CHAPTER 4. ENVIRONMENTAL IMPACTS

This chapter describes potential environmental impacts from construction, operation, and accidents associated with the proposed action and its alternatives. Section 4.1 describes the operational impacts of each alternative within the scope of this environmental impact statement (EIS). Section 4.2 describes risks to members of the public and onsite workers from potential facility accidents associated with the management of spent nuclear fuel (SNF) at the Savannah River Site (SRS). Section 4.3 describes impacts that could result from construction activities associated with SNF management at SRS. The purpose of the information presented in this chapter is to provide comparisons among alternatives. For new facilities, this information is based on DOE's best estimates of these facilities' operational characteristics. These data are not intended to be used for safety analysis purposes or compared to safety documents such as a Safety Analysis Report.

As discussed in Section 2.3.2, the Department of Energy (DOE) has identified three candidate sites for the potential construction of a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility: (1) the east side of L Area inside the facility fence, (2) the southeast side of C Area inside the facility fence, and (3) the northeast side of P Area. In addition, the facility could be constructed on a site inside the F-Area or H-Area fence or in an existing reactor building such as Building 105-L.

In most instances, implementing the technology options described in Chapter 2 would result in the same or very similar environmental impacts, regardless of location. If, during the preparation of this EIS, analyses indicated that a technology option would produce different environmental impacts at one of the candidate sites, DOE analyzed the site that would have the greatest impact (the bounding site). The analysis of the atmospheric releases of radioactivity described in the air resources and public and worker health sections is based on the assumption that emissions from a Transfer and Storage Facility or Transfer, Storage, and Treatment Facility would occur in C Area. Releases from C Area would result in higher estimated radiation doses to members of the public than releases from L or P Area (i.e., C Area would result in doses to the maximally exposed offsite individual approximately 1.7 times higher than those in L Area and 1.1 times higher than those in P Area). All other impacts would be independent of location.

The impacts reported in this chapter are based on the entire SNF inventory described in Chapter 1 and Appendix C. However, as noted in Section 1.3, some foreign reactor operators may not participate in DOE's program of accepting U.S.-origin SNF. This reduction in receipts could potentially impact the amounts of fuel in Groups B, D, and E. Therefore, the amounts of fuel to be managed in those fuel groups could be less than the amounts assumed for the calculations in Chapter 4. DOE believes that annual impacts for normal operations, construction impacts, and accident impacts would be unaffected by modest reductions in the expected fuel inventory. The annual impacts are based on the maximum year's impacts; decreasing the foreign fuel shipments may lessen the number of years of fuel handling, conditioning, or treatment, but would not affect the maximum annual impact. SNF accidents usually involve small amounts of fuel and thus are insensitive to the total inventory. Construction impacts are similarly insensitive to the reduction in total fuel inventory that could occur. Eleven environmental impact measures are based on activities that occur over the entire period of analysis. These impacts would be sensitive to reductions in fuel receipts. Where applicable, the tables in this chapter explain how to adjust reported impacts for potentially reduced fuel receipts.

4.1 Impacts from Normal Operations

This section describes environmental impacts that could result from operational activities associated with SNF management at SRS for existing and new facilities. Because the only potential impacts to geologic and cultural resources would occur during construction (see Section 4.3), Section 4.1 does not consider geologic or cultural resource impacts. DOE does not anticipate a significant increase in employment due to the implementation of any technology options (Table 4.1-1). The existing site work force should be sufficient to provide the necessary operations and support personnel; therefore, there would be no socioeconomic impacts from operations under any technology.

Table 4.1-1. Estimated operational staffing for any of the technology options.

Technology option	Operations personnel	Support personnel	Total personnel
Melt and Dilute	200	200	400
Mechanical Dilution	175	175	350
Repackage and Prepare to Ship	75	75	150
Vitrification	317	317	634
Electrometallurgical	238	238	476
Conventional Processing	300	300	600
Continued Wet Storage	80	80	160

Source: Bickford et al. 1997.

DOE used the following process to estimate the impacts associated with new facilities/processes. First, DOE identified the facilities that would be needed to implement each of the technologies described in Chapter 2 (see Table 2-4). Next, DOE identified the major systems required within each facility for each technology. DOE then identified the energy sources, potential waste and effluent streams, and sources of potential radiation exposure associated with each of these major systems. These results were then compared to similar processes with which DOE has operational experience to determine the relative magnitude of the impact. These impacts were presented as annual impacts; integrated impacts were then calculated as described below in Section 4.1.1.

DOE does not expect normal operations to have any appreciable impacts on ecological resources. Impacts would be limited to minor disturbances of animals in undeveloped areas adjacent to SNF management facilities caused by increased movement and noise from personnel, vehicles, and equipment. However, these impacts would be negligible under all proposed technology options because they would occur in areas where industrial activities already exist. Impacts to potential human receptors from normal releases of radioactive and nonradioactive contaminants to the environment would be small for any of the technologies under consideration (Section 4.1.1.3). Therefore, these releases would not be likely to produce measurable effects on nearby plant and animal communities or to accumulate in aquatic or terrestrial ecosystems.

4.1.1 IMPACTS OF TECHNOLOGY OPTIONS

This section describes the environmental impacts of each technology. The analysis covers the environmental impacts of actions over the 38-year period from 1998 through 2035 and presents both maximum annual impacts from these technologies and estimated total impacts over the entire period. For example, the discussions of water and air resources present maximum annual radiation doses to members of the public from liquid and airborne emissions associated with each technology and compares the resulting values to Federal limits. The section on public and worker health, on the other hand, presents radiation doses to members of the public from liquid and airborne emissions over the entire implementation period. EC The waste generation and utilities and energy sections also present impacts over the entire period of analysis (1998-2035).

To estimate total impacts, DOE identified the activities necessary to implement each technology, the amount of time required for each step (*phase*) of the technology option, and the annual impacts likely to occur during each phase. DOE summed the annual impacts over the entire duration of the phase, together with other phases needed to implement that option. For the Conventional Processing option, DOE used historic data for F- and H-Canyon operations to estimate the time needed to process the entire inventory of each type of fuel (McWhorter 1997). For the other technology options with a treatment phase, DOE used engineering judgments to estimate the duration of this phase for each fuel group. Appendix E describes the assumed durations for each phase. If annual impact data (i.e., utilities and energy, waste generation, and worker radiation dose) for each type of fuel were not available, DOE assumed that the fraction of the impact attributable to each type of fuel would be equal to the fraction of that fuel's fissile mass to the total fissile mass of SNF in the scope of this EIS. DOE derived the annual impact calculations from the available data (Bickford et al. 1997) based on the total radionuclide inventory for each type of fuel. Appendix C contains the radionuclide inventories, using a "reference fuel assembly" i.e., a conservative estimate of the radionuclide and curie content for an SNF assembly designed to bound the characteristics of fuel assigned to SRS. The engineering report that provides data upon which the impacts presented in this chapter are based (Bickford et al. 1997) is available for review at the DOE public reading room in Aiken, South Carolina.

4.1.1.1 Water Resources

This section describes the effects of normal operations associated with the technologies to SRS waters. All process water would come from groundwater. None of the technologies require much water to process the fuels. At most, less than 6,000 liters per year (equivalent to 1,585 gallons per year) would be required. The SRS annually withdraws more than 5×10^9 liters of groundwater (DOE 1997).

As discussed below, the only technology that would result in discharges of radionuclides or nonradioactive hazardous materials to surface water would be conventional processing. The major sources of liquid effluents from facilities associated with conventional processing would be process cooling water and steam condensate that could contain small quantities of radionuclides and chemicals. Conventional processing would use wastewater treatment facilities and other equipment designed for full production (i.e., five production reactors, two separation facilities, and other industrial facilities) loads. Therefore, capacities would be sufficient to handle the liquid effluents and other secondary waste associated with conventional processing.

Liquid effluents associated with the SNF technologies would use existing wastewater treatment facilities and outfalls described in Section 3.2.1.3. Sanitary waste would be treated at the SRS Central Wastewater Treatment Facility (CSWTF) and discharged through an existing NPDES outfall (G-10). Because technology options would not increase the number of permanent SRS employees, the CSWTF treatment rates would not be affected, and it would continue to meet the requirements of the SRS NPDES permit.

DOE evaluated in the Programmatic SNF EIS (DOE 1995b) the potential impacts to groundwater from a direct leak to the subsurface from a breach in a storage pool during routine operations. Because basin water could contain some radionuclides but would not contain any toxic or harmful chemicals, the following evaluation addresses only the consequences of radionuclide releases. The analysis conservatively assumed a 5-gallon (19-liter) per-day leak as a result of secondary containment or piping failure at the Receiving Basin for Offsite Fuels, L-Reactor Disassembly Basin, or a new wet receipt basin in a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility. The analysis assumed further that the leak would go undetected for 1 month.

The reliability and sensitivity of the leak detection devices at a new wet receipt basin would be equal to or superior to those required by the U.S. Nuclear Regulatory Commission (NRC 1975) for SNF storage facilities in commercial nuclear power plants. Constant process monitoring, mass balance, and facility design (including double-walled containment of vessels and piping) also would be used by DOE to limit operational releases from a new wet receipt facility to near zero.

A leak from the Receiving Basin for Offsite Fuels, or the L-Reactor Disassembly Basin, could result in the introduction of radionuclide-contaminated water into the ground at depths as much as 44 feet (13.4 meters) below grade. Such a release would go directly to the uppermost aquifer (Upper Three Runs), which at SRS is not suitable for use as a drinking water source because of its low yield and the presence of contaminants. Any contaminants would move through the Upper Three Runs and Gordon aquifers and ultimately discharge to SRS streams. The processes governing the plume movement (i.e., the hydraulic conductivity, hydraulic gradient, and effective porosity of aquifers in F, H, and the Reactor Areas) and the processes resulting in the attenuation of contaminants and radionuclides (i.e., radioactive decay, trapping of particulates in the soil, ion exchange in the soil, and adsorption to soil particles) would mitigate impacts to surface- or groundwater resources. Localized contamination of groundwater in the surface aquifer could occur in the immediate vicinity of the storage facility. However, this aquifer is not used as a source of drinking water. DOE concludes that no radionuclide contamination of deeper confined aquifers that are sources of onsite or offsite drinking water would be likely to occur from a leak in a storage basin.

The aquifer used as the primary source for drinking water is separated from the shallower aquifers by a confining unit. The hydraulic pressure of the lower aquifer is greater than that of the overlying aquifer. Therefore, water flows from the lower to the upper aquifer. This upward flow would prevent the downward migration of released contaminants.

4.1.1.1.1 Radiological Impacts

With the exception of conventional processing which is the maximum impact alternative, none of the technologies proposed in this EIS is likely to result in measurable increases in radionuclides released to water (Bickford et al. 1997). No other proposed technology would have a process discharge to surface waters.

The prolonged storage of SNF in the basins (i.e., the No-Action Alternative) could lead to a higher rate of fuel failures and releases to basin water, but probably would not affect routine releases (i.e., those from national pollutant discharge elimination system [NPDES] permitted outfalls). DOE would maintain water quality by monitoring basin water, deionizing basin water using resin beds, and stabilizing leaking assemblies.

Calculations of radiological doses through water pathways based on these releases are supported by the use of LADTAPXL, a spreadsheet version of the LADTAP II computer code developed by the U.S. Nuclear Regulatory Commission (NRC) to estimate radiation doses associated with normal reactor system liquid effluent releases to individuals, populations, and biota (Hamby 1991). LADTAP II uses the models in NRC Regulatory Guide 1.109 (NRC 1977) to calculate doses received from water and fish ingestion and from recreational water activities. Parameters used to calculate dose for the maximally exposed individual are consistent with regularly published SRS environmental reports (e.g., Arnett and Mamatey 1996).

Any radionuclide releases to surface water resulting from the technologies would be to SRS streams that discharge to the Savannah River. For all technology options, the ingestion of fish contaminated with 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 smaller contributors for the approximately 70,000 people served by water treatment plants near Port Wentworth, Georgia (60,000) and Beaufort, South Carolina (10,000) (Arnett and Mamatey 1996). Table 4.1-2 lists both the maximally exposed individual dose and the collective dose due to liquid releases to the 620,100-person population surrounding SRS. TC

Table 4.1-2. Estimated maximum incremental annual dose to hypothetical maximally exposed individual and 620,100-person population surrounding SRS due to liquid releases from Conventional Processing.

	Fuel group	MEI dose (millirem)	Population dose (person-rem)
A.	Uranium and Thorium Metal Fuels	4.2×10^{-5}	2.4×10^{-4}
B.	Materials Test Reactor-Like Fuels	0.042	0.14
C.	HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging	0.014	0.047
D.	Loose Uranium Oxide in Cans	1.4×10^{-3}	4.7×10^{-3}
E.	Higher Actinide Targets	NA	NA
F.	Non-Aluminum-Clad Fuels	NA	NA

NA = Technology is not applicable to this fuel type.
HEU = Highly Enriched Uranium.
LEU = Low Enriched Uranium.
MEI = Maximally Exposed Individual.

4.1.1.1.2 Nonradiological Impacts

This assessment 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 3.2-1 shows that conventional processing activities would not occur in the 100-year floodplain. DOE would treat sanitary waste generated by any of the alternatives in this EIS in existing sewage treatment facilities; discharges from these facilities would continue to meet NPDES permit limits.

