted uranium compounds from Argonne	FB-Line
Plutonium-depleted uranium compounds from Hanford	FB-Line
Plutonium-depleted uranium compounds from Hanford and Argonne	FB-Line
Plutonium-depleted uranium oxide from Hanford	FB-Line
Plutonium-depleted uranium oxide material from Argonne	FB-Line
Plutonium-depleted uranium-molybdenum alloy (Zero Power Plutonium Reactor)	FB-Line
Plutonium-natural uranium compounds from Argonne	Building 235-F
Plutonium-natural uranium compounds from Argonne and Hanford	FB-Line
Plutonium-natural uranium oxide from Hanford	FB-Line
Plutonium-natural uranium oxides (high-fired) from Hanford	FB-Line
Plutonium-natural uranium oxides from Hanford	FB-Line
<i>Scrap and residue plutonium solids</i> - Approximately 600 packages containing reactive or unknown plutonium forms with unknown reactivity such as plutonium turnings, sand, slag, crucibles, some plutonium compounds and metal fragments, and other alloys, metals, compounds, and oxides of plutonium-239 having minimal other actinide impurities other than americium-241, the decay daughter of plutonium-239. Sand, slag, and crucibles are a process residue containing potentially reactive calcium and fluorides and could be reactive if exposed to improper conditions:	
Analytical laboratory sample residues containing plutonium-242 oxide	Building 772-F
Anode heel metal (americium-241 and plutonium-239) from Rocky Flats	FB-Line
Depleted uranium oxide material from Battelle	Building 235-F
Depleted uranium-plutonium pellets and powder	SRTC
FB-Line cabinet floor sweepings (plutonium)	FB-Line
Formed plutonium metal from Livermore	FB-Line
Miscellaneous plutonium from crucibles	FB-Line
Natural uranium compounds from Battelle and Argonne	FB-Line
Natural uranium-plutonium oxides (low-fired) from Battelle	Building 235-F
Plutonium and natural uranium-depleted uranium pellets	FB-Line

Plutonium and sweepings received from Los Alamos	FB-Line
Plutonium compounds from Westinghouse Electric	FB-Line
Plutonium metal alloy and graphite residues from Rocky Flats	Building 235-F
Plutonium metal (formed) from Livermore	FB-Line
Plutonium metal from Los Alamos (test dissolution)	Building 235-F
Plutonium metal pieces	FB-Line
Plutonium metal button fragments	FB-Line
Plutonium metal turnings	FB-Line
Plutonium metal turnings from Rocky Flats	FB-Line
Plutonium oxide	FB-Line
Plutonium oxide from Hanford	FB-Line
Plutonium oxide in crucible from Fast Flux Test Reactor at Hanford	FB-Line
Plutonium powder	FB-Line
Plutonium residues (sand, slag, and crucible)	FB-Line
Plutonium rods	FB-Line
Plutonium scrub alloy or salt buttons from Rocky Flats	Building 235-F
Plutonium turnings	FB-Line
Plutonium-depleted uranium and plutonium-depleted uranium-silicon from Argonne	FB-Line

**Table A-1.** (continued).

<b>Description and Storage Management Activities</b>	<b>Location</b>
Plutonium-depleted uranium and plutonium-natural uranium compounds from Nuclear Energy	FB-Line
Plutonium-depleted uranium material from Argonne	FB-Line
Plutonium-depleted uranium material from Battelle	FB-Line
Plutonium-depleted uranium material	FB-Line
Plutonium-depleted uranium oxide from Battelle	Building 235-F
Plutonium-depleted uranium residue from Hanford	FB-Line
Plutonium-depleted uranium residue from Oak Ridge	FB-Line

Plutonium-depleted uranium residue from West Virginia Medical Center	FB-Line
Plutonium-natural uranium compounds from Argonne	FB-Line
Plutonium-natural uranium compounds from Battelle	Building 235-F
Plutonium-natural uranium oxides	FB-Line
Plutonium-oxide high in plutonium-240	FB-Line
Plutonium-zirconium alloy from Argonne	FB-Line
Pump oxide mix from Hanford and Oak Ridge	FB-Line
Sand, slag, and crucible residues from Rockwell	FB-Line
Scrap depleted uranium-plutonium oxide fuel rods from Savannah River Laboratory	Building 235-F
<p>Enriched uranium mixed solids - This grouping consists of approximately 500 packages of plutonium or neptunium alloys, metals, compounds, and oxides contaminated or mixed with enriched uranium (necessitating processing in H-Area). Package configuration is can/ba/nepa/dbgraphics/eishtml/eis-0220/can or ba/nepa/dbgraphics/eishtml/eis-0220/can/ba/nepa/dbgraphics/eishtml/eis-0220/can, stored in vaults. Neptunium solids are shielded to minimize the effects of gamma rays from protactinium-233. During storage, packages are monitored for evidence of internal pressurization or corrosion; these include evidence of bulging, weight gain, or package degradation. If conditions change, package would be radiographed to better define conditions of the interior packaging. If monitoring indicates packaging failure (or imminent failure), material would be repackaged or over-packed, as needed.</p>	
<p><i>Fissile mixed solids</i> - Approximately 300 packages containing more than 100 grams (3.5 ounces) of fissile material per package:</p>	
Enriched uranium alloy (passivated) from Argonne	Building 235-F
Enriched uranium alloy solids and powder from Los Alamos	Building 235-F
Enriched uranium metal or oxide from Oak Ridge	Building 235-F
Enriched uranium oxide (high-fired and contaminated with plutonium)	Building 235-F
Enriched uranium oxide (high-fired with possible plutonium contamination) from Westinghouse	Building 235-F
Enriched uranium oxide contaminated with plutonium from Rocky Flats	Building 235-F
Enriched uranium oxide from Rocky Flats	Building 235-F
Enriched uranium parts (plutonium contaminated) from Livermore	Building 235-F
Enriched uranium-plutonium alloy from Argonne	FB-Line
Enriched uranium-plutonium compound from Argonne	Building 235-F, FB-Line
Enriched uranium-plutonium compound from Rocky Flats	235-F
Enriched uranium-plutonium compound from West Virginia University reactor	235-F

Enriched uranium-plutonium compound from Westinghouse	FB-Line
Enriched uranium-plutonium compounds from Battelle	Building 235-F, FB-Line
Enriched uranium-plutonium high-fired oxides from Los Alamos	Building 235-F
Enriched uranium-plutonium metal and powder from Battelle	Building 235-F
Enriched uranium-plutonium oxide (high-fired) from Atomics International	Building 235-F
Enriched uranium-plutonium oxide from Battelle	Building 235-F

**Table A-1.** (continued).

<b>Description and Storage Management Activities</b>	<b>Location</b>
Enriched uranium-plutonium oxide from Rocky Flats	Building 235-F
Enriched uranium-plutonium oxide powder from Westinghouse	Building 235-F
Enriched uranium-plutonium oxides (high-fired) from Oak Ridge	FB-Line
Enriched uranium-plutonium oxides (high-fired) from Hanford	Building 235-F
Enriched uranium-plutonium oxides from Hanford	FB-Line
Enriched uranium-plutonium oxides, pellets, powder from Hanford	Building 235-F
Enriched uranium-plutonium-natural uranium oxide from Oak Ridge	Building 235-F
Enriched uranium-plutonium-neptunium compounds from Livermore	FB-Line
Plutonium-enriched uranium (passivated) alloy from Argonne	Building 235-F
Plutonium-enriched uranium alloy from Argonne	FB-Line
Plutonium-enriched uranium oxide from Los Alamos	Building 235-F
Plutonium-enriched uranium oxides from Rocky Flats	Building 235-F
Plutonium-neptunium compounds from Livermore	FB-Line
Plutonium-neptunium oxide from Hanford	FB-Line
<i>Scrap and residue mixed solids</i> - Approximately 200 packages containing less than 100 grams (3.5 ounces) of plutonium or neptunium per package:	
Enriched uranium and plutonium oxides from Battelle	Building 235-F
Enriched uranium and plutonium oxides from Hanford	Building 235-F
Enriched uranium-neptunium-aluminum scrap (desicooler packaging)	Building 235-F
Enriched uranium-plutonium alloy from Argonne	FB-Line

Enriched uranium-plutonium and natural uranium-plutonium oxides from Battelle	Building 235-F
Enriched uranium-plutonium compound from Argonne	Building 235-F
Enriched uranium-plutonium compounds from Battelle	235-F, FB-Line
Enriched uranium-plutonium compounds from Los Alamos	Building 235-F
Enriched uranium-plutonium from Argonne	Building 235-F
Enriched uranium-plutonium oxides from Hanford	FB-Line
Enriched uranium-plutonium reject fuel rods from Vallecitos	Building 235-F
Enriched uranium-plutonium-thorium alloy with zirconium cladding	Building 235-F
Enriched uranium-plutonium-titanium alloy (passivated) and glass from Argonne	Building 235-F
Enriched uranium-plutonium-titanium in zirconium oxide crucible from Argonne	Building 235-F
Enriched uranium-plutonium-zirconium alloy from Argonne	Building 235-F
Enriched uranium-plutonium-zirconium compound from Argonne	Building 235-F
Enriched uranium-plutonium-zirconium oxides from University of Virginia	Building 235-F
Enriched uranium-zirconium alloy from Argonne	Building 235-F
Plutonium-enriched uranium compound from Nuclear Energy	FB-Line
Plutonium-enriched uranium compound from Oak Ridge	FB-Line
Plutonium-enriched uranium-thorium alloy from Argonne	Building 235-F
Plutonium-neptunium-curium-ameridium compounds	FB-Line
Plutonium-thorium alloy from Battelle	Building 235-F
Plutonium-thorium compounds from Battelle	Building 235-F
Plutonium-thorium compounds from Hanford	FB-Line
Scrap (high-fired enriched uranium oxide) from Hanford	FB-Line

**Table A-1.** (continued).

<b>Description and Storage Management Activities</b>	<b>Location</b>
<i>Plutonium-238 scrap materials</i> - Approximately 120 packages of material containing quantities of plutonium-238, mostly in the form of plutonium oxide.	
Plutonium-238 miscellaneous solids and nickel-coated oxide spheres from Mound and Rocky Flats	235-F
Plutonium-238 scrap materials from H-Area	HB-Line Vaults

Description and Storage Management Activities	Location
Plutonium-238 scrap material containing iron oxide	Old HB-Line
Plutonium-238 oxide and compounds from program uses of plutonium-238	SRTC
<p><b>Mark-31 targets</b> - Approximately 16,000 target slugs, containing 147 metric tons (160 tons) of nuclear material (primarily uranium-238 and plutonium-239) clad with aluminum. Most targets are in reactor basins in stainless-steel buckets within stainless-steel boxes equipped with a loose-fitting lid. The reactor basin water chemistry is being improved to minimize the corrosion of the targets.<sup>c</sup> Approximately 2,500 of the targets are in the F-Canyon basin, where water quality is not controlled:</p>	
Unirradiated contaminated Mark-31B slug	F-Canyon
Irradiated aluminum-clad Mark-31A targets	F-Canyon
Irradiated Mark-31 slugs (depleted uranium, plutonium, neptunium-237)	L-Reactor Disassembly Basin
Unirradiated contaminated Mark-31 slugs	K-, L-Reactor Disassembly Basins
<p><b>Mark-16 and Mark-22 fuels</b> - Approximately 3,350 enriched uranium-aluminum alloy tubular fuel elements clad with aluminum. Corrosion of these fuel tubes is primarily at galvanic couples of dissimilar metals of the hangers and the aluminum cladding. The impact of this corrosion is less than that for the Mark-31 targets. The reactor basin water chemistry is being improved to minimize the corrosion of the targets.<sup>c</sup> Approximately 40 of the elements are in H-Canyon, where basin water quality is not controlled. Two of these are from the Sterling Forest reactor and are left from earlier processing:</p>	
Bundles of irradiated enriched uranium fuel, aluminum-clad, from Sterling Forest reactor	H-Canyon
Mark-16 irradiated fuel assemblies	K-, L-, P-Reactor Disassembly Basins, H-Canyon
Mark-22 irradiated fuel assemblies	K-, P-Reactor Disassembly Basins
<p><b>Other aluminum-clad fuel and targets</b> - About 650 aluminum-clad fuel and targets containing thorium to produce uranium-233, cobalt used as part of the reactor power control because it is a neutron absorber, thulium, monitor pins and slugs. The reactor basin water chemistry is being improved to minimize the corrosion of the targets.<sup>c</sup></p>	
Cobalt slugs	K-, L-, P-Reactor Disassembly Basins
Irradiated aluminum-clad slugs in quatrefoils	P-Reactor Disassembly Basin
Irradiated thulium slugs	L-Reactor Disassembly Basin
Mark-50A thorium elements containing uranium-233	K-, L-Reactor Disassembly Basins
Mark-42 target assemblies	P-Reactor Disassembly Basin
Special Curium target slugs	P-Reactor Disassembly Basin
Special Americium-241 targets	P-Reactor Disassembly Basin
Flux monitor pins and slugs	L-Reactor Disassembly Basin

<sup>a</sup>. RBOF = Receiving Basin for Offsite Fuels.

<sup>b</sup>. SRTC = Savannah River Technology Center.

<sup>c</sup>. The reactor basin water chemistry is being improved to minimize the corrosion of the targets. The water is deionized to lower its conductivity, which reduces general aluminum cladding corrosion and the galvanic couple between racks and target and fuel assemblies. Stored materials are monitored for evidence of corrosion and other failure and, as needed, repackaged to reduce sludge formation on basin bottom.







## ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
Am	americium
AQCR	Air Quality Control Region
ATTA	Advanced Tactical Training Area
C	carbon
CAA	Clean Air Act
Ce	cerium
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Cm	curium
Co	cobalt
Cs	cesium
CSEG	Criticality Safety Evaluation Group
CWA	Clean Water Act
D&D	decontamination and decommissioning
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Du	depleted uranium
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency

ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety and Health
Eu	europium
FFA	Federal Facility Agreement
FFCA	Federal Facilities Compliance Agreement
FR	Federal Register
FWS	U.S. Fish and Wildlife Service
H	hydrogen
H-3	tritium
HEPA	high-efficiency particulate air (filter)
HEU	highly enriched uranium
HLW	high-level waste
I	iodine
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IMNM	Interim Management of Nuclear Materials
lcf	latent cancer fatality
LEU	low enriched uranium
MEI	maximally exposed individual
mrem	millirem (1/1000 rem)
NAAQS	National Ambient Air Quality Standard
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection and Measurements
NCSE	Nuclear Criticality Safety Evaluations
NEPA	National Environmental Policy Act
Ni	nickel
NIM	Nuclear Incident Monitor

Np	neptunium
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
Pu	plutonium
RBOF	Receiving Basin for Offsite Fuel
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RINM	reactor irradiated nuclear materials
ROI	region of influence
Ru	ruthenium
S	sulfur
SAR	Safety Analysis Report
SCDHEC	South Carolina Department of Health and Environmental Control
SNF	spent nuclear fuel
Sr	strontium
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TRU	transuranic
U	uranium
UNH	uranyl nitrate hexahydrate
USF	Uranium Solidification Facility
WSRC	Westinghouse Savannah River Company
Xe	xenon
Zr	zirconium

## Abbreviations for measurements

cfm	cubic feet per minute
cfs	cubic feet per second
g	acceleration due to gravity (seismology)
/nepa/dbgraphics/eishtml/eis-0220/L	grams per liter
gpm	gallons per minute
L	liter
lb	pound
km	kilometer
m	meter
mg	milligram
mo	month
mw	megawatt
pCi	picocurie
yr	year
m	micron
mCi	microcurie
mg	microgram
°C	degrees Celsius
°F	degrees Fahrenheit

## Metric System

Typically, scientific reports use metric units; therefore, this EIS presents metric units of measure (meters, liters, grams, etc.) rather than the more common U.S. Customary Units (feet, gallons, pounds, etc.). However, the text sections also provide U.S. Customary Units in parentheses for ease of understanding.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

mega 1,000,000 (10<sup>6</sup>; one million)

kilo 1,000 (10<sup>3</sup>; one thousand)

hecto 100 (10<sup>2</sup>; one hundred)

centi 0.01 (10<sup>-2</sup>; one one-hundredth)

milli 0.001 (10<sup>-3</sup>; one one-thousandth)

micro 0.000001 (10<sup>-6</sup>; one one-millionth)

nano 0.000000001 (10<sup>-9</sup>; one one-billionth)

pico 0.000000000001 (10<sup>-12</sup>; one one-quadrillionth)

DOE Order 5900.2A, "Use of the Metric System of Measurement" (3/26/92) prescribes the use of this system in DOE documents. The following list presents conversion factors for the metric units used in this EIS as an aid to readers who are more familiar with U.S. Customary Units.

### **Conversion from Metric to U.S. Customary Units**

1 meter = 3.281 feet = 39.37 inches = 1.094 yards

1 kilometer = 0.6214 mile

1 square meter = 10.764 square feet

1 square kilometer = 0.3861 square mile = 247.1 acres

1 liter = 61.025 cubic inches = 0.2642 gallon

1 cubic meter = 35.31 cubic feet = 1.308 cubic yards = 264.2 gallons

### **Discharge**

1 cubic meter per second = 35.31 cubic feet per second = 15,850.3 gallons per minute

### **Mass**

1 kilogram = 2.205 pounds (mass)

1 metric ton = 2,205 pounds = 1.1023 (short) tons

### **Pressure**

1 Pascal = 0.02089 pound per square foot

1 kilogram (force) per square meter = 0.2048 pound (force) per square foot

### **Velocity**

1 meter per second = 3.281 feet per second = 2.237 miles per hour

1 kilometer per hour = 0.6214 mile per hour

### **Temperature**

$^{\circ}\text{C}$  to  $^{\circ}\text{F}$ ,  $^{\circ}\text{C} \times 1.8 + 32$  (i.e.,  $20^{\circ}\text{C} = 20 \times 1.8 + 32 = 68^{\circ}\text{F}$ )





## APPENDIX B. UNCLASSIFIED SUMMARY

### Programmatic Need For And Use Of Plutonium-242

Appendix B (which is classified) contains quantitative projections of plutonium-242 requirements to support research and development activities, descriptions of the uses, and analyses of the capabilities of alternative sources to meet the requirements. Appendix B also includes a description of the effects that would result from a decision to not meet the programmatic need.

The DOE decisionmaker will review Appendix B to ensure the incorporation of all applicable data in the decisions resulting from this EIS.







## APPENDIX C. FACILITY AND PROCESS DESCRIPTIONS

This appendix describes the principal facilities associated with the nuclear materials described in this environmental impact statement. The operations described are historic; the descriptions do not indicate how DOE would implement the alternatives discussed in this EIS. [Figure C-1](#) shows the historic cycle and facilities used to produce, process, and store nuclear materials at the Savannah River Site. Chapter 2 describes the operations that would be associated with the alternatives, and includes short descriptions of proposed facilities or major modifications of SRS structures that would affect the alternatives, and of waste management facilities that would process wastes associated with stabilizing nuclear materials.

### C.1 Fuel and Target Fabrication (M-Area)

M-Area (see [Figure C-2](#)) contains facilities used historically to fabricate fuel, special targets, and components for SRS production reactors. The facilities contain conventional equipment for melting, casting, and shaping metal, including furnaces, extrusion presses, lathes, handling equipment, and storage racks.

Buildings 313-M, 321-M, and 320-M contain the equipment used to fabricate depleted uranium targets, reactor fuel, and tritium targets, respectively. Building 321-M also contains the extrusion presses and finishing equipment that DOE used to extrude neptunium-237 oxide billets into neptunium targets, which were irradiated to produce plutonium-238. "Deinventory" of the facility (i.e., packaging unused nuclear materials and placing them in storage at the SRS or returning them to their sources) is underway. Buildings 313-M, 320-M, and 322-M (the Metallurgical Laboratory) have been deinventoried. Building 321-M is being deinventoried at present.

The SRS received raw aluminum, uranium, lithium, etc., at Building 315-M from commercial vendors and other DOE sites. The raw materials were cast, extruded, and machined into long cylindrical tubes or short cylindrical slugs of metal, depending on whether the reactor component was fuel or target. After fabrication, the fuel and targets were shipped to a reactor area (C, K, L, P, or R) for irradiation.

### C.2 Reactors

Of the five production reactors constructed at the SRS in the early 1950s, four (C, L, P, and R) have been permanently shut down, and one (K-Reactor) is in indefinite "cold standby," ([Figure C-3](#)). R-Reactor is scheduled for decontamination and decommissioning.

[Figure C-1.](#)

[Figure C-2.](#)

[Figure C-3.](#)

Each reactor has an assembly area for the receipt, handling, and storage of new (i.e., unirradiated) fuel and targets. Racks and vaults store new fuel and targets. Similarly, each reactor has a disassembly area for the storage, handling, and shipment of irradiated fuel and targets that have been removed from the reactor. The disassembly area consists primarily of water-filled basins with metal racks designed for vertical or horizontal storage of fuel tubes, and metal buckets for storing targets. The disassembly basins are about 49 meters (160 feet) wide, 67 meters (220 feet) long and 5 to 9 meters (17 to 30 feet) deep. The volume of water in the basins ranges from 12,800,000 to 18,200,000 liters (3,380,000 to 4,800,000 gallons). The K- and L-Reactor disassembly basins are identical; the P-Reactor basin is the largest. The basins are constructed of unlined concrete coated with vinyl paint. Each has systems for circulating,

filtering, and deionizing the water to maintain proper chemistry. Cranes, rigging, and handling equipment in the disassembly area can move or load fuel in casks for shipment to other areas on the Site.

Fuel and targets from M-Area were placed in storage racks or concrete vaults, then were grouped into assemblies and placed in a reactor core. The irradiation of the targets and fuel produced special isotopes. The irradiation time depended on the isotope to be produced. After their removal from the reactor core, the targets and fuel were placed in the water-filled basin to cool the fuel and targets and to allow the decay of short-lived radioactive products. The water also provided radiation shielding to operating personnel. After the targets or fuel had cooled for a brief period (12 to 18 months), they were disassembled and loaded in heavily shielded casks on rail cars (see [Figure C-4](#)), which were transferred to F- or H-Area for further processing.

### C.3 Chemical Separations (F-Canyon and H-Canyon)

The similar F- and H-Canyon facilities use radiochemical processes for the separation and recovery of plutonium, neptunium, and uranium isotopes. The F-Canyon separated plutonium, irradiated natural or depleted uranium, and radioactive decay products. H-Canyon recovered uranium, highly enriched uranium-235, neptunium-237, and plutonium-238 from irradiated reactor fuels and targets. The following paragraphs apply to both canyons unless noted.

The F- and H-Canyons (see [Figures C-5](#) and [C-6](#); [Figure C-6](#) also shows the Defense Waste Processing Facility in the adjoining S-Area) are reinforced concrete structures, 255 meters (836.6 feet) long, 37 meters (308 feet) wide, and 20 meters (121.4 feet) high. They are named for the two areas ("canyons") in each structure that house the large equipment (tanks, process vessels, evaporators, etc.) used in the chemical separations processes performed in each facility. The canyons are long (170 meters or 557.7 feet), narrow (an average of 6 meters or 19.7 feet), and deep

[Figure C-4.](#)

[Figure C-5.](#)

[Figure C-6.](#)

(20 meters or 65.6 feet). The "hot" and "warm" canyons in each facility are parallel and open from floor to roof. A center section, which has four floors or levels, separates the canyons. The center section contains office space, the control room for all facility operations, and support equipment such as ventilation fans. [Figure C-7](#) is a cross-section view of a canyon facility. Processing operations involving high radiation levels (dissolution, fission product separation, and high-level radioactive waste evaporation) would occur in the hot canyon, which has thick concrete walls to shield people outside the facility and in the center section from radiation. The final steps of the chemical separations process, which generally involve lower radiation levels, would occur in the warm canyon.

