CHAPTER 5. CUMULATIVE IMPACTS

In its regulations for implementing the procedural provisions of NEPA, the Council on Environmental Quality (CEQ) defines cumulative impacts as follows: the impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7). The cumulative impacts analysis presented in this chapter is based on the incremental actions associated with the highest potential impact for each resource area considered for all alternatives for HLW tank closure at the SRS, other actions associated with onsite activities, and offsite activities with the potential for related environmental impacts. The highest impact alternative varied based on the resource area being evaluated as shown in the data tables within this chapter.

> DOE has examined impacts of the construction and operation of SRS over its 50-year history. It has analyzed trends in the environmental characteristics of the site and nearby resources to establish a baseline for measurement of the incremental impact of tank closure activities and other reasonably foreseeable onsite and offsite activities with the potential for related environmental impact.

SRS History

In 1950, the U.S. Government selected a large rural area of nearly 400 square miles in southwest South Carolina for construction and operation of facilities required to produce nuclear fuels (primarily defense-grade plutonium and tritium) for the nation's defense. Then called the Savannah River Plant, the facility would have full production capability, including fuel and target fabrication, irradiation of the fuel in five production reactors, product recovery in two chemical separations plants, and waste management facilities, including the high-level waste tank farms (DOE 1980).

Construction impacts included land clearing, excavation, air emissions from construction vehicles, relocation of about 6,000 persons, and the formation of mobile home communities to house workers and families during construction; peak construction employment totaled 38,500 in 1952 (DOE 1980).

Socioeconomic effects stabilized quickly. The largest community on the Site, Ellenton, was relocated immediately north of the Site boundary and was renamed New Ellenton.

Aftereffects of construction are minimal. The site, later reduced to approximately 300 square miles, is predominately (73 percent) open fields and pine and hardwood forests. Twenty-two (22) percent is wetlands, streams, and reservoirs, and only five percent is dedicated to production and support areas, roads, and utility corridors (DOE 1997). The Savannah River Natural Resource Management and Research Institute (SRI) (formerly the Savannah River Forest Station) manages the natural resources at SRS. The SRI supports forest research, erosion control projects, and native plants and animals (through maintenance and improvements to their habitats). SRI sells timber, manages controlled-burns, plants new seedlings, and maintains secondary roads and exterior boundaries (Arnett and Mamatey 1997a).

Normal operations included non-radioactive and radioactive emissions of pollutants to the surrounding air and discharges of pollutants to onsite streams. Impacts to these releases to the environment were minimal. In addition, large withdrawals of cooling water from the Savannah River caused minimal entrainment and impingement of aquatic biota and severe thermal impacts due to the subsequent discharge of the cooling water to onsite streams. The thermal discharges stripped the vegetation along stream channels and adjacent banks and destroyed cypress-tupelo forests in the Savannah River Swamp. Thermal effects did not extend beyond the site boundary. In 1991, DOE committed to

reforest the Pen Branch delta in the Savannah River Swamp using appropriate wetland species and to manage it until successful reforestation had been achieved (56 FR 5584-5587; February 11, 1991).

Groundwater contamination also occurred in areas of hazardous, radioactive, and mixed waste sites and seepage basins. Due to the large buffer area from the center of operations to the site boundary (approximately five miles), offsite effects were minimal. Groundwater contamination plumes did not move offsite, and onsite surface water contamination had minimal effect offsite because they are discharged to the Savannah River and diluted to concentrations that are well below concentrations of concern.

SRS has had a beneficial socioeconomic effect on employment in the region. The operations workforce varied from 7,500 (DOE 1980) to almost 26,000 (Halliburton NUS 1992), and presently numbers approximately 14,000 by February 2000 (DOE 2000a).

Over the years of operation, mitigation measures have substantially reduced onsite environmental stresses. DOE installed a Liquid Effluent Treatment Facility that minimized liquid releases of pollutants except tritium before discharge through a National Pollutant Discharge Elimination System outfall. Direct discharge of highly tritiated disassembly basin purge water to surface streams was replaced by discharge to seepage basins that enabled substantial decay during transport in the groundwater before their eventual outcrop to onsite streams. In addition, DOE eliminated thermal discharges with construction of a cooling lake for L-Reactor operation and a cooling tower intended to support K-Reactor operation.

Other agencies contributed to this trend by improving the quality and regulation of flows in the Savannah River. Five large reservoirs upriver of SRS were constructed in the 1950s through early 1980s. They have reduced peak flows in the Savannah River, moderated flood cycles in the Savannah River Swamp and, with the exception of a severe drought in 1985 through 1988, maintained flows sufficient for water quality and managing fish and wildlife resources downstream (DOE 1990). In 1975, the city of Augusta installed a secondary sewage treatment plant to eliminate the discharge of untreated or inadequately treated domestic and industrial waste into the Savannah River and its tributaries. Similarly, treatment facilities for Aiken County began operation in 1979 (DOE 1987).

In 1988, DOE placed the active site reactors on standby, and the end of the cold war resulted in permanent shutdown. DOE planted wetland hardwood species in 300-400 acres of the Pen Branch delta. Successful reforestation has begun and is ongoing.

Once operations ceased, key indicators of environmental impact decreased rapidly. For example, one discriminator for measuring impacts to human health is the dose to the *maximally exposed offsite individual* (MEI). The impact that it measures is the estimated probability of a latent cancer fatality, which is assumed to be directly proportional to dose. The estimate of latent cancers is, at best, an order of magnitude approximation. Thus an estimate of 10^{-5} latent cancer fatalities is likely between 10^{-6} and 10^{-4}. By 1996, the dose to the MEI (and the associated probability of a latent cancer fatality) decreased to about 1/8th of its 1987 value (Arnett and Mamatey 1997b). Further detail on the MEI is discussed later under public and worker health.

In general, the combination of mitigation measures and post-cold war cleanup efforts demonstrates an environmental trend of protecting and improving the quality of the SRS environment with minimal impact on the offsite environment. Although groundwater modeling indicates that most contaminants in the groundwater have reached their peak concentrations, several slow moving constituents would peak in this millennium at the 100-meter well (DOE 1987). Long-Term Cumulative Impacts are discussed further in Section 5.7 of this chapter.

CEQ Cumulative Effects Guidance

A handbook prepared by CEQ (1997) guides this chapter. In accordance with the handbook, DOE identified the resource areas in which tank closure could add to the impacts of past, present, and reasonably foreseeable actions within the project impact zones as defined by CEQ (1997).

Based on an examination of the environmental impacts of actions resulting from tank closure coupled with DOE and other agency actions, and some private actions it was determined that cumulative impacts for the following areas need to be presented: (1) air resources; (2) water resources; (3) public and worker health; (4) waste generation; (5) utilities and energy consumption; and (6) land use (long-term only). Discussion of cumulative impacts for the following resources is omitted because impacts from the proposed tank closure activities would be so small that their potential contribution to cumulative impacts would be very small: geologic resources, ecological resources, aesthetic and scenic resources, cultural resources, traffic, socioeconomics, and environmental justice.

In accordance with the CEQ guidance, DOE defined the geographic (spatial) and time (temporal) boundaries to encompass cumulative impacts on the five identified resources of concern.

Spacial and Temporal Boundaries

For determining the human health impact from airborne emissions the population within the 50-mile radius surrounding SRS was selected as the project impact zone. Although the doses are almost undetectable at the 50-mile boundary, this is the customary definition of the offsite public. For aqueous releases, onsite streams and the downstream population that uses the Savannah River as its source of drinking water was selected. Analyses revealed that other potential incremental impacts from tank closure, including air quality, waste management, and utilities and energy diminish within or quite near the site boundaries. The effective project impact zone for each of these is identified in the discussions that follow.

Nuclear facilities in the vicinity of SRS include Georgia Power's Plant Vogtle Electric Generating Plant across the river from SRS; Chem-Nuclear Inc., a commercial low-level waste burial site just east of SRS; and Starmet CMI, Inc. (formerly Carolina Metals), located southeast of SRS, which processes uranium-contaminated metals. Plant Vogtle, Chem-Nuclear, and Carolina Metals are approximately 11, 8, and 15 miles, respectively, from the SRS HLW Tank Farms. Other nuclear facilities are clearly too far (greater than 50 miles) to have a cumulative effect. Therefore, the project impact zone for cumulative impacts on air quality from radioactive emissions is 15 miles. Radiological impacts from the operation of the Vogtle Electric Generating Plant, a two-unit commercial nuclear power plant are minimal, but DOE has factored them into the analysis. *The SCDHEC Annual Report* (SCDHEC 1995) indicates that operation of the Chem-Nuclear Services facility and the Starmet CMI facility does not noticeably impact radiation levels in air or water in the vicinity of SRS. Therefore, they are not included in this assessment.

The counties surrounding SRS have numerous existing (e.g., Bridgestone Tire, textile mills, paper product mills, and manufacturing facilities) and planned industrial facilities with permitted air emissions and discharges to surface waters. Because of the distances between SRS and the private industrial facilities, there is little opportunity for interactions of plant emissions and no major cumulative impact on air or water quality. As indicated in results from the SRS Environmental Surveillance program report, ambient levels of pollutants in air and water have remained below regulatory levels in and around the SRS region (Arnett and Mamatey 1998).

An additional offsite facility with the potential to affect the nonradiological environment is South Carolina Electric and Gas Company's Urquhart Station. Urquhart Station is a three-unit, 250-megawatt, coal- and natural-gas-fired steam electric plant in Beech Island, South Carolina, located about 20 river miles and about 18 aerial miles north of SRS. Because of the distance between SRS and the Urquhart Station and the

regional wind direction frequencies, there is little opportunity for any interaction of plant emissions, and no significant cumulative impact on air quality. Thus, the project impact zone for nonradiological atmospheric releases is less than 18 miles.

Finally, utility and energy capacity is available onsite and is too small to affect the offsite region. Similarly, onsite waste disposal capacity can satisfy the quantities generated by tank closure. Thus the extent of the project impact zone (from utilities, energy, and waste generation) is best described as the SRS boundary.

Temporal limits were defined by examining the period of influence from both the proposed action and other Federal and non-Federal actions that have the potential for cumulative impacts. Actions for tank closure are expected to begin in 2001.

With the exception of the long-term cumulative impacts described in Section 5.7, the period of interest for the cumulative impacts analysis for this EIS includes 2000 to 2030.

Reasonably Foreseeable DOE Actions

DOE also evaluated the impacts from its own proposed future actions by examining impacts to resources and the human environment as shown in NEPA documentation related to SRS (see Section 1.6). Additional NEPA documents related to SRS that are considered in the cumulative impacts section include the following:

- *Final Environmental Impact Statement - Interim Management of Nuclear Materials* (DOE/EIS-0220) (DOE 1995a). DOE is in the process of implementing the preferred alternatives for the nuclear materials discussed in the Interim Management of Nuclear Materials EIS. SRS baseline data in this chapter reflect projected impacts from implementation.

- *Final Environmental Impact Statement for the Accelerator Production of Tritium at the Savannah River Site* (DOE/EIS-0270) (DOE 1999a). DOE has proposed an accelerator design (using helium-3 target blanket material) and an alternate accelerator design (using lithium-6 target blanket material). If an accelerator were to be built, it would have been located at SRS. However, since the record of decision (64 FR 26369; May 14, 1999) states the preferred alternative as use of an existing commercial light-water reactor, data from this EIS are not used.

- *Environmental Assessment for the Tritium Facility Modernization and Consolidation Project at the Savannah River Site* (DOE/EA-1222) (DOE 1997). This environmental assessment addresses the impacts of consolidating the tritium activities currently performed in Building 232-H into the new Building 233-H and Building 234-H. Tritium extraction functions will be transferred to the Tritium Extraction Facility. The overall impact will be to reduce the tritium facility complex net tritium emissions by up to 50 percent. Another positive effect of this planned action will be to reduce the amount of low-level radioactive job-control waste. Effects on other resources will be negligible. Therefore, impacts from the environmental assessment have not been included in this cumulative impacts analysis.

- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (DOE/EIS-0240) (DOE 1996). This cumulative impacts analysis incorporates blending highly enriched uranium at SRS to 4 percent low-enriched uranium as uranyl nitrate hexahydrate, as decided in the Record of Decision (61 FR 40619, August 5, 1996).

- *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site* (DOE/EIS-0277F) (DOE 1998a). As stated in the record of decision (64 FR 8068; February 18, 1999), DOE will process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site. These materials are plutonium residues and

scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at Rocky Flats. DOE has decided to ship certain residues from the Rocky Flats Environmental Technology Site to SRS for plutonium separation and stabilization. The separated plutonium will be stored at SRS pending disposition decisions. Environmental impacts from using F Canyon to chemically separate the plutonium from the remaining materials at SRS are included in this section.

- *Draft and Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site* DOE/EIS-0271) (DOE 1998b, 1999b). As stated in the record of decision (64 FR 26369; May 14, 1999), DOE will construct and operate a Tritium Extraction Facility on SRS to provide the capability to extract tritium from commercial light water reactor targets and targets of similar design. The purpose of the proposed action and alternatives evaluated in the EIS is to provide tritium extraction capability to support either accelerator or reactor tritium production. Environmental impacts from the maximum processing option in both the draft and final EISs are included in this section. The final EIS presents responses to public comments and a record of changes to the draft EIS.

- *Surplus Plutonium Disposition Final Environmental Impact Statement* (DOE/EIS-0283) (DOE 1999d). This EIS analyzed the activities necessary to implement DOE's disposition strategy for surplus plutonium. As announced in the Record of Decision (65 FR 1608; January 11, 2000), SRS was selected for three disposition facilities, pit (a nuclear weapon component) disassembly and conversion, plutonium conversion and immobilization, and mixed oxide fuel fabrication. The DOE decision allows the immobilization of approximately 17 metric tons of surplus plutonium and the use of up to 33 metric tons of surplus plutonium as mixed oxide fuel. Both methods in this hybrid approach ensure that surplus plutonium produced for nuclear weapons is never again used for nuclear weapons. Impacts from this EIS are included in this section.

- *Defense Waste Processing Facility (DWPF) Supplemental Environmental Impact Statement* (DOE/EIS-0082-S) (DOE 1994). The selected alternative in the Record of Decision (60 FR 18589, April 12, 1995) was the completion and operation of the DWPF to immobilize HLW at the SRS. The facility is currently processing sludge from SRS HLW tanks. However, SRS baseline data are not representative of full DWPF operational impacts, including processing of salt and supernate from these tanks. Therefore, the DWPF data are listed separately.

- *Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE/EIS-0306) (DOE 2000b). DOE has prepared a Final EIS for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel (65 FR 47987, August 4, 2000). One of the alternatives evaluated in the EIS would involve processing INEEL's sodium-bonded fuel inventory at SRS using the Plutonium-Uranium Extraction process. Because processing at SRS is a reasonable alternative to processing of INEEL, it has been included in this cumulative impact analysis. This method of stabilization of spent nuclear fuel could be used for the sodium-bonded spent nuclear fuel, most of which is currently in storage at INEEL. There are approximately 22.4 metric tons of heavy metal (MTHM) of Experimental Breeder Reactor-II (EBR-II) fuel and 34.2 MTHM of Fermi-1 fuel to be processed. This fuel would be declad before shipment to SRS. Because the decladding activities would occur at INEEL, the impacts of these decladding activities are not included in this chapter.

In the Record of Decision (65 FR 56565; September 19, 2000), DOE decided to electrometallurgically treat the EBR-II fuel at Argonne National Laboratory-West. However, due to the different characteristics of the Fermi-1 fuel, DOE decided to continue

to store this material while alternative treatments are evaluated.

- *Savannah River Site Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279)* (DOE 2000c). The proposed DOE action described in this EIS is to implement appropriate processes for the safe and efficient management of spent nuclear fuel and targets at SRS, including placing these materials in forms suitable for ultimate disposition. Options to treat, package, and store this material are discussed. The material included in this EIS consists of approximately 68 MTHM of spent nuclear fuel (20 MTHM of aluminum-based spent nuclear fuel at SRS, as much as 28 MTHM of aluminum-clad spent nuclear fuel from foreign and domestic research reactors to be shipped to SRS through 2035, and 20 MTHM of stainless-steel or zirconium-clad spent nuclear fuel and some programmatic material stored at SRS for repackaging and dry storage pending shipment offsite).

  In the Record of Decision (65 FR 48224; August 7, 2000), DOE decided to implement the Preferred Alternative. As part of the Preferred Alternative, DOE will develop and demonstrate the Melt and Dilute technology. Following development and demonstration of the technology, DOE will begin detailed design, construction, testing, and startup of a Treatment and Storage Facility (TSF). The SNF will remain in wet storage until treated and placed in dry storage in the TSF.

  DOE also decided to use conventional processing to stabilize about 3 percent by volume and 40 percent by mass of the aluminum-based SNF. DOE also decided to continue to store small quantities of higher actinide materials until DOE determines their final disposition. Finally, DOE decided to ship non-aluminum-based SNF from the SRS to the Idaho National Engineering and Environmental Laboratory.

Other materials under consideration for processing at SRS canyons include various components currently located at other DOE sites, including Oak Ridge, Rocky Flats, Los Alamos, and Hanford. These materials, which were identified during the processing needs assessment, consist of various plutonium and uranium components. If DOE were to propose to process these materials in the SRS chemical separations facilities, additional NEPA reviews would need to be performed. In this chapter, estimates of the impacts of processing these materials (DOE 2000b) have been included in the cumulative analysis. These estimates are qualitative because DOE has not yet proposed to process the materials. When considering cumulative impacts, the reader should be aware of the indeterminate nature of some of the actions for which impacts have been estimated.

In addition, the cumulative impacts analysis includes the impacts from actions proposed in this EIS. Risks to members of the public and site workers from radiological and nonradiological releases are based on operational impacts from the alternatives described in Section Chapter 4.

The cumulative impacts analysis also accounts for other SRS operations. Most of the SRS baseline data are based on 1998 environmental report information (Arnett and Mamatey 1999), which are the most recent published data available.

5.1 Air Resources

Table 5-1 compares the cumulative concentrations of nonradiological air pollutants from the SRS, including the tank closure alternative with the largest impact (the Saltstone Option under the Clean and Stabilize Tanks Alternative) to Federal and State regulatory standards. The listed values are the maximum modeled concentrations that could occur at ground level at the site boundary. The data demonstrate that total estimated concentrations of nonradiological air pollutants from SRS would in all cases be below the regulatory standards at the site boundary.

The highest percentages of the regulatory standards are for sulfur dioxide concentrations for the shorter time interval (approximately

Table 5-1. Estimated maximum cumulative ground-level concentrations of nonradiological pollutants (micrograms per cubic meter) at SRS boundary.[a]

Pollutant[b]	Averaging time	SCDHEC ambient standard (μg/m^3)[c]	SRS baseline[d] (μg/m^3)	Tank closure[e] (μg/m^3)	Other foreseeable planned SRS activities[f] (μg/m^3)	Maximum cumulative concentration[g] (μg/m^3)	Percent of standard
Carbon monoxide	1 hour	40,000	10,000	3.4	46.4	10,050	25
	8 hours	10,000	6,900	0.8	6.5	6,907	69
Oxides of nitrogen	Annual	100	26	0.07	7.7	33.8	34
Sulfur dioxide	3 hours	1,300	1,200	0.6	9.7	1,210	93
	24 hours	365	350	0.12	2.6	352.7	97
	Annual	80	34	0.006	0.19	34.2	43
Ozone[h]	1 hour	235	NA[i]	2.0	1.51	3.5	1.5
Lead	Max. quarter	1.5	0.03	4.1×10^{-6}	<0.00001	0.03	2
Particulate matter (≤10 microns aero-dynamic diameter)[h]	24 hours	150	130	0.06	3.37	133.43	89
	Annual	50	25	0.03	0.15	25.2	50
Total suspended particulates (μg/m^3)	Annual	75	67	0.005	0.08	67.1	90

a. DOE (1994, 1996, 1997, 1998a,b, 1999c,d; 2000b,c).
b. Hydrochloric acid, formaldehyde, hexane, and nickel are not listed in Table 5-1 because tank closure or other foreseeable, planned SRS activities would not result in any change to the SRS baseline concentrations of these toxic pollutants.
c. SCDHEC (1976).
d. Source: Table 3.3-3.
e. Data based on the Saltstone Option under the Clean and Stabilize Tanks Alternative (Table 4.1.3-2).
f. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.
g. Includes tank closure concentrations.
h. New NAAQS for ozone (1 hr replaced by 8 hr standard = 0.08 ppm) and particulate matter ≤ 2.5 microns (24 hr standard = 65 μg/m^3 and annual standard of 15 μg/m^3) may become enforceable during the stated temporal range of the cumulative impacts analyses.
NA = Not available.
μg/m^3 = micrograms per cubic meter.

97 percent of standard for the 24-hour averaging time and 93 percent of the standard for the 3-hour average time), for particulate matter of less than 10 microns (approximately 89 percent of standard for the 24-hour averaging time), and total suspended particulates (approximately 90 percent of standard). The remaining pollutant concentrations would range from under 2 to 69 percent of the applicable standards. The majority of the concentration comes from estimated SRS baseline concentrations and not tank closure and other foreseeable actions. The incremental impact from tank closure would not be noticeable. Also, it is unlikely that actual concentrations at ambient monitoring stations would be as high as that shown for the SRS baseline values. The SRS baseline values are based on the maximum potential emissions from the 1998 air emissions inventory and for all SRS sources, and observed concentrations from nearby ambient air monitoring stations.

DOE also evaluated the cumulative impacts of airborne radioactive releases in terms of dose to a maximally exposed individual at the SRS boundary and dose to the 50-mile population (see Table 5-2). Although comparable results for Plant Vogtle were not available for the nonradiological analysis (Table 5-1), DOE included the impacts of Plant Vogtle (NRC 1996) in this cumulative radioactive release total. The South Carolina Department of Health and Environmental Control Annual Report (SCDHEC 1995)

Table 5-2. Estimated average annual cumulative radiological doses and resulting health effects to the maximally exposed offsite individual and population in the 50-mile radius from airborne releases.

Activity	Offsite Population			
	Maximally exposed individual		50-mile population	
	Dose (rem)	Probability of fatal cancer risk	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	7.0×10^{-5}	3.5×10^{-8}	3.5	1.8×10^{-3}
Tank Closure[a]	5.2×10^{-8}	2.6×10^{-11}	3.0×10^{-3}	1.5×10^{-6}
Other foreseeable SRS activities[c]	5.1×10^{-5}	2.5×10^{-8}	3.4	1.7×10^{-3}
Plant Vogtle[d]	5.4×10^{-7}	2.7×10^{-10}	0.042	2.1×10^{-5}
Total	1.2×10^{-4}	6.1×10^{-8}	6.9	3.5×10^{-3}

a. Data is based on the Saltstone Option under the Clean and Stabilize Tanks Alternative (Table 4.1.8-1).
b. Arnett and Mamatey (1999) for 1998 data for maximally exposed individual and population.
c. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.
d. NRC (1996).

indicates that operation of the Chem-Nuclear low-level waste disposal facility just east of SRS does not noticeably impact radiation levels in air or water in the vicinity of SRS and thus are not included.

Table 5-2 lists the results of this analysis using 1998 emissions (1992 for Plant Vogtle) which are the latest available data for the SRS baseline. The cumulative dose to the maximally exposed member of the public would be 0.0001 rem (or 0.10 millirem) per year, well below the regulatory standard of 10 millirem per year (40 CFR 61). Summing the doses to the maximally exposed individual for the actions and baseline SRS operations listed in Table 5-2 is an extremely conservative approach because in order to get the calculated dose, the maximally exposed individual would have to occupy different physical locations at the same time, which is impossible.

Adding the population doses from current and projected activities at SRS, Plant Vogtle, and tank closure activities could yield a total annual cumulative dose of 6.9 person-rem from airborne sources. The total annual cumulative dose translates into 0.0035 excess latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS.

5.2 Water Resources

At present, a number of SRS facilities discharge treated wastewater to Upper Three Runs and its tributaries and Fourmile Branch via NPDES-permitted outfalls. These include the F- and H-Area Effluent Treatment Facility (ETF) and the M-Area Liquid Effluent Treatment Facility. As stated in Section 4.1.2, the SRS storm drainage system is designed to enable operators to secure specific storm sewer zones and divert potentially contaminated water to lined retention basins. Therefore, during the short term, tank closure activities are not expected to result in any radiological or nonradiological discharges to groundwater. Discharges to surface water would be treated to remove contaminants prior to release into SRS streams. Other potential sources of contaminants into Upper Three Runs during the tank closure activities period include the accelerator production of tritium, the tritium extraction facility, environmental restoration, and decontamination and decommissioning activities, as well as modifications to existing SRS facilities. Discharges associated with the accelerator production of tritium and tritium extraction facility activities would not add significant amounts of nonradiological contaminants to Upper Three Runs. The amount of discharge associated with environmental restoration and decontamination and decommissioning activities

would vary based on the level of activity. All the potential activities that could result in wastewater discharges would be required to comply with the NPDES permit limits that ensure protection of the water quality needed to support state-designated uses for the receiving stream. Studies of water quality and biota in Upper Three Runs suggest that discharges from facilities outfalls have not degraded the stream (Halverson et al. 1997).

5.3 Public and Worker Health

Table 5-3 summarizes the cumulative radiological health effects of routine SRS operations, proposed DOE actions, and non-Federal nuclear facility operations (Plant Vogtle Electric Generating Facility). In addition to estimated radiological doses to the hypothetical maximally exposed offsite individual, the offsite population, and the involved workers population. Table 5-3 also lists the potential number of excess latent cancer fatalities for the public and workers due to exposure to radiation and the involved workers population and the risk of a latent cancer fatality to the maximally exposed offsite individual. The radiation dose to the maximally exposed offsite individual from air and liquid pathways would be 0.00035 rem (0.35 mrem) per year, which is well below the applicable DOE regulatory limits (10 mrem per year from the air pathway, 4 mrem per year from the liquid pathway, and 100 mrem per year for all pathways). The total annual population dose for current and projected activities of 8.9 person-rem translates into 0.0045 latent cancer fatality for each year of exposure for the population living within a 50-mile radius of the SRS. As stated in Section 5.1, for comparison, 144,000 deaths from cancer due to all causes would be likely in the same population over their lifetimes.

The annual radiation dose to the involved worker population would be 1,344 person-rem, which could result in 0.54 latent cancer fatalities. Closure actions under the Clean and Remove Tanks Alternative would result in 0.2 latent cancer fatalities per year. In addition, doses to individual workers would be kept below the regulatory limit of 5,000 mrem per year (10 CFR 835). Furthermore, as low as reasonably achievable principles would be exercised to maintain individual worker doses below the SRS Administrative Control Level of 500 mrem per year. Tank closure activities would add minimal amounts to the overall radiological health effects of the workers and general public.

5.4 Waste Generation and Disposal Capacity

As stated in Section 4.1.10, HLW, low-level waste, and hazardous/mixed waste would be generated from tank closure activities.

Table 5-4 lists cumulative volumes of HLW, low-level, transuranic, and hazardous and mixed wastes that SRS would generate. The table includes data from the SRS 30-year expected waste forecast. The 30-year expected waste forecast is based on operations, environmental restoration, and decontamination and decommissioning waste forecasts from existing generators and the following assumptions: secondary waste from the DWPF, a form of HLW salt processing (In-Tank Precipitation), and Extended Sludge Processing operations are addressed in the DWPF EIS; HLW volumes are based on the selected option for the F-Canyon Plutonium Solutions EIS and the Interim Management of Nuclear Materials at SRS EIS; some investigation-derived wastes are handled as hazardous waste per RCRA regulations; purge water from well samplings is handled as hazardous waste; and the continued receipt of small amounts of low-level waste from other DOE facilities and nuclear naval operations would occur. The estimated quantity of radioactive/hazardous waste from operations in this forecast during the next 30 years would be approximately 143,000 cubic meters. In addition, radioactive/hazardous waste associated with environmental restoration and decontamination and decommission activities would have a 30-year expected forecast of approximately 68,000 cubic meters. Waste generated from the Clean and Remove Tanks Alternative would add a total of 117,000 cubic meters. During this same time period, other reasonably foreseeable activities that were not included in the 30-year forecast would add an

Table 5-3. Estimated average annual cumulative radiological doses and resulting health effects to offsite population and facility workers.

Activity	Maximally exposed individual				Offsite population[a]				Workers	
	Dose from airborne releases (rem)	Dose from water releases (rem)	Total dose (rem)	Probability of fatal cancer risk	Collective dose from airborne releases (person-rem)	Collective dose from water releases (person-rem)	Total collective dose (person-rem)	Excess latent cancer fatalities	Collective dose (person-rem)	Excess latent cancer fatalities
SRS Baseline[b]	7.0×10^{-5}	1.2×10^{-4}	1.9×10^{-4}	9.5×10^{-8}	3.5	1.8	5.3	2.7×10^{-3}	160	0.066
Tank Closure[c]	5.2×10^{-8}	(f)	5.2×10^{-8}	2.6×10^{-11}	3.0×10^{-3}	(f)	3.0×10^{-3}	1.5×10^{-6}	490	0.20
Other foreseeable SRS activities[d]	5.1×10^{-5}	5.7×10^{-5}	1.1×10^{-4}	5.4×10^{-8}	3.4	0.19	3.6	1.8×10^{-3}.	694	0.28
Plant Vogtle[e]	5.4×10^{-7}	5.4×10^{-5}	5.5×10^{-5}	2.7×10^{-8}	0.042	2.5×10^{-3}	0.045	2.1×10^{-5}	NA	NA
Total	1.2×10^{-4}	2.3×10^{-4}	3.5×10^{-4}	1.8×10^{-7}	6.9	2.0	8.9	4.5×10^{-3}	1,344	0.54

N/A = not available

a. A collective dose to the 50-mile population for atmospheric releases and to the downstream users of the Savannah River for aqueous releases.

b. Arnett and Mamatey (1999) for 1998 data for MEI and population. Worker dose is based on 1997 data (WSRC 1998).

c. Collective worker dose of 490 person-rem is based on closure of two tanks per year for the Clean and Remove Tanks Alternative (Table 4.1.8-2).

d. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.

e. NRC (1996).

f. Less than minimum reportable levels.

Table 5-4. Estimated cumulative waste generation from SRS concurrent activities (cubic meters).

Waste type	SRS baseline[a,b]	Tank closure[c]	ER/D&D[b,d]	Other waste volume[e]	Total
HLW	14,000	97,000	0	80,000	191,000
Low-level	119,000	19,260	61,600	251,000	450,000
Hazardous/mixed	3,900	470	6,200	4,700	15,200
Transuranic	6,000	0	0	12,500	18,500
Total[f]	143,000	117,000	67,800	348,000	675,000

a. Source: Halverson 1999.
b. Based on a total 30-year expected waste generation forecast, which includes previously generated waste.
c. Waste volume estimates based on the Clean and Remove Tanks Alternative (Table 4.1.10-2).
d. ER/D&D = environmental restoration/decontamination & decommissioning; based on a total 30-year expected waste forecast.
e. Sources: DOE (1996, 1997, 1998a,b, 1999b,c, 2000b,c). Life-cycle waste associated with reasonably foreseeable future activities such as spent nuclear fuel management, tritium extraction facility, plutonium residues, surplus plutonium disposition, highly-enriched uranium, commercial light water reactor waste, sodium-bonded spent nuclear fuel, and weapons components that could be processed in SRS canyons. Impacts for the last two groups are based on conventional processing impacts of spent nuclear fuel "Group A"; DOE (2000c).
f. Totals have been rounded.

additional 348,000 cubic meters. The major contributor to the other waste volumes would be from weapons components from various DOE sites that could be processed in SRS canyons and from SNF management activities. Therefore, the potential cumulative amount of waste generated from SRS activities during the period of interest would be 675,000 cubic meters.

This large quantity of radioactive and hazardous waste must be managed safely and effectively to avoid severe impacts to human health and the environment. Such management is a major component of new missions for DOE. DOE has facilities in place and is developing new ways to better contain radioactive and hazardous substances. It is important to note that the quantities of waste generated are not equivalent to the amounts that will require disposal. For example, HLW is evaporated and concentrated to a smaller volume for final disposal.

The Three Rivers Solid Waste Authority Regional Waste Management Center at SRS accepts non-hazardous and non-radioactive solid wastes from SRS and eight surrounding South Carolina counties. This municipal solid waste landfill provides state-of-the-art Subtitle D (nonhazardous) facilities for landfilling solid wastes while reducing the environmental consequences associated with construction and operation of multiple county-level facilities (DOE 1995b). It was designed to accommodate combined SRS and county solid waste disposal needs for at least 20 years, with a projected maximum operational life of 45 to 60 years (DOE 1995b). The landfill is designed to handle an average of 1,000 tons per day and a maximum of 2,000 tons per day of municipal solid wastes. SRS and eight cooperating counties had a combined generation rate of 900 tons per day in 1995. The Three Rivers Solid Waste Authority Regional Waste Management Center opened in mid-1998.

Tank closure activities and other planned SRS activities would not generate larger volumes of radioactive, hazardous, or solid wastes beyond current and projected capacities of SRS waste storage and/or management facilities.

5.5 Utilities and Energy

Table 5-5 lists the cumulative total of water consumption from activities at SRS. The values are based on annual consumption estimates. DOE has also evaluated the SRS water needs during tank closure. At present, the SRS rate of groundwater withdrawal is estimated to be a maximum of 1.7×10^{10} liters per year. The maximum estimated amount of water needed annually for the Grout Option under the Clean

Table 5-5. Estimated average annual cumulative water consumption.

Activity	Water usage[a] (liters)
SRS Baseline	1.70×10^{10}
SRS HLW Tank Closure[b]	8.65×10^{6}
Other foreseeable SRS activities[c]	8.84×10^{8}
Total	1.79×10^{10}

a. Includes groundwater and surface-water usage.
b. Based on the Grout Option under the Clean and Stabilize Tanks Alternative (Table 4.1.11-1).
c. Includes Spent Nuclear Fuel, Highly Enriched Uranium, Tritium Extraction Facility, Management of Certain Plutonium Residues and Scrub Alloy Concentrations, Defense Waste Processing Facility, and Disposition of Surplus Plutonium, Sodium-Bonded Spent Nuclear Fuel, and components from throughout the DOE complex.

and Stabilize Tanks Alternative would increase this demand by less that 0.1 percent (Table 5-5) when added to present groundwater withdrawals and that for other foreseeable SRS activities. This level of water withdrawal is not expected to exceed SRS capacities.

Overall SRS electricity consumption would not be impacted by tank closure activities. Electricity usage for tank closure would be similar to current consumption levels in F- and H-Tank Farms Area.

5.6 Closure – Near-Term Cumulative Impacts

The above analysis demonstrates minimal cumulative impacts due to the increment of near-term (2000-2030) tank-closure activities for the five resource areas that required evaluation. Table 5-6 summarizes the near-term cumulative impact of past, present, proposed, and other reasonably foreseeable actions for the resource areas presented in this chapter.

5.7 Long-Term Cumulative Impacts

SRS personnel have prepared a report, referred to as the *Composite Analysis* (WSRC 1997), that calculated the potential cumulative impact to a hypothetical member of the public over a period of 1,000 years from releases to the environment from all sources of residual radioactive material expected to remain in the SRS General Separations Area which contains all of the SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The impact of primary concern was the increased probability of fatal cancers. The *Composite Analysis* also included contamination in the soil in and around the HLW tank farms resulting from previous surface spills, pipeline leaks, and Tank 16 leaks as sources of residual radioactive material. The *Composite Analysis* considered 114 potential sources of radioactive material containing 115 radionuclides.

The *Composite Analysis* calculated maximum radiation doses to hypothetical members of the public at the mouth of Fourmile Branch, at the mouth of Upper Three Runs, and on the Savannah River at the Highway 301 bridge. The estimated peak all-pathway dose (excluding the drinking water pathway) from all radionuclides was 14 mrem/year (7×10^{-7} fatal cancer risk to a hypothetical member of the public at the mouth of Fourmile Branch), 1.8 mrem/year (mouth of Upper Three Runs), and 0.1 mrem/year (Savannah River). The major contributors to dose were tritium, carbon-14, neptunium-237, and isotopes of uranium (WSRC 1997). These impacts are small because they are substantially below the NRC (and DOE) exposure limit of 100 mrem/yr for offsite individuals.

The analysis also calculated radiation doses from drinking water in Fourmile Branch and Upper Three Runs. The estimated peak drinking water doses from all radionuclides for these

Table 5-6. Summary of short-term cumulative effects on resources from HLW tank closure alternatives.

Resource	Key Indicator of Environmental Impacts	Past Actions	Present Actions	HLW Tank Closure Alternatives	Other Future Actions	Cumulative Effect
Air	24-hour sulfur dioxide concentration	No residual impacts remain from past emissions.	Conservatively estimated to be 96 percent of applicable standard	Incremental increase from the Saltstone Option under the Clean and Stabilize Tanks Alternative is about 0.03 percent of present condition.	Increment about 0.33 percent of present condition.	Unchanged by proposed and other future actions.
Water	Tritium to onsite streams	No residual impacts of past direct discharges. Tritium in the Savannah River was a small fraction of federally mandated limit.	Largest contributor to dose from drinking water dramatically reduced from past operations.	No addition of tritium to Upper Three Runs under any tank closure alternative.	Very small addition of tritium to Upper Three Runs.	No meaningful increment from present, satisfactory conditions.
Health	Annual radiological dose to offsite maximally exposed individual	All-pathway dose of 1.6 mrem is small fraction of 100 mrem limit	All-pathway dose of 0.07 mrem is very small fraction of 100 mrem limit	All pathway dose from the Saltstone Option under the Clean and Stabilize Tanks Alternative is less than 0.1 percent of current dose of 0.07 mrem (which is a small fraction of the 100 mrem limit).	Approximately 60 percent of current dose of 0.07 mrem (which is a small fraction of the 100 mrem limit).	All pathway dose of 0.12 mrem is small fraction of 100 mrem limit.
Waste management	High-level waste (HLW) generation	Large, continual quantities of HLW generated.	Less annual generation, minimal additional tank space needed, 34 million gallons in storage	About 50 percent of cumulative total from the Clean and Remove Tanks Alternative	Highly radioactive fraction immobilized in DWPF. Separated, low activity waste disposed in onsite vaults	Actions initiated to handle this substantial quantity (191,000 cubic meters) of HLW with minimal impact to human health and the environment.
Utility and Energy	Annual withdrawal of groundwater	No cumulative impact to aquifer from past high withdrawals	Aquifer is not stressed by annual withdrawals of $1.7x10^{10}$ liters.	Very small fraction (0.05 percent) of current withdrawals from the Grout Option under the Clean and Stabilize Tanks Alternative.	Moderate increase (13 percent) in groundwater withdrawals	Potential cumulative impacts are not added to by the proposed action.

creeks were 23 mrem/year (1.2×10^{-5} fatal cancer risk to a hypothetical member of the public at Fourmile Branch) and 3 mrem/year for Upper Three Runs (WSRC 1997).

In this EIS, DOE estimated peak doses over a 10,000 year period of analysis. The highest estimated radiation dose in these creeks from the No Action Alternative, the first location where it could interact with contaminants from these other facilities, is 2.3 mrem/year. The location for which this value is calculated is upstream of the location presented in the Composite Analysis. DOE expects additional dilution to occur as the contaminants from HLW tank closure activities move downstream. Therefore, the dose and the associated impact (1.2×10^{-6} fatal cancer risk to a hypothetical member of the public) from HLW tank closure activities would be a small fraction of the doses due to the other activities analyzed in the Composite Analysis.

In addition, the peak radiation doses from HLW tank closure activities would occur substantially later in time than the impacts of the other activities evaluated in the *Composite Analysis*. For example, because the radioactive contamination in the soil in and around the HLW tanks farms does not have the benefit of a concrete layer below or above it (as would the residual activity remaining in the closed HLW tanks under the fill with grout option), these contaminants would reach the groundwater (and thus the seepline and the surface water) long before the contaminants in the in the closed HLW tanks. Therefore there would be no overlap in time of these contaminants.

As described in Section 4.2.4, DOE has developed a future use policy for the SRS. A key component of this policy is that residential uses of all SRS land would be prohibited in any area of the site. This policy also states that SRS boundaries would remain unchanged, and the land would remain under the ownership of the Federal government. The area around the General Separations Area would remain an industrial use zone. Residential uses of the General Separations Area would be prohibited under any circumstances.

The future condition of the F- and H-Area Tank Farms would vary among the alternatives. Under the No Action Alternative, structural collapse of the tanks would create unstable ground conditions and form holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. For the Clean and Stabilize Tanks Alternative, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure. For the Clean and Remove Tanks Alternative, the tank voids remaining after excavation would be filled in. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. The alternatives evaluated in this EIS are limited to closure of the tanks and associated equipment. They do not address other potential sources of contamination co-located with the tank systems such as soil or groundwater contamination from past releases or other facilities. Consequently, future land use of the Tank Farms areas is not solely determined by the alternatives for closure of the tank systems. For example, the Environmental Restoration program may determine that the Tank Farms areas should be capped to control the spread of contaminants through the groundwater. Such decisions would constrain future use of the Tank Farms areas. The Clean and Stabilize Tanks Alternative would render the Tank Farms areas least suitable for other uses, as the closed grout-filled tanks would remain in the ground. The Clean and Remove Tanks Alternative would have somewhat less impact on future land use since the tank systems would be removed. However, DOE does not

expect the General Separations Area, which surrounds the F and H-Area Tank Farms, to be available for other uses making future uses of the Tank Farms areas a moot point.

References

Arnett, M. W., and A. R. Mamatey, 1997a, *Savannah River Site Environmental Report for 1997*, (Environmental Monitoring Section), WSRC-TR-97-00322, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1997b, *Savannah River Site Environmental Report for 1996 (Summary)*, WSRC-TR-97-0173, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1999, *Savannah River Site Environmental Data for 1998*, WSRC-TR-98-00314, Westinghouse Savannah River Company, Aiken, South Carolina.

CEQ (Council on Environmental Quality), 1997, *Considering Cumulative Effects Under the National Environmental Policy Act*, Executive Office of the President, Washington, D.C. (Available at http://ceq.eh.doe.gov/nepa/ccenepa/ccenepa.htm).

DOE (U.S. Department of Energy), 1980, *The Savannah River Plant*, DOE-SR-0002, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Final Waste Management Activities for Groundwater Protection Environmental Impact Statement*, DOE/EIS 0120, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1990, *Final Continued Operation of K-, L-, and P-Reactors Environmental Impact Statement*, DOE/EIS 0147, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994, *Final Defense Waste Processing Facility Supplemental Environmental Impact Statement*, DOE/EIS-0082-S, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995a, *Final Environmental Impact Statement - Interim Management of Nuclear Materials*, DOE/EIS-0220, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1995b, *Environmental Assessment for the Construction and Operation of the Three Rivers Solid Waste Authority Regional Waste Management Center at the Savannah River Site*, DOE/EA-1079, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact*, DOE/EIS-0240, Office of Fissile Materials Disposition, Washington, D.C.

DOE (U.S. Department of Energy), 1997, *Environmental Assessment for the Tritium Facility Modernization and Consolidation Project at the Savannah River Site,* DOE/EA-1222, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998a, *Final Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy at the Rocky Flats Environmental Technology Site,* DOE/EIS-0277F, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999a, *Final Environmental Impact Statement Accelerator Production of Tritium at Savannah River Site*, DOE/EIS-0270, Savannah River Operations Office, Aiken, South Carolina, March.

DOE (U.S. Department of Energy), 1999b, *Final Environmental Impact Statement for the Construction and Operation of a Tritium Extraction Facility at the Savannah River Site*, DOE/EIS-0271, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1999c, *Surplus Plutonium Disposition Final Environmental Impact Statement*, DOE/EIS-0283, Office of Fissile Materials Disposition, Washington, D.C.

DOE (U.S. Department of Energy), 1999d, *Final Environmental Impact Statement for Construction and Operation of a Tritium Extraction Facility at the Savannah River Site,* DOE/EIS-0271, Savannah River Operations Office, Aiken, South Carolina, March.

DOE (U.S. Department of Energy) 2000a, *Savannah River Site Force Report*, facsimile transmission from Becky Craft (DOE Office of External Affairs) to Jim Oliver, February 30.

DOE (U.S. Department of Energy), 2000b, *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel*, DOE/EIS-0306, Washington, D.C., July.

DOE (U.S. Department of Energy), 2000c, *Final Environmental Impact Statement for Savannah River Site Spent Nuclear Fuel Management*, DOE/EIS-0279, Aiken, South Carolina, March.