Activities associated with the New Packaging Technology options and all new treatment options under the New Processing Technology, including Melt and Dilute, Mechanical Dilution, Vitrification, and Electrometallurgical Treatment, would conform to current regulatory standards, and would not have nonradiological waterborne releases (Bickford et al. 1997). Under conventional processing, process cooling water treatment would result in releases of the following concentrations from F Area to Upper Three Runs:

- Nitrate - 40 micrograms per liter
- Ammonia - 30 micrograms per liter
- Manganese - 10 micrograms per liter
- Uranium - 20 micrograms per liter
- Nickel - 50 micrograms per liter
- Chromium - 20 micrograms per liter
- Aluminum - 200 micrograms per liter
- Copper - 10 micrograms per liter
- Zinc - 70 micrograms per liter

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. The discharges would also comply with South Carolina Water Quality Standards contained in South Carolina Regulation R.61-68. In general, the release concentrations would be no greater than those currently measured in Upper Three Runs and Fourmile Branch (Arnett 1996), with the exception of zinc and ammonia; however, zinc concentrations in the discharge would be only a small fraction of the South Carolina Water Quality Standards, which are based on the taste and odor of drinking water. Ammonia concentrations in the discharge (only H-Area releases would increase current stream concentrations) would be well within state standards. Lead, nickel, and chromium generally were not detected in Upper Three Runs and Fourmile Branch in 1995.

4.1.1.2 Air Resources

This section describes incremental air quality impacts from nonradiological and radiological emissions for the operation of each technology option for each fuel group; this description includes impacts to on- and offsite individuals and populations.

This analysis presents results in terms of ground-level air concentrations for nonradiological constituents and radiation dose for radionuclides because these are the best measures of potential adverse human health effects.

4.1.1.2.1 Nonradiological Emissions

DOE estimated nonradiological emission rates for each technology option (Bickford et al. 1997) and used them with the meteorological data described in Section 3.3.1 to estimate site boundary and noninvolved worker concentrations. This analysis assumed average meteorological conditions.

Onsite Concentrations

The purpose of this analysis is to estimate air concentrations to which SRS workers not involved in SNF management and related operations would be exposed. Atmospheric emissions would occur from F or H Area (conventional processing), L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuels (continued wet storage), and the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility. To determine impacts to noninvolved workers, the analysis used a generic location 2,100 feet (640 meters) from the release in the direction of the plume of greatest concentration. The 2,100-foot criterion is based on NRC guidance. Also, the use of this distance ensures consistency between this and previous SRS EISs.

The analysis assumed that operational nonradiological releases would be from the same release stack as radiological releases. In addition, this EIS does not include onsite concentrations at distances greater than 2,100 feet; the analysis considered such concentrations and found that they would be less than those at 2,100 feet.

Tables F-1 through F-10 in Appendix F list estimated air concentrations above baseline (i.e., incremental increases) resulting from nonradiological atmospheric emissions associated with SNF fuel groups. No incremental atmospheric emissions above the baseline presented in Chapter 3 would be associated with Repackage and Prepare to Ship, the only option applicable to the non-aluminum-clad fuels. The air quality regulatory standards listed in Tables F-6 through F-10 in Appendix F are applicable to the Site boundary concentration from all SRS emissions. While these standards are included only for reference, all the incremental concentrations from SNF activities would be at least two orders of magnitude less than any of the corresponding standards except those for nitric acid, oxides of nitrogen, and gaseous fluorides emitted during conventional processing or vitrification of fuel Group B. The concentrations would range from less than 1 percent to about 55 percent of the offsite standard (for nitrogen oxides). If a new facility or a major modification to an existing facility were being considered, new permitting actions would be required as part of the Clean Air Act Title V permit compliance requirements. Under the current Title V permit, SRS would have to conduct a Prevention of Significant Deterioration review, since the nitrogen oxide levels exceed the 25 μm per cubic meter per year threshold of NO_2 for a Class II area. In addition, there would be a requirement for ambient monitoring to verify emission levels once the process began.

Offsite Concentrations

This analysis presents projected maximum offsite nonradiological incremental air concentrations in much the same way it presents the onsite concentrations. The estimated maximum incremental concentrations listed in Tables F-6 through F-10 in Appendix F would occur at the SRS boundary for emissions associated with SNF. The air quality regulatory standards listed in the tables are applicable to the Site boundary concentrations from all SRS emissions. All the incremental concentrations are at least three orders of magnitude less than any of the corresponding standards except those for oxides of nitrogen and gaseous fluorides emitted during conventional processing or vitrification. The concentrations ranged from less than 1 percent to about 2 percent of the offsite standard.

4.1.1.2.2 Radiological Emissions

DOE estimated airborne radionuclide emission rates for each technology option (Bickford et al. 1997), and used them with the meteorology data from Section 3.3.1 as inputs to the SRS computer models MAXIGASP and POPGASP (Hamby 1994) to determine doses to onsite (noninvolved worker) and offsite (hypothetical maximally exposed individual) recipients and the surrounding population (620,000 persons) within a 50-mile (80-kilometer) radius of the center of the Site (Simpkins 1996). The analysis uses the meteorological data to determine annual average concentrations in air. The values presented in Tables 4.1-3, 4.1-4, and 4.1-5 represent current reactor-area emissions (including two SNF wet basins).

Onsite Doses

Atmospheric doses to the noninvolved worker represent the radiological exposures of a hypothetical worker who is nearby but not involved in SNF operations. Table 4.1-3 lists the estimated maximum incremental annual doses to noninvolved workers from atmospheric emissions of radionuclides for each viable technology option for each fuel group. The EPA limit of 10 millirem per year (40 CFR Part 61, Subpart H) is a point of comparison for these doses. (In fact, this EC limit is applicable to offsite individuals from sitewide airborne releases; see Chapter 5). The highest incremental dose to the noninvolved worker would be 0.27 millirem (from Melt and Dilute, Vitrification, or Electrometallurgical Treatment of Materials Test Reactor-like Fuels). Incremental doses to the noninvolved worker from all viable options would be 3 percent or less of the national emission standards for hazardous air pollutants (NESHAP) limit.

There would be no pathways for exposure of personnel inside SNF management facilities from atmospheric releases of radioactivity. Section 4.1.1.3 discusses radiation doses to SNF management workers, including from in-facility airborne releases of radioactivity.

Offsite Doses

Atmospheric doses to the hypothetical maximally exposed offsite individual assume a person who resides at the SRS boundary at the point of maximum exposure. Every member of the public would have a dose less than that received by this individual. Table 4.1-4 lists the estimated maximum incremental annual dose to this individual from atmospheric emissions of radionuclides for each technology option for each fuel group. As with the doses to noninvolved workers, the NESHAP limit of 10 millirem per year (40 CFR Part 61, Subpart H) is a point of comparison. The maximum incremental annual dose from any technology option for a given fuel group would be 0.033 millirem per year (from Melt and Dilute, Vitrification, or Electrometallurgical Treatment of Materials Test Reactor-like Fuels), a factor of 300 less than the EPA limit.

Table 4.1-5 lists the estimated maximum incremental annual population dose (the collective dose to the entire population around SRS) for each viable option. The maximum incremental annual population dose from any option would be 1.2 person-rem per year (from Melt and Dilute, Vitrification, or Electrometallurgical Treatment of Materials Test Reactor-like Fuels).

4.1.1.3 <u>Worker and Public Health</u>

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from the technology options for the management of SNF; it does not include impacts of potential accidents, which are discussed in Section 4.2. DOE based its calculations of health effects from the air- and waterborne radiological releases on (1) the dose to the hypothetical maximally exposed individual

in the public; (2) the collective dose to the population within a 50-mile (80-kilometer) radius around the SRS (approximately 620,000 people); (3) the collective dose to workers involved in implementing a given alternative (i.e., the workers involved in SNF management activities); and (4) the dose to the maximally exposed noninvolved worker (i.e., SRS employees who may work in the vicinity of the SNF management facilities but are not directly involved in SNF work). All radiation doses mentioned in this EIS are effective dose equivalents; internal exposures are committed effective dose equivalents. This section presents total impacts for the entire length of time necessary to implement each technology, using the durations listed in Appendix E. The annual impacts attributable to each phase were multiplied by the duration of that phase. The impacts from all phases were summed to calculate the total impact for the technology. This discussion characterizes health effects as additional lifetime latent cancer fatalities likely to occur in the general population around SRS and in the population of workers who would be associated with the options.

4.1.1.3.1 Radiological Health Effects

Radiation can cause a variety of health effects in people. The major effects that environmental and occupational radiation exposures could cause are delayed cancer fatalities, which are called latent cancer fatalities because the cancer can take many years to develop and cause death.

To relate a dose to its effect, DOE has adopted a dose-to-risk conversion factor of 0.0004 latent cancer fatality per person-rem for workers and 0.0005 latent cancer fatality per person-rem for the general population (NCRP 1993). The factor for the population is slightly higher due to the presence of infants and children who might be more sensitive to radiation than workers, who are, generally speaking, healthy adults.

DOE uses these conversion factors to estimate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to background radiation (0.3 rem per year), DOE would calculate 15 latent cancer fatalities per year caused by radiation (100,000 persons × 0.3 rem per year × 0.0005 latent cancer fatality per person-rem).

Calculations of the number of latent cancer fatalities associated with radiation exposure might not yield whole numbers and, especially in environmental applications, might yield values less than 1. For example, if a population of 100,000 were exposed only to a dose of 0.001 rem to each person, the collective dose would be 100 person-rem, and the corresponding number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatality per person-rem).

DOE also has employed these concepts in estimating the effects of radiation exposure to a single individual. For example, consider the effects of exposure to background radiation over a lifetime. The number of latent cancer fatalities corresponding to an individual's exposure over a (presumed) 72-year lifetime at 0.3 rem per year would be 0.011 latent cancer fatality (1 person × 0.3 rem per year × 72 years × 0.0005 latent cancer fatality per person-rem).

This number should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure to the exposed individual is a 1.1-percent lifetime chance that the individual might incur a latent fatal cancer. Vital statistics on mortality rates for 1994 (CDC 1996) indicate that the overall lifetime fatality rate in the United States from all forms of cancer is about 23.4 percent (23,400 fatal cancers per 100,000 deaths).

These factors, which DOE uses in this EIS to relate radiation exposure to latent cancer fatalities, are based on the *Recommendations of the International Commission on Radiation Protection* (ICRP 1991). They are consistent with the factors used by the U.S. Nuclear Regulatory Commission in its rulemaking *Standards for Protection Against Radiation* (10 CFR Part 20). The factors apply if the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At doses greater than 20 rem, the factors used to relate radiation doses to latent cancer fatalities are doubled. At much higher dose rates, prompt effects, rather than latent cancer fatalities, would be the primary concern.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation; these include nonfatal cancers among the exposed population and genetic effects in subsequent generations. Previous studies have concluded that these effects are less probable than fatal cancers as consequences of radiation exposure (ICRP 1991). Dose-to-risk conversion factors for nonfatal cancers and hereditary genetic effects (0.0001 per person-rem and 0.00013 per person-rem, respectively) are substantially lower than those for fatal cancers. This EIS presents estimated effects of radiation only in terms of latent cancer fatalities because that is the major potential health effect from exposure to radiation. Estimates of nonfatal cancers and hereditary genetic effects can be estimated by multiplying the radiation doses by the effects dose-to-risk conversion factors.

DOE expects minimal worker and public health impacts from the radiological consequences of managing SNF under any of the technology options, as well as Continued Wet Storage. However, some options would result in increased radiological releases. Public radiation doses include doses from airborne releases (Section 4.1.1.2) and liquid releases (Section 4.1.1.1). Table 4.1-6 lists incremental radiation doses estimated for the public (maximally exposed individual and collective population dose) and corresponding incremental latent cancer fatalities, for each fuel group and technology option.

The values in Tables 4.1-6 and 4.1-8 for the No-Action Alternative represent current reactor-area emissions (including two SNF wet basins) for the entire period of analysis. The values for the other alternatives would be incremental above these baseline values. Summing these baseline and incremental values would be conservative, however, because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

DOE based estimated worker doses on past operating experience and the projected durations for implementation of the alternative actions (Bickford et al. 1997). For the maximally exposed worker, DOE assumed that no worker would receive an annual dose greater than 500 millirem from any option because SRS uses the 500-millirem value as an administrative limit for normal operations; that is, an employee who receives an annual dose approaching the administrative limit normally is reassigned to duties in a nonradiation area. (Note: If DOE privatized the Transfer and Storage Facility or treatment operations, the licensee would adopt NRC worker dose limits, and administrative limits could be subject to adjustment.) Tables 4.1-7 and 4.1-8 estimate radiation doses for the collective population of workers who would be directly involved in implementing the options and for the noninvolved worker (a worker not directly involved with implementing the option but located 2,100 feet [640 meters] from the SNF facility) for each fuel group and technology option. These tables also list the latent cancer fatalities likely attributable to the doses. TC

Of the fuels considered for treatment (all except higher actinide targets and non-aluminum clad fuel), the highest expected radiological health effects to the public generally would occur under conventional processing. The single exception would be fewer latent cancer fatalities predicted for the population from the conventional processing of uranium and thorium metal fuels (Table 4.1-6). For the noninvolved workers, the conventional processing of Groups C and D fuels would result in the greatest radiological health effects. No measurable incremental increases would be likely for the higher actinide targets or the non-aluminum-clad fuels for any option because the only options applied to those groups are repackaging and continued wet storage. The estimated collective dose for workers who would be directly involved in managing SNF (Table 4.1-7) depends largely on the difference in the number of workers involved in each option and not on the difference in the amount of radioactivity.

The estimated number of latent cancer fatalities in the public listed in Table 4.1-6 can be compared to the projected number of fatal cancers (145,100) in the public around the SRS from all causes (as discussed in Section 3.7.1). Similarly, the estimated number of latent cancer fatalities in the worker population can be compared to the number in the worker population from all causes (approximately 23.4 per- cent; see Section 3.7.1). In all cases, the incremental impacts from the options would be negligible.

4.1.1.3.2 Nonradiological Health Effects

DOE evaluated the range of chemicals to which the public and workers would be exposed due to SNF management activities and expects minimal health impacts from nonradiological exposures. Section 4.1.1.1.1 discusses offsite chemical concentrations from air emissions. DOE estimated worker impacts and compared them to Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) or ceiling limits for protecting worker health, and concluded that all impacts would be 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 4.1-9 summarizes the values of Permissible Exposure Limits that DOE compared to the data in Tables F-1 through F-5 in Appendix F.