[Figure C-7.](#) F-Canyon building sections.

Services typical for a large industrial chemical facility are required to support F- and H-Canyon operations. For example, steam heats process vessels and is the motive force for transferring solutions through process cycles; lights, motors, control systems, etc., use electricity; compressed air provides pressure needed for various process monitoring systems (e.g., liquid level indicators) and powers some control systems; and a ventilation system provides conditioned air for the comfort of facility workers and for environmental control for the operation of sensitive equipment.

A separate ventilation system serves portions of the facility, such as the hot and warm canyons, that contain the radioactive process equipment. This system ensures the air pressure in such areas is below the pressure of the air outside the facility and the area occupied by workers. This design helps prevent the release of radioactive material outside the facility by ensuring that air always flows from outside to inside the process areas. Air in the process areas is exhausted from the facility through a large sand filter that removes 99.5 percent of any airborne radioactive material. A 61-meter (200-foot)-tall stack behind each canyon discharges this filtered air to the atmosphere and serves as the pathway for airborne emissions associated with the normal operation of the canyons.

There are two primary pathways for liquid effluents from the canyons:

- Condensates from secondary evaporators at the A-Line Outside Facilities containing low levels of radionuclides flow to the Effluent Treatment Facility (ETF) for further decontamination, if necessary, before their discharge to surface waters.
- A water system cools the hot and warm canyon process vessels. Underground pipes carry water to the canyons and distribute it. The water passes through coils inside the vessels ([Figure C-8](#) shows a standard canyon process vessel) and flows back out of the canyon. Constant monitoring detects radioactivity in the water. If radioactivity is detected, the water is diverted to a treatment facility where the radioactivity is reduced below applicable limits before the water is discharged.

The equipment and processing stages in the canyons have been configured to separate and recover uranium and plutonium from irradiated fuel or targets, as described for each canyon in the following paragraphs.

### C.3.1 F-Canyon (PUREX) Process

The PUREX process consists of several major operations, referred to as "unit operations," which recover plutonium and uranium from irradiated reactor targets. The targets normally would be fabricated from uranium depleted in a uranium-235 isotopic (e.g., at a level below the naturally occurring 0.711 weight percent). The irradiation process is designed to produce weapons-grade plutonium [i.e., plutonium that is greater than 93 percent plutonium-239, with the remainder of the plutonium isotopes similar to plutonium-240 and -241 (NAS 1994)]. The major unit operations are dissolution, head end, first cycle, second uranium cycle, and second plutonium cycle (see [Figure C-9](#)). Unit operations that support the product recovery operations are high-activity waste,

[Figure C-8.](#)

[Figure C-9.](#) Historic PUREX process flow.

low-activity waste, solvent recovery, laboratory waste evaporation, etc. The F-Canyon process also has recovered neptunium-237 that results from PUREX process waste; this activity, which is no longer performed, is not part of this evaluation. Processes within the inner box are conducted in F-Canyon.

The following paragraphs describe major and support unit operations in F-Canyon:

- **Dissolution** - Irradiated targets on a rail car through an air lock are brought into the south end of the hot canyon. Each target consists of a cylinder of depleted uranium clad in aluminum. The targets have been irradiated in an SRS reactor to transform a portion of the depleted uranium into plutonium. Large water-filled casks on rail cars transfer the targets. The targets are removed from the casks and loaded into a large tank called a dissolver. Sodium hydroxide removes the aluminum cladding from the targets. The cladding solution is transferred to the high-level waste tanks. Heated nitric acid in the tank dissolves the target, resulting in a solution containing depleted uranium, plutonium, and radioactive decay products from the reactor irradiation process.
- **Head End** - This process occurs in two steps to prepare the target solution for uranium and plutonium separation. First, gelatin is added to precipitate silica and other impurities. Then the solution is transferred to a centrifuge where silica and other impurities are removed as waste. The clarified product solution is adjusted with nitric acid and water in preparation for the first cycle unit operation. The waste stream generated from the process is chemically neutralized and sent to the F-Area high-level waste tanks. The major components for this operation are a gelatin "strike" tank, a centrifuge feed tank, and a centrifuge.
- **First Cycle** - First cycle operation, which occurs in the hot canyon, has two functions: (1) to remove fission products and other chemical impurities, and (2) to separate the solution into two product streams (uranium and plutonium) for further processing. This separation process occurs as the product solution passes through a series of equipment consisting of a centrifugal contactor and mixer-settler banks. Before the introduction of the feed solution from the head end process, flows of solvent and acid solution are established in the equipment. When an equilibrium is established, the feed solution is introduced. The chemical properties of the acid/solvent/feed solutions in contact with each other cause radioactive decay products to separate from the uranium and

plutonium. Later in the first cycle process, the plutonium is separated from the uranium in a similar manner. The first cycle produces four process streams: plutonium (with some residual radioactive decay products), which goes to the second plutonium cycle; a uranium solution (with some residual radioactive decay products), which goes to the second uranium cycle; a solvent stream, which goes to the solvent recovery cycle; and an aqueous acid stream, which goes to the high-level waste tanks. The acid stream contains most of the radioactive decay products. The equipment for this operation consists of a centrifugal contactor, mixer-settler banks, decanter tanks, and hold tanks.

- **Second Uranium Cycle** - The second uranium cycle (in the warm canyon) purifies the uranium solution from the first cycle and prepares the uranium for transfer to the FA-Line. The purification process is a separation process that occurs in a manner similar to that described for the first cycle. The uranium product solution, which contains a low concentration of radioactive decay products, is transferred from the warm canyon to storage tanks in the FA-Line facility, which is adjacent to the F-Canyon.
- **Second Plutonium Cycle** - The second plutonium cycle (in the warm canyon) purifies the plutonium solution from the first cycle by removing residual radioactive decay products, and prepares the plutonium for transfer to FB-Line. The purification process is a separation process that occurs in a manner similar to that described for the first cycle. The impurities are removed in an aqueous stream that goes to the low-activity waste unit operation for processing. The plutonium product solution, which contains a low concentration of radioactive decay products, is transferred to hold tanks for use as FB-Line feed material.
- **High- and Low-Activity Waste** - These unit operations reduce the volumes of the aqueous streams that contain radioactive decay products by using a series of evaporators in the hot and warm canyons. The feed to the evaporators originates with the primary separation process unit operations, such as the first cycle. The evaporator overheads, which contain most of the water and acid and very little of the radioactive decay product and chemicals used in solvent extraction, are transferred to tanks outside the building for acid recovery and recycling. The radioactive decay products and chemicals in the evaporator concentrate are neutralized and sent to the F-Area high-level waste tanks.
- **Solvent Recovery** - The primary purpose of this unit operation is to wash the solvent to remove impurities, and to recover the solvent and recycle it to solvent extraction cycles for reuse. This operation reconditions and removes impurities from the solvent. The impurities are transferred to low-activity waste for processing. A separate solvent recovery is used with each extraction cycle.
- **Laboratory Waste Evaporation** - The waste handling facilities receive high-level laboratory wastes from F-Area and the Savannah River Technology Center (SRTC) laboratories (see Section C.6.6) and transfer them to the warm canyon for evaporation. These wastes are evaporated and the recovered water is returned to the Outside Facilities for recycling and reuse. The concentrated waste is discharged to the F-Area high-level waste tanks.

### C.3.2 H-Canyon Process

The H-Canyon process consists of the recovery of highly enriched uranium (HEU) from reactor fuel and the recovery of neptunium-237 and plutonium-238 from targets. This EIS evaluates the highly enriched uranium, but not the neptunium-237 and plutonium-238 processing. The major unit operations associated with highly enriched uranium are dissolution, head end, first solvent extraction cycle, second uranium solvent extraction cycle, and second neptunium (or second actinide) solvent extraction cycle (see [Figure C-10](#)). Unit operations that support the product recovery operations are high-activity waste, low-activity waste, and solvent recovery.

[Figure C-10](#). Historic H-Canyon process flow.

The following paragraphs discuss major and support unit operations in H-Canyon:

- **Dissolution** - Irradiated reactor fuel on a rail car through an air lock is brought into the south end of the hot canyon. The fuel consists of highly enriched uranium fuel tubes clad in aluminum. As a result of the irradiation process, some of the material in the fuel was converted into radioactive decay products and other isotopes such as neptunium-237. Large water-filled casks on rail cars transport the fuel. The fuel is removed from the casks and loaded into a dissolver tank. Heated nitric acid and mercuric nitrates in the tank dissolves the fuel, resulting in a solution containing highly enriched uranium, neptunium, small quantities of plutonium, radioactive decay

products from the reactor irradiation process, and the aluminum cladding.

- **Head End** - This process occurs in two steps to prepare the target solution for uranium and neptunium separation. First, gelatin is added to precipitate silica and other impurities. Then the solution is transferred to a centrifuge, where silica and other impurities are removed as waste. The clarified product solution is adjusted with nitric acid and water in preparation for the first cycle unit operation. The waste stream generated from the head end process is chemically neutralized and sent to the H-Area high-level waste tanks. The major components for this operation are a gelatin "strike" tank, a centrifuge feed tank, and a centrifuge.
- **First Cycle** - This operation, which occurs in the hot canyon, has two functions: (1) to remove radioactive decay products and other chemical impurities, and (2) to separate the solution into two product streams (highly enriched uranium and neptunium if recovery is scheduled) for further processing. During the solvent extraction process, the product solution passes through a series of mixer-settler banks. Before the introduction of the highly enriched uranium and neptunium feed solution, flows of solvent and acid (including nitric acid, as discussed for F-Area) solution start through the equipment. When equilibrium has been established, the feed solution from the head end is introduced. The chemical properties of the acid/solvent/feed solutions in contact with each other cause the radioactive decay products, the uranium, and the neptunium to separate. The first cycle produces four process streams: a highly enriched uranium solution with most of the radioactive decay product removed, which goes to the second uranium cycle; a neptunium solution with most of the radioactive decay products removed, which goes to the second neptunium cycle; a solvent stream, which goes to the solvent recovery system; and an aqueous acid stream containing most of the radioactive decay products and chemical salts used in the process, which goes to the high-level waste evaporators. If neptunium recovery is not desired, the solvent extraction cycle is revised and the neptunium is discarded with the aqueous acid stream. The equipment for this unit operation consists of mixer-settler banks, decanter tanks, and hold tanks.
- **Second Uranium Cycle** - The second uranium cycle (in the warm canyon) further purifies the highly enriched uranium solution from the first cycle and prepares it for transfer to the A-Line. The purification process is a solvent extraction process that occurs in a manner similar to that described for the first cycle. The highly enriched uranium product solution is transferred from the warm canyon to storage tanks in the A-Line facility, which is adjacent to the H-Canyon.
- **Second Neptunium (Second Product) Cycle** - The second neptunium cycle (in the warm canyon) purifies the neptunium solution from the first cycle if neptunium recovery is required by removing most of the residual radioactive decay products, and prepares the neptunium for transfer to HB-Line. The purification process is a solvent extraction process that occurs in a manner similar to that for the first cycle. The impurities are removed in an aqueous stream that goes to the low-activity waste unit operation for processing. The neptunium product solution is transferred to hold tanks for use as HB-Line feed material.
- **High- and Low-Activity Waste** - These unit operations reduce the volumes of the aqueous streams that contain radioactive decay products by using a series of evaporators in the hot and warm canyons. The feed to the evaporators originates with the primary separation process operations (e.g., the first cycle). The evaporator overheads, which contain most of the water and acid and very little of the radioactive decay product and chemicals used in solvent extraction, are transferred to tanks outside the building for acid recovery and recycling. The fission products and chemicals in the evaporator concentrate are neutralized and sent to the H-Area high-level waste tanks.
- **Solvent Recovery** - The primary purpose of this unit operation is to wash the solvent to remove impurities, and to recover and recycle the solvent extraction for reuse. The impurities are transferred to low-activity waste for processing. Solvent recovery is used with each extraction cycle.

## C.4 FB-Line

The FB-Line is located on the top of the F-Canyon structure (see [Figure C-11](#)). Its exterior walls and roof are poured reinforced concrete. The portion of the structure that contains process equipment is approximately 39 meters (130 feet) long by 20 meters (67 feet) wide. The single-story extension to the north is about 11 meters (35 feet) wide by 6 meters (20 feet) long. Tanks and reaction vessels are enclosed in engineered cabinets or gloveboxes to minimize the spread of contamination and to provide shielding from radiation (see [Figure C-12](#)).

The FB-Line process includes purification and concentration of plutonium by cation exchange, precipitation of

plutonium as a trifluoride, recovery of the trifluoride by filtration, drying of the trifluoride in an oxygen atmosphere, and reduction with calcium metal to form plutonium metal buttons. [Figure C-13](#) shows the typical process flow through the line.







## APPENDIX D: ANNUAL DATA FOR PHASES ASSOCIATED WITH THE MANAGEMENT OF MATERIALS

This appendix contains the annual data used to calculate 10-year impacts from the various alternatives (see [Chapter 4](#)). Most of the alternatives would involve the use of multiple facilities and sequential steps to achieve the primary objective (i.e., stabilization or a form that satisfied program requirements). DOE estimated the annual impacts that could occur for each step or "phase" of each alternative. DOE then estimated durations for each phase of each alternative to generate the 10-year data.

This EIS uses the following generic names for the phases to facilitate the presentation of data, even though the different alternatives would involve different activities and facilities.

- **Existing Storage:** Actions associated with storing the material in its present form and configuration.
- **Characterization:** Actions that would be necessary to prepare the material for conversion, including visual inspection, weighing, and chemical and radioactive analysis. The characterization of the material would be needed to determine the implementation of proper processing technique(s).
- **Conversion:** Actions associated with changing the physical or chemical form of the material (i.e., liquid to solid). This typically would involve transfer of the material to a chemical processing facility and operation of the facility.
- **Interim Storage:** For some alternatives, the initial conversion or processing would not complete the stabilization process. Additional steps could be required, such as special packaging or further separations operations. Interim storage would include actions associated with storing the material in preparation for the next phase.
- **Additional Conversion:** Any additional actions necessary to place the material in a suitable form for continued storage, such as heating or repackaging solid forms of plutonium.
- **Packagin/nepa/dbgraphics/eishtml/eis-0220/Repackaging:** Actions necessary to place the suitable material form into an acceptable storage configuration, such as treatment in the Actinide Packaging Facility or repackaging.
- **Post-Stabilization Storage:** Actions associated with the material after it had been placed in a configuration and facility suitable for an extended storage period.

Table D-1 presents general information on actions associated with the phases for the alternatives that DOE considered for each material. In this table, "NA" indicates that a phase does not apply to an alternative.

The description of alternatives in [Chapter 2](#) presents the projected durations for "active" phases (i.e., phases that would not involve storage) for the stabilization alternatives. For some alternatives, the latter phases are not likely to be completed by the end of the 10-year period analyzed in this EIS. For a few alternatives, the latter phases would not start within the 10-year period. [Chapter 4](#) presents the impacts estimated for the next 10 years for various combinations of alternatives. To ensure a complete analysis, Tables D-2 through D-44 present the estimated annual impacts for each phase of every alternative, even though some are not likely to occur within the 10-year period. In general, the highest annual data are related to the conversion phase, because this phase would involve the transfer of the nuclear material and the operation of major facilities. The values for post-stabilization storage are generally less than those for existing storage, reflecting changes in material properties or storage configuration.



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## APPENDIX E. ACCIDENTS

This appendix summarizes accidents that could involve nuclear material management. It provides consequences (e.g., resulting doses) from potential releases of specific nuclear materials for each alternative discussed in this EIS.

In preparing this environmental impact statement, DOE reviewed safety analysis reports and supporting accident analyses for facilities that the alternatives described in [Chapter 2](#) could involve. There are no accident analyses for alternatives that would involve new facilities or extensive modifications to existing facilities. In such cases, DOE used accident analyses for existing facilities at SRS that perform similar operations or that process and handle forms of nuclear material that are more hazardous than those being considered in this EIS. DOE believes that the types of accidents evaluated for such existing facilities would be comparable to those for new or modified facilities.

### E.1 General Accident Information

An "accident," as discussed in this appendix, is an unplanned release of radioactive or hazardous materials resulting from "initiating" events and the additional failures resulting from the initiating event. In this case, an accident is an inadvertent release of radioactive or hazardous materials from their containers or confinement to the environment.<sup>1</sup> Initiating events are typically defined in three broad categories:

- External initiators originate outside the facility and potentially affect the ability of the facility to maintain confinement of its materials. Examples of external initiators include aircraft crashes, nearby explosions, and hazardous material releases from nearby facilities that could affect the ability of personnel to manage the facility and its materials properly.
- Internal initiators originate within a facility and are usually the result of facility operation. Examples of internal initiators include equipment failures and human errors.
- Natural phenomena initiators are natural occurrences such as weather-related (e.g., floods and tornadoes) and seismic events (i.e., earthquakes).

The likelihood of an accident occurring and its consequences usually depend on the type of initiator(s) causing the accident, the frequency at which that initiator occurs, and the frequency of conditions that will lead to a release caused by the initiating event. Accidents can be grouped into four categories -- anticipated accidents, unlikely accidents, extremely unlikely accidents, and not reasonably foreseeable accidents -- based on their estimated frequency or likelihood of occurrence. Table E-1 lists these accident categories and their corresponding frequency ranges.

**Table E-1. Accident frequency categories.<sup>a</sup>**

Frequency category	Frequency range (incidents per year)	Description
1. Anticipated accidents	Less than once in 10 years but greater than once in 100 years	Accidents that might occur several times during the lifetime of the facility.
2. Unlikely accidents	Less than once in 100 years but greater than once in 10,000 years	Accidents that are not likely to occur during the lifetime of the facility; natural phenomena of this probability class include Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
3. Extremely unlikely	Less than once in 10,000 years but greater	Accidents that probably will not occur during the life cycle of the facility; this includes a severe tornado, airplane crash, etc.

accidents	than once in 1,000,000 years	
4. Not reasonably foreseeable accidents	Less than once in 1,000,000 years	All other accidents (e.g., a direct meteorite strike)

<sup>a</sup> Source: DOE (1994a).

This EIS evaluation examined a full spectrum of accidents; the tables in this appendix reflect the bounding (risk or consequence) event for the frequency ranges listed in Table E-1, in which risk is defined as the product of the frequency (events per year) and the consequence of an event.

The bounding consequence events would result in the largest projected increases in latent cancer fatalities, were these accidents to occur. The bounding risk events would represent the highest individual likelihood of contracting a fatal cancer, or the highest incremental cancer fatality rate in an exposed population, expressed in units of latent cancer fatalities per year. The tables in [Section E.3](#) present the highest point estimate of risk to the maximally exposed offsite individual for each phase in bold type. This bolded number, when compared to the 1990 United States annual average risk of dying of cancer of about 0.002 (DOC 1992), provides a perspective on whether the event would be likely to increase an individual's lifetime cancer risk due to an accident dose received in that year.

## E.2 Accident Analysis Method

The accidents analyzed in this EIS would result from events that are considered "reasonably foreseeable" (expected to occur at least once in 1,000,000 years). The frequencies listed in the tables in this appendix are usually associated with the initial event that leads to a release of radioactive material. In most cases, this is a conservative frequency (i.e., it overestimates the risk) because in reality a chain of events, each with its own frequency, must occur; this includes the unlikely and highly unfavorable meteorological conditions assumed to prevail at the time of the accident. In addition, the analysis might have used conservative release assumptions to calculate potential consequences (doses) that could result from such accidents. These consequences are conservative because the release of radioactivity from the facility associated with the initiating event (e.g., earthquake) could occur only after the failure of a number of safety systems.

For example, a release of radioactive material from a chemical separations facility (e.g., F-Canyon) could occur in the following manner: An earthquake occurs during a tank-to-tank transfer of radioactive solution in the canyon. The transfer pipe fails or ruptures but the transfer continues and half the contents of the tank spill to the floor of the canyon. Simultaneous with the pipe rupture, the walls of the canyon crack, providing a release pathway to the environment. In addition, the canyon ventilation system fails. (The ventilation system normally maintains the interior of the canyon at a lower pressure than the outside environment. In this way, air leaks are normally into rather than out of the canyon.) After the radioactive material spills, a fraction becomes airborne and passes through the cracks in the canyon walls. This airborne radioactivity is blown off the Site.

This scenario is conservative because tank-to-tank transfers do not occur on a continuous basis, and the earthquake would have to occur during a transfer. DOE assumes that the following failures would allow the release to reach the offsite population at the projected dose levels: (1) the transfer pipe fails, (2) operators fail to respond or are unable to stop the transfer, (3) the canyon walls crack sufficiently to allow the escape of 10 percent of the airborne radioactive material, and (4) power distribution and electrical relays associated with the ventilation system fail. In addition, all released material escapes the facility in the first 2 hours and the meteorological conditions are such that only limited dispersion (or dilution) of the material has occurred by the time it reaches the SRS boundary. [Figure E-1](#) is a sample event tree that shows the effects of this hypothetical earthquake.

The analytical method described in the following sections did not include emergency response actions to accident situations (e.g., evacuation of personnel to a safe distance or notification of the public to perform such response actions

as taking shelter) in its determination of potential impacts on workers or members of the public. To minimize potential human exposures and impacts on the environment from postulated accidents, the SRS has established an Emergency Plan (WSRC 1994a) that governs responses to potential accidents.

**Figure E-1.** Example of a fault tree.

The presentation of data in this appendix uses an alternative scientific notation that facilitates comparisons of the results in tables that sometimes cover several pages. This notation is explained below:

$$7.1\text{E}-01 = 7.1 \times 10^{-1}$$

or = 0.71

$$2.4\text{E}+3 = 2.4 \times 10^{+3}$$

or = 2,400

The use of this notation shows the relative magnitude of any data entry. The absence of an "E" notation indicates an actual number without the need for a multiple of 10.

To approximate the potential accident impact contribution for each material (or group of materials) of interest, DOE created a flow diagram showing the location, condition, and chemical or physical form of the material. If a safety analysis report provided different frequencies for an event depending on location in a facility (e.g., a fire is more likely in a glovebox than in a dissolver tank), the analysis used the appropriate frequency for each location housing the material. In some cases, the current forms of the materials differ greatly, although two material groups both might contain primarily plutonium-239. At some point in the processing of both materials (under the preferred alternative), the original form would be lost and the newly generated form would be virtually identical. An example would be Mark-31 plutonium targets and H-Canyon plutonium solutions. After dissolution and processing, the Mark-31 targets would have formed "newly generated" plutonium solutions. These solutions would not pose the same level of concern as those in F-Canyon, which have been stored for several years longer than planned.

In addition to customizing the frequency by location, the analysis customized the source term and composition of the material to the extent possible. For example, if a solution has been processed through a canyon, concentrated, and purified by removing fission products, the source term was adjusted to the maximum concentration with fission product contributions subtracted. The effect of this type of customization is evident in the tables that list the impacts from earthquakes. The frequency remains constant, but both the quantity (in terms of curies) and the isotopic composition (e.g., more americium-241 than plutonium-239) vary by material. These variations enable discrimination of the impacts from one material to another. This discrimination can determine the potential risk reduction if the material of interest is stabilized.

If it was not possible to customize the frequency or source term for a material, the results from the safety analysis report were used. These results represent the bounding accident analysis and are useful for predictions of the impacts from a common mode failure (i.e., a severe earthquake). [Table E-5](#) lists F-Canyon bounding severe earthquake impacts under the heading "F-Canyon (full operation)." [Table E-6](#) lists H-Canyon bounding severe earthquake impacts under the heading "H-Canyon (limiting solution source term)."] Because severe earthquake impacts from the canyons would far exceed those from other facilities involved in the interim management of nuclear materials, a total impact due to a severe earthquake could be approximated by adding the individual impacts from F- and H-Canyons. This cumulative impact is conservative because it is unlikely that both canyons would experience the maximum effects from a severe earthquake.