Halliburton NUS Environmental Corporation, 1992, *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site*, July.

Halverson, N. V., L. D. Wike, K. K. Patterson, J. A. Bowers, A. L. Bryan, K. F. Chen, C. L. Cummins, B. R. del Carmen, K. L. Dixon, D. L. Dunn, G. P. Friday, J. E. Irwin, R. K. Kolka, H. E. Mackey, Jr., J. J. Mayer, E. A. Nelson, M. H. Paller, V. A. Rogers, W. L. Specht, H. M. Westbury, and E. W. Wilde, 1997, *SRS Ecology Environmental Information Document*, WSRC-TR-97-0223, Westinghouse Savannah River Company, Aiken, South Carolina.

Halverson, N.V., 1999, Revised Cumulative Impacts Data, Westinghouse Savannah River Company Interoffice Memorandum to C.B. Shedrow, SRT-EST-99-0328, Rev. 1, Aiken, South Carolina, August 17.

NRC (U.S. Nuclear Regulatory Commission), 1996, *Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1992*, NUREG/CR 2850, Vol. 14, Washington, D.C.

SCDHEC (South Carolina Department of Health and Environmental Control), 1976, *South Carolina Code of Laws*, SCDHEC Regulation, "Air Pollution Control Regulations and Standards," Columbia, South Carolina. (Available at http://www.lpitr.state.sc.us/coderegs/61b.htm).

SCDHEC (South Carolina Department of Health and Environmental Control), 1995, *South Carolina Nuclear Facility Monitoring - Annual Report 1995*, Columbia, South Carolina.

WSRC (Westinghouse Savannah River Company), 1997, *Composite Analysis - E-Area Vaults and Saltstone Disposal Facilities*, WSRC-RP-97-311, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *Savannah River Site Radiological Performance*, 4th Quarter 1997, ESH-SHP-98-0007, Savannah River Site, Aiken, South Carolina.

CHAPTER 6. RESOURCE COMMITMENTS

This chapter describes the unavoidable adverse impacts, short-term uses of environmental resources versus long-term productivity, and irreversible or irretrievable commitments of resources associated with cleaning, isolating, and stabilizing the HLW tanks and related systems at the SRS. This chapter also includes discussions about DOE waste minimization, pollution prevention, and energy conservation programs in relation to implementation of the proposed action.

6.1 Unavoidable Adverse Impacts

Implementing any of the alternatives considered in this EIS for the closure of the HLW tanks at SRS would result in unavoidable adverse impacts to the human environment. The construction and operation of a saltstone mixing facility in F- and H-Areas (combined with the continued operation of the current Saltstone Manufacturing and Disposal Facility in Z-Area) under the Clean and Fill with Saltstone Option, or the construction and operation of temporary batch plants for grout production in F- and H-Areas under the Clean and Fill with Grout Option, would result in minimal short-term adverse impacts to geologic resources, traffic, and cultural resources as described in Chapter 4. Short-term impacts span from year 2000 through final closure of the existing HLW tanks in approximately 2030. Generally all construction activities would occur within the boundary of the tank farms (67 acres total) in an already-developed industrial complex. An additional 1 to 3 acres would be required outside the fenced areas as a lay-down area to support construction activities under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative.

Excavation of backfill material from an onsite borrow area could result in potential adverse impacts to geologic and surface water resources. Under the Clean and Stabilize Tanks Alternative, the soil elevation configurations surrounding four tanks in F-Area and four tanks in H-Area would require backfill soil to bring the ground surface at these tanks up to the surrounding surface elevation to prevent surface water from collecting in the surface depressions. An estimated 170,000 cubic meters of soil would be required to fill the depressions to grade. Under the Clean and Remove Tanks Alternative, 356,000 cubic meters of soil would be required to backfill the voids left by the removal of the tanks. As part of the required sediment and erosion control plan (using Best Management Practices), storm water management and sediment control measures (i.e., retention basins) would minimize runoff from these areas and any potential discharges of silts, solids, and other contaminants to surface-water streams. Any stormwater collected in the lined retention basins would be sent to Fourmile Branch (if uncontaminated rainwater), to the Effluent Treatment Facility for removal of contaminants, or rerouted to the tank farms for temporary storage prior to treatment. In addition, use of Best Management Practices would minimize any short-term adverse impacts to geologic resources.

Impacts from the borrow site development would include the physical alteration of 7-14 acres of land (and attended loss of potential wildlife habitat) and noise disturbances to wildlife in nearby woodlands, assuming woodlands are present. Any site selected for the borrow area would be within the central developed core of the SRS, which is dedicated to industrial facilities. There would be no change in overall land use patterns on the SRS.

Adverse impacts to ecological resources would be minimal and short-term because most activities would occur within the previously disturbed and fenced areas. Although noise levels would be relatively low outside the immediate areas of construction, the combination of construction noise and human activity probably would displace small numbers of animals associated with an approximate 20-acre area surrounding the F- and H-Areas.

6.2 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The proposed locations for any new facilities would all be within developed industrial landscapes. Each of the options for the Clean and Stabilize Tanks Alternative would require approximately 1 to 3 additional acres for lay-down areas. The existing infrastructure (roads and utilities, etc.) within the F- and H-Areas is sufficient to support the proposed facilities.

For both F- and H-Area saltstone mixing facilities, after the operational life (i.e., all tanks are filled and closed) DOE could decontaminate and decommission the facilities in accordance with applicable regulatory requirements and restore the area to a brown-field site that would be available for other industrial use. Appropriate NEPA review would be conducted prior to the initiation of any decontamination and decommissioning action. In all likelihood, none of the sites would be restored to a natural terrestrial habitat (DOE 1998).

The project-related uses of environmental resources for the implementation of any of the proposed alternatives are characterized in the following paragraphs:

- Groundwater would be used in tank washing and cleaning and to meet process and sanitary water needs over the short-term impact period (i.e., 2000 to 2030). Long-term groundwater use would be limited to amounts necessary to support sanitary and drinking water needs during monitoring of the institutional area. After use and treatment (in the F- and H-Area Effluent Treatment Facility), this water would be released through permitted discharges into surface water streams. Therefore, the withdrawal, use, and treatment of groundwater would not affect the long-term productivity of this resource.
- Air emissions associated with implementation of any of the alternatives would add small amounts of radiological and nonradiological constituents to the air of the region. During the short-term impacts period (i.e., 2000 to 2030), these emissions would result in an additional loading and exposure but would not impact SRS compliance with air quality or radiation exposure standards. During the long-term impacts period, air emissions associated with the proposed action would be negligible. Therefore, there would be no significant residual environmental affects to long-term environmental productivity.
- Radiological contamination of the groundwater below and adjacent to the F- and H-Areas would occur over time. Because some tank groups in the H-Area lie beneath the water table, the contaminants from these tanks would be released directly into the groundwater. In addition, some contaminants from each tank farm would be transported by groundwater through the Water Table and Barnwell-McBean Aquifers to the seepline along Fourmile Branch. For tanks situated north of the groundwater divide in the H-Area Tank Farm, contaminants released to the Water Table or Barnwell-McBean Aquifers may discharge to unnamed tributaries to Upper Three Runs or migrate downward to underlying aquifers. Beta-gamma dose and alpha concentrations would be below Maximum Contaminant Levels at the seepline in both F- and H-Areas for two of the three preferred options (i.e., Clean and Fill with Grout, Clean and Fill with Sand). In addition, the No Action Alternative would exceed the Maximum Contaminant Levels at the seepline. DOE calculated peak radiation dose to aquatic and terrestrial receptors at the seepline and receiving surface water and compared the dose to the limit of 1.0 rad per day. Results indicated that all calculated absorbed doses to the referenced organisms are below the regulatory limit and therefore would have

no impact on the long-term productivity of the ecosystem at the seepline.

- Residual contaminants remaining in the HLW tanks after closure following the period of institutional control could result in long-term impacts to the public health. DOE evaluated the impacts over a 10,000-year period in which the contaminants would be leached from the tank structures to the groundwater. The seepline was determined to be the area of greatest concern (i.e., area of maximum dose). Results indicated that the maximum dose to an adult receptor at the seepline for either tank farm is 6.2 mrem for the No Action Alternative. This dose is less than the 100 mrem public dose limit. Based on this low dose, DOE would not expect any long-term productivity health effects to an adult receptor.

- The management and disposal of waste (low-level, hazardous, mixed, industrial, and sanitary) and non-recyclable radiological waste over the project's life would require energy and space at SRS treatment, storage, or disposal facilities (e.g., Z-Area Saltstone, E-Area Vaults, Consolidated Incineration Facility, Three Rivers Sanitary Landfill). The land required to meet the solid waste needs would require a long-term commitment of terrestrial resources. DOE established a future use policy for the SRS for the next 50 years in the 1998 *Savannah River Site Future Use Plan* (DOE 1998). This report sets forth guidance that would exclude the tank farm and associated waste disposal areas from non-conforming land uses. Therefore, this policy ensures that the areas would be removed from long-term productivity.

6.3 Irreversible and Irretrievable Resource Commitments

Resources that would be irreversibly and irretrievably committed during the implementation of HLW tank closure alternatives include those that cannot be recovered or recycled and those that are consumed or reduced to unrecoverable forms. The commitment of capital, energy, labor, and material during the implementation of HLW tank closure alternatives would generally be irreversible.

Energy expended would be in the form of fuel for equipment and vehicles, electricity for facility operations [e.g., bulk waste removal and production of grout at batch plant(s)], production of steam (i.e., for operation of ventilation systems on the waste tanks and heating of the cleaning solutions), and human labor. Construction (e.g., new saltstone mixing facilities) would generate nonrecyclable materials such as sanitary solid waste and construction debris. Implementation of any of the options for the Clean and Stabilize Tanks Alternative would generate nonrecyclable waste streams such as radiological and nonradiological wastes including liquids, low-level, hazardous, mixed low-level, and industrial. For example, oxalic acid cleaning would require between 225,000 and 500,000 gallons of oxalic acid for washing of each Type III tank (see Section 4.1.10 for greater detail). However, certain materials (e.g., copper, stainless steel) used during construction and operation of any proposed facility or facilities could be recycled when the facility is decontaminated and decommissioned. Some construction materials, particularly those associated with existing F- and H-Area Tank Farm facilities would not be salvageable due to radioactive contamination. Table 6-1 lists estimated requirements for materials consumed during the closure of a single Type III tank.

The implementation of the any of the HLW tank closure alternatives considered in this EIS, including the No Action Alternative, would require water, electricity, and diesel fuel. Table 6-2 lists the utilities and energy that would be consumed as a result of implementing each of the proposed alternatives.

Water would be obtained from onsite groundwater sources. Electricity, oxalic acid, sand, and diesel fuel would be purchased from commercial sources. These commodities are readily available, and the amounts required would not

Table 6-1. Estimated maximum quantities of materials consumed for each Type III tank closed.[a]

Materials	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tank Alternative	No Action Alternative
Oxalic acid[b] (4 percent) (gal)	225,000	225,000	225,000	500,000	-
Sand (gal)	-	2,640,000	-	-	-
Cement (gal)	2,640,000	-	52,800	-	-
Fly Ash	-	-	Included in	-	-
Boiler slag	-	-	saltstone	-	-
Additives (grout) (gal)	500	-	-	-	-
Saltstone (gal)	-	-	2,640,000	-	-

a. The SRS HLW tank systems includes four tank designs (Types I, II, III, and IV). Estimates were developed for closure of a single Type III tank system. Closure of a Type III tank system represents the maximum material consumption relative to the other tank designs. Waste generation estimates for closure of the other tank designs are assumed to be: Type I – 60 percent of Type III estimate, Type II – 80 percent of Type III estimates, and Type IV – 90 percent of Type III estimate (Johnson 1999a).
b. At the present time, potential safety considerations restrict the use of oxalic acid in the HLW tanks (see Section 2.2.1).

Table 6-2. Total estimated utility and energy usage for the HLW tank closure alternatives.[a]

	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Sand Option	Clean and Stabilize Tanks Alternative: Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative	No Action Alternative
Water (gallons)	48,930,000	12,840,000	12,840,000	25,680,000	NA[b]
Electricity	NA	NA	NA	NA	NA
Steam (pounds)	8,560,000	8,560,000	8,560,000	17,120,000	NA
Fossil fuel (gallons)	214,000	214,000	214,000	428,000	NA
Total utility cost	$4,280,000	$4,280,000	$4,280,000	$12,840,000	NA

a. Source: Johnson (1999a,b,c,d).
b. NA = Not applicable to this alternative. Utility and energy usage for these alternatives would not differ significantly from baseline consumption.

have an appreciable impact on available supplies or capacities.

6.4 Waste Minimization, Pollution Prevention, and Energy Conservation

6.4.1 WASTE MINIMIZATION AND POLLUTION PREVENTION

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.

To implement a waste minimization and pollution prevention program for the closure of the HLW tanks, DOE would characterize waste streams and identify opportunities for reducing or eliminating them. Emphasis would be placed on minimizing the largest waste stream, radioactive liquid waste, through source reductions, efficiencies, and recycling (if possible). Selected waste minimization practices could include:

- Process design changes to eliminate the potential for spills and to minimize contamination areas
- Decontamination of equipment to facilitate reuse
- Recycling metals and other usable materials, especially during the construction phase of the project
- Preventive maintenance to extend process equipment life
- Modular equipment designs to isolate potential failure elements to avoid changing out entire units
- Use of non-toxic or less toxic materials to prevent pollution and minimize hazardous and mixed waste streams
- Gloveboxes to eliminate the need for plastic suits and air hoses during maintenance activities and line breaks
- Incineration at the Consolidated Incineration Facility and other volume reduction techniques (i.e., compaction, cutting) to reduce waste volumes

During construction, DOE would implement actions to control surface water runoff and construction debris and to prevent infiltration of contaminants into groundwater. The construction contractor would be selected, in part, based on prior pollution prevention practices.

6.4.2 ENERGY CONSERVATION

SRS has an active energy conservation and management program. Since the mid-1990s more than 40 onsite administrative buildings have undergone energy efficiency upgrades. Representative actions include the installation of energy-efficient light fixtures, the use of occupancy sensors in rooms, use of diode light sticks in exit signs, and the installation of insulating blankets around hot water heaters. Regardless of location, the incorporation of these types of energy-efficient technologies into facility design, along with the implementation of process efficiencies and waste minimization concepts, would facilitate energy conservation by any of the tank closure alternatives.

Reference

DOE (U.S. Department of Energy), 1998, *Savannah River Site Future Plan*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, January.

Hunter, C. H., 1999, "Non-Radiological Air Quality Modeling for the High-Level Waste Tank Closure Environmental Impact Statement (EIS)," SRT-NTS-990067, interoffice memorandum to C. B. Shedrow, Westinghouse Savannah River Company, Aiken, South Carolina, March 26.

Johnson G., 1999a, Westinghouse Savannah River Company, "Draft Input to Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 8.

Johnson G., 1999b, Westinghouse Savannah River Company, "Re: FW: Draft Input to Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 13.

Johnson G., 1999c, Westinghouse Savannah River Company, "Responses to 4/20/99 Questions for Tank Closure EIS," e-mail to P. Young, Tetra Tech NUS, Aiken, South Carolina, April 21.

Johnson G., 1999d, Westinghouse Savannah River Company, "Re: Tank Closure EIS," e-mail to L. Matis, Tetra Tech NUS, Aiken, South Carolina, May 20.

CHAPTER 7. APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

This chapter identifies and summarizes the major laws, regulations, Executive Orders, and DOE Orders that could apply to the closure of the HLW tank systems at the SRS. Permits or licenses could be required under some of these laws and regulations.

Section 7.1 describes the process DOE used to develop the methodology and performance standards for closure of the SRS HLW tank systems. Section 7.2 discusses the major Federal and State of South Carolina statutes and regulations that impose environmental protection requirements on DOE and that require DOE to obtain approval prior to closing the HLW tank systems. Each of the applicable regulations establishes how potential releases of pollutants and radioactive materials are to be controlled or monitored and include requirements for the issuance of permits for new operations or new emission sources. In addition to environmental permit requirements, the statutes may require consultations with various authorities to determine if an action requires a permit or the implementation of protective or mitigative measures. Sections 7.2.1 and 7.2.2 discuss the environmental permitting process and list the environmental permits and consultations (see Table 7-1) applicable to closure of the SRS HLW tank systems.

Sections 7.3 and 7.4 address the major Federal statutes, regulations, and Executive Orders, respectively, which address issues such as protection of public health and the environment, worker safety, and emergency planning. The Executive Orders clarify issues of national policy and set guidelines under which Federal agencies must act.

DOE implements its responsibilities for protection of public health, safety, and the environment through a series of departmental regulations and orders (see Section 7.5) that are typically mandatory for operating contractors of DOE-owned facilities.

7.1 Closure Methodology

7.1.1 CLOSURE STANDARDS

The SRS HLW tank systems are permitted by SCDHEC under authority of the South Carolina Pollution Control Act (SC Code Ann., Section 48-1-10, et seq.) (see Section 7.2.1) as industrial wastewater treatment facilities. DOE is required to close the HLW tank systems in accordance with Atomic Energy Act requirements (e.g., DOE Orders) and SC Regulation R.61-82 "Proper Closeout of Wastewater Treatment Facilities." This regulation requires the performance of such closures to be carried out in accordance with site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. To facilitate compliance with this requirement and recognize the need for consistency with overall remediation of SRS under the Federal Facility Agreement (see Section 7.3.2), DOE has adopted a general strategy for HLW tank system closure that includes evaluation of an appropriate range of closure alternatives with respect to pertinent, substantive environmental requirements and guidance and other appropriate criteria (e.g., technical feasibility, cost). The general strategy for HLW tank system closure is set forth in the *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems* (DOE 1996a). The general strategy is consistent with comparative analyses performed as part of a corrective measures study/feasibility study under the Federal Facility Agreement.

DOE will close all of the HLW tank systems in the F- and H-Area Tank Farms in accordance with the general strategy, including Tank 16, which is no longer operational and hence was not permitted as part of the industrial wastewater treatment facility. With respect to closure,

Table 7-1. Environmental permits and consultations required by law (if needed).

Activity/Topic	Law	Requirements	Agency
Site Preparation	Federal Clean Water Act (Section 404)	Stormwater Pollution Prevention Plan for Industrial Activity	SCDHEC[a]
Wastewater Discharges	Federal Clean Water Act S.C. Pollution Control Act	Stormwater Pollution Prevention/Erosion Control Plan for construction activity	SCDHEC
		NPDES Permit(s) for Process Wastewater Discharges	SCDHEC
		Process Wastewater Treatment Systems Construction and Operation Permits (if applicable)	SCDHEC
		Sanitary Waste Water Pumping Station Tie-in Construction Permit; Permit to Operate	SCDHEC
Air	Clean Air Act – NESHAP[b]	Rad Emissions - Approval to construct new emission source (if needed)	EPA[c]
		Air Construction and Operation permits - as required (e.g., Fire Water Pumps; Diesel Generators)	SCDHEC
		General source - Stacks, Vents, Concrete batch plant	SCDHEC
		Air Permit - Prevention of Significant Deterioration (PSD)	SCDHEC
Domestic Water	Safe Drinking Water Act	Construction and operation permits for line to domestic water system	SCDHEC
Endangered Species	Endangered Species Act	Consultation	U.S. Fish and Wildlife Service; National Marine Fisheries Service
Migratory Birds	Migratory Bird Treaty Act	Consultation	U.S. Fish and Wildlife Service
Historical/Cultural Resources	National Historic Preservation Act	Consultation	State Historic Preservation Officer

a. South Carolina Department of Health and Environmental Control.
b. National Emissions Standards for Hazardous Air Pollutants.
c. Environmental Protection Agency.

Tank 16 is subject to the same considerations that determine acceptable closure alternatives for the other 50 HLW tank systems. The past release from Tank 16 that resulted in its removal from service will be addressed along with the releases from the Tank 37 condensate transfer system as part of the H-Area Tank Farm Groundwater Operable Unit in accordance with the Federal Facility Agreement.

The General Closure Plan identifies the resources potentially affected by contaminants remaining in the tanks after waste removal and closure, describes how the tanks would be cleaned and how the tank systems and residual wastes would be stabilized, and identifies Federal and state environmental regulations and guidance that apply to the tank closures. It also describes the methodology using fate and transport models to calculate potential environmental exposure concentrations or radiological dose rates from the residual waste left in the tank systems and provides a methodology to account for closure impacts of individual tank systems such that all closures would comply with environmental standards. This closure plan specifies the management of residual waste as waste incidental to reprocessing.

In developing its general closure strategy that includes extensive consultation with environmental regulators, DOE identified the substantive environmental requirements and guidance documents most pertinent to the selection and implementation of HLW tank system closure options. These requirements and guidance are comparable to those established as applicable or relevant and appropriate requirements (known as "ARARs") and to-be-considered materials (known as "TBCs") in the context of a corrective measures study/feasibility study under the Federal Facility Agreement. A compilation of the ARARs and TBCs can be found in Appendix C of DOE (1996a).

DOE reviewed the requirements and guidance to identify (1) standards for environmental protection that are invoked by more than one regulatory program or authority, and (2) conflicting requirements. This process resulted in a list of requirements and guidance, including DOE Orders (435.1, 5400.1, 5400.5) and state and Federal regulations, that DOE used to identify specific regulatory standards for protection of human health and the environment. Overlapping requirements and guidance were reduced to a single list representing only the most stringent or most specific standards. This listing became the closure performance standards. The performance standards are generally numerical, such as concentrations or dose limits for specific radiological or chemical constituents in releases to the environment, which are set forth in the requirements and standards guidance. The numerical standards apply at different points of compliance and at varying times during or after closure. The performance standards apply to the entire tank farm area. Performance standards are established for environmental media. For example, the performance standard for groundwater will be the groundwater protection standard applied at the point where groundwater discharges to the surface (known as the seepline). For surface water, the performance standard will be the surface water quality standard applied in the receiving stream. Tables 7-2 and 7-3 present the radiological and nonradiological water quality criteria identified as performance standards for the SRS HLW tank closures.

7.1.2 PERFORMANCE OBJECTIVE

DOE will establish performance objectives for closure of each HLW tank. Each performance objective will correspond to a performance standard in the Closure Plan. Performance objectives will normally be more stringent than the performance standard. For example, if the performance standard for drinking water in the receiving stream is 4 millirem per year, the contribution of contaminants from all tanks (and other facilities) will not exceed the 4 millirem per year limit. DOE will evaluate closure options for specific tank systems to determine if use of a specific closure option will allow DOE to meet the performance objectives. Based on this analysis, DOE will develop a closure module for each HLW tank system such that the performance objectives for the tank system can be met.

Table 7-2. Nonradiological groundwater and surface water performance standards applicable to SRS HLW tank closure.

Constituents of concern[a]	Maximum contaminant level (40 CFR §141.62) (mg/l)	Maximum contaminant level goal (40 CFR §141.51) (mg/l)	Maximum contaminant levels (SC R.61-58.5.B(2)) (mg/l)	Water quality criteria for protection of human health (SC R.61-68, Appendix 2) (mg/l)	Criteria to protect aquatic life (SC R.61-68, Appendix 1) (mg/l)	
					Average	Maximum
Aluminum					0.087	0.750
Chromium III				637.077	0.120	0.980
Chromium VI				0.050	0.011	0.016
Total chromium	0.1	0.1	0.1		0.011	0.016
Copper		1.3			0.0065	0.0092
Fluoride	4.0	4.0	4.0			
Iron					1.000	2.000
Lead		zero[b]		0.050	0.0013	0.034
Mercury	0.002	0.002	0.002	1.53×10^{-4}	1.2×10^{-5}	0.0024
Nickel			0.1	4.584	0.088	0.790
Nitrate	10 (as N)	10 (as N)	10 (as N)			
Nitrite	1 (as N)	1 (as N)	1 (as N)			
Total nitrate and nitrite	10 (as N)	10 (as N)	10 (as N)			
Selenium	0.05	0.05	0.05	0.010	0.0050	0.020
Silver				0.050		0.0012

Source: DOE (1996a)
a. Includes SRS HLW constituents for which water quality performance standards were identified.
b. Action level for lead is 0.015 mg/l.

Table 7-3. Radiological groundwater and surface water performance standards applicable to SRS HLW tank closure.

Constituent of concern	Standard
Beta particle and photon radioactivity	4 mrem/yr
Combined radium-226 and radium-228	5 pCi/l
Gross alpha	15 pCi/l (including radium-226 but excluding radon and uranium)
Tritium	20,000 pCi/l
Strontium	8 pCi/l
Radiation dose to native aquatic organisms	1 rad/day from liquid discharges to natural waterways

Source: DOE (1996a).

The performance evaluation will focus on the exposure pathways and contaminants of most concern for a specific HLW tank system. DOE anticipates that the exposure pathway of most concern will be the contaminant release to groundwater and migration to onsite streams. The contaminants of most concern will be those subject to the most stringent performance standards for points of compliance within the exposure pathway. The lowest concentration limit for a specific constituent would become the performance objective for that constituent.

An example of comparison to performance objectives is provided in Table 7-4.

7.1.3 INCIDENTAL WASTE

The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying wastes that might otherwise be considered HLW due to their origin, but are actually managed as low-level or transuranic waste, as appropriate, if the waste incidental to reprocessing requirements contained in DOE Radioactive Waste Management Manual (DOE M 435.1-1) are met. This is a process by which DOE can make a determination that, for example, wastes residues remaining in HLW tanks, equipment, or transfer lines, are managed as low-level or transuranic waste if the requirements in Section II.B of DOE M 435.1-1 have been or will be met.

The requirements contained in DOE M 435.1-1 are divided into two processes: the "citation" process and the "evaluation" process. When determining whether spent nuclear fuel reprocessing plant wastes are another waste type or HLW, either the citation or evaluation process described in DOE M 435.1-1 shall be used.

- Citation – Waste incidental to reprocessing by "citation" includes spent nuclear fuel processing plant wastes that meet the "incidental waste" description included in the Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7. These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

- Evaluation – Waste incidental to reprocessing by "evaluation" includes spent nuclear fuel processing plant wastes that: (1) have been processed, or will be processed to remove key radionuclides to the maximum extent that is technically and economically practical, (2) will be managed to meet safety requirements comparable to the performance standards set forth in Subpart C of 10 CFR 61 (if low-level waste) or will be incorporated in a solid physical form and meet alternative requirements for waste classification and characteristics authorized by DOE (if transuranic waste), and (3) managed as low-level or transuranic waste pursuant to DOE's authority under the Atomic Energy Act in accordance with the applicable provisions of DOE M 435.1-1.

Those waste streams that meet the requirements, either by citation or evaluation, would be excluded from the scope of HLW. In the absence of an "incidental waste" or "waste incidental to reprocessing" determination, DOE would continue management of HLW due to its origin as HLW regardless of its radionuclide content.

Per DOE guidance in DOE G 435.1, the DOE Field Element Manager is responsible for ensuring that waste incidental to reprocessing determinations are made consistent with either the citation or the evaluation process. A determination made using the evaluation process will include consultation and coordination with the DOE Office of Environmental Management. The U.S. Nuclear Regulatory Commission (NRC) has participated in regulatory reviews using these evaluation criteria in the past and has expertise that is expected to complement DOE's internal review. Hence, consultation with NRC staff regarding the requirements for the evaluation process is strongly encouraged under the guidance for DOE O 435.1.

DOE has consulted with NRC regarding the incidental waste determination for the SRS tank system residuals. To facilitate the consultations, DOE prepared a demonstration that the material remaining in the SRS tank systems at closure satisfies criteria for classification as "incidental waste" (DOE 1997b). NRC has completed its review of the Savannah River Operations Office's HLW tank closure methodology and concluded that DOE's methodology reasonably analyzes the relevant considerations for an incidental waste determination (65 FR 62377, October 18, 2000).

Table 7-4. Comparison of modeling results to performance objectives at the seepline.[a]

	Units	Adjusted PO	F-Area GTS impact	Previous closures impact[b]	Tank 17 impact	Remaining PO
Radiological						
Beta-gamma dose	mrem/yr	4.0	1.9	0.0055	0.022	3.99
Alpha concentration	pCi/L	15	3.9×10^{-2}	(c)	(c)	15
Total dose	mrem/yr	4.0	1.9	0.0055	0.022	3.99
Nonradiological						
Nickel	mg/L	0.1	(d)	0	(d)	0.1
Chromium[e]	mg/L	0.1	4.6×10^{-5}	5.0×10^{-6}	1.1×10^{-5}	0.1
Mercury	mg/L	0.002	(d)	0	(d)	0.002
Silver	mg/L	0.05	1.7×10^{-3}	1.9×10^{-4}	4.1×10^{-4}	0.049
Copper	mg/L	1.3	(d)	0	(d)	1.3
Nitrate	mg/L	10 (as N)	1.2×10^{-2}	1.3×10^{-3}	7.5×10^{-3}	10 (as N)
Lead	mg/L	0.015	(d)	0	(d)	0.015
Fluoride	mg/L	4.0	1.1×10^{-3}	1.3×10^{-4}	2.7×10^{-4}	4
Barium	mg/L	2.0	(d)	0	(d)	2

a. Source: DOE 1997a
b. Tank 20
c. Concentration is less than 1.0×10^{-13} pCi/L.
d. Concentration is less than 1.0×10^{-06} mg/L
e. Total chromium (chromium III and VI).
PO = Performance Objective; GTS = Groundwater Transport Segment.

7.1.4 ENVIRONMENTAL RESTORATION PROGRAM

Upon completion of closure activities for a group of tanks (and their related equipment) in a particular section of a tank farm, responsibility for the tanks and associated equipment in the group would be transferred to the SRS environmental restoration program. The environmental restoration program would conduct soil assessments and remedial actions to address any contamination in the environment (including previous known leaks) and develop a post-closure strategy. Consideration of alternative remedial actions under the remediation program is outside the scope of this EIS, and would be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. However, DOE has established a formal process to ensure that tank closure activities are coordinated with the environmental restoration program. This process is described in the *High-Level Waste Tank Closure Program Plan* (DOE 1996b). This process requires that, once a group of tanks in a particular section of a tank farm is closed, the HLW operations organization and the environmental restoration organization would establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation.

The HLW organization would be responsible for operational control and the environmental restoration organization would be responsible for environmental restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the environmental restoration activities in the tank farm areas. The activities of the environmental restoration program would be governed by the CERCLA, RCRA corrective action, and the Federal Facility Agreement between DOE, SCDHEC, and EPA. As such, it is beyond the scope of this EIS.

DOE's HLW tank closure strategy was designed to be consistent with the requirements of RCRA and CERCLA under which the Tank Farm will eventually be remediated. The details of the proposed closure configuration for individual tank systems will be detailed in modules that are submitted to SCDHEC for approval. The modules are also provided to the SCDHEC and EPA Region IV Federal Facility Agreement project managers for review to ensure consistency with the Agreement's requirements for overall remediation of the Tank Farms. DOE's intention is that HLW tank closure actions would not interfere with or foreclose remedial alternatives for past releases.

7.2 Statutes and Regulations Requiring Permits or Consultations

Environmental regulations require that the owner or operator of a facility obtain permits for the construction and operation of new (water and air) emissions sources and for new domestic drinking water systems. To obtain these permits, the facility operator must apply to the appropriate government agency for a discharge permit for discharges of wastewater to the waters of the state and submit construction plans and specifications for the new emission sources, including new air sources. The environmental permits contain specific conditions with which the permittee must comply during construction and operation of a new emission source, describe pollution abatement and prevention methods to be utilized for reduction of pollutants, and contain emissions limits for pollutants which will be emitted from the facility. Section 7.2.1 discusses the environmental statutes and regulations under which DOE will be required to obtain permits. Table 7-5 identifies the major State of South Carolina statutes and their implementing regulations applicable to HLW tank system closures. The table also provides the underlying federal statutes and implementing regulations. Table 7-1 lists the permits.

7.2.1 ENVIRONMENTAL PROTECTION PERMITS

Clean Air Act, as amended, (42 USC 7401 et seq.), (40 CFR Parts 50-99); South Carolina Pollution Control Act [Section 48-1-10 et seq., SCDHEC Regulation 61-62]

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

The Act requires EPA to establish National Ambient Air Quality Standards to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC 7409). It also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC 7411) and the evaluation of specific emission increases to prevent a significant deterioration in air quality (42 USC 7470). In addition, the Clean Air Act regulates emissions of hazardous air pollutants, including radionuclides, through the National Emission Standards for Hazardous Air Pollutants (NESHAP) program (42 USC 7412). Air emission standards are established at 40 CFR Parts 50 through 99. The following describes four key aspects of the Clean Air Act.

- ***Prevention of Significant Deterioration*** – Prevention of Significant Deterioration, as defined by the Clean Air Act, applies to major stationary sources and is designed to permanently limit the degradation of air quality from specific pollutants in areas that meet attainment standards. The Prevention

Table 7-5. Major state and federal laws and regulations applicable to high-level waste tank system closures.

South Carolina laws and regulations	Federal laws and regulations
South Carolina Pollution Control Act (SC Code Section 48-1-10)	Clean Air Act (42 USC 7401)
	Clean Water Act (33 USC 1251)
Safe Drinking Water Act (SC Code Section 44-55-10)	Safe Drinking Water Act (42 USC 300(f))
Hazardous Waste Management Act (SC Code Section 44-56-10)	Resource Conservation and Recovery Act (42 USC 6901 et seq.)
R.61-9 Water Pollution Control Permits	40 CFR Part 122 *EPA Administered Permit Programs: The National Pollutant Discharge Elimination System*
R.61-58 *State Primary Drinking Water Regulations*	40 CFR Part 141 *National Primary Drinking Water Regulations*
R. 61-62 *Air Pollution Control Regulations and Standards*	40 CFR Part 50 *National Primary and Secondary Ambient Air Quality Standards*
	40 CFR §51.166 *Prevention of Significant Deterioration of Air Quality*
	40 CFR Part 60 *Standards of Performance for New Stationary Sources*
	40 CFR Part 61 *National Emission Standards for Hazardous Air Pollutants*
R.61-68 *Water Classification and Standards* R.61-69 *Classified Waters*	40 CFR 131 *Water Quality Standards*
R.61-79 *Hazardous Waste Management Regulations*	40 CFR Parts 260-266, 268, 270 (RCRA Subtitle C implementing regulations)
R.61-82 *Proper Closeout of Wastewater Treatment Facilities*	No federal equivalent

of Significant Deterioration regulations apply to new construction and to major modifications made to stationary sources. A major modification is defined as a net increase in emissions beyond thresholds listed at 40 CFR 51.166(b)(23). Construction or modifications of facilities that fall under this classification are subject to a preconstruction review and permitting under the program that is outlined in the Clean Air Act. In order to receive approval, DOE must show that the source (1) will comply with ambient air quality levels designed to prevent deterioration of air quality, (2) will employ "best available control technology" for each pollutant regulated under the Clean Air Act that will emit significant amounts, and (3) will not adversely affect visibility.

- ***Title V Operating Permit*** – Congress amended the Clean Air Act in 1990 to include requirements for a comprehensive operating permit program. Title V of the 1990 amendments requires EPA to develop a Federally enforceable operating permit program for air pollution sources to be administered by the state and/or local air pollution agencies. The purpose of this permit program is to consolidate in a single document all of the Federal and state regulations applicable to a source, in order to facilitate source compliance and enforcement. The EPA promulgated regulations at Section 107 and 110 of the Clean Air Act that define the requirements for state programs.

- ***Hazardous Air Pollutants*** – Hazardous air pollutants are substances that may cause health and environmental effects at low concentrations. Currently, 189 compounds have been identified as hazardous air pollutants. A major source is defined as any stationary source, or a group of stationary sources located within a contiguous area under common control, that emits or has the potential to emit at least 10 tons per year of any single hazardous air pollutant or 25 tons per year of a combination of pollutants.

  The 1990 amendments to the Clean Air Act substantially revised the program to regulate potential emissions of hazardous air pollutants. The aim of the new control program is to require state-of-the-art pollution control technology on most existing and all new emission sources. These provisions regulate emissions by promulgating emissions limits reflecting use of the maximum achievable control technology. These emission limits are then incorporated into a facility's operating permit.

- ***National Emission Standards for Hazardous Air Pollutants for Radionuclides*** – Radionuclide emissions other than radon from DOE facilities are also covered under the National Emission Standards for Hazardous Air Pollutants program (40 CFR Part 61, Subpart H). To determine compliance with the standard, an effective dose equivalent value for the maximally exposed members of the public is calculated using EPA-approved sampling procedures, computer models, or other EPA-approved procedures.

  Any fabrication, erection, or installation of a new building or structure within a facility whose emissions would result in an effective dose equivalent to a member of the public that would exceed 0.1 millirem per year would require that an application be submitted to EPA. This application must include the name of the applicant, the location or proposed location of the source, and technical information describing the source. If the application is for a modification of an existing facility, information provided to EPA must include the precise nature of the proposed changes, the productive capacity of the source before and after the changes are completed, and calculations of estimates of emissions before and after the changes are completed.

EPA has overall authority for the Clean Air Act; however, it delegates primary authority to states that have established an air pollution control program approved by EPA. In South Carolina, EPA has retained authority over radionuclide emissions (40 CFR Part 61) and has delegated to SCDHEC the responsibility for the rest of the regulated pollutants under the authority of the South Carolina Pollution Control Act (48-1-10 et. seq.,) and SCDHEC Air Pollution Control Regulation 61-62.

Construction and operation permits or exemptions will be required for new nonradiological air emission sources (diesel generators, concrete batch plants etc.) constructed and operated as part of the HLW tank systems closure process. The permits will contain operating conditions and effluent limitations for pollutants emitted from the facilities (see Table 7-1).

DOE will determine if a NESHAP permit will be required for radiological emissions from any facilities (stacks, process vents, etc.) used in the HLW tank systems closure process. As described in 40 CFR Part 61.96, if all emissions from facility operations would result in an effective dose equivalent to a member of the public that would not exceed 0.1 mllirem per year, an application for approval to construct under 40 CFR Part 61.07 is not required to be filed. 40 CFR Part 61.96 also allows DOE to use, with prior EPA approval, methods other than EPA standard methods for estimating the source term for use in calculating the projected dose. If DOE's calculations indicate that the emissions from the HLW tank system closure operations will exceed 0.1 millirem per year, DOE will, prior to the start of construction, complete an application for approval to construct under 40 CFR 61.07.

Federal Clean Water Act, as amended (33 USC 1251 et seq.); SC Pollution Control Act (SC Code Section 48-1-10 et seq., 1976) (SCDHEC Regulation 61-9.122 et. seq.)

The purpose of the Clean Water Act, which amended the Federal Water Pollution Act, is to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States (Section 101). Section 313 of the Act generally requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements.

Under the Clean Water Act, states generally set water quality standards, and EPA or states regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System (NPDES) permitting program. EPA regulations for this program are codified at 40 CFR Part 122. If the construction or operation of the selected action would result in point-source discharges, DOE could need to obtain a National Pollutant Discharge Elimination System permit.

EPA has delegated primary enforcement authority for the Clean Water Act and the NPDES permitting program to SCDHEC for waters in South Carolina. In 1996, SCDHEC, under the authority of the Pollution Control Act (48-1-10 et seq.) and Regulation 61-9.122, issued NPDES Permit SC0000175, which addresses wastewater discharges to SRS streams and NPDES permit SCG250162 which addresses general utility water discharges. Permit SC0000175 contains effluent limitations for physical parameters such as flow and temperature and for chemical pollutants with which DOE must comply. DOE will apply for a discharge permit for HLW tank system closure operations if the process chosen results in discharges to waters of the State (see Table 7-1).

Under the authority of the Pollution Control Act, SCDHEC has issued industrial wastewater treatment "as-built" construction permits numbers 14,338, 14,520, and 17,434-IW covering the SRS HLW tank systems. These permits establish design and operating requirements for the tank systems based on the standards set forth in Appendix B of the SRS Federal Facility Agreement (see Section 7.3.2).

Section 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires the EPA to establish regulations for the Agency or individual states to issue permits for stormwater discharges associated with industrial activity, including construction activities that could disturb five or more acres (40 CFR Part 122). SCDHEC has issued a General Permit for Storm Water Discharges Associated with Industrial Activities (Permit No. SCR000000) authorizing stormwater discharges to the waters of the State of South Carolina in accordance with effluent limitations, monitoring requirements, and conditions as set forth in the permit. This permit requires preparation and submittal of a Pollution Prevention Plan for all new and existing point source discharges associated with industrial activity. Accordingly, DOE-SR has developed a Storm Water Pollution Prevention Plan for storm water discharges at SRS. The SRS Storm Water Pollution Prevention Plan would need to be revised to include pollution prevention measures to be implemented for HLW tank system operations (See Table 7-1) if industrial activities are exposed to storm water. SCDHEC has issued a General Permit for storm water discharges from construction activities that are "Associated with Industrial Activity" (Permit No. SCR100000). An approved plan would be needed that includes erosion control and pollution prevention measures to be implemented for construction activities.

Section 404 of the Clean Water Act requires that a 404 permit be issued for discharge of dredge or fill material into the waters of the United States. The authority to implement these re-

quirements has been given to the U.S. Army Corps of Engineers. Section 401 of the Clean Water Act requires certification that discharges from construction or operation of facilities, including discharges of dredge and fill material into navigable waters, will comply with applicable water standards. This certification, which is granted by SCDHEC, is a prerequisite for the 404 permit. DOE does not believe that a 404 permit will be required for the HLW tank system closures.

Federal Safe Drinking Water Act, as amended [42 USC 300 (f) et seq., 40 CFR Parts 100-149]; South Carolina Safe Drinking Water Act (Title 44-55-10 et seq.), State Primary Drinking Water Regulations, (SCDHEC R.61-58)

The primary objective of the Safe Drinking Water Act is to protect the quality of water supplies. This law grants EPA the authority to protect quality of public drinking water supplies by establishing national primary drinking water regulations. In accordance with the Safe Drinking Water Act, the EPA has delegated authority for enforcement of drinking water standards to the states. Regulations (40 CFR Part 123, 141, 145, 147, and 149) specify maximum contaminant levels, including those for radioactivity, in public water systems, which are generally defined as systems that serve at least 15 service connections or regularly serve at least 25 year-round residents. Construction and operation permits would be required for lines to drinking water supply systems associated with HLW tank closure activities (see Table 7-1). Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

As a regulatory practice and policy, the Safe Drinking Water Act maximum contaminant levels are also used as groundwater protection standards. For example, the regulations specify that the average annual concentration of man-made radionuclides in drinking water shall not produce a dose equivalent to the total body or an internal organ dose greater than 4 mrem per year beta-gamma activity. This radionuclide maximum contaminant level is the primary performance objective for the SRS HLW tank system closures.

EPA has delegated primary enforcement authority to SCDHEC for public water systems in South Carolina. Under the authority of the South Carolina Safe Drinking Water Act (44-55-10 et seq.), SCDHEC has established a drinking water regulatory program (R.61-58). SCDHEC has also established groundwater and surface water classifications and standards under R. 61-68. Along with the Federal maximum contaminant levels (40 CFR 141), these South Carolina water quality standards are the groundwater and surface water performance standards applicable to closure of the HLW tank systems.

Resource Conservation and Recovery Act, as amended (Solid Waste Disposal Act) (42 USC 6901 et seq.); South Carolina Hazardous Waste Management Act, Section 44-56-30, South Carolina Hazardous Waste Management Regulations (R.61-79.124 et seq.)

RCRA regulates the treatment, storage, and disposal of hazardous wastes. The EPA regulations implementing RCRA are found in 40 CFR Parts 260-280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements. This area of the law deals with two different approaches to regulation. First, RCRA regulates the wastes themselves and sets standards for waste forms that may be disposed of. Second, RCRA regulates the design and operation of the waste management facilities and establishes standards for their performance.

EPA defines waste that exhibits the characteristics of ignitability, corrosivity, reactivity, or toxicity as "characteristic" hazardous waste. EPA has also identified certain materials as hazardous waste by listing them in the RCRA regulations. These materials are referred to as "listed" hazardous waste. "Mixed waste" is radioactively contaminated hazardous waste. The definition of "solid waste" in RCRA specifically excludes the radiological component

(source, special nuclear, or byproduct material as defined by the Atomic Energy Act). As a result, mixed waste is regulated under multiple authorities: by RCRA, as implemented by EPA or authorized states for the hazardous waste components; and by the Atomic Energy Act for radiological components as implemented by either DOE or the Nuclear Regulatory Commission.