4.1.1.4 <u>Waste Generation</u>

This section presents waste generation estimates for each technology option and fuel group that DOE considers in this EIS. Tables 4.1-10 through 4.1-13 list these estimates. For each technology option, this analysis considered three handling phases as potential sources of waste: wet storage (pretreatment storage), treatment or conditioning, and dry storage (post-treatment storage pending final disposition). The period and waste generation rate associated with each phase varied depending on the fuel group and the technology. As discussed above, DOE summed waste volumes from each phase; the values listed in the tables represent the total projected waste volumes for each technology option in a given fuel group.

DOE used the annual waste generation rates to calculate the estimates in the tables (Bickford et al. 1997); the rates are based on applicable current and past SRS operations or on process

Table 4.1-9. Permissible Exposure Limits (milligrams per cubic meter) of nonradiological air pollutants regulated by the Occupational Safety and Health Administration.[a]

Pollutant	Averaging time	OSHA PEL[b]
Carbon monoxide	8 hours	55
Nitrogen oxides	1 hour	9[c]
Sulfur dioxide	8 hours	13
Carbon dioxide	8 hours	9,000
Nitric acid	8 hours	5

a. Source: 29 CFR Part 1910.1000.
b. Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL).

c. OSHA ceiling limit not to be exceeded at any time during the workday.

knowledge for new treatment technologies. The operating history that was the basis for these estimates would maximize projected waste generation rates. As described in Section 3.8, the Site generates several types of waste (high-level, transuranic, mixed, hazardous, low-level, and sanitary). Wastes generated by SNF management activities would be comparable to wastes the SRS currently handles and would, therefore, not require unique treatment, storage, or disposal actions. This section does not consider sanitary waste, the production of which would be in direct proportion to the number of employees, because none of the technologies would increase the number of permanent Site employees.

DOE has implemented an aggressive waste minimization and pollution prevention program at SRS at the sitewide level and for individual organizations and projects. As a result, significant reductions have been achieved in the amounts of wastes discharged into the environment and sent to landfills, resulting in significant cost savings.

L1-5 To implement a waste minimization and pollution prevention program at the SNF management facilities, DOE would characterize waste streams and identify opportunities for reducing or eliminating them. Emphasis would be placed on minimizing the largest waste stream, low-level waste, through source reduction and recycling. Selected waste minimization practices could include: (1) process design changes to reduce the potential for spills and to minimize contamination areas, (2) decontamination of equipment to facilitate reuse, (3) recycling metals and other usable materials, especially during the construction phase of the project, (4) preventive maintenance to extend process equipment life, (5) modular equipment designs to isolate potential failure elements to avoid changing out entire units, and (6) use of non-toxic or less toxic materials to prevent pollution and minimize hazardous and mixed waste streams.

EC The following sections describe the differences in waste generation by waste type among the SNF management technologies considered in this EIS.

4.1.1.4.1 High-Level Waste

SRS reports high-level waste as liquid high-level waste, and in the related quantities of equivalent Defense Waste Processing Facility (DWPF) canisters and saltstone. The volume estimates for liquid high-level waste reported in Table 4.1-10 are for volumes as they leave the process and enter the high-level waste tanks. While it is necessary to consider this volume when evaluating the interim storage of high-level waste in the tank farms, the volume of liquid high-level waste is not meaningful when considering the storage and disposition of final waste forms. The liquid waste is evaporated and concentrated in the high-level waste tanks. The generation of secondary waste in the high-level waste tanks and DWPF, including waste generated as a result of activities described in this SNF EIS, is evaluated in the DWPF Supplemental EIS (DOE 1994). Therefore, capacity for management of SNF secondary waste in the tank farms and DWPF is provided within the scope of DWPF operations. DWPF canisters and saltstone are the product of liquid high-level waste treatment and evaporation and would be the basis for final storage and disposition considerations. Because the production of saltstone and DWPF canisters from a given liquid waste volume are generally proportional, this discussion applies equally to DWPF canisters and saltstone. For Conventional Processing, DWPF canisters would be the only product to be disposed in a geologic repository. EC TC

Conventional Processing is the only option that would generate significant quantities of high-level waste during the treatment phase. Each option would produce high-level waste during the wet storage phase and technologies such as melt and dilute, that require off-gas collection systems, would also produce high-level waste, but the quantity produced generally would be much lower than that associated with Conventional Processing. The waste generated during wet storage and new technology processing operations would not meet the formal definition of high-level waste (waste resulting from the processing of SNF), but would consist of such items as deionizer backwash and off-gas collection products, which the SRS typically manages (or would manage) as high-level waste. The lengthy period associated with continued wet storage generally would make it the second largest producer of high-level waste. For the higher actinide targets, Conventional Processing was not considered, making Continued Wet Storage the greatest potential for high-level waste production. The volumes of high-level waste generated by the other options would vary depending on the duration of storage and the amount of fissile material in the fuel, but would be fairly comparable within a given fuel type and substantially less than the volumes associated with conventional processing. In addition, the condition of the fuel would influence the high-level waste generation rate (i.e., fuel in poor condition would result in higher generation of deionizer backwash).

Based on the capacities of the high-level waste tank farms and the current volume of high-level waste in storage (see Table 3.8-2), these projected high-level waste volumes probably would not require additional treatment and storage facilities beyond those currently available at SRS. DOE bases this conclusion on continued removal and treatment of the existing tank farm inventory. DWPF would be available to treat these projected high-level waste volumes.

4.1.1.4.2 Transuranic Waste

For all applicable fuel types, conventional processing would produce the largest volume of transuranic waste due to a higher generation rate and a longer processing time. Conventional processing of all applicable fuel groups would generate 3660 cubic meters of transuranic waste which is 29 percent of the total SRS transuranic waste generation forecast (Table 3.8-1). The next largest quantity that could be generated would be from the Vitrification and Electrometallurgical Treatments of all applicable fuel groups. Those technologies would generate 700 cubic meters of transuranic waste over the life of the project, which is less than 6 percent of the total SRS transuranic waste generation forecast. These two technologies would produce 9 to 37 percent of that produced by conventional processing, depending on the fuel group.

None of the treatment options associated with the higher actinide targets or non-aluminum-clad fuels would produce transuranic waste.

4.1.1.4.3 Hazardous/Low-Level Mixed Waste

For this EIS analysis, DOE grouped hazardous and low-level mixed wastes together because none of the options is likely to produce significant quantities of either.

The highest hazardous/low-level mixed waste generation rates would be associated with Vitrification and Electrometallurgical Treatments, followed by Mechanical Dilution. However, due to the longer time required to process the loose uranium oxide in cans, the Materials Test Reactor-like fuels, and the highly enriched uranium/low enriched uranium (HEU/LEU) oxides and silicides requiring resizing or special packaging, conventional processing would produce the largest volume of hazardous or mixed waste for those fuel groups. Vitrification and Electrometallurgical Treatments generally would produce the next largest quantities (35 to 88 percent of that produced by conventional processing, depending on the fuel group). For the uranium and thorium metal fuels, Vitrification and Electrometallurgical Treatments produce the largest quantities of hazardous/low-level mixed waste, followed by conventional processing. For applicable fuel groups, the Direct Disposal/Direct Co-Disposal technology would consistently produce the smallest quantities of hazardous or mixed waste. The waste volumes that continued wet storage or the Melt and Dilute technology would produce would be roughly comparable and generally intermediate among the technologies. For the higher actinide targets, the two technologies being considered (Repackage and Prepare to Ship and Continued Wet Storage) would produce small, comparable quantities of hazardous or mixed waste.

When all applicable technologies are considered, conventional processing would generate the largest volume (264 cubic meters) of hazardous and low-level mixed waste, which is less than 1 percent of the 30-year forecast.

4.1.1.4.4 Low-Level Waste

The Direct Disposal/Direct Co-Disposal and Repackage and Prepare to Ship technology options would produce the least low-level waste. The Mechanical Dilution and Melt and Dilute options would produce intermediate quantities of low-level waste, between 9 and 37 percent of the maximum volume generated and within approximately 150 percent of the minimum volume, depending on the fuel group. For applicable fuel groups, conventional processing would produce the most low-level waste. In each case, continued wet storage would produce the next highest volume due to the combined effect of storage time and generation rate. When all applicable fuel groups are included, conventional processing would generate 138,200 cubic meters of low-level waste (29 percent of the SRS low-level waste 30-year forecast) and continued wet storage would generate 56,650 cubic meters (12 percent of the forecast). Of the two options being considered for the higher actinide targets, the Repackage and Prepare to Ship option would produce the smallest quantity of low-level waste, 32 percent of that estimated for Continued Wet Storage.

4.1.1.4.5 By-products of converting SNF into a waste form that is suitable for disposal in a geologic repository

With the exception of continued wet storage under the No-Action Alternative, the technology options would convert the fuels into a waste form that is likely to be suitable for permanent disposal in a geologic repository. The radioactive inventory in the final waste form would be substantially greater than 99 percent of the original fuel inventory. Very small amounts of residual radioactivity would remain in secondary low-level, hazardous/mixed low-level, and transuranic waste streams as illustrated in Figures 4.1-1 through 4.1-7. SRS would use the surplus capacity in existing waste management facilities to treat, store, dispose of, or recycle the secondary waste in accordance with applicable regulations.

The melt and dilute and vitrification technologies would release from the fuel matrix volatile fission products (primarily cesium) from the fuel matrix which would be recovered as illustrated in Figure 4.1-3 and Figure 4.1-5. Residual cesium, strontium, and plutonium from conventional processing (as well as volatile fission products from melt and dilute, and vitrification technology options) would be moved from the high-level waste tanks and separated into a high volume – low radioactivity salt stream and a low volume – high radioactivity slurry. The salt stream would be approximately 95 percent of the total (before separation) volume and the slurry would capture approximately 99.999 percent of the cesium, strontium, and plutonium activity (Choi 1992). The slurry would be encapsulated in glass and poured into canisters at the Defense Waste Processing Facility The canisters would be stored in a Glass Waste Storage Building for ultimate disposal in a geologic repository. The salt stream would be mixed into and solidified with concrete and disposed of in the Z-Area vaults.

4.1.1.4.6 Spent Fuel Canisters

DOE does not consider the SNF canisters resulting from alternate technology options to constitute a waste stream because they would be the end product of the new packaging options or new processing technology options being proposed. Nevertheless, the number of canisters is a useful measure of onsite storage space needed and the volume of the material that, after processing, could possibly be placed in a repository. Table 4.1-14 indicates the numbers of two types of canisters for the various technologies. The 17-inch canister would be used for co-disposal. The 24-inch canister would be used when the technology produces a vitrified product identical

Table 4.1-14. Numbers of spent fuel co-disposal and high-level waste canisters.

Technology	Co-Disposal or Direct Disposal canisters	24-inch high-level waste canisters
Prepare for direct co-disposal	1,400	NA[a]
Repackage and prepare to ship	NA[b]	1
Melt and dilute	400	10
Mechanical dilution[c]	630	10
Vitrification technologies[d]	1,350	10
Electrometallurgical treatment	–	90
Conventional processing[e]	–	150
Continued wet storage	–	41

a. NA = not applicable, since DOE would use Co-Disposal.
b. Canisters would not be required to transfer material to another site.
c. Values were calculated for the press and dilute technology.
d. Values represent dissolve and vitrify and glass material oxidation and dissolution system technologies. The plasma arc technology would produce 490 canisters.
e. Values are for conventional processing the entire SNF inventory.

to the DPWF high-level waste borosilicate glass. After conventional processing, the 24-inch canisters would be stored in DWPF's Glass Waste Storage Building. The number of high-level waste canisters (Table 4.1-14) includes the secondary waste stream components generated by the technologies reported in Table 4.1-10.

4.1.1.5 Utility and Energy Resources

This section describes the estimated utility and energy requirements associated with each technology option under consideration in this EIS. Water, electricity, steam, and diesel fuel would be required to support many of the options. Estimates of water use include domestic water supplies and makeup water for process operations or equipment cooling. Steam is used primarily to heat facilities. Fuel consumption is based on use of diesel generators for backup power. Electrical requirements include that for normal office consumption such as heating, cooling, ventilation, and office equipment, and for specialized process-related equipment. The process equipment and the associated electrical demands would vary from option to option. All technologies would require canister loading and welding equipment. For the Melt and Dilute technology, the resistive heating associated with melting would require additional electricity. For aqueous processing, electrical requirements would include the operation of canyon pumps, circulators or mixers, and denitriting equipment. For Vitrification, electrical equipment would be used for resistive heating and dissolution. For Electrometallurgical Treatment, electricity would be used for resistive melting of fuels, operation of an electrolytic bath for metal purification, final melting of the refined uranium product, and blending down with depleted uranium.

Tables 4.1-15 through 4.1-18 list estimated utility and energy requirements for the technology options applicable to each fuel group. For each option, this analysis considered three handling phases as potential sources of energy consumption: wet storage (pretreatment storage), treatment, and dry storage (post-treatment storage pending final disposition). The durations for these phases are provided in Appendix E. The period and utility use rate associated with each phase would vary depending on the fuel group and the option. As discussed above, DOE summed utility use from each phase; the values listed in the tables represent the total projected utility use for each option in a given fuel group.