## E.2.1 AFFECTED FACILITIES

Appendix C discusses the facilities used for nuclear material management activities within the scope of this EIS. In addition to the primary areas that house nuclear material, other SRS facilities contain nuclear materials (e.g., the TNX facility has two tanks of depleted uranyl nitrate solution and N-Area has drums of depleted uranium oxide). DOE has evaluated these facilities for their potential hazards and has determined that safety analysis reports were not required

due to the low hazards posed by the facilities. This means that a total release of materials without mitigation would result in consequences below the threshold requiring detailed analysis. As a result, the extent of quantitative impact data is limited. In most cases, the impacts will be compared to known impacts that bound those from secondary facilities. To determine the types of accident scenarios this appendix would present, DOE performed an extensive review of existing safety documentation for facilities that either perform or support activities that could be involved with management of nuclear material.

## E.2.2 RADIOLOGICAL ACCIDENT ANALYSIS METHOD

DOE used computer models to determine the consequences resulting from the release of radioactivity. This evaluation assumed the release of 1 curie of pertinent isotopes to a surface stream (for liquids) or to the atmosphere at ground level and at an elevated level, such as through an exhaust stack for the various facilities involved in the alternatives discussed in this EIS. Using the computer models, the evaluation calculated doses to an uninvolved worker, the maximally exposed offsite individual, and the offsite population within 80 kilometers (50 miles) of the Site (Simpkins 1994a,b).

DOE used two SRS-specific computer codes -- AXAIR89Q and LADTAP XL -- to calculate the doses from each of the 1-curie releases postulated. Both codes perform accident analyses described in facility safety analysis reports and postulated accident impacts presented in other EISs developed for the SRS.

The AXAIR89Q computer code (WSRC 1994b), which was developed in accordance with guidelines established by the U.S. Nuclear Regulatory Commission for modeling atmospheric releases, models the doses from airborne constituents of postulated accidental releases of radionuclides to the environment. The modeling of the various accidents postulated for the facilities associated with the different alternatives assumed conservative (99.5 percentile) meteorological conditions (e.g., direction and speed of prevailing wind). "Conservative meteorological conditions" are those for which, for a given release, the concentration of radionuclides (and the resulting doses) at a fixed downwind location will not be exceeded 99.5 percent of the time. Usually, this means a highly stable-low wind speed weather condition where the wind provides only limited dilution of the material released. Use of these meteorological conditions results in consequences approximately three to four times higher for onsite workers and between 10 and 100 times higher for the offsite population than those that would occur during average (50 percentile) meteorological conditions.

The LADTAP XL computer code was developed to model aqueous (i.e., liquid) releases of radionuclides during routine operations and potential accidents. The modeling of the aqueous releases associated with the postulated accidents described in this appendix took no credit for the holdup of radionuclides within the soils surrounding the area where the accidents would occur. In other words, the modeling assumed that the entire release would discharge directly as a liquid to the ground, migrate to the Savannah River either directly or through Fourmile Branch, Pen Branch, etc., and enter the drinking water supply.

DOE calculated most of the impacts (e.g., exposure, expressed as millirem or projected cancer incidence) to individuals from postulated accidental releases of radionuclides to the environment for the various facilities by multiplying the quantity of each isotope in the source term release (in curies per isotope) presented in the safety analysis documents by the doses calculated for a 1-curie release, as discussed in the previous paragraphs. For example, if a facility safety analysis report stated that 0.00044 curie of strontium-90 was released at ground level in the F-Area, and the projected dose to the maximally exposed offsite individual from a 1-curie release of strontium-90 at ground level in the F-Area is 0.1 millirem, then the dose to the maximally exposed offsite individual from the release would be determined by multiplying 0.00044 curie by 0.1 millirem per curie, resulting in a dose of 0.000044 millirem. The total projected dose would then equal the sum of the doses received from each radionuclide (isotope) released during the accident. This approach was not used for impacts already presented in other NEPA documents (e.g., high-level waste tank accidents or plutonium-238 accidents); in such cases, the impacts were obtained from those documents. [Section E.3](#) presents the doses to uninvolved workers, maximally exposed offsite individuals, and the offsite population postulated for the facility radiological accidents evaluated in this appendix.

Each table in [Section E.3](#) reflects the projected consequences in terms of dose (millirem or person-rem), point estimate

of risk (dose  $\times$  frequency, in units of millirem per year or person-rem per year), and latent cancer fatalities based on projections using guidelines developed by the International Commission of Radiation Protection (see [Chapter 4](#)). These guidelines, which are based on several decades of statistical analyses, provide a projection of an individual's chance of developing a cancer that proves to be fatal over time or a projection of the number of fatal cancers that would be likely to result from a population of individuals receiving a collective dose. These numbers enable comparisons of the highest consequence accidents among alternatives and among the phases of an alternative. The projections do not reflect the actual risk to an individual or population because the analysis does not consider the frequency of the accident (likelihood of occurrence). The risk of developing cancer resulting from SRS activities to manage nuclear material would be very low because accidents with large consequences from radioactive materials have not occurred historically and are unlikely to occur in the future. Each table also contains a column listing the total number of released curies estimated for each accident. The variations in dose estimates from similar release amounts is due to the varying impacts of different radioactive isotopes (e.g., 1 curie of plutonium-239 has almost five times the impact of 1 curie of plutonium-241).

As discussed above, this appendix describes risks to uninvolved workers and members of the public from radiological accidents involving nuclear materials in a quantitative fashion using such parameters as dose, accident frequency, and latent cancer fatalities in the population (as discussed in [Section E.3](#)). However, it presents potential impacts to involved, or "close-in" workers, from postulated accidents in a qualitative rather than a quantitative (in numerical terms) fashion, primarily because there is no adequate method for calculating meaningful consequences at or near the location where the accidental release occurs (DOE 1994a). The following example illustrates this concept.

A typical method for attempting to calculate the dose to an involved worker is to assume that the material is released in a room occupied by the worker and that the material instantly disperses throughout the room. Because the worker would be in the room when the release occurred, that individual probably would breathe some fraction of the radioactive materials for a given number of seconds before leaving the room. Typically, estimates of exposure time are based on assumptions about worker response to the incident (e.g., how long before the worker left the room, or whether the worker evacuated the room through an area of higher airborne concentrations). For example, consider the instance in which the worker drops a container with 2,000 grams (4.4 pounds) of plutonium oxide powder. Depending on the size of the room where the release occurred, the assumptions made on how much of the released powder became airborne and respirable, and the length of time the exposed worker remained in the room, the calculated dose to the worker could be anywhere between 80 and 78,000 rem (DOE 1994a). The uncertainty of this estimate is large, and no additional insight into the activity is available because the occurrence is accepted as undesirable without needing to perform the calculations. Historic evidence (DOE 1994a) indicates that this would be a nonfatal accident resulting in room contamination with the potential for minor personnel contamination and assimilation. Presenting this wide range of worker dose is not helpful in comparisons of impacts among alternatives. [Section E.3.2](#) discusses potential radiological impacts to facility workers from accidents in a facility.

### **E.2.3 HAZARDOUS MATERIAL ACCIDENT ANALYSIS METHODOLOGY**

A full understanding of the hazards associated with SRS nuclear facilities under the alternatives considered in this EIS requires analyses of potential accidents involving both hazardous and radiological materials. For chemically toxic materials, several government agencies recommend quantifying the health effects that cause short-term consequences as threshold values of concentrations in air. Because the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure, a determination of potential health effects from exposures to hazardous materials is more subjective than a determination of health effects from exposure to radiation. Therefore, the consequences from accidents involving hazardous materials postulated in this appendix are in terms of airborne concentrations at various distances from the accident location, rather than dose or latent cancer fatalities. Because hazardous materials are used during the operations of each facility, the actual quantity associated with a particular alternative for the materials discussed in this EIS cannot be determined. For example, if a chemical is used to prevent microbiological growth in service water for a facility, then that chemical's tank or vessel must be assumed to be present for the duration of any facility function. Some or all of the hazardous substances could be eliminated if the mission of the facility were completed. None of the primary facilities involved in the storage or management of nuclear material is likely to complete its total mission within the period covered by this EIS.



To determine potential health effects to workers and members of the public that could result from accidents involving hazardous materials, DOE determined the airborne concentrations of such materials released during an accident where the uninvolved worker and offsite individual would be [i.e., 640 meters (2,100 feet) and the nearest SRS boundary, respectively] and compared them to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the material or chemical being considered, for three general severity levels to ensure that the necessary emergency actions occur to minimize worker and public exposures after accidents. These severity levels include the following:

- ERPG-1 Values. Exposure to airborne concentrations greater than ERPG-1 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.
- ERPG-2 Values. Exposure to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impair one's ability to take protective action.
- ERPG-3 Values. Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Because all hazardous materials do not have ERPG values, DOE could not use such values to estimate potential impacts on the public from each hazardous material accident postulated for the SRS facilities discussed in this appendix. For chemicals that do not have ERPG values, this assessment compared airborne concentrations of hazardous materials resulting from postulated accidents to the most restrictive available exposure limits established by other guidelines (WSRC 1992) to control worker exposures to hazardous materials. Table E-2 lists the hierarchy of exposure limits that DOE used to evaluate potential health effects resulting from postulated hazardous material accidents.

DOE used a bounding approach to determine the potential impacts on individuals at different positions (e.g., uninvolved workers and the maximally exposed offsite individual) from postulated accidents in each facility area from Extremely Hazardous Substances; the amounts of such substances and their locations were determined from the SRS Tier Two Emergency and Hazardous Chemical Inventory Report (WSRC 1994c). This annual report identifies the chemicals at the Site that are

**Table E-2. Hierarchy of established limits and guidelines used to determine impacts from postulated hazardous material accidents.**

Primary airborne concentration guideline	Hierarchy of alternative guidelines (if primary guidelines are unavailable)	Reference of alternative guideline
ERPG-3	EEGL <sup>a</sup> (30-minute exposure) IDLH <sup>b</sup>	NAS (1985) NIOSH (1990)
ERPG-2	EEGL (60-minute exposure) LOC <sup>c</sup> PEL-C <sup>d</sup> TLV-C <sup>e</sup> TLV-TWA <sup>f</sup> multiplied by 5	NAS (1985) EPA (1987) 29 CFR Part 1910.1000, Subpart Z ACGIH (1992) ACGIH (1992)
ERPG-1	TWA-STEL <sup>g</sup> TLV-STEL <sup>h</sup> TLV-TWA multiplied by 3	29 CFR Part 1910.100, Subpart Z ACGIH (1992) ACGIH (1992)

**<sup>a</sup> Emergency Exposure Guidance Level (EEGL):** "A concentration of a substance in air (as a gas, vapor, or aerosol) that may be judged by the Department of Defense to be acceptable for the performance of specific tasks during emergency conditions lasting for a period of 1 to 24 hours. Exposure at an EEGL might produce reversible effects that do not impair judgment and do not interfere with proper responses to an emergency." The EEGL is "...a ceiling guidance level for a single emergency exposure, usually lasting from 1 to 24 hours -- an occurrence expected to be infrequent in the lifetime of a person."

**<sup>b</sup> Immediately Dangerous to Life and Health (IDLH):** "The maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects."

**<sup>c</sup> Level of Concern (LOC):** "The concentration of an extremely hazardous substance in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time."

**<sup>d</sup> Permissible Exposure Limit - Ceiling (C):** "The employee's exposure which shall not be exceeded during any part of the work day."

**<sup>e</sup> Threshold Limit Value - Ceiling (TLV-C):** "The concentration that should not be exceeded during any part of the working exposure."

**<sup>f</sup> Threshold Limit Value - Time Weighted Average (TLV-TWA):** "The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect."

**<sup>g</sup> Time Weighted Average - Short-Term Exposure Limit (TWA-STEL):** "The employee's 15-minute time weighted average exposure which shall not be exceeded at any time during a work day unless another time limit is specified...."

**<sup>h</sup> Threshold Limit Value - Short-Term Exposure Limit (TLV-STEL):** "The concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded."

hazardous or that require the establishment of emergency response procedures. Following identification of the amounts and locations of the Extremely Hazardous Substances (see [Section E.4](#)) in each area, DOE calculated the airborne concentrations at 640 meters (2,100 feet) from the point of release and the nearest SRS boundary (i.e., locations of the uninvolved worker and maximally exposed offsite individual, respectively) that would be likely from a release of the maximum inventory of each Extremely Hazardous Substance in a single location. EPICode™ (Emergency Prediction and Information Code), a commercially available computer code for modeling routine or accidental releases of hazardous chemicals to the environment (Homann 1988), calculated the airborne concentrations at the different locations.

## **E.3 Postulated Accidents Involving Radioactive Materials**

### **E.3.1 Impacts to Uninvolved Workers and Members of the Public**

This EIS presents the consequences and risks of bounding accidents. In this EIS, the term "bounding accident" represents postulated events or accidents that have higher consequences or risks (i.e., consequences × frequencies) than other accidents postulated in the same frequency range. A consideration of the risks associated with bounding events or accidents for a facility can establish an understanding of the overall risk to workers, members of the public, and the environment from nuclear material management activities. In addition, the risks of different alternatives can be compared relatively by comparing the risks associated with the bounding accidents for the phases of each alternative.



Figure E-2 shows the concept of bounding risk accidents. The accident impact tables in this section list the bounding events for each pertinent frequency range. These tables list in bold type the highest overall point estimate of risk for the maximally exposed offsite individual and the highest consequence to the population for each phase. Some tables also list a representative selection from the full spectrum of accidents to aid in comparisons among alternatives or to demonstrate the elimination of some accidents for specific materials.

Table E-3 is a summary matrix of the facilities used for each phase of the alternatives considered for each material category. The No-Action alternative column lists the facility where the material is currently stored; this alternative has no phases. The "conversion" phase refers to any initial treatment; it is not limited to processing in a canyon. Not all alternatives have all phases (e.g., the additional conversion phase could be beyond the timeframe of this EIS).

Table E-3 is intended for use in conjunction with Tables E-4 through E-12, which list accident analysis data for each material and the facilities that could be involved in a specific phase for the corresponding material. [Table E-3](#) can be used to determine the facility accidents analyzed that would be applicable to a specific phase. However, because the canyons and their support facilities are similar, conversion activities could occur in either area. As stated above, the tables list in bold type the maximum point estimate of risk for the maximally exposed offsite individual and the highest consequence to the population for each phase. Because an alternative might not involve every facility listed in each phase, these maximum values would not necessarily apply to all alternatives. For example, the highest point estimate of risk for the conversion phase of the H-Canyon uranium solutions (0.0000036 latent fatal cancers per year) would occur for H-Canyon. However, the Low Enriched Uranium Alternative for this material would use FA-Line for the processing phase; therefore, the maximum point estimate of risk for this alternative during processing would be 0.00000000018 latent fatal cancer per year. As noted above, the accident consequences have been tailored to the extent possible to reflect consequences attributable to the specific material.

#### **Table E-2**

#### [Table E-3.](#)

#### [Table E-4](#)

#### [Table E-5](#)

#### [Table E-6](#)

#### [Table E-7](#)

#### [Table E-8](#)

#### [Table E-9](#)

- a. MEI = maximally exposed individual.
- b. These data were not available.

[Section E.8](#) includes a glossary of accident descriptions. These descriptions describe the events listed in the tables. The tables use titles that indicate the facility mode as used throughout the tables [e.g., "F-Canyon (without dissolver)]." This entry means the action of dissolving would not be part of the management alternative for this material; the safety analysis report data for this mode or condition has not been used.

### **E.3.2 Impacts to Facility Workers from Postulated Facility Accidents**

### **E.3.2.1 F-Canyon and H-Canyon**

No fatalities to involved or "close-in" workers from the accident scenarios postulated under current or full operations in the F- or H-Canyon are a likely result of exposure to radiation. Releases from most accidents would be contained in the processing area and filtered through the canyon ventilation system. Because the ventilation system flows from areas of lowest to highest radioactivity, and because releases flow through an exhaust stack after passing through a filtration system, the doses received by workers from these accidents are not likely to be substantially larger than those received during routine operations. For postulated accidents in which the release was not likely to be maintained within the ventilation system (i.e., airborne releases from the ground level or liquid releases), involved worker exposures would be unlikely to result in adverse health effects. For an inadvertent nuclear criticality in the processing vessels, the doses to involved workers would likely be minimized due to the shielding between the vessels and the locations a worker could occupy.

### **E.3.2.2 FB-Line Facility**

With the exception of an inadvertent nuclear criticality during processing, no fatalities to involved workers from the accident scenarios postulated under current or full operations in the FB-Line would be likely as a result of exposure to radiation (see [Section E.7](#)). Current operations primarily involve storage activities in the FB-Line vaults. Because access to storage areas in the FB-Line is limited, only a small number of individuals could receive impacts from an accidental release of material or an inadvertent nuclear criticality in a storage vault. Under full operations, potential accidents resulting from processing, such as a fire or uncontrolled chemical reaction, would not result in substantial exposures because most work would occur inside gloveboxes. Based on historic accident information, exposures to involved workers would be within limits established for routine operations if the implementation of emergency response actions occurred. Of the approximately 74 persons who could be in the FB-Line facility during processing activities, about 56 would be in areas where they could receive substantial doses from a criticality. Of the 56, an estimated 4 workers could receive lethal doses of radiation, while the other individuals would receive varying nonlethal levels.

### **E.3.2.3 FA-Line**

For accidents postulated for FA-Line, with the exception of a red-oil explosion or a severe earthquake, no substantial injuries to involved workers are likely. The force of the explosion or flying debris initiated by the red-oil explosion could result in physical injuries to involved workers. Although the likelihood for an involved worker fatality due to radiation exposure alone after a severe earthquake is minimal, the earthquake itself could result in significant injuries or death for involved workers.

### **E.3.2.4 235-F Storage Vaults**

With the exception of an inadvertent nuclear criticality in the storage vaults, no fatalities to involved workers from the accident scenarios postulated for the 235-F facility are likely as a result of exposure to radiation. [Section E.7](#) discusses the criticality safety program. Because the number of persons permitted in the 235-F storage vaults is limited, the number of individuals who could be impacted from an inadvertent nuclear criticality would be limited. No more than two involved workers would be likely to receive lethal doses of radiation, with a limited number of additional individuals receiving exposures significantly above the annual administrative limit established for routine operations. For other postulated accident scenarios for the 235-F facility, exposures to involved workers are likely to be within limits established for routine operations, even if the inventories of materials within the vaults increased as a result of stabilization of materials at other SRS facilities.

### **E.3.2.5 HB-Line Facility**

Fatalities to involved or close-in workers from the accident scenarios postulated for full operation of the HB-Line facility are not a likely result of exposure to radiation. For many of the accidents, releases would be contained in the

gloveboxes and filtered through the process system and canyon ventilation systems. Because the ventilation system flows from areas of lowest to highest radioactivity, and because releases flow through an exhaust stack after passing through a filtration system, the worker doses from these accidents are not likely to be substantially larger than those received during routine operations. For postulated accidents in which the release is not likely to remain in the ventilation system, such as a ground-level airborne release initiated by a severe earthquake, involved worker exposures would be unlikely to result in adverse health effects. An inadvertent nuclear criticality is not considered credible in the HB-Line, either during current or full operations, due to the forms and isotopes of the materials. Therefore, exposures or fatalities are not likely from inadvertent nuclear criticalities.

#### **E.3.2.6 Uranium Solidification Facility**

With the exception of an inadvertent nuclear criticality during processing, no fatalities to involved workers from the accident scenarios postulated for the Uranium Solidification Facility are likely as a result of exposure of radiation. [Section E.7](#) discusses the criticality safety program. If an inadvertent nuclear criticality occurred, either during processing (criticality in a liquid) or packaging and storage (criticality in a powder), the radiation field generated by the criticality could lead to involved worker fatalities. However, DOE expects that the number of fatalities would be limited to two; additional individuals in the facility could receive doses that significantly exceeded their annual administrative exposure limits.

#### **E.3.2.7 H-Area Receiving Basin for Offsite Fuels**

No fatalities are likely to involved workers from the radiological accident scenarios postulated for the Receiving Basin for Offsite Fuels. Worker doses for all postulated basin accidents would be minimal.

#### **E.3.2.8 Reactor Disassembly Basins**

No fatalities are likely to involved workers from the radiological accident scenarios postulated for the reactor disassembly basins. Worker doses for all postulated basin accidents would be minimal. This conclusion is based on the fact that the fuels and targets stored in each basin are maintained at a distance below the surface level of the water sufficient to minimize involved worker exposures. In addition, in events that involved a substantial loss of basin water after which fuels and targets could be exposed to the air (e.g., draindown of half the basin water or discharge of all basin water following a severe earthquake), sufficient time would be available to allow involved workers to take the precautions necessary to evacuate the area or implement other actions to minimize exposures.

#### **E.3.2.9 Other Facilities**

In addition to the facilities discussed above, M-Area buildings, the Savannah River Technology Center, the TNX facility, and the high-level waste tanks contain nuclear materials addressed by this EIS.

No fatalities to involved workers from the accident scenarios postulated for M-Area are likely as a result of exposure to radiation. DOE anticipates that involved worker doses received from accidents would be minimal because the area serves as a storage vault for stable materials and involves only routine monitoring and maintenance activities.

No fatalities to involved workers from the accident scenarios postulated for the Savannah River Technology Center are likely as a result of exposure to radiation from accidents involving these materials, and DOE anticipates that involved worker doses received from accidents would be minimal. This conclusion is based on the very small amount of irradiated, aluminum-clad fuel assembly pieces, which would be a candidate for further stabilization in other facilities. The only alternative proposed for this material in the Savannah River Technology Center is No Action.

DOE anticipates no radiation-induced fatalities would result from accidents in the TNX facility or the waste tanks. The tanks in both areas store liquid radioactive materials and involve routine monitoring or remote transfers. The high-level waste tanks are in F- and H-Areas.

### **E.3.3 STABLE MATERIALS**

Although this EIS considers no alternatives other than Continued Storage (No Action) for stable materials, this section summarizes the accident analyses presented in the safety analysis reports for the facilities housing these materials. These documents discuss accident impacts for an uninvolved worker and the maximally exposed individual off the Site.

#### **E.3.3.1 Postulated Radiological Accidents for the M-Area Reactor Materials Facilities**

The primary purpose of the M-Area facilities was to manufacture fuel and target assemblies. The enriched uranium storage vault is constructed of reinforced concrete with walls and roof 30 centimeters (12 inches) thick. The four walls extend 1.8 meters (6 feet) into the ground and rest on 0.6-meter (2-foot)-thick footings. The storage vault was constructed to be a "maximum resistance" area [able to withstand a Fujita Intensity Five (F-5) tornado or a Modified Mercalli VIII (MM VIII) earthquake with little or no damage]. The SRS document explaining the limited continued operations in M-Area contains accident analyses for the facilities containing the nuclear materials addressed by this EIS. The bounding event for impact on the maximally exposed individual is an explosion in Building 320-M, which would result in a risk of 0.00014 rem per year and a latent cancer fatality projection of 0.00000007. For the uninvolved worker for the same event, the estimated risk would be 0.00044 rem per year and the latent cancer fatality projection would be 0.00000018. This accident is representative of bounding events related to the storage of a variety of materials for which further stabilization is not required. This group contains all material in the Reactor Material Area, including miscellaneous depleted uranium and uranium metal, oxide, slugs, cores, sludges, enriched uranium residues, lithium aluminum control rods, spargers, targets, unirradiated Mark-22s with lithium target tubes, natural and enriched lithium metal in cans, Mark-16 and Mark-22 tubes, Mark-31 slugs, and neptunium targets. Stable material is stored in Buildings 313-M, 315-M, 320-M, 321-M, 322-M, and 341-1M. Unirradiated Mark-31 slugs (depleted uranium in aluminum housings) constitute most of the inventory. The No-Action Alternative is proposed for the materials currently stored in M-Area.