RCRA applies mainly to active facilities that generate and manage hazardous waste. This law imposed management requirements on generators and transporters of hazardous waste and upon owners and operators of treatment, storage, and disposal facilities. EPA has established a comprehensive set of regulations governing all aspects of treatment, storage, and disposal facilities, including location, design, operation, and closure. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply for EPA authorization of its program. EPA has delegated primary enforcement authority to SCDHEC, which has established hazardous waste management requirements under SC Regulation R.61-79.

Under Section 3004(u) of RCRA, DOE is required to assess releases from solid waste management units and implement corrective action plans where necessary. The RCRA corrective action requirements for SRS are set forth in the Federal Facility Agreement (Section 7.3.2).

The HLW managed in the F- and H-Area Tank Farms is considered mixed waste because it exhibits characteristics of RCRA hazardous waste (i.e., corrosivity and toxicity for certain metals) and contains source, special nuclear, or byproduct material regulated under the Atomic Energy Act. Waste removed from the tank systems will be managed in accordance with applicable RCRA requirements (i.e., treated to meet the land disposal restrictions standards prior to disposal). The HLW tank systems are exempt from the design and operating standards and permitting requirements for hazardous waste management units because they are wastewater treatment units regulated under the Clean Water Act [see 40 CFR 260.10, 264.1(g)(6), and 270.1(c)(2)(v)].

The Federal Facility Compliance Act (42 USC 6921 (et. seq.)

The Federal Facility Compliance Act amended RCRA in 1992 and requires DOE to prepare plans for developing treatment capacity for mixed wastes stored or generated at each facility. After consultation with other affected states, the host-state or EPA must approve each plan. The appropriate regulator must also issue an order requiring compliance with the plan.

On September 20, 1995, SCDHEC approved the Site Treatment Plan for SRS. SCDHEC issued a consent order, signed by DOE, requiring compliance with the plan on September 29, 1995. DOE provides SCDHEC with annual updates to the information in the SRS Site Treatment Plan. DOE would be required to notify SCDHEC of any new mixed waste streams generated as result of HLW tank system closure activities.

7.2.2 PROTECTION OF BIOLOGICAL, HISTORIC, AND ARCHAEOLOGICAL RESOURCES

Endangered Species Act, as amended (16 USC 1531 et seq.)

The Endangered Species Act provides a program for the conservation of threatened and endangered species and the ecosystems on which those species rely. All Federal agencies must assess whether the potential impacts of a proposed action could adversely affect threatened or endangered species or their habitat. If so, the agency must consult with the U.S. Fish and Wildlife Service (part of the U.S. Department of the Interior) and the National Marine Fisheries Service (part of the Department of Commerce), as required under Section 7 of the Act. The outcome of this consultation may be a biological opinion by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service that states whether the proposed action would jeopardize the continued existence of the species under consideration. If there is non-jeopardy opinion,

but if some individuals might be killed incidentally as a result of the proposed action, the Services can determine that such losses are not prohibited as long as measures outlined by the Services are followed. Regulations implementing the Endangered Species Act are codified at 50 CFR Part 15 and 402.

The HLW tank systems are located within fenced, disturbed industrial areas. Construction associated with closure of the tank systems would not disturb any threatened or endangered species, would not degrade any critical or sensitive habitat, and would not affect any jurisdictional wetland. Therefore DOE concludes that no consultation with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service concerning the alternatives considered in this EIS is required.

The following statutes pertain to protection of animals or plants, historic sites, archaeological resources, and items of significance to Native Americans. DOE does not expect these requirements to apply to the closure of the SRS HLW tank systems since these facilities are located in previously disturbed industrial areas.

- Migratory Bird Treaty Act, as amended (16 USC 703 et seq.)
- Bald and Golden Eagle Protection Act, as amended (16 USC 668-668d)
- National Historic Preservation Act, as amended (16 USC 470 et seq.)
- Archaeological Resource Protection Act, as amended (16 USC 470 et seq.)
- Native American Grave Protection and Repatriation Act of 1990 (25 USC 3001)
- American Indian Religious Freedom Act of 1978 (42 USC 1996)

7.3 Statutes and Regulations Related to Emergency Planning, Worker Safety, and Protection of Public Health and the Environment

7.3.1 ENVIRONMENTAL PROTECTION

National Environmental Policy Act of 1969, as amended (42 USC 4321 et seq.)

NEPA requires agencies of the Federal Government to prepare EISs on potential impacts of proposed major Federal actions that may significantly affect the quality of the human environment. DOE has prepared this EIS in accordance with the requirements of NEPA as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and DOE NEPA regulations (10 CFR Part 1021).

Pollution Prevention Act of 1990 (42 USC 13101 et seq.)

The Pollution Prevention Act of 1990 establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmentally safe recycling, treatment, and disposal. DOE requires each of its sites to establish specific goals to reduce the generation of waste. If the Department were to build and operate facilities, it would also implement a pollution prevention plan.

Comprehensive Guideline for Procurement of Products Containing Recovered Materials (40 CFR Part 247)

This regulation is issued under the authority of Section 6002 of RCRA and Executive Order 12783, which set forth requirements for Federal agencies to procure products containing

recovered materials for use in their operations using guidelines established by the EPA. The purpose of these regulations is to promote recycling by using government purchasing to expand markets for recovered materials. RCRA Section 6002 requires that any purchasing agency, when using appropriated funds to procure an item, shall purchase it with the highest percentage of recovered materials practicable. The procurement of materials to be used in HLW tank system closure activities should be conducted in accordance with these regulations.

Toxic Substances Control Act, as amended (USC 2601 et seq.) (40 CFR Part 700 et seq.)

The Toxic Substances Control Act provides EPA with the authority to require testing of both new and old chemical substances entering the environment and to regulate them where necessary. The Act also regulates the manufacture, use, treatment, storage, and disposal of certain toxic substances not regulated by RCRA or other statutes, specifically polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. DOE does not expect to use these materials during closure of the HLW tank systems. Programs and procedures would need to be implemented to address appropriate management and disposal of waste generated as a result of their use, if necessary.

7.3.2 EMERGENCY PLANNING AND RESPONSE AND PUBLIC HEALTH

This section discusses the regulations that address protection of public health and worker safety and require the establishment of emergency plans and coordination with local and Federal agencies related to facility operations. DOE Orders generally set forth the programs and procedures required to implement the requirements of these regulations. See Section 7.5.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.)

The Atomic Energy Act, as amended, provides fundamental jurisdictional authority to DOE and the Nuclear Regulatory Commission over governmental and commercial use of nuclear materials. The Atomic Energy Act ensures proper management, production, possession, and use of radioactive materials. It gives the Nuclear Regulatory Commission specific authority to regulate the possession, transfer, storage, and disposal of nuclear materials, as well as aspects of transportation packaging design requirements for radioactive materials, including testing for packaging certification. Commission regulations applicable to the transportation of radioactive materials (10 CFR Part 71 and 73) require that shipping casks meet specified performance criteria under both normal transport and hypothetical accident conditions.

The Atomic Energy Act provides DOE the authority to develop generally applicable standards for protecting the environment from radioactive materials. In accordance with the Atomic Energy Act, DOE has established a system of requirements that it has issued as DOE Orders.

DOE Orders and regulations issued under authority of the Atomic Energy Act include the following:

- ***DOE Order 435.1 (Radioactive Waste Management)*** – This Order and its associated Manual and Guidance establish authorities, responsibilities, and requirements for the management of DOE HLW, transuranic waste, low-level waste, and the radioactive component of mixed waste. Those documents provide detailed HLW management requirements including waste incidental to reprocessing determinations; waste characterizations, certification, storage, treatment, and disposal; and HLW facility design and closure.

- ***DOE Order 5400.1 (General Environmental Protection Program)*** – This Order establishes environmental protection program requirements, authorities, and responsibilities for DOE operations for ensuring compliance with applicable Federal, state, and local environmental protection laws and regulations as well as internal DOE policies.

- ***DOE Order 5400.5 (Radiation Protection of the Public and the Environment)*** – This Order establishes standards and requirements for DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation. The requirements of this Order are also codified in the proposed 10 CFR Part 834, Radiation Protection of the Public and the Environment.

- ***DOE Order 440.1A (Worker Protection Management for DOE Federal and Contractor Employees)*** – This Order establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal and contractor workers with a safe and healthful workplace.

Section 202(4) of the Energy Reorganization Act of 1974 (42 USC §5842(4)) gives the NRC licensing and related regulatory authority over DOE "facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the Administration [now known as DOE] which are not used for, or are part of, research and development activities." DOE has determined that NRC's licensing authority is limited to DOE facilities that are (1) authorized by Congress for the express purpose of long-term storage of HLW and (2) developed and constructed after the passage of the Energy Reorganization Act (Sullivan 1998). None of the SRS HLW tank systems meet both of these criteria. DOE's Savannah River Operations Office has consulted with NRC concerning criteria regarding incidental waste for the SRS tank residuals.

Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.) <u>Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release</u> (10 CFR Part 30.72 Schedule C)

This list is the basis for both the public and private sector to determine if the radiological materials they deal with must have an emergency response plan for unscheduled releases. It is one of the threshold criteria documents for DOE Emergency Preparedness Hazard Assessments required by DOE Order 151.1, "Comprehensive Emergency Management System." An emergency response plan addressing HLW tank system closure operations would need to be prepared in accordance with this regulation.

Reorganization Plan No. 3 of 1978, Public Health and Welfare (42 USC 5121 et seq.), Emergency Management and Assistance (44 CFR Part 1-399)

These regulations generally include the policies, procedures, and responsibilities of the Federal Emergency Management Agency, NRC, and DOE for implementing a Federal Emergency Preparedness Program including radiological planning and preparedness. An emergency response plan, including radiological planning and preparedness for HLW tank system closure operations, would need to be prepared and implemented, in accordance with this regulation.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC 11001 et seq.) (also known as "SARA Title III")

Under Subtitle A of the Emergency Planning and Community Right-to Know Act, Federal facilities, including those owned by DOE, must provide information on hazardous and toxic chemicals to state emergency response commissions, local emergency planning committees, and EPA. The goal of providing this information is to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. The required information includes inventories of specific chemicals used or stored and descriptions of releases that occur

from sites. This law, implemented at 40 CFR Parts 302 through 372, requires agencies to provide material safety data sheet reports, emergency and hazardous chemical inventory reports, and toxic chemical release reports to appropriate local, state, and Federal agencies.

DOE submits hazardous chemical inventory reports for SRS to SCDHEC. The chemical inventory could change depending on the HLW tank system closure alternative(s) DOE implemented; however, subsequent reports would reflect any change to the inventory.

Hazardous Materials Transportation Act, 49 U.S.C. 1801 and Regulations

Federal law provides for uniform regulation of the transportation of hazardous and radioactive materials. Transport of hazardous and radioactive materials, substances, and wastes is governed by U.S. Department of Transportation, Nuclear Regulatory Commission, and EPA regulations. These regulations may be found in 49 CFR 100-178, 10 CFR 71, and 40 CFR 262, respectively.

U.S. Department of Transportation hazardous material regulations govern the hazard communication (marking, hazard labeling, vehicle placarding, and emergency response telephone number) and transport requirements, such as required entries on shipping papers or EPA waste manifests. Nuclear Regulatory Commission regulations applicable to radioactive materials transportation are found in 10 CFR 71 and detail packaging design requirements, including the testing required for package certification. EPA regulations govern offsite transportation of hazardous wastes. DOE Order 460.1A (Packaging and Transportation Safety) sets forth DOE policy and assigns responsibilities to establish safety requirements for the proper packaging and transportation of DOE offsite shipments and onsite transfers of hazardous materials and for modal transport. (Offsite is any area within or outside a DOE site to which the public has free and uncontrolled access; onsite is any area within the boundaries of a DOE site or facility to which access is controlled.)

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (42 USC 9601 et seq.) National Oil and Hazardous Substance Contingency Plan (40 CFR Part 300 et seq.)

CERCLA, as amended by the Superfund Amendments and Reauthorization Act, authorizes EPA to require responsible site owners, operators, arrangers, and transporters to clean up releases of hazardous substances, including certain radioactive substances. This Act applies to both the Federal government and to private citizens. Executive Order 12580 delegates to heads of executive departments and agencies the responsibility for undertaking remedial actions for releases or threatened releases at sites that are not on the National Priorities List and removal actions other than emergencies where the release is from any facility under the jurisdiction or control of executive departments or agencies.

Sites determined to have a certain level of risk to health or the environment are placed upon the National Priorities List so that their clean up can be scheduled and tracked to completion. SRS was placed on the National Priorities List in 1989.

DOE, SCDHEC, and EPA have signed a Federal Facility Agreement to coordinate cleanup at SRS, as required by Section 120 of CERCLA. The Agreement addresses RCRA corrective action and CERCLA requirements applicable to cleanup at SRS. Section IX of the Agreement sets forth requirements for the SRS HLW tank systems. Design and operating standards for the HLW tank systems are found in Appendix B of the Agreement. DOE has submitted a waste removal plan and schedule for the tank systems that do not meet the applicable secondary containment standards to SCDHEC. The approved waste removal schedule appears in Appendix B of the *High-Level Waste Tank Closure Program Plan* (DOE 1996b). DOE must provide SCDHEC with an annual report on the status of the HLW tank systems being removed from service. After waste removal is completed, the tank systems are available for closure in accor-

dance with general closure strategy presented in DOE (1996a).

CERCLA also establishes an emergency response program in the event of a release or a threatened release to the environment. The Act includes requirements for reporting to Federal and state agencies releases of certain hazardous substances in excess of specified amounts. The requirements of the Act could apply to the proposed project in the event of a release of hazardous substances to the environment.

CERCLA also addresses damages for the injury, destruction, or loss of natural resources that are not or cannot be addressed through the remedial action. The Federal government, state governments, and Indian tribes are trustees of the natural resources that belong to, are managed by, or are otherwise controlled by those respective governing bodies. As trustees, they may assess damages and recover costs necessary to restore, replace, or acquire equivalent resources when there is injury to natural resources as a result of release of a hazardous substance.

Occupational Safety and Health Act of 1970, as amended (29 USC 651 et seq.); Occupational Safety and Health Administration Emergency Response, Hazardous Waste Operations and Worker Right to Know (29 CFR Part 1910 et seq.)

The Occupational Safety and Health Act (29 USC 651) establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. While OSHA and EPA both have a mandate to reduce exposures to toxic substances, OSHA's jurisdiction is limited to safety and health conditions that exist in the workplace environment. In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. The OSHA regulations (29 CFR) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. This regulation sets down the OSHA requirements for employee safety in a variety of working environments. It addresses employee emergency and fire prevention plans (Section 1910.38), hazardous waste operations and emergency response (Section 1910.120), and hazard communication (Section 1910.1200) that enable employees to be aware of the dangers they face from hazardous materials at their workplace. DOE places emphasis on compliance with these regulations at its facilities and prescribes through DOE Orders OSHA standards that contractors shall meet, as applicable to their work at Government-owned, contractor-operated facilities. DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths required by OSHA regulations.

Noise Control Act of 1972, as amended (42 USC 4901 et seq.)

Section 4 of the Noise Control Act directs Federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements related to noise that would be generated by activities associated with tank closures.

7.4 Executive Orders

The following executive orders would be in effect for the HLW tank system closures. DOE Orders generally set forth the programs and procedures required to implement the requirements of the orders.

Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands)

Executive Order 11988 directs Federal agencies to establish procedures to ensure that any Federal action taken in a floodplain considers the

potential effects of flood hazards and floodplain management and avoids floodplain impacts to the extent practicable.

Executive Order 11990 directs Federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for compliance with floodplain and wetlands activity are codified at 10 CFR 1022.

Executive Order 12856 (Right-to-Know Laws and Pollution Prevention Requirements)

This Order directs Federal agencies to reduce and report toxic chemicals entering any waste stream; improve emergency planning, response, and accident notification; and encourage the use of clean technologies and testing of innovative prevention technologies. In addition, the Order states that Federal agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which requires agencies to meet the requirements of the Act.

Executive Order 12898 (Environmental Justice)

This Order directs Federal agencies, to the extent practicable, to make the achievement of environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations in the United States and its territories and possessions. The order provides that the Federal agency responsibilities it establishes are to apply equally to Native American programs.

Executive Order 12902 (Energy Efficiency and Water Conservation at Federal Facilities)

Executive Order 12902 requires Federal agencies to develop and implement a program for conservation of energy and water resources.

Executive Order 13045 (Protection of Children from Environmental Health Risks and Safety Risks)

Because of the growing body of scientific knowledge that demonstrate that children may suffer disproportionately from environmental health and safety risks, Executive Order 13045 directs each Federal agency to make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children.

Executive Order 13112 (Invasive Species)

Executive Order 13112 requires Federal agencies whose actions may affect the status of invasive species to identify such actions and to use relevant programs and authorities to prevent the introduction of invasive species, detect and respond rapidly to control the populations of such species, monitor invasive species populations, provide for restoration of native species and habitat conditions in ecosystems that have been invaded, conduct research on invasive species and provide for environmentally sound control, and promote public education on invasive species and the means to address them.

7.5 DOE Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its

facilities are the promulgation of regulations and the issuance of DOE Orders. Table 7-6 lists the major DOE Orders applicable to the closure of the SRS HLW tank systems.

The DOE regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For the purposes of this EIS, relevant regulations include 10 CFR Part 820, *Procedural Rules for DOE Nuclear Facilities*; 10 CFR Part 830, *Nuclear Safety Management; Contractor and Subcontractor Activities*; 10 CFR Part 835, *Occupational Radiation Protection*; 10 CFR Part 1021, *Compliance with NEPA*; and 10 CFR Part 1022, *Compliance with Floodplains/Wetlands Environmental Review Requirements*. DOE has enacted occupational radiation protection standards to protect DOE and its contractor employees. These standards are set forth in 10 CFR Part 835, *Occupational Radiation Protection*; the rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities, including those conducted by DOE contractors. The activity may be, but is not limited to, design, construction, or operation of DOE facilities.

Table 7-6. DOE Orders and Standards relevant to closure of the HLW tank systems.

	DOE Orders
151.1	Comprehensive Emergency Management System
225.1A	Accident Investigations
231.1	Environment, Safety and Health Reporting
232.1A	Occurrence Reporting and Processing of Operations Information
420.1	Facility Safety
425.1A	Startup and Restart of Nuclear Facilities
430.1A	Life Cycle Asset Management
435.1	Radioactive Waste Management
440.1A	Worker Protection Management for DOE Federal and Contractor Employees
451.1A	National Environmental Policy Act Compliance Program
460.1A	Packaging and Transportation Safety
460.2	Departmental Materials Transportation and Packaging Management
470.1	Safeguards and Security Program
471.1	Identification and Protection of Unclassified Controlled Nuclear Information
471.2A	Information Security Program
472.1B	Personnel Security Activities
1270.2B	Safeguards Agreement with the International Atomic Energy Agency
1300.2A	Department of Energy Technical Standards Program
1360.2B	Unclassified Computer Security Program
3790.1B	Federal Employee Occupational Safety and Health Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5400.1	General Environmental Protection Program
5400.5	Radiation Protection of the Public and the Environment
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
5480.21	Unreviewed Safety Questions
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Report
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5632.1C	Protection and Control of Safeguards and Security Interests
5633.3B	Control and Accountability of Nuclear Materials
5660.1B	Management of Nuclear Materials
6430.1A	General Design Criteria
1020-94	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities
1021-93	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components
1024-92	Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites for Department of Energy Facilities
1027-92	Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23 Nuclear Safety Analysis Reports
3009-94	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports
3011-94	Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans

References

DOE (U.S. Department of Energy), 1996a, *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems, Savannah River Site, Construction Permit Numbers 14,338, 14,520, 17,424-IW,* Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996b, *High-Level Waste Tank Closure Program Plan*, Revision 0, Savannah River Operations Office, Aiken, South Carolina, December 16.

DOE (U.S. Department of Energy), 1997a, *Industrial Wastewater Closure Module for the High-Level Waste Tank 17 System*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *Regulatory Basis for Incidental Waste Classification at the Savannah River Site High-level Waste Tank Farms*, Revision 1, Savannah River Operations Office, Aiken, South Carolina, April 30.

DOE (U.S. Department of Energy), 1999, *Radioactive Waste Management*, DOE Order and Manual 435.1, Office of Environmental Management, Washington DC, July 9. (Available at http://www.explorer.doe.gov:1776/pdfs/doe/doetext/neword/435/m4351-1.pdf).

Sullivan, M. A., 1998, U.S. Department of Energy, General Counsel, letter to J. T. Greeves, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, "Natural Resources Defense Council Petition to Exercise Licensing Authority over Savannah River Site High-Level Waste Tanks," September 30.

APPENDIX A

TANK FARM DESCRIPTION AND CLOSURE PROCESS

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APPENDIX A. TANK FARM DESCRIPTION AND CLOSURE PROCESS

A.1 Introduction

Over the last 45 years, SRS has produced special radioactive isotopes for various national programs. These isotopes were primarily produced in the site's nuclear reactors, which generated neutrons that bombarded specifically designed targets. The neutrons bombarding the targets result in transmutation of the target atoms to produce the desired radioisotopes. The spent nuclear fuel and the targets were reprocessed to recover unused reactor fuel and the isotopes produced in the reactors. The reprocessing activity involved dissolving the fuel and targets in large, heavily shielded chemical separations facilities, in the F- and H-Areas known as the F-Canyon and H-Canyon, respectively. These facilities concentrated the valuable materials DOE wanted to recover but produced large quantities of highly radioactive liquid waste known as HLW (see Chapter 1 for a more complete definition of high-level waste). The HLW has been stored in the Tank Farms in F- and H-Area.

DOE has recently reviewed its HLW management practices in two recent EISs: the *DWPF Supplemental EIS* (DOE 1994) and the *SRS Waste Management EIS* (DOE 1995). This HLW Tank Closure EIS is focused on closure of the tank farms after the HLW has been removed. Nevertheless, a discussion on how the tank farms fit into the overall SRS HLW management program is useful to understanding the nature of the residual waste in the tanks and the tanks' current use and history. Therefore, Section A.2 provides an overview of HLW management at SRS. Section A.3 describes the tank farm equipment and operations. Section A.4 describes the activities needed to close the tank farms under the various closure alternatives.

A.2 Overview of SRS HLW Management

The main processes involved in HLW management are generation, storage, evaporation, sludge processing, salt processing, vitrification, and saltstone manufacture and disposal. Figure A-1 shows the process flows among the processes.

Although the F- and H-Canyons are the only facilities at SRS that generate HLW in the regulatory sense, other facilities produce liquid radioactive waste that has characteristics similar to those of HLW. These facilities include the Receiving Basin for Offsite Fuel, the Savannah River Technology Center, the H-Area Maintenance Facility, and the reactor areas. Selected wastes from these facilities are managed at SRS as if they were HLW and are thus sent to the tank farms for storage and ultimate processing. Also, the DWPF, which is the final treatment for SRS HLW, recycles wastewater back to the tank farms.

The tank farms receive the HLW, immediately isolating it from the environment, SRS workers, and the public. The tank farms provide a sufficiently long period of storage to allow many of the short-lived radionuclides to decay to much lower concentrations. After pH adjustment and introduction into the tanks, the HLW is allowed to settle, separating into a sludge layer at the bottom and a salt solution layer at the top known as supernate. SRS uses evaporators to concentrate the supernate to produce a third form of HLW in the tank farms known as crystallized saltcake. As a result of intertank transfers, some of the tanks are now primarily salt tanks, some are primarily sludge tanks, some tanks contain a mixture of salt and sludge, and some tanks are empty.

Before 1994, the Canyons generated two waste streams which were sent to the tank farms. High-radioactivity waste, which contained most of the radionuclides, was aged in a high-radioactivity waste tank before evaporation. Low-radioactivity waste, which contained lower concentration of radionuclides, was sent directly to an evaporator. This historical practice is shown on Figure A-1. Under current SRS operations, high-radioactivity waste is no longer

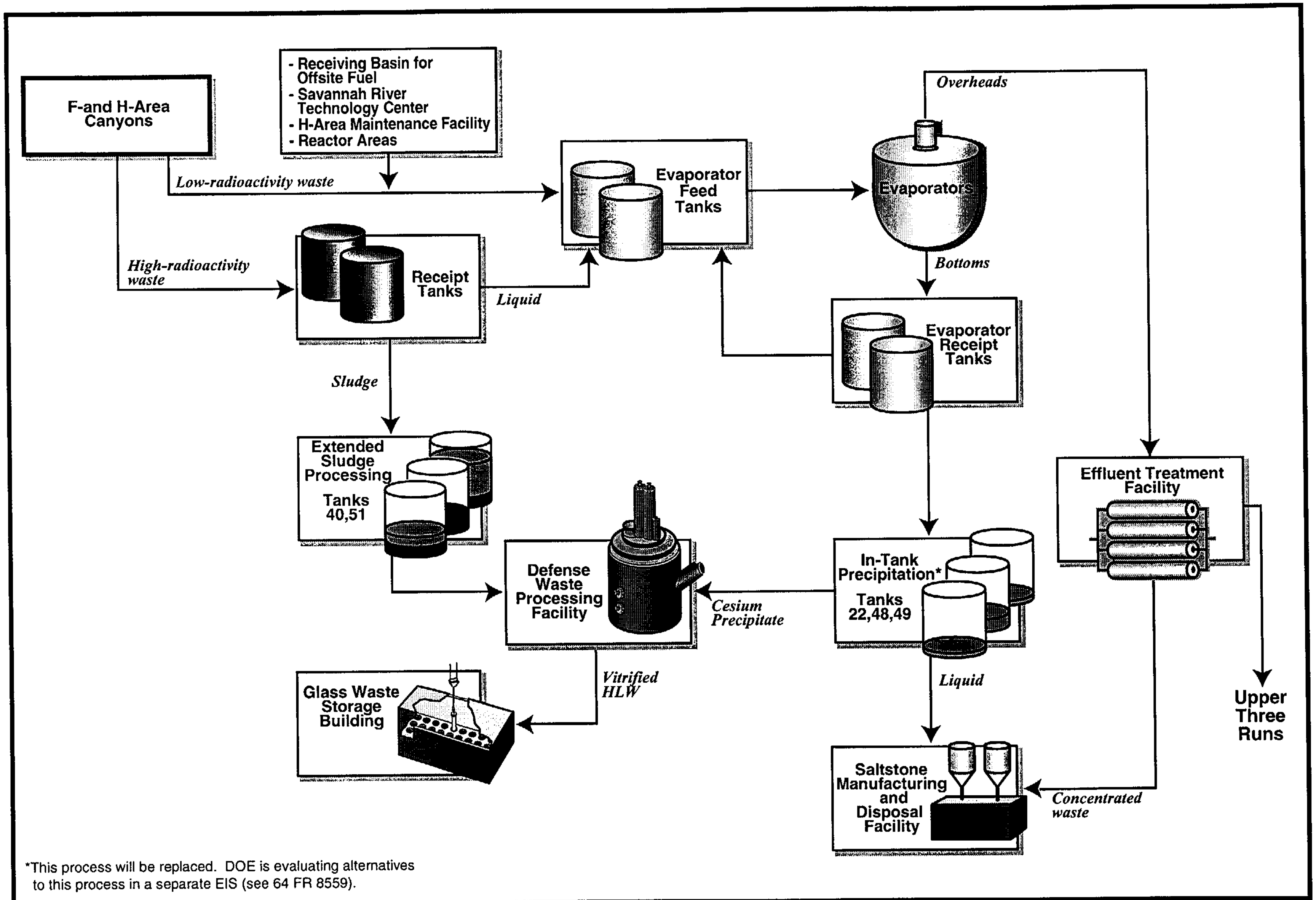

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Figure A-1. Process flows for Savannah River Site High-Level Waste Management System.

generated because SRS reactors ceased operation in 1988. All incoming waste streams to the tank farms can be directed to the same receipt tanks and evaporator feed tanks.

SRS designed and built a facility using four H-Tank Farm tanks, known as the In-Tank Precipitation Facility, to process the saltcake and concentrated supernate. This salt processing facility was designed to receive redissolved saltcake and precipitate the chemical cesium that is responsible for the most prominent and penetrating radiation emitting from the waste. The cesium precipitate was designed to go DWPF for processing in the salt cell with the aqueous cesium portion to be melted into a glass matrix and the organic portion sent to the Consolidated Incineration Facility. The remaining liquid salt solution was designed to go to the Saltstone Manufacturing and Disposal Facility for solidification and burial in underground vaults. DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements. Therefore, DOE is now evaluating a replacement salt processing technology in an EIS being prepared concurrently with this one (64 FR 8558).

The sludge in the tanks, which contains approximately 54 percent of the HLW radioactivity, is treated in a process known as Extended Sludge Processing. Extended Sludge Processing uses existing tanks in the H-Area Tank Farm. The process removes aluminum hydroxide and soluble salts from the sludge before transferring the sludge to the DWPF for vitrification. Aluminum affects the hardness of the glass and the overall volume of glass waste. The soluble salts interfere with the desired chemical composition of the glass. The wastewaters from Extended Sludge Processing and the DWPF are recycled back to the tank farm.

The DWPF receives washed sludge and salt precipitate, mixes it with appropriate additives, and melts it into a glass form in a process known as vitrification. The glass is poured into stainless steel canisters and stored in the Glass Waste Storage Building, a facility containing an underground vault for canister storage. Because the In-Tank Precipitation Facility has been inoperable, the DWPF has been vitrifying only sludge waste. The DWPF will continue sludge-only processing until the feed is available from the salt processing facility. In order to minimize the number of HLW canisters that are produced, SRS planning documents (WSRC 1998a) call for maintaining the sludge and salt precipitate feeds to the DWPF in an acceptable balance to avoid having any precipitate left over when all of the sludge inventory has been vitrified. The ultimate disposition of the HLW glass canisters is a geologic repository. Currently, the government is determining whether the candidate repository site at Yucca Mountain in Nevada is appropriate for ultimate disposal of the nation's spent nuclear fuel and HLW (DOE 1999).

The Saltstone Manufacturing and Disposal Facility receives the salt solution after the cesium has been precipitated. The salt solution is mixed with cement, slag, and flyash to form a grout with chemical and physical properties designed to retard the leaching of contaminants over time. The grout is poured into disposal vaults and hardens into what is known as saltstone. This is the final disposition of the salt solution. The Saltstone Manufacturing and Disposal Facility has received salt solution from the In-Tank Precipitation Process demonstration operations and concentrated wastes from the F/H-Area Effluent Treatment Facility and has been producing saltstone from these waste feeds. The Effluent Treatment Facility receives evaporator overheads from the Separations Areas and tank farms evaporators and treats the water for discharge to Upper Three Runs.

A.3 Description of the Tank Farms

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks, 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure A-2 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site that contains 29 waste tanks, 3 evaporator systems (including the new Replacement High-level Waste Evaporator, 242-25H), the In-Tank Pre-

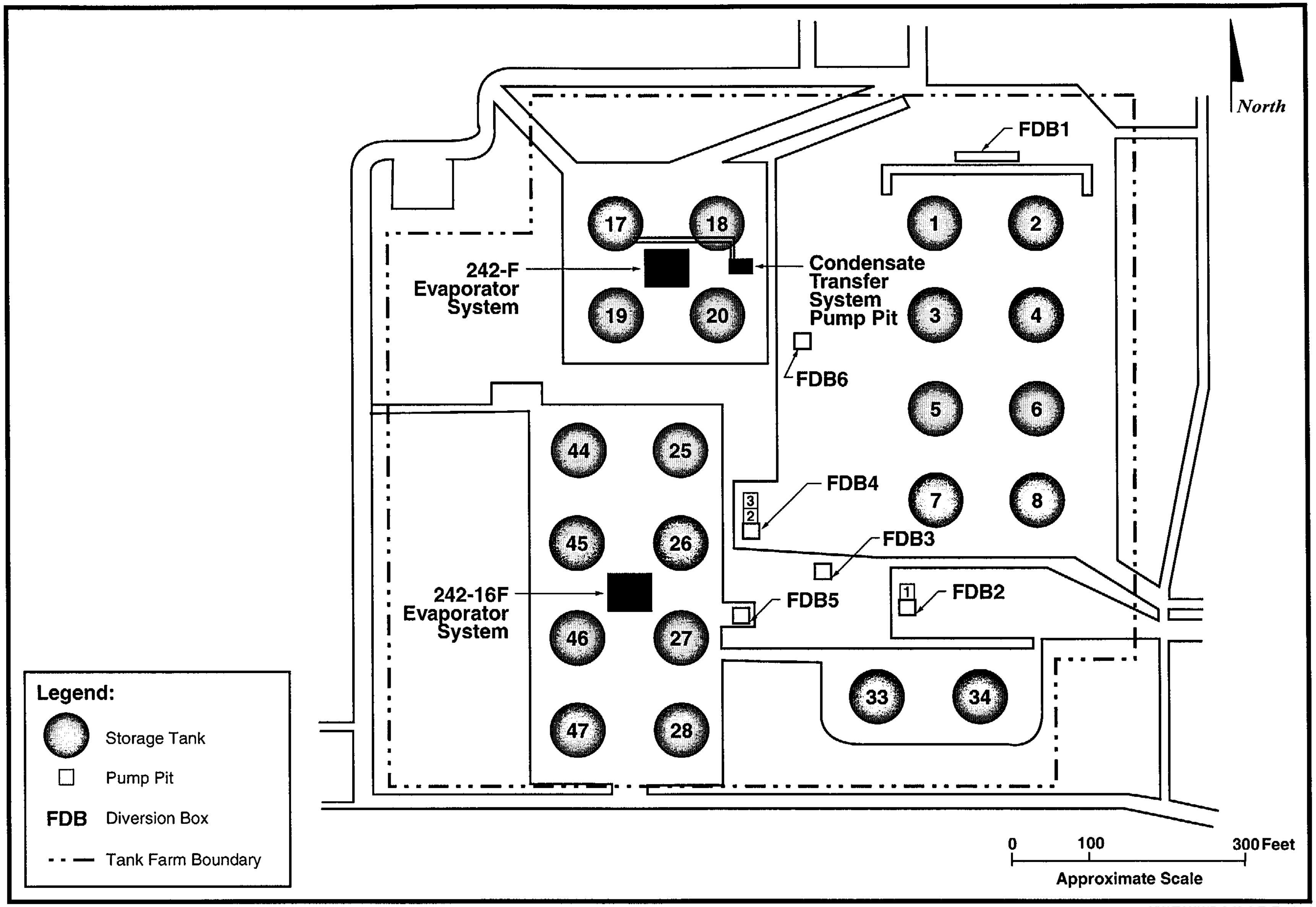

Figure A-2. General layout of F-Area Tank Farm.

cipitation Process, the Extended Sludge Processing facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure A-3 shows the general layout of the H-Area Tank Farm.

A.3.1 TANKS

The F- and H-Area tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. Table A-1 summarizes information about the tanks. Two designs (Types I and II) have 5-foot high secondary annulus "pans" and active cooling (Figure A-4). Figure A-5 indicates the status and content of all 51 tanks.

The 12 Type I tanks (Tanks 1 through 12) were built in 1952 and 1953, 5 of which (Tanks 1, 9 through 12) have known leak sites in which waste leaked from the primary containment to the secondary containment. The leaked waste is kept dry by air circulation, and there is no evidence that the waste has leaked from the secondary containment. The fill line to Tank 8 leaked approximately 1,500 gallons to the soil and potentially to the groundwater in 1961. The tank tops are about 9.5 feet below grade. The bottoms of Tanks 1 through 8, in F-Area, are situated above the seasonal high water table. Tanks 9 through 12 in the H-Area Tank Farm are in the water table.

The four Type II tanks (Tanks 13 through 16) were built in 1956 in the H-Area Tank Farm (Figure A-4). All four have known leak sites in which waste leaked from primary to secondary containment. In 1983, about 100 gallons of waste spilled on to the surface of Tank 13 through a cracked flush water line attached to an evaporator feed pump. No spilled waste reached the subsurface. The spill was cleaned up, and the contaminated material was returned to the waste tank or disposed of (Boore et al., 1986). The contamination remaining is negligible and would affect neither tank closure nor future cleanup of the tank farm area. In Tank 16, the waste overflowed the annulus pan (secondary containment) and a few 10s of gallons of waste migrated into the surrounding soil, presumably through a construction joint in the concrete encasement. Waste removal from the Tank 16 primary vessel was completed in 1980. However, the waste that leaked into the annulus has not been removed. These tanks are above the seasonal high water table.

The eight Type IV tanks (Tanks 17 through 24) were built between 1958 and 1962. These tanks have a single steel wall and do not have active cooling (Figure A-4). Tanks 17 through 20 are in the F-Area Tank Farm and Tanks 21 through 24 are in H-Area. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank wall. Small amounts of groundwater have leaked into these tanks; there is no evidence that waste ever leaked out. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original basemat under the tank area. Tanks 17 and 20 have already been closed in a manner described in DOE's Preferred Alternative.

The newest design (Type III) has a full-height secondary tank and active cooling (Figure A-4). All of the Type III tanks (25 through 51) are above the water table. These tanks were placed in service between 1969 and 1986. None of them has known leak sites. In 1989, a Tank 37 transfer line leaked about 500 pounds of concentrated waste to the environment.

By 2022, DOE is required to remove from service and close all the remaining tank systems that have experienced leaks or do not have full-height secondary containment (WSRC 1998a). The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for the tanks.

Areas of contamination in the tank farms have been identified based on groundwater monitoring past incident reports, and contamination surveys. The areas of significant contamination have been identified in the SRS Federal Facility Agreement and have been designated as RCRA/CERCLA units or Site Evaluation Units. Controls are in place to ensure that any activities performed around thee areas are conducted in a

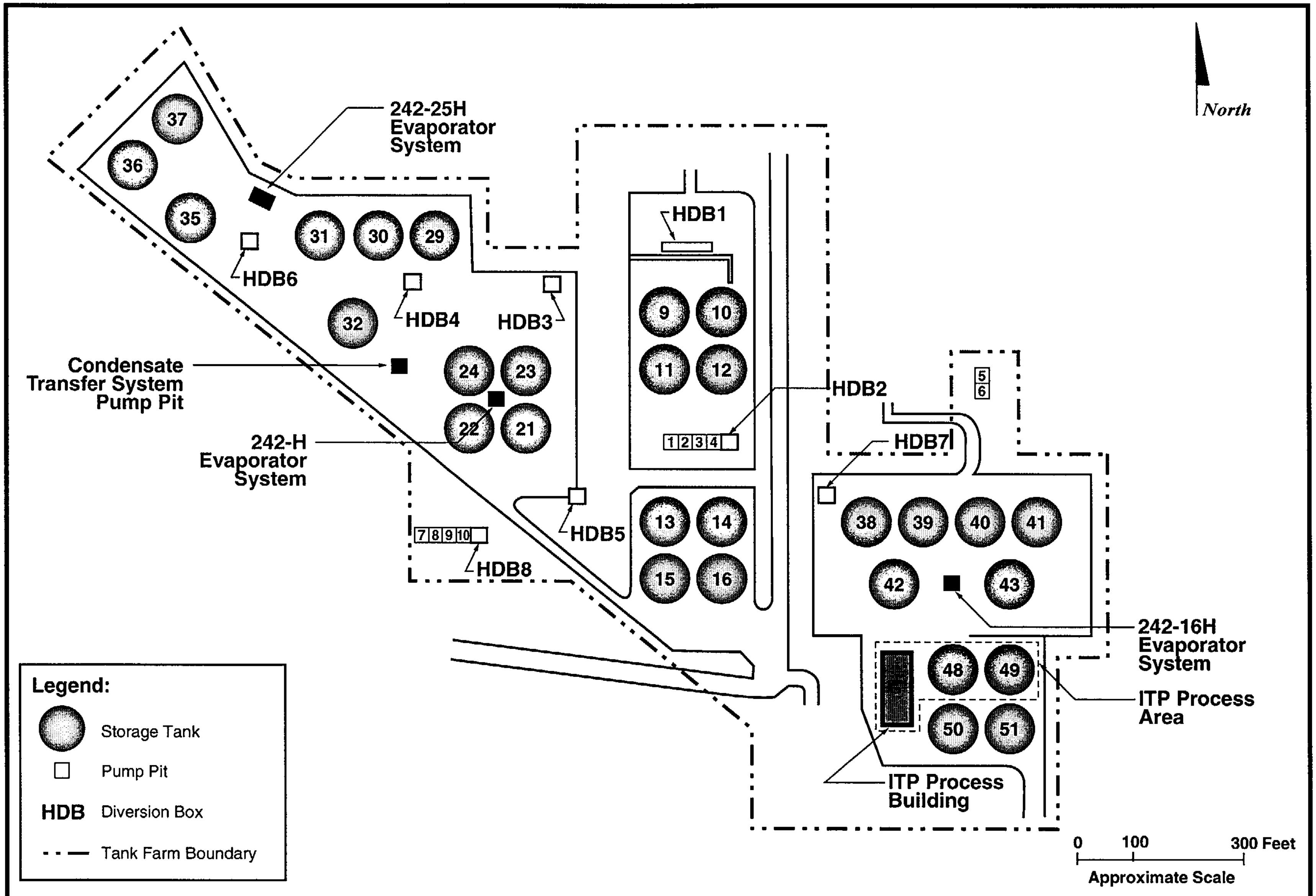

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Figure A-3. General layout of H-Area Tank Farm.

Table A-1. Waste tank usage.[a]

Tank number	Design type	Location	Year constructed	First used	Current usage
1[b]	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
2	I	F	1952	1955	Inactive, HHW/LHW salt cake tank
3	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
4	I	F	1952	1961	Inactive, HHW sludge and salt cake tank
5	I	F	1952	1959	Inactive, HHW sludge tank
6	I	F	1952	1964	Inactive, HHW sludge tank
7	I	F	1952	1954	Inactive, HHW/LHW sludge tank
8	I	F	1952	1958	Inactive, LHW sludge tank
9[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
10[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
11[b]	I	H	1953	1955	Inactive, HHW sludge tank
12[b]	I	H	1953	1956	Inactive, HHW sludge tank
13[b]	II	H	1956	1959	HHW evaporator feed tank (contains HHW sludge)
14[b]	II	H	1956	1957	Inactive, HHW sludge and salt cake tank
15[b]	II	H	1956	1960	Inactive, HHW/LHW sludge tank
16[b]	II	H	1956	1960	Tank is empty, HHW supernate removed, tank interior cleaned out, initial annulus cleaning complete; this tank is not covered by the industrial wastewater permit because it was taken out of service before the Tank farms were permitted by the state (this tank is listed as a RCRA/CERCLA unit under the Federal Facility Agreement)
17	IV	F	1958	1961	Closed
18	IV	F	1958	1958	Inactive, LHW supernate removed, residual LHW sludge remains
19	IV	F	1958	1961	Inactive, LHW supernate removed, residual LHW sludge and salt remains (most of the tank sludge consists of spent CRC ion exchange resin)
20[b]	IV	F	1958	1960	Closed
21	IV	H	1961	1961	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
22	IV	H	1962	1965	ITP tank[c], LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
23	IV	H	1962	1963	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters

Table A-1. (Continued).

Tank number	Design type	Location	Year constructed	First used	Current usage
24	IV	H	1962	1963	Inactive, LHW supernate removed, residual LHW sludge remains (most of the tank sludge consists of spent CRC ion exchange resin); may be used to hold dilute solutions or recycle wastewaters
25	III	F	1978	1980	HHW/LHW concentrate receipt tank
26	III	F	1978	1980	Fresh LHW receipt tank and LHW evaporator feed, contains LHW sludge
27	III	F	1978	1980	HHW/LHW concentrate receipt tank; also receives occasional wastes (i.e., ion exchange resins from the CRC)
28	III	F	1978	1980	HHW/LHW concentrate receipt tank
29	III	H	1970	1971	HHW concentrate tank
30	III	H	1970	1974	HHW concentrate tank
31	III	H	1970	1972	HHW concentrate tank
32	III	H	1970	1971	HHW receipt tank, future HHW evaporator feed tank (242-25H evaporator system), contains HHW sludge
33	III	F	1969	1969	HHW tank, contains HHW sludge
34	III	F	1972	1972	HHW tank, contains HHW sludge
35	III	H	1976	1977	HHW tank (future HHW concentrate tank), contains HHW sludge
36	III	H	1977	1977	HHW concentrate tank (future HHW tank)
37	III	H	1977	1978	HHW concentrate tank
38	III	H	1979	1981	LHW concentrate tank
39	III	H	1979	1982	HHW tank, contains HHW sludge
40	III	H	1979	1986	Sludge processing/DWPF vitrification sludge feed
41	III	H	1979	1982	LHW concentrate tank
42	III	H	1979	1982	ITP feed/blend tank[c]
43	III	H	1979	1982	Fresh LHW tank and LHW evaporator feed, contains LHW sludge
44	III	F	1980	1982	LHW concentrate tank
45	III	F	1980	1982	LHW concentrate tank
46	III	F	1980	1994	LHW concentrate tank
47	III	F	1980	1980	LHW concentrate tank; also used to receive waste transported by bulk tank truck (i.e., filter backwash waste from the reactor areas and cold runs wastewater from the DWPF Vitrification Facility), contains LHW sludge
48	III	H	1981	1983	ITP reaction tank[c]
49	III	H	1981	1983	ITP precipitate receiver/DWPF vitrification feed tank[c]

Table A-1. (Continued).