DOE used annual utility consumption rates to calculate the estimates in the tables (Bickford et al. 1997); the rates are based on applicable cur-

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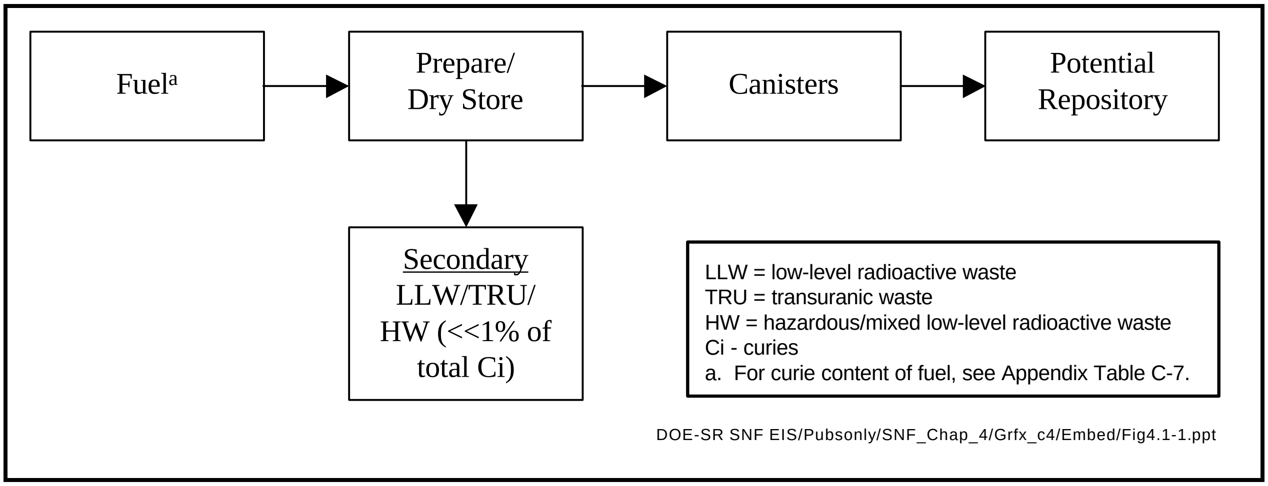

Figure 4.1-1. Type and source of waste streams generated by the Prepare for Direct Co-Disposal technology option.

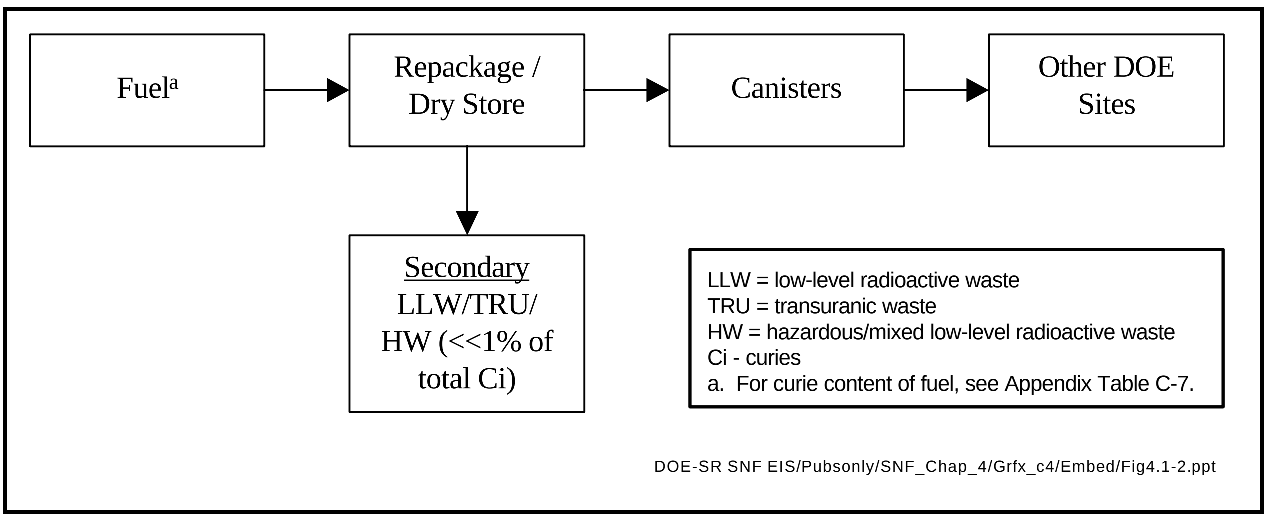

Figure 4.1-2. Type and source of waste streams generated by the Repackage and Prepare to Ship technology option.

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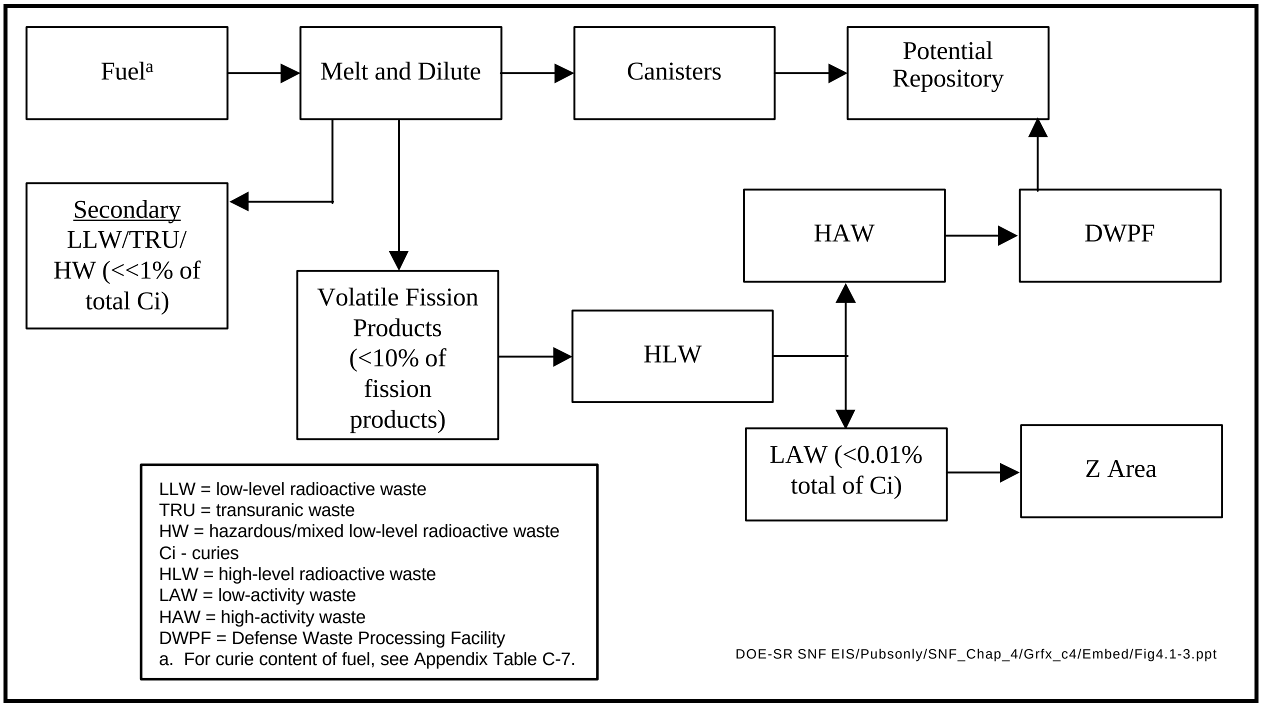

Figure 4.1-3. Type and source of waste streams generated by the Melt and Dilute technology option.

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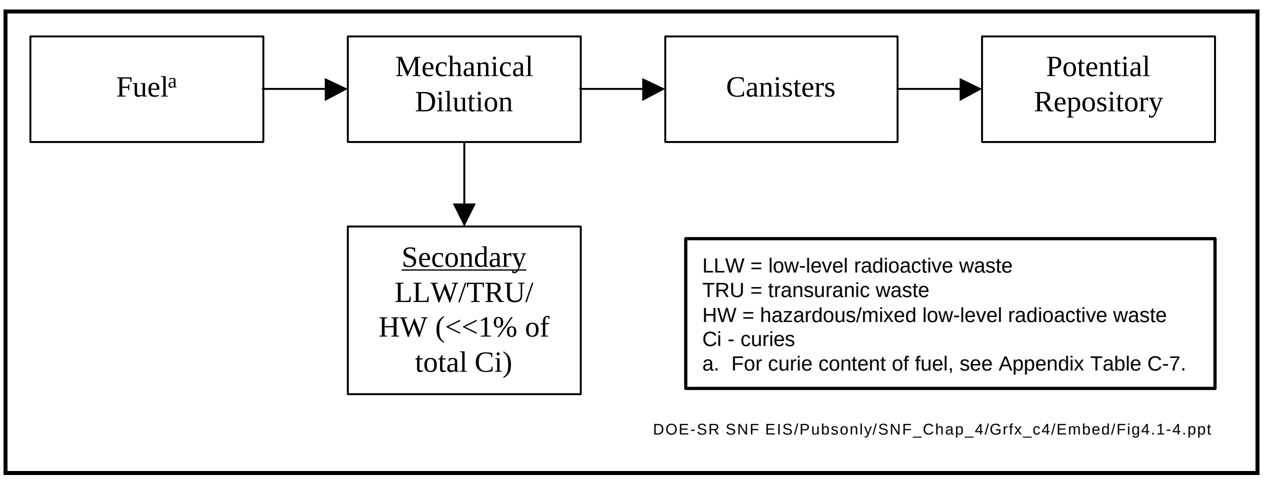

Figure 4.1-4. Type and source of waste streams generated by the Mechanical Dilution technology option.

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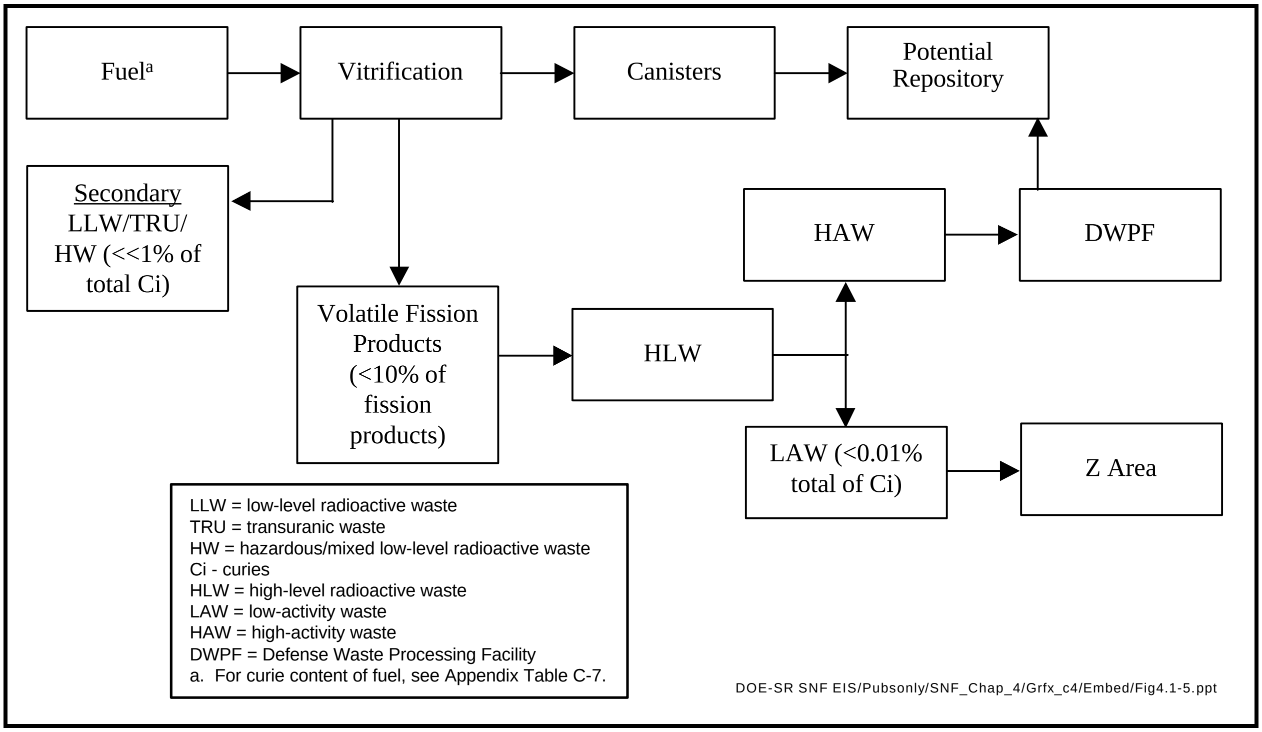

Figure 4.1-5. Type and source of waste streams generated by the Vitrification technology options.

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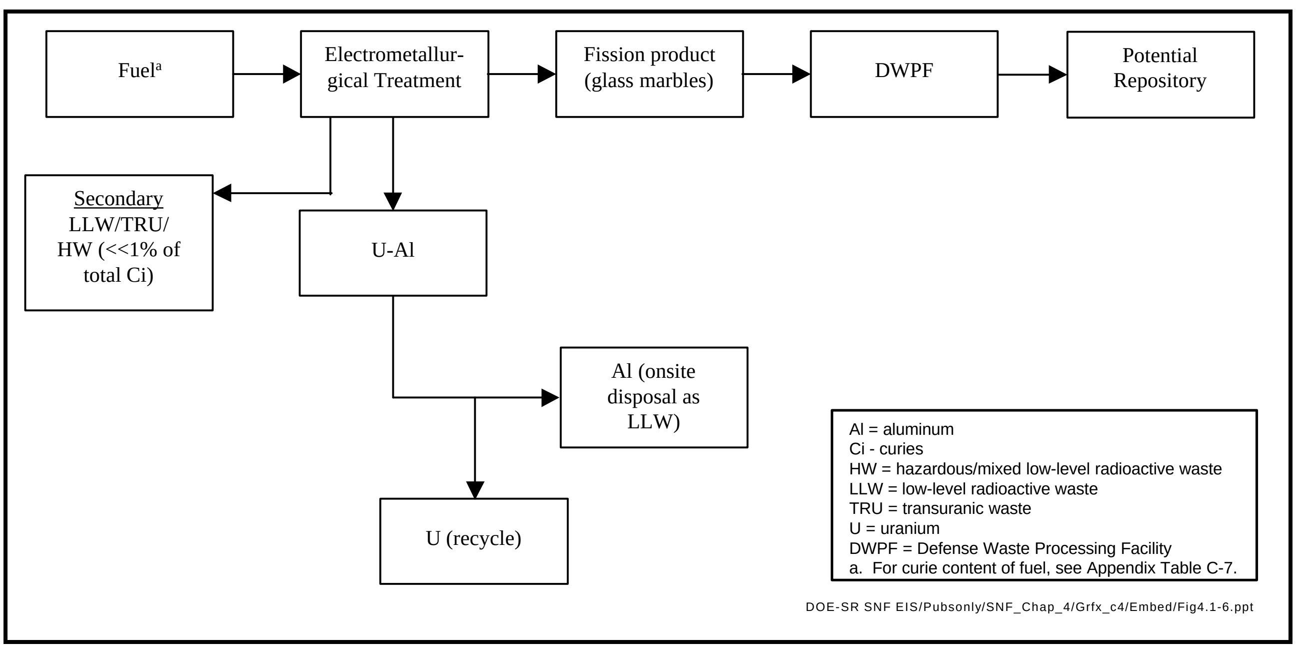

Figure 4.1-6. Type and source of waste streams generated by the Electrometallurgical Treatment technology option.