#### **E.3.3.2 Postulated Radiological Accidents for Savannah River Technology Center**

Nuclear material used or stored in the Savannah River Technology Center includes a small amount of americium and curium solution and targets; americium-241 scrap; depleted uranium slurry, metal, and oxide; enriched uranium sweepings; etc.

Under the No-Action Alternative, current research activities at the Savannah River Technology Center would continue, and DOE would continue to store equivalent amounts and types of material in Building 773-A laboratories and cells. These materials are generally stored in limited-quantity cans, bottles, or sample carriers. Most are contained further in laboratory hoods, gloveboxes, or cells. These items, or equivalent new sample quantities, would be in a safe stable form for storage for several years.

The Savannah River Technology Center Safety Analysis Report summarizes consequences from postulated accidents at the center involving areas that contain the materials listed above. The actual contribution to the accident scenarios from these materials would be negligible, but these events are bounding for all alternatives for stable materials (i.e., the No-Action Alternative). An earthquake with a magnitude of 0.2 times gravity poses the highest risk for the maximally exposed individual. The risk associated with this event would be 0.00023 rem per year and the latent cancer fatality projection would be 0.00000012. In the highly unlikely event that this accident occurred, it would cause a projected increase of 0.48 in latent cancer fatalities. From the same event, the uninvolved worker risk would be 0.0043 rem per year and the latent cancer fatality projection would be 0.0000017.

#### **E.3.3.3 Postulated Radiological Accidents for the TNX Research Facility**

The TNX facility is a "radiological facility," as determined by the quantity of nuclear material present (DOE 1992). This hazard classification is the lowest for a facility that contains radioactive materials and requires no safety analysis report. This assessment does not summarize accident analyses for this facility because the impacts are bounded by

those for several other facilities; only the No-Action Alternative would apply.

## E.4 Postulated Accidents Involving Extremely Hazardous Substances

Because of the many types of materials and chemicals at the Site and the varying quantities of these materials in different locations, the analysis of potential accident scenarios involving hazardous materials was limited to substances categorized by the U.S. Environmental Protection Agency as "Extremely Hazardous Substances" (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986. Although materials not categorized as Extremely Hazardous Substances can affect the health and safety of workers and the public if released in sufficient quantities and forms, the Site has implemented programs in accordance with DOE Order requirements (e.g., DOE 1985, 1993, 1994b) that incorporate programmatic and management requirements of other government agencies, such as the Occupational Safety and Health Administration. While these materials might present hazards to workers or the public if accidentally released to the environment, their impacts are likely to be bounded by potential impacts from accidents involving Extremely Hazardous Substances; therefore, this appendix does not analyze them.

This section presents potential impacts from postulated chemical accidents at facilities that are or could be involved with safely managing or stabilizing SRS nuclear materials. For each area, it presents potential impacts of the bounding hypothetical chemical accident scenarios (as calculated using the method described in Section E.2.4).

Substances present in bulk quantities can, in some cases, be reduced or eliminated after stabilization of the associated nuclear material. In other cases (e.g., the Receiving Basin for Offsite Fuels), the chemicals support long-term facility functions independent of the interim management of the nuclear materials covered in this EIS. The accident consequences presented in this section assume a maximum chemistry inventory and are bounding for all alternatives.

### [Table E-10](#)

### [Table E-11](#)

### [Table E-12](#)

## E.4.1 POSTULATED CHEMICAL ACCIDENTS FOR F-AREA FACILITIES

Based on a review of current inventories at the facilities in the F-Area (DOE 1994c), DOE determined that seven Extremely Hazardous Substances are in use in the area. Table E-13 lists the maximum amounts of each substance in a single location in the F-Area.

**Table E-13. Inventories of Extremely Hazardous Substances<sup>a</sup> in F-Area.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Hydrochloric acid	34.0
Hydrogen fluoride	1,174.8
Hydrogen peroxide	122.5
Nitric acid	65,771.6
Phenol	0.9

Phosphorous pentoxide	0.9
Sulfuric acid	3,823.8

**<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.**

**<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.**

**<sup>c</sup> Amounts are based on 1993 (1-year) values.**

To determine airborne concentrations at 640 meters (2,100 feet) and the nearest SRS boundary (the locations of the uninvolved worker and maximally exposed offsite individual, respectively), DOE assumed an inadvertent release to the environment of the maximum amount of each material in a single location. This method enables a comparison of the impacts of the various substances as well as impacts at the facilities housing these substances. These impacts are conservative because the analysis does not consider the frequency of an initiating event that could lead to the release of this maximum amount.

DOE used the EPICode™ computer code (see Section E.2.6) to model the release of each material. Table E-14 lists the results of the analyses and compares expected airborne concentrations at the uninvolved worker and maximally exposed individual locations to the different threshold Emergency Response and Planning Guidelines or their equivalents.

**Table E-14. Impacts from potential non-seismic-initiated releases of extremely hazardous substances in F-Area**

Substance released	Maximum amount in F-Area (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Hydrochloric acid	3.4E+01	6.3E-03	8.5E-05	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	1.2E+03	2.2E+02	2.9	4.0	1.6E+01	4.1E+01
Hydrogen peroxide	1.2E+02	2.3E-02	3.1E-04	1.4	--	1.1E+02
Nitric acid	6.6E+04	1.4E+01	3.6	5.2	3.9E+01	7.7E+01
Phenol	9.1E-01	1.5E-04	1.7E-06	3.9E+01	1.9E+02	7.7E+02
Phosphorous pentoxide	9.1E-01	1.5E-04	1.7E-06	5.0	2.5E+01	1.0E+02
Sulfuric acid	3.8E+03	2.2E-07	3.7E-09	2.0	1.0E+01	3.0E+01

**<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.**

**<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.**

**<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.**

**<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).**

**<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as**

discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

Because a severe seismic event has the potential to initiate the release of the same material from different locations in the F-Area, DOE analyzed a release of the maximum daily inventory. Table E-15 lists the results of these analyses. A total release of the entire inventory of a particular material from the F-Area to the environment is extremely unlikely, especially if the material is in several different locations, facilities, or buildings in the area. However, the assumption of a total release of the maximum inventories in the area provides a bounding estimate for the largest airborne concentrations DOE could expect following a severe earthquake.

As listed in Tables E-14 and E-15, the airborne concentrations for a gaseous release of hydrogen fluoride (hydrofluoric acid) would exceed the ERPG-3 threshold limits at 640 meters (2,100 feet) from the point of release. As explained in Section E.2.4, ERPG-3 threshold values represent concentrations at which an individual would experience or develop life-threatening health effects if exposed for longer than 1 hour. Because individuals could be notified and evacuated to a safe location (e.g., inside a building with adequate ventilation) within 1 hour of an inadvertent release of hydrogen fluoride, DOE does not expect any life-threatening or long-term health effects to uninvolved workers. Uninvolved workers could experience mild burning of the lungs from inhaling hydrogen fluoride, burning of the eyes, and mild skin irritations. In addition, because the airborne concentrations at the nearest SRS boundary would be below ERPG-1 threshold values, no measurable health effects are likely to members of the public. However, for involved workers, there is a potential for serious worker injury and potential fatalities because of the large concentrations expected at locations close to the point of release, which could hinder personnel from taking appropriate emergency response actions.

**Table E-15. Impacts from potential releases of extremely hazardous substances in F-Area resulting from a severe earthquake**

Substance released	Maximum daily amount in entire F-Area (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Hydrochloric acid	1.0E+02	1.9E-02	2.6E-04	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	1.2E+03	2.2E+02	2.9	4.0	1.6E+01	4.1E+01
Hydrogen peroxide	1.2E+02	2.3E-02	3.1E-04	1.4	--	1.1E+02
Nitric acid	2.7E+05	3.9E+02	1.4E+01	5.2	3.9E+01	7.7E+01
Phenol	1.4	2.3E-04	2.6E-06	3.9E+01	1.9E+02	7.7E+02
Phosphorous pentoxide	9.1E-01	1.5E-04	1.7E-06	5.0	2.5E+01	1.0E+02
Sulfuric acid	4.0E+03	2.3E-07	4.0E-09	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per



**million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.**

[Table E-15](#) indicates that, in the event of a severe earthquake, a release of the total quantity of nitric acid in the F-Area would exceed ERPG-3 values at a distance of 640 meters (2,100 feet) and ERPG-1 values at the nearest SRS boundary. As explained in Section E.2.4, the health effects from being exposed to ERPG-1 threshold values for greater than 1 hour are minor (e.g., irritation of the eyes and objectionable odor). For uninvolved and involved workers, although the release would exceed ERPG-3 threshold values, no worker fatalities from exposure to airborne acid concentrations would be likely; some individuals could experience significant short-term health effects, such as burning of the lungs and irritation of the skin. Because this scenario assumes that all nitric acid in the F-Area would be released from a single location during a severe earthquake, airborne concentrations would be lower than those listed in [Table E-15](#).

#### E.4.2 POSTULATED CHEMICAL ACCIDENTS FOR H-AREA FACILITIES

Based on a review of current inventories at the various H-Area facilities (DOE 1994b), DOE determined that seven Extremely Hazardous Substances are in use in the H-Area. Table E-16 lists the maximum amounts of each substance in a single location in the H-Area.

**Table E-16. Inventories of Extremely Hazardous Substances<sup>a</sup> in H-Area.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Ammonia	27.2
Hydrochloric acid	2.7
Hydrogen fluoride	2.3
Nitric acid	39,814.7
Nitric oxide	1,315.4
Phosphorous pentoxide	1.4
Sulfuric acid	0.9

<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.

<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>c</sup> Amounts are based on 1993 (1-year) values.

Table E-17 lists the results of the analyses and compares the expected airborne concentrations at the uninvolved worker and maximally exposed individual locations to the different threshold Emergency Response and Planning Guidelines or their equivalents. Because a severe seismic event has the potential to initiate the release of the same material from different locations within the H-Area, DOE analyzed a release of the maximum daily inventory to the environment. [Table E-18](#) lists the results of these analyses.

As listed in Tables [E-17](#) and [E-18](#), the airborne concentrations for a gaseous release of nitric oxide would exceed the ERPG-3 threshold limits at a distance of 640 meters (2,100 feet) from the point of release. [Table E-18](#) indicates that, in a severe earthquake, a release of the total quantities of nitric acid in the H-Area would exceed ERPG-3 values at a distance of 640 meters (2,100 feet) and ERPG-1 values at the nearest SRS boundary. For uninvolved and involved

workers, although the release would exceed ERPG-3 threshold values, no worker fatalities from exposure to the airborne acid concentrations would be likely; some individuals could experience significant short-term health effects, such as burning of the lungs and irritation of the skin. Because this scenario assumes that all nitric acid in the H-Area would be released from a single location during a severe earthquake, airborne concentrations would be lower than those listed in [Table E-18](#).

**Table E-17. Impacts from potential non-seismic-initiated releases of Extremely Hazardous Substances in H-Area**

Substance released	Maximum amount in a single H-Area location (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Ammonia	2.7	5.1E-03	5.8E-05	2.5E+01	2.0E+02	1.0E+03
Hydrochloric acid	2.7	5.0E-04	5.7E-06	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	2.3	4.3E-04	4.9E-06	4.0	1.6E+01	4.1E+01
Nitric acid	4.0E+04	9.5E+01	1.9	5.2	3.9E+01	7.7E+01
Nitric Oxide	1.3E+03	4.9E+03	4.4	9.3E+01	1.2E+02 <sup>f</sup>	1.2E+02
Phosphorous pentoxide	1.4	1.2E-01	1.1E-03	5.0	2.5E+01	1.0E+02
Sulfuric acid	9.0E-01	1.7E-04	1.9E-06	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

<sup>f</sup> Alternative concentration limit guideline for ERPG-2 value (TWA × 5) was adjusted down to the next higher range value (IDLH).

**Table E-18. Impacts from potential releases of extremely hazardous substances in H-Area resulting from a severe earthquake.**

		Airborne concentration (milligram per cubic meter) <sup>b</sup>				

Substance released	Maximum daily amount in entire H-Area (kg) <sup>a</sup>	At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Ammonia	2.7E+01	5.1E-03	5.8E-05	2.5E+01	2.0E+02	1.0E+03
Hydrochloric acid	1.1E+01	2.1E-03	2.4E-05	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	3.6	6.7E-04	7.6E-06	4.0	1.6E+01	4.1E+01
Nitric acid	1.2E+05	2.3E+02	5.7	5.2	3.9E+01	7.7E+01
Nitric Oxide	1.3E+03	4.9E+03	4.4	9.3E+01	1.2E+02 <sup>f</sup>	1.2E+02
Phosphorous pentoxide	1.4	1.2E-01	1.1E-03	5.0	2.5E+01	1.0E+02
Sulfuric acid	2.7	5.0E-04	5.7E-06	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

<sup>f</sup> Alternative concentration limit guideline for ERPG-2 value (TWA × 5) was adjusted down to the next higher range value (IDLH).

#### E.4.3 POSTULATED CHEMICAL ACCIDENTS FOR K-, L-, AND P-REACTOR BASINS

Based on a review of the chemical inventory that supports the water chemistry in the L-Reactor basin, DOE determined that the only identified Extremely Hazardous Substance was a small quantity of nitric acid. For 45.6 kilograms (100 pounds) of nitric acid modeled as a liquid spill (the maximum daily amount in the basin), the airborne concentration at 640 meters (2,100 feet) would be several orders of magnitude lower than the ERPG-1 concentration limit. DOE assumed that this was typical for all SRS reactor basins that store nuclear material.

In addition, because the airborne concentrations at the nearest SRS boundary would be considerably below ERPG-1 threshold values, no measurable health effects to members of the public would be likely. No impacts would hinder involved workers from taking appropriate emergency response actions.

#### E.4.4 POSTULATED CHEMICAL ACCIDENTS FOR M-AREA FACILITIES

Based on a review of current inventories at the various facilities in the M-Area (DOE 1994b), DOE determined that five Extremely Hazardous Substances are in use in the area. Table E-19 lists the maximum amounts of each substance in a single location in the M-Area. However, M-Area contains nuclear materials that require no further stabilization. Therefore, this EIS proposes no alternatives for the safe management of nuclear materials in M-Area. As a result, no

further chemical accident analysis is required.

**Table E-19. Inventories of Extremely Hazardous Substances<sup>a</sup> in M-Area.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Hydrochloric acid	34.0
Hydrofluoric acid	2.27
Nitric acid	34,807.5
Phenol	2.27
Sulfuric acid	15,241.0

<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.

<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>c</sup> Amounts are based on 1993 (1-year) values.

#### E.4.5 SAVANNAH RIVER technology center

Based on a review of current inventories at the various facilities in the Savannah River Technology Center (DOE 1994d), DOE determined that eight Extremely Hazardous Substances are in use in SRTC facilities. Table E-20 lists the total annual maximum and average daily quantities of these substances based on 1993 (1-year) inventories. In addition, Table E-20 lists the maximum amounts of each substance in a single location in the SRTC. However, the Center contains nuclear materials that require no further stabilization. Therefore, this EIS proposes no alternatives for the safe management of the nuclear materials in SRTC facilities. As a result, no further chemical accident analysis is required.

**Table E-20. Inventories of Extremely Hazardous Substances<sup>a</sup> in Savannah River Technology Center.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Ammonia	0.5
Hydrochloric acid	2,215.4
Hydrogen fluoride	38.1
Nitric acid	3,864.2
Nitric oxide	0.9
Phenol	4.5
Phosphorous pentoxide	3.18
Sulfuric acid	13.6

<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the

**Emergency Planning and Community Right-to-Know Act of 1986.**

<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>c</sup> Amounts are based on 1993 (1-year) values.

**E.4.6 POSTULATED CHEMICAL ACCIDENTS FOR THE TNX AREA**

Based on a review of chemical usage in the TNX area, DOE determined that no chemicals in the area were required to support the continued safe management of nuclear materials. As a result, no further chemical accident analysis was performed for the TNX area.

**E.5 Environmental Justice**

When the 99.5 percent meteorology model is used, the SRS sector most affected by accidents is the Northwest. Although this is not typical of weather conditions (e.g., not the prevailing wind direction), the model calculated the highest impact to an individual at the SRS boundary.

Figures [3-7](#) and [3-8](#) show the distributions, by census tracts, of people of color and low-income populations, respectively. Parts of two census tracts in the Northwest sector adjoin the SRS. Neither tract is a low-income community or a community comprised of 50 percent or more of people of color, although one of the tracts contains between 35 and 50 percent people of color.

Farther from the SRS in the Northwest sector are low-income communities and communities that contain 50 percent or more of people of color. However, other communities in the sector are not low-income and contain fewer than 35 percent people of color, and they are as close as, or closer to, the SRS boundaries than the low-income communities or the communities of people of color.

Based on the distribution of types of communities and on the low dose received by the maximally exposed individual (see tables in this appendix), the accident scenarios would not result in disproportionately high or adverse human health and environmental impacts on people of color or low-income populations.

**E.6 Accident Mitigation**

Although DOE expends extensive efforts and large amounts of money to prevent accidents involving radioactive and hazardous materials, accidents and inadvertent releases to the environment can still occur. Therefore, an important part of the accident analysis process is the identification of actions that can mitigate consequences from accidents if they occur.<sup>2</sup> This section summarizes the SRS Emergency Plan, which governs responses to accident situations that could affect Site employees or the offsite population.

The *Savannah River Site Emergency Plan* (WSRC 1994a) defines appropriate response measures for the management of SRS emergencies (e.g., radiological or hazardous material accidents). It incorporates into one document the entire process designed to respond to and mitigate the consequences of a potential accident. For example, it establishes protective action guidelines for accidents involving chemical releases to keep onsite and offsite exposures as low as possible. It accomplishes minimization or prevention of exposures by minimizing time spent in the vicinity of the hazard or the release plume, keeping personnel as far from the hazard or plume as possible (e.g., using physical barricades and evacuation), and taking advantage of available shelter.

Emergencies that could cause activation of all or portions of this plan and the SRS Emergency Response Office include the following:

- Events (operational, transportation, etc.) with the potential to cause releases above allowable limits of radiological or hazardous materials.
- Events (fires, explosions, tornadoes, hurricanes, earthquakes, dam failures, etc.) that affect or could affect safety systems designed to protect Site and offsite populations and the environment. The effectiveness of the

- emergency plan would depend on the severity of the event and the impact on the Site and local infrastructure.
- Events (bomb threats, hostage situations, etc.) that reduce the security posture of the Site.
- Events created by proximity to other facilities such as the Vogtle Electric Generating Plant (a commercial nuclear utility across the Savannah River from the Site) or nearby commercial chemical facilities.

Depending on the types of postulated accidents and the potential impacts that could result from those accidents, emergencies are classified in several categories in accordance with requirements defined in the DOE 5500 Series of Orders, as follows:

- Alerts are confined within the affected facility boundary; no measurable impacts to workers or members of the public outside the facility boundary are likely.
- Site Area Emergencies are events that are in progress or that have occurred involving actual or likely major failures of facility safety or safeguards systems needed for the protection of onsite personnel, the public, the environment, or national security; because they have the potential to impact workers at colocated facilities or members of the public in the SRS vicinity, these situations require notification of and coordination of responses with the appropriate local authorities.
- General Emergencies produce consequences that require the implementation of protective actions to minimize impacts to both workers and the public; full mobilization of all available onsite and offsite resources is usually required to deal with the event and its consequences.

In accordance with the Site Emergency Plan, DOE conducts periodic drills and exercises at the SRS to develop, maintain, and test response capabilities, and validate the adequacy of emergency facilities, equipment, communications, procedures, and training. For example, drills occur for the following accident scenarios in the facilities or facility areas: facility or area evacuations, shelter protection, toxic gas releases, nuclear incident monitor alarms (following an inadvertent nuclear criticality), fire alarms, medical emergencies, and personnel accountability (to ensure that all personnel have safely evacuated a facility or area following an emergency). DOE and Westinghouse Savannah River Company conduct and evaluate periodic drills with the following organizations or groups to ensure that they continue to maintain (from both a personnel and an equipment standpoint) the capability to respond adequately to emergency situations: first aid teams; rescue teams; fire wardens, fire response and firefighting teams; SRS medical and Health Protection personnel and personnel from the Eisenhower Army Medical Center; SRS and local communications personnel and systems; SRS security forces; and SRS Health Protection agencies.

## **E.7 Nuclear Criticality Safety Program**

As discussed above, with the exception of an inadvertent nuclear criticality, no fatalities to involved workers from accident scenarios postulated for the management, stabilization, or storage of nuclear material would be likely to result from exposure to radiation. A criticality occurs when a neutron fissions the nucleus of a fissionable material to produce energy, fission fragments, neutrons, and various radiations. While nuclear reactors are specifically designed to produce energy from fission by controlling this neutron chain reaction, nonreactor nuclear facilities at the SRS do not generally provide the same control, shielding, and containment characteristics. Thus, an inadvertent fission chain reaction (nuclear criticality) in an SRS nonreactor nuclear facility could produce harmful radiation-related effects on nearby personnel.

As a result, nuclear criticality safety has been defined as "the prevention or termination of inadvertent nuclear chain reactions in nonreactor environments." In practice, the first concept--prevention--is by far the primary goal. As a consequence, SRS maintains a nuclear criticality safety program that establishes and defines the principles, practices, and controls to be used for the prevention of criticality accidents. When it has been determined that the potential for an inadvertent nuclear criticality accident exists for a facility, the design of criticality controls, including equipment and procedures, shall meet, at a minimum, the requirements described in the WSRC Nuclear Criticality Safety Manual. For a new facility, the use of physical design features to prevent criticality would be preferable. To ensure the successful

implementation of this program, a training policy recently adopted at the SRS supports the goal that all reasonable efforts shall be taken to reduce or eliminate the potential for, and consequences of, a criticality accident. Nuclear criticality safety training programs at the SRS are developed to be consistent with DOE Orders 5480.20 and 5480.24 for operating facility personnel and all other personnel requiring criticality safety training.

Positive identification of fissionable material, particularly fissile material, is essential to criticality safety. Adequate labeling of fissionable material and clear posting of work and storage areas in which fissionable materials are present are important in avoiding the accumulation of unsafe quantities of such materials. Appropriate fissionable material labeling and area posting are maintained at SRS nonreactor nuclear facilities specifying material identification and all parameter limits subject to procedural control. Storage requirements include minimum spacing distances to prevent sufficient material from being in close proximity. Criticality "poisons," such as boron, are often used in storage racks or packaging for material.

Written plans and procedures govern operations at SRS in which criticality safety is a consideration. These plans and procedures cover startup, operations, and any modifications that might affect criticality safety. Procedures clearly specify all controlled parameters and limits related to criticality safety. All criticality safety-related limits contained in the operating procedures are based on Nuclear Criticality Safety Evaluations (NCSEs). New or revised procedures containing nuclear safety steps, criticality safety limits, or criticality safety requirements undergo review and approval by a Criticality Safety Engineering Group (CSEG) before implementation. In the event of a criticality limit violation, SRS procedures specifically govern actions to be taken in the event of an undesirable situation; the objective of such procedures is to place the operation into as stable and safe a condition as possible until a criticality safety engineer or specialist can conduct an evaluation.