Tank number	Design type	Location	Year constructed	First used	Current usage
50	III	H	1981	1983	ITP filtrate receiver/F/H ETF waste concentrate receiver/Z-Area SMDF feed tank[c] (this tank is permitted under SCDHEC Permit No. 14520)
51	III	H	1981	1986	Extended sludge processing/DWPF vitrification sludge feed

a. Source: WSRC (1991, 1999).
b. Has one or more known cracks in primary tank shell
c. No longer required for ITP. Will be returned to Tank Farm service.

manner protective of human health and the environment, and in a way that minimizes the impact on future investigation, removal, and remedial action. [Reference: SRS Plan for Performing Maintenance in Federal Facility Agreement Areas (Operations and Maintenance Plan), WSRC-RP-96-45, 12/15/96].

A total of 17 RCRA/CERCLA units or Site Evaluation Units have been identified in the tank farms. In 14 of the 17 areas, the contamination is the result of past spills on the surface, and the contamination is on the surface or near the surface. The amount of contamination in these 14 sites appears to be small, and will probably not be a significant contributor to estimated doses in a tank closure performance evaluation.

In 2 of the 17 areas, the contamination came from pipelines located 10 to 15 feet below grade that leaked directly into the ground. The first area was a leak from the secondary containment of a pipeline near tank 8, which happened in 1961, at a depth of about 10 to 15 feet below grade. The leak resulted from an inadvertent overfill of Tank 8. The volume leaked to the soil was estimated to be 1500 gallons (Odum 1976). The second area was a leak from a Concentrate Transfer System near Tank 37 line (between 10 and 15 feet below grade), which was discovered in 1989 (The actual date of the leak is not known). The volume of this leak was estimated to be a few gallons.

The last area, the Tank 16 RCRA/CERCLA unit, is the only instance at SRS where waste is known to have leaked to the soil from a high-level waste tank. In September of 1960, leaks from the Tank 16 primary tank caused the level in the annulus pan (the tank secondary containment) to exceed the top of the pan, which is five feet high. The waste was still contained in the concrete encasement that surrounds the tank, but surveys indicated that some waste leaked into the soil, presumably through a construction joint on the side of the encasement that is located near the top of the annulus pan, about 25 feet below grade. Based on soil borings around the tank, it is estimated that some tens of gallons of waste leaked into the soil. Assuming that the waste did leak from the construction joint, the leaked waste is in the vicinity of the seasonal water table and is at times below the water table.

All tanks at SRS have leak detection, so it is unlikely that waste has leaked from other tanks without being detected. In eight tanks other than Tank 16, observable amounts of waste have leaked from primary containment into secondary containment. But, other than Tank 16, there is no evidence that waste has leaked into the soil from a tank.

A.3.2 EVAPORATOR SYSTEMS

Each tank farm has two single-stage, bent-tube evaporators that concentrate waste following receipt from the canyons. At present, two evaporators are operating, one in each tank farm. An additional evaporator system, the Replacement High-Level Waste Evaporator, has been built in H-Area. Each operating evaporator is made of stainless steel with a hastelloy tube bundle and operates at near atmospheric pressure under alkaline conditions. The older evapo-

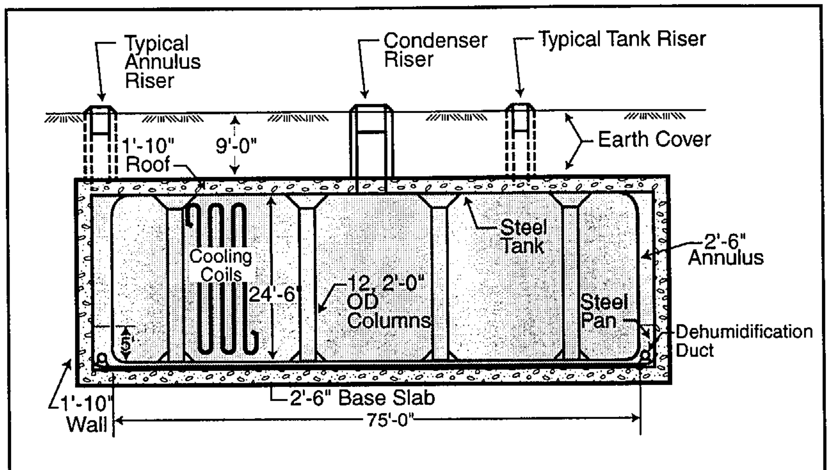

Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

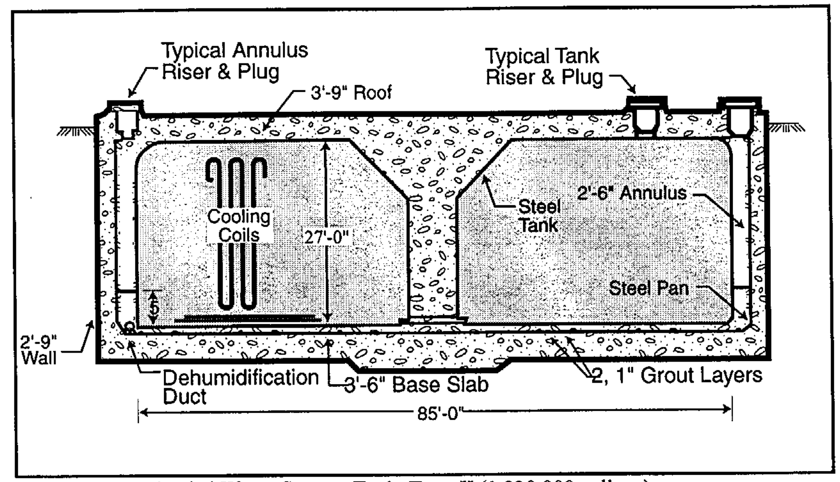

Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

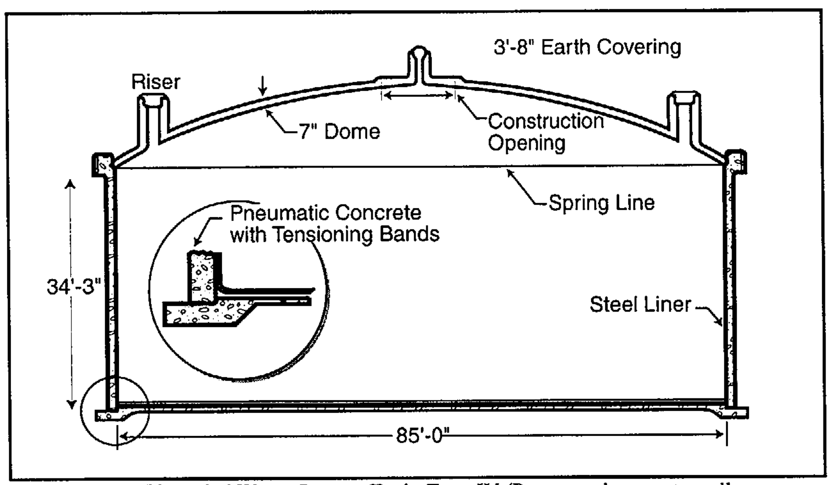

Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

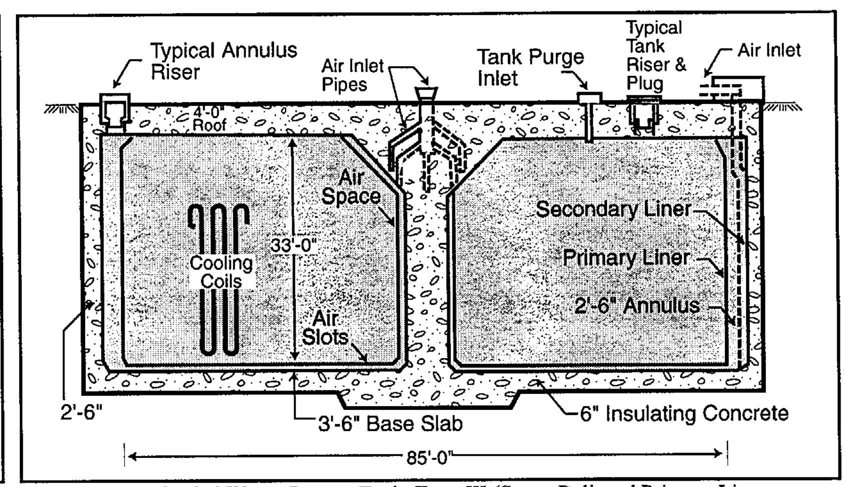

Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

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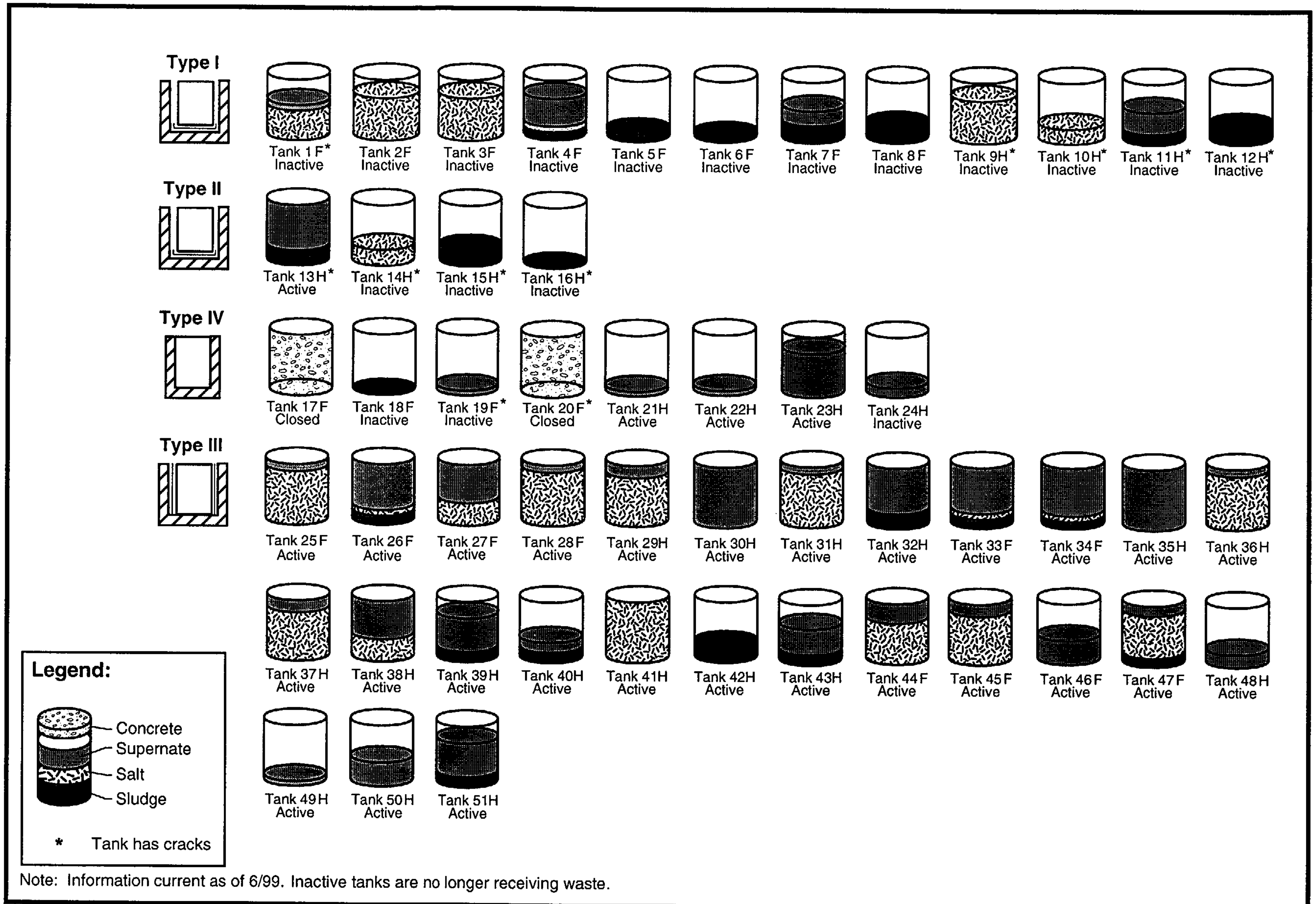
Figure A-4. Tank configuration.



NW TANK/Grfx/A-5 Waste tank.ai

Figure A-5. Savannah River Site high-level waste tanks and status.

rating capacity of approximately 1,800 gallons. The Replacement High-Level Waste Evaporator is fabricated of INCO alloy G3 to allow higher design temperatures; it has almost twice the operating capacity of the existing evaporators. Because of the radioactivity emitted from the waste, the evaporator systems are either shielded (i.e., lead, steel, or concrete vaults) or placed underground. The process equipment is designed to be operated and maintained remotely.

Waste supernate is transferred from the evaporator feed tanks and heated to the aqueous boiling point in the evaporator vessel. The evaporated liquids (overheads) are condensed and, if required, processed through an ion-exchange column for cesium removal. The overheads are transferred to the F/H Effluent Treatment Facility for final treatment before being discharged to Upper Three Runs. The overheads can be recycled back to a waste tank if evaporator process upsets occur. Supernate can be reduced to about 25 percent of its original volume and immobilized as crystallized salt by successive evaporations of liquid supernate.

A.3.3 TRANSFER SYSTEM

A network of transfer lines is used to transfer wastes between the waste tanks, process units, and various SRS areas (i.e., F-Area, H-Area, S-Area, and Z-Area). These transfer lines have diversion boxes that contain removable pipe segments (called jumpers) to complete the desired transfer route. Jumpers of various sizes and shapes can be fabricated and installed to enable the transfer route to be changed. The use of diversion boxes and jumpers allows flexibility in the movement of wastes. The diversion boxes are usually underground, constructed of reinforced concrete, and either sealed with waterproofing compounds or lined with stainless steel.

Pump pits are intermediate pump stations in the F- and H-Area Tank Farm transfer systems. These pits contain pump tanks and hydraulic pumps or jet pumps. Many pump pits are associated with diversion boxes. The pits are constructed of reinforced concrete and have a stainless-steel liner.

A.3.4 PRECIPITATION/FILTRATION SYSTEM

DOE has concluded that the In-Tank Precipitation process as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559). Therefore, this system is the subject of an ongoing EIS on salt disposition.

The In-Tank Precipitation process consisted of three Type III tanks, one Type IV tank, and an aboveground building that contains filtration equipment, stripper columns, hold tanks, and a laboratory. The In-Tank Precipitation process was designed to remove radionuclides (primarily cesium) from the waste with a precipitation/adsorption reaction with sodium tetraphenylborate and sodium titanate. The resultant precipitate slurry would be continuously pumped to a filter cell, filtered through a sintered metal filter, and returned to the reaction tank for sampling. The filtrate (called decontaminated salt solution) would be combined with the concentrate reject from the Effluent Treatment Facility and transferred to the Saltstone Manufacturing and Disposal Facility for solidification and onsite disposal. The remaining precipitate slurry would undergo a washing step that removes residual soluble salts and process chemicals before transfer to DWPF for vitrification into a solid glass matrix suitable for disposal.

A.3.5 SLUDGE WASHING SYSTEM

The waste streams generated by the F- and H-Area Canyons contain insoluble and highly radioactive metal hydroxides (manganese, iron, and aluminum) that settle to the bottom of the waste tanks to form a sludge layer. In addition to the fresh waste receipt aging, the accumulated sludge is aged to allow radioactive decay. The aged sludge is transferred to the sludge processing tanks for washing and, if necessary, aluminum dissolution with a sodium hydroxide solution. The sludge processing takes place in two Type III tanks in H-Area. The washed sludge slurry is transferred to the DWPF for vitrification into a solid glass matrix that is easier to handle and much more suitable for disposal.

A.4 Tank Farm Closure Activities

A.4.1 WASTE REMOVAL

In the Federal Facility Agreement between DOE, EPA, and the State of South Carolina, DOE committed to removing wastes from older tanks that do not meet secondary containment requirements (Types I, II, and IV). DOE has reviewed bulk waste removal from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks. As described in this EIS, however, tank closure activities would comply with the proposed plan and schedule provided under the Agreement. Also, even under the No-Action Alternative, DOE would continue to remove waste from the tanks as their missions cease. All tanks would be empty by 2028.

The schedule for removing waste from the tanks is closely linked to salt and sludge processing capacity and the DWPF schedule. The priorities for determining the sequence of waste removal from the tanks are as follows:

1. maintain emergency tank space in accordance with safety analyses
2. control tank chemistry, including radionuclides and fissile material inventory
3. enable continued operation of the evaporators
4. ensure blending of processed waste to meet salt processing, sludge processing, defense waste processing, and saltstone feed criteria
5. remove waste from tanks with leakage history
6. remove waste from tanks that do not meet the Federal Facility Agreement requirements
7. provide continuous radioactive waste feed to the DWPF
8. maintain an acceptable precipitate balance with the salt processing facility
9. support the startup and continued operation of the Replacement High-Level Waste Evaporator
10. remove waste from the remaining tanks

The general technique for waste removal is hydraulic slurrying. First, slurry pump support structures are installed above the tank top, along with electrical service and motor controls. Then, slurry pumps are installed in the risers of the tank: usually three for salt removal and four for sludge removal. For the salt tanks, the pump discharges are positioned just above the level of the saltcake. Water is added to the tanks and the pumps turned on to agitate and dissolve a layer of salt. When the water becomes saturated with salt, the solution is pumped out. For sludge tanks, the pumps are placed into the top layer of sludge. As with salt removal, water is added and the pumps turned on to agitate the sludge. When the sludge is well mixed, the slurry is pumped out. For both salt and sludge, the pumps are then lowered to continue the process. Pumps may be lowered one or more times before a salt or sludge transfer is made. DOE is also exploring other methods for more efficient waste removal.

A.4.2 DETERMINATION AND USE OF PERFORMANCE OBJECTIVES

DOE has identified pertinent substantive requirements with which it will comply and guidance it will consider (Chapter 7) to ensure that closure of the tank systems will be protective of human health and the environment. DOE will use these requirements and guidance to develop tank system closure performance objectives that provide a basis for comparison of different closure configurations. The performance objectives apply to the completed closure of all 51 tank systems; however, DOE must close the tanks one at a time over a period of decades. (DOE anticipated that the need for HLW tanks will cease some time before 2030. The tanks would be closed as their individual missions end.) Therefore, the Department evaluates the impacts of each tank closure in the context of the entire Tank Farm. This methodology ensures that as tanks are closed, the total closure impacts do not exceed the performance objectives.

To further ensure that closure of the tank system will be protective of human health and the environment, DOE also evaluates contamination from non-tank farm related sources. Studies of groundwater transport (DOE 1996) in the General Separations Area indicate that contaminant plumes from F- and H-Area tanks would not intersect. Therefore, DOE has established independent Groundwater Transport Segments for the two tank farms that represent the contaminant plume from the tank farm. DOE requires that contributions from all contaminant sources within a Groundwater Transport Segment, both tank farm-related and non-tank farm-related, be considered in comparison of modeled impacts to the performance objectives.

A.4.3 TANK CLEANING

DOE's preferred method for tank cleaning is spray water washing. In this process, heated water is sprayed throughout the tank using spray jets installed in the tank risers. After spraying, the contents of the tank are then agitated with slurry pumps and pumped to another HLW tank still in service.

After the spray washing, remotely operated video cameras are used to survey the interior of the tank to identify areas needing further cleaning. Based on experience with two tanks that have been spray washed, DOE has learned that some sludge tends to remain on the bottom of the tank and that the sludge tends to be distributed around the edge of the tank bottom after the single water wash performed as the last phase of waste removal.

Eleven HLW tanks at SRS have shown evidence of cracks in the primary tank shell. In two of the tanks, the cracks are above the current liquid level and there is no evidence that waste escaped primary containment. In the remaining nine tanks, leaked salt has been observed on the exterior of the primary tank shell. The cracks in these tanks are hairline cracks and the annuli in these tanks are ventilated to dry the waste. The waste seeped through the cracks slowly and dried in the annulus. This waste appears as dried salt deposits on the side of the primary tank and sometimes on the floor of the secondary tank (WSRC 2000). DOE has developed methods to clean the annulus using recirculating water jets installed through annulus risers. The water is heated and circulated through the annulus into the primary tank.

In five of the tanks (Tanks 1, 11, 12, 13, and 15), photographic inspections indicate that the amount of leaked waste is small. The waste is limited to salt deposits on the walls of the tank or perhaps covering part of the floor of the annulus. The leaked waste is virtually all salt because sludge is relatively immobile and will not migrate significantly through hairline cracks. The small amount of salt in these annuli should be relatively easy to remove with water.

In the remaining four tanks (Tanks 9, 10, 14, and 16), enough waste has leaked to completely cover the floor of the annulus. The annuli of these four tanks will be the most difficult to clean of all the tanks. Because of the large amount of waste that leaked in these four tanks, some waste may have leaked underneath the primary tanks. Also, waste has entered the ventilation ducts in the annuli. Special waste removal techniques will need to be developed for

these tanks to ensure that water penetrates to the locations of the waste.

In three of the four tanks (Tanks 9, 10, and 14), the waste in the annulus is primarily salt, so it should be relatively easy to remove once it is dissolved. The difficulty is primarily getting the water to where it is needed and then removing the salt solution. Since the problem is limited to a few tanks, plans are to develop these techniques when needed. The techniques may differ between tanks (for example, a different annulus cleaning technique would be needed if waste has seeped underneath the primary tank).

Tank 16 is the most badly cracked tank and represents a special case for annulus cleaning. In this tank, a number of welds were sandblasted to understand the stress corrosion cracking phenomena. The sand fell on top of the salt and then mixed with the salt during a waste removal effort in 1978 that removed about 70 percent of the salt. Recent samples have shown that the sand and compounds that formed when the sand mixed with the salt make it more difficult to dissolve the waste in this annulus. Chemical cleaning (such as oxalic acid) may be needed to dissolve the waste in the Tank 16 annulus. Since this will be a one-time operation, plans are to develop the cleaning techniques when needed.

It is possible that some tanks may prove to be more difficult to clean than others. To meet performance criteria for tank closure, DOE may need to perform more rigorous cleaning than spray water washing. The method DOE expects to use is oxalic acid cleaning. In this process, hot oxalic acid is sprayed through the nozzles that were used for spray washing. Oxalic acid was selected above other cleaning agents for the following reasons (Bradley and Hill 1977):

- Oxalic acid dissolves portions of the sludge and causes the particles to break down, allowing removal of sludge deposits that are difficult to mobilize using spray washing alone.

- Oxalic acid is only moderately aggressive against carbon steel. Corrosion rates are on the order of 0.001 inch per week. This rate is acceptable for a short-term process such as cleaning. More aggressive agents such as nitric acid would be more effective in tank cleaning, but they could potentially cause release of contaminants to the environment in a mobile form.

- Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity. However, at the present time potential safety considerations restrict the use of oxalic acid in the high-level waste tanks. The Liquid Radioactive Waste Handling Facility Safety Analysis Report (WSRC 1998b) specifically states that oxalic acid cleaning of any waste tank is prohibited. A Nuclear Criticality Safety Evaluation would be necessary to address oxalic acid use because oxalic acid would reduce the pH of the cleaning solution to the point where a quantity of fissile materials greater than currently anticipated would go into solution. This could create the potential for a nuclear criticality. In addition, an Unreviewed Safety Question evaluation and subsequent SAR revision would be necessary.

Between 1978 to 1980, Tank 16 was the subject of a rigorous waste removal, water washing, and oxalic acid cleaning demonstration. The demonstration determined the increased effectiveness of oxalic acid cleaning. However, the process generates large quantities of sodium oxalate that must be disposed in the Saltstone Manufacturing and Disposal Facility. After oxalic acid cleaning is complete, the tank would be spray washed with inhibited water to neutralize the remaining acid.

A.4.4 STABILIZATION

DOE has identified three options for tank stabilization under the Clean and Stabilize Tanks Alternative as described in Chapter 2: grout fill, sand fill, and saltstone fill. In addition, another alternative would not stabilize the tank but would remove the interior liner (which has been in contact with the HLW) from the concrete vault for disposal in some other location. The

sections below describe the activities associated with the action alternatives.

Grout Fill

After tank cleaning, each tank and its associated piping and ancillary equipment would be filled with a pumpable, self-leveling grout, a concrete-like material. The material would have a high pH to be compatible with the carbon steel of the tank. The fill material would also be formulated with chemical properties that would retard the movement of radionuclides and chemical constituents from the closed tank. A combination of different types of grout would be used. They would be mixed at a nearby batch plant constructed for the purpose and pumped to the tank. Figure A-6 shows how the sandwich layers of grout would be poured. The potential combination of layers of grout is as follows:

- Reducing grout is a pumpable, self-leveling backfill material similar in composition to that used at the SRS Saltstone Manufacturing and Disposal Facility, composed primarily of cement, flyash, and blast furnace slag. The chemical properties of the liquid that leaches through this backfill material will reduce the mobility of selected radionuclides and chemical constituents. The formulation of the backfill material for each waste tank will be adjusted based on specific circumstances for each tank. The material is pumped into the waste tank through an available opening (e.g., tank riser). Observations of Tank 20 during pouring of the reducing grout indicate that the grout lifts some of the sludge on the bottom of the tank and carries it like a wave until it eventually envelops the sludge in the grout. Nevertheless, DOE's use of the reducing grout is not dependent on fully enveloping the sludge but upon the grout's ability to chemically alter any water leaching through the grout to the sludge.

- Controlled Low-Strength Material (CLSM) is a self-leveling concrete composed of sand and cement formers. Similar to reducing grout, it is pumped into the tank. The compressive strength of the material is controlled by the amount of cement in the mixture. The advantages of using CLSM rather

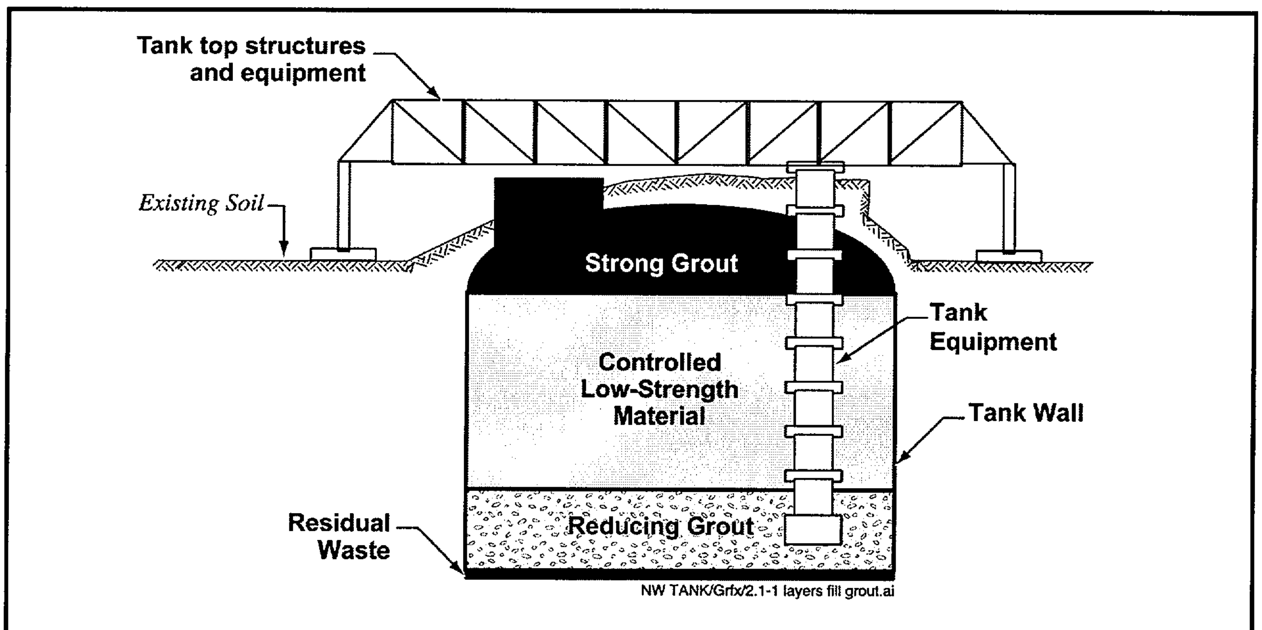


Figure A-6. Typical layers of the fill with grout option.

than ordinary concrete or grout for most of the fill are:

- The compressive strength of the material can be controlled so that it will provide adequate strength for the overbearing strata and yet could be potentially excavated with conventional excavation equipment. Although excavation of the tank is not anticipated, filling the tank with low-strength material would enhance the opportunity for future removal of tank contaminants or perhaps the tank itself, if future generations were to decide that excavation is desirable.
- CLSM has a low heat of hydration, which allows large or continuous pours. The heat of hydration in ordinary grout limits the rate at which the material can be placed because the high temperatures generated by thick pours prevent proper curing of the grout. Thus, large pours of grout are usually made in layers, allowing the grout from each layer to cool before the next layer is poured.
- CLSM is relatively inexpensive.
- CLSM is widely used at SRS, so there is considerable experience with its formulation and placement, and in controlling the composition to provide the required properties.

• Strong grout is a runny grout with compressive strengths in the normal concrete range. This formulation is advantageous near the top of the tank because:

  - The runny consistency of the grout is advantageous for filling voids near the top of the tank created around risers and tank equipment. The grout would be injected in such a manner to ensure that voids were filled to the extent practicable. This may involve several injection points, each with a vent.
  - A relatively strong grout will discourage an intruder from accidentally accessing the waste if institutional control of the area is discontinued.

Other potential combinations of multiple or single grout layers may be used.

The specific actions needed before and during closure include tank isolation, tank modifications to facilitate introduction of grout, production and installation of grout, and riser cleanup. These activities are described below in more detail.

Mechanical and electrical services would be isolated from the tank such that future use is prohibited. Tank isolation is an activity that must be performed regardless of the closure option. Accessible piping and conduits would be removed and pulled back from each riser so that a physical break is made from the tank. Any transfer lines would be cut and capped.

DOE would leave the tank structures intact. No support steel would be removed unless it is necessary to be removed to disconnect services from the tank risers. Equipment already installed in the tank and equipment directly used in tank closure operations (such as temporary submersible pumps, cables, temporary transfer hoses, backfill transfer pipes or tremmies, and sample pump) would be entombed in the backfill material as part of the closure process. Items removed in preparation for closure under this module (such as slurry pump motors, instrument racks, piping, and insulation) may be decontaminated to such levels that they may be sent to the Solid Waste Management Facilities as scrap. Otherwise, they would be appropriately characterized and shipped as low-level waste.

The tank risers would be modified to permit backfill material to be placed into the tank. Provisions would be made to provide a delivery point into the tank, to manage air displacement, to address bleed water build-up, and to handle any tank top overflow.

Risers would be prepared to allow addition of the backfill material. Equipment located at the riser would be disconnected. A backfill transfer line would be inserted through an access port to

allow introduction of the backfill into the tank. Tank venting would be predominately through the existing permanently installed ventilation system until the backfill material nears the top of the tank. However, a newly constructed vent device, equipped with a breather high-efficiency particulate filter, would be supplied for the final filling operation.

During the filling process, excess water (bleed water) is expected to float to the top of the grout and CLSM. The amount of bleed water would be minimized during the actual closure operation by limiting the amount of water in the grout and CLSM and by specifying the fill material cure times. It is expected that any bleed water produced would be re-absorbed back into the fill material. The amount of re-absorption would be dictated by the cure times. Any bleed water not absorbed would be removed from the tank and returned to the tank farm systems by siphoning it off and transferring it through a temporary aboveground transfer line to another waste tank or processed at the Effluent Treatment Facility. The possible overflow of bleed water and grout from around the riser joints would be controlled by constructing forms around the risers and sealing those forms for watertightness as part of pre-closure preparation for riser grouting operations. Each riser would be prepared for local filling and venting to ensure that the top void spaces are filled.

Portable concrete batch plants would supply the grout and CLSM backfill needed to fill the tanks. The plants may require a SCDHEC Bureau of Air Quality permit to operate. All process water would be recycled.

Backfill material produced at the plants would be introduced into the risers of the tanks through piping from the plants located just outside the Tank Farm fence.

The actual backfill material installation would be governed by SRS procedures in accordance with Design Engineering requirements as outlined in the construction and subcontractor work packages. The filling progress would be monitored by an in-tank video camera. The backfill material level would be measured using visual indications. During riser closure operations, containment provisions would be made to restrict or contain grout overflows. Tank components such as the transfer pump, slurry pumps, wiring, cables, steel tapes, hoses, and sample collection apparatus would be encapsulated during tank grouting operations.

The risers and void spaces in the installed equipment remaining in the tank would be filled with highly flowable reducing grout material to ensure that all voids are filled to the fullest extent possible. The tank fill and riser backfilling operations would be performed in such a way as to eliminate rainwater intrusion into the tank. Upon completion of the tank closure, the riser tops would be left in a clean and orderly condition. Risers would be encapsulated in concrete using forms constructed of rolled steel plates or removable wooden forms previously installed around each riser. The riser encapsulation would be completed at the end of the tank dome fill operation.

Piping and conduit at each of the risers that is not removed would be entombed in the riser filling operations. Each riser and the lead lining would be encased in concrete, and decontamination of the remaining riser formwork structures and adjacent areas will be performed, if necessary. The tank appurtenances, such as the riser inspection port plugs, riser plug caps, and the transfer valve box covers, which would have been removed to ensure complete backfilling of the tank, would be entombed at the same time as the associated risers are filled and backfilled.

Sand Fill

This option is similar to the fill with grout option except that sand would be used instead of grout. There would be no layers for intruder protection or chemical conditioning of leaching water. The sand would be carried by truck to an area near the tank farm and conveyed to the tank.

Sand is readily available and is inexpensive. However, its emplacement is more difficult than grout as it does not flow readily into voids. Over time, sand will settle in the tank, creating

additional void spaces. The tank top would then become unsupported and would sag and crack, although there would not be the catastrophic collapse that would be anticipated in the no-action case. Also, the sand would tend to protect the contamination to some extent and prevent winds from spreading the contaminants. However, sand is highly porous and rainwater infiltrates rapidly and does not run off. Also, sand is relatively inert and could not be formulated to retard the migration of radionuclides and chemical constituents. Thus, the expected contamination levels in groundwater would be higher than for the grout fill option.

A variation of this alternative could involve filling the tanks with contaminated soils excavated during the remediation of SRS waste sites. Placement of soils in the tanks would present similar disadvantages to those described above for sand fill. In addition, handling contaminated soils would complicate the project, resulting in increased costs. Soils could not be readily formulated to retard the migration of radionuclides and chemical constituents, and the additional contamination associated with the soil fill would have to be factored into the performance evaluation for the closure configuration. Because of these disadvantages, the use of contaminated soils as a fill material is not evaluated further in this EIS.

Saltstone Fill

This option is the same as the fill with grout option except that saltstone would replace the reducing grout and the CLSM. Saltstone is a low-radioactivity fraction separated from HLW mixed with cement, flyash, and slag to form a concrete-like mixture. This option has the advantage of reducing the amount of disposal space needed at the Saltstone Manufacturing and Disposal Facility; however, it has several disadvantages:

- Because of the fast saltstone set-up times, two new saltstone mixing facilities (one in F-Area and one in H-Area) would be required.
- The amount of saltstone to be made is projected to be greater than 160 million gallons. This volume is considerably greater than the capacity of the HLW tanks. Therefore, the existing Saltstone Manufacturing and Disposal Facility in Z-Area would still need to be operated.
- Filling the tank with a grout mixture that is contaminated would considerably complicate the project and increase worker radiation exposure, further adding to expense and risk.
- Saltstone grout cannot be poured as fast as CLSM because of its relatively high heat of hydration. Saltstone grout would have to be poured in discrete pours, allowing sufficient time between pours for the grout to cool.

Clean and Remove Tanks

This alternative involves additional cleaning of the tanks beyond that described in Section A.4.2. Such cleaning could include mechanical cleaning or other steps not yet defined. The steel components (including any piping and ancillary equipment) would be sectioned, removed, placed in burial boxes for disposal, and transported to SRS low-level waste disposal facilities.

For tank removal operations, DOE would enclose the top of the tanks with structures designed to contain airborne contamination. These structures would be fitted air locks and operate at negative pressure during cutting operations. Air discharges from the tanks and enclosures would be filtered with high-efficiency particulate air filters. DOE would backfill the void created by tank removal with a soil type similar to soils currently surrounding the tank.

The advantages of this option are:

- This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.

- This option exposes the surrounding soils such that they could be exhumed. This is the only option that has the potential to leave the waste tank area as an unrestricted area for future uses.

The disadvantages include:

- High radiation exposure to workers during the removal process.
- Extremely high cost to remove the tank.
- Considerable impact on other SRS operations.
- Extremely high cost to dispose of the tank components elsewhere. Also, disposal of the tank could create another zone of restricted use (i.e., the restricted use zone is merely shifted rather than being eliminated).

A.4.5 ENVIRONMENTAL RESTORATION PROGRAM ACTIVITIES

After a tank is closed, the SRS Environmental Restoration Program will conduct field investigations and remedial actions. The Environmental Restoration Program is concerned with all aspects of assessment and cleanup of both contaminated facilities in use and of sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and groundwater, are responsibilities of this program. The investigations will take place after nearby tanks in an operational grouping are closed (to avoid interference with the other operational tanks) and conditions are determined to be safe for Environmental Restoration intrusive sampling. Once an operational grouping is closed, the HLW operations organization and the Environmental Restoration organization will establish a Co-Occupancy Plan to ensure safe and efficient soils assessment and remediation. The HLW organization will be responsible for operational control and the Environmental Restoration organization will be responsible for Environmental Restoration activities. The primary purpose of the Co-Occupancy Plan is to provide the two organizations with a formal process to plan, control, and coordinate the Environmental Restoration activities in the tank farm areas where the existing HLW management and operational procedures can be continuously utilized.

The High-Level Waste Tank Closure Program Plan (DOE 1996) provides general information on postclosure activities and tank-specific closure modules will also address postclosure activities. However, the investigation, determination of remediation requirements, and implementation of potential remedial actions related to soil and groundwater contamination at the tank farms will be conducted in accordance with RCRA/CERCLA requirements pursuant to the Federal Facility Agreement. The Environmental Restoration organization would have the responsibility for these activities. Plans for such postclosure measures as monitoring, inspections, and corrective action plans would also be governed by the Federal Facility Agreement and would be premature to state at this time because conditions that would exist at the restored area are not known. For example, the area may be capped or an *in situ* groundwater treatment system may be installed.

Figure A-7 presents an example of the closure configuration for a group of tanks. The necessity for a low-permeability cap, such as a clay cap, over a tank group to reduce rainwater infiltration will be established in accordance with the environmental restoration program described in the Federal Facility Agreement (EPA 1993). Figure A-7 shows a conceptual cap design. The cap construction would ensure that rain falling on the area drains away from the closed tank(s) and surrounding soil. A soil cover could be placed over the cap and seeded to prevent erosion.

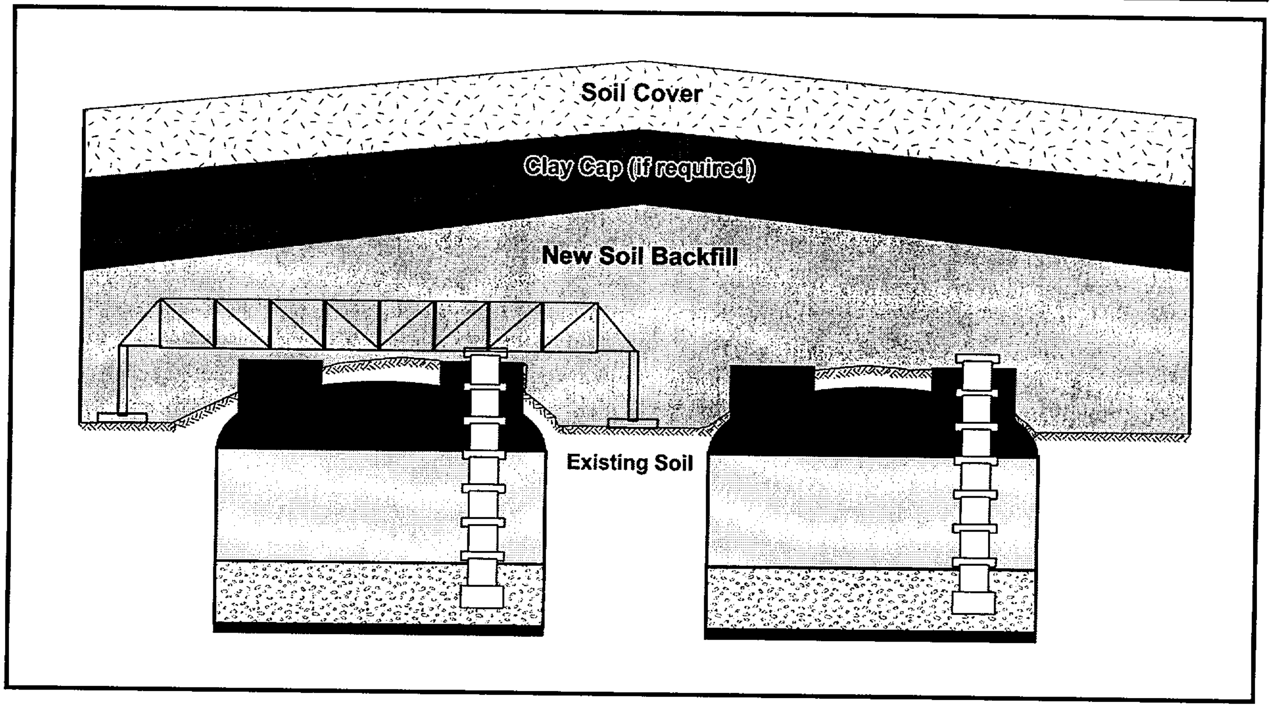


Figure A-7. Area closure example.

References

Boore, W. B., et al., 1986, *Radioactive Waste Spill and Cleanup on Storage Tank at the Savannah River Plant*, DP-1722, March.

Bradley, R. F. and A. J. Hill, 1997, *Chemical Dissolving of Sludge from a High-Level Waste Tank at the Savannah River Site*, DP-1471, November.

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082-S, Savannah River Operations Office, Aiken, South Carolina, November.

DOE (U.S. Department of Energy), 1995, *Savannah River Site Waste Management Final Environmental Impact Statement*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina, July.

DOE (U.S. Department of Energy), 1996, *High-Level Waste Tank Closure Program Plan*, Revision 0, Savannah River Operations Office, Aiken, South Carolina, December 16.

DOE (U.S. Department of Energy), 1999, *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain*, Nye County, Nevada, DOE/EIS-0250D, Office of Civilian Radioactive Waste Management, Washington, D.C., July.

EPA (Environmental Protection Agency), 1993, Federal Facility Agreement Between the U.S. Environmental Protection Agency Region IV, the U.S. Department of Energy, and the South Carolina Department of Health and Environmental Control. Docket No. 89-05-FF, August 16. (Available at http://www.srs.gov/general/srenviro/erd/ffa/ffaa.pdf)

Odum, J.V., 1976, *Soil Contamination Adjacent to Waste Tank 8*, DPSPU 76-11-4, E.I. du Pont de Nemours and Company, Inc., Aiken, South Carolina, November.

WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste System Plan*, Revision 9, HLW-OVP-98-0037, High-Level Waste Management Division, Aiken, South Carolina, April. (Available at https://www.osti.gov/servlets/purl/301986-t5EGMP/webviewable/301986.pdf).

WSRC (Westinghouse Savannah River Company), 1998b, *Safety Analysis Report - Liquid Radioactive Waste Handling Facility*, WSRC-SA-33, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999, *Savannah River Site High Level Waste System Plan,* HLW-99-0008, Aiken South Carolina, Rev. 10, June 1999 with October 1999 Update.