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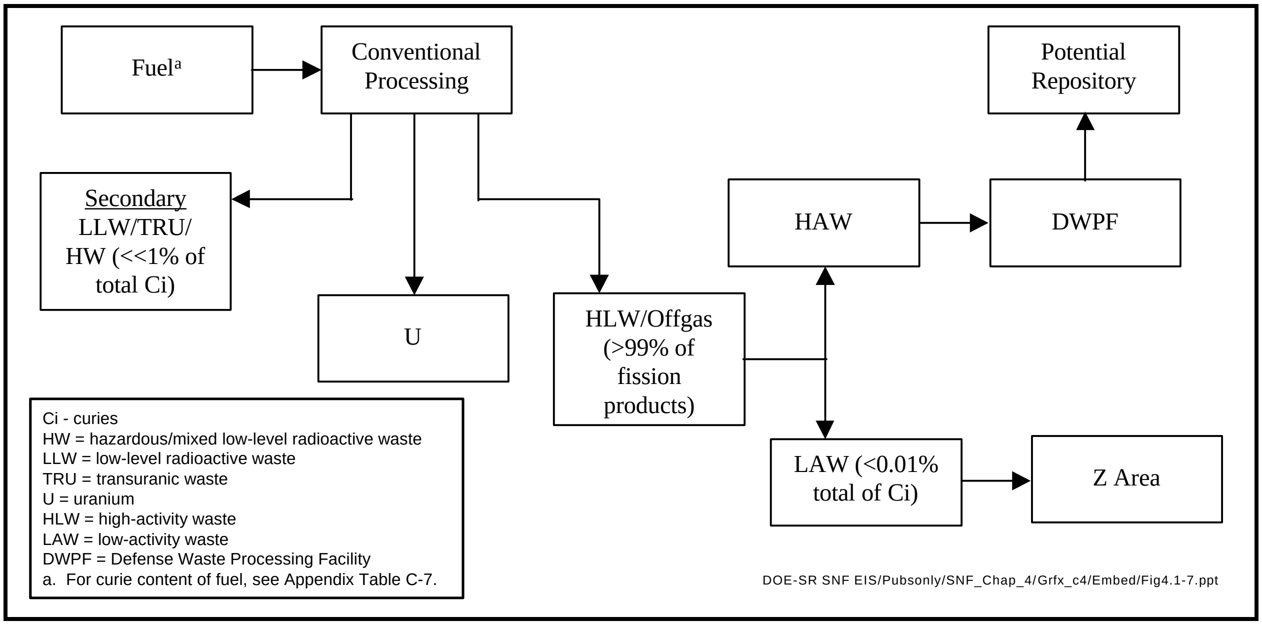

Figure 4.1-7. Type and source of waste streams generated by the Conventional Processing technology option.

rent and past SRS operations or on engineering judgments for new treatment technologies.

The following paragraphs describe estimated utility requirements for the options.

4.1.1.5.1 Water Use

Vitrification and Electrometallurgical Treatment would require the most water, followed by Conventional Processing. Total requirements for Vitrification and Electrometallurgical Treatment of all applicable fuel groups would be less than 6,000 liters per year, (the equivalent of 4.3 gallons per day) which is a minute portion (0.00001 percent) of groundwater withdrawal of more than 5×10^9 liters per year (DOE 1997). Due to the comparatively long period required to process the HEU/LEU oxides and silicides requiring resizing or special packaging (Fuel Group C) and the loose uranium oxide in cans (Fuel Group D), the Conventional Processing technology would require the greatest amount of water for those groups. For the higher actinide targets, Repackage and Prepare to Ship would require 67 percent of the water needed to support the only other option under consideration for that fuel group, Continued Wet Storage. In general, the Direct Disposal/Direct Co-Disposal, Melt and Dilute, Mechanical Dilution, and Repackage and Prepare to Ship technologies would require the least water for their applicable fuel groups, approximately 5 to 6 percent of the maximum requirement for a given group.

4.1.1.5.2 Electricity Use

Vitrification and Electrometallurgical Treatment would have the highest annual demand for electricity, followed by Conventional Processing. Differences in the time necessary to treat a fuel group under different options would affect total electricity requirements. Due to the longer period required to process the materials test reactor-like fuels (Fuel Group B), HEU/LEU oxides and silicides requiring resizing or special packaging (Fuel Group C), and loose uranium oxide in cans (Fuel Group D), Conventional Processing would require the most total electricity for those groups. For the higher actinide targets, Repackage and Prepare to Ship would require less than half the electricity needed to support continued wet storage. In general, for the appropriate fuel groups, the least electricity would be required to support Direct Co-Disposal and Mechanical Dilution.

Annually, the maximum impact alternative electrical demand is 23,600 megawatt-hours, which is approximately 3.5 percent of the current SRS annual usage of 660,000 megawatt-hours.

4.1.1.5.3 Steam Use

Where applicable, Conventional Processing would have the highest annual demand for steam. For higher actinide targets, Repackage and Prepare to Ship would require half the steam needed to support continued wet storage. In general, Direct Co-Disposal and Mechanical Dilution would require the least steam.

4.1.1.5.4 Diesel Fuel Use

For several options, DOE would use diesel fuel to support SNF treatment and storage. On an annual basis, Conventional Processing and Melt and Dilute would need the most diesel fuel. The least diesel fuel would be associated with the Vitrification and Electrometallurgical Treatment technologies, because both would require fuel only to support initial wet storage. The two options that DOE is considering for the higher actinide targets (Repackage and Prepare to Ship and Continued Wet Storage) would require comparable amounts of diesel fuel.

4.1.1.6 Environmental Justice

This section examines whether minority or low-income communities (as defined in Section 3.5.3) could receive disproportionately high and adverse human health and environmental impacts as a result of the actions described in this EIS. Even though DOE does not anticipate adverse health impacts from the options, it analyzed for the possibility of "disproportionately high and adverse human health or environmental effects on minority populations or low-income populations" (Executive Order 12898). Figures 3.5-1 and 3.5-2 show minority and low-income communities by census tract. This section discusses average radiation doses that individuals in those communities could receive and compares them to predicted doses that individuals in the other communities within the 80-kilometer- (50-mile) radius region could receive.

Figure 4.1-8 has SRS as the center of a circle with 22.5-degree sectors and concentric rings from 10 to 50 miles (16 to 80 kilometers) out from the center at 10-mile (16-kilometer) intervals. For this analysis, DOE calculated a fraction of the total population dose for each sector, laid the sector circle over the census tract map, and assigned each tract to a sector. If a tract fell in more than one sector, DOE assigned it to the sector with the largest dose value.

DOE analyzed impacts by comparing the per capita dose that each type of community would receive to doses other types of communities in the same ring would receive. To eliminate the possibility of diluting and masking impacts to a low-population community close to SRS with a high dose per person by including them with impacts to a high-population community farther from the Site, the analysis made comparisons in a series of concentric circles, the radii of which increase in 10-mile (16-kilometer) increments.

To determine the radiation dose received per person in each type of community, the analysis multiplied the number of people in each tract by that tract's dose value to obtain a total community population dose for each tract, summed these population doses in each concentric circle, and divided by the total community population in the circle to get a community per capita dose for each area of the circle. Because the per capita dose for communities (Table 4.1-19) would be constant for every alternative, the relative differences in impacts between communities would also be constant. Thus, Figure 4.1-9 and Table 4.1-19 indicate the distribution of per capita doses to types of communities in the 50-mile (80-kilometer) region. As shown in Figure 4.1-9, atmospheric releases would not disproportionately affect minority communities (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 50-mile region; that is, a comparison

Figure 4.1-8. Annular sectors around the Savannah River Site.

Table 4.1-19. Estimated per capita annual dose (rem) for identified communities in 80-kilometer (50-mile) region.[a]

Distance	Low income: Less than 25 percent of population (rem)	Low income: Equal to or more than 25 percent of population (rem)	Minorities: Less than 35 percent of population (rem)	Minorities: 35 percent to 50 percent of population (rem)	Minorities: Equal to or more than 50 percent of population (rem)	All communities (rem)
0-10 miles (0-16 km[b])	1.1×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.2×10^{-5}	1.0×10^{-5}	1.1×10^{-5}
0-20 miles (0-32 km)	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	7.0×10^{-6}	4.0×10^{-6}	5.0×10^{-6}
0-30 miles (0-48 km)	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	2.0×10^{-6}	3.0×10^{-6}
0-40 miles (0-64 km)	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}	3.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}
0-50 miles (0-80 km)	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}

a. Per capita dose based on a population dose of 1 person-rem. Per capita doses for other population doses can be obtained by multiplying the values in this table by the population dose.
b. km = kilometers.

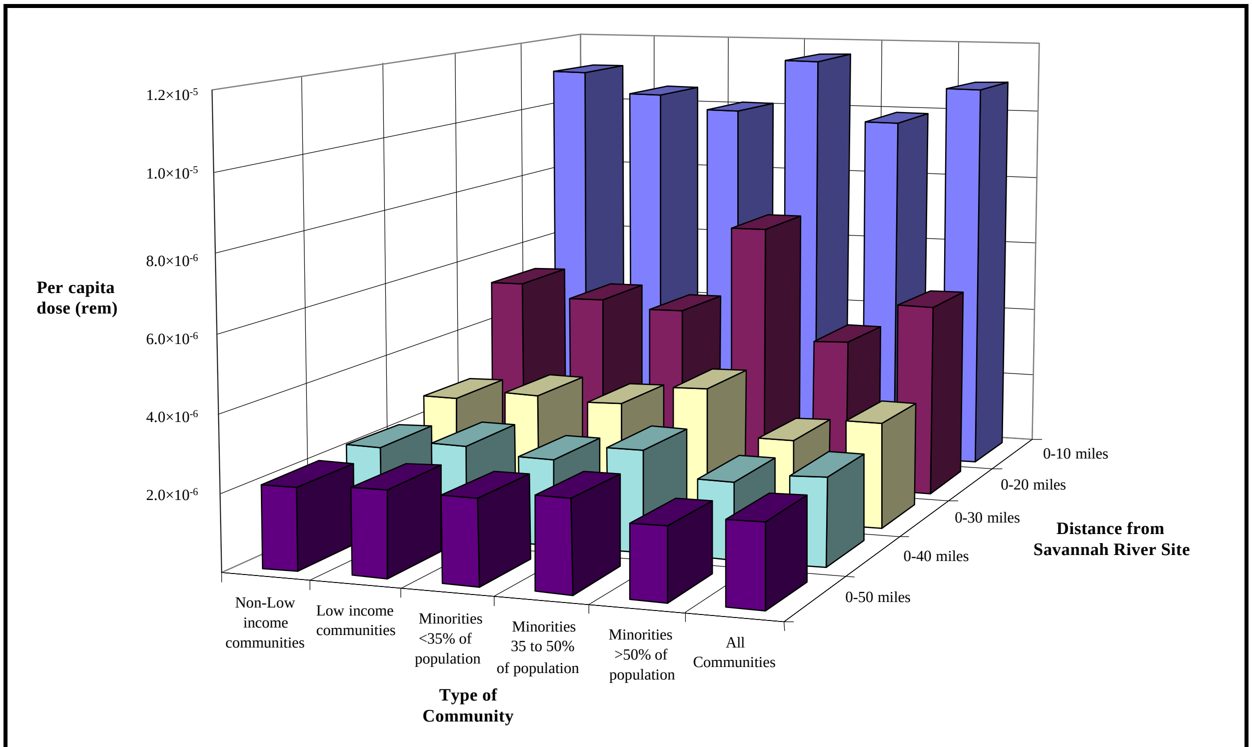

Figure 4.1-9. Distribution of a hypothetical unit population dose among SRS communities.

of per capita doses indicates that they do not vary greatly.

For example, DOE used an annual total population dose of 1 person-rem to prepare Figure 4.1-9 and its supporting data in Table 4.1-19. In comparison, the maximum annual total population dose of 0.56 person-rem for the maximum impact alternative (see Section 4.1.2) would result in 56 percent of the impact shown in Figure 4.1-9 and Table 4.1-19. For any other population dose, the per capita dose for communities can be determined by multiplying that population dose by the values listed in Table 4.1-19.

The distribution of carcinogenic and criteria pollutant emissions from routine operations and of criteria pollutants from construction activities would be essentially identical to those described for airborne radiological emissions because the distribution pathways would be the same. As a result, nonradiological emissions from any option would not cause disproportionate impacts on minority or low-income communities. Because nonradiological pollutant emissions would cause minimal impacts for any option, and because there would not be disproportionate distribution of these impacts among types of communities, environmental justice concerns would not be associated with the alternatives.

4.1.1.7 <u>Transportation</u>

This section discusses the potential radiological consequences of the onsite transportation of SNF and the potential consequences of transportation to a geologic repository. All onsite shipments (those that originate and terminate on SRS) would be by rail. Movements of SNF within an SRS area (e.g., H Area or F Area) are operational transfers, not onsite shipments. The potential consequences of shipping SNF from the SRS to a geologic repository are a conservative (based on worst-case number of shipments and mode of transportation) representation of impacts based on preliminary information. The full analysis of transportation impacts will be included in the EIS for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (currently in preparation).