Water, the most often used firefighting agent, is an efficient moderator and reflector of neutrons (i.e., it can contribute to a criticality). In the absence of moderating materials such as water, relatively large masses of dry fissile materials such as powders or metals can be handled safely. In the event of a fire, SRS nonreactor nuclear facilities maintain prefire plans prepared by the management and engineering staff of each facility with the assistance by the Criticality Safety Engineering Group, SRS fire safety engineers, and the Area Fire Department, as necessary. These plans help provide a framework for the successful combination of firefighting and criticality safety. The CSEG approves the prefire plans for each facility in which criticality safety is of concern.

The SRS maintains criticality alarm systems, or Nuclear Incident Monitors (NIMs). The primary purpose of NIM systems is to minimize, by means of quick detection and alarm, the acute dose received by personnel from a criticality (and potential recriticality) accident in areas where the cumulative absorbed dose in free air might exceed 12 rads. The secondary purpose of the NIM system is to notify people to stay clear of the evacuated area and to notify appropriate response teams.

Emergency procedures for criticality accidents are prepared for each SRS facility in which criticality safety controls are instituted or criticality alarm systems are installed. Such emergency plans are approved by the appropriate management and the cognizant Criticality Safety Engineering Group, and consistent with the Site Emergency Plan (WSRC 1994a).

## **E.8 Accident Descriptions**

The larger facilities contain a variety of processes, equipment, and techniques used depending on the intended function. In determining the source terms for use in accident analysis, DOE examined the appropriate process or section of a facility for the specific material and adjusted the source term to correspond where necessary. The tables in [Section E.3](#) list the "modes" or conditions to reflect the selection for that material. The following paragraphs explain the accident titles used in the tables in [Section E.3](#).



**Unpropagated fire** – A fire that has localized impact and does not spread. It can be caused by ignition of flammable solvent, spontaneous burning of plutonium metal exposed to oxygen, or other causes. Radioactive particulates are dispersed in the immediate area of the fire and some might be released to the environment (e.g., during a filter fire). The fire lasts for a short period because the amount of combustible material is limited.

**Inadvertent transfer** – An unplanned transfer of a solution or liquid to an unintended location due to personnel error. The usual causes of such accidents are incorrectly installed piping connections or overflows from a vessel into a sump resulting from human errors.

**Coil and tube failure** – Some process vessels and tanks have internal coils for cooling or heating the stored solutions. The coils usually contain water or steam. The pressure inside the coils is normally higher than the pressure in the vessel. Should the coils leak or fail their internal pressure could be lost, resulting in radioactive solution entering the cooling water (or steam) system. If the leak is undetected, the contaminated water could be released through the system to the atmosphere without treatment.

**Inadvertent criticality** – These events are discussed in [Section E.7](#).

**Severe earthquake** – An earthquake that would be expected every 5,000 years. The severity or magnitude is based on an assumed horizontal ground acceleration of 20 percent of the acceleration due to gravity. An earthquake of this magnitude could result in structural damage and a loss of confinement of nuclear materials.

**Rupture storage container** – Certain radioactive materials can cause a buildup of gases inside the container in which they are stored (e.g., metal can) if it contains organic materials (e.g., plastic bags). Other materials (e.g., plutonium metal) can oxidize and gain moisture if the container is not completely airtight. Eventually, the pressure buildup can cause the storage container to bulge or rupture. This could disperse the material in the area around the container and result in exposure of a worker performing routine surveillance.

**Eruption** - A thermal or chemical reaction causes material to spew from its container. This could be an energetic event resulting in localized contamination. For the materials discussed in this EIS, such events would occur inside the canyons and no workers would be directly affected.

**Red-oil explosion** - So named because the substance causing the explosion is a thick red liquid produced by the inadvertent addition of organics to a high nitrate solution. The event can be very energetic and can result in a sudden localized explosion. The radiological consequences would probably be confined to areas within the canyon facilities.

**Tornado** - A tornado exerts pressure due to high wind speed on the surfaces of a structure. The resulting damage could cause releases of stored materials within the structure or could disperse materials stored in pads.

**Uncontrolled reaction** - Adjustments are routinely made to solutions to produce a reaction under known controlled conditions. If an adjustment (e.g., adding acid) or a change in condition (e.g., heating the contents) produces unexpected or rapid reaction, that reaction is "uncontrolled." The energy from this type of reaction could cause radioactive solutions to overflow or erupt outside the tank in which they are stored.

**Propagated fire** - A fire that goes beyond the area of ignition. For the materials discussed in this EIS, a propagated fire does not self-extinguish. For example, it might spread from a glovebox into the surrounding room or other areas of the facility.

**Basin overflow/draindown** - An unplanned movement of water, either into the reactor basins (causing an overflow) or from the reactor basins (draindown), which results in a flow of the basin water to sumps or storm drains and into the Savannah River. Basin overflow would normally be caused by human error; basin draindown could be caused by a breach of the basin integrity due to an earthquake.

**Hydrogen explosion** - Hydrogen gas is generated by radiolysis when water is in a tank or can with nuclear materials. If a sufficient quantity of the atmosphere in the container is hydrogen, the gas can detonate or explode, rupturing the container and releasing nuclear material.

**Energetic event** - Energetic events cause penetration of the primary confinement barrier and, if sufficiently energetic, can result in the bypass of a secondary barrier. Medium energetic events include a cabinet fire, an uncontrolled reaction, and criticality.

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## APPENDIX E. ACCIDENTS

This appendix summarizes accidents that could involve nuclear material management. It provides consequences (e.g., resulting doses) from potential releases of specific nuclear materials for each alternative discussed in this EIS.

In preparing this environmental impact statement, DOE reviewed safety analysis reports and supporting accident analyses for facilities that the alternatives described in [Chapter 2](#) could involve. There are no accident analyses for alternatives that would involve new facilities or extensive modifications to existing facilities. In such cases, DOE used accident analyses for existing facilities at SRS that perform similar operations or that process and handle forms of nuclear material that are more hazardous than those being considered in this EIS. DOE believes that the types of accidents evaluated for such existing facilities would be comparable to those for new or modified facilities.

### E.1 General Accident Information

An "accident," as discussed in this appendix, is an unplanned release of radioactive or hazardous materials resulting from "initiating" events and the additional failures resulting from the initiating event. In this case, an accident is an inadvertent release of radioactive or hazardous materials from their containers or confinement to the environment.<sup>1</sup> Initiating events are typically defined in three broad categories:

- External initiators originate outside the facility and potentially affect the ability of the facility to maintain confinement of its materials. Examples of external initiators include aircraft crashes, nearby explosions, and hazardous material releases from nearby facilities that could affect the ability of personnel to manage the facility and its materials properly.
- Internal initiators originate within a facility and are usually the result of facility operation. Examples of internal initiators include equipment failures and human errors.
- Natural phenomena initiators are natural occurrences such as weather-related (e.g., floods and tornadoes) and seismic events (i.e., earthquakes).

The likelihood of an accident occurring and its consequences usually depend on the type of initiator(s) causing the accident, the frequency at which that initiator occurs, and the frequency of conditions that will lead to a release caused by the initiating event. Accidents can be grouped into four categories -- anticipated accidents, unlikely accidents, extremely unlikely accidents, and not reasonably foreseeable accidents -- based on their estimated frequency or likelihood of occurrence. Table E-1 lists these accident categories and their corresponding frequency ranges.

**Table E-1. Accident frequency categories.<sup>a</sup>**

Frequency category	Frequency range (incidents per year)	Description
1. Anticipated accidents	Less than once in 10 years but greater than once in 100 years	Accidents that might occur several times during the lifetime of the facility.
2. Unlikely accidents	Less than once in 100 years but greater than once in 10,000 years	Accidents that are not likely to occur during the lifetime of the facility; natural phenomena of this probability class include Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.

3. Extremely unlikely accidents	Less than once in 10,000 years but greater than once in 1,000,000 years	Accidents that probably will not occur during the life cycle of the facility; this includes a severe tornado, airplane crash, etc.
4. Not reasonably foreseeable accidents	Less than once in 1,000,000 years	All other accidents (e.g., a direct meteorite strike)

<sup>a</sup> Source: DOE (1994a).

This EIS evaluation examined a full spectrum of accidents; the tables in this appendix reflect the bounding (risk or consequence) event for the frequency ranges listed in Table E-1, in which risk is defined as the product of the frequency (events per year) and the consequence of an event.

The bounding consequence events would result in the largest projected increases in latent cancer fatalities, were these accidents to occur. The bounding risk events would represent the highest individual likelihood of contracting a fatal cancer, or the highest incremental cancer fatality rate in an exposed population, expressed in units of latent cancer fatalities per year. The tables in [Section E.3](#) present the highest point estimate of risk to the maximally exposed offsite individual for each phase in bold type. This bolded number, when compared to the 1990 United States annual average risk of dying of cancer of about 0.002 (DOC 1992), provides a perspective on whether the event would be likely to increase an individual's lifetime cancer risk due to an accident dose received in that year.

## E.2 Accident Analysis Method

The accidents analyzed in this EIS would result from events that are considered "reasonably foreseeable" (expected to occur at least once in 1,000,000 years). The frequencies listed in the tables in this appendix are usually associated with the initial event that leads to a release of radioactive material. In most cases, this is a conservative frequency (i.e., it overestimates the risk) because in reality a chain of events, each with its own frequency, must occur; this includes the unlikely and highly unfavorable meteorological conditions assumed to prevail at the time of the accident. In addition, the analysis might have used conservative release assumptions to calculate potential consequences (doses) that could result from such accidents. These consequences are conservative because the release of radioactivity from the facility associated with the initiating event (e.g., earthquake) could occur only after the failure of a number of safety systems.

For example, a release of radioactive material from a chemical separations facility (e.g., F-Canyon) could occur in the following manner: An earthquake occurs during a tank-to-tank transfer of radioactive solution in the canyon. The transfer pipe fails or ruptures but the transfer continues and half the contents of the tank spill to the floor of the canyon. Simultaneous with the pipe rupture, the walls of the canyon crack, providing a release pathway to the environment. In addition, the canyon ventilation system fails. (The ventilation system normally maintains the interior of the canyon at a lower pressure than the outside environment. In this way, air leaks are normally into rather than out of the canyon.) After the radioactive material spills, a fraction becomes airborne and passes through the cracks in the canyon walls. This airborne radioactivity is blown off the Site.

This scenario is conservative because tank-to-tank transfers do not occur on a continuous basis, and the earthquake would have to occur during a transfer. DOE assumes that the following failures would allow the release to reach the offsite population at the projected dose levels: (1) the transfer pipe fails, (2) operators fail to respond or are unable to stop the transfer, (3) the canyon walls crack sufficiently to allow the escape of 10 percent of the airborne radioactive material, and (4) power distribution and electrical relays associated with the ventilation system fail. In addition, all released material escapes the facility in the first 2 hours and the meteorological conditions are such that only limited dispersion (or dilution) of the material has occurred by the time it reaches the SRS boundary. [Figure E-1](#) is a sample event tree that shows the effects of this hypothetical earthquake.

The analytical method described in the following sections did not include emergency response actions to accident situations (e.g., evacuation of personnel to a safe distance or notification of the public to perform such response actions as taking shelter) in its determination of potential impacts on workers or members of the public. To minimize potential human exposures and impacts on the environment from postulated accidents, the SRS has established an Emergency Plan (WSRC 1994a) that governs responses to potential accidents.

**Figure E-1.** Example of a fault tree.

The presentation of data in this appendix uses an alternative scientific notation that facilitates comparisons of the results in tables that sometimes cover several pages. This notation is explained below:

$$7.1\text{E}-01 = 7.1 \times 10^{-1}$$

or = 0.71

$$2.4\text{E}+3 = 2.4 \times 10^{+3}$$

or = 2,400

The use of this notation shows the relative magnitude of any data entry. The absence of an "E" notation indicates an actual number without the need for a multiple of 10.

To approximate the potential accident impact contribution for each material (or group of materials) of interest, DOE created a flow diagram showing the location, condition, and chemical or physical form of the material. If a safety analysis report provided different frequencies for an event depending on location in a facility (e.g., a fire is more likely in a glovebox than in a dissolver tank), the analysis used the appropriate frequency for each location housing the material. In some cases, the current forms of the materials differ greatly, although two material groups both might contain primarily plutonium-239. At some point in the processing of both materials (under the preferred alternative), the original form would be lost and the newly generated form would be virtually identical. An example would be Mark-31 plutonium targets and H-Canyon plutonium solutions. After dissolution and processing, the Mark-31 targets would have formed "newly generated" plutonium solutions. These solutions would not pose the same level of concern as those in F-Canyon, which have been stored for several years longer than planned.

In addition to customizing the frequency by location, the analysis customized the source term and composition of the material to the extent possible. For example, if a solution has been processed through a canyon, concentrated, and purified by removing fission products, the source term was adjusted to the maximum concentration with fission product contributions subtracted. The effect of this type of customization is evident in the tables that list the impacts from earthquakes. The frequency remains constant, but both the quantity (in terms of curies) and the isotopic composition (e.g., more americium-241 than plutonium-239) vary by material. These variations enable discrimination of the impacts from one material to another. This discrimination can determine the potential risk reduction if the material of interest is stabilized.

If it was not possible to customize the frequency or source term for a material, the results from the safety analysis report were used. These results represent the bounding accident analysis and are useful for predictions of the impacts from a common mode failure (i.e., a severe earthquake). [Table E-5](#) lists F-Canyon bounding severe earthquake impacts under the heading "F-Canyon (full operation)." [Table E-6](#) lists H-Canyon bounding severe earthquake impacts under the heading "H-Canyon (limiting solution source term)."] Because severe earthquake impacts from the canyons would far exceed those from other facilities involved in the interim management of nuclear materials, a total impact due to a severe earthquake could be approximated by adding the individual impacts from F- and H-Canyons. This cumulative impact is conservative because it is unlikely that both canyons would experience the maximum effects from a severe earthquake.

## E.2.1 AFFECTED FACILITIES

Appendix C discusses the facilities used for nuclear material management activities within the scope of this EIS. In addition to the primary areas that house nuclear material, other SRS facilities contain nuclear materials (e.g., the TNX



facility has two tanks of depleted uranyl nitrate solution and N-Area has drums of depleted uranium oxide). DOE has evaluated these facilities for their potential hazards and has determined that safety analysis reports were not required due to the low hazards posed by the facilities. This means that a total release of materials without mitigation would result in consequences below the threshold requiring detailed analysis. As a result, the extent of quantitative impact data is limited. In most cases, the impacts will be compared to known impacts that bound those from secondary facilities. To determine the types of accident scenarios this appendix would present, DOE performed an extensive review of existing safety documentation for facilities that either perform or support activities that could be involved with management of nuclear material.

## **E.2.2 RADIOLOGICAL ACCIDENT ANALYSIS METHOD**

DOE used computer models to determine the consequences resulting from the release of radioactivity. This evaluation assumed the release of 1 curie of pertinent isotopes to a surface stream (for liquids) or to the atmosphere at ground level and at an elevated level, such as through an exhaust stack for the various facilities involved in the alternatives discussed in this EIS. Using the computer models, the evaluation calculated doses to an uninvolved worker, the maximally exposed offsite individual, and the offsite population within 80 kilometers (50 miles) of the Site (Simpkins 1994a,b).

DOE used two SRS-specific computer codes -- AXAIR89Q and LADTAP XL -- to calculate the doses from each of the 1-curie releases postulated. Both codes perform accident analyses described in facility safety analysis reports and postulated accident impacts presented in other EISs developed for the SRS.

The AXAIR89Q computer code (WSRC 1994b), which was developed in accordance with guidelines established by the U.S. Nuclear Regulatory Commission for modeling atmospheric releases, models the doses from airborne constituents of postulated accidental releases of radionuclides to the environment. The modeling of the various accidents postulated for the facilities associated with the different alternatives assumed conservative (99.5 percentile) meteorological conditions (e.g., direction and speed of prevailing wind). "Conservative meteorological conditions" are those for which, for a given release, the concentration of radionuclides (and the resulting doses) at a fixed downwind location will not be exceeded 99.5 percent of the time. Usually, this means a highly stable-low wind speed weather condition where the wind provides only limited dilution of the material released. Use of these meteorological conditions results in consequences approximately three to four times higher for onsite workers and between 10 and 100 times higher for the offsite population than those that would occur during average (50 percentile) meteorological conditions.

The LADTAP XL computer code was developed to model aqueous (i.e., liquid) releases of radionuclides during routine operations and potential accidents. The modeling of the aqueous releases associated with the postulated accidents described in this appendix took no credit for the holdup of radionuclides within the soils surrounding the area where the accidents would occur. In other words, the modeling assumed that the entire release would discharge directly as a liquid to the ground, migrate to the Savannah River either directly or through Fourmile Branch, Pen Branch, etc., and enter the drinking water supply.

DOE calculated most of the impacts (e.g., exposure, expressed as millirem or projected cancer incidence) to individuals from postulated accidental releases of radionuclides to the environment for the various facilities by multiplying the quantity of each isotope in the source term release (in curies per isotope) presented in the safety analysis documents by the doses calculated for a 1-curie release, as discussed in the previous paragraphs. For example, if a facility safety analysis report stated that 0.00044 curie of strontium-90 was released at ground level in the F-Area, and the projected dose to the maximally exposed offsite individual from a 1-curie release of strontium-90 at ground level in the F-Area is 0.1 millirem, then the dose to the maximally exposed offsite individual from the release would be determined by multiplying 0.00044 curie by 0.1 millirem per curie, resulting in a dose of 0.000044 millirem. The total projected dose would then equal the sum of the doses received from each radionuclide (isotope) released during the accident. This approach was not used for impacts already presented in other NEPA documents (e.g., high-level waste tank accidents or plutonium-238 accidents); in such cases, the impacts were obtained from those documents. [Section E.3](#) presents the doses to uninvolved workers, maximally exposed offsite individuals, and the offsite population postulated for the facility radiological accidents evaluated in this appendix.



Each table in [Section E.3](#) reflects the projected consequences in terms of dose (millirem or person-rem), point estimate of risk (dose  $\times$  frequency, in units of millirem per year or person-rem per year), and latent cancer fatalities based on projections using guidelines developed by the International Commission of Radiation Protection (see [Chapter 4](#)). These guidelines, which are based on several decades of statistical analyses, provide a projection of an individual's chance of developing a cancer that proves to be fatal over time or a projection of the number of fatal cancers that would be likely to result from a population of individuals receiving a collective dose. These numbers enable comparisons of the highest consequence accidents among alternatives and among the phases of an alternative. The projections do not reflect the actual risk to an individual or population because the analysis does not consider the frequency of the accident (likelihood of occurrence). The risk of developing cancer resulting from SRS activities to manage nuclear material would be very low because accidents with large consequences from radioactive materials have not occurred historically and are unlikely to occur in the future. Each table also contains a column listing the total number of released curies estimated for each accident. The variations in dose estimates from similar release amounts is due to the varying impacts of different radioactive isotopes (e.g., 1 curie of plutonium-239 has almost five times the impact of 1 curie of plutonium-241).

As discussed above, this appendix describes risks to uninvolved workers and members of the public from radiological accidents involving nuclear materials in a quantitative fashion using such parameters as dose, accident frequency, and latent cancer fatalities in the population (as discussed in [Section E.3](#)). However, it presents potential impacts to involved, or "close-in" workers, from postulated accidents in a qualitative rather than a quantitative (in numerical terms) fashion, primarily because there is no adequate method for calculating meaningful consequences at or near the location where the accidental release occurs (DOE 1994a). The following example illustrates this concept.

A typical method for attempting to calculate the dose to an involved worker is to assume that the material is released in a room occupied by the worker and that the material instantly disperses throughout the room. Because the worker would be in the room when the release occurred, that individual probably would breathe some fraction of the radioactive materials for a given number of seconds before leaving the room. Typically, estimates of exposure time are based on assumptions about worker response to the incident (e.g., how long before the worker left the room, or whether the worker evacuated the room through an area of higher airborne concentrations). For example, consider the instance in which the worker drops a container with 2,000 grams (4.4 pounds) of plutonium oxide powder. Depending on the size of the room where the release occurred, the assumptions made on how much of the released powder became airborne and respirable, and the length of time the exposed worker remained in the room, the calculated dose to the worker could be anywhere between 80 and 78,000 rem (DOE 1994a). The uncertainty of this estimate is large, and no additional insight into the activity is available because the occurrence is accepted as undesirable without needing to perform the calculations. Historic evidence (DOE 1994a) indicates that this would be a nonfatal accident resulting in room contamination with the potential for minor personnel contamination and assimilation. Presenting this wide range of worker dose is not helpful in comparisons of impacts among alternatives. [Section E.3.2](#) discusses potential radiological impacts to facility workers from accidents in a facility.

### **E.2.3 HAZARDOUS MATERIAL ACCIDENT ANALYSIS METHODOLOGY**

A full understanding of the hazards associated with SRS nuclear facilities under the alternatives considered in this EIS requires analyses of potential accidents involving both hazardous and radiological materials. For chemically toxic materials, several government agencies recommend quantifying the health effects that cause short-term consequences as threshold values of concentrations in air. Because the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure, a determination of potential health effects from exposures to hazardous materials is more subjective than a determination of health effects from exposure to radiation. Therefore, the consequences from accidents involving hazardous materials postulated in this appendix are in terms of airborne concentrations at various distances from the accident location, rather than dose or latent cancer fatalities. Because hazardous materials are used during the operations of each facility, the actual quantity associated with a particular alternative for the materials discussed in this EIS cannot be determined. For example, if a chemical is used to prevent microbiological growth in service water for a facility, then that chemical's tank or vessel must be assumed to be present for the duration of any facility function. Some or all of the hazardous substances could be eliminated if the mission of the facility were completed. None of the primary facilities involved in the storage or

management of nuclear material is likely to complete its total mission within the period covered by this EIS.

To determine potential health effects to workers and members of the public that could result from accidents involving hazardous materials, DOE determined the airborne concentrations of such materials released during an accident where the uninjured worker and offsite individual would be [i.e., 640 meters (2,100 feet) and the nearest SRS boundary, respectively] and compared them to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the material or chemical being considered, for three general severity levels to ensure that the necessary emergency actions occur to minimize worker and public exposures after accidents. These severity levels include the following:

- ERPG-1 Values. Exposure to airborne concentrations greater than ERPG-1 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.
- ERPG-2 Values. Exposure to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impair one's ability to take protective action.
- ERPG-3 Values. Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Because all hazardous materials do not have ERPG values, DOE could not use such values to estimate potential impacts on the public from each hazardous material accident postulated for the SRS facilities discussed in this appendix. For chemicals that do not have ERPG values, this assessment compared airborne concentrations of hazardous materials resulting from postulated accidents to the most restrictive available exposure limits established by other guidelines (WSRC 1992) to control worker exposures to hazardous materials. Table E-2 lists the hierarchy of exposure limits that DOE used to evaluate potential health effects resulting from postulated hazardous material accidents.