WSRC (Westinghouse Savannah River Company), 2000, *Annual Radioactive Waste Tank Inspection Program – 1999*, WSRC-TR-2000-00067, Westinghouse Savannah River Company, Aiken, South Carolina, May.

APPENDIX B

ACCIDENT ANALYSIS

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APPENDIX B. ACCIDENT ANALYSIS

This appendix provides detailed information on the potential accident scenarios associated with the closure of the HLW tanks at SRS. The appendix provides estimates of the quantity and composition of hazardous materials that could be released in an accident as well as the consequences to workers and the public, estimated in terms of dose and latent cancer fatalities for radiological releases and of concentration levels for chemical releases.

The primary sources of information for the accident analyses are a specific calculation (Yeung 1999) and the safety analysis report for the Liquid Radioactive Waste Handling Facility (WSRC 1998a).

B.1 General Accident Information

An accident, as discussed in this appendix, is an inadvertent release of radiological or chemical hazardous materials as a result of a sequence of one or more probable events. The sequence usually begins with an initiating event, such as a human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of 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. Examples include equipment or structural failures and human errors.
- *External initiators* – are independent of facility operations and normally originate from outside the facility. Some external initiators affect the ability of the facility to maintain its confinement of hazardous materials because of potential structural damage. Examples include aircraft crashes, vehicle crashes, nearby explosions, and toxic chemical releases at nearby facilities that affect worker performance.
- *Natural phenomena initiators* – are natural occurrences that are independent of facility operations and occurrences at nearby facilities or operations. Examples include earthquakes, high winds, floods, lightning, and snow. Although natural phenomena initiators are independent of external facilities, their occurrence can involve those facilities and compound the progression of the accident.

The likelihood of an accident occurring and its consequences usually depend on the initiator and the sequence of events and their frequencies or probabilities. Accidents can be grouped into four categories—anticipated, unlikely, extremely unlikely, and beyond extremely unlikely, as listed in Table B-1. DOE based the frequencies of accidents at the liquid radioactive waste handling facility on safety analyses and historical data about event occurrences.

B.2 Accident Analysis Method

For the alternatives for HLW tank closure, Yeung (1999) identified potential accident scenarios that involved the release of both radiological and non-radiological, hazardous materials. Section B.2.1 provides information about the various alternatives for tank closure. B.2.2 provides details about the specific analyses methods that were employed in this appendix.

The accident sequences analyzed in this EIS would occur at frequencies generally greater than once in 1,000,000 years. However, the analysis considered accident sequences with smaller frequencies if their impacts could provide information important to decisionmaking.

Table B-1. Accident frequency categories.

Accident frequency category	Frequency range (occurrences per year)	Description
Anticipated	Less than once in 10 years but greater than once in 100 years	Accidents that might occur several times during facility lifetime.
Unlikely	Less than once in 100 years but greater than once in 10,000 years	Accidents that are not likely to occur during facility lifetime; natural phenomena include Uniform Building Code-level earthquake, maximum wind gust, etc.
Extremely unlikely	Less than once in 10,000 years but greater than once in 1,000,000 years	Accidents that probably will not occur during facility life cycle; this includes the design basis accidents.
Beyond extremely unlikely	Less than once in 1,000,000 years	All other accidents.

Source: DOE (1994).

B.2.1 HIGH-LEVEL WASTE TANK CLOSURE ALTERNATIVES

DOE has organized the accident data in this appendix by alternative. DOE has also organized the accident impacts in Chapter 4 by alternative to reflect potential accident occurrences for the associated alternative.

Approximately 34 million gallons of HLW are stored in underground tanks in F-Area and H-Area. DOE intends to remove from service all 51 HLW tanks. Because two of these tanks (Tanks 17 and 20) are already closed, this appendix addresses the potential impacts from accidents associated with the closure of the 49 remaining waste tanks.

The alternatives considered in this EIS include:

- No Action Alternative
- Clean and Stabilize Tanks Alternative
  - Clean and Fill with Grout Option (Preferred Alternative)
  - Clean and Fill with Sand Option
  - Clean and Fill with Saltstone Option
- Clean and Remove Tanks Alternative

B.2.2 RADIOLOGICAL HAZARDS

The accidents identified for HLW tank closure are described in Section B.3. These descriptions include an approximation of the material-at-risk (MAR) that would potentially be involved in the accident. Depending on the particular scenario, release fractions have been applied to the MAR to determine the amount of the materials that would be released to the environment. This amount is referred to as the source term. Source terms are provided in Yeung (1999) for airborne, ground surface runoff, and underground releases. The airborne releases are of short duration and could have impacts to the worker and offsite population. The surface runoff and underground releases, however, would not have short-term impacts to any of the analyzed receptors. In the case of surface runoff, DOE would employ mitigative actions to prevent the release from reaching the Savannah River (i.e., clean-up actions, berms, dams in surface water pathways, etc.). In the unlikely event that radionuclides reached the river, DOE's mitigative actions would include notification of municipalities downstream that use the Savannah River for drinking water supply. These mitigative actions would preclude any offsite dose from a liquid release pathway. In the case of underground releases, radiological materials released directly into the soil would take a long period of time to reach any of the human receptors evaluated in this analysis. The potential conse-

quences of such releases are determined as part of the EIS long-term impacts.

The analysis of airborne releases used the computer code AXAIRQ to model accidental atmospheric radioactive releases from SRS that are of relatively short duration. AXAIRQ strictly follows the guidance in Regulatory Guide 1.145 (NRC 1982) on accidental releases and has been verified and validated (Simpkins 1995a and 1995b). Since all considered accidents would occur at or below ground level, the releases for AXAIRQ assumed ground level releases with no modification for release height. In accordance with the regulatory guide, the code considers plume meander and fumigation under certain conditions. Plume rise due to buoyancy or momentum is not available. The program uses a 5-year meteorological database for SRS and determines the shortest distance to the Site boundary in each of the 16 sectors by determining the distance to one of 875 locations along the boundary. The impacts that were derived from the use of this code used the average, or 50 percent, meteorology. Since these accidents could occur in either F- or H-Area at SRS, the largest unit dose conversion factor was chosen (applicable to F- or H-Area) dependent on the receptor being evaluated. The code uses the shortest distance in each sector to calculate the concentration for that sector. DOE used the computer code PRIMUS, which was developed by the Oak Ridge National Laboratory, to consider decay and daughter ingrowth.

Simpkins (1997) provided unit dose conversion factors for a wide list of radionuclides for release locations in F- and H-Areas. These factors were applied to the airborne source terms to calculate the doses to the various receptors.

The analysis assumes that all tritium released would have the form of tritium oxide and, following International Commission on Radiological Protection methodology, the dose conversion factor for tritium has been increased by 50 percent to account for absorption through the skin. For population dose calculations, age-specific breathing rates are applied, but adult dose conversion factors are used. Radiation doses were calculated to the maximally exposed individual, to the population within 50 miles of the facility, and to a noninvolved worker assumed to be 640 meters downwind of the facility.

After DOE calculated the total radiation dose to the public, it used dose-to-risk conversion factors established by the National Council on Radiation Protection and Measurements (NCRP) to estimate the number of latent cancer fatalities that could result from the calculated exposure. No data indicate that small radiation doses cause cancer; however, to be conservative, the NCRP assumes that any amount of radiation has some risk of inducing cancer. DOE has adopted the NCRP factors of 0.0005 latent cancer fatality for each person-rem of radiation exposure to the general public and 0.0004 latent cancer fatality for each person-rem of radiation exposure to radiation workers (NCRP 1993).

B.2.3 CHEMICAL HAZARDS

For chemically toxic materials, the long-term health consequences of human exposure to hazardous materials are not as well understood as those related to radiation exposure. A determination of potential health effects from exposures to chemically hazardous materials, compared to radiation, is more subjective. Therefore, the consequences from accidents involving hazardous materials are expressed in terms of airborne concentrations at various distances from the accident location, rather than in terms of specific health effects.

To determine the potential health effects to workers and the public that could result from accidents involving hazardous materials, the airborne concentrations of such materials released during an accident at varying distances from the point of release were compared to the Emergency Response Planning Guideline (ERPG) values (AIHA 1991). The American Industrial Hygiene Association established these values, which depend on the chemical substance, for the following general severity levels to ensure that the necessary emergency actions occur to minimize exposures to humans.

- ERPG-1 Values. Exposure to airborne concentrations greater than ERPG-1 values for a

period greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects or perception of a clearly defined objectionable odor.

- ERPG-2 Values. Exposures to airborne concentrations greater than ERPG-2 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects or symptoms that could impair a person's ability to take protective action.

- ERPG-3 Values. Exposure to airborne concentrations greater than ERPG-3 values for a period greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Not all hazardous materials have ERPG values. For chemicals that do not have ERPG values, a comparison was made to the most restrictive available exposure limits established by other guidelines to control worker accidental exposures to hazardous materials. In this document, the ERPG-2 equivalent that is used is the PEL-TWA (Permissible Exposure Limit – Time Weighted Average) from 29 CFR Part 1910.1000, Subpart Z.

B.3 Postulated Accident Scenarios Involving Radioactive Materials

These sections describe the potential accident scenarios associated with each alternative that could involve the release of radioactive materials. The impacts of these scenarios are shown in Section B.4.

B.3.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

The Clean and Stabilize Tanks Alternative, including all of its stabilization options, would require cleaning the inside of the tank to the extent technically and economically possible. This cleaning would involve a two-step process. Initially, after bulk waste removal, the waste tank interiors would be water-washed using rotary spray jets put down into the tank interior through the tank risers. Water for these jets would be supplied from a skid-mounted tank and pump system. Following water washing, additional cleaning may be required using a hot oxalic acid solution through the same spray jets.

Six potential accident scenarios associated with the cleaning process were identified in Yeung (1999) that required evaluation. These included:

- Deflagration
- Transfer errors
- Vehicle impacts
- Chemical (oxalic acid) spill
- Seismic events
- Tornado

Criticality was not addressed as a potential accident scenario in Yeung (1999) because DOE considers inadvertent criticality to be beyond extremely unlikely in high-level waste tanks (Nomm 1995). The criticality safety of the waste sludge was based on the neutron-absorbing characteristics of the iron and manganese contained in the sludge. However, the review assumed that the waste would remain alkaline and did not address the possibility that chemicals wold be used that would dissolve sludge solids. Therefore, the *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited.

A formal Nuclear Criticality Safety Evaluation (Unreviewed Safety Question evaluation and subsequent Safety Analysis Report revision) must be completed before oxalic acid could be introduced into the Tank Farm. Oxalic acid can dissolve uranium, plutonium, and the two neutron poisons that are credited for preventing a criticality-iron and manganese. The Nuclear Criticality Safety Evaluation would address the relative rates at which each of these species dissolves and would examine potential scenarios that could cause fissile material to concentrate.

Following the cleaning process, the tanks would be back-filled with a pumpable material (grout, sand, or saltstone). Yeung (1999) indicated that the scenarios identified above for the cleaning operations bound all postulated accidents during back-filling the waste tanks with either grout or sand. Since saltstone is a radioactive material, any uncontrolled release of radioactive materials associated with the Clean and Fill with Saltstone Option must be evaluated. WSRC (1992a) evaluated a failure of the Salt Solution Hold Tank. Yeung (1999) identified no accident scenarios for the post-closure period for this alternative.

B.3.1.1 Deflagration

Scenario: One postulated accident during cleaning of the waste tanks would be a release of radiological materials due to an explosion inside of the waste tank. The explosion could possibly consist of a deflagration or detonation. The transition from deflagration to detonation would occur only if the deflagration flame front accelerates to sonic speeds. In order for the deflagration to occur, flammable chemicals must be introduced into the waste tanks as a result of human error, and ignition sources must be present (Yeung 1999).

Probability: The determination of the probability of this event was based on the availability of flammable chemicals, the potential that they would be introduced into the waste tank, and the fact that an ignition source is present. There are no flammable chemicals required for the cleaning process. For a deflagration to occur, multiple operator errors and violation of multiple administrative controls would be required. From Benhardt et al. (1994), the combined probability of violation of an administrative control bringing in the flammable chemical and chemical addition into the tank would be 1.5×10^{-6} per year. Considering that in addition to the above, a significant amount of flammable material would be required to be introduced into the tank (e.g., 440 kilograms of benzene), by engineering judgement the additional probability of this event was estimated to be 1×10^{-2} per year (Yeung 1999). Therefore, the probability of a deflagration during the cleaning process was estimated to be 1.5×10^{-8} per year. Since the tank is relatively free of internal structures, the transition from deflagration to detonation occurs less than one time in a hundred for a near stoichiometric mixture. Therefore, the frequency of a detonation event was estimated to be 1×10^{-10} per year (Yeung 1999).

Since the likelihood of these events is well below 1×10^{-7}, they are considered beyond extremely unlikely and are not evaluated further in this EIS.

B.3.1.2 Transfer Errors

Scenario: The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998a) reports that all transfer error events in the Liquid Radioactive Waste Handling Facility can be bounded by a waste tank overflow event, which would result in an above-ground spill of 15,600 gallons of waste (520 gpm for 30 minutes). A postulated accident during water spray washing of the waste tanks would be a release of diluted waste due to continuous maximum flow through a transfer line direct to the environment for 30 minutes without operator intervention. WSRC (1998a) assumed that the spill would occur above ground and result in seepage into the ground and evaporation into the air. This scenario would bound all leak/spill events.

Probability: It is considered unlikely that aboveground equipment failures leading to leakage or catastrophic release of the tank contents would go undetected (WSRC 1998a). Therefore, failures of aboveground equipment and the failure of the operators to detect and stop the leaks were considered in Yeung (1999). It was estimated that equipment failures and operator errors to detect and stop the leaks leading to the release of the bounding source terms described below could occur with a frequency of 1×10^{-3} per year (Yeung 1999). This frequency is in the unlikely range.

Source Term: After bulk waste removal and before spray washing, there would be approximately 9,000 gallons of HLW in the form of sludge or sludge slurry left in each tank. Based on the bounding sludge dose potential as given

in the Safety Analysis Report (WSRC 1998a), it was assumed that the sludge slurry before spray washing would be characterized by the activities of 81,000 curies (Ci) of plutonium-238 (Pu-238) and 2,180,000 Ci of strontium-90 (Sr-90). The volume of the water used for spray cleaning was assumed to be 140,000 gallons (WSRC 1998b). This would result in a total waste volume of 149,000 gallons with nuclide concentrations in the diluted waste solution estimated at 0.54 Ci/gallons and 14.63 Ci/gallons for Pu-238 and Sr-90, respectively. The instantaneous airborne release for a spill of 15,600 gallons was estimated to be 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 (Yeung 1999). An additional entrainment source term of 0.34 Ci of Pu-238 and 9.1 Ci of Sr-90 was estimated assuming no mitigative actions were taken within a 10-hour period following the event.

B.3.1.3 Vehicle Impact

Scenario: Another postulated accident during cleaning of the waste tanks would be a release of diluted waste due to failure of the above ground pumping equipment and piping resulting from a construction vehicle impact. It was assumed that the equipment used to pump out the waste-water slurry from the tanks would be damaged to the point where pumping continued releasing the slurry onto the ground.

Probability: The frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). The Safety Analysis Report (WSRC 1998a) conservatively assumes that 0.1 percent of the accidents occurring at the H-Area and F-Area Tank Farm impact above-ground equipment, resulting in an overall frequency of 2.7×10^{-6} per year. The possibility that a fire could occur following a crash was also evaluated. Assuming that 97.7 percent of all truck accidents are minor (WSRC 1992b), and that fires resulting from minor accidents have an extremely low probability, the overall frequency of a fire resulting from a vehicle crash is estimated to be 6.2×10^{-8} per year. Therefore, vehicle impacts involving a coincident fire were considered to be beyond extremely unlikely.

Source Term: The MAR for this scenario was assumed to be the same as that in Section 3.1.2. Since the source term for this scenario is the same as estimated for the transfer errors and the expected frequency is smaller, the risk associated with this scenario would be bounded by the transfer error accident. No further evaluation of vehicle impacts are required in this appendix.

B.3.1.4 Chemical (Oxalic Acid) Spill

This accident would involve the release of non-radiological hazardous materials, which is addressed in Section B.5.

B.3.1.5 Seismic Event

Scenario: Yeung (1999) postulated that a design basis earthquake could occur during cleaning of the waste tanks, resulting in a release of liquid radiological materials. Only one tank in each tank farm would undergo closure at any one time. It was therefore assumed that the earthquake would occur immediately following water spray washing, which had been performed on two tanks simultaneously (one in each tank farm). The seismic event was assumed to fail the same transfer piping and equipment as was mentioned in the previous scenarios.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the cleaning of two tanks would take approximately 14 days, a release of the bounding source term would occur at an annual probability of 1.9×10^{-5}. This accident would be categorized as extremely unlikely.

Source Term: The aboveground MAR was assumed to be same as in Section 3.1.2 except that the source term would be doubled because two tanks would be involved. Yeung (1999) provided the source term as an instantaneous airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90. If mitigation measures were not taken, entrainment would result in an additional airborne release of 0.68 Ci of Pu-238 and 18 Ci of Sr-90 over a 10-hour period.

B.3.1.6 Tornado

The design basis tornado was postulated to occur during water spray washing of the waste tanks. From WSRC (1998a), it was assumed that administrative controls stipulate the cessation of waste transfer operations at the first instance of tornado/high wind warning.

All waste tanks are underground and are protected by a concrete roof. With all transfer operations stopped, there would be no MAR aboveground. Some aboveground components of the transfer system may fail, but their contributions to the release of radiological materials were considered insignificant (Yeung 1999). As a result, this scenario would be bounded by several other scenarios and not evaluated further.

B.3.1.7 Failure of Salt Solution Hold Tank

Scenario: This scenario assumes that a Saltstone Mixing Facility would be built in F-area and H-Area similar to that currently operating in Z-Area. This accident would involve a worst-case release of the salt solution contained in a Salt Solution Hold Tank prior to mixing with cement, flyash, and slag to form the saltstone. The Salt Solution Hold Tank was assumed to contain 45,000 gallons of salt solution. The entire volume was assumed to be released and allowed to evaporate over a two-hour period (WSRC 1992a). No credit was taken for operator intervention, absorption into the ground, or containment of the spill in the diked area of the tank. In reality, this would significantly reduce the airborne release. It would take an extremely high-energy event to vaporize such a large quantity in such a short period of time (WSRC 1992a). Failure of the Salt Solution Hold Tank was assumed to occur during the design basis earthquake.

Probability: The design basis earthquake has an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10 percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source Term: The 45,000 gallons of salt solution (1.2 kilograms per liter) in the Salt Solution Hold Tank was assumed to contain the radionuclides in Table B-2 (WSRC 1992a). Table B-2 also contains the assumed release fractions resulting in the final estimated source terms (unmitigated) (WSRC 1992a). This accident would also involve the release of non-radiological hazardous materials. The evaluation of these releases is addressed in Section B.5.

B.3.2 CLEAN AND REMOVE TANKS ALTERNATIVE

Following bulk waste removal, water spray washing, and additional cleaning, including the use of oxalic acid, additional cleaning steps (yet to be defined) would be performed until the tanks are clean enough to remove. The additional cleaning steps would increase worker radiation exposure and contamination. They would also increase the potential for industrial safety accidents. Following cleaning, the tank components would be sectioned, removed, placed in burial boxes for disposal, and transported to onsite waste disposal facilities.

The scenarios in Section B.3.1 were assumed to bound any postulated tank accident scenarios associated with this alternative.

B.3.2.1 Flooding

Scenario: Yeung (1999) postulated that abandoning the waste tanks in place following waste removal would lead to long-term tank degradation, failure of the tank roof, and exposure of the radiological materials to potential flooding and release to the environment. DOE has assumed that institutional control would be maintained for at least a period of 100 years. Beyond institutional control, it has been assumed that the waste tanks would retain their basic structural integrity for another 100 years without catastrophic failure. Therefore, this EIS considers any impacts associated with failure of these waste tanks after a period of 200 years to be long-term impacts and not addressed further in this appendix.

Table B-2. Radiological source term for failure of Salt Solution Hold Tank.

Radionuclide	Activity (curies)[a]	Assumed release fraction	Total airborne activity released (curies)[a]
H-3	380	1.0	380
Co-60	15	1.0×10^{-4}	0.0015
Sr-89	13	1.0×10^{-4}	0.0013
Sr-90	13	1.0×10^{-4}	0.0013
Tc-99	210	1.0×10^{-2}	2.1
Ru-106	130	1.0×10^{-2}	1.3
Sb-125	31	1.0×10^{-2}	0.31
I-129	4.2	3.0×10^{-1}	1.3
Cs-137	21	1.0×10^{-2}	0.21
Ba-137m	21	1.0×10^{-2}	0.21
Eu-154	3.4	1.0×10^{-4}	0.00034
Total alpha	11	1.0×10^{-4}	0.0011
Other beta-gamma	840	1.0×10^{-4}	0.084
Total	1680		383

Source: WSRC (1992a)
a. Values rounded to 2 significant figures.

B.3.3 NO ACTION ALTERNATIVE

For the No Action Alternative, no action would be taken to clean the tank beyond that which is included in bulk waste removal. Flooding was the only scenario identified in Yeung (1999), applicable to this alternative, which would result in an airborne release of radiological materials.

B.4 Accident Impacts Involving Radioactive Materials

This section presents the potential impacts associated with the accident scenarios involving the release of radioactive materials identified in Section B.3. Table B-3 provides the accident impacts for each of the scenarios from airborne releases. It also provides the resultant latent cancer fatalities expected from the offsite impacts.

B.5 Postulated Accidents Involving Nonradioactive Hazardous Materials

This section summarizes the potential accident scenarios involving hazardous chemicals for the various alternatives. Two accidents involving hazardous material releases were identified in Yeung (1999).

B.5.1 OXALIC ACID SPILL

Scenario: A postulated accident during cleaning of the waste tanks would be a worst-case spill of 10,000 gallons of 4 percent (concentration) oxalic acid from any cause (vehicle crash, earthquake, or tornado). It was assumed that oxalic acid used for cleaning would be stored in an above ground 10,000-gallon stainless steel portable tank. The oxalic acid was assumed to be heated to a temperature of 80°C. This scenario would bound all accidents involving a chemical release of oxalic acid.

Probability: The annual probability of exceedance for the design basis earthquake is 5.0×10^{-4} (WSRC 1998c). Assuming that the oxalic acid tank would be used for 30 days out of the year, then the overall frequency was calculated to be 4.1×10^{-5} per year. For the design basis tornado, annual probability of exceedance is 2×10^{-5} (WSRC 1998c). Combined with the 30-day time at risk, probability resulted in an overall annual probability of 1.6×10^{-6}. If the tank is moved into a shelter or protected by administrative controls (e.g., erect missile barrier and/or tie

Table B-3. Radiological impacts from airborne releases.

Accident	Total curies released	Accident frequency	Non-involved worker (rem)	Maximally exposed individual (rem)	Offsite population (person-rem)	Latent cancer fatalities
Transfer errors	19	Once in 1,000 years	7.3	0.12	5,500	2.8
Seismic (DBE)	38	Once in 53,000 years	14.6	0.24	11,000	5.5
Salt Solution Hold Tank failure	380	Once in 20,000 years	0.015	0.00042	16.7	0.0084

down the tank), the annual probability for this event could be reduced to 8×10^{-8} (Yeung 1999). If a vehicle crash was considered, then the frequency of a vehicle crash occurring over all the Liquid Radioactive Waste Handling Facilities is bounded between 7.4×10^{-4} and 4.7×10^{-3} events per year (WSRC 1998a). Conservatively assuming that 0.1 percent of the accidents occurring at the F-Area and H-Area Tanks (WSRC 1998a) impact the oxalic acid tank resulted in an overall frequency of 2.7×10^{-6} per year. Considering these three different initiating events, the most credible scenario would be a design basis earthquake with an annual probability of 4.1×10^{-5}. This scenario would be extremely unlikely.

Source Term: The chemical release MAR would consist of 10,000 gallons of 4 percent oxalic acid. The oxalic acid source term was conservatively estimated to be an airborne release of 150 grams of 100 percent oxalic acid at a release rate of 168 milligrams per second (Yeung 1999).

B.5.2 FAILURE OF SALT SOLUTION HOLD TANK

Scenario: As described in Section B.3.1.7, this scenario would involve the failure of the Salt Solution Hold Tank, which would be used in one of the options in the Clean and Stabilize Tanks Alternative during the preparation of the saltstone that would be used to backfill the empty tanks. The Salt Solution Hold Tank would contain both radiological and hazardous materials. The radiological impacts are discussed in Section B.4.

Probability: The initiating event that was assumed to cause the Salt Solution Hold Tank failure was a design basis earthquake with an annual probability of exceedance of 5×10^{-4} (WSRC 1998c). Assuming that the Salt Solution Hold Tank has a 10 percent chance of failing during the earthquake, a release of the bounding source term was estimated to occur at an annual probability of 5×10^{-5}. This scenario would be extremely unlikely.

Source term: The source term for hazardous materials released from the failed Salt Solution Hold Tank is given in Table B-4. They were obtained from the Safety Analysis Report for the Saltstone Facility (WSRC 1992a).

B.6 Accident Impacts Involving Non-radioactive Hazardous Materials

As Section B.4 provided for the radiological consequences of identified accidents, this section provides the potential impacts associated with the release of non-radioactive hazardous materials from the two accident scenarios.

B.6.1 OXALIC ACID SPILL

The oxalic acid spill, described in Section B.5.1, would result in the release of 150 grams of oxalic acid at a release rate of 168 milligrams per second. Table B-5 provides atmospheric dispersion factors for the two individual receptors, the uninvolved worker and the maximally exposed offsite individual (MEI) (Hope 1999). By ap-

Table B-4. Chemical source term for failure of Salt Solution Hold Tank.

Chemical	Total inventory in Salt Solution Hold Tank (kg)	Assumed release fraction	Evaporation release rate (milligrams per second)
Arsenic	170	1.0×10^{-4}	2.4
Barium	170	1.0×10^{-4}	2.4
Cadmium	51	1.0×10^{-4}	0.71
Chromium	340	1.0×10^{-4}	4.7
Lead	170	1.0×10^{-4}	2.4
Mercury	85	1.0×10^{-4}	1.2
Selenium	60	1.0×10^{-4}	0.83
Silver	170	1.0×10^{-4}	2.4
Benzene	0.52	1.0	73
Phenol	170	1.0×10^{-2}	240

Source: Yeung (1999).

Table B-5. Chemical concentrations to various receptors for oxalic acid spill accident.

Chemical	Evaporation release rate (milligrams per second)	Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (micrograms per cubic meter)	
		Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
4 percent Oxalic acid	168	1.7×10^{-4}	5.7×10^{-7}	0.03	0.0001

plying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-5.

Since the Permissible Exposure Limit – Time Weighted Average (PEL-TWA), which equates to the ERPG-2 value described in Section B.2.3, is 1.0 milligrams per cubic meter for oxalic acid, there would be no significant impacts to the onsite or offsite receptors from this accident.

B.6.2 FAILURE OF SALT SOLUTION HOLD TANK

The failure of the Salt Solution Hold Tank, described in Section B.5.2, would result in the release of the hazardous chemical inventory provided in Table B-4. Table B-6 provides atmospheric dispersion factors for the two individual receptors, the noninvolved worker and the maximally exposed offsite individual (Hope 1999). By applying these factors, the maximum concentrations at those receptor locations were calculated. These concentrations are also presented in Table B-6.

Since the most restrictive exposure limits for these hazardous materials are no less than 0.5 milligrams per cubic meter, there would be no significant impacts to the onsite or offsite receptors from this accident.

B.7 Environmental Justice

In the event of an accidental release of radioactive or hazardous chemical substances, the dispersion of such substances would depend on meteorology conditions, such as wind direction, at the time. Given the variability of meteorology conditions, the low probability of accidents, the location of minority and low-income communities in relation to SRS, and the small magnitude of estimated offsite impacts, disproportionately high or adverse human health and environmental impacts to minorities or low-income population are not expected to be very likely.

Table B-6. Chemical concentrations to various receptors for failure of the Salt Solution Hold Tank.

		Atmospheric dispersion factor (seconds per cubic meter)		Resultant concentration (milligrams per cubic meter)	
Chemical	Evaporation release rate (milligrams per second)	Noninvolved worker	Maximally exposed individual	Noninvolved Worker	Maximally exposed individual
Arsenic	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Barium	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Cadmium	0.71	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.0×10^{-7}
Chromium	4.7	1.7×10^{-4}	5.7×10^{-7}	0.0022	2.7×10^{-6}
Lead	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Mercury	1.2	1.7×10^{-4}	5.7×10^{-7}	0.0002	6.7×10^{-7}
Selenium	0.83	1.7×10^{-4}	5.7×10^{-7}	0.0001	4.7×10^{-7}
Silver	2.4	1.7×10^{-4}	5.7×10^{-7}	0.0004	1.4×10^{-6}
Benzene	73	1.7×10^{-4}	5.7×10^{-7}	0.012	4.2×10^{-5}
Phenol	240	1.7×10^{-4}	5.7×10^{-7}	0.040	1.4×10^{-4}

References

AIHA (American Industrial Hygiene Association), 1991, *Emergency Response Planning Guidelines*, Emergency Response Planning Guidelines Committee, Akron, Ohio.

Benhardt, H. C., et al., 1994, *Savannah River Site Human Error Database Development for Non-reactor Nuclear Facilities*, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1994, *Preparation Guide for U.S. DOE Non-reactor Nuclear Facility Safety Analysis Reports*, Standard DOE-STD-3009-94, Washington, D.C. (Available at http://tis.eh.doe.gov/techstds/standard/std3009/std300994CN.pdf).

Hope, E. P., 1999, *Parametric Dispersion Calculations for H-Area Releases*, S-CLC-H-00693, Revision 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitation of Exposure to Ionizing Radiation*, Report No. 116, Bethesda, Maryland.

Nomm, E., 1995, Frequency of Criticality in High Level Waste Facilities (U), S-CLC-H-00380, Revision 0, Westinghouse Savannah River Company, Aiken, South Carolina.

NRC (U.S. Nuclear Regulatory Commission), 1982, *Regulatory Guide 1.145: Atmospheric Dispersion Models for Potential Accidental Consequence Assessments at Nuclear Power Plants*, Revision 1, Washington, D.C.

Simpkins, A. A., 1995a, *Verification of AXAIRQ*, WSRC-RP-95-708, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1995b, *Verification of AXAIRQ*, WSRC-RP-95-709, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Simpkins, A. A., 1997, memorandum to C. B. Shedrow, "Spent Nuclear Fuel EIS Accidental Release Environmental Dosimetry Calculations," SRT-EST-97-196, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, March 13.

WSRC (Westinghouse Savannah River Company), 1992a, *Safety Analysis Report – Z-Area, Chapter 9, Analysis of Operations,* WSRC-SA-3, DOE Review Draft, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1992b, *Evaluation of Accident Risks in the Transportation of Hazardous Materials by Truck and Rail at the Savannah River Site*, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998a, *Safety Analysis Report – Liquid Radioactive Waste Handling Facility*, WSRC-SA-33, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *High Level Waste System Plan*, HLW-OVP-98-0037, Revision 9, Savannah River Site, Aiken, South Carolina. (Available at https://www.osti.gov/servlets/purl/301986-t5EGMP/webviewable/301986.pdf).

WSRC (Westinghouse Savannah River Company), 1998c, *Structural Design Criteria*, Savannah River Site Engineering Standard 01060, Savannah River Site Engineering Standards Manual, WSRC-TM-95-1, Revision 3, Savannah River Site, Aiken, South Carolina.

Yeung, M. R., 1999, *Determination of Accident Sequence, Frequency, and Source Term Selection for the Waste Tank Closure Environmental Impact Statement*, S-CLC-G-00181, Revision 0, Westinghouse Safety Management Solutions, Aiken, South Carolina.

APPENDIX C

LONG-TERM CLOSURE MODELING

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APPENDIX C. LONG-TERM CLOSURE MODELING

This appendix provides a discussion of the fate and transport modeling that was performed to determine the long-term impacts from the alternatives described in Chapter 2 of this EIS. This modeling estimates the potential human health and ecological impacts of residual contamination remaining in closed HLW tanks for all alternatives and estimates the concentration and dose levels at the location where the groundwater outcrops into the environment (i.e., the seepline).

In the modeling described in this appendix, the F-Area and H-Area Tank Farms were modeled assuming conditions that would exist after tank closure for four scenarios as follows: (1) No Action Alternative, (2) Clean and Fill with Grout Option, (3) Clean and Fill with Sand Option, and (4) Clean and Fill with Saltstone Option. None of the analyzed scenarios took credit for engineered caps to be placed after completion of closure activities.

DOE intends that the area immediately around the tank farms would remain in commercial/industrial use for the entire 10,000-year period of analysis and would be unavailable for residential use. However, DOE has estimated the impacts if residents have access to the tank farm area.

Potential impacts to the following hypothetical individuals were analyzed:

- *Worker:* An adult who has authorized access to, and works at, the tank farm and surrounding areas but is considered to be a member of the public for compliance purposes. This analysis assumes that the worker remains on the banks of Fourmile Branch or Upper Three Runs during working hours.
- *Intruder:* A teenager who gains unauthorized access to the tank farm and is potentially exposed to contaminants.
- *Nearby adult resident:* An adult who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.
- *Nearby child resident:* A child who lives in a dwelling across either Fourmile Branch or Upper Three Runs downgradient of the tank farms, near the stream.

In addition to the hypothetical individuals identified above, concentration and dose levels were calculated at the groundwater seepline point of exposure. For H-Area, the seepline is approximately 1,200 meters downgradient from the center of the tank farm, while for F-Area the seepline is roughly 1,800 meters downgradient from the tank farm. These distances are the linear distances to the seepline; the actual travel distances are somewhat greater due to the curved path of the groundwater. Concentration and dose levels were also calculated at 1-meter and 100-meters downgradient from the edge of the F-Area and H-Area Tank Farms, and an estimate of the dose from all pathways at these locations was performed.

Uncertainty in Analysis

In this EIS, DOE has made assumptions on numerical parameters that affect the calculated impacts. There is some uncertainty associated with the values of these parameter due to unavailable data and current state of knowledge about closure processes and long-term behavior of materials.

The principal parameters that affect modeling results are the following:

- **Inventory:** The amount of material in the tank directly affects the concentrations at any given location, unless the amount of material is so great that the solubility limit is exceeded. Once the solubility limit is exceeded, greater amounts of source material do not necessarily result in increased con-

centrations at receptor locations. In this modeling effort, both plutonium and uranium were assumed to be limited by solubility. Inventory results are based primarily on process knowledge at this time. As each tank is prepared for closure, specific sampling would be conducted to determine the inventory.

- **Hydraulic conductivity:** The actual rate of water movement through the material is ultimately affected by the hydraulic conductivity of the strata underneath the source. Generally, the grout or concrete basemat is the limiting layer with regard to water infiltration. At the time of structural failure, the hydraulic conductivity is increased dramatically, making more water available to carry contaminants to the aquifer. In general, this will result in greater doses/concentrations due to the increased movement of material.

- **Distribution coefficient:** The distribution coefficient (K_d) affects the rate at which contaminates move through strata. Large K_d values provide holdup time for short-lived radionuclides.

- **Vadose zone thickness:** The thickness of the strata between the contaminated region and the aquifer does not necessarily reduce the concentration so much as it slows the progress toward the aquifer. Therefore, for shorter-lived radionuclides, extra time granted by thicker strata can decrease the activity before the contaminants reach the aquifer.

- **Distance downgradient to receptor location:** The distance to a given receptor location affects (a) the time at which contaminants will arrive at the location and (b) how much dispersion occurs. For greater distances, longer travel times will be encountered, resulting in lower activity values for short-lived radioactive constituents and greater dispersion for all constituents.

DOE recognizes that over the period of analysis in this EIS, there is also uncertainty in the structural behavior of materials and the geologic and hydrogeologic setting of the Savannah River Site. DOE realizes that overly conservative assumptions can be used to bound the estimates of impacts; however, DOE believes that this approach could result in masking of differences of impacts among alternatives. Therefore, DOE has attempted to use assumptions in its modeling analysis that are reasonable based on current knowledge so that meaningful comparisons among alternatives can be made.

C.1 Analyzed Scenario

The hydrogeology under various areas of the SRS has been modeled several times in the last few years. Most of the modeling has focused on specific locations (e.g., the Saltstone Manufacturing and Disposal Facility in Z-Area, the seepage basins in H- and F-Areas) and is thus subject to updating as new information becomes available. DOE is continually refining the model for the General Separations Area based on recent hydrogeologic measurements. DOE has prepared this EIS using the methodology and the modeling assumptions as presented in the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste-Tank Systems.* DOE recognizes that future refining of the models described in the closure plan may result in slightly different estimates of impacts. However, DOE believes that using the methodology described in the closure plan provides a consistent basis for evaluating the alternatives.

The tank farms were modeled individually to determine the impacts from the respective source. In the analyzed scenario, the mobile contaminants in the tanks are assumed to gradually migrate downward through unsaturated soil to the groundwater aquifer. The aquifers underneath F-Area Tank Farm were assumed to discharge primarily to Fourmile Branch while the aquifers underneath H-Area Tank Farm were assumed to discharge to both Fourmile Branch and Upper Three Runs. Therefore, the contaminants would be transported by the groundwater to the seepline and subsequently to Fourmile Branch or Upper Three Runs. Upon reaching

the surface water, some contaminants would migrate to the sediments at the bottom of the streams and the shoreline. Aquatic organisms in the stream and plants along the shoreline would be exposed to the contaminants. Terrestrial organisms might then ingest the contaminated vegetation and also obtain their drinking water from the contaminated stream. Humans are assumed to be exposed to contaminants through various pathways associated with the surface water.

The following sections describe specific assumptions incorporated into the modeling calculations for the analyzed alternatives.

C.1.1 SCENARIO 1 – NO ACTION ALTERNATIVE

The No Action Alternative assumes that for the 100 years of institutional control, the tanks would contain necessary ballast water that would be treated to minimize corrosion. The tank is assumed to have a constant leak rate (simulated and limited by the hydraulic conductivity of the intact concrete basemat), which causes some passage through the tank bottom. At 100 years, the tanks are filled with water and abandoned but not capped.

At some point in the future, degradation associated with the aging of the tanks would destroy the tanks. The contaminants are then assumed to reside at the bottom of a hole equal to the depth of the tank (generally 30 to 40 feet). Although debris would exist in the hole, it is assumed to play no role in inhibiting infiltration or preventing flow into the soil. Because of the lack of structural support, the tanks and concrete basemat are assumed to fail completely at 100 years, exposing the contaminated media to rainfall with subsequent infiltration to groundwater.

The No Action Alternative is the only alternative that could conceivably expose individuals by the atmospheric pathway from the tank area, because each of the other alternatives would fill the tanks with material that would cover the contaminants and prevent their escape via atmospheric dispersion. The only foreseeable occurrence of an atmospheric release under No Action would be if the tank structures collapsed, causing the suspension of particulates containing contaminants. However, the likelihood of an atmospheric release is considered to be minimal, at best, for the following reasons:

- The amount of rainfall in the area would tend to keep the tank contents damp through the time of failure. After failure, a substantial amount of debris on top of the contaminated material would prevent release even if the contents were to dry during a period of drought.
- The considerable depth of the tanks below grade would tend to discourage resuspension of any of the tanks' contents.

Based on these reasons, no analyses were performed for the atmospheric pathway.

C.1.2 SCENARIO 2 – CLEAN AND FILL WITH GROUT OPTION

Scenario 2 assumes that the tanks would be filled with grout, and engineered structures would not be used to reduce the infiltration of rain water. By analogy with the analysis presented in the *E-Area Vault Radiological Performance Assessment* (WSRC 1994a), the concrete tank structure could enter a period of degraded performance due to cracking at around 1,400 years. Assuming that the approximately 34 feet of grout continue to support the tank roof and provide an additional barrier to infiltration for an indefinite period of time [Z-Area RPA (WSRC 1992)], water infiltration should occur much later than 1,400 years. However, for this scenario, the assumption is made that the tank top, grout, and basemat fail at 1,000 years, with a corresponding increase in their respective hydraulic conductivities.

C.1.3 SCENARIO 3 – CLEAN AND FILL WITH SAND OPTION

Scenario 3 assumes that the tanks would be filled with sand, and engineered structures would not be used to reduce the infiltration of

rain water. Eventually, the sides and roof of the tanks would collapse, allowing water to infiltrate the tank and leach the contaminants down to the aquifers. DOE has assumed that the tank fails at 100 years.

C.1.4 SCENARIO 4 – CLEAN AND FILL WITH SALTSTONE OPTION

Scenario 4 is similar to Scenario 2 in that a cementitious material is used to fill the tanks. However, in this scenario, the fill material is saltstone, a composite material made of cement, flyash, slag, and slightly contaminated media from processing of high-level waste. Currently, saltstone is disposed in Z-Area; under this alternative, saltstone would be used to fill the tanks and (as in Scenario 2) would be assumed to remain intact for 1,000 years following tank closure.

C.2 Methodology

C.2.1 HUMAN HEALTH ASSESSMENT

C.2.1.1 General Methodology

Utilizing the Multimedia Environmental Pollutant Assessment System (MEPAS) computer code (Buck et al. 1995), a multi-pathway risk model developed by Pacific Northwest Laboratory, calculations were performed to assess the impacts of the leaching of contaminants to the groundwater for each of the four tank closure scenarios. To model the four closure scenarios, infiltration rates were selected that represent the vertical moisture flux passing through the tanks for each closure alternative. These infiltration rates are dependent upon the chemical and physical characteristics of the tank fill material for each scenario.

Based on the calculated inventories of chemical and radioactive contaminants remaining in the tanks after bulk waste removal and spray washing, the model was set up to simulate the transport of contaminants from the contaminated zone (residual waste layer), through the concrete basemat (first partially saturated zone), the vadose zone directly beneath the basemat (second partially saturated zone), and into the underlying aquifers (saturated zones). Model runs were completed for both early timeframes (before the assumed failure occurs) and late timeframe (after assumed failure occurs) conditions.

In addition to the four tank closure scenarios, modeling was performed for pollutants remaining in the ancillary equipment and piping above the tanks. In this calculation, the piping and equipment were considered to be the contaminated zone while the partially saturated zone was the layer of soil extending from the surface to the saturated zones.

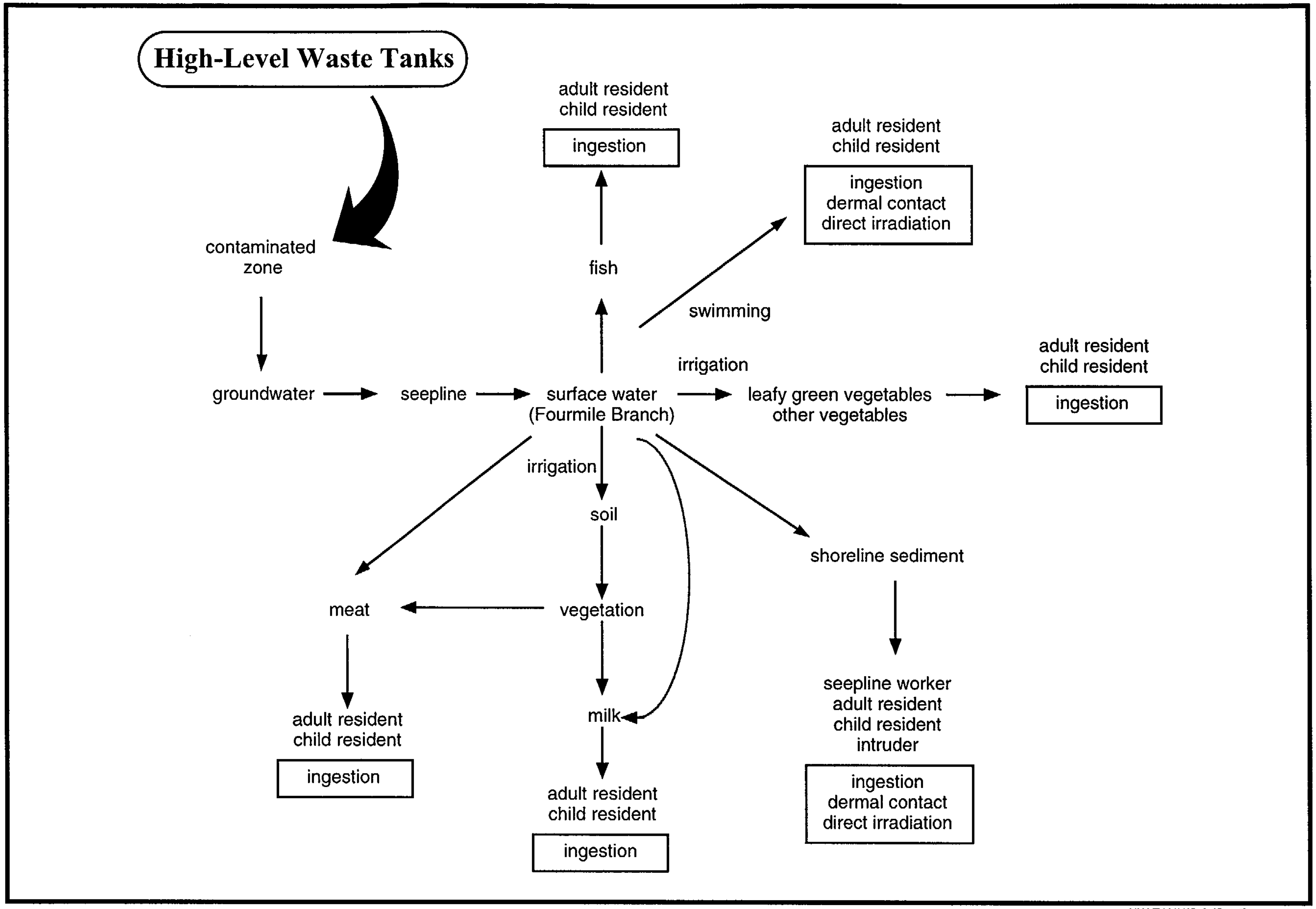
Calculated pollutant concentrations and dose levels are provided at 1 meter and 100 meters downgradient from the edge of the tank farms, at the seepline, and in the surface waters of Fourmile Branch and Upper Three Runs for the hypothetical individuals discussed in Section C.2.1.2. DOE has not calculated groundwater concentrations underneath the tanks because of inherent limitations involved in those calculations. Specifically, the large size of the tank farms and the pattern of groundwater movement make calculations for locations in proximity to the source speculative.