4.1.1.7.1 Onsite Incident-Free Transportation Analysis [SRS]

The analysis assumed a crew of four engineers for each shipment and that the external dose rate 6.6 feet (2 meters) from the shipping cask was 100 millirem per hour (HNUS 1994a), which is the SRS procedurally-allowed maximum dose rate during onsite fuel shipments. Actual receptor dose rates would depend on receptor distance from the shipping cask (39.4 feet [12 meters]). The duration of exposure would depend on the transport vehicle speed. In addition, vehicle crew time would depend on the distance of each shipment.

Table 4.1-20 summarizes the collective doses (person-rem) and health effects (latent cancer fatalities) associated with a single incident-free onsite shipment of SNF at SRS.

To determine the incident-free transportation dose for management of all SRS spent nuclear fuel, it is necessary to calculate the total dose over all shipments. DOE has estimated that it would take approximately 150 rail shipments to de-inventory the Receiving Basin for Offsite Fuels to the L-Area Disassembly Basin. This action would occur under all alternatives, including the No-Action Alternative. The radiation dose to the crew from these shipments is estimated to be approximately 0.57 person-rem, which could result in 2.3×10^{-4} latent cancer fatalities.

DOE has estimated that it would take approximately 300 rail shipments to transport the contents of the L-Area Disassembly Basin (including the fuel that was previously in the Receiving Basin for Offsite Fuels) to the Transfer and Storage Facility; the Transfer, Storage, and Treatment Facility; or the F- and H-Area Canyons. This action would occur under all alternatives, except the No-Action Alternative. Assuming the bounding location for the

Table 4.1-20. Collective doses and health effects for onsite incident-free SNF shipments.[a]

Shipment origin/destination	Crew dose per shipment (person-rem)	Number of LCFs[b] per shipment
		Crew
L Area/H Area	3.80×10^{-3}	1.52×10^{-6}
L Area/F Area	4.10×10^{-3}	1.64×10^{-6}
F Area/H Area	1.40×10^{-3}	5.60×10^{-7}
P Area/H Area	4.90×10^{-3}	1.96×10^{-6}
P Area/F Area	3.88×10^{-3}	1.55×10^{-6}
C Area/H Area	3.33×10^{-3}	1.33×10^{-6}
C Area/F Area	4.20×10^{-3}	1.68×10^{-6}

a. Derived from HNUS (1994a).
b. LCF = latent cancer fatality.

Transfer and Storage Facility or the Transfer, Storage, and Treatment Facility, the radiation dose to the crew from these shipments is estimated to be approximately 1.23 person-rem which could result in $4.9\text{x}10^{-4}$ latent cancer fatalities. Therefore, for the No-Action Alternative, the total radiation dose to the shipping crew would be approximately 0.57 person-rem, which could result in $2.3\text{x}10^{-4}$ latent cancer fatalities. For all other alternatives, the total radiation dose to the crew would be approximately 1.8 person-rem, which could result in $7.2\text{x}10^{-4}$ latent cancer fatalities.

4.1.1.7.2 Incident-Free Transportation Analysis [Geologic Repository]

DOE estimated the impacts of shipping SNF from SRS to a theoretical geologic repository in the Western United States (approximately 4,000 kilometers [2,500 miles] from SRS) by truck. TC This analysis assumes all shipments from SRS, approximately 1,400 (worst case among the alternatives), would be by truck because the impacts would bound the impacts of rail shipments. Because the transport of SRS spent fuel would use existing highways, it would represent a very small fraction of national highway traffic. Consequently, there would be negligible impacts on land use; air quality; hydrology; biological resources and cultural resources; socioeconomics; noise; aesthetics; utilities, energy, and materials; or waste management. The analysis of the potential impacts of transporting SRS spent nuclear fuel to the repository focuses on the potential radiological impacts to workers and the public.

DOE recognizes that it cannot predict with any certainty the specific routes that would be used to ship SNF to a repository. Nonetheless, the analysis uses current regulations governing highway shipments to select actual highway routes to estimate the potential environmental TC impacts of national transportation. Assumed distances within the various rural, suburban, and urban population zones can be found on Table 4.1-21.

Loading Operations

Prior to shipping the fuel, DOE would load it into NRC certified Type B shipping casks. The potential dose to involved workers from the loading operation would be less than that expected at a commercial nuclear facility because the radionuclide inventory of commercial fuel is higher than that of the DOE SNF. The dose would be further limited by worker rotation and other administrative controls. DOE expects any dose to uninvolved workers would be negligible because they would not have tasks that could result in radiation exposure. Likewise, DOE expects radiation exposure to the public would not occur because of the distance of the loading operations from the areas of public access.

Table 4.1-21. Incident-free radiological impacts of 1,400 offsite truck shipments of spent nuclear fuel to the proposed Yucca Mountain Geologic Repository.

Exposure group	Unit risk factors (person-rem kilometer)[a]			Kilometers traveled		
	Rural	Suburban	Urban	Rural	Suburban	Urban
Occupational	4.6×10^{-5}	1.0×10^{-4}	1.7×10^{-4}	3,292.6	570.2	65.9
Off-link[b]	1.2×10^{-7}	1.6×10^{-5}	1.1×10^{-4}	3,292.6	570.2	65.9
On-link[c]	5.0×10^{-6}	1.5×10^{-5}	1.5×10^{-4}	3,292.6	570.2	65.9
Stops	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}	3,292.6	570.2	65.9

	Collective dose (person-rem)			Total collective dose	LCF[d]
	Rural	Suburban	Urban		
Occupational	212	80	16	308	0.123
General population					
Off-link[b]	1	13	10	24	0.012
On-link[c]	23	12	14	49	0.024
Stops	553	96	11	660	0.330
General population total					0.366

a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.
b. Off-link general population are persons within 800 meters (2,625 feet) of the highway.
c. On-link general population are persons sharing the highway.
d. LCF = latent cancer fatality.

Transportation to a Geologic Repository

To estimate the potential impacts of incident-free transportation of SNF to a repository, the analysis considered both the public and workers. Unit risk factors commonly used in a number of other DOE EISs were used to determine the potential person-rem exposure per kilometer for both workers and public. In the case of the general population, both off-link and on-link doses were calculated. The off-link dose could affect persons within 800 meters (2,625 feet) of the highway; the on-link dose could affect persons sharing the highway. Table 4.1-21 presents the potential incident-free radiological impacts from 1,400 shipments of SNF from the SRS to a theoretical geologic repository. As can be seen from the table, potential latent cancer fatalities could result in less than 1 additional death from radiation over the life of the shipments.

4.1.1.7.3 Onsite Transportation Accident Analysis [SRS]

DOE analyzed radiological impacts from potential accidents to the onsite maximally exposed individual from onsite rail shipments. The analysis calculated doses using the RADTRAN computer code (Neuhauser and Kanipe 1992) with site-specific meteorology, and calculated risk using site-specific rail accident rates and accident probabilities (HNUS 1994b).

The analysis assumed a release of the maximum reasonably foreseeable amount of radioactive material for the type of SNF shipped on SRS (HNUS 1994b). Radiological doses were modeled for three human receptor groups: the onsite worker population, members of the public residing near SRS, and the maximally exposed offsite individual. The consequences are expressed as excess latent cancer fatalities in each receptor group.

Table 4.1-22 summarizes the radiation doses resulting from the most severe reasonably foreseeable onsite transportation accident and associated latent cancer fatalities.

4.1.1.7.4 Transportation Accident Analysis [Geologic Repository]

Potential impacts from accidents resulting from transporting SNF to a geologic repository are not quantified in this document but have been analyzed in the EIS for a Geologic Repository for Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. Previous EISs, including the Foreign Research Reactor Spent Fuel EIS (DOE 1996) and the Programmatic Spent Fuel EIS (DOE 1995b) analyzed the potential accident impacts of transporting SNF. The following discussions summarize the types of accidents that could be expected. Impacts are presented in Table 4.1-23.

Loading Operation

In general, accidents from loading operations could be caused by unplanned contact (bumping) during lifting or handling of casks, canisters, or fuel assemblies. Initiating events could include fires, explosions, earthquakes, cask tornadoes, canister or basket drops, and loaded shipping drops. The Interim Management of Nuclear Materials at SRS EIS (DOE 1995a) assessed the radiological impacts from potential accidents associated with preparing, storing, and onsite shipment of some spent nuclear fuel.

Transportation to a Geologic Repository

Several types of accidents potentially could occur while transporting SNF. The first type of accident, resulting in the most radiological exposure to the public, assumes the breach of a shipping cask during an accident resulting in the release of a fraction of its contents to the air. This accident would be very unlikely. The second type of accident would involve truck wrecks that could result in non-radiological fatalities to workers or members of the public. The probability of an accident is dependent upon the number of shipments made and total miles traveled.

4.1.2 IMPACTS OF THE ALTERNATIVES

As discussed in Chapter 2, none of the options for the management of SNF, except Continued Wet Storage, would address the requirements of all six fuel types. Therefore, DOE must consider combinations of technologies to satisfy the purpose and need identified in Chapter 1. This

Table 4.1-22. Impacts on SRS workers, maximally exposed offsite individuals, and offsite population from SNF transportation accidents on Savannah River Site.

Accident frequency	Worker dose (rem)	Probability of a worker LCF[b]	MEI[c] dose (rem)	Probability of a LCF to the MEI	Population dose (person-rem)	Population LCFs
1.28×10^{-4}	2.78	1.11×10^{-3}	2.2×10^{-5}	1.08×10^{-8}	0.16	8.21×10^{-5}

a. Source: DOE (1995a).
b. LCF = latent cancer fatality.
c. MEI = maximally exposed individual.

Table 4.1-23. Truck transportation accident analysis impacts.

Radiological impacts				Traffic impacts		
Risk factor (person-rem/ shipment)[a]	Maximum number shipments	Total (person-rem)	Total LCFs	Risk factor (fatality/ shipment)[b]	Maximum number shipments	Total fatality
1.79×10^{-5}	1,400	0.025	1.25×10^{-5}	1.12×10^{-4}	1,400	0.16

LCF = latent cancer fatalities.
a. DOE (1996).
b. Adapted from DOE (1999).

section provides the results of analyzing combinations of the technology options applicable to the fuel groups. Excluding continued wet storage, there are more than 700 combinations of technology options and fuel groups that could be analyzed. However, it would be impractical and unreasonable to do so. DOE has identified four sets of combinations for analysis as alternatives in this EIS (in addition to No Action) which it believes are representative. These four alternatives are the Minimum Impact Alternative, Direct Disposal Alternative, Preferred Alternative, and Maximum Impact Alternative. The data in Section 4.1.1 can be used to compile the impacts of other configurations of viable cases.

Continued wet storage for all fuel types is the No-Action Alternative. National Environmental Policy Act (NEPA) regulations require the evaluation of No Action, (which would not meet the purpose and need described in Chapter 1); however, it provides a baseline against which DOE can compare the action alternative combinations.

The second alternative, Minimum Impact, would result in the smallest environmental impacts to human health. It is also the environmentally-preferred alternative.

The third alternative is Direct Disposal. All fuel types that could be dry stored would be. Higher Actinide Targets and Non-Aluminum-Clad Fuels would be Repackaged and Prepared to Ship Offsite. Uranium and Thorium Metal Fuels and Loose Uranium Oxide in Cans would undergo conventional processing.

The fourth alternative is the Preferred Alternative. Melt and Dilute would be used to treat the Materials Test Reactor-like fuels, most of the HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (Group C), and most of the Loose Uranium Oxide in Cans (Group D).
EC Group A and the remaining Group C and Group D fuels (<10 percent of the material in these fuel groups) would be treated with conventional processing. Finally, the Higher Actinide Targets and the Non-Aluminum-Clad fuels would be Repackaged and Prepared to Ship offsite.

The final alternative would apply the chemical processing option to all the fuel except the higher actinide targets and non-aluminum-clad SNF and probably would produce the greatest environmental impacts, and therefore, provides an upper bound. It is termed the Maximum Impact Alternative. Section 2.4 provides a complete description of the SNF management alternatives.

Tables 4.1-24 through 4.1-26 list the impacts of the five alternatives summed from the operational impacts of each appropriate technology presented in Section 4.1.1. The following sections describe the alternatives and the bases for their selection. The conclusions from Section 4.1.1.5 on environmental justice would apply to all the alternatives.

DOE based the values listed for annual radiation dose to the noninvolved worker, the offsite maximally exposed individual, and the 620,000-person population surrounding SRS on the sum of the annual doses for each technology-fuel group included in the alternative. Since the time intervals over which these annual doses would occur might not coincide, this method could overestimate the annual doses that actually would occur.

The values in Table 4.1-26 for health effects to the noninvolved worker, maximally exposed individual, and the offsite population for the No-Action Alternative represent current reactor area emissions (including two SNF wet basins) for the entire period of analysis. The values for the other alternatives would be incremental above these baseline values. Summing these baseline and incremental values would be conservative, however, because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

Table 4.1-24. Estimated maximum incremental concentrations of nonradiological air pollutants for the noninvolved worker.