DOE used a bounding approach to determine the potential impacts on individuals at different positions (e.g., uninjured workers and the maximally exposed offsite individual) from postulated accidents in each facility area from Extremely Hazardous Substances; the amounts of such substances and their locations were determined from the SRS Tier Two Emergency and Hazardous Chemical Inventory Report (WSRC 1994c). This annual report identifies the chemicals at the Site that are

**Table E-2. Hierarchy of established limits and guidelines used to determine impacts from postulated hazardous material accidents.**

Primary airborne concentration guideline	Hierarchy of alternative guidelines (if primary guidelines are unavailable)	Reference of alternative guideline
ERPG-3	EEGL <sup>a</sup> (30-minute exposure) IDLH <sup>b</sup>	NAS (1985) NIOSH (1990)
ERPG-2	EEGL (60-minute exposure) LOC <sup>c</sup> PEL-C <sup>d</sup> TLV-C <sup>e</sup> TLV-TWA <sup>f</sup> multiplied by 5	NAS (1985) EPA (1987) 29 CFR Part 1910.1000, Subpart Z ACGIH (1992) ACGIH (1992)
ERPG-1	TWA-STEL <sup>g</sup> TLV-STEL <sup>h</sup> TLV-TWA multiplied by 3	29 CFR Part 1910.100, Subpart Z ACGIH (1992) ACGIH (1992)

**<sup>a</sup> Emergency Exposure Guidance Level (EEGL): "A concentration of a substance in air (as a gas, vapor, or aerosol) that may be judged by the Department of Defense to be acceptable for the performance of specific tasks during emergency conditions lasting for a period of 1 to 24 hours. Exposure at an EEGL might produce reversible effects that do not impair judgment and do not interfere with proper responses to an emergency." The EEGL is "...a ceiling guidance level for a single emergency exposure, usually lasting from 1 to 24 hours -- an occurrence expected to be infrequent in the lifetime of a person."**

**<sup>b</sup> Immediately Dangerous to Life and Health (IDLH): "The maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects."**

**<sup>c</sup> Level of Concern (LOC): "The concentration of an extremely hazardous substance in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time."**

**<sup>d</sup> Permissible Exposure Limit - Ceiling (C): "The employee's exposure which shall not be exceeded during any part of the work day."**

**<sup>e</sup> Threshold Limit Value - Ceiling (TLV-C): "The concentration that should not be exceeded during any part of the working exposure."**

**<sup>f</sup> Threshold Limit Value - Time Weighted Average (TLV-TWA): "The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect."**

**<sup>g</sup> Time Weighted Average - Short-Term Exposure Limit (TWA-STEL): "The employee's 15-minute time weighted average exposure which shall not be exceeded at any time during a work day unless another time limit is specified...."**

**<sup>h</sup> Threshold Limit Value - Short-Term Exposure Limit (TLV-STEL): "The concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded."**

hazardous or that require the establishment of emergency response procedures. Following identification of the amounts and locations of the Extremely Hazardous Substances (see [Section E.4](#)) in each area, DOE calculated the airborne concentrations at 640 meters (2,100 feet) from the point of release and the nearest SRS boundary (i.e., locations of the uninvolved worker and maximally exposed offsite individual, respectively) that would be likely from a release of the maximum inventory of each Extremely Hazardous Substance in a single location. EPICode™ (Emergency Prediction and Information Code), a commercially available computer code for modeling routine or accidental releases of hazardous chemicals to the environment (Homann 1988), calculated the airborne concentrations at the different locations.

## **E.3 Postulated Accidents Involving Radioactive Materials**

### **E.3.1 Impacts to Uninvolved Workers and Members of the Public**

This EIS presents the consequences and risks of bounding accidents. In this EIS, the term "bounding accident" represents postulated events or accidents that have higher consequences or risks (i.e., consequences × frequencies) than other accidents postulated in the same frequency range. A consideration of the risks associated with bounding events or accidents for a facility can establish an understanding of the overall risk to workers, members of the public, and the environment from nuclear material management activities. In addition, the risks of different alternatives can be

compared relatively by comparing the risks associated with the bounding accidents for the phases of each alternative. Figure E-2 shows the concept of bounding risk accidents. The accident impact tables in this section list the bounding events for each pertinent frequency range. These tables list in bold type the highest overall point estimate of risk for the maximally exposed offsite individual and the highest consequence to the population for each phase. Some tables also list a representative selection from the full spectrum of accidents to aid in comparisons among alternatives or to demonstrate the elimination of some accidents for specific materials.

Table E-3 is a summary matrix of the facilities used for each phase of the alternatives considered for each material category. The No-Action alternative column lists the facility where the material is currently stored; this alternative has no phases. The "conversion" phase refers to any initial treatment; it is not limited to processing in a canyon. Not all alternatives have all phases (e.g., the additional conversion phase could be beyond the timeframe of this EIS).

Table E-3 is intended for use in conjunction with Tables E-4 through E-12, which list accident analysis data for each material and the facilities that could be involved in a specific phase for the corresponding material. [Table E-3](#) can be used to determine the facility accidents analyzed that would be applicable to a specific phase. However, because the canyons and their support facilities are similar, conversion activities could occur in either area. As stated above, the tables list in bold type the maximum point estimate of risk for the maximally exposed offsite individual and the highest consequence to the population for each phase. Because an alternative might not involve every facility listed in each phase, these maximum values would not necessarily apply to all alternatives. For example, the highest point estimate of risk for the conversion phase of the H-Canyon uranium solutions (0.0000036 latent fatal cancers per year) would occur for H-Canyon. However, the Low Enriched Uranium Alternative for this material would use FA-Line for the processing phase; therefore, the maximum point estimate of risk for this alternative during processing would be 0.00000000018 latent fatal cancer per year. As noted above, the accident consequences have been tailored to the extent possible to reflect consequences attributable to the specific material.

#### **Table E-2**

#### [Table E-3.](#)

#### [Table E-4](#)

#### [Table E-5](#)

#### [Table E-6](#)

#### [Table E-7](#)

#### [Table E-8](#)

#### [Table E-9](#)

a. MEI = maximally exposed individual.

b. These data were not available.

[Section E.8](#) includes a glossary of accident descriptions. These descriptions describe the events listed in the tables. The tables use titles that indicate the facility mode as used throughout the tables [e.g., "F-Canyon (without dissolver)]." This entry means the action of dissolving would not be part of the management alternative for this material; the safety analysis report data for this mode or condition has not been used.

### **E.3.2 Impacts to Facility Workers from Postulated Facility Accidents**

### **E.3.2.1 F-Canyon and H-Canyon**

No fatalities to involved or "close-in" workers from the accident scenarios postulated under current or full operations in the F- or H-Canyon are a likely result of exposure to radiation. Releases from most accidents would be contained in the processing area and filtered through the canyon ventilation system. Because the ventilation system flows from areas of lowest to highest radioactivity, and because releases flow through an exhaust stack after passing through a filtration system, the doses received by workers from these accidents are not likely to be substantially larger than those received during routine operations. For postulated accidents in which the release was not likely to be maintained within the ventilation system (i.e., airborne releases from the ground level or liquid releases), involved worker exposures would be unlikely to result in adverse health effects. For an inadvertent nuclear criticality in the processing vessels, the doses to involved workers would likely be minimized due to the shielding between the vessels and the locations a worker could occupy.

### **E.3.2.2 FB-Line Facility**

With the exception of an inadvertent nuclear criticality during processing, no fatalities to involved workers from the accident scenarios postulated under current or full operations in the FB-Line would be likely as a result of exposure to radiation (see [Section E.7](#)). Current operations primarily involve storage activities in the FB-Line vaults. Because access to storage areas in the FB-Line is limited, only a small number of individuals could receive impacts from an accidental release of material or an inadvertent nuclear criticality in a storage vault. Under full operations, potential accidents resulting from processing, such as a fire or uncontrolled chemical reaction, would not result in substantial exposures because most work would occur inside gloveboxes. Based on historic accident information, exposures to involved workers would be within limits established for routine operations if the implementation of emergency response actions occurred. Of the approximately 74 persons who could be in the FB-Line facility during processing activities, about 56 would be in areas where they could receive substantial doses from a criticality. Of the 56, an estimated 4 workers could receive lethal doses of radiation, while the other individuals would receive varying nonlethal levels.

### **E.3.2.3 FA-Line**

For accidents postulated for FA-Line, with the exception of a red-oil explosion or a severe earthquake, no substantial injuries to involved workers are likely. The force of the explosion or flying debris initiated by the red-oil explosion could result in physical injuries to involved workers. Although the likelihood for an involved worker fatality due to radiation exposure alone after a severe earthquake is minimal, the earthquake itself could result in significant injuries or death for involved workers.

### **E.3.2.4 235-F Storage Vaults**

With the exception of an inadvertent nuclear criticality in the storage vaults, no fatalities to involved workers from the accident scenarios postulated for the 235-F facility are likely as a result of exposure to radiation. [Section E.7](#) discusses the criticality safety program. Because the number of persons permitted in the 235-F storage vaults is limited, the number of individuals who could be impacted from an inadvertent nuclear criticality would be limited. No more than two involved workers would be likely to receive lethal doses of radiation, with a limited number of additional individuals receiving exposures significantly above the annual administrative limit established for routine operations. For other postulated accident scenarios for the 235-F facility, exposures to involved workers are likely to be within limits established for routine operations, even if the inventories of materials within the vaults increased as a result of stabilization of materials at other SRS facilities.

### **E.3.2.5 HB-Line Facility**

Fatalities to involved or close-in workers from the accident scenarios postulated for full operation of the HB-Line

facility are not a likely result of exposure to radiation. For many of the accidents, releases would be contained in the gloveboxes and filtered through the process system and canyon ventilation systems. Because the ventilation system flows from areas of lowest to highest radioactivity, and because releases flow through an exhaust stack after passing through a filtration system, the worker doses from these accidents are not likely to be substantially larger than those received during routine operations. For postulated accidents in which the release is not likely to remain in the ventilation system, such as a ground-level airborne release initiated by a severe earthquake, involved worker exposures would be unlikely to result in adverse health effects. An inadvertent nuclear criticality is not considered credible in the HB-Line, either during current or full operations, due to the forms and isotopes of the materials. Therefore, exposures or fatalities are not likely from inadvertent nuclear criticalities.

#### **E.3.2.6 Uranium Solidification Facility**

With the exception of an inadvertent nuclear criticality during processing, no fatalities to involved workers from the accident scenarios postulated for the Uranium Solidification Facility are likely as a result of exposure of radiation. [Section E.7](#) discusses the criticality safety program. If an inadvertent nuclear criticality occurred, either during processing (criticality in a liquid) or packaging and storage (criticality in a powder), the radiation field generated by the criticality could lead to involved worker fatalities. However, DOE expects that the number of fatalities would be limited to two; additional individuals in the facility could receive doses that significantly exceeded their annual administrative exposure limits.

#### **E.3.2.7 H-Area Receiving Basin for Offsite Fuels**

No fatalities are likely to involved workers from the radiological accident scenarios postulated for the Receiving Basin for Offsite Fuels. Worker doses for all postulated basin accidents would be minimal.

#### **E.3.2.8 Reactor Disassembly Basins**

No fatalities are likely to involved workers from the radiological accident scenarios postulated for the reactor disassembly basins. Worker doses for all postulated basin accidents would be minimal. This conclusion is based on the fact that the fuels and targets stored in each basin are maintained at a distance below the surface level of the water sufficient to minimize involved worker exposures. In addition, in events that involved a substantial loss of basin water after which fuels and targets could be exposed to the air (e.g., draindown of half the basin water or discharge of all basin water following a severe earthquake), sufficient time would be available to allow involved workers to take the precautions necessary to evacuate the area or implement other actions to minimize exposures.

#### **E.3.2.9 Other Facilities**

In addition to the facilities discussed above, M-Area buildings, the Savannah River Technology Center, the TNX facility, and the high-level waste tanks contain nuclear materials addressed by this EIS.

No fatalities to involved workers from the accident scenarios postulated for M-Area are likely as a result of exposure to radiation. DOE anticipates that involved worker doses received from accidents would be minimal because the area serves as a storage vault for stable materials and involves only routine monitoring and maintenance activities.

No fatalities to involved workers from the accident scenarios postulated for the Savannah River Technology Center are likely as a result of exposure to radiation from accidents involving these materials, and DOE anticipates that involved worker doses received from accidents would be minimal. This conclusion is based on the very small amount of irradiated, aluminum-clad fuel assembly pieces, which would be a candidate for further stabilization in other facilities. The only alternative proposed for this material in the Savannah River Technology Center is No Action.

DOE anticipates no radiation-induced fatalities would result from accidents in the TNX facility or the waste tanks. The tanks in both areas store liquid radioactive materials and involve routine monitoring or remote transfers. The high-level waste tanks are in F- and H-Areas.



### **E.3.3 STABLE MATERIALS**

Although this EIS considers no alternatives other than Continued Storage (No Action) for stable materials, this section summarizes the accident analyses presented in the safety analysis reports for the facilities housing these materials. These documents discuss accident impacts for an uninvolved worker and the maximally exposed individual off the Site.

#### **E.3.3.1 Postulated Radiological Accidents for the M-Area Reactor Materials Facilities**

The primary purpose of the M-Area facilities was to manufacture fuel and target assemblies. The enriched uranium storage vault is constructed of reinforced concrete with walls and roof 30 centimeters (12 inches) thick. The four walls extend 1.8 meters (6 feet) into the ground and rest on 0.6-meter (2-foot)-thick footings. The storage vault was constructed to be a "maximum resistance" area [able to withstand a Fujita Intensity Five (F-5) tornado or a Modified Mercalli VIII (MM VIII) earthquake with little or no damage]. The SRS document explaining the limited continued operations in M-Area contains accident analyses for the facilities containing the nuclear materials addressed by this EIS. The bounding event for impact on the maximally exposed individual is an explosion in Building 320-M, which would result in a risk of 0.00014 rem per year and a latent cancer fatality projection of 0.00000007. For the uninvolved worker for the same event, the estimated risk would be 0.00044 rem per year and the latent cancer fatality projection would be 0.00000018. This accident is representative of bounding events related to the storage of a variety of materials for which further stabilization is not required. This group contains all material in the Reactor Material Area, including miscellaneous depleted uranium and uranium metal, oxide, slugs, cores, sludges, enriched uranium residues, lithium aluminum control rods, spargers, targets, unirradiated Mark-22s with lithium target tubes, natural and enriched lithium metal in cans, Mark-16 and Mark-22 tubes, Mark-31 slugs, and neptunium targets. Stable material is stored in Buildings 313-M, 315-M, 320-M, 321-M, 322-M, and 341-1M. Unirradiated Mark-31 slugs (depleted uranium in aluminum housings) constitute most of the inventory. The No-Action Alternative is proposed for the materials currently stored in M-Area.

#### **E.3.3.2 Postulated Radiological Accidents for Savannah River Technology Center**

Nuclear material used or stored in the Savannah River Technology Center includes a small amount of americium and curium solution and targets; americium-241 scrap; depleted uranium slurry, metal, and oxide; enriched uranium sweepings; etc.

Under the No-Action Alternative, current research activities at the Savannah River Technology Center would continue, and DOE would continue to store equivalent amounts and types of material in Building 773-A laboratories and cells. These materials are generally stored in limited-quantity cans, bottles, or sample carriers. Most are contained further in laboratory hoods, gloveboxes, or cells. These items, or equivalent new sample quantities, would be in a safe stable form for storage for several years.

The Savannah River Technology Center Safety Analysis Report summarizes consequences from postulated accidents at the center involving areas that contain the materials listed above. The actual contribution to the accident scenarios from these materials would be negligible, but these events are bounding for all alternatives for stable materials (i.e., the No-Action Alternative). An earthquake with a magnitude of 0.2 times gravity poses the highest risk for the maximally exposed individual. The risk associated with this event would be 0.00023 rem per year and the latent cancer fatality projection would be 0.00000012. In the highly unlikely event that this accident occurred, it would cause a projected increase of 0.48 in latent cancer fatalities. From the same event, the uninvolved worker risk would be 0.0043 rem per year and the latent cancer fatality projection would be 0.0000017.

#### **E.3.3.3 Postulated Radiological Accidents for the TNX Research Facility**

The TNX facility is a "radiological facility," as determined by the quantity of nuclear material present (DOE 1992). This hazard classification is the lowest for a facility that contains radioactive materials and requires no safety analysis



report. This assessment does not summarize accident analyses for this facility because the impacts are bounded by those for several other facilities; only the No-Action Alternative would apply.

## E.4 Postulated Accidents Involving Extremely Hazardous Substances

Because of the many types of materials and chemicals at the Site and the varying quantities of these materials in different locations, the analysis of potential accident scenarios involving hazardous materials was limited to substances categorized by the U.S. Environmental Protection Agency as "Extremely Hazardous Substances" (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986. Although materials not categorized as Extremely Hazardous Substances can affect the health and safety of workers and the public if released in sufficient quantities and forms, the Site has implemented programs in accordance with DOE Order requirements (e.g., DOE 1985, 1993, 1994b) that incorporate programmatic and management requirements of other government agencies, such as the Occupational Safety and Health Administration. While these materials might present hazards to workers or the public if accidentally released to the environment, their impacts are likely to be bounded by potential impacts from accidents involving Extremely Hazardous Substances; therefore, this appendix does not analyze them.

This section presents potential impacts from postulated chemical accidents at facilities that are or could be involved with safely managing or stabilizing SRS nuclear materials. For each area, it presents potential impacts of the bounding hypothetical chemical accident scenarios (as calculated using the method described in Section E.2.4).

Substances present in bulk quantities can, in some cases, be reduced or eliminated after stabilization of the associated nuclear material. In other cases (e.g., the Receiving Basin for Offsite Fuels), the chemicals support long-term facility functions independent of the interim management of the nuclear materials covered in this EIS. The accident consequences presented in this section assume a maximum chemistry inventory and are bounding for all alternatives.

### [Table E-10](#)

### [Table E-11](#)

### [Table E-12](#)

## E.4.1 POSTULATED CHEMICAL ACCIDENTS FOR F-AREA FACILITIES

Based on a review of current inventories at the facilities in the F-Area (DOE 1994c), DOE determined that seven Extremely Hazardous Substances are in use in the area. Table E-13 lists the maximum amounts of each substance in a single location in the F-Area.

**Table E-13. Inventories of Extremely Hazardous Substances<sup>a</sup> in F-Area.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Hydrochloric acid	34.0
Hydrogen fluoride	1,174.8
Hydrogen peroxide	122.5
Nitric acid	65,771.6
Phenol	0.9

Phosphorous pentoxide	0.9
Sulfuric acid	3,823.8

**<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.**

**<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.**

**<sup>c</sup> Amounts are based on 1993 (1-year) values.**

To determine airborne concentrations at 640 meters (2,100 feet) and the nearest SRS boundary (the locations of the uninvolved worker and maximally exposed offsite individual, respectively), DOE assumed an inadvertent release to the environment of the maximum amount of each material in a single location. This method enables a comparison of the impacts of the various substances as well as impacts at the facilities housing these substances. These impacts are conservative because the analysis does not consider the frequency of an initiating event that could lead to the release of this maximum amount.

DOE used the EPICode™ computer code (see Section E.2.6) to model the release of each material. Table E-14 lists the results of the analyses and compares expected airborne concentrations at the uninvolved worker and maximally exposed individual locations to the different threshold Emergency Response and Planning Guidelines or their equivalents.

**Table E-14. Impacts from potential non-seismic-initiated releases of extremely hazardous substances in F-Area**

Substance released	Maximum amount in F-Area (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Hydrochloric acid	3.4E+01	6.3E-03	8.5E-05	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	1.2E+03	2.2E+02	2.9	4.0	1.6E+01	4.1E+01
Hydrogen peroxide	1.2E+02	2.3E-02	3.1E-04	1.4	--	1.1E+02
Nitric acid	6.6E+04	1.4E+01	3.6	5.2	3.9E+01	7.7E+01
Phenol	9.1E-01	1.5E-04	1.7E-06	3.9E+01	1.9E+02	7.7E+02
Phosphorous pentoxide	9.1E-01	1.5E-04	1.7E-06	5.0	2.5E+01	1.0E+02
Sulfuric acid	3.8E+03	2.2E-07	3.7E-09	2.0	1.0E+01	3.0E+01

**<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.**

**<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.**

**<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.**

**<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).**

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

Because a severe seismic event has the potential to initiate the release of the same material from different locations in the F-Area, DOE analyzed a release of the maximum daily inventory. Table E-15 lists the results of these analyses. A total release of the entire inventory of a particular material from the F-Area to the environment is extremely unlikely, especially if the material is in several different locations, facilities, or buildings in the area. However, the assumption of a total release of the maximum inventories in the area provides a bounding estimate for the largest airborne concentrations DOE could expect following a severe earthquake.

As listed in Tables E-14 and E-15, the airborne concentrations for a gaseous release of hydrogen fluoride (hydrofluoric acid) would exceed the ERPG-3 threshold limits at 640 meters (2,100 feet) from the point of release. As explained in Section E.2.4, ERPG-3 threshold values represent concentrations at which an individual would experience or develop life-threatening health effects if exposed for longer than 1 hour. Because individuals could be notified and evacuated to a safe location (e.g., inside a building with adequate ventilation) within 1 hour of an inadvertent release of hydrogen fluoride, DOE does not expect any life-threatening or long-term health effects to uninvolved workers. Uninvolved workers could experience mild burning of the lungs from inhaling hydrogen fluoride, burning of the eyes, and mild skin irritations. In addition, because the airborne concentrations at the nearest SRS boundary would be below ERPG-1 threshold values, no measurable health effects are likely to members of the public. However, for involved workers, there is a potential for serious worker injury and potential fatalities because of the large concentrations expected at locations close to the point of release, which could hinder personnel from taking appropriate emergency response actions.

**Table E-15. Impacts from potential releases of extremely hazardous substances in F-Area resulting from a severe earthquake**

Substance released	Maximum daily amount in entire F-Area (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Hydrochloric acid	1.0E+02	1.9E-02	2.6E-04	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	1.2E+03	2.2E+02	2.9	4.0	1.6E+01	4.1E+01
Hydrogen peroxide	1.2E+02	2.3E-02	3.1E-04	1.4	--	1.1E+02
Nitric acid	2.7E+05	3.9E+02	1.4E+01	5.2	3.9E+01	7.7E+01
Phenol	1.4	2.3E-04	2.6E-06	3.9E+01	1.9E+02	7.7E+02
Phosphorous pentoxide	9.1E-01	1.5E-04	1.7E-06	5.0	2.5E+01	1.0E+02
Sulfuric acid	4.0E+03	2.3E-07	4.0E-09	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as

discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

Table E-15 indicates that, in the event of a severe earthquake, a release of the total quantity of nitric acid in the F-Area would exceed ERPG-3 values at a distance of 640 meters (2,100 feet) and ERPG-1 values at the nearest SRS boundary. As explained in Section E.2.4, the health effects from being exposed to ERPG-1 threshold values for greater than 1 hour are minor (e.g., irritation of the eyes and objectionable odor). For uninvolved and involved workers, although the release would exceed ERPG-3 threshold values, no worker fatalities from exposure to airborne acid concentrations would be likely; some individuals could experience significant short-term health effects, such as burning of the lungs and irritation of the skin. Because this scenario assumes that all nitric acid in the F-Area would be released from a single location during a severe earthquake, airborne concentrations would be lower than those listed in Table E-15.

#### E.4.2 POSTULATED CHEMICAL ACCIDENTS FOR H-AREA FACILITIES

Based on a review of current inventories at the various H-Area facilities (DOE 1994b), DOE determined that seven Extremely Hazardous Substances are in use in the H-Area. Table E-16 lists the maximum amounts of each substance in a single location in the H-Area.

**Table E-16. Inventories of Extremely Hazardous Substances<sup>a</sup> in H-Area.**

Substance	Maximum amount in a single location (kilograms) <sup>b,c</sup>
Ammonia	27.2
Hydrochloric acid	2.7
Hydrogen fluoride	2.3
Nitric acid	39,814.7
Nitric oxide	1,315.4
Phosphorous pentoxide	1.4
Sulfuric acid	0.9

<sup>a</sup> Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.

<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>c</sup> Amounts are based on 1993 (1-year) values.

Table E-17 lists the results of the analyses and compares the expected airborne concentrations at the uninvolved worker and maximally exposed individual locations to the different threshold Emergency Response and Planning Guidelines or their equivalents. Because a severe seismic event has the potential to initiate the release of the same material from different locations within the H-Area, DOE analyzed a release of the maximum daily inventory to the environment. Table E-18 lists the results of these analyses.