C.2.1.2 Receptors

The potential receptors and exposure pathways are identified in the following sections and illustrated in Figure C-1.

Worker

The worker is assumed to be located in the area including and surrounding either of the tank farms. Because institutional controls are in place, the potential for exposure of the worker to the primary source (residual at the bottom of the tanks) is minimal, owing to the structural integrity of the tank, the lack of any industrial work that would be performed over the tanks, and safety measures that would be taken to further reduce potential exposure. Therefore, this analysis assumes that the worker is located constantly at the nearest place where contaminants



NW TANK/Grfx/C-1 Expo paths.ai

Figure C-1. Potential exposure pathways for human receptors.

would be accessible (i.e., on the bank of Fourmile Branch or Upper Three Runs, as part of his work duties). The assumption is conservative because the worker has a greater potential for exposure to contaminants at the seepline. However, the fact that he is a worker limits, and, hence, eliminates pathways that might be considered if he were considered a resident. The potential exposure pathways for the seepline worker are:

- Direct irradiation from the deposits along the banks of the streams (radioactive contaminants only)
- Incidental ingestion of the soil from the deposits along the banks of the streams
- Dermal contact with dust from the deposits along the banks of the streams

Exposure from inhalation of resuspended soil was not evaluated because the soil conditions at the seepline (i.e., the soil is very damp) are such that the amount of soil resuspended and potentially inhaled would be minimal.

Intruder

Another potential receptor is the intruder, a person who gains unauthorized access to the tank farm site and becomes exposed to the contaminants in some manner. The intruder scenario is analyzed after institutional controls have ceased. Because the intruder is assumed not to have residential habits, he or she would not have exposure pathways like that of a resident (e.g., the intruder does not build a house, grow produce, etc.); instead, the intruder is potentially exposed to the same pathways as the seepline worker but for a shorter duration (4 hours per day, as noted in Section C.3.2.5).

Nearby Adult Resident/Nearby Child Resident

Nearby residents could also potentially be exposed to contaminants from the tank farms. Members of the public are assumed to construct a dwelling near the tank farms on SRS (but outside the tank farm site). The location of the residential dwelling is assumed to be downgradient near one of the two main streams (Fourmile Branch or Upper Three Runs) on the side opposite the tank farms at a point 100 meters downstream of the groundwater outcropping in these streams. The residents of this dwelling include both adults and children. The adult resident was modeled separately from the child resident because of different body weights and consumption rates.

The resident is assumed to use the stream for recreational purposes; to grow and consume produce irrigated with water from the stream; to obtain milk from cows raised on the residential property; and to consume meat that was fed contaminated vegetation from the area. Therefore, potential exposure pathways for both the nearby adult and nearby child resident are the following:

- Incidental ingestion of contaminated soil from deposits along the banks of the streams
- Inhalation of contaminated soil from deposits along the banks of the streams
- Direct irradiation from deposits along the banks of the streams (radioactive contaminants only)
- Direct irradiation from surface water (radioactive contaminants only - recreation)
- Dermal contact with surface water
- Incidental ingestion of surface water
- Ingestion of contaminated meat
- Ingestion of produce grown on contaminated soil irrigated with water from Fourmile Branch
- Ingestion of milk from cows that are fed contaminated vegetation
- Ingestion of aquatic foods (e.g., fish) from Fourmile Branch

Because of the physical circumstances of the fate and transport modeling, the most likely location for soil ingestion is on the shoreline of the streams. Figure C-1 shows this pathway, which is identified as "shoreline sediment" along with the appropriate exposure pathways: ingestion, dermal contact, and direct irradiation. While analyses of some waste sites do show that soil ingestion is a dominant pathway, this usually occurs when the residents have direct access to the highly contaminated soils excavated from the waste site. Because of the depth of the waste tanks so far below grade and the fill material that would be in place, there is n credible situation by which the residents could have direct access to this material in this EIS; therefore, the soil ingestion pathway is not dominant.

Although the basic assumption for the residents is that they are not located at the tank farms, DOE has nevertheless estimated the impact if residents are allowed access to the tank farms.

Atmospheric Pathway Receptors

Based on the reasoning presented in Sections C.1.1 and C.2.1.2, no analyses were performed for the atmospheric pathway.

C.2.1.3 Computational Code

Groundwater and surface water concentrations and human health impacts were calculated using the MEPAS computer code (Buck et al. 1995). MEPAS was developed by Pacific Northwest National Laboratories under DOE contract and integrates source-term, transport, and exposure models for contaminants. In the MEPAS code, contaminants are transported from a contaminated area to potentially exposed humans through various transport pathways (groundwater, surface water, soils, food, etc.). These exposed individuals then receive doses, both chemical and radiation, through exposure or intake routes (ingestion, dermal contact, inhalation, etc.) and numerous exposure pathways (drinking water, leafy vegetables, meat, etc.).

MEPAS includes models to estimate human health impacts from radiation exposure (radionuclides and direct radiation), carcinogenic chemicals, and noncarcinogenic chemicals. Health effects resulting from radiation and radionuclide exposures are calculated as annual dose (millirem per year). Cancer incidence rates are calculated for carcinogens.

The MEPAS code is widely used (PNL 1999) and accepted throughout the DOE complex and has been presented to and accepted by other regulatory agencies such as EPA. Examples of its use by DOE include the EH-Environmental Survey Risk Assessment and the Complex-Wide Programmatic Waste Management EIS Impact Analysis. This code has been used to demonstrate environmental impacts in RCRA-Subpart X permit applications to various EPA regions; these analyses were accepted and permits based on them were issued.

C.2.1.4 Calculational Methodology

The modeling results presented in this appendix are based on the amount of contaminants remaining in the tanks after bulk waste removal and spray washing (except for No Action, which assumes only bulk waste removal with no spray washing). The results can generally be scaled to differing amounts of residual contaminants left in a tank. Although the waste is present as supernate (salt solution), damp saltcake and sludge, the total residual waste volume was assumed to be sludge, based on the assumption that all the residual contaminants reside in the sludge (Newman 1999).

Analyses were performed specifying infiltration rates that relate to the four closure scenarios. An infiltration rate of 40 centimeters per year (average infiltration rate for SRS soils) was used to model time periods after tank failure (WSRC 1994a). This value takes into account the average annual precipitation and the amount of rainfall that evaporates, flows to streams and land surface, etc. and is not available for infiltration into soil. An infiltration rate of 122 centimeters per year was used for the No Action Alternative to simulate infiltration of 100 percent of the average annual precipitation assuming no runoff or evaporation. The latter assumption is consid-

ered to be reasonable given the fact that the tanks are located in a depression that could fill with rainwater if the storm drain system fails.

As discussed in Section C.1.1, tank failure for the No Action Alternative would involve an initial release of the ballast water that would be limited by the hydraulic conductivity.

MEPAS calculations were performed for early (before structural failure) and late (after structural failure) conditions for each closure scenario. As discussed above, a failure time was assumed for each closure scenario based on anticipated performance of the tank fill material and concrete basemat. The tank fill and concrete basemat were assumed to fail simultaneously and completely in terms of retaining waste. Failure was simulated for modeling purposes by increasing the infiltration rate to 40 centimeters per year (except for No Action which remains at 122 centimeters per year) and increasing the hydraulic conductivity of the basemat to that of sand. Because radionuclide and chemical pollutants could leach though the concrete before failure occurs, the original source term was reduced by an amount equal to the quantities released to the aquifer during the prefailure period. In addition, radionuclides continually decay, further changing the source term. Thus, for late runs, in addition to changing the infiltration rates and hydraulic conductivities, the source term concentrations were adjusted to reflect losses and decay occurring before failure.

In the groundwater transport pathway, infiltration causes leaching of pollutants from the tanks through distinct media found below the waste unit down to the groundwater aquifer (saturated zone). To model the movement of the pollutants from the waste unit to the aquifer, MEPAS requires that the distinct strata that the pollutants encounter be identified. For modeling the tank farms, the residual at the bottom of the tanks was considered to be the contaminated zone.

Between the contaminated zone and the saturated zone, two discernible layers were identified: the concrete basemat of the tank and the unsaturated (vadose) zone. Parameters describing the concrete layer were defined for both pre- and postfailure conditions because values for parameters such as porosity, field capacity, and hydraulic conductivity change with degradation state. Analysis of flow through the vadose zone is complicated in that movement varies with soil-moisture content and wetting and drying conditions. Therefore, values for saturated zone soil parameters (e.g., density, porosity) were used to describe the unsaturated zone.

For each of the four layers identified for this site (contaminated zone, concrete basemat, vadose zone, and saturated zone), surface distribution coefficients, K_d values, were selected for each radionuclide and chemical for each modeled layer. Because distribution coefficients are a chemical property, the K_d values were not changed for degraded or failed materials. The identification and derivation of the K_d values is discussed in detail in Section C.3.2.1.

As contaminants are transported from the contaminated zone to the seepline, they are longitudinally (along the streamline of fluid flow), vertically, and transversely (out sideways) dispersed by the transporting medium. MEPAS incorporates longitudinal dispersivity of pollutants moving downward through the partially saturated zone layers (i.e., concrete basemat and vadose zone) in concentration calculations. In the saturated zone, MEPAS incorporates into concentration calculations the three-dimensional dispersion along the length of travel. Dispersion distances were calculated through the concrete basemat, the vadose zone, and the groundwater aquifer. Logically, dispersion generally increases with longer travel distances, and it should be noted that the travel distance is determined by the hydraulic gradients and not by linear distance.

Groundwater concentrations and doses due to ingestion of water are calculated at hypothetical wells at 1 meter and 100 meters downgradient from the edge of the respective tank farms, at the respective seeplines, and in Fourmile Branch and Upper Three Runs.

As discussed earlier, impacts to adult and child residential receptors are evaluated at a point 100 meters downstream of the groundwater outcropping in Fourmile Branch and Upper Three Runs. The concentration of contaminants in the streams was also calculated. Based on the dimensions, flow rate, and stream velocities, MEPAS accounts for mixing of the contaminant-containing water from the aquifer with stream water and other groundwater contributions. For both adult and child residents, ingestion rates were based on site-specific parameters. Parameters and associated assumptions used in calculating human impacts are presented in Section C.3.2.5.

In addition to the four closure scenarios, MEPAS runs were performed to determine the effects of leaving in place the piping, vessels, and other tank-specific systems outside the tanks, all of which contain residual pollutants. It was assumed that an additional 20 percent of the radioactive contaminants remaining in the tanks after bulk cleaning and spray washing would be distributed in the ancillary equipment (d'Entremont 1996). Modeling was performed for two options: (1) leaving the piping and other equipment as they currently exist (assumed for the No Action Alternative and Clean and Fill with Sand Option), and (2) filling, where possible, the piping and other outside equipment with grout (assumed for the Clean and Fill with Grout and Clean and Fill with Saltstone Option). For modeling in MEPAS, the ancillary equipment was considered to be the contaminated zone, and the entire distance between the contaminated zone and the saturated zone was characterized as one layer of typical SRS soil. Therefore, no credit was taken for the additional reduction of leachate afforded by the tanks, thus providing conservative results.

C.2.2 ECOLOGICAL RISK ASSESSMENT

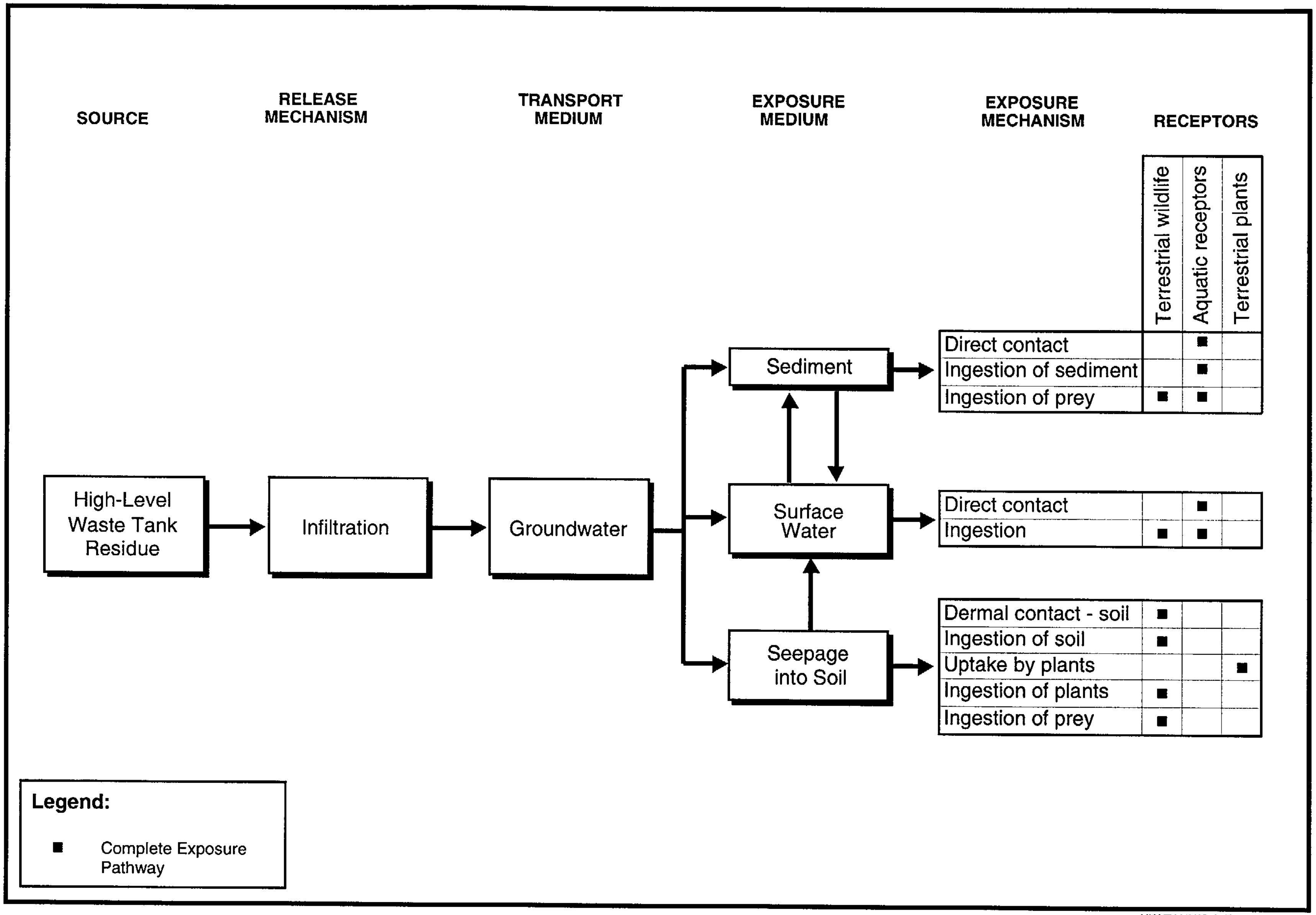
C.2.2.1 General Methodology

Several potential contaminant release mechanisms were considered for assessing ecological risks associated with tank closure. These included contamination of runoff water during rainstorms, soil contamination from air emissions following tank collapse, and contamination of groundwater. Onsite inspection showed that the tanks are well below (4 to 7 meters) the surrounding, original land surface. Therefore, runoff or soil contamination was not a reasonable assumption. Groundwater contamination was determined to be the most likely means of contaminant transport.

Several contaminant migration pathways were evaluated, which for half of H-Area (south of the groundwater divide) include seepage of the groundwater from the Water Table and Barnwell-McBean Aquifers at a downgradient outcrop (seepline) and subsequent mixing in Fourmile Branch and outcrop from the Congaree Aquifer and subsequent mixing in Upper Three Runs. For the other half of H-Area (north of the groundwater divide), all three aquifers outcrop at Upper Three Runs with subsequent mixing with this stream. For F-Area, the analysis included seepage of the groundwater from the Water Table and Barnwell-McBean Aquifers at a downgradient outcrop (seepline) and subsequent mixing in Fourmile Branch, and outcrop from the Congaree Aquifer and subsequent mixing in Upper Three Runs. Each of these migration pathways was evaluated using four methods for tank stabilization, which include the Clean and Fill with Grout Option, the Clean and Fill with Sand Option, the Clean and Fill with Saltstone Option, and the No Action Alternative (no stabilization). The groundwater-to-surface water contaminant migration pathway, together with potential routes of entry into ecological receptors, is shown in the conceptual site model (Figure C-2).

The habitat in the vicinity of the seeplines is bottomland hardwood forest. On the upslope side of the bottomland, the forest becomes a mixture of pine and hardwood.

Potential impacts to terrestrial receptors at the seepline and aquatic receptors in Fourmile Branch and Upper Three Runs were evaluated. For the assessment of risk due to toxicants, the aquatic receptors are treated as a group because



NW TANK/Grfx/C-2 Eco Risk.ai

Figure C-2. Ecological Risk Assessment Conceptual Site Model.

water quality criteria have been derived for protection of aquatic life in general. These criteria, or equivalent values, are used as threshold concentrations. For the radiological risk assessment, the redbreast sunfish was selected as an indicator species due to its abundance in Fourmile Branch and Upper Three Runs (Halverson et al. 1997).

There are no established criteria for the protection of terrestrial organisms from toxicants. Receptor indicator species are usually selected for risk analysis and the results extrapolated to the populations, communities, or feeding groups (e.g., herbivores, predators) they represent. Two terrestrial animal receptors, the southern short-tailed shrew and the mink, were selected in accordance with EPA Region IV guidance, which calls for investigation of small animals with small home ranges. The guidance also calls for investigation of predators when biomagnifying contaminants (such as mercury) are being studied. The southern short-tailed shrew is small and one of the most common mammals on the SRS; the mink is a small-bodied predator associated with waterways and is found on SRS (Cothran et al. 1991). Species that are more abundant on SRS than the mink with similar eclogues were considered for use in this assessment, including the raccoon. However, the mink has a small body size relative to similar species, which results in a more conservative estimate of exposure. Also, the mink is considered to be a highly contaminant-sensitive species, and is almost exclusively carnivorous (which maximizes toxicant exposure). The short-tailed shrew and mink are also used in the radiological assessment.

The seepage areas are estimated to be small, about 0.5 hectare (DOE 1997), so risk to plant populations would be negligible even if individual plants were harmed. The only case in which harm to individual plants might be a concern in such a small area would be if protected plant species are present. Because no protected plant species are known to occur in these areas, risks to terrestrial plants are not treated further in the risk assessment.

The following exposure routes were chosen for calculating absorbed radiation dose to the terrestrial mammals of interest (shrew and mink) located on or near the seeplines: ingestion of food (earthworms, slugs, insects and similar organisms for the shrew, and shrews for the mink); ingestion of soil; and ingestion of water. The following exposure routes were chosen for calculating absorbed dose to aquatic animals of interest (sunfish) living in Fourmile Branch and Upper Three Runs: uptake of contaminants from water and direct irradiation from submersion in water. Standard values for parameter such as mass, food ingestion rate, water ingestion rate, soil ingestion rate, and bioaccumulation factors were used (see Section C.3.3).

C.2.2.2 Exposure and Toxicity Assessment

Exposure to Chemical Toxicants

Exposure for aquatic receptors is simply expressed as the concentration of contaminants in the water surrounding them. This is the surface-water exposure medium shown in the conceptual site model (Figure C-2). The conceptual model also includes sediment as an exposure medium; sediment can become contaminated from the influence of the surface water or from seepage that enters sediment directly. However, this exposure medium was not evaluated because estimating sediment contamination from surface water inputs would be highly speculative and seepage into sediment is not considered in the groundwater model; all of the transported material is assumed to come out at the seepline.

Exposure for terrestrial receptors is based on dose, expressed as milligrams of contaminant ingested per kilogram of body mass per day. The routes of entry (exposure routes) used for estimating dose were ingestion of food and water. Dermal absorption is a possibility, but the fur of shrews and minks was considered to be an effective barrier against this route. The food of shrews is mainly soil invertebrates, and the mink eats small mammals, fish, and a variety of other small animals. Contaminants in seepage water were considered to be directly ingested as drinking water (shrew), ingested as drinking

water after dilution in Fourmile Branch (mink), ingested in aquatic prey (mink), and transferred to soil, soil invertebrates, shrews, and mink through a simple terrestrial food chain.

Chemical Toxicity Assessment

The goal of the toxicity assessment is to derive threshold exposure levels which are protective of the receptors (Table C.2.2-1). For aquatic receptors, most of the threshold values are ambient water quality criteria for chronic exposures. Others include the concentration for silver, which is an acute value (no chronic level was available).

For terrestrial receptors, toxicity thresholds are based on the lowest oral doses found in the literature that are no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) for chronic endpoints that could affect population viability or fitness (Table C.2.2-2). Usually the endpoints are adverse effects on reproduction or development. Uncertainty factors are applied to these doses to extrapolate from LOAELs to NOAELs and from subchronic or acute-to-chronic study durations. The derivation of these values is listed in Table C.2.2-3. Adjustments for differences in metabolic rates between experimental animals, usually rats or mice, and indicator species are made by applying a factor based on relative differences in estimated body surface area to mass ratios.

C.2.2.3 Calculational Design

Chemical Contaminants

For terrestrial receptors, the exposure calculation is a ratio of total contaminant intake to body mass, on a daily basis. This dose is divided by the toxicity threshold value to obtain a hazard quotient. Modeled surface water concentrations in Fourmile Branch and Upper Three Runs were divided by aquatic threshold levels to obtain a hazard quotient.

Radioactive Contaminants

Animal ingestion dose conversion factors (DCFs) for both terrestrial animals (shrew and mink) were estimated, for purposes of these calculations, by assuming that the animals possess similar metabolic processes as humans with regard to retention and excretion of radioisotopes; the chemistry of radioisotopes in the animals' bodies is assumed to be similar to that of humans. This assumption is appropriate because much of the data used to determine the chemistry of radioisotopes in the humans' bodies was derived from studies of small mammals. Equations from International Commission on Radiological Protection (ICRP) Publication 2 (ICRP 1959) were used to predict the uptake rate and body burden of radioactive material over the life span of the animals. All isotopes were assumed to be uniformly distributed throughout the body of the animal. Dose conversion factors for the aquatic animal, sunfish, were calculated by assuming a steady-state concentration of radioactive material within the tissues of the animal and a uniform concentration of radioactive material in the water surrounding the sunfish.

The quantity of radioactivity ingested by the organisms of interest was estimated by assuming that the organisms live their entire lives in the contaminated region (the seepline area for the terrestrial organisms and Fourmile Branch and Upper Three Runs near the seepline for the sunfish). The shrews are assumed to drink seepline water at the maximum calculated concentrations of radioactivity and to eat food that lives in the soil/sediments near the seepline. The concentrations of radioactivity in these media were derived from the calculated seepline and Fourmile Branch or Upper Three Runs concentrations. The mink is assumed to drink Fourmile Branch or Upper Three Runs water and eat only shrews that live near the seepline.

The estimated amount of radioactivity that the terrestrial organisms would ingest, through all postulated pathways, was then multiplied by the

Table C.2.2-1. Threshold toxicity values.

Contaminant	Aquatic receptors (milligrams per liter)	Terrestrial receptors (milligrams per kilograms per day)	
		Shrew	Mink
Aluminum	0.087	27.7	6.4
Barium	0.0059	1.78	0.41
Chromium	0.011	11.6	2.7
Copper	0.0014[a]	52.2	12
Fluoride	NA[b]	8.3	2.5
Iron	1.0	NA	NA
Lead	0.00013[a]	0.012	0.003
Manganese	NA	52.9	12.1
Mercury	0.000012	0.082	0.019
Nickel	0.019[a]	29.7	6.8
Nitrate (as N)	NA	(c)	–
Silver	0.000055[a]	0.33	0.077
Uranium	0.00187	4.48	1.01
Zinc[a]	0.0127	14.0	3.17

a. Based on a hardness of 8.2 mg $CaCO_3$/L.
b. Screening for MCL (10 mg/L) in seep water considered protective for nitrate.
NA: Not applicable (normally not a toxin for this type of receptor).

DCFs to calculate an annual radiation dose to the organism. For the sunfish, the concentration of radioactivity in the surface water was multiplied by the submersion and uptake dose conversion factors to calculate an annual radiation dose. These radiation doses are compared to the limit of 1,000 millirad per day (365,000 millirad per year).

C.3 Assumptions and Inputs

C.3.1 SOURCE TERM

C.3.1.1 Radionuclides

Radioactive material source terms for the tank farms and ancillary piping residuum used for the modeling are listed in Table C.3.1-1. These source terms relate to quantities remaining after bulk waste removal and spray washing. The ancillary piping and evaporator residual was conservatively estimated to be equal to 20 percent of the tank inventories.

The No Action Alternative analyzed in this EIS assumes that only bulk waste removal is performed. Based on experience in removing waste from Tanks 16, 17, and 20, DOE has assumed that the amount of radionuclides remaining after only bulk waste removal would be five times higher than that reported in Table C.3.1-1. Also, the Clean and Fill with Saltstone Option would introduce additional radioactive material into the HLW tanks. DOE used inventory estimates from the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994) for saltstone content to account for this additional radioactivity.

C.3.1.2 Chemicals

Chemical material source terms used in this modeling are listed in Table C.3.1-2. As with the radioactive source term, the ancillary piping and evaporator residual was conservatively estimated to be equal to 20 percent of the tank inventories. In addition, the lead in the tank top risers (500 pounds per riser, 6 risers per tank) was modeled.

Table C.2.2-2. Toxicological basis of NOAELs for indicator species.

Analyte	Surrogate species	LOAEL (milligrams per kilograms per day)	Duration	Effect	NOAEL (milligrams per kilograms per day)	Reference	Notes
Inorganics							
Aluminum	Mouse	–	13 mo	Reproductive system	19	Ondreicka et al. (1966) in ATSDR (1992)	
Barium	Rat	5.4	16 mo	Systemic	0.54	Perry et al. (1983) in Opresko et al. (1995)	
Chromium VI	Rat	–	1 y	Systemic	3.5	Mackenzie et al. (1958) in ATSDR (1993)	
Copper	Mink	15	50 w	Reproductive	12	Aulerich et al. (1982) in Opresko et al. (1995)	
Fluoride	Rat	5	60 d	Reproductive	–	Araibi et al. (1989) in ATSDR (1993)	
	Mink	5	382 d	Systemic	–	Aulerich et al. (1987) in ATSDR (1993)	Systemic LOAEL < reproductive
Iron							Data inadequate; essential nutrient
Lead	Rat	0.28	30 d	Reproductive	0.014	Hilderbrand et al. (1973)	
Manganese	Rat	–	100-224 d	Reproductive	16	Laskey et al. (1982)	
Mercury	Mink	0.25	3 mo	Death; devel.	0.15	Wobeser et al. (1976) in Opresko et al. (1995)	
Nickel	Rat	18	3 gens	Reproductive	–	Ambrose et al. (1976)	Based on first-generation effects
Nitrate (as N)							MCL of 10 mg/L at seepline is protective
Silver	Mouse	23	125 d	Behavioral	–	Rungby & Danscher (1984)	
Uranium	Mouse	–	~102 d	Reproductive	3.07	Paternain et al. (1989) in Opresko et al. (1995)	
Zinc	Mouse	96	9-12 mo	Systemic	–	Aughey et al. (1977)	Small data base

Table C.2.2-3. Derivation of NOAELs for indicator species.

Contaminant of concern	Surrogate species	NOAEL or LOAEL in surrogate species (milligrams per kilograms per day)	UF[a]	Body surface area conversion factor	Indicator species	Indicator species NOAEL (milligrams per kilograms per day)	Notes
Inorganics							
Aluminum	Mouse	19	1	0.33	Mink	6.4	
	Mouse	19	1	1.46	Shrew	27.7	
Barium	Rat	0.54	1	0.76	Mink	0.41	
	Rat	0.54	1	3.30	Shrew	1.78	
Chromium VI	Rat	3.5	1	0.76	Mink	2.7	
	Rat	3.5	1	3.30	Shrew	11.6	
Copper	Mink	12	1	1.00	Mink	12.0	
	Mink	12	1	4.35	Shrew	52.2	
Fluoride	Mink	5	2	1.00	Mink	2.5	UF from less serious LOAEL
	Rat	5	2	3.30	Shrew	8.3	UF from less serious LOAEL
Iron							Data inadequate; essential nutrient
Lead	Rat	0.014	4	0.76	Mink	0.003	UF for study duration
	Rat	0.014	4	3.30	Shrew	0.012	UF for study duration
Manganese	Rat	16	1	0.76	Mink	12.1	
	Rat	16	1	3.30	Shrew	52.9	
Mercury	Mink	0.15	8	1.00	Mink	0.019	UF for study duration
	Mink	0.15	8	4.35	Shrew	0.082	UF for study duration
Nickel	Rat	18	2	0.76	Mink	6.8	UF from LOAEL: NOAEL in 2nd and 3rd generations
	Rat	18	2	3.30	Shrew	29.7	UF from LOAEL: NOAEL in 2nd and 3rd generations
Nitrate (as N)							MCL of 10 mg/L at seepline is protective
Silver	Mouse	23	100	0.33	Mink	0.077	UF for LOAEL and nature of study
	Mouse	23	100	1.46	Shrew	0.33	UF for LOAEL and nature of study
Uranium	Mouse	3.07	1	0.33	Mink	1.01	
	Mouse	3.07	1	1.46	Shrew	4.48	
Zinc	Mouse	96	10	0.33	Mink	3.17	UF: LOAEL to NOAEL
	Mouse	96	10	1.46	Shrew	14.0	UF: LOAEL to NOAEL

a. UF = Uncertainty factor.

Table C.3.1-1. Tank farm residual after bulk waste removal and spray washing (curies).[a]

Radionuclide	F-Area Tank Farm	H-Area Tank Farm
Se-79	1.2	1.7
Sr-90	6.2×10^4	9.5×10^4
Tc-99	20	29
Sn-126	2.2	2.2
Cs-135	0.013	0.02
Cs-137	4,300	5,600
Eu-154	350	1,200
Np-237	0.06	0.12
Pu-238	0[b]	1,680
Pu-239	130	22

a. Derived from Newman (1999) and Hester (1999). Ancillary equipment is assumed to constitute an additional 20 percent of contaminants.
b. Only trace amounts of Pu-238 are present in F-Area Tank Farm.

Table C.3.1-2. Tank farm residual after bulk waste removal and spray washing (kilograms).[a]

Constituent	F-Area Tank Farm	H-Area Tank Farm
Iron	2,300	1,000
Manganese	240	140
Nickel	55	26
Aluminum	820	250
Chromium VI	20[b]	6.7[b]
Mercury	6.3	89
Silver	27	0.9
Copper	14	1.7
Uranium	450	4.3
Nitrate	150	62
Zinc	27	8.6
Fluoride	14.2	2
Lead[c]	24	12

a. Derived from Newman (1999) and Hester (1999). Ancillary equipment is assumed to constitute an additional 20 percent of contaminants.
b. All chromium was modeled as Chromium VI.
c. Additional lead from risers are not included in this value.

The No Action Alternative analyzed in this EIS assumes that only bulk waste removal is performed. Consequently, DOE has assumed that the amount of chemical constituents remaining after only bulk waste removal would be five times higher than that reported in Table C.3.1-2. Also, the Clean and Fill with Saltstone Option would introduce additional material into the HLW tanks. DOE used inventory estimates from the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994) for saltstone content to account for this additional material.

C.3.2 CALCULATIONAL PARAMETERS

The modeling described in this appendix was designed to be specific to the tank farms. This was accomplished by utilizing site-specific data where available. For the hundreds of MEPAS input parameters, default values were used only for the distribution coefficients for chemical constituents.

For the four closure scenarios modeled, the majority of the MEPAS input parameters remain constant. Examples of constant parameters include contaminants of concern (radionuclide and chemical) and their respective initial source terms, spatial dimensions and elevation of the contaminated zone, strata thicknesses, chemical and physical properties (hydraulic conductivity and gradient, distribution coefficients) of SRS soil, exposure pathways, dose conversion factors and downgradient distances to compliance points.

Input parameters that changed for the various closure scenarios and were shown by sensitivity analyses to markedly affect the breakthrough times and peak concentrations include constituent and strata specific distribution factors, rainwater infiltration factors, and concrete basemat hydraulic conductivities. These and other important parameters are discussed in the following sections.

C.3.2.1 Distribution Coefficients

The distribution coefficient, K_d, is defined for two-phased systems as the ratio of the constituent concentration in the solid (soil) to the concentration of the constituent in the interstitial liquid (leachate). For a given element, this parameter may vary over several orders of magnitude depending on such conditions as soil pH and clay content. Experiments have been performed (Bradbury and Sarott 1995) that have demonstrated that strong oxidizing or reducing environments tend to affect the K_d values markedly. Because this parameter is highly sensitive in relation to breakthrough and peak times (but not necessarily peak concentration), careful selection is imperative to achieve reasonable results. For this reason, several literature sources were used to assure the most current and appropriate K_d values were selected for the example calculation.

For modeling purposes, four distinct strata were used for groundwater contaminant transport for all four closure scenarios (except for ancillary equipment and piping, which used only three, see below). These four strata are identified as (1) contaminated zone (CZ), (2) first partially saturated zone or concrete basemat, (3) second partially saturated zone or vadose zone, and (4) saturated zone. Distribution coefficients for each of these zones differ depending on the closure scenario-specific chemical and physical characteristics.

The models for ancillary equipment/piping and tanks were similar, except the piping model was assumed to have only one partially saturated zone. For this model, the concrete basemat was conservatively assumed to have no effect on reducing the transport rate of contaminants to the saturated zone. The thickness of the vadose zone was increased to 45 feet to reflect the higher elevation of the piping in relation to the saturated zone.

Distribution coefficients for each strata under various conditions are listed in Table C.3.2-1. A detailed discussion of the selection process is provided for each closure scenario.

Scenario 1 – No Action Alternative

For this scenario, K_d values for the CZ were assumed to behave similarly to that of clay found in the vicinity of the SRS tank farms. For the radionuclides and chemicals of interest, these K_d values are listed in Column V of Table C.3.2-1.

For the first partially saturated zone (concrete basemat), K_d values were selected for concrete in a non-reducing environment and are listed in Column II of Table C.3.2-1. K_d values for the second partially saturated zone (vadose zone) and the saturated zone are the same and were selected to reflect characteristics of SRS soil. These values are listed in Column I of Table C.3.2-1. For the ancillary equipment and piping, K_d values for the CZ are presented in Column V, partially saturated and saturated zones are listed in Column I of Table C.3.2-1.

Scenario 2 – Clean and Fill With Grout Option

This scenario assumes that the tanks and ancillary piping would be filled with a strongly reducing grout. Therefore, for the tank model, K_d values for the CZ, first and second partially saturated zones, and the saturated zone are listed in Columns IV, III, I, and I of Table C.3.2-1, respectively.

Similarly, for the piping model, K_d values for the CZ, partially saturated zone, and the saturated zone are listed in Columns IV, I, and I of Table C.3.2-1, respectively.

Scenario 3 – Clean and Fill With Sand Option

This scenario uses the same K_d values as for scenario 1.

Scenario 4 – Clean and Fill With Saltstone Option

This scenario assumes that the tanks and ancillary piping would be filled with saltstone with composition like that in the Z-Area Saltstone Manufacturing and Disposal Facility. There-

Table C.3.2-1. Radionuclide and chemical groundwater distribution coefficients, cubic centimeters per gram.

	I		II		III		IV		V		VI	
	SRS Soil	Ref.	Non-Reducing Concrete[l]	Ref.	Reducing[j] Concrete	Ref.	Reducing[j] CZ	Ref.	Non-Reducing CZ	Ref.	Saltstone	Ref.
Se-79[a]	5	b	0	b	0.1	i	0.1	i	740[m]	b	7	s
Sr-90	10	b	10	b	1	i	1	i	110[m]	b	10	s
Tc-99	0.36	b	700	b	1,000	i	1,000	i	1[m]	b	700	s
Sn-126	130	b	200	b	1,000	i	1,000	i	670[m]	b	t	
Cs-135, 137	100	b	20	b	2	i	2	i	1,900[m]	b	t	s
Eu-154[p]	800[d]	c	1,300	e	5,000[q]	i	5,000[q]	i	1,300	e	t	
Np-237	10	b	5,000	b	5,000	b	5,000	i	55	b	t	
Pu-238, 239	100	b	5,000	b	NA	f	NA	f	5,100[m]	b	t	
Iron	15	g	15	n	1.5	o	1.5	o	15	n	t	
Manganese	16.5	g	36.9	n	100	i	100	i	36.9	n	t	
Nickel	300	b	650	n	100	i	100	i	650	n	t	
Aluminum	35,300	g	35,300	n	353	o	353	o	35,300	n	t	
Chromium VI[h]	16.8	g	360	n	7.9	o	7.9	o	360	n	t	
Mercury	322	g	5,280	n	5,280	o	5,280	o	5,280	n	t	
Silver	0.4	g	40	n	1	i	1	i	40	n	t	
Copper	41.9	g	336	n	33.6	o	33.6	o	336	n	t	
Uranium	50	b	1,000	n	NA	u	NA	u	1,600	b	t	
Nitrate	0	g	0	n	0	o	0	o	0	n	0	s
Zinc	12.7	g	50	n	5	o	5	o	50	n	t	
Fluoride	0	g	0	n	0	o	0	o	0	n	t	
Lead	234	g	NA	r	NA	r	NA	r	NA	r	NA	r

a. Values also used for chemical contaminants.
b. E-Area RPA (WSRC 1994a), Table 3.3-2, page 3-69.
c. Yu et al. (1993), Table 32.1, page 105.
d. Value used for loam from c.
e. Value used for clay from c.
f. Solubility limit of 4.4×10^{-13} mols/liter used, WSRC (1994a), page C-32.
g. MEPAS default for soil <10% clay and pH from 5-9.
h. For conservatism, all chromium modeled as VI valence.
i. Bradbury and Sarott (1995), Table 4, Region 1, page 42.
j. Reducing environment assumed for grout fill.
k. Non-reducing environments assumed for No Action and sand fill option.
l. Values used for basemat concrete for No Action and sand fill option.
m. Value used for clay from WSRC (1994a).
n. MEPAS default used for soil >30% clay and pH from 5-9.
o. MEPAS default used for soil >30% clay and pH >9.
p. Characteristics similar to Sm per Table 3, page 16 of Bradbury and Scott (1995).
q. Characteristics similar to Am per Table 3, page 16 of Bradbury and Scott (1995).
r Lead is outside of reducing environments for all cases. Therefore, value from Column I is used for all cases.
s Z-Area Saltstone Radiological Performance Assessment (WSRC 1992), page A-13.
t Values of K_d for these contaminants were based on non-reducing concrete.
u Solubility limit of 3.0×10^{-10} μ/liter used to determine K_d, E-Area (WSRC 1994a) p. D-34.

fore, for the tank model, K_d values for the CZ, first and second partially saturated zones, and the saturated zone are listed in Columns VI, III, I, and I of Table C.3.2-1, respectively.

C.3.2.2 MEPAS Groundwater Input Parameters

Table C.3.2-2 lists input parameters used for the partially saturated zones for the various closure scenarios, and Table C.3.2-3 lists input parameters for the saturated zone. The values used for the concrete basemat and vadose layer for the partially saturated zone were constant for all tank groups within both tank farms with the exception of the vadose zone thickness. Because there are significant differences in the bottom elevation between the various tank groups, the thickness of the vadose zone was modeled specifically for each tank group. Some tank groups in the H-Area were modeled without a vadose zone because the tanks are situated in the Water Table Aquifer. When horizontal flow was modeled in each of the aquifer layers all of the overlying layers were treated as part of the partially saturated zone (i.e., vertical transport only) for that simulation.

The values for the remaining partially saturated zone layers and for all of the saturated zone layers are constant for all tank groups within either the F- or H-Area that have groundwater flow to the same point of discharge (i.e., to Fourmile Branch or Upper Three Runs). The parameters do vary, however, among the different layers and along different groundwater flow paths. For this reason, Tables C.3.2-2 and C.3.2-3 contain three sets of input parameters: flow from the F-Area Tank Farm toward Fourmile Branch (all tank groups); flow from the H-Area Tank Farm toward Fourmile Branch (four tank groups); and flow from the H-Area Tank Farm toward Upper Three Runs (three tank groups). Because only one-dimensional vertical flow was considered for the Tan Clay and Green Clay layers in both the partially saturated and saturated conditions, the input parameters were the same for these layers for each of the groupings shown in the tables.

C.3.2.3 Hydraulic Conductivities

Because leach rate is ultimately limited by the lowest hydraulic conductivity of the strata and structures above and below the contaminated zone, this parameter is highly sensitive in its effect on breakthrough times and peak concentrations at the receptor locations. For modeling purposes, it was assumed that excess water has a place to run off (over the sides of the basemat) and that ponding above the contaminated zone does not occur.

C.3.2.4 Human Health Exposure Parameters and Assumed Values

Because the impact on a given receptor depends in large part on the physical characteristics and habits of the receptor, it is necessary to stipulate certain values to obtain meaningful results. Certain of these values are included as default values in MEPAS; however, others must be specified so the receptors are modeled appropriately for the scenario being described.

For this modeling effort, site-specific values were used as much as possible; that is, values that had been used in other modeling efforts for the SRS were incorporated when available and appropriate. Table C.3.2-4 lists the major parameters that were used in assigning characteristics to the receptors used in the calculations.

C.3.3 ECOLOGICAL RISK ASSESSMENT

The exposure factors used in calculating doses to the shrew and mink are listed in Table C.3.3-1. An important assumption of the exposure calculation is that no feeding or drinking takes place outside the influence of the seepage, even though the home ranges of the shrew and the mink typically are larger than the seep areas. EPA (1993) presents a range of literature-based home ranges for the short-tailed shrew that vary from 0.03 to 1.8 ha. Home ranges for the mink also vary widely in the literature from 7.8 to 770 ha (EPA 1993). The bioaccumulation factor for soil and soil invertebrates is 1 for all metals, as is the factor

Table C.3.2-2. Partially saturated zone MEPAS input parameters.