Pollutant	Averaging Time	Regulatory Standard[a]	No Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
Toxic Pollutants (mg/m³)							
Nitric acid	24-hour	5	0.03	0.02	2.75	2.62	7.95
1,1,1-Trichloroethane	24-hour	1,900	–	–	0.02	0.02	0.05
Benzene	24-hour	3.19	–	–	0.02	0.02	0.05
Ethanolamine	24-hour	6	0.03	0.02	0.02	0.02	0.03
Ethyl benzene	24-hour	435	–	–	0.01	0.01	0.02
Ethylene glycol	24-hour	None	0.03	0.02	0.02	0.02	0.03
Formaldehyde	24-hour	0.75	0.03	0.02	0.02	0.02	0.03
Glycol ethers	24-hour	80	0.03	0.02	0.02	0.02	0.03
Hexachloronaphthalene	24-hour	0.2	0.03	0.02	0.02	0.02	0.03
Hexane	24-hour	1,800	0.03	0.02	0.03	0.03	0.06
Manganese	24-hour	5	–	–	0.01	0.01	0.02
Mercury	24-hour	0.1	–	–	0.01	0.01	0.02
Methyl alcohol	24-hour	260	0.03	0.02	0.02	0.02	0.03
Methyl ethyl ketone	24-hour	590	0.03	0.02	0.02	0.02	0.03
Methyl isobutyl ketone	24-hour	410	–	–	0.01	0.01	0.02
Methylene chloride	24-hour	86.7	–	–	0.02	0.02	0.05
Napthalene	24-hour	50	0.03	0.02	0.02	0.02	0.03
Phenol	24-hour	19	–	–	0.01	0.01	0.02
Phosphorus	24-hour	0.1	–	–	0.01	0.01	0.02
Sodium hydroxide	24-hour	2.0	–	–	0.01	0.01	0.02
Toluene	24-hour	754	0.03	0.02	0.03	0.03	0.06
Trichloroethene	24-hour	537	–	–	0.01	0.01	0.02
Vinyl acetate	24-hour	None	–	–	0.01	0.01	0.02
Xylene	24-hour	435	0.03	0.02	0.05	0.05	0.10
Criteria Pollutants (μg/m³)							
Nitrogen oxides	Annual	NA	–	0.05	38.2	36.4	111
Total Suspended Particulates (total dust)	8-hour	15	–	0.02	0.35	0.34	0.99
Particulate Matter (<10 μm)	8-hour	5	–	0.09	0.08	0.08	0.05
	24-hour	NA	–	0.99	0.86	0.87	0.62
Carbon monoxide	8-hour	55	0.03	0.25	1.81	1.82	4.78
	1-hour	NA	0.03	0.79	5.65	5.68	14.93
Sulfur dioxide	Annual	NA	–	0.02	0.04	0.04	0.08
	8-hour	13	–	0.02	0.31	0.30	0.86
	3-hour	NA	–	0.02	0.72	0.70	2.07
Gaseous fluorides	1-month	None	–	-	0.10	0.10	0.29
	1-week	NA	–	-	0.18	0.17	0.52
	24-hour	NA	–	-	0.55	0.52	1.59
	12-hour	NA	–	-	0.80	0.76	2.32
Ozone (as VOC)	1-hour	0.2	–	nc	nc	nc	nc

– = no air emission associated with this combination.
NA = not applicable.
nc = not calculated.
VOC = volatile organic compound.
a. 29 CFR 1910.1000, Subpart Z and OSHA 8-hour time-weighted averages.

Table 4.1-25. Estimated maximum incremental concentrations of nonradiological air pollutants at the Site boundary.

Pollutant	Averaging Time	Regulatory Standard[a]	No Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative	
Toxic Pollutants (mg/m^3)								
Nitric acid	24-hour	125	–	–	0.11	0.10	0.31	
1,1,1-Trichloroethane	24-hour	9,550	0.03	0.03	0.03	0.03	0.03	
Benzene	24-hour	150	–	–	0.01	0.01	0.02	
Ethanolamine	24-hour	200	0.03	0.03	0.03	0.03	0.03	
Ethyl benzene	24-hour	4,350	–	–	0.01	0.01	0.02	
Ethylene glycol	24-hour	650	0.03	0.03	0.03	0.03	0.03	
Formaldehyde	24-hour	15	0.03	0.03	0.03	0.03	0.03	
Glycol ethers	24-hour	+	0.03	0.03	0.03	0.03	0.03	
Hexachloronaphthalene	24-hour	1	0.03	0.03	0.03	0.03	0.03	
Hexane	24-hour	200	0.03	0.03	0.03	0.03	0.03	TC
Manganese	24-hour	25	–	–	0.01	0.01	0.02	
Mercury	24-hour	0.25	–	–	0.01	0.01	0.02	
Methyl alcohol	24-hour	1,310	0.03	0.03	0.03	0.03	0.03	
Methyl ethyl ketone	24-hour	14,750	0.03	0.03	0.03	0.03	0.03	
Methyl isobutyl ketone	24-hour	2,050	–	–	0.01	0.01	0.02	
Methylene chloride	24-hour	8,750	–	–	0.01	0.01	0.02	
Napthalene	24-hour	1,250	0.03	0.03	0.03	0.03	0.03	
Phenol	24-hour	190	–	–	0.01	0.01	0.02	
Phosphorus	24-hour	0.5	–	–	0.01	0.01	0.02	
Sodium hydroxide	24-hour	20	–	–	0.01	0.01	0.02	TC
Toluene	24-hour	2,000	0.03	0.03	0.03	0.03	0.03	
Trichloroethene	24-hour	6,750	–	–	0.01	0.01	0.02	
Vinyl acetate	24-hour	176	–	–	0.01	0.01	0.02	
Xylene	24-hour	4,350	0.03	0.03	0.03	0.03	0.03	
Criteria Pollutants ($\mu g/m^3$)								
Nitrogen oxide	Annual	100	0.03	0.02	1.17	1.12	3.36	
Total Suspended Particulates	Annual	75	0.03	0.02	0.02	0.02	0.02	
Particulate Matter (<10 μm)	Annual	50	–	–	0.01	0.01	0.02	
	24-hour	150	–	–	0.05	0.04	0.13	
Carbon monoxide	8-hours	10,000	0.03	0.07	0.49	0.50	1.31	
	1-hour	40,000	0.03	0.37	3.60	3.57	9.76	
Sulfur dioxide	Annual	80	–	0.02	0.02	0.02	0.02	
	24-hour	365	–	0.03	0.07	0.07	0.13	
	3-hour	1300	–	–	0.34	0.32	0.98	
Gaseous fluoride	1-month	0.8	–	–	0.01	0.01	0.02	
	1-week	1.6	–	–	0.02	0.01	0.04	
	24-hour	2.9	–	–	0.03	0.02	0.07	
	12-hour	3.7	–	–	0.05	0.04	0.13	
Ozone (as VOC)	1-hour	235	–	0.16	0.38	0.41	0.80	

– = no air emission associated with this option.
+ = no state standard.
VOC = volatile organic compound.
a. SCDHEC standard No. 2 (criteria pollutants) and No. 8 (toxic pollutants). TC

Table 4.1-26. Impacts from alternatives.[a]

Impact	No Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative[b]	Maximum Impact Alternative
TC **Health Effects for the Entire Period of Analysis (1998-2035)**[f]					
MEI[c] dose (millirem)	0.63[d]	6.1×10^{-4}	7.2×10^{-3}	0.19	0.67
MEI LCF[e] probability	3.1×10^{-7}[d]	3.0×10^{-10}	3.6×10^{-9}	9.5×10^{-8}	3.4×10^{-7}
Population dose (person-rem)	22.6[d]	0.022	0.077	6.9	8.7
Population LCFs (unitless)	0.011[d]	1.1×10^{-5}	3.8×10^{-5}	3.4×10^{-3}	4.4×10^{-3}
Collective worker dose (person-rem)	760	690	840	841	2,100
Collective worker LCFs (unitless)	0.30	0.28	0.34	0.33	0.84
Noninvolved worker dose (millirem)	4.25[d]	5.0×10^{-3}	0.02	1.53	1.53
Noninvolved worker LCF probability	1.7×10^{-6}[d]	2.0×10^{-9}	9.6×10^{-9}	6.1×10^{-7}	6.3×10^{-7}
Annual Radiological Air Emission Impacts					
Maximum annual MEI[d] dose (millirem)	0.02[d]	6.1×10^{-4}	7.4×10^{-4}	0.044	0.015
Maximum annual population dose (person-rem)	0.59[d]	0.022	0.027	1.6	0.56
Maximum annual noninvolved worker dose (millirem)	0.11[d]	5.0×10^{-3}	6.0×10^{-3}	0.36	0.12
Annual Radiological Liquid Emission Impacts					
Maximum annual MEI dose (millirem)	0	0	1.4×10^{-3}	4.2×10^{-5}	0.057
Maximum annual population dose (person-rem)	0	0	4.9×10^{-3}	2.4×10^{-4}	0.19
Waste Generation (cubic meters) for the Entire Period of Analysis (1998-2035)					
High-level waste					
Liquid	2,300	660	1,200	1,050	10,500
Equivalent DWPF canisters	38	11	20	17	160
Saltstone	6,100	1,800	3,200	2,700	27,000
Transuranic waste	0	15	360	563	3,700
Hazardous/low-level mixed waste	76	25	46	103	267
Low-level waste	57,000	20,000	31,000	35,260	140,000
Utilities and Energy Required for the Entire Period of Analysis (1998-2035)					
Water (millions of liters)	1,100	660	1,400	1186	8,000
Electricity (megawatt-hours)	46,000	27,000	81,000	116,000	600,000
Steam (millions of kilograms)	340	195	520	650	3,600
Diesel fuel (thousands of liters)	230	180	2,300	2760	22,000

a. In the event that fuel receipts are less than those reported in Chapter 1, the values in this table that report impacts over the entire period of analysis would be less. Instructions for scaling impacts are provided in the appropriate Chapter 4 tables that provide input to this table.
b. In the calculation of preferred alternative impacts, all the HEU/LEU oxides and silicides requiring resizing or special packaging have been accounted for in the melt and dilute technology even though a very small percentage would be conventionally processed. On the other hand, the loose-uranium-oxide-in-cans preferred alternative impacts do consider that 60 percent would be conventionally processed and the remaining 40 percent would be melted and diluted.
c. MEI = maximally exposed offsite individual.
d. Reflects current reactor-area emissions (including two SNF wet basins).
e. LCF = latent cancer fatality.
f. To calculate an annual impact, divide a number by 38. To calculate an impact for a given duration, multiply the annual impact by the duration in years. For example, the annual dose to the MEI from the preferred alternative would be 0.005 mrem (0.17/38). The estimated dose to the MEI until a storage facility would be operational (18 years from now) would be 0.040 mrem (0.005x8). TC

4.1.2.1 No-Action Alternative

Under the No-Action Alternative, SRS would continue to receive shipments of SNF from foreign research reactors, domestic research reactors, and other DOE sites. DOE would store the fuel in the L-Reactor Disassembly Basin or the Receiving Basin for Offsite Fuels, in addition to the currently stored SNF, under continued wet storage, and would ship the non-aluminum-clad fuel from these basins offsite. DOE would maintain the wet storage basins, performing upgrades as necessary to maintain proper water quality. The continued long-term underwater storage of aluminum-based SNF could lead to increased corrosion with increased environmental, health, and safety vulnerabilities. The No-Action Alternative consists of cases A8, B8, C8, D8, E8, and F8 (Table 4.1-27).

4.1.2.2 Minimum Impact Alternative

The identification of the Minimum Impact Alternative required both quantitative and quantitative analyses. The first step identified the minimum-impact technology for each fuel group for each analytical parameter (e.g., volume of high-level waste, air concentrations). However, the selection process often resulted in a combination of high and low impacts among parameters for a specific fuel group-technology combination cases; in other words, no clearly identified “best” or “worst” configuration was identified. Therefore, the second step was a qualitative examination of trends in configurations of cases that identified overall minimum impacts. Human health effects and environmental pollution impacts received slightly greater weight than consumption of natural resources or waste disposal space. In addition, impacts to the general public received slightly greater weight than those to SRS workers. The analysis indicates that cases A1, B1, C1, D3, E2, and F2 would provide minimum impacts (Table 4.1-28). Although other analysts could select different cases, DOE believes that the range of impacts from reasonable choices of minimum-impact scenarios would be small and that the impacts of this combination would be representative of the lower bound of impacts from the proposed action.

4.1.2.3 Direct Disposal Alternative

This alternative combines the New Packaging and the Conventional Processing Technologies. Materials Test Reactor-like fuels and HEU/LEU Oxides and Silicides (except the failed and sectioned fuels) would be treated using the Direct Disposal/Direct Co-Disposal technology and placed in the Transfer and Storage Facility with a minimum of treatment (e.g., cold-vacuum drying and canning). The repackaging of the higher actinide targets and non-aluminum-clad fuels in the Transfer and Storage Facility would use the Repackage and Prepare to Ship technology. The uranium and thorium metal fuel, loose uranium oxide in cans, and failed and sectioned fuel from the HEU/LEU Oxides and Silicides fuel group would be treated using the Conventional Processing Alternative to alleviate the potential health and safety vulnerabilities discussed in Section 2.4.3.2 and because this material probably would not be suitable for placement in a geologic repository if treated with the Direct Disposal/Co-Disposal option. Therefore, the Direct Disposal alternative consists of cases A7, B1, C1, D7, E2, and F2 (Table 4.1-29). TC

4.1.2.4 Preferred Alternative

DOE proposes to implement several of the technologies identified in Section 2.2 to manage spent nuclear fuel at SRS. These technologies are Melt and Dilute, Conventional Processing, and Repackage and Prepare to Ship. Each of these technologies would treat specific groups of spent nuclear fuel, as described below. The technology and fuel group combinations form DOE’s Preferred Alternative in this EIS. The configuration of this preferred alternative is identified in Table 4.1-30.

4.1.2.4.1 Melt And Dilute

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

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

If DOE identifies any health or safety concerns involving any aluminum-based SNF prior to the melt and dilute facility becoming operational, DOE could use F and H Canyons to stabilize the material of concern, if the canyons were not decommissioned.

4.1.2.4.2 Conventional Processing

DOE has identified conventional processing to manage a relatively small volume of aluminum-based SNF at the SRS (about 3 percent by volume; less than 3,000 MTRE) that presents a potential health and safety vulnerability or is in a form that may be unacceptable for placement in a geologic repository. That SNF includes the Experimental Breeder Reactor-II fuel, the Sodium Reactor Experiment fuel, the Mark-42 targets and the core filter block from the Uranium and Thorium Metal fuel group; the failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuels and a Mark-14 target from the HEU/LEU Oxides and Silicides fuel group; and the Sterling Forest Oxide (and any other powdered/oxide fuel that may be received at SRS while H Canyon is still in operation) from the Loose Uranium Oxide in Cans fuel group.