As listed in Tables E-17 and E-18, the airborne concentrations for a gaseous release of nitric oxide would exceed the ERPG-3 threshold limits at a distance of 640 meters (2,100 feet) from the point of release. Table E-18 indicates that, in a severe earthquake, a release of the total quantities of nitric acid in the H-Area would exceed ERPG-3 values at a

distance of 640 meters (2,100 feet) and ERPG-1 values at the nearest SRS boundary. For uninvolved and involved workers, although the release would exceed ERPG-3 threshold values, no worker fatalities from exposure to the airborne acid concentrations would be likely; some individuals could experience significant short-term health effects, such as burning of the lungs and irritation of the skin. Because this scenario assumes that all nitric acid in the H-Area would be released from a single location during a severe earthquake, airborne concentrations would be lower than those listed in [Table E-18](#).

**Table E-17. Impacts from potential non-seismic-initiated releases of Extremely Hazardous Substances in H-Area**

Substance released	Maximum amount in a single H-Area location (kg) <sup>a</sup>	Airborne concentration (milligram per cubic meter) <sup>b</sup>				
		At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Ammonia	2.7	5.1E-03	5.8E-05	2.5E+01	2.0E+02	1.0E+03
Hydrochloric acid	2.7	5.0E-04	5.7E-06	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	2.3	4.3E-04	4.9E-06	4.0	1.6E+01	4.1E+01
Nitric acid	4.0E+04	9.5E+01	1.9	5.2	3.9E+01	7.7E+01
Nitric Oxide	1.3E+03	4.9E+03	4.4	9.3E+01	1.2E+02 <sup>f</sup>	1.2E+02
Phosphorous pentoxide	1.4	1.2E-01	1.1E-03	5.0	2.5E+01	1.0E+02
Sulfuric acid	9.0E-01	1.7E-04	1.9E-06	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

<sup>f</sup> Alternative concentration limit guideline for ERPG-2 value (TWA × 5) was adjusted down to the next higher range value (IDLH).

**Table E-18. Impacts from potential releases of extremely hazardous substances in H-Area resulting from a severe earthquake.**

	Airborne concentration (milligram per cubic meter) <sup>b</sup>
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Substance released	Maximum daily amount in entire H-Area (kg) <sup>a</sup>	At 640m <sup>c</sup>	At Site boundary <sup>d</sup>	ERPG-1 <sup>e</sup>	ERPG-2 <sup>e</sup>	ERPG-3 <sup>e</sup>
Ammonia	2.7E+01	5.1E-03	5.8E-05	2.5E+01	2.0E+02	1.0E+03
Hydrochloric acid	1.1E+01	2.1E-03	2.4E-05	4.5	3.0E+01	1.5E+02
Hydrogen fluoride	3.6	6.7E-04	7.6E-06	4.0	1.6E+01	4.1E+01
Nitric acid	1.2E+05	2.3E+02	5.7	5.2	3.9E+01	7.7E+01
Nitric Oxide	1.3E+03	4.9E+03	4.4	9.3E+01	1.2E+02 <sup>f</sup>	1.2E+02
Phosphorous pentoxide	1.4	1.2E-01	1.1E-03	5.0	2.5E+01	1.0E+02
Sulfuric acid	2.7	5.0E-04	5.7E-06	2.0	1.0E+01	3.0E+01

<sup>a</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>b</sup> Airborne concentrations derived assuming conservative (99.5 percentile) meteorological conditions for the Site.

<sup>c</sup> Location of the uninvolved worker, assumed to be located 640 meters (2,100 feet) downwind from the release.

<sup>d</sup> Location of the maximally exposed offsite individual, assumed to reside at the nearest SRS boundary downwind from the point of release at 10.6 kilometers (6.6 miles).

<sup>e</sup> Either the Emergency Response Planning Guidelines value or most restrictive exposure guideline available, as discussed in Section E.2.4 and listed in Table E-2. For substances with limits established in terms of parts per million, the value in milligrams per cubic meter was determined using the following equation: milligrams per cubic meter = (limit in parts per million) × (gram molecular weight of substance) / 24.45.

<sup>f</sup> Alternative concentration limit guideline for ERPG-2 value (TWA × 5) was adjusted down to the next higher range value (IDLH).

#### E.4.3 POSTULATED CHEMICAL ACCIDENTS FOR K-, L-, AND P-REACTOR BASINS

Based on a review of the chemical inventory that supports the water chemistry in the L-Reactor basin, DOE determined that the only identified Extremely Hazardous Substance was a small quantity of nitric acid. For 45.6 kilograms (100 pounds) of nitric acid modeled as a liquid spill (the maximum daily amount in the basin), the airborne concentration at 640 meters (2,100 feet) would be several orders of magnitude lower than the ERPG-1 concentration limit. DOE assumed that this was typical for all SRS reactor basins that store nuclear material.

In addition, because the airborne concentrations at the nearest SRS boundary would be considerably below ERPG-1 threshold values, no measurable health effects to members of the public would be likely. No impacts would hinder involved workers from taking appropriate emergency response actions.

#### E.4.4 POSTULATED CHEMICAL ACCIDENTS FOR M-AREA FACILITIES

Based on a review of current inventories at the various facilities in the M-Area (DOE 1994b), DOE determined that five Extremely Hazardous Substances are in use in the area. Table E-19 lists the maximum amounts of each substance in a single location in the M-Area. However, M-Area contains nuclear materials that require no further stabilization. Therefore, this EIS proposes no alternatives for the safe management of nuclear materials in M-Area. As a result, no

further chemical accident analysis is required.

**Table E-19. Inventories of Extremely Hazardous Substances<sup>a</sup> in M-Area.**

<b>Substance</b>	<b>Maximum amount in a single location (kilograms)<sup>b,c</sup></b>
Hydrochloric acid	34.0
Hydrofluoric acid	2.27
Nitric acid	34,807.5
Phenol	2.27
Sulfuric acid	15,241.0

<sup>a</sup> **Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the Emergency Planning and Community Right-to-Know Act of 1986.**

<sup>b</sup> **To determine the quantity in pounds, multiply by 2.2046.**

<sup>c</sup> **Amounts are based on 1993 (1-year) values.**

#### **E.4.5 SAVANNAH RIVER technology center**

Based on a review of current inventories at the various facilities in the Savannah River Technology Center (DOE 1994d), DOE determined that eight Extremely Hazardous Substances are in use in SRTC facilities. Table E-20 lists the total annual maximum and average daily quantities of these substances based on 1993 (1-year) inventories. In addition, Table E-20 lists the maximum amounts of each substance in a single location in the SRTC. However, the Center contains nuclear materials that require no further stabilization. Therefore, this EIS proposes no alternatives for the safe management of the nuclear materials in SRTC facilities. As a result, no further chemical accident analysis is required.

**Table E-20. Inventories of Extremely Hazardous Substances<sup>a</sup> in Savannah River Technology Center.**

<b>Substance</b>	<b>Maximum amount in a single location (kilograms)<sup>b,c</sup></b>
Ammonia	0.5
Hydrochloric acid	2,215.4
Hydrogen fluoride	38.1
Nitric acid	3,864.2
Nitric oxide	0.9
Phenol	4.5
Phosphorous pentoxide	3.18
Sulfuric acid	13.6

<sup>a</sup> **Materials categorized as Extremely Hazardous Substances (40 CFR Part 355), as designated under the**



**Emergency Planning and Community Right-to-Know Act of 1986.**

<sup>b</sup> To determine the quantity in pounds, multiply by 2.2046.

<sup>c</sup> Amounts are based on 1993 (1-year) values.

**E.4.6 POSTULATED CHEMICAL ACCIDENTS FOR THE TNX AREA**

Based on a review of chemical usage in the TNX area, DOE determined that no chemicals in the area were required to support the continued safe management of nuclear materials. As a result, no further chemical accident analysis was performed for the TNX area.

**E.5 Environmental Justice**

When the 99.5 percent meteorology model is used, the SRS sector most affected by accidents is the Northwest. Although this is not typical of weather conditions (e.g., not the prevailing wind direction), the model calculated the highest impact to an individual at the SRS boundary.

Figures [3-7](#) and [3-8](#) show the distributions, by census tracts, of people of color and low-income populations, respectively. Parts of two census tracts in the Northwest sector adjoin the SRS. Neither tract is a low-income community or a community comprised of 50 percent or more of people of color, although one of the tracts contains between 35 and 50 percent people of color.

Farther from the SRS in the Northwest sector are low-income communities and communities that contain 50 percent or more of people of color. However, other communities in the sector are not low-income and contain fewer than 35 percent people of color, and they are as close as, or closer to, the SRS boundaries than the low-income communities or the communities of people of color.

Based on the distribution of types of communities and on the low dose received by the maximally exposed individual (see tables in this appendix), the accident scenarios would not result in disproportionately high or adverse human health and environmental impacts on people of color or low-income populations.

**E.6 Accident Mitigation**

Although DOE expends extensive efforts and large amounts of money to prevent accidents involving radioactive and hazardous materials, accidents and inadvertent releases to the environment can still occur. Therefore, an important part of the accident analysis process is the identification of actions that can mitigate consequences from accidents if they occur.<sup>2</sup> This section summarizes the SRS Emergency Plan, which governs responses to accident situations that could affect Site employees or the offsite population.

The *Savannah River Site Emergency Plan* (WSRC 1994a) defines appropriate response measures for the management of SRS emergencies (e.g., radiological or hazardous material accidents). It incorporates into one document the entire process designed to respond to and mitigate the consequences of a potential accident. For example, it establishes protective action guidelines for accidents involving chemical releases to keep onsite and offsite exposures as low as possible. It accomplishes minimization or prevention of exposures by minimizing time spent in the vicinity of the hazard or the release plume, keeping personnel as far from the hazard or plume as possible (e.g., using physical barricades and evacuation), and taking advantage of available shelter.

Emergencies that could cause activation of all or portions of this plan and the SRS Emergency Response Office include the following:

- Events (operational, transportation, etc.) with the potential to cause releases above allowable limits of radiological or hazardous materials.
- Events (fires, explosions, tornadoes, hurricanes, earthquakes, dam failures, etc.) that affect or could affect safety systems designed to protect Site and offsite populations and the environment. The effectiveness of the

- emergency plan would depend on the severity of the event and the impact on the Site and local infrastructure.
- Events (bomb threats, hostage situations, etc.) that reduce the security posture of the Site.
- Events created by proximity to other facilities such as the Vogtle Electric Generating Plant (a commercial nuclear utility across the Savannah River from the Site) or nearby commercial chemical facilities.

Depending on the types of postulated accidents and the potential impacts that could result from those accidents, emergencies are classified in several categories in accordance with requirements defined in the DOE 5500 Series of Orders, as follows:

- Alerts are confined within the affected facility boundary; no measurable impacts to workers or members of the public outside the facility boundary are likely.
- Site Area Emergencies are events that are in progress or that have occurred involving actual or likely major failures of facility safety or safeguards systems needed for the protection of onsite personnel, the public, the environment, or national security; because they have the potential to impact workers at colocated facilities or members of the public in the SRS vicinity, these situations require notification of and coordination of responses with the appropriate local authorities.
- General Emergencies produce consequences that require the implementation of protective actions to minimize impacts to both workers and the public; full mobilization of all available onsite and offsite resources is usually required to deal with the event and its consequences.

In accordance with the Site Emergency Plan, DOE conducts periodic drills and exercises at the SRS to develop, maintain, and test response capabilities, and validate the adequacy of emergency facilities, equipment, communications, procedures, and training. For example, drills occur for the following accident scenarios in the facilities or facility areas: facility or area evacuations, shelter protection, toxic gas releases, nuclear incident monitor alarms (following an inadvertent nuclear criticality), fire alarms, medical emergencies, and personnel accountability (to ensure that all personnel have safely evacuated a facility or area following an emergency). DOE and Westinghouse Savannah River Company conduct and evaluate periodic drills with the following organizations or groups to ensure that they continue to maintain (from both a personnel and an equipment standpoint) the capability to respond adequately to emergency situations: first aid teams; rescue teams; fire wardens, fire response and firefighting teams; SRS medical and Health Protection personnel and personnel from the Eisenhower Army Medical Center; SRS and local communications personnel and systems; SRS security forces; and SRS Health Protection agencies.

## **E.7 Nuclear Criticality Safety Program**

As discussed above, with the exception of an inadvertent nuclear criticality, no fatalities to involved workers from accident scenarios postulated for the management, stabilization, or storage of nuclear material would be likely to result from exposure to radiation. A criticality occurs when a neutron fissions the nucleus of a fissionable material to produce energy, fission fragments, neutrons, and various radiations. While nuclear reactors are specifically designed to produce energy from fission by controlling this neutron chain reaction, nonreactor nuclear facilities at the SRS do not generally provide the same control, shielding, and containment characteristics. Thus, an inadvertent fission chain reaction (nuclear criticality) in an SRS nonreactor nuclear facility could produce harmful radiation-related effects on nearby personnel.

As a result, nuclear criticality safety has been defined as "the prevention or termination of inadvertent nuclear chain reactions in nonreactor environments." In practice, the first concept--prevention--is by far the primary goal. As a consequence, SRS maintains a nuclear criticality safety program that establishes and defines the principles, practices, and controls to be used for the prevention of criticality accidents. When it has been determined that the potential for an inadvertent nuclear criticality accident exists for a facility, the design of criticality controls, including equipment and procedures, shall meet, at a minimum, the requirements described in the WSRC Nuclear Criticality Safety Manual. For a new facility, the use of physical design features to prevent criticality would be preferable. To ensure the successful

implementation of this program, a training policy recently adopted at the SRS supports the goal that all reasonable efforts shall be taken to reduce or eliminate the potential for, and consequences of, a criticality accident. Nuclear criticality safety training programs at the SRS are developed to be consistent with DOE Orders 5480.20 and 5480.24 for operating facility personnel and all other personnel requiring criticality safety training.

Positive identification of fissionable material, particularly fissile material, is essential to criticality safety. Adequate labeling of fissionable material and clear posting of work and storage areas in which fissionable materials are present are important in avoiding the accumulation of unsafe quantities of such materials. Appropriate fissionable material labeling and area posting are maintained at SRS nonreactor nuclear facilities specifying material identification and all parameter limits subject to procedural control. Storage requirements include minimum spacing distances to prevent sufficient material from being in close proximity. Criticality "poisons," such as boron, are often used in storage racks or packaging for material.

Written plans and procedures govern operations at SRS in which criticality safety is a consideration. These plans and procedures cover startup, operations, and any modifications that might affect criticality safety. Procedures clearly specify all controlled parameters and limits related to criticality safety. All criticality safety-related limits contained in the operating procedures are based on Nuclear Criticality Safety Evaluations (NCSEs). New or revised procedures containing nuclear safety steps, criticality safety limits, or criticality safety requirements undergo review and approval by a Criticality Safety Engineering Group (CSEG) before implementation. In the event of a criticality limit violation, SRS procedures specifically govern actions to be taken in the event of an undesirable situation; the objective of such procedures is to place the operation into as stable and safe a condition as possible until a criticality safety engineer or specialist can conduct an evaluation.

Water, the most often used firefighting agent, is an efficient moderator and reflector of neutrons (i.e., it can contribute to a criticality). In the absence of moderating materials such as water, relatively large masses of dry fissile materials such as powders or metals can be handled safely. In the event of a fire, SRS nonreactor nuclear facilities maintain prefire plans prepared by the management and engineering staff of each facility with the assistance by the Criticality Safety Engineering Group, SRS fire safety engineers, and the Area Fire Department, as necessary. These plans help provide a framework for the successful combination of firefighting and criticality safety. The CSEG approves the prefire plans for each facility in which criticality safety is of concern.

The SRS maintains criticality alarm systems, or Nuclear Incident Monitors (NIMs). The primary purpose of NIM systems is to minimize, by means of quick detection and alarm, the acute dose received by personnel from a criticality (and potential recriticality) accident in areas where the cumulative absorbed dose in free air might exceed 12 rads. The secondary purpose of the NIM system is to notify people to stay clear of the evacuated area and to notify appropriate response teams.

Emergency procedures for criticality accidents are prepared for each SRS facility in which criticality safety controls are instituted or criticality alarm systems are installed. Such emergency plans are approved by the appropriate management and the cognizant Criticality Safety Engineering Group, and consistent with the Site Emergency Plan (WSRC 1994a).

## **E.8 Accident Descriptions**

The larger facilities contain a variety of processes, equipment, and techniques used depending on the intended function. In determining the source terms for use in accident analysis, DOE examined the appropriate process or section of a facility for the specific material and adjusted the source term to correspond where necessary. The tables in [Section E.3](#) list the "modes" or conditions to reflect the selection for that material. The following paragraphs explain the accident titles used in the tables in [Section E.3](#).

**Unpropagated fire** – A fire that has localized impact and does not spread. It can be caused by ignition of flammable solvent, spontaneous burning of plutonium metal exposed to oxygen, or other causes. Radioactive particulates are dispersed in the immediate area of the fire and some might be released to the environment (e.g., during a filter fire). The fire lasts for a short period because the amount of combustible material is limited.

**Inadvertent transfer** – An unplanned transfer of a solution or liquid to an unintended location due to personnel error. The usual causes of such accidents are incorrectly installed piping connections or overflows from a vessel into a sump resulting from human errors.

**Coil and tube failure** – Some process vessels and tanks have internal coils for cooling or heating the stored solutions. The coils usually contain water or steam. The pressure inside the coils is normally higher than the pressure in the vessel. Should the coils leak or fail their internal pressure could be lost, resulting in radioactive solution entering the cooling water (or steam) system. If the leak is undetected, the contaminated water could be released through the system to the atmosphere without treatment.

**Inadvertent criticality** – These events are discussed in [Section E.7](#).

**Severe earthquake** – An earthquake that would be expected every 5,000 years. The severity or magnitude is based on an assumed horizontal ground acceleration of 20 percent of the acceleration due to gravity. An earthquake of this magnitude could result in structural damage and a loss of confinement of nuclear materials.

**Rupture storage container** – Certain radioactive materials can cause a buildup of gases inside the container in which they are stored (e.g., metal can) if it contains organic materials (e.g., plastic bags). Other materials (e.g., plutonium metal) can oxidize and gain moisture if the container is not completely airtight. Eventually, the pressure buildup can cause the storage container to bulge or rupture. This could disperse the material in the area around the container and result in exposure of a worker performing routine surveillance.

**Eruption** - A thermal or chemical reaction causes material to spew from its container. This could be an energetic event resulting in localized contamination. For the materials discussed in this EIS, such events would occur inside the canyons and no workers would be directly affected.

**Red-oil explosion** - So named because the substance causing the explosion is a thick red liquid produced by the inadvertent addition of organics to a high nitrate solution. The event can be very energetic and can result in a sudden localized explosion. The radiological consequences would probably be confined to areas within the canyon facilities.

**Tornado** - A tornado exerts pressure due to high wind speed on the surfaces of a structure. The resulting damage could cause releases of stored materials within the structure or could disperse materials stored in pads.

**Uncontrolled reaction** - Adjustments are routinely made to solutions to produce a reaction under known controlled conditions. If an adjustment (e.g., adding acid) or a change in condition (e.g., heating the contents) produces unexpected or rapid reaction, that reaction is "uncontrolled." The energy from this type of reaction could cause radioactive solutions to overflow or erupt outside the tank in which they are stored.

**Propagated fire** - A fire that goes beyond the area of ignition. For the materials discussed in this EIS, a propagated fire does not self-extinguish. For example, it might spread from a glovebox into the surrounding room or other areas of the facility.

**Basin overflow/draindown** - An unplanned movement of water, either into the reactor basins (causing an overflow) or from the reactor basins (draindown), which results in a flow of the basin water to sumps or storm drains and into the Savannah River. Basin overflow would normally be caused by human error; basin draindown could be caused by a breach of the basin integrity due to an earthquake.

**Hydrogen explosion** - Hydrogen gas is generated by radiolysis when water is in a tank or can with nuclear materials. If a sufficient quantity of the atmosphere in the container is hydrogen, the gas can detonate or explode, rupturing the container and releasing nuclear material.

**Energetic event** - Energetic events cause penetration of the primary confinement barrier and, if sufficiently energetic, can result in the bypass of a secondary barrier. Medium energetic events include a cabinet fire, an uncontrolled reaction, and criticality.

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## GLOSSARY

### **abnormal transients**

A state resulting from an unusual incident in which operating parameters affecting control of radioactive materials move out of the normal operating range.

### **absorbed dose**

The energy deposited per unit mass by ionizing radiation. The unit of absorbed dose is the rad.

### **air quality**

A measure of the quantity of pollutants in the air.

### **air quality standards**

The prescribed quantity of pollutants in the outside air that cannot be exceeded legally during a specified time in a specified area.

### **alpha (α) particle**

A positively charged particle consisting of two protons and two neutrons that is emitted from the nucleus of certain nuclides during radioactive decay. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

### **ambient air**

The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.

### **aqueous**

In liquid form (i.e., dissolved in water).

### **aquifer**

A geologic formation that contains sufficient saturated permeable material to conduct groundwater and to yield worthwhile quantities of groundwater to wells and springs.

### **atmosphere**

The layer of air surrounding the earth.

### **AXAIR89Q**

A computer model that is used to analyze doses from accidental airborne radionuclide releases. Developed in accordance with U.S. Nuclear Regulatory Commission Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accidental Consequence Assessments at Nuclear Power Plants*, February 1993.

### **background exposure**

See exposure to radiation.

### **background radiation**

Normal radiation present in the lower atmosphere from cosmic rays and earth sources. Background radiation varies with location, depending on altitude and natural radioactivity present in the surrounding geology.

### **beta (β) particle**

An elementary particle emitted from a nucleus during radioactive decay. It is negatively charged, is identical to an



electron, and is easily stopped by a thin sheet of metal.

**bounded**

Producing greater or lesser consequences than other accidents; or would "bound" the remainder of the accidents.

**burial ground**

A place for burying unwanted radioactive materials in which the earth acts to contain or prevent the escape of radiation. In this EIS, materials are incorporated into concrete to prevent the leaching of materials or movement in the underground environment.

**button**

Plutonium metal in a hemispherical shape, weighing about 1.8 kilograms (4 pounds).

**°C**

Degree Celsius.  $^{\circ}\text{C} = (^{\circ}\text{F} - 32)$ .

**cancer**

A malignant tumor of potentially unlimited growth, capable of invading surrounding tissue or spreading to other parts of the body by metastasis.

**canister**

A stainless-steel container in which nuclear material is sealed.

**canyon**

A heavily shielded building used in the chemical processing of radioactive materials to recover special isotopes for national defense or other programmatic purposes. Operation and maintenance are by remote control.

**capable (fault)**

Determination if a geological fault has moved at or near the ground surface within the past 35,000 years.

**carcinogen**

An agent capable of producing or inducing cancer.

**carcinogenic**

Capable of producing or inducing cancer.

**cask**

A heavily shielded massive container for holding nuclear materials during shipment.

**cesium**

Naturally occurring element with 55 protons in its nucleus. Some manmade isotopes of cesium are radioactive (e.g., cesium 134, cesium-137).

**cladding**

The material (generally aluminum in SRS reactors) that covers each tubular fuel and target assembly.

**collective dose**

The sum of the individual doses to all members of a specific population.

**committed effective dose equivalent**

Used in cases when a person has an intake of radioactive material to denote that the dose is calculated for a period of 50 years following the intake. (See effective dose equivalent.)

**community (environmental justice definition)**

A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land

values, or exposed to industry that stimulates unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.

**concentration**

The amount of a substance contained in a unit quantity of a sample.

**condensate**

Liquid water obtained by cooling the steam (overheads) produced in an evaporator system.

**constituents**

Parts or components of a chemical system.

**converting**

The process for changing special isotopes into usable chemical forms to satisfy current or projected needs for a unique product.

**criticality**

A state in which a self-sustaining nuclear chain reaction is achieved.

**cumulative effects**

Additive environmental, health, and socioeconomic effects that result from a number of similar activities in an area.