	Concrete basemat		Vadose Zone layer	Water Table layer	Tan clay layer	Barnwell-McBean layer	Green clay layer
	Intact	Failed					
F-Area Tank Farm, flow toward Fourmile Branch							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,200[c]	91[c]	1,800[c]	150[c]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field Capacity	15%[d]	9%[e]	12%[e]	35%[e]	33.4%[e]	35%[e]	32.5%[e]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	12	0.91	18	1.5
Vertical hydraulic conductivity (centimeters per second)	9.6×10^{-9}[d]	6.6×10^{-3}[e]	7.1×10^{-4}[h]	7.1×10^{-4}[h]	1.6×10^{-6}[h]	5.6×10^{-4}[h]	4.4×10^{-9}[h]
H-Area Tank Farm, flow toward Fourmile Branch							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,900[i]	300[i]	2,000[i]	300[i]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field capacity	15%[d]	9%[e]	12%[e]	35%[j]	33.4%[j]	35%[j]	32.5%[j]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	19	3.0	20	3.0
Vertical hydraulic conductivity (centimeters per second)	$9.\times10^{-9}$[d]	6.6×10^{-3}[e]	1.6×10^{-4}[i]	1.6×10^{-4}[i]	3.2×10^{-7}[i]	1.6×10^{-4}[i]	3.5×10^{-8}[i]
H-Area Tank Farm, flow toward Upper Three Runs							
Thickness (centimeters)	18[a]	18[a]	Varies[b]	1,900[i]	300[i]	1,800[i]	300[i]
Bulk density (grams per cubic centimeters)	2.21[d]	1.64[e]	1.59[d]	1.59[d]	1.36[e]	1.59[d]	1.39[e]
Total porosity	15%[d]	38%[e]	35%[f]	35%[f]	40%[f]	35%[f]	40%[f]
Field capacity	15%[d]	9%[e]	12%[e]	35%[j]	33.4%[j]	35%[j]	32.5%[j]
Longitudinal dispersion (centimeters)[g]	0.18	0.18	Varies	19	3.0	18	3.0
Vertical hydraulic conductivity (centimeters per second)	9.6×10^{-9}[d]	6.6×10^{-3}[e]	1.3×10^{-4}[i]	1.3×10^{-4}[i]	3.0×10^{-7}[i]	1.3×10^{-4}[i]	3.5×10^{-8}[i]

a. Type IV tank shown; Type I = 3.54, Type III = 2.74.
b. Distance between tank bottom elevation (see a. above) and historic groundwater elevation.
c. GeoTrans (1987).
d. WSRC (1994a). Radiological Performance Assessment for the E-Area Vaults Disposal Facility (U), WSRC-RP-94-218.
e. Buck et al. (1995), MEPAS Table 2.1.
f. Aadland (1995).
g. Buck et al. (1995); calculated using MEPAS formula for longitudinal dispersivity, based on total travel distance.
h. GeoTrans (1993); where Kz = 0.1 Kx for aquifer layers.
i. WSRC (1994b). WSRC E-7 Procedure Document Q-CLC-H-00005, Revision 0.
j. Buck et al. (1995), MEPAS Table 2.1; assumes aquifer layers are saturated and clay layers nearly saturated.

Table C.3.2-3. MEPAS input parameters for the saturated zone.

	Water Table Aquifer	Barnwell-McBean Aquifer	Congaree Aquifer
F-Area Tank Farm, flow toward Fourmile Branch			
Thickness (centimeters) [a]	1,200	1,800	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)	1/20 th of the flow distance		
Hydraulic conductivity (centimeters per second)	7.1×10^{-3}	5.6×10^{-3}	0.013
Hydraulic gradient [a]	0.006	0.004	0.006
H-Area Tank Farm, flow toward Fourmile Branch			
Thickness (centimeters) [a]	1,900	2,000	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)	1/20 th of the flow distance		
Hydraulic conductivity (centimeters per second)	1.6×10^{-3}	1.6×10^{-3}	1.4×10^{-3}
Hydraulic gradient [a]	0.014	0.011	0.004
H-Area Tank Farm, flow toward Upper Three Runs			
Thickness (centimeters) [a]	1,900	1,800	3,000
Bulk density (grams per cubic centimeter) [b]	1.59	1.59	1.64
Total porosity [c]	35%	35%	34%
Effective porosity [d]	20%	20%	25%
Longitudinal dispersion (centimeters)	1/20 th of the flow distance		
Hydraulic conductivity (centimeters per second)	1.3×10^{-3}	1.3×10^{-3}	1.4×10^{-3}
Hydraulic gradient [a]	0.015	0.009	0.003

a. GeoTrans (1987 and 1993).
b. Buck et al. (1995), MEPAS Table 2.1.
c. Aadland (1995)
d. EPA (1989) and WSRC (1994b) WSRC E-7 Procedure Document Q-CLC-H-00005, Revision 0.

Table C.3.2-4. Assumed human health exposure parameters.

Parameter	Applicable receptor	Value	Comments
Body mass	Adult	70 kg	This value is taken directly from ICRP (1975). In radiological dose calculations, this is the standard value in the industry.
	Child	30 kg	This value was obtained from ICRP (1975). Both a male and female child of age 9 have an average mass of 30 kg.
Exposure period	All	1 year	This value is necessary so that MEPAS will calculate an annual radiation dose. Lifetime doses can be calculated by multiplying the annual dose by the assumed life of the individual.
Leafy vegetable ingestion rate	Adult	21 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	8.53 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Other vegetables ingestion rate	Adult	163 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	163 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Meat ingestion rate	Adult	43 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	16 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Milk ingestion rate	Adult	120 L/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	128 L/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Water ingestion rate	All	2 L/day	This value is standard in MEPAS and is consistent with maximum drinking water rates in NRC (1977).
Finfish ingestion rate	Adult	9 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	2.96 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Time spent at shoreline	Adult resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Seepline worker	2080 hrs/yr	This value is based on the assumption of continuous exposure of the seepline worker during each working day.
	Intruder	1040 hrs/yr	This value is based on the conservative assumption of half-time exposure during each working day.
Time spent swimming	Adult resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).

Table C.3.3-1. Parameters for foodchain model ecological receptors.

Receptor	Feeding group	Parameter	Value	Notes; Reference
Southern short-tailed shrew (*Blarina carolinensis*)	Insectivore	Body weight	9.7 grams	Mean of 423 adults collected on SRS; Cothran et al. (1991)
		Water ingestion	2.2 grams/day	0.223 g/g/day X 9.7g; EPA (1993)
		Food ingestion	5.2 grams/day	0.541 g/g/day X 9.7g; Richardson (1973) cited in Cothran et al. (1991)
		Soil ingestion	10% of diet	Between vole (2.4%) and armadillo (17%); Beyer et al. (1994)
		Home range	0.96 ha	Mean value on SRS; Faust et al. (1971) cited in Cothran et al. (1991)
Mink (*Mustela vison*)	Carnivore	Body weight	800 grams	"Body weight averages 0.6 to 1.0 kg"; Cothran et al. (1991)
		Water ingestion	22.4 grams/day	0.028 g/g/day X 800g; EPA (1993)
		Food ingestion	110 grams/day	Mean of male and female estimates; EPA (1993)
		Soil ingestion	5% of diet	Between red fox (2.8%) and raccoon (9.4%); Beyer et al. (1994)
		Home range	variable	7.8-20.4 ha (Montana); 259-380 ha (North Dakota; EPA 1993) Females: 6-15 ha, males: 18-24 ha (Kansas; Bee et al. 1981)

for soil invertebrates and shrews. K_d values for estimating-contaminant concentrations in soil due to the influence of seepage are from Baes et al. (1984). Bioconcentration factors for estimating contaminant concentrations in aquatic prey items are from the EPA Region IV water quality criteria table. For contaminants with no listing in the Region IV table for a bioconcentration factor, a factor of 1 is used. The mink was modeled as obtaining half of its diet from shrews at the seep area and the other half from aquatic prey downstream of the seepline.

C.4 Results

C.4.1 HUMAN HEALTH ASSESSMENT

For each scenario, the maximum concentration or dose was identified for each receptor and for each contaminant along with the time period during which the maximum occurred within a 10,000-year performance period. In addition, for radiological constituents, the total dose was calculated to allow evaluation of the impact of all radiological constituents. Because the maximum doses for each radionuclide do not necessarily occur simultaneously, it is not appropriate to add the maximum doses for each radionuclide. Rather, it is more appropriate to assess the doses as a function of time, sum the doses from all radionuclides for each time increment, and then select the maximum total dose from this compilation. Therefore, the total dose reported in the following tables for radiological constituents may not necessarily correlate to the maximum dose or time period for any individual radionuclide because of the contributions from all radionuclides at a given time. In addition to total dose, the gross alpha concentration was calculated to enable comparison among the alternatives

Non-radiological constituent concentrations in the various water bodies were calculated to allow direct comparison among the alternatives. For each constituent, the maximum concentration was calculated along with the time period during which the maximum concentration occurred. None of the non-radiological constituents are known ingestion carcinogens; therefore cancer risk was not calculated for these contaminants.

Tables C.4.1-1 through C.4.1-26 list impact estimates for the four scenarios described in Section C.2. For those tables describing radiological impacts, doses are presented for postulated individuals (i.e., Adult Resident, Child Resident, Seepline Worker, and Intruder) and at the seepline. Additional calculations were performed at groundwater locations close to the tank farm and are reported as drinking water does to allow comparison to the appropriate maximum contaminant level. DOE estimates that the total dose at the locations would not exceed the drinking water doses by more than 20%. For nonradiological constituents, the maximum concentration of each contaminant is reported for each water location.

For the case of No Action, the reported doses are those arising strictly from the water pathways; impacts from air pathways, in principle, would increase the total dose to a given receptor. It is expected, however, that atmospheric release of the tanks' contents would not be appreciable because:

- The amount of rainfall in the area would tend to keep the tank contents damp through the time of failure. After failure, a substantial amount of debris on top of the contaminated material would prevent release even if the contents were to dry during a period of drought.
- The considerable depth of the tanks below grade would tend to discourage resuspension of any of the tanks' contents.

As discussed in Chapters 3 and 4 of this EIS, DOE performed groundwater modeling calculations for the three uppermost aquifers underneath the tank farms: the Water Table Aquifer, the Barnwell-McBean Aquifer, and the Congaree Aquifer. Tables C.4.1-1 through C.4.1-26 present results for each tank farm and by aquifer. Although more than one aquifer may outcrop to the same point on the seepline, the

Table C.4.1-1. Radiological results for F-Area Tank Farm in the Water Table Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	Maximum value	1.9×10^{-2}	2.9×10^{-2}	1.7×10^{-1}	3.3
	Time of maximum (yrs)	385	175	7035	1155
Child resident (total dose)	Maximum value	1.7×10^{-2}	2.7×10^{-2}	1.6×10^{-1}	3.1
	Time of maximum (yrs)	385	175	7035	1155
Seepline worker (total dose)	Maximum value	(a)	(a)	(a)	9.6×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	105
Intruder (total dose)	Maximum value	(a)	(a)	(a)	4.8×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	105
1-meter well (drinking water dose)	Maximum value	4.3×10^{1}	1.3×10^{2}	3.0×10^{2}	3.6×10^{5}
	Time of maximum (yrs)	385	35	5705	245
100-meter well (drinking water dose)	Maximum value	1.6×10^{1}	5.1×10^{1}	1.4×10^{2}	6.0×10^{3}
	Time of maximum (yrs)	315	35	7035	315
Seepline (drinking water dose)	Maximum value	1.0	1.4	9.5	1.8×10^{2}
	Time of maximum (yrs)	385	175	7455	1155
Surface water (drinking water dose)	Maximum value	6.9×10^{-3}	1.1×10^{-2}	6.3×10^{-2}	1.2
	Time of maximum (yrs)	385	175	7035	1155

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-2. Radiological results for F-Area Tank Farm in the Barnwell-McBean Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean with water, fill with saltstone	No Action Alternative
Adult resident (total dose)	Maximum value	2.7×10^{-2}	5.1×10^{-2}	3.7×10^{-1}	6.2
	Time of maximum (yrs)	875	245	7525	1225
Child resident (total dose)	Maximum value	2.4×10^{-2}	4.7×10^{-2}	3.4×10^{-1}	5.7
	Time of maximum (yrs)	875	245	7525	1225
Seepline worker (total dose)	Maximum value	(a)	(a)	1.0×10^{-3}	1.8×10^{-2}
	Time of maximum (yrs)	(a)	(a)	7525	1225
Intruder (total dose)	Maximum value	(a)	(a)	(a)	9.0×10^{-3}
	Time of maximum (yrs)	(a)	(a)	(a)	1225
1-meter well (drinking water dose)	Maximum value	1.3×10^{2}	4.2×10^{2}	7.9×10^{2}	3.5×10^{4}
	Time of maximum (yrs)	665	105	6965	35
100-meter well (drinking water dose)	Maximum value	5.1×10^{1}	1.9×10^{2}	5.1×10^{2}	1.4×10^{4}
	Time of maximum (yrs)	665	105	6685	35
Seepline (drinking water dose)	Maximum value	1.9	3.5	2.5×10^{1}	4.3×10^{2}
	Time of maximum (yrs)	875	245	6475	1225
Surface water (drinking water dose)	Maximum value	9.8×10^{-3}	1.9×10^{-2}	1.3×10^{-1}	2.3
	Time of maximum (yrs)	875	245	7525	1225

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-3. Radiological results dose for F-Area Tank Farm in the Congaree Aquifer (millirem per year).

		Maximum concentration			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	Maximum value	(a)	(a)	1.4×10^{-2}	1.1×10^{-1}
	Time of maximum (yrs)	(a)	(a)	8855	1365
Child resident (total dose)	Maximum value	(a)	(a)	1.3×10^{-2}	1.0×10^{-1}
	Time of maximum (yrs)	(a)	(a)	8855	1365
Seepline worker (total dose)	Maximum value	(a)	(a)	(a)	(a)
	Time of maximum (yrs)	(a)	(a)	(a)	(a)
Intruder (total dose)	Maximum value	(a)	(a)	(a)	(a)
	Time of maximum (yrs)	(a)	(a)	(a)	(a)
1-meter well (drinking water dose)	Maximum value	9.1×10^{-1}	1.2	3.0×10^{1}	1.7×10^{2}
	Time of maximum (yrs)	4935	2905	6615	1155
100-meter well (drinking water dose)	Maximum value	2.2×10^{-1}	2.5×10^{-1}	6.4	4.2×10^{1}
	Time of maximum (yrs)	1225	3115	8435	1295
Seepline (drinking water dose)	Maximum value	6.5×10^{-3}	8.7×10^{-3}	1.9×10^{-1}	1.6
	Time of maximum (yrs)	5495	3325	7805	1295
Surface water (drinking water dose)	Maximum value	(a)	(a)	5.0×10^{-3}	4.2×10^{-2}
	Time of maximum (yrs)	(a)	(a)	8855	1365

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-4. Radiological results dose for H-Area Tank Farm in the Water Table Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.4×10^{-3}	1.2×10^{-2}	2.6×10^{-2}	1.2
		Time of maximum (years)	455	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.0×10^{-2}	1.6×10^{-2}	1.9×10^{-1}	2.4
		Time of maximum (years)	455	175	6125	1015
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.3×10^{-3}	1.1×10^{-2}	2.4×10^{-2}	1.1
		Time of maximum (years)	455	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	9.3×10^{-3}	1.5×10^{-2}	1.8×10^{-1}	2.2
		Time of maximum (years)	455	175	6125	1015
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	3.5×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	105
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	7.0×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1015
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	1.7×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	105
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	3.5×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1015
1-meter well (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	1.0×10^{5}	1.3×10^{5}	1.0×10^{5}	9.3×10^{6}
		Time of maximum (years)	175	175	175	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{2}	2.5×10^{2}	5.5×10^{2}	8.3×10^{5}
		Time of maximum (years)	315	385	4725	245
100-meter well (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	3.0×10^{2}	9.2×10^{2}	8.7×10^{2}	9.0×10^{4}
		Time of maximum (years)	245	35	5915	35
	South of Groundwater Divide	Maximum value (mrem/yr)	2.9×10^{1}	6.1×10^{1}	2.9×10^{2}	6.1×10^{3}
		Time of maximum (years)	315	35	5635	35
Seepline (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	2.5	2.5×10^{1}	4.6×10^{1}	2.5×10^{3}
		Time of maximum (years)	455	105	5635	105
	South of Groundwater Divide	Maximum value (mrem/yr)	9.5×10^{-1}	1.4	1.6×10^{1}	2.0×10^{2}
		Time of maximum (years)	455	175	5425	1015
Surface water (drinking water dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	4.3×10^{-3}	9.6×10^{-3}	4.5×10^{-1}
		Time of maximum (years)	(a)	105	6125	105
	South of Groundwater Divide	Maximum value (mrem/yr)	3.7×10^{-3}	6.0×10^{-3}	7.1×10^{-2}	9.0×10^{-1}
		Time of maximum (years)	455	175	6125	1015

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-5. Radiological results for H-Area Tank Farm in the Barnwell-McBean Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	2.1×10^{-3}	1.1×10^{-2}	2.4×10^{-1}
		Time of maximum (years)	(a)	455	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.4×10^{-3}	7.8×10^{-3}	1.2×10^{-1}	1.4
		Time of maximum (years)	4515	385	6335	1155
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	2.0×10^{-3}	1.0×10^{-2}	2.2×10^{-1}
		Time of maximum (years)	(a)	455	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.1×10^{-3}	7.2×10^{-3}	1.1×10^{-1}	1.3
		Time of maximum (years)	4515	385	6335	1155
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	4.2×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1155
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	2.1×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1155
1-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	9.7×10^{1}	1.9×10^{3}	1.7×10^{3}	1.7×10^{5}
		Time of maximum (years)	1155	105	4165	105
	South of Groundwater Divide	Maximum value (mrem/yr)	5.3×10^{1}	1.4×10^{2}	4.3×10^{2}	2.5×10^{4}
		Time of maximum (years)	4445	245	5005	945
100-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	3.2×10^{1}	4.6×10^{2}	6.4×10^{2}	5.8×10^{4}
		Time of maximum (years)	1155	105	5845	105
	South of Groundwater Divide	Maximum value (mrem/yr)	1.6×10^{1}	5.1×10^{1}	2.7×10^{2}	4.9×10^{3}
		Time of maximum (years)	1155	245	6405	105
Seepline (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	7.5×10^{-1}	4.5	2.3×10^{1}	4.9×10^{2}
		Time of maximum (years)	4515	385	6125	385
	South of Groundwater Divide	Maximum value (mrem/yr)	3.5×10^{-1}	8.4×10^{-1}	1.3×10^{1}	1.6×10^{2}
		Time of maximum (years)	4445	385	6895	1155
Surface water (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	4.2×10^{-3}	8.8×10^{-2}
		Time of maximum (years)	(a)	(a)	6195	385
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{-3}	2.9×10^{-3}	4.6×10^{-2}	5.3×10^{-1}
		Time of maximum (years)	4515	385	6265	1155

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-6. Total radiation dose for H-Area Tank Farm in the Congaree Aquifer (millirem per year).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	1.1×10^{-2}	8.6×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.6×10^{-3}	2.0×10^{-3}	6.6×10^{-2}	4.3×10^{-1}
		Time of maximum (years)	5285	3395	6755	1645
Child resident (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	1.0×10^{-2}	7.9×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.4×10^{-3}	1.8×10^{-3}	6.1×10^{-2}	4.0×10^{-1}
		Time of maximum (years)	5285	3395	6755	1645
Seepline worker (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	1.2×10^{-3}
		Time of maximum (years)	(a)	(a)	(a)	1645
Intruder (total dose)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	(a)	(a)
		Time of maximum (years)	(a)	(a)	(a)	(a)
1-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	3.2×10^{1}	9.8×10^{1}	7.7×10^{2}	9.7×10^{3}
		Time of maximum (years)	5005	595	5145	595
	South of Groundwater Divide	Maximum value (mrem/yr)	1.2×10^{1}	1.6×10^{1}	2.0×10^{2}	3.2×10^{3}
		Time of maximum (years)	5215	3115	5355	1505
100-meter well (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	5.6	2.5×10^{1}	2.5×10^{2}	2.5×10^{3}
		Time of maximum (years)	4935	665	6475	595
	South of Groundwater Divide	Maximum value (mrem/yr)	1.7	2.3	6.4×10^{1}	4.6×10^{2}
		Time of maximum (years)	4935	3185	7105	1435
Seepline (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	9.8×10^{-2}	2.7×10^{-1}	3.2	2.5×10^{1}
		Time of maximum (years)	5005	805	6755	805
	South of Groundwater Divide	Maximum value (mrem/yr)	1.9×10^{-2}	2.3×10^{-2}	7.7×10^{-1}	4.8
		Time of maximum (years)	5285	3325	7665	1645
Surface water (drinking water)	North of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	4.0×10^{-3}	3.2×10^{-2}
		Time of maximum (years)	(a)	(a)	6825	805
	South of Groundwater Divide	Maximum value (mrem/yr)	(a)	(a)	2.4×10^{-2}	1.6×10^{-1}
		Time of maximum (years)	(a)	(a)	6755	1645

a. Radiation dose for this alternative is less than 1×10^{-3} millirem.

Table C.4.1-7. Alpha concentration for F-Area Tank Farm in the Water Table Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	5.2	5.3	5.2	7.6×10^{2}
	Time of maximum (yrs)	1855	945	1855	455
100-meter well	Maximum value	1.9	1.9	1.9	2.4×10^{2}
	Time of maximum (yrs)	1995	1085	1995	595
Seepline	Maximum value	2.6×10^{-2}	2.6×10^{-2}	2.6×10^{-2}	5.6
	Time of maximum (yrs)	3885	2905	3885	9555
Surface water	Maximum value	1.8×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	4.1×10^{-2}
	Time of maximum (yrs)	3885	2975	3885	9555

Table C.4.1-8. Alpha concentration for F-Area Tank Farm in the Barnwell-McBean Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	1.3×10^{1}	1.3×10^{1}	1.3×10^{1}	1.7×10^{3}
	Time of maximum (yrs)	2695	1785	2695	875
100-meter well	Maximum value	4.7	4.6	4.7	5.3×10^{2}
	Time of maximum (yrs)	2905	1995	2905	1085
Seepline	Maximum value	3.9×10^{-2}	3.9×10^{-2}	3.9×10^{-2}	9.2
	Time of maximum (yrs)	6405	5495	6405	9975
Surface water	Maximum value	2.2×10^{-4}	2.2×10^{-4}	2.2×10^{-4}	4.8×10^{-2}
	Time of maximum (yrs)	6265	5355	6265	9975

Table C.4.1-9. Alpha concentration for F-Area Tank Farm in the Congaree Aquifer (picocuries per liter).

		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action
1-meter well	Maximum value	3.1×10^{-3}	3.1×10^{-3}	3.1×10^{-3}	1.7
	Time of maximum (yrs)	8295	7315	8295	9975
100-meter well	Maximum value	1.3×10^{-3}	1.2×10^{-3}	1.3×10^{-3}	3.6×10^{-1}
	Time of maximum (yrs)	8225	8225	8225	9975
Seepline	Maximum value	3.7×10^{-5}	3.7×10^{-5}	3.7×10^{-5}	9.4×10^{-3}
	Time of maximum (yrs)	9345	8435	9345	9975
Surface water	Maximum value	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}	2.6×10^{-4}
	Time of maximum (yrs)	8365	7455	8365	9975

Table C.4.1-10. Alpha concentration for H-Area Tank Farm in the Water Table Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	2.4×10^{1}	2.9×10^{2}	2.4×10^{1}	1.3×10^{4}
		Time of maximum (years)	1925	175	1925	1715
	South of Groundwater Divide	Maximum value	8.6-	8.6	8.6	1.1×10^{3}
		Time of maximum (years)	1855	945	1855	455
100-meter well	North of Groundwater Divide	Maximum value	7.0	3.8×10^{1}	7.0	3.8×10^{3}
		Time of maximum (years)	2205	455	2205	455
	South of Groundwater Divide	Maximum value	2.0	2.0	2.0	2.0×10^{2}
		Time of maximum (years)	2065	1155	2065	665
Seepline	North of Groundwater Divide	Maximum value	1.5×10^{-1}	3.3×10^{-1}	1.5×10^{-1}	3.4×10^{1}
		Time of maximum (years)	4655	2695	4655	2345
	South of Groundwater Divide	Maximum value	1.9×10^{-2}	1.9×10^{-2}	1.9×10^{-2}	4.9
		Time of maximum (years)	4585	3675	4585	8925
Surface water	North of Groundwater Divide	Maximum value	3.1×10^{-5}	6.1×10^{-5}	3.1×10^{-5}	6.2×10^{-3}
		Time of maximum (years)	4585	2765	4585	2695
	South of Groundwater Divide	Maximum value	7.9×10^{-5}	7.9×10^{-5}	7.9×10^{-5}	2.2×10^{-2}
		Time of maximum (years)	4655	3745	4655	8855

Table C.4.1-11. Alpha concentration for H-Area Tank Farm in the Barnwell-McBean Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	3.8	2.1×10^{1}	3.8	2.2×10^{3}
		Time of maximum (years)	5355	3185	5355	2975
	South of Groundwater Divide	Maximum value	1.9	1.9	1.9	6.6×10^{2}
		Time of maximum (years)	5005	4095	5005	8435
100-meter well	North of Groundwater Divide	Maximum value	1.2	5.7	1.2	6.0×10^{2}
		Time of maximum (years)	5845	3605	5845	3325
	South of Groundwater Divide	Maximum value	5.2×10^{-1}	5.2×10^{-1}	5.2×10^{-1}	1.2×10^{2}
		Time of maximum (years)	5355	4445	5355	8785
Seepline	North of Groundwater Divide	Maximum value	1.0×10^{-2}	6.4×10^{-2}	1.0×10^{-2}	6.0
		Time of maximum (years)	9975	9975	9975	9625
	South of Groundwater Divide	Maximum value	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.7
		Time of maximum (years)	9205	8295	9205	7875
Surface water	North of Groundwater Divide	Maximum value	2.0×10^{-6}	1.2×10^{-5}	2.0×10^{-6}	1.1×10^{-3}
		Time of maximum (years)	9975	9975	9975	9765
	South of Groundwater Divide	Maximum value	3.8×10^{-5}	3.8×10^{-5}	3.8×10^{-5}	6.4×10^{-3}
		Time of maximum (years)	9555	8645	9555	7735

Table C.4.1-12. Alpha concentration for H-Area Tank Farm in the Congaree Aquifer (picocuries per liter).

			Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	North of Groundwater Divide	Maximum value	7.3×10^{-4}	7.2×10^{-2}	7.3×10^{-4}	9.5
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	2.5×10^{-4}	1.2×10^{-3}	2.5×10^{-4}	4.0×10^{-1}
		Time of maximum (years)	9975	9975	9975	9975
100-meter well	North of Groundwater Divide	Maximum value	1.9×10^{-4}	1.6×10^{-2}	1.9×10^{-4}	2.1
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	5.2×10^{-5}	2.8×10^{-4}	5.2×10^{-5}	1.0×10^{-1}
		Time of maximum (years)	9975	9975	9975	9975
Seepline	North of Groundwater Divide	Maximum value	6.7×10^{-9}	4.4×10^{-6}	6.7×10^{-9}	7.8×10^{-4}
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	7.8×10^{-10}	1.6×10^{-8}	7.8×10^{-10}	1.8×10^{-5}
		Time of maximum (years)	9975	9975	9975	9975
Surface water	North of Groundwater Divide	Maximum value	2.6×10^{-11}	6.4×10^{-9}	2.6×10^{-11}	1.1×10^{-6}
		Time of maximum (years)	9975	9975	9975	9975
	South of Groundwater Divide	Maximum value	8.0×10^{-11}	9.3×10^{-10}	8.0×10^{-11}	8.8×10^{-7}
		Time of maximum (years)	9975	9975	9975	9975

Table C.4.1-13. Concentration in groundwater and surface water of silver (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.2×10^{-1}	7.9×10^{-2}	1.2×10^{-1}	8.2×10^{-1}	8.6×10^{-3}	6.3×10^{-3}	8.6×10^{-3}	5.3×10^{-1}	9.7×10^{-4}	7.2×10^{-4}	9.7×10^{-4}	4.9×10^{-2}
	Time (yr)	1015	245	1015	105	1015	245	1015	105	1015	245	1015	105
	Barnwell-McBean	3.2×10^{-1}	2.0×10^{-1}	3.2×10^{-1}	3.4	7.1×10^{-4}	9.4×10^{-4}	7.1×10^{-4}	9.3×10^{-2}	8.8×10^{-5}	8.9×10^{-5}	8.8×10^{-5}	9.0×10^{-3}
	Time (yr)	1155	385	1155	245	2695	1855	2695	1785	2765	1715	2765	1645
	Congaree	3.1×10^{-5}	3.1×10^{-5}	3.1×10^{-5}	3.3×10^{-4}	2.0×10^{-5}	2.4×10^{-5}	2.0×10^{-5}	2.3×10^{-3}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-4}
	Time (yr)	4165	3325	4165	3115	9975	9765	9975	9555	9975	9205	9975	9205
100-meter well	Water Table	2.3×10^{-2}	1.4×10^{-2}	2.3×10^{-2}	1.8×10^{-1}	1.5×10^{-3}	1.9×10^{-3}	1.5×10^{-3}	1.5×10^{-1}	2.0×10^{-4}	1.7×10^{-4}	2.0×10^{-4}	1.1×10^{-2}
	Time (yr)	1015	245	1015	105	1015	35	1015	35	1015	245	1015	175
	Barnwell-McBean	6.5×10^{-2}	3.9×10^{-2}	6.5×10^{-2}	9.0×10^{-1}	1.2×10^{-4}	1.9×10^{-4}	1.2×10^{-4}	1.8×10^{-2}	1.7×10^{-5}	1.6×10^{-5}	1.7×10^{-5}	1.7×10^{-3}
	Time (yr)	1155	385	1155	245	2625	1785	2625	1785	2765	1645	2765	1645
	Congaree	5.7×10^{-6}	5.7×10^{-6}	5.7×10^{-6}	6.7×10^{-5}	3.1×10^{-6}	4.0×10^{-6}	3.1×10^{-6}	3.7×10^{-4}	(a)	(a)	(a)	2.0×10^{-5}
	Time (yr)	4235	3325	4235	3115	9905	9695	9905	9835	(a)	(a)	(a)	9415
Seepline	Water Table	7.1×10^{-4}	5.8×10^{-4}	7.1×10^{-4}	1.1×10^{-2}	4.5×10^{-5}	5.8×10^{-5}	4.5×10^{-5}	6.0×10^{-3}	5.2×10^{-6}	5.1×10^{-6}	5.2×10^{-6}	5.5×10^{-4}
	Time (yr)	1085	315	1085	245	1155	175	1155	175	1155	385	1155	245
	Barnwell-McBean	1.7×10^{-3}	1.2×10^{-3}	1.7×10^{-3}	2.1×10^{-2}	3.9×10^{-6}	5.7×10^{-6}	3.9×10^{-6}	4.8×10^{-4}	(a)	(a)	(a)	6.7×10^{-5}
	Time (yr)	1365	525	1365	455	3115	2275	3115	2065	(a)	(a)	(a)	1925
	Congaree	(a)	(a)	(a)	1.9×10^{-6}	(a)	(a)	(a)	4.0×10^{-6}	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	3185	(a)	(a)	(a)	9835	(a)	(a)	(a)	(a)
Surface Water	Water Table	4.5×10^{-6}	3.8×10^{-6}	4.5×10^{-6}	7.8×10^{-5}	(a)	(a)	(a)	1.2×10^{-6}	(a)	(a)	(a)	2.4×10^{-6}
	Time (yr)	1085	315	1085	245	(a)	(a)	(a)	245	(a)	(a)	(a)	245
	Barnwell-McBean	8.8×10^{-6}	6.5×10^{-6}	8.8×10^{-6}	1.1×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	1365	595	1365	455	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-14. Concentrations in groundwater and surface water of aluminum (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-15. Concentrations in groundwater and surface water of barium (milligrams per liter).

		F-Area				H-Area: North of Groundwater Divide				H-Area: South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	6.3×10^{-5}	(a)	6.3×10^{-5}	2.9×10^{-4}	1.9×10^{-4}	2.2×10^{-5}	1.9×10^{-4}	7.2×10^{-4}	(a)	(a)	(a)	(a)
	Time (yr)	9975	(a)	9975	9975	7945	8435	7945	6475	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	2.6×10^{-6}	(a)	(a)	(a)	4.0×10^{-6}	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-16. Concentrations in groundwater and surface water of fluoride (milligrams per liter).

						H-Area							
		F-Area				North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.1×10^{-2}	6.5×10^{-2}	1.1×10^{-2}	4.2×10^{-1}	1.2×10^{-2}	1.3×10^{-2}	1.2×10^{-2}	7.4×10^{-1}	2.6×10^{-3}	9.1×10^{-3}	2.6×10^{-3}	5.1×10^{-1}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	2.0×10^{-1}	2.1×10^{-1}	2.0×10^{-1}	1.9	1.2×10^{-2}	1.2×10^{-2}	1.2×10^{-2}	9.5×10^{-1}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0
	Time (yr)	1015	105	1015	105	1015	105	1015	105	1015	105	1015	105
	Congaree	1.1×10^{-3}	1.2×10^{-3}	1.1×10^{-3}	1.0×10^{-2}	2.2×10^{-3}	3.1×10^{-3}	2.2×10^{-3}	2.7×10^{-1}	1.2×10^{-3}	1.3×10^{-3}	1.2×10^{-3}	1.4×10^{-1}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
100-meter well	Water Table	3.8×10^{-3}	1.2×10^{-2}	3.8×10^{-3}	1.1×10^{-1}	3.2×10^{-3}	3.6×10^{-3}	3.2×10^{-3}	3.3×10^{-1}	6.0×10^{-4}	1.8×10^{-3}	6.0×10^{-4}	1.3×10^{-1}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	4.5×10^{-2}	4.7×10^{-2}	4.5×10^{-2}	5.0×10^{-1}	2.3×10^{-3}	2.4×10^{-3}	2.3×10^{-3}	2.2×10^{-1}	1.7×10^{-3}	1.7×10^{-3}	1.7×10^{-3}	1.7×10^{-1}
	Time (yr)	1015	105	1015	105	1015	35	1015	35	1015	105	1015	105
	Congaree	2.0×10^{-4}	2.2×10^{-4}	2.0×10^{-4}	2.1×10^{-3}	3.5×10^{-4}	6.0×10^{-4}	3.5×10^{-4}	4.8×10^{-2}	1.7×10^{-4}	2.0×10^{-4}	1.7×10^{-4}	2.1×10^{-2}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
Seepline	Water Table	1.8×10^{-4}	7.0×10^{-4}	1.8×10^{-4}	8.4×10^{-3}	1.5×10^{-4}	1.7×10^{-4}	1.5×10^{-4}	1.6×10^{-2}	1.9×10^{-5}	8.4×10^{-5}	1.9×10^{-5}	7.8×10^{-3}
	Time (yr)	105	105	105	105	35	35	35	35	105	105	105	105
	Barnwell-McBean	1.1×10^{-3}	1.4×10^{-3}	1.1×10^{-3}	2.0×10^{-2}	6.3×10^{-5}	8.0×10^{-5}	6.3×10^{-5}	5.9×10^{-3}	5.5×10^{-5}	5.5×10^{-5}	5.5×10^{-5}	4.1×10^{-3}
	Time (yr)	1015	105	1015	105	1085	175	1085	175	1085	175	1085	105
	Congaree	5.8×10^{-6}	6.3×10^{-6}	5.8×10^{-6}	6.8×10^{-5}	5.6×10^{-6}	8.1×10^{-6}	5.6×10^{-6}	5.5×10^{-4}	1.6×10^{-6}	1.9×10^{-6}	1.6×10^{-6}	1.8×10^{-4}
	Time (yr)	1085	175	1085	175	1225	315	1225	315	1225	315	1225	315
Surface Water	Water Table	1.2×10^{-6}	4.8×10^{-6}	1.2×10^{-6}	6.1×10^{-5}	(a)	(a)	(a)	3.0×10^{-6}	(a)	(a)	(a)	3.5×10^{-5}
	Time (yr)	105	105	105	105	(a)	(a)	(a)	35	(a)	(a)	(a)	105
	Barnwell-McBean	5.7×10^{-6}	7.3×10^{-6}	5.7×10^{-6}	1.1×10^{-4}	(a)	(a)	(a)	1.1×10^{-6}	(a)	(a)	(a)	1.4×10^{-5}
	Time (yr)	1015	105	1015	105	(a)	(a)	(a)	175	(a)	(a)	(a)	105
	Congaree	(a)	(a)	(a)	1.8×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	5.8×10^{-6}
	Time (yr)	(a)	(a)	(a)	175	(a)	(a)	(a)	(a)	(a)	(a)	(a)	315

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-17. Concentrations in groundwater and surface water of chromium (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.1×10^{-2}	8.5×10^{-3}	2.1×10^{-2}	1.9×10^{-1}	5.4×10^{-3}	2.7×10^{-3}	5.4×10^{-3}	3.2×10^{-1}	3.6×10^{-3}	1.8×10^{-3}	3.6×10^{-3}	2.1×10^{-1}
	Time (yr)	1715	1925	1715	805	1645	1855	1645	805	1575	1785	1575	805
	Barnwell-McBean	2.3×10^{-2}	1.9×10^{-2}	2.3×10^{-2}	3.8×10^{-1}	2.9×10^{-6}	1.1×10^{-5}	2.9×10^{-6}	3.8×10^{-3}	1.4×10^{-6}	1.4×10^{-5}	1.4×10^{-6}	3.7×10^{-3}
	Time (yr)	3745	4025	3745	2065	9975	9975	9975	9975	9975	9975	9975	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	2.7×10^{-3}	1.5×10^{-3}	2.7×10^{-3}	3.5×10^{-2}	7.6×10^{-4}	5.4×10^{-4}	7.6×10^{-4}	7.4×10^{-2}	5.2×10^{-4}	4.1×10^{-4}	5.2×10^{-4}	3.4×10^{-2}
	Time (yr)	1855	2065	1855	945	1995	2415	1995	1155	2065	2065	2065	1155
	Barnwell-McBean	4.4×10^{-3}	3.7×10^{-3}	4.4×10^{-3}	8.1×10^{-2}	(a)	1.2×10^{-6}	(a)	3.8×10^{-4}	(a)	1.4×10^{-6}	(a)	4.3×10^{-4}
	Time (yr)	4165	4305	4165	2485	(a)	9975	(a)	9975	(a)	9975	(a)	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	3.1×10^{-5}	2.9×10^{-5}	3.1×10^{-5}	5.2×10^{-4}	1.5×10^{-5}	1.3×10^{-5}	1.5×10^{-5}	1.0×10^{-3}	9.2×10^{-6}	9.2×10^{-6}	9.2×10^{-6}	4.4×10^{-4}
	Time (yr)	4865	4865	4865	3955	5495	5565	5495	4235	6265	5775	6265	4935
	Barnwell-McBean	4.6×10^{-5}	4.5×10^{-5}	4.6×10^{-5}	8.0×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9625	9625	9625	8015	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	3.7×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	2.0×10^{-6}
	Time (yr)	(a)	(a)	(a)	4095	(a)	(a)	(a)	(a)	(a)	(a)	(a)	4935
	Barnwell-McBean	(a)	(a)	(a)	4.2×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	7945	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-18. Concentrations in groundwater and surface water of copper (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	6.0×10^{-3}	4.6×10^{-3}	6.0×10^{-3}	6.2×10^{-2}	9.0×10^{-4}	7.1×10^{-4}	9.0×10^{-4}	6.6×10^{-2}	4.5×10^{-4}	3.4×10^{-4}	4.5×10^{-4}	2.9×10^{-2}
	Time (yr)	2765	2905	2765	1295	2695	2835	2695	1295	2555	2695	2555	1295
	Barnwell-McBean	9.4×10^{-3}	8.8×10^{-3}	9.4×10^{-3}	1.5×10^{-1}	(a)	(a)	(a)	8.0×10^{-4}	(a)	(a)	(a)	6.5×10^{-4}
	Time (yr)	6195	6405	6195	3115	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
	Congaree	(a)	(a)	(a)	5.2×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9835	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	7.6×10^{-4}	6.8×10^{-4}	7.6×10^{-4}	1.1×10^{-2}	1.2×10^{-4}	1.1×10^{-4}	1.2×10^{-4}	1.4×10^{-2}	4.5×10^{-5}	4.7×10^{-5}	4.5×10^{-5}	4.2×10^{-3}
	Time (yr)	3255	3465	3255	1785	3465	4025	3465	2135	3465	3745	3465	2345
	Barnwell-McBean	1.5×10^{-3}	1.6×10^{-3}	1.5×10^{-3}	2.7×10^{-2}	(a)	(a)	(a)	2.0×10^{-5}	(a)	(a)	(a)	2.4×10^{-5}
	Time (yr)	6895	7385	6895	4095	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	7.9×10^{-6}	8.1×10^{-6}	7.9×10^{-6}	1.2×10^{-4}	1.5×10^{-6}	1.6×10^{-6}	1.5×10^{-6}	1.6×10^{-4}	(a)	(a)	(a)	4.0×10^{-5}
	Time (yr)	9975	9975	9975	8505	9835	9975	9835	9835	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	1.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9905	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-19. Concentrations in groundwater and surface water of iron (milligrams per liter).