4.1.2.4.3 Repackaging

DOE proposes to repackage the non-aluminum-clad fuel at SRS and transfer the material to dry storage. DOE would transfer the non-aluminum-clad fuel to that facility for storage pending offsite shipment. DOE expects transfer operations would begin in time to support closing the Receiving Basin for Offsite Fuels by 2007. Depending on receipt schedules for research reactor fuels and the operating schedule for the melt and dilute facility, DOE could deinventory the Receiving Basin for Offsite Fuels and move any remain fuel to the Building 105-L wet basin prior to packaging the fuel for dry storage.

The Preferred Alternative would include cases A7, B3, C3, D3, E2, and F2 (Table 4.1-30).

4.1.2.4.4 Continued Wet Storage

DOE proposed to maintain the higher actinide target fuel group in continued wet storage pending decisions on final dispositon.

4.1.2.5 <u>Maximum Impact Alternative</u>

This alternative provides the upper bound on the range of impacts from potential configurations. It would provide conventional processing for all SNF except the higher actinide targets and the non-aluminum-clad fuels selected for offsite shipment and deemed inappropriate for conventional processing. The higher actinide targets would be repackaged for potential offsite shipment and dry-stored until DOE made a decision regarding their disposition. The non-aluminum-clad fuels would be packaged for shipment and dry stored until they were ready for shipment to the Idaho National Engineering and Environmental Laboratory.

Analyses of the maximum impact alternative are conservative in that they assume that the entire SNF inventory would be processed in the canyons, which would produce the greatest impacts of all the treatment options. No credit is taken for discontinuing use of the canyons and processing some of the inventory in a new treatment facility. The Conventional Processing Alternative would include cases A7, B7, C7, D7, E2, and F2 (Table 4.1-31). DOE believes that this combination would provide an upper bound on impacts.

4.2 Accident Analysis

This section summarizes risks to the public and workers from potential accidents associated with the technology options for SNF management at the SRS.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as a human error followed by an explosion, or an earthquake followed by structural failure. A succession of other events, such as a ventilation system failure, that are dependent or independent of the initial event, could affect the magnitude of the accident and the materials released. Initiating events fall into three categories:

- *Internal initiators* normally originate in and around the facility but are always a result of facility operations (equipment or structural failures, human errors, internal flooding).

- *External initiators* are independent of facility operations and normally originate outside the facility (aircraft crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance); some can affect the ability of the facility to maintain confinement of hazardous materials because of structural damage.

- *Natural* phenomena initiators are natural occurrences that are independent of facility operations and of *events* at nearby facilities or operations (earthquakes, high winds, floods, lightning, snow). Natural phenomena initiators could affect external facilities, which could in turn affect other facilities and compound the progression of the accident.

Table 4.2-1 summarizes the estimated impacts to workers and the public from potential accidents for each SNF technology option. All the options would require the use of the Receiving Basin for Offsite Fuels and the L-Reactor Disassembly Basin. All except Continued Wet Storage would require the construction and operation of a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility.

The table lists the impacts of potential accidents in relation to the phases required to implement each option. They list only the accident with the worst impacts based on the maximally exposed offsite individual. Appendix D contains details of the impacts of other postulated accidents. Table 4.2-1 lists potential accident consequences as latent cancer fatalities, without consideration of the accident's probability. The calculation of latent cancer fatalities from population dose is performed in the same manner as for non-accident radiological health effects presented in section 4.1.1.3.1. TC

DOE estimated impacts to three receptors: (1) an uninvolved worker 2,100 feet (640 meters) from the accident location as discussed in DOE (1994), (2) the maximally exposed individual at the SRS boundary, and (3) the offsite population in an area within 50 miles (80 kilometers).

Many of the analysis results presented in Table 4.2-1 are substantially different from those given in the draft EIS. DOE has continued to conduct research and development, including accident analyses, to determine the feasibility of implementing technologies and the potential health and safety consequences of doing so. In some cases design changes have been TC

Table 4.2-1. Estimated maximum consequence accident for each technology.

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

TC

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

TC considered specifically to reduce the potential for accidents with adverse consequences. During that process, assumptions about the design and operation of the proposed technologies have changed. Changes in the assumptions have resulted in changes in the outcome of the accident analyses. Details concerning the analyses are found in Appendix D of this EIS.

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. However, prediction of latent potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the receptor decreases because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The worker also may be acutely.injured or killed by physical effects of the accident itself. DOE identified potential accidents through a detailed hazard assessment and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix D.

TC Results of accident calculations listed in Table 4.2-1 have been updated since the Draft EIS to incorporate evolution of the technology alternatives and to incorporate information that was not available at the time the Draft EIS was prepared.

4.3 Construction Impacts

This section describes environmental impacts that could result from construction activities associated with SNF management at SRS. These activities would include the construction of a Transfer and Storage Facility under theNew Packaging Technology or the construction of a Transfer, Storage, and Treatment Facility under the New Processing Technology or Conventional Processing. DOE does not expect such construction activities to have appreciable impacts on geologic resources, groundwater, traffic, transportation, or cultural resources, as explained below

4.3.1 GEOLOGY AND GROUNDWATER

DOE would confine the construction of new facilities to previously disturbed and developed areas and, therefore, expects little or no environmental impacts to the geologic resources of the area. Neither the construction nor the operation of the proposed Transfer and Storage Facility or Transfer, Storage, and Treatment Facility would affect groundwater in the area. The proposed DOE action to remove stored fuels from existing basins would eliminate a potential source of environmental releases (leaks from wet basins). The Transfer and Storage Facility or Transfer, Storage, and Treatment Facility could include the capability to perform wet receipt and unloading of SNF.

4.3.2 TRAFFIC AND TRANSPORTATION

DOE would transport construction materials, wastes, and excavated materials associated with building the proposed facilities both on and off SRS. These activities would result in increases in the operation of personal vehicles by construction workers, commercial truck traffic, and traffic associated with the daily operations of SRS. However, increases in worker and materials traffic would be small in comparison to existing traffic loads. Increased traffic congestion would be minimal.

4.3.3 CULTURAL RESOURCES

As discussed in Section 3.6, activities associated with the proposed action and alternatives for SNF management at SRS that could affect cultural resources would be the use of the three candidate sites for the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility. These sites are in reactor areas (L, C, and P) within 100 to 400 yards (91 to 366 meters) of the reactor buildings. The Savannah River Archaeological Research Program has not examined these sites. The Site Use Program, which requires a permit for clearing land on the SRS, usually initiates archaeological investigations. DOE would direct an investigation of the selected site before starting facility design and construction. Although there were homesites at or near the proposed facility sites in C and L Areas, the likelihood of historic resources surviving the construction of the reactors in the early 1950s, before the enactment of regulations to protect such resources would be small (Sassaman 1997).

The potential for the presence of prehistoric sites in the candidate locations also is limited. The L-Area site is in archaeological site density Zone 3, which has the least potential for prehistoric sites of significance. The C-Area site is in Zones 2 and 3 and has more potential. Zone 2 includes areas of moderate archaeological site density. The P-Area site is in Zone 2. However, as with any historic sites, reactor construction activities probably destroyed or severely damaged prehistoric deposits. DOE would direct an examination of the selected location for prehistoric resources before starting the design and construction of the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility (Sassaman 1997).

4.3.4 SURFACE WATER RESOURCES

Construction at SRS must comply with the requirements of South Carolina stormwater management and sediment reduction regulations, which became effective in 1992 as part of the Clean Water Act. These regulations and their associated permits require DOE to prepare erosion and sediment control plans for all projects, regardless of the land area. Runoff from the construction site would be part of a stormwater management and sedimentation control plan to minimize potential discharges of silts, solids, and other contaminants to surface-water streams. Effective January 2, 1997, the South Carolina Department of Health and Environmental Control (SCDHEC) approved General Permit coverage for stormwater management and sediment reduction at the SRS (SCDHEC 1996). Although the General Permit does not exempt any land-disturbing and construction activities from the requirements of State stormwater management and sediment control regulations, it does preclude the necessity of SCDHEC plan review and approval for land disturbing and construction activities at the SRS.

Before beginning construction, DOE would develop erosion and sediment control plans for the planned facilities. After construction and depending on the location of the construction site, the *SRS Stormwater Pollution Prevention Plan* (WSRC 1993), which is a requirement of the general NPDES stormwater permit covering industrial activities (Permit SCR000000), would include applicable erosion and sediment control measures; inclusion in the plan would not be necessary if the facility to be constructed was in the drainage area of a stormwater collection system permitted as part of NPDES Permit SC0000175.

4.3.5 AIR RESOURCES

The potential construction of facilities for the management of SNF would cause emissions of fugitive dust (particulate matter) from land-clearing activities and exhaust emissions from construction equipment (earth-moving vehicles, diesel generators). DOE has considered such impacts for activities at SRS that were similar in facility size and application and concluded that impacts to air quality would be minimal (DOE 1995a,b) and would have no effect on SRS compliance with state and Federal ambient air quality standards. Concentrations of pollutants emitted during construction activities would be at least an order of magnitude less than the South Carolina ambient air quality standards.

4.3.6 ECOLOGICAL RESOURCES

DOE is considering three brown field sites for the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility, if they are not constructed in a renovated reactor: C Area, L Area, and P Area. As noted in Section 3.4, the sites would encompass approximately 60,700 square meters (15 acres), including the main building and land required for ancillary facilities. The Treatment Facility could also be constructed on a previously disturbed site inside the F-Area or H-Area fences.

All construction activity for the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility would take place within the boundary of one of the three reactor areas in an already-developed brownfield area. Undeveloped portions of the three proposed sites provide some low-quality wildlife habitat.

Construction of the Transfer and Storage Facility or Transfer, Storage, and Treatment Facility would involve the movement of workers and construction equipment, and would be associated with relatively loud noises from earth-moving equipment, portable generators, pile-driving equipment, pneumatic tools, drills, hammers, and the like. Although noise levels in construction areas could be as high as 110 dBA, these high local noise levels would not extend far beyond the boundaries of the project site.

Table 4.3-1 gives the attenuation of construction noise over relatively short distances. At 120 meters (400 feet) from the construction site, construction noises would range from approximately 60 to 80 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be minimal Potential for disturbing birds and small mammals outside a 120-meter radius from the construction site.

Although noise levels would be relatively low outside the immediate area of construction, the combination of construction noise and human activity probably would displace small numbers of animals (e.g., songbirds and small mammals) that could forage, feed, nest, rest, or den in the area. Construction-related disturbances are likely to create impacts to wildlife that would be small, temporary (approximately 24 months), and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous in these areas. Construction would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any jurisdictional wetlands.

Table 4.3-1. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.[a]

Source	Noise level (peak)	Distance from source			
		50 feet[b]	100 feet	200 feet	400 feet
Heavy trucks	95	84-89	78-83	72-77	66-71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Fork lift	100	95	89	83	77

a. Source: Golden et al. (1980).
b. To convert feet to meters, multiply by 0.3048.

4.3.7 IMPACTS FROM RENOVATING AN EXISTING FACILITY

4.3.7.1 Waste Generation

As discussed in Section 2.3.2.3, DOE could locate the Transfer, Storage, and Treatment Facility in a renovated reactor area, such as the 105-L facility. This would require decontamination and removal of components and systems and subsequent construction activities inside the reactor building and would result in impacts that would not occur during the construction of a virgin facility. Impacts would include generation of radioactive waste during decontamination, removal and construction. DOE has estimated that decontamination and removal and construction activities would result in the generation of approximately 476 m^3 of low-level waste over the total duration of the activities (WSRC 1998). Eventual decontamination and decommissioning (D&D) of the Transfer, Storage, and Treatment Facility (either stand-alone or in a renovated reactor facility) also would result in generation of radioactive waste.

4.3.7.2 Worker Health

DOE could locate the Transfer, Storage, and Treatment Facility in a renovated reactor area, such as the 105-L facility. This would require decontamination and removal of components and systems and subsequent construction activities inside the reactor building and would result in impacts that would not occur during the construction of a virgin facility. Impacts would include radiation exposure of workers performing these activities. The decontamination and removal and construction activities would result in a total collective worker radiation dose of 32 person-rem, based on 54 total workers and a duration of 1 year to complete all activities (Nathen 1998). The collective worker dose is estimated to result in 1.3×10^{-3} latent cancer fatalities. Eventual decontamination and decommissioning (D&D) of the Transfer, Storage, and Treatment Facility (either stand-alone or in a renovated reactor facility) also would result in radiation exposure of D&D workers.

4.3.8 SOCIOECONOMIC IMPACTS

The implementation of the alternatives discussed in this EIS could result in the construction and operation of a Transfer and Storage Facility or a Transfer, Storage and Treatment Facility, which could in turn cause incremental socioeconomic impacts in the SRS area Section 2.3.2 discusses the construction and operation of the Transfer and Storage Facility. Its construction would cost an estimated $200 million. A 2-year construction period would result in a short-term increase of fewer than 500 jobs in the region, approximately 75 percent of which would be in construction. This would be an increase in consruction jobs of approximately 2 percent (from about 16,000) and an increase of considerably less than 1 percent in total employment for the region (REMI 1995). After the 2-year period, employment would return back to its previous equilibrium. The small temporary increases in employment would not present significant impacts to the regional economy, services, or infrastructure. TC

DOE would construct the treatment phase of the Transfer, Storage, and Treatment Facility after the Transfer and Storage phase was constructed; the construction periods would not overlap. The treatment phase would require less effort to construct and would employ fewer construction employees.

None of these construction activities would significantly increase regional employment or population, and socioeconomic impacts would be negligible.

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