**curie (Ci)**

A unit of radioactivity equal to 37,000,000,000 decays per second.

**daughter**

A nuclide formed by the radioactive decay of another nuclide, which is the "parent."

**decay, radioactive**

The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).

**decommissioning**

The removal from service of facilities such as processing plants, waste tanks, and burial grounds, and the reduction or stabilization of radioactive contamination. Decommissioning concepts include:

- Decontaminate, dismantle, and return area to original condition without restrictions.
- Partially decontaminate, isolate remaining residues, and continue surveillance and restrictions.

**defense waste**

Nuclear waste generated by government defense programs as distinguished from waste generated by commercial and medical facilities.

**depleted uranium**

A mixture of uranium isotopes where uranium-235 represents less than 0.7 percent of the uranium by mass.

**design-basis accident (DBA)**

A postulated accident scenario for establishing the need for certain design features; normally, the accident that causes the most severe consequence when engineered safety features function as intended.

**disposal/disposition**

After designation as "surplus"; movement; placement in an onsite or offsite facility after a decision that future uses are unlikely or undesirable; determining whether the disposal of items must be "retrievable" under public law.

**dose rate**

The radiation dose delivered per unit time (e.g., rem per year).

**ecology**

The science dealing with the relationship of all living things with each other and with the environment.

**ecosystem**

A complex of the community of living things and the environment forming a functioning whole in nature.

**effective dose equivalent**

A quantity used to estimate the biological effect of ionizing radiation. It is the sum over all body tissues of the product of absorbed dose, the quality factor (to account for the different penetrating ability of the various radiations), and the tissue weighting factor (to account for the different radiosensitivity of the various tissues of the body).

**effluent**

Liquid or airborne material released to the environment. In general usage, however, "effluent" implies liquid releases.

**effluent standards**

Defined limits of effluent in terms of volume, content of contaminants, temperature, etc.

**EIS**

Environmental impact statement, a legal document required by the National Environmental Policy Act (NEPA) of 1969, as amended, for Federal actions involving potentially significant environmental impacts.

**element**

One of the 105 known chemical substances that cannot be divided into simpler substances by chemical means. All isotopes of an element have the same atomic number (number of protons) but have a different number of neutrons.

**Emergency Response Planning Guidelines (ERPG)**

Values used to determine potential health effects from chemical accidents.

**emission standards**

Legally enforceable limits on the quantities and kinds of air contaminants that can be emitted into the atmosphere.

**endangered species**

Plants and animals in an area that are threatened with either extinction or serious depletion.

**energy**

The capacity to produce heat or do work.

**environment**

The sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism.

**epicenter**

The point on the earth's surface directly above the focus of an earthquake.

**EPICODE**

A computer model used to estimate the airborne concentration of toxic chemicals as a result of routine or accidental releases to the environment.

**erosion**

The process in which the actions of wind or water carry away soil and clay.

**exceedence**

A value over a prescribed limit.

**exposure to radiation**

The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that occurs at a person's workplace. Population exposure is the exposure to a number of persons who inhabit an area.

**°F**

Degree Fahrenheit.  $F = °C \times 1.8 + 32$ .

**fallout**

The descent to earth and deposition on the ground of particulate matter (that might be radioactive) from the atmosphere.

**fault**

A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage of the earth's crust has occurred in the past.

**fissile**

Capable of being split or divided (fissioned) by the absorption of thermal neutrons. The most common fissile materials are uranium-233, uranium-235, and plutonium-239.

**fission**

The splitting of a heavy nucleus into two approximately equal parts, which are nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or can be induced by nuclear bombardment.

**fission products**

Nuclei from the fission of heavy elements (primary fission products); also, the nuclei formed by the decay of the primary fission products, many of which are radioactive.

**floodplain**

Level land built up by flowing stream deposition and periodically submerged by floodwater from that stream.

**frit**

Finely ground glass.

**gamma (g) rays**

High-energy, short-wavelength electromagnetic radiation accompanying fission, radioactive decay, or nuclear reactions. Gamma rays are very penetrating and require relatively thick shields to absorb the rays effectively.

**geology**

The science that deals with the earth: the materials, processes, environments, and history of the planet, especially the lithosphere, including the rocks, their formation and structure.

**glovebox**

Large enclosure that separates workers from equipment used to process hazardous material but enables the workers to be in physical contact with the equipment; normally constructed of stainless steel with large acrylic/lead glass windows. Workers have access to equipment through the use of heavy-duty, lead-impregnated rubber gloves, the cuffs of which are sealed in portholes in the glovebox windows.

**groundwater**

The supply of fresh water under the earth's surface in an aquifer.

**habitat**

The place or type of site where a plant or animal naturally or normally lives and grows.

**half-life (radiological)**

The time in which half the atoms of a radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

**heavy metals**

Metallic elements of high molecular weight, such as mercury, chromium, cadmium, lead, and arsenic, that are toxic to plants and animals at known concentrations.

**HEPA filter**

High efficiency particulate air filter designed to remove 99.9 percent of particles as small as 0.3 micrometer in diameter from a flowing air stream.

**high-fired oxide**

Oxide chemical form of plutonium produced by heating the material to approximately 1,000·C. High-fired oxide is considered more chemically stable than low-fired oxide because the higher heat removes moisture and other impurities more effectively.

**high-level waste**

The highly radioactive wastes that result from processing of defense materials at SRS.

**historic resources**

The sites, districts, structures, and objects considered limited and nonrenewable because of their association with historic events, persons, or social or historic movements.

**immobilization**

Conversion of high-level waste into a form that will be resistant to environmental dispersion.

**intensity (earthquake)**

A numerical rating used to describe the effects of earthquake ground motion on people, structures, and the earth's surface. The numerical rating is based on an earthquake intensity scale such as the Richter Scale commonly used in the United States.

**interim storage**

Safe and secure capacity in the near term to support continuing operations in the interim period (10 years).

**involved worker**

For this EIS, an SRS worker who is involved in the operation of a facility when a radioactive release occurs.

**ion**

An atom or molecule that has gained or lost one or more electrons to become electrically charged.

**ion exchange**

Process in which a solution containing soluble ions to be removed is passed over a solid ion-exchange medium, which removes the soluble ions by exchanging them with labile ions from the surface of the column. The process is reversible so that the trapped ions can be collected (eluted) and the column regenerated.

**ion-exchange medium**

A substance (e.g., a resin) that preferentially removes certain ions from a solution.

**ionization**

The process that creates ions. Nuclear radiation, X-rays, high temperatures, and electric discharges can cause ionization.

**ionizing radiation**

Radiation capable of displacing electrons from atoms or molecules to produce ions.

**irradiation**

Exposure to radiation.

**ISC2**

A computerized dispersion program used to calculate ground-level concentrations of air pollutants.

**isotope**

An atom of a chemical element with a specific atomic number and atomic weight. Isotopes of the same element have the same number of protons but different numbers of neutrons. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus. For example, plutonium-239 is a plutonium atom with 239 protons and neutrons.

**LADTAP**

A computer program used to calculate individual and population doses from liquid pathways.

**latent cancer fatalities**

Deaths resulting from cancer that has become active following a latent period (i.e., a period of inactivity).

**low-fired oxide**

Oxide chemical form of plutonium produced by heating the material to approximately 550°C. Low-fired oxide is considered less chemically stable than high-fired oxide because the lower heat does not remove moisture and other impurities as effectively.

**low-income communities**

A community where 25 percent or more of the population is identified as living in poverty.

**low-level waste**

Radioactive waste not classified as high-level waste; the wastes (mostly salts) remaining after removal of the highly radioactive nuclides from the liquid high-level wastes for immobilization.

**Mark-x (Mk-x)**

An historic naming system for a specific design of fuel or target material used in SRS production reactors (e.g., Mk-31, Mk-42, Mk-16).

**MAXIGASP**

A computer program used to calculate doses of airborne releases of radioactivity to the maximally exposed member of the public.

**maximum contaminant levels (MCLs)**

The maximum permissible level of a contaminant in water that is delivered to a user of a public water system.

**maximally exposed individual**

A hypothetical person located to receive the maximum possible dose by a given exposure scenario.

**migration**

The natural travel of a material through the air, soil, or groundwater.

**mitigate**

To take practicable means to avoid or minimize environmental harm from a selected alternative.

**monitoring**

Continuing control and accountability, particularly of special nuclear materials such as plutonium-239 and highly enriched uranium, but also including oversight of hazardous or reactive compounds before they are disposed of or converted to a stable long-term storage form.

**National Register of Historic Places**

A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state, or national importance.

**natural radiation or natural radioactivity**

Background radiation. Some elements are naturally radioactive, whereas others are induced to become radioactive by bombardment in a reactor or accelerator.

**NEPA**

National Environmental Policy Act of 1969 (42 USC 4321); it requires the preparation of an EIS for Federal projects that could present significant impacts to the environment.

**nonproliferation**

The restriction of ability to easily access fissile materials in concentrations sufficient to assemble a nuclear weapon.

**NO<sub>x</sub>**

Oxides of nitrogen, primarily nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). These are produced in the combustion of fossil fuels, and can constitute an air pollution problem.

**NRC**

Nuclear Regulatory Commission; the independent Federal commission that licenses and regulates nuclear facilities.

**nuclear energy**

The energy liberated by a nuclear reactor (fission or fusion) or by radioactive decay.

**nuclear radiation**

Radiation, usually alpha, beta, or gamma, that emanates from an unstable atomic nucleus.

**nuclear reaction**

An interaction between a photon, particle, or nucleus and a target nucleus, leading to the emission of one or more particles and photons.

**nuclear reactor**

A device in which a fission chain reaction is maintained, used for the irradiation of materials or the generation of electricity.

**nuclide**

An atomic nucleus specified by atomic weight, atomic number, and energy state; a radionuclide is a radioactive nuclide.

**organic compounds**

Chemical compounds containing carbon.

**outfall**

Place where liquid effluents enter the environment and are monitored.

**oxide**

A compound in which an element chemically combines with oxygen.

**ozone**

A compound of oxygen in which three oxygen atoms are chemically attached to each other.

**particulates**

Solid particles and liquid droplets small enough to become airborne.



**passive safety system**

A system that provides safety features requiring no human intervention or adverse condition to actuate.

**pH**

A measure of the hydrogen ion concentration in aqueous solution. Pure water has a pH of 7, acidic solutions have a pH less than 7, and basic solutions have a pH greater than 7.

**people of color communities**

A population classified by the U.S. Bureau of the Census as Black, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons, the composition of which is at least equal to or greater than the state minority average of a defined area or jurisdiction.

**permeability**

Ability of liquid to flow through rock, groundwater, soil, or other substance.

**person-rem**

The radiation dose to a given population; the sum of the individual doses received by a population segment.

**physiographic**

Geographic regions based on geologic setting.

**plutonium (Pu)**

A transuranic, heavy (average atomic mass about 244 atomic mass units), silvery metal with 15 isotopes that is produced by the neutron irradiation of natural uranium. Plutonium-239 is used both in nuclear weapons and commercial nuclear power applications. Plutonium-238 is used to power onboard generators during manned and unmanned space flights.

**plutonium solutions**

Chemical solutions containing plutonium.

**poison**

A material that has an affinity for absorbing neutrons. Poisons are added to nuclear materials with a potential criticality concern to lessen the likelihood of an uncontrolled nuclear reaction.

**pollution**

The addition of an undesirable agent to an ecosystem in excess of the rate at which natural processes can degrade, assimilate, or disperse it.

**POPGASP**

A computer mathematical model used to calculate doses of airborne releases of radioactivity to the population within 80 kilometers (50 miles) of the SRS.

**population**

In this EIS, a collection of members of the public who are located outside the boundaries of the SRS. Impacts in this EIS are estimated for the population within a given area, depending on the appropriate environmental pathways. For example, the affected population for liquid releases to the Savannah River includes downstream residents.

**precipitate**

A solid (used as a noun). To form a solid substance in a solution by a chemical reaction (used as a verb).

**PUREX process**

A chemical separation process to retrieve plutonium, uranium, and other radionuclides from reactor fuel and targets.

**radiation**

The emitted particles and photons from the nuclei of radioactive atoms; a shortened term for ionizing radiation or

nuclear radiation as distinguished from nonionizing radiation (microwaves, ultraviolet rays, etc.).

**radioactivity**

The spontaneous decay of unstable atomic nuclei, accompanied by the emission of radiation.

**radioisotopes**

Radioactive isotopes. Some radioisotopes are naturally occurring (e.g., potassium-40) while others are produced by nuclear reactions.

**radiolysis**

The decomposition of a material (usually water) into different molecules due to ionizing radiation. In water, radiolysis results in the production of hydrogen gas and oxygen.

**repository**

A place for the disposal of immobilized high-level waste in isolation from the environment.

**resin**

An ion-exchange medium; organic polymer used for the preferential removal of certain ions from a solution.

**Richter Scale**

A scale of measure used in the United States to quantify earthquake intensity.

**risk**

In accident analysis, the probability weighted consequence of an accident, defined as the accident frequency per year multiplied by the dose. The term "risk" is also used commonly in other applications to describe the probability of an event occurring.

**runoff**

The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually returns to streams. Runoff can carry pollutants into receiving waters.

**saltstone**

Low-radioactivity fraction of high-level waste from the in-tank precipitation process mixed with cement, flyash, and slag to form a concrete block.

**seismicity**

The tendency for earthquakes to occur.

**shield**

Material used to reduce the intensity of radiation that would irradiate personnel or equipment.

**short-lived**

A designation for radionuclides with relatively short half-lives (i.e., they decay to stable materials relatively quickly).

**stabilization**

The action of making a nuclear material more stable by converting its physical or chemical form or placing it in a more stable environment.

**stack**

A vertical pipe or flue designed to exhaust gases and suspended particulates.

**strontium**

Naturally occurring element with 38 protons in its nucleus. Some manmade isotopes of strontium are radioactive (e.g., strontium-89, strontium-90),

**surface water**

All water on the surface (streams, ponds, etc.), as distinguished from underground water.

**tank farm**

An installation of interconnected underground tanks for the storage of high-level radioactive liquid wastes.

**target**

In this EIS, a tube of material placed in a reactor to absorb neutrons and be changed to a desired end product.

**transuranic waste**

Waste material containing more than a specified concentration of transuranic elements (presently, more than 10 nanocuries per gram of waste).

**tritium**

A radioactive isotope of hydrogen; its nucleus contains one proton and two neutrons.

**uninvolved worker**

For this EIS, an SRS worker who is not involved in the operation of a facility when a radioactive release occurred, and who is assumed to be 640 meters (2,100 feet) from the point of release.

**uranium (U)**

A heavy (average atomic mass of about 238 atomic mass units), silvery-white metal with 14 radioactive isotopes. One of the isotopes, uranium-235, is most commonly used as fuel for nuclear fission and another, uranium-238, is transformed into fissionable plutonium-239 following its capture of a neutron in a nuclear reactor.

**vault**

A reinforced concrete structure for storing strategic nuclear materials used in national defense or other programmatic purposes.

**vitrification**

Incorporation of a material into a glass form.

**vulnerability**

Condition or weakness that could lead to exposure to the public, unnecessary or increased exposure to workers, or release of radioactive materials to the environment.

**waste, radioactive**

Materials from nuclear operations that are radioactive or are contaminated with radioactive materials and for which there is no practical use or for which recovery is impractical.





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**EIS RESPONSIBILITY:** Prepared socioeconomics section; provided technical input to environmental justice sections.

**NAME: CONSTANCE M. HAGA**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** • B.S., Meteorology, The Pennsylvania State University, 1986

**TECHNICAL EXPERIENCE:** Seven years experience in air quality modeling and permitting and air emissions inventory.

**EIS RESPONSIBILITY:** Prepared nonradiological air resources sections; provided technical input to radiological air resources sections.

**NAME: EDWARD J. JACKSON**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Soil Science, University of Wisconsin, 1987

· B.S., Molecular Biology, University of Wisconsin, 1981

**TECHNICAL EXPERIENCE:** More than 5 years experience in contaminant transport and remediation of soils.

**EIS RESPONSIBILITY:** Prepared geological resources section.

**NAME: KIRK H. JENKS**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.S., Chemistry, Virginia Polytechnic Institute and State University, 1975

**TECHNICAL EXPERIENCE:** Eighteen years experience in nuclear operations, emergency preparedness, and nuclear safety.

**EIS RESPONSIBILITY:** Prepared section on health effects from accidents.

**NAME: LOUISE S. MOORE**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.A., Geography, University of Maryland, 1968

**TECHNICAL EXPERIENCE:** Twelve years experience in environmental planning, socioeconomic studies, and cultural resource studies.

**EIS RESPONSIBILITY:** Provided technical input on cultural resources.

**NAME: PHILIP R. MOORE**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Wildlife Biology (Fisheries), Clemson University, 1983

- Post-baccalaureate study, Zoology, Clemson University, 1977-1979
- B.A., English, University of South Carolina, 1975

**TECHNICAL EXPERIENCE:** More than 10 years experience in environmental impact assessment of hydroelectric, fossil, and nuclear powerplants.

**EIS RESPONSIBILITY:** Prepared cumulative impacts chapter.

**NAME: TISH B. MORGAN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · Masters Equivalent, Nuclear Physics, Western Kentucky University, 1973

· B.S., Physics and Mathematics, Western Kentucky University, 1972

**TECHNICAL EXPERIENCE:** Twenty years experience in nuclear safety, accident analysis, risk assessment, and issue management.

**EIS RESPONSIBILITY:** Prepared Accidents sections. Provided technical input to Appendix E.

**NAME: JAMES L. OLIVER**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.S., Biology, Murray State University, 1971

**TECHNICAL EXPERIENCE:** Twenty-two years experience in environmental impact assessment, environmental research, project management, limnological studies, thermal effects, entrainment and impingement, ecology.

**EIS RESPONSIBILITY:** Management reviewer for Halliburton NUS Corporation.

**NAME: RICHARD F. ORTHEN, JR.**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.S., Chemistry, Emory University, 1979

**TECHNICAL EXPERIENCE:** Thirteen years experience planning, implementing, and evaluating occupational and environmental health physics programs; perform routine and emergency offsite dose assessments using source-term and environmental surveillance data.

**EIS RESPONSIBILITY:** Technical reviewer for radiological air and traffic sections.

**NAME: JON W. OUSLEY**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · U.S. Navy schools and prototype training in naval nuclear power and electronics

**TECHNICAL EXPERIENCE:** Twenty-five years in nuclear reactor experience, including naval facility operation, risk assessments, development of safety analysis reports, safety base development, and operational readiness reviews.

**EIS RESPONSIBILITY:** Reviewed accident analyses and supporting documentation.

**NAME: KAREN K. PATTERSON**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.A., Biology, Wake Forest University, 1977

· B.A., Biology, Randolph-Macon Women's College, 1973

**TECHNICAL EXPERIENCE:** Twenty-one years in technical and management roles in multidisciplinary environmental programs.

**EIS RESPONSIBILITY:** Provided technical input to ecological resources sections.

**NAME: W. LEE POE**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Chemical Engineering, University of Alabama, 1951

· B.S., Chemistry, Tulane University, 1949

**TECHNICAL EXPERIENCE:** Forty-two years experience, most working with nuclear materials at SRS. Experience includes 22 years providing full-time technical support for processes in F- and H-Canyons, H- and FB-Line, and 235-F facilities.

**EIS RESPONSIBILITY:** Technical reviewer.

**NAME: ROBERT L. SCHLEGEL, PE**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Nuclear Engineering, Columbia University, 1961

· B.S., Chemical Engineering, Massachusetts Institute of Technology, 1959

**TECHNICAL EXPERIENCE:** Thirty-two years experience in radiological dose assessments.

**EIS RESPONSIBILITY:** Prepared radiological air resources sections; provided technical input to nonradiological air resources sections.

**NAME: PATRICIA L. SHAW-ALLEN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Zoology/Ecotoxicology, Oklahoma State University, 1990

· B.S., Wildlife Management, University of New Hampshire, 1987

**TECHNICAL EXPERIENCE:** More than 4 years experience in aquatic toxicology/water quality, ecological risk assessments, natural resource management, and ecotoxicology.

**EIS RESPONSIBILITY:** Provided technical input on ecological resources section.

**NAME: JOHN O. SHIPMAN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.A., English, Georgetown University, 1966

**TECHNICAL EXPERIENCE:** Twenty-seven years in environmental impact statements and impact analyses, technical writing and editing, and publications production.

**EIS RESPONSIBILITY:** Technical editor of draft EIS.

**NAME: DIANE S. SINKOWSKI**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.E., Environmental Engineering Sciences, University of Florida, 1994

· B.S., Nuclear Engineering Sciences, University of Florida, 1990

**TECHNICAL EXPERIENCE:** One year of experience in health physics investigations and evaluations.

**EIS RESPONSIBILITY:** Provided technical input to Waste Management section.

**NAME: RONALD J. SMITH, CHP**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Health Physics, University of Florida, 1987

· B.S., Physics, University of South Florida, 1985

**TECHNICAL EXPERIENCE:** Eight years in environmental and occupational health physics programs at commercial nuclear reactor sites.

**EIS RESPONSIBILITY:** Technical reviewer for transportation sections.

**NAME: CATHERINE J. THOMAS**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.A., Journalism, Texas A&M University, 1983

**TECHNICAL EXPERIENCE:** More than 10 years writing and editing NEPA documents, procedures, and newspapers.

**EIS RESPONSIBILITY:** Edited technical appendixes.

**NAME: ALAN L. TOBLIN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Chemical Engineering, University of Maryland, 1970

· B.E., Chemical Engineering, The Cooper Union, 1968

**TECHNICAL EXPERIENCE:** Twenty-two years of experience in analyzing radiological and chemical contaminant transport in water resources.

**EIS RESPONSIBILITY:** Prepared water resources sections.

**NAME: GILBERT H. WALDMAN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.S., Nuclear Engineering, University of Florida, 1991

**TECHNICAL EXPERIENCE:** Three years experience in dose modeling, health effects and safety, radiation verification, powerplant engineering, reactor operation, health physics; Licensed Reactor Operator.

**EIS RESPONSIBILITY:** Provided technical input to water resources consequences section.

**NAME: KARL E. WALTZER**



**AFFILIATION:** U.S. Department of Energy, Savannah River Operations Office

**EDUCATION:** · B.S., Mechanical Engineering, West Virginia University, 1979

**TECHNICAL EXPERIENCE:** Fifteen years nuclear industry experience in maintenance, waste management, safety analysis, and chemical separations technology.

**EIS RESPONSIBILITY:** Technical reviewer for Department of Energy.

**NAME: TIMOTHY A. WASHBURN**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Biology, University of Richmond, 1979

· B.S., Biology, University of Richmond, 1977

**TECHNICAL EXPERIENCE:** Eighteen years experience in environmental and occupational health physics at commercial and government nuclear facilities.

**EIS RESPONSIBILITY:** Prepared traffic and transportation sections.

**NAME: ROBERT H. WERTH**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · B.A., Physics, Gordon College, 1973

**TECHNICAL EXPERIENCE:** Seventeen years in acoustics and air quality studies.

**EIS RESPONSIBILITY:** Provided technical input on noise impacts.

**NAME: PHILIP L. YOUNG**

**AFFILIATION:** Halliburton NUS Corporation

**EDUCATION:** · M.S., Health Physics, Georgia Institute of Technology, 1989

· B.S., Radiation Health (Health Physics), Oregon State University, 1988

**TECHNICAL EXPERIENCE:** More than six years in environmental health physics and nuclear engineering, with emphasis on radiological effluent monitoring, environmental surveillance, environmental dosimetry, radiological risk assessment, and radioactive waste management.

**EIS RESPONSIBILITY:** Provided technical input to cumulative impacts chapter.