Location	Aquifer	F-Area				H-Area: North of Groundwater Divide				H-Area: South of Groundwater Divide			
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.6	2.7	2.6	3.0×10^{1}	1.1	1.1	1.1	8.2×10^{1}	4.8×10^{-1}	4.8×10^{-1}	4.8×10^{-1}	2.9×10^{1}
	Time (yr)	1575	735	1575	385	1575	665	1575	385	1505	665	1505	385
	Barnwell-McBean	4.7	4.7	4.7	7.4×10^{1}	4.5×10^{-1}	4.5×10^{-1}	4.5×10^{-1}	6.2×10^{1}	2.2×10^{-1}	2.1×10^{-1}	2.2×10^{-1}	2.6×10^{1}
	Time (yr)	2485	1645	2485	805	3605	2695	3605	1575	3465	2485	3465	1435
	Congaree	5.9×10^{-3}	6.0×10^{-3}	5.9×10^{-3}	7.6×10^{-2}	1.5×10^{-2}	2.5×10^{-2}	1.5×10^{-2}	2.6	4.1×10^{-3}	6.2×10^{-3}	4.1×10^{-3}	6.1×10^{-1}
	Time (yr)	4795	4095	4795	2695	9975	9905	9975	9345	9975	9975	9975	9835
100-meter well	Water Table	3.4×10^{-1}	3.3×10^{-1}	3.4×10^{-1}	4.7	1.3×10^{-1}	1.4×10^{-1}	1.3×10^{-1}	1.1×10^{1}	7.4×10^{-2}	7.6×10^{-2}	7.4×10^{-2}	4.6
	Time (yr)	1785	875	1785	595	1995	1085	1995	735	1925	1085	1925	875
	Barnwell-McBean	7.4×10^{-1}	7.2×10^{-1}	7.4×10^{-1}	1.3×10^{1}	6.2×10^{-2}	6.4×10^{-2}	6.2×10^{-2}	7.1	4.7×10^{-2}	4.5×10^{-2}	4.7×10^{-2}	3.7
	Time (yr)	2835	1925	2835	1225	4445	3535	4445	2275	4095	3185	4095	1995
	Congaree	1.1×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	1.6×10^{-2}	2.1×10^{-3}	4.2×10^{-3}	2.1×10^{-3}	3.9×10^{-1}	9.2×10^{-4}	1.5×10^{-3}	9.2×10^{-4}	1.2×10^{-1}
	Time (yr)	4865	3955	4865	2695	9975	9975	9975	9695	9975	9905	9975	9345
Seepline	Water Table	3.9×10^{-3}	3.9×10^{-3}	3.9×10^{-3}	6.0×10^{-2}	2.3×10^{-3}	2.4×10^{-3}	2.3×10^{-3}	1.6×10^{-1}	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	7.7×10^{-2}
	Time (yr)	4585	3605	4585	3255	5145	4165	5145	3675	5425	4585	5425	4305
	Barnwell-McBean	5.8×10^{-3}	5.8×10^{-3}	5.8×10^{-3}	9.2×10^{-2}	1.7×10^{-4}	3.3×10^{-4}	1.7×10^{-4}	3.1×10^{-2}	7.9×10^{-4}	7.9×10^{-4}	7.9×10^{-4}	4.6×10^{-2}
	Time (yr)	7665	6825	7665	6055	9975	9975	9975	9975	9065	8225	9065	6895
	Congaree	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	4.1×10^{-4}	(a)	(a)	(a)	2.8×10^{-4}	(a)	(a)	(a)	7.3×10^{-5}
	Time (yr)	6405	5495	6405	4445	(a)	(a)	(a)	9975	(a)	(a)	(a)	9975
Surface Water	Water Table	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	4.2×10^{-4}	(a)	(a)	(a)	3.7×10^{-5}	6.2×10^{-6}	6.2×10^{-6}	6.2×10^{-6}	3.5×10^{-4}
	Time (yr)	4445	3535	4445	3255	(a)	(a)	(a)	3815	5635	4725	5635	4235
	Barnwell-McBean	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	4.9×10^{-4}	(a)	(a)	(a)	5.6×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	3.0×10^{-6}	1.7×10^{-4}
	Time (yr)	7665	6825	7665	6195	(a)	(a)	(a)	9905	8785	7945	8785	6615
	Congaree	(a)	(a)	(a)	1.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	2.6×10^{-6}
	Time (yr)	(a)	(a)	(a)	4585	(a)	(a)	(a)	(a)	(a)	(a)	(a)	9975

(a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-20. Concentrations in groundwater and surface water of mercury (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	2.6×10^{-5}	3.6×10^{-5}	2.6×10^{-5}	1.6×10^{-3}	1.4×10^{-3}	7.4×10^{-4}	1.4×10^{-3}	1.2×10^{-1}	(a)	(a)	(a)	1.2×10^{-1}
	Time (yr)	9975	9975	9975	9975	9835	5285	9835	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	2.7×10^{-6}	(a)	1.3×10^{-4}	3.0×10^{-5}	5.3×10^{-5}	3.0×10^{-5}	5.3×10^{-3}	(a)	(a)	(a)	2.8×10^{-5}
	Time (yr)	(a)	9975	(a)	9905	9975	9975	9975	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-21. Concentrations in groundwater and surface water of nitrate (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.2×10^{-1}	6.7×10^{-1}	4.2×10^{3}	4.8	2.3×10^{-1}	2.7×10^{-1}	2.4×10^{4}	1.5×10^{1}	7.5×10^{-2}	2.5×10^{-1}	8.7×10^{3}	1.3×10^{1}
	Time (yr)	105	105	385	105	35	35	35	35	105	105	245	105
	Barnwell-McBean	2.1	2.2	4.4×10^{4}	2.2×10^{1}	2.8×10^{-1}	2.8×10^{-1}	3.5×10^{4}	2.3×10^{1}	2.9×10^{-1}	2.9×10^{-1}	3.4×10^{4}	2.7×10^{1}
	Time (yr)	1015	105	1015	105	1015	105	1015	105	1015	105	1015	105
	Congaree	1.2×10^{-2}	1.2×10^{-2}	4.2×10^{2}	1.2×10^{-1}	5.2×10^{-2}	7.2×10^{-2}	1.6×10^{4}	6.2	3.2×10^{-2}	3.7×10^{-2}	5.3×10^{3}	3.4
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
100-meter well	Water Table	3.9×10^{-2}	1.3×10^{-1}	1.0×10^{3}	1.3	6.5×10^{-2}	7.6×10^{-2}	6.8×10^{3}	6.9	2.1×10^{-2}	6.0×10^{-2}	2.3×10^{3}	3.6
	Time (yr)	105	105	1015	105	35	35	35	35	105	105	1015	105
	Barnwell-McBean	4.7×10^{-1}	4.9×10^{-1}	1.8×10^{4}	5.8	6.1×10^{-2}	6.1×10^{-2}	1.4×10^{4}	4.6	5.9×10^{-2}	5.9×10^{-2}	9.9×10^{3}	4.6
	Time (yr)	1015	105	1015	105	1015	105	1015	35	1015	105	1015	105
	Congaree	2.0×10^{-3}	2.3×10^{-3}	7.1×10^{1}	2.4×10^{-2}	8.9×10^{-3}	1.4×10^{-2}	2.1×10^{3}	1.1	5.6×10^{-3}	6.9×10^{-3}	9.3×10^{2}	5.6×10^{-1}
	Time (yr)	1085	175	1085	105	1155	245	1155	245	1155	245	1155	245
Seepline	Water Table	1.8×10^{-3}	7.4×10^{-3}	5.8×10^{1}	1.0×10^{-1}	3.1×10^{-3}	4.2×10^{-3}	3.0×10^{2}	3.4×10^{-1}	9.8×10^{-4}	3.5×10^{-3}	1.5×10^{2}	2.2×10^{-1}
	Time (yr)	105	105	1015	105	35	105	35	35	1015	105	1015	105
	Barnwell-McBean	1.2×10^{-2}	1.5×10^{-2}	4.2×10^{2}	2.4×10^{-1}	1.7×10^{-3}	2.1×10^{-3}	3.3×10^{2}	1.5×10^{-1}	2.5×10^{-3}	2.5×10^{-3}	4.2×10^{2}	1.1×10^{-1}
	Time (yr)	1015	105	1085	105	1085	175	1085	175	1085	175	1085	105
	Congaree	6.1×10^{-5}	6.5×10^{-5}	2.3	8.1×10^{-4}	1.5×10^{-4}	2.0×10^{-4}	3.0×10^{1}	1.3×10^{-2}	7.0×10^{-5}	8.5×10^{-5}	1.2×10^{1}	5.1×10^{-3}
	Time (yr)	1085	175	1085	175	1225	315	1225	315	1225	315	1225	315
Surface Water	Water Table	1.2×10^{-5}	5.0×10^{-5}	3.9×10^{-1}	7.3×10^{-4}	(a)	(a)	5.5×10^{-2}	6.5×10^{-5}	4.4×10^{-6}	1.5×10^{-5}	6.6×10^{-1}	9.9×10^{-4}
	Time (yr)	105	105	1015	105	(a)	(a)	35	35	1015	105	1015	105
	Barnwell-McBean	5.9×10^{-5}	7.7×10^{-5}	2.3	1.3×10^{-3}	(a)	(a)	6.0×10^{-2}	2.7×10^{-5}	9.3×10^{-6}	9.4×10^{-6}	1.6	4.1×10^{-4}
	Time (yr)	1015	105	1085	105	(a)	(a)	1085	175	1085	175	1085	105
	Congaree	1.6×10^{-6}	1.7×10^{-6}	5.9×10^{-2}	2.2×10^{-5}	(a)	(a)	3.8×10^{-2}	1.7×10^{-5}	2.3×10^{-6}	2.8×10^{-6}	3.8×10^{-1}	1.7×10^{-4}
	Time (yr)	1085	175	1085	175	(a)	(a)	1225	315	1225	315	1225	315

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-22. Concentrations in groundwater and surface water of manganese (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.9×10^{-1}	2.2×10^{-1}	1.9×10^{-1}	2.2	2.9×10^{-1}	3.5×10^{-1}	2.9×10^{-1}	2.5×10^{1}	5.5×10^{-2}	6.2×10^{-2}	5.5×10^{-2}	4.0
	Time (yr)	1995	875	1995	455	1295	245	1295	245	1925	805	1925	455
	Barnwell-McBean	3.6×10^{-1}	3.8×10^{-1}	3.6×10^{-1}	5.5	2.2×10^{-2}	4.5×10^{-2}	2.2×10^{-2}	6.0	1.8×10^{-2}	2.0×10^{-2}	1.8×10^{-2}	2.2
	Time (yr)	3115	1925	3115	945	5145	2765	5145	2415	4445	3885	4445	2415
	Congaree	2.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}	3.6×10^{-3}	1.3×10^{-6}	1.6×10^{-4}	1.3×10^{-6}	3.1×10^{-2}	(a)	8.7×10^{-6}	(a)	4.9×10^{-3}
	Time (yr)	6405	5425	6405	4795	9975	9975	9975	9975	(a)	9975	(a)	9975
100-meter well	Water Table	2.8×10^{-2}	3.1×10^{-2}	2.8×10^{-2}	7.0×10^{-1}	4.3×10^{-2}	3.9×10^{-2}	4.3×10^{-2}	4.1	6.4×10^{-3}	6.5×10^{-3}	6.4×10^{-3}	5.6×10^{-1}
	Time (yr)	2205	1085	2205	805	1715	665	1715	665	2345	1155	2345	875
	Barnwell-McBean	6.2×10^{-2}	6.1×10^{-2}	6.2×10^{-2}	1.6	6.2×10^{-3}	1.1×10^{-2}	6.2×10^{-3}	1.3	2.8×10^{-3}	3.2×10^{-3}	2.8×10^{-3}	3.5×10^{-1}
	Time (yr)	3535	2345	3535	1505	6125	3675	6125	3045	5215	4445	5215	3115
	Congaree	4.6×10^{-5}	4.6×10^{-5}	4.6×10^{-5}	1.1×10^{-3}	(a)	3.0×10^{-5}	(a)	6.0×10^{-3}	(a)	(a)	(a)	6.3×10^{-4}
	Time (yr)	6755	5705	6755	4585	(a)	9975	(a)	9975	(a)	(a)	(a)	9975
Seepline	Water Table	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}	1.2×10^{-2}	5.4×10^{-4}	5.5×10^{-4}	5.4×10^{-4}	4.7×10^{-2}	6.8×10^{-5}	6.7×10^{-5}	6.8×10^{-5}	6.4×10^{-3}
	Time (yr)	5215	4165	5215	3535	5215	4305	5215	3815	6195	5005	6195	4585
	Barnwell-McBean	5.6×10^{-4}	5.6×10^{-4}	5.6×10^{-4}	1.8×10^{-2}	4.0×10^{-6}	4.2×10^{-5}	4.0×10^{-6}	5.4×10^{-3}	3.4×10^{-5}	3.7×10^{-5}	3.4×10^{-5}	3.7×10^{-3}
	Time (yr)	8855	7805	8855	6545	9975	9975	9975	9975	9905	9485	9905	8155
	Congaree	1.2×10^{-6}	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	8225	7175	8225	6335	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	2.5×10^{-6}	2.5×10^{-6}	2.5×10^{-6}	8.5×10^{-5}	(a)	(a)	(a)	9.5×10^{-6}	(a)	(a)	(a)	2.8×10^{-5}
	Time (yr)	5215	4165	5215	3745	(a)	(a)	(a)	4025	(a)	(a)	(a)	4515
	Barnwell-McBean	2.9×10^{-6}	2.9×10^{-6}	2.9×10^{-6}	9.8×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1.3×10^{-5}
	Time (yr)	8785	7735	8785	7035	(a)	(a)	(a)	(a)	(a)	(a)	(a)	7875
	Congaree	(a)	(a)	(a)	1.1×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	6335	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L

Table C.4.1-23. Concentrations in groundwater and surface water of nickel (milligrams per liter).

		F-Area				H-Area North of Groundwater Divide				H-Area South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.0×10^{-4}	2.2×10^{-5}	1.0×10^{-4}	1.1×10^{-1}	4.8×10^{-3}	4.7×10^{-3}	4.8×10^{-3}	2.9×10^{-1}	5.8×10^{-4}	2.4×10^{-4}	5.8×10^{-4}	5.9×10^{-2}
	Time (yr)	9975	9975	9975	6335	5495	4725	5495	5285	9975	9975	9975	6335
	Barnwell-McBean	(a)	(a)	(a)	6.7×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	(a)	(a)	(a)	1.9×10^{-2}	2.9×10^{-4}	3.4×10^{-4}	2.9×10^{-4}	3.4×10^{-2}	(a)	(a)	(a)	3.4×10^{-3}
	Time (yr)	(a)	(a)	(a)	9905	9975	9975	9975	9905	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-24. Concentrations in groundwater and surface water of lead (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	5.2×10^{-4}	2.9×10^{-4}	5.2×10^{-4}	2.3×10^{-2}	7.3×10^{-4}	2.0×10^{-4}	7.3×10^{-4}	8.5×10^{-2}	3.9×10^{-4}	1.4×10^{-5}	3.9×10^{-4}	3.0×10^{-2}
	Time (yr)	9975	6055	9975	6475	9975	3745	9975	6965	9975	9975	9975	6545
	Barnwell-McBean	(a)	(a)	(a)	1.3×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	8.3×10^{-5}	8.0×10^{-5}	8.3×10^{-5}	4.2×10^{-3}	3.7×10^{-5}	3.4×10^{-5}	3.7×10^{-5}	8.1×10^{-3}	(a)	(a)	(a)	2.9×10^{-3}
	Time (yr)	8575	8505	8575	9765	9975	9765	9975	9975	(a)	(a)	(a)	9975
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-25. Concentrations in groundwater and surface water of uranium (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	7.6×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	1.7×10^{-4}	3.7×10^{-5}	3.7×10^{-5}	3.7×10^{-5}	2.2×10^{-4}
	Time (yr)	8365	7035	8365	9975	9975	8925	9975	9695	9695	8785	9695	9345
	Barnwell-McBean	(a)	1.4×10^{-6}	(a)	1.5×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	9975	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}	4.5×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.0×10^{-4}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-5}	1.3×10^{-4}
	Time (yr)	8995	8435	8995	9695	9485	8505	9485	9485	9975	9065	9975	9135
	Barnwell-McBean	(a)	(a)	(a)	6.1×10^{-5}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Barnwell-McBean	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

Table C.4.1-26. Concentrations in groundwater and surface water of zinc (milligrams per liter).

		F-Area				H-Area							
						North of Groundwater Divide				South of Groundwater Divide			
Location	Aquifer	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
1-meter well	Water Table	4.4×10^{-3}	4.4×10^{-3}	4.4×10^{-3}	8.7×10^{-2}	6.7×10^{-4}	4.8×10^{-4}	6.7×10^{-4}	5.4×10^{-2}	1.5×10^{-3}	1.5×10^{-3}	1.5×10^{-3}	2.4×10^{-2}
	Time (yr)	2135	1155	2135	595	2135	1225	2135	1925	2555	1645	2555	1015
	Barnwell-McBean	3.3×10^{-3}	5.7×10^{-3}	3.3×10^{-3}	1.3×10^{-1}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9975	9975	9975	5425	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
100-meter well	Water Table	1.5×10^{-3}	1.5×10^{-3}	1.5×10^{-3}	2.8×10^{-2}	1.6×10^{-4}	1.6×10^{-4}	1.6×10^{-4}	1.5×10^{-2}	7.4×10^{-4}	7.4×10^{-4}	7.4×10^{-4}	1.1×10^{-2}
	Time (yr)	2205	1295	2205	735	2345	1435	2345	2205	2975	2065	2975	1295
	Barnwell-McBean	1.2×10^{-3}	1.2×10^{-3}	1.2×10^{-3}	3.2×10^{-2}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	7315	6335	7315	5845	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Water Table	2.3×10^{-5}	2.3×10^{-5}	2.3×10^{-5}	5.5×10^{-4}	3.7×10^{-6}	3.7×10^{-6}	3.7×10^{-6}	5.3×10^{-4}	2.3×10^{-5}	2.3×10^{-5}	2.3×10^{-5}	3.1×10^{-4}
	Time (yr)	8855	7875	8855	4375	5005	4165	5005	4375	5775	4865	5775	4515
	Barnwell-McBean	9.3×10^{-6}	1.8×10^{-5}	9.3×10^{-6}	9.0×10^{-4}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	9975	9975	9975	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Surface Water	Water Table	(a)	(a)	(a)	3.9×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1.4×10^{-6}
	Time (yr)	(a)	(a)	(a)	4375	(a)	(a)	(a)	(a)	(a)	(a)	(a)	4165
	Barnwell-McBean	(a)	(a)	(a)	4.7×10^{-6}	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	9975	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Congaree	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)

a. Concentration is less than 1×10^{-6} mg/L.

concentration values at the seepline are not additive. Therefore, DOE used only the maximum seepline concentration for Fourmile Branch and Upper Three Runs from the alternatives in its comparison of impacts among the alternatives.

C.4.2 ECOLOGICAL RISK ASSESSMENT

C.4.2.1 Nonradiological Analysis

H-Area: Upper Three Runs – Barnwell McBean, Water Table, and Congaree Aquifers

Aquatic Hazard Quotients (HQs) for each contaminant were summed to obtain an aquatic Hazard Index (HI). All HIs were less than 1.0 for all four alternatives. All terrestrial HQs for the shrew and the mink were less than 1.0 for all four scenarios: (Tables C.4.2-1 through C.4.2-4). Thus potential risks to ecological receptors at and downgradient of the Upper Three Runs seeps (from all aquifers under H-Area) are negligible.

H-Area: Fourmile Branch – Barnwell McBean and Water Table Aquifers, Upper Three Runs – Congaree Aquifers

Aquatic HQs for each contaminant were summed to obtain an aquatic Hazard Index (HI). All HIs were less than 1.0 for the four scenarios. All terrestrial HQs for the shrew and the mink were less than 1.0 for these alternatives and options (Tables C.4.2-5 through C.4.2-8). Thus potential H risks to ecological receptors at and downgradient of the Fourmile Branch seep (from the Barnwell McBean and Water Table Aquifers and under H-Area) are negligible, as are those for the Congaree at Upper Three Runs.

F-Area: Fourmile Branch – Barnwell McBean and Water Table Aquifers; Upper Three Runs – Congaree Aquifer

Aquatic HQs for each contaminant were summed to obtain an aquatic Hazard Index (HI). All aquatic HIs were less than 1.0 for the Clean and Fill with Sand and Clean and Fill with Saltstone Options. The maximum HI for the Clean and Fill with Grout Option with the Water Table Aquifer was 1.42. In addition, HIs for the No Action Alternative with the Barnwell McBean and Water Table Aquifers were greater than 1.0: 2.0 and 1.42, respectively. This suggests some potential risks, although the relatively low HI values suggest that these risks are generally low. HQs for the shrew and the mink were less than 1.0 for all four scenarios (Tables C.4.2-9 through C.4.2-12). The exception was a silver HQ of 1.55 for the shrew under the No Action Alternative (Barnwell-McBean Aquifer). Although this indicates that risks are possible at the Fourmile Branch seep (via groundwater under F-Area), the relatively low HQ suggests that these risks are somewhat low.

C.4.2.2 Radiological Analysis

Calculated absorbed doses to the referenced organisms are presented in Tables C.4-2-13 through C.4.2-21. All calculated doses are below the regulatory limit of 365,000 mrad per year (365 rad per year).

C.5 Ecological Risk Assessment Uncertainties

Most of the data and assumptions used in the exposure calculations (exclusive of the exposure concentrations, which were calculated by the groundwater model) are average or midpoint values. Uncertainty for these values is largely a question of precision in measurement or variability about these points. However, two assumptions are conservative, meaning that they are likely to overestimate risk.

The relationship between seep area and home range has already been mentioned; the lack of correction for home range is likely to overestimate risk to an individual shrew by a factor of two and to an individual mink by a factor greater than ten. The other assumption is that when contaminants in seepage adsorb to the soil, they are not removed from the water. In other words, the seepage concentration is used to predict soil concentrations and downstream water concentrations without adjustment for losses.

Table C.4.2-1. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-2. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-3. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-4. Results of terrestrial risk assessment for H-Area/Upper Three Runs (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative.

Analyte	Barnwell-McBean Aquifer			Congaree Aquifer			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	2.19×10^{-2}	3.94×10^{-2}	4,235
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	2.43×10^{-2}	5.76×10^{-2}	175	b	b	NA	6.6×10^{-2}	1.56×10^{-1}	35
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	1.93×10^{-2}	3.54×10^{-2}	2,065	b	b	NA	2.41×10^{-1}	4.43×10^{-1}	175
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
NA = Not applicable.

Table C.4.2-5. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-6. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-7. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	b	NA	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	b	b	NA
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-8. Results of terrestrial risk assessment for H-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	1.69×10^{-2}	4.0×10^{-2}	105	b	b	NA	3.22×10^{-2}	7.61×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	b	b	NA	b	b	NA	2.21×10^{-2}	4.06×10^{-2}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-9. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Grout Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	1.14×10^{-2}	2.05×10-2	3,955
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.07×10^{-2}	1,015	b	b	NA	3.47×10^{-2}	8.2×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	6.83×10^{-2}	1.25×10^{-1}	1,365	b	b	NA	4.42×10^{-1}	8.12×0^{-1}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-10. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Sand Option.

Analyte	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.37×10^{-2}	105	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	4.82×10^{-2}	8.85×10^{-2}	525	b	b	NA	2.33×10^{-2}	4.28×10^{-2}	315
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-11. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), Clean and Fill with Saltstone Option.

	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of	Maximum HQ		Time of	Maximum HQ		Time of
Analyte	Mink	Shrew	maximum HQ[a]	Mink	Shrew	maximum HQ	Mink	Shrew	maximum HQ
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	b	b	NA	b	b	NA	b	b	NA
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	b	1.07×10^{-2}	1,105	b	b	NA	b	b	NA
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	6.83×10^{-2}	1.25×10^{-1}	1,365	b	b	NA	2.85×10^{-2}	5.24×10^{-2}	1,085
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-12. Results of terrestrial risk assessment for F-Area/Fourmile Branch (Barnwell-McBean, Water Table, and Congaree Aquifers), No Action Alternative

Analyte	Barnwell-McBean Aquifer			Congaree Aquifer[c]			Water Table Aquifer		
	Maximum HQ		Time of maximum HQ[a]	Maximum HQ		Time of maximum HQ	Maximum HQ		Time of maximum HQ
	Mink	Shrew		Mink	Shrew		Mink	Shrew	
Aluminum	b	b	NA	b	b	NA	b	b	NA
Barium	b	b	NA	b	b	NA	b	b	NA
Chromium	1.76×10^{-2}	3.15×10^{-2}	8,015	b	b	NA	1.14×10^{-2}	2.05×10^{-2}	3,955
Copper	b	b	NA	b	b	NA	b	b	NA
Fluoride	8.25×10^{-2}	1.95×10^{-1}	105	b	b	NA	3.47×10^{-2}	8.2×10^{-2}	105
Lead	b	b	NA	b	b	NA	b	b	NA
Manganese	b	b	NA	b	b	NA	b	b	NA
Mercury	b	b	NA	b	b	NA	b	b	NA
Nickel	b	b	NA	b	b	NA	b	b	NA
Silver	8.44×10^{-1}	1.55	455	b	b	NA	4.42×10^{-1}	8.12×10^{-1}	245
Uranium	b	b	NA	b	b	NA	b	b	NA
Zinc	b	b	NA	b	b	NA	b	b	NA

a. Years after closure.
b. HQ is less than ~ 1×10^{-2}.
c. Congaree Aquifer discharges to Upper Three Runs for this scenario.
NA = Not applicable.

Table C.4.2-13. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Tank Farm – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0027	0.0016	0.025	0.49
Shrew dose	10.1	6.3	94.9	2,530
Mink dose	1.1	0.9	9.9	1,690

Table C.4.2-14. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Area Tank Farm – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0038	0.0072	0.053	0.89
Shrew dose	18.7	34.5	372	4,320
Mink dose	2.0	3.6	265	452

Table C.4.2-15. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for F-Area Tank Farm – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	6.7×10^{-5}	8.9×10^{-5}	0.002	0.016
Shrew dose	0.1	0.1	1.9	15.8
Mink dose	0	0	0.2	1.7

Table C.4.2-16. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	0.0014	0.0023	0.027	0.35
Shrew dose	9.5	14.4	158.9	2,260
Mink dose	1.0	1.5	17.8	669.1

Table C.4.2-17. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	2.2×10^{-4}	0.0011	0.018	0.21
Shrew dose	0.2	8.3	126.6	1,580
Mink dose	0	0.9	13.3	165.7

Table C.4.2-18. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Four Mile Branch – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	4.8×10^{-4}	2.8×10^{-4}	0.0095	0.061
Shrew dose	3.5	0.2	7.6	47.5
Mink dose	0.4	0	0.8	5.0

Table C.4.2-19. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Water Table Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	2.1×10^{-4}	0.0017	0.0037	0.039
Shrew dose	24.8	244.5	460.5	24,450
Mink dose	3.3	25.6	48.7	2,560

Table C.4.2-20. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Barnwell-McBean Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	5.4×10^{-5}	3.1×10^{-4}	0.0016	0.014
Shrew dose	7.5	44.6	230.1	4,890
Mink dose	0.8	4.7	24.1	512

Table C.4.2-21. Calculated absorbed radiation dose (millirad per year) to aquatic and terrestrial organisms for H-Area Tank Farm to Upper Three Runs – Congaree Aquifer.

	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Sunfish dose	4.8×10^{-5}	1.3×10^{-4}	0.0016	0.012
Shrew dose	1.0	2.7	31.6	244.5
Mink dose	0.1	0.3	3.3	25.6

Uncertainty in the toxicity assessment includes the selection of a particular dose and the factors applied to ensure that it is protective. The fluoride dose selected as a threshold, a LOAEL of 5 milligram per kilogram per day associated with relatively less serious effects in rats and minks, could have been a higher dose based on effects more likely to cause decreased fitness. The data base available for silver toxicity is not good, and this is reflected in the high uncertainty factor (100X) used to lower the selected dose.

Because toxicity data is mostly limited to individual responses, a risk assessment is usually limited to the probability of risk to an individual. This makes the evaluation of risk to populations, communities, and ecosystems a speculative and uncertain undertaking, even though characterization of risks to populations is the typical goal of an ecological risk assessment. In the case of the seep, it is reasonable to assume that terrestrial effects will be limited to this area because the contaminants have not been shown to bioaccumulate in terrestrial systems. Surface water is the only likely pathway for contaminants to exit the seep area. [Mercury is known to accumulate in aquatic food chains, but only a minimal amount of mercury is transported to the seepline during the 10,000 year modeled time period.]

References

Aadland, R. K., J. A. Gellici, and P. A. Thayer, 1995, *Hydrogeologic Framework of West-Central South Carolina*, Report 5, State of south Carolina Department of Natural Resources – Water Resources Division, Columbia, South Carolina.

Ambrose, A. M., P. S. Larson, J. F. Borzelleca. 1976, "Long-Term Toxicologic Assessment of Nickel in Rats and Dogs," *Journal of Food Science Technology,* 13, pp. 181-187.

ATSDR (Agency for Toxic Substances and Disease Registry), 1992, *Toxicological Profile for Aluminum*, U.S. Public Health Service, Atlanta, Georgia.

ATSDR (Agency for Toxic Substances and Disease Registry), 1993, *Toxicological Profile for Chromium*, U.S. Public Health Service, Atlanta, Georgia.

ATSDR (Agency for Toxic Substances and Disease Registry), 1993, *Toxicological Profile for Fluoride*, U.S. Public Health Service, Atlanta, Georgia.

Aughey, E., L. Grant, B. L. Furman, et al., 1977, *The Effects of Oral Zinc Supplementation in the Mouse*, Journal of Comparative Pathology, 87, pp. 1-14.

Baes III, C. F., R. A. Sharp, A. L. Sjoreen, R. W. Shor, 1984, *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Bee, J. W., G. Glass, R. S. Hoffman, and R. R. Patterson, 1981, *Mammals in Kansas*, University of Kansas Publications, Lawrence, Kansas.

Beyer, W. N., E. E. Conner, and S. Gerould, 1994, "Estimates of Soil Ingestion by Wildlife," *Journal Wildlife Management*, 58(2), pp. 375-382.

Bradbury, M. H., and F. Sarott, 1995, *Sorption Database for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment*, ISSN 1019-0643, Paul Scherrer Institute, Switzerland.

Buck, J. W., G. Whelan, J. G. Droppo, Jr., D. L. Strenge, K. J. Castleton, J. P. McDonald, C. Sato, G. P. Streile, 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance: Guidance for Evaluating MEPAS Parameters for Version 3.1,* PNL-10395, Pacific Northwest Laboratory, Richland, Washington, February.

Cothran, E. G., M. H. Smith, J. O. Wolff, and J. B. Gentry, 1991, *Mammals of the Savannah River Site*, SRO-NERP-21, Savannah River Ecology Laboratory, Aiken, South Carolina.

d'Entremont, P., 1996, "Waste Characterization Input Information for NUS Performance Assessment," memorandum to J. Newman, Westinghouse Savannah River Company, Aiken, South Carolina, March 26.

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility*, DOE/EIS-0082, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997, *Industrial Wastewater Closure Module for the High-Level Waste Tank 17 System*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

EPA (U.S. Environmental Protection Agency), 1989, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance*, EPA/530-SW-89-026, Office of Solid Waste, Washington, D.C., April.

EPA (U.S. Environmental Protection Agency), 1993, *Wildlife Exposure Factors Handbook*, EPA/600/R-93/187, Office of Research and Development, Washington, D.C. (Available at http://www.epa.gov/ncea/wefh.htm).

GeoTrans, Inc., 1987, *Characterization of Ground Water Flow and Transport in the General Separations Area, Savannah River Plant: Evaluation of Closure Cap Effectiveness Mixed Waste Management Facility (643-28G), Phase I Report*, Prepared for E.I. duPont de Nemours & Co., Atomic Energy Division, Aiken, South Carolina, May.

GeoTrans, Inc., 1993, *Groundwater Model Calibration and Review of Remedial Alternatives at the F- and H-Area Seepage Basins*, WSRC-TR-93-384, Prepared for Westinghouse Savannah River Company Environmental Restoration Group, Aiken, South Carolina, July.

Halverson, N. V., L. D. Wike, K. K. Patterson, J. A. Bowers, A. L. Bryan, K. F. Chen, C. L. Cummins, B. R. del Carmen, K. L. Dixon, D. L. Dunn, G. P. Friday, J. E. Irwin, R. K. Kolka, H. E. Mackey, Jr., J. J. Mayer, E. A. Nelson, M. H. Paller, V. A. Rogers, W. L. Specht, H. M. Westbury, and E. W. Wilde 1997, *SRS Ecology Environmental Information Document*, WSRC-TR-97-0223, Westinghouse Savannah River Company, Aiken, South Carolina.

Hamby, D. M., 1993, *Soil Concentration Guidelines for the Savannah River Site Using the DOE/RESRAD Methodology (U),* WSRC-TC-93-304, Westinghouse Savannah River Company, Savannah River Technology Center, Aiken, South Carolina.

Hester, J. R., 1999, Westinghouse Savannah River Company, "Tank Surrogates" electronic message to P Fulmer, Tetra, Tech NUS.

Hilderbrand, A. C., et al., 1973, "Effect of Lead Acetate on Reproduction," *American Journal of Obstetrics and Gynecology*, Volume 115, pp. 1058-1065.

ICRP (International Commission on Radiological Protection), 1959, *Recommendation of the International Commission on Radiological Protection,* Publication No. 2, Pergamon Press, New York.

ICRP (International Commission on Radiological Protection), 1975, *Report of the Task Group on Reference Man,* Publication No. 23, Pergamon Press, New York.

Laskey, J. W., G. L. Rehnberg, and J. F. Hein, 1982, "Effects of Chronic Manganese (Mn_3O_4) Exposure on Selected Reproductive Parameters in Rats," *Journal of Toxicology Environmental Health,* 9: pp. 677-687.

Newman, J. L., 1999, Westinghouse Savannah River Company, "WCS Database" electronic message to P. Fulmer, Tetra Tech NUS.

NRC (U.S. Nuclear Regulatory Commission), 1977, *Regulatory Guide 1.109, Calculation of Annual Dose to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*, Washington, D.C.

Opresko, A. M., B. E. Sample, and G. W. Suter II, 1995, *Toxicological Benchmarks for Wildlife: 1995 Revision*, ES/ER/TM-86/R1, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (Available at https://www.osti.gov/servlets/purl/455959-nmGylo/webviewable/455959.pdf).

PNL (Pacific National Laboratories), 1999, "Bibliography on MEPAS (Multimedia Environmental Pollutant Assessment System)," July 20. (Available at http://mepas.pnl.gov:2080/mepbibli.htm).

Rungby, J. and G. Danscher, 1984, "Hypoactivity in Silver Exposed Mice," *Acta Pharmacol et Toxicol.*, 55, pp. 398-401.

WSRC (Westinghouse Savannah River Company), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility (U)*, WSRC-RP-92-1360, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993, *1992 Renewal Application for a RCRA Part B Permit*, Volume IV, *F-Area HWMF Postclosure*, WSRC-IM-91-53, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1994a, *Radiological Performance Assessment for the E-Area Vaults Disposal Facility (U)*, WSRC-RP-94-218, Savannah River Site, Aiken, South Carolina, April 15.

WSRC (Westinghouse Savannah River Company), 1994b, *Westinghouse Savannah River Company Procedure Document, E-7*, Q-CLC-H-00005, Rev. 0, Savannah River Site, Aiken, South Carolina.

Yu, C., 1993, *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAO/LD-2, Argonne National Laboratory, Argonne, Illinois, September.

APPENDIX D

PUBLIC SCOPING SUMMARY

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APPENDIX D. PUBLIC SCOPING SUMMARY

This Appendix describes how DOE defined the scope of the *Savannah River Site High-Level Waste Tank Systems Closure Program Environmental Impact Statement*. It also describes the comments received from the stakeholders of SRS on this planned environmental impact statement (EIS), the issues raised during the scoping process, and the DOE responses to these comments.

D.1 Scoping Process

On December 29, 1998, DOE announced its intent to prepare an EIS to assess the environmental impacts of closing the HLW tanks at the SRS in accordance with the *Industrial Wastewater Closure Plan for F-and H-Area High Level Waste Tank Systems*. The Notice of Intent began a scoping period, which extended until February 12, 1999, and announced that DOE would hold scoping meetings in Columbia and North Augusta, South Carolina during the scoping period. The scoping meetings were subsequently announced in newspapers in the vicinity of the meeting locations.

DOE encouraged SRS stakeholders and other interested parties to submit comments for consideration in the preparation of the EIS and established several methods for such submittals:

- By letter to the Savannah River Operations Office
- By voice mail using a toll-free telephone number
- By facsimile transmission (fax) using a toll-free telephone number
- By electronic mail to an address at the Savannah River Site
- Orally or in writing at public scoping meetings

DOE held scoping meetings on the planned EIS in North Augusta, South Carolina on January 14, 1999 and in Columbia, South Carolina on January 19, 1999. DOE held an afternoon and an evening session at each meeting. Each session included an introduction to the NEPA process in relation to the tank closure proposal, a description of the HLW tanks and alternatives for closure, and a video showing some aspects of the closure of Tank 17 at the SRS. Each session also included opportunities to ask questions of DOE officials and opportunities to offer comments on the scope of the EIS for the record. Transcripts of the question and answer and comment portions of the meetings are available for inspection at the DOE Public Reading Room, Gregg-Graniteville Library, University of South Carolina at Aiken, University Parkway, Aiken, South Carolina.

D.2 Summary of Scoping Comments and Issues

During the scoping period DOE received the following:

- Three comment letters
- One comment E-mail
- One recommendation from the Savannah River Site Citizens Advisory Board
- Seven verbal comments given at the scoping meetings

In these submittals and presentations, DOE identified thirty-six separate comments. The Department reviewed and categorized these comments. The following paragraphs discuss the comments and provide DOE's responses to them.

Comments Relative to the Alternatives: Six comments recommended changes or additions to the alternatives. Comments included the following:

- The scope of this EIS should be expanded to include identification of an alternative, such as ion exchange, to the In-Tank Precipitation process.

DOE Response: DOE has chosen to prepare a separate Supplemental EIS on the construction and operation of a new salt disposition technology to replace In-Tank Precipitation. The selection of a new technology is independent of tank closure, from both technical and regulatory viewpoints. The two EISs are being prepared on similar schedules, and overlap of DOE staff assigned to support the two programs ensures consistent treatment of common issues.

- The EIS should include an alternative of completely emptying the tanks and thoroughly washing them. This alternative would provide the greatest long-term protection of the environment around and down gradient of the tanks as well as the most protection to future generations.

DOE Response: This suggested alternative is essentially what would happen for both the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative.

- Any alternative for tank closure that is premised on the re-classification of residual high-level waste as "incidental waste," violates the 1982 Nuclear Waste Policy Act ("NWPA"), §§ 10101 et seq., and therefore cannot be considered as a viable alternative in the proposed EIS.

DOE Response: DOE has evaluated the characteristics of the expected residual waste relative to the DOE Order 435.1 process for incidental waste, and has concluded that the Order requirements will be met for waste left in the tanks.

- Add an alternative "Delayed Tank Closure" pending research and development activities. Delay subsequent tank closures (but not tank emptying and cleaning activities) beyond 2003; perform technology development to enable removal of residual tank waste.

DOE Response: DOE finds the "Delayed Closure" proposed alternative to be no different than no action. DOE has ongoing research and development efforts underway aimed at improving closure techniques.

- Add an alternative to have separate actions: tank removal and grouting taking place in different tanks, as needed.

DOE Response: This Draft EIS examines the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet the performance requirements for a given tank, the decisionmaker may elect to remove a tank if it is not possible to meet the performance requirements by another method. This Draft EIS examines the alternative of cleaning the tanks and removing them for appropriate disposal.

- Add the alternative "complete tank removal," with point of compliance for groundwater contamination located within F- and H-Area Tank Farms, and no reliance on long-term institutional controls for intruder scenario exposures evaluated for the impact assessment.

DOE Response: DOE has evaluated in the draft EIS potential contamination at 1 meter and 100 meters from the tank farm for each alternative. Intruder scenarios are evaluated without consideration of institutional controls after 100 years. DOE intends however, to maintain long-term institutional control, consistent with applicable regulations.

Comments Related to Data Needs: Three comments suggested data to be included. Comments included the following:

- DOE should include the total volume of waste and the total amount of each radionuclide and chemical expected to remain in the tanks.

- DOE should include a description of the grout or other material proposed to fill the tanks.

- DOE should include potential release of contaminants from closed tanks.

DOE Response: A list of radionuclides and their half-lives that may remain in the tanks is provided in the Draft EIS. See Appendix C, Table C.3.1-1. DOE has described the types of grout used to fill the tanks and provided reference to the research and development methods and results. See Appendix A, Section A.4.3. The potential for release of contaminants from closed tanks to the soil is described in the Draft EIS. Section Chapter 4, Section 4.2.1.

Comments Related to Evaluations and Analyses: Eleven comments suggested evaluations to be used or concerns about analyses. Comments included the following:

- DOE should remove one tank to see what the ground is like underneath.

DOE Response: The cost and risk to workers to remove one tank would make the suggested procedure difficult to perform. As part of the overall closure process conditions around and under the tanks would be assessed using monitoring and sampling data, and the results used as part of the closure module modeling.

- DOE should use an evaluation technique cited in a 1995 article from the Harvard School of Public Health.

DOE Response: This approach applies to setting priorities, not deciding on a particular action and, therefore, does not apply. For example, even if the evaluation recommended by this comment showed that more lives would be saved by funding public health and safety instead of closing the tanks, DOE could not do so.

- The interaction of all contamination from the tanks with all other sources at the SRS should be considered.

DOE Response: The Closure Plan requires that the process of establishing performance requirements for closure modules for individual tanks explicitly examine the sources of contamination that could interact with residual waste in the tank.

- The effects of contamination as they impact subsistence sportsmen should be included.

DOE Response: In the Draft EIS, DOE has estimated the potential health effects to a hypothetical maximally exposed individual, who drinks water, eats food (including fish), and breathes air exposed to SRS releases. In addition, the SRS Annual Environmental Monitoring report estimates the exposure of a recreational sportsman resulting from SRS releases via all pathways.

- Intergenerational concerns and long-term hazards to local ecosystems should be discussed.

DOE Response: DOE calculates adverse health effects to workers and the general public in terms of an estimated number of total fatal cancers. The calculated numbers of excess cancers reported in the Draft EIS are less than one for all alternatives. The risk of genetic effects is smaller than the latent cancer risk (on a per person-rem basis); therefore DOE does not expect any cross-generational effects from implementation of any of the alternatives.

In the Draft EIS DOE has addressed the issue of the potential for long-term hazards to ecosystems. See Chapter 4, section 4.2.3.

- Analyses should use using the data obtained from the closure of Tanks 17 and 20, including (1) data from emptying and cleaning work; (2) analyses of residual waste (predictions from process records and actual measurements); (3) worker dosimetry; (4) regulatory and legal issues; and (5) costs.

- Dosimetric records of workers performing closure of Tanks 17 and 20 must be included in the EIS, and contrasted with the EA-1164 estimates for worker exposure.

DOE Response: One of the primary purposes of the EIS is to incorporate lessons learned from closure of tanks 17 and 20 into actions for closure of the remainder of the tanks. DOE has used (1) data from emptying and cleaning work; (2) analyses of residual waste (predictions from process records and actual measurements); (3) worker dosimetry; and (4) cost. DOE has made the dosimetric comparisons and contrasts for workers to the extent possible given the availability of the required information.

- DOE cannot rely on the current groundwater transport modeling (MEPAS) to support the EIS conclusions.

DOE Response: DOE does not find the MEPAS model inadequate for representing contaminant fate and transport. The South Carolina Department of Health and Environmental Control and the Environmental Protection Agency – Region IV have concurred with DOE's use of the MEPAS code for fate and transport modeling.

- New data from recent measurements at the Nevada Test Site have shown that more rapid groundwater transport of actinides can occur via the mechanism of actinide binding with colloids, should be used in the EIS analysis.

DOE Response: DOE has reviewed the Nevada data. DOE finds that the data represent phenomena specific to conditions at the Nevada Test Site. The modeling for this Draft EIS represents site specific conditions wherever possible.

- Horizontal groundwater flow and tank failure due to this horizontal flow must be modeled.

DOE Response: DOE has performed the necessary calculations to account for the differences in groundwater flows. The results are represented in the fate and transport modeling in the Draft EIS. See Appendix C.

Comments Related to Criteria and Regulations: Six comments dealt with concerns about criteria used or regulatory compliance. Comments included the following:

- The EIS should clearly define the criteria for assessing technical and economic feasibility, solicit public comment on the criteria, and then should use the criteria in assessing alternatives.

DOE Response: The criteria for assessing technical and economic feasibility are given in the "waste incidental to reprocessing" process in DOE Order 435.1. Public input to this Order was solicited when this Order went through the standards review / development process which all DOE Orders must have.

- Ensure that the EIS data and conclusions feed into the CERCLA process to save time and costs.

DOE Response: DOE will ensure that the EIS data gathering and analysis supports the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process for the ultimate closure of the Tank Farms. See Chapter 7, Section 7.3.2.

- DOE should include in the EIS a full discussion of applicable requirements of the Resource Conservation and Recovery Act, Comprehensive Emergency Response, compensation, and Liability Act, and the Nuclear Regulatory Commission (NRC) criteria.

DOE Response: The Draft EIS has a full discussion of applicable laws and regulations in Chapter 7.

- The choice of the seepline as the point-of-compliance for evaluation provides a highly misleading measure of the significant environmental contamination resulting from tank closure.

DOE Response: In addition to the point of compliance information, the Draft EIS presents estimated groundwater contamination at distances of 1 meter and 100 meters from the tank farm. See Section 4.2.

- Activities that result in residual High-Level Waste cannot be conducted with the approval of the SCDHEC if the NRC does not classify residual waste as "incidental."

- This reclassification of the residual High-Level Waste as "incidental" violates the 1982 NWPA and, accepting arguendo its legitimacy, is inconsistent with the narrow scope of the exemption for incidental waste.

DOE Response: The Draft EIS discusses the bases for determining that residual waste remaining after tank cleaning is "waste incidental to reprocessing."

Comments Related to Schedule and Process: Two comments dealt with schedule or EIS process. Comments include the following:

- Sweeping the SRS tank closure into a national program has or will slow down the process of closing the tanks at SRS.

- The EIS should be cancelled unless there are significant worker safety, public health and environmental protection issues that need to be addressed. But if the EIS proceeds, it should be done in a minimum amount of time with a minimum expenditure of funds.

DOE Response: Preparing an EIS at this time will not slow down the tank closure process. SRS is committed to closing additional tanks in 2003 in accordance with the Federal Facility Agreement. Bulk waste removal will proceed as scheduled while the EIS is being prepared. DOE will continue the EIS process. While DOE knows of no new issues, the EIS process involves a more thorough look at worker and public safety and health issues, and environmental protection issues, than was accomplished with the 1996 environmental assessment. DOE will devote the amount of funds and time necessary to complete the EIS.

Comments Covering Miscellaneous Topics: Four comments dealt with a variety of topics that do not fit in any of the areas given above. Comments include the following:

- Tanks that are being considered for closure are the same tanks that have been reported to have leaked in the past.

DOE Response: Some of the high-level waste tanks at SRS have leaked in the past. The HLW tanks are of four different designs (identified as Type I, II, III, or IV), all constructed of carbon-steel inside reinforced concrete containment vaults. The major design features and dimensions of each tank design are shown in Figure 1-5.

There are 12 Type I tanks (4 in H-Area and 8 in F-Area) that were built in 1952 and 1953. These tanks have partial-height secondary containment and active cooling. The tank tops are 9.5 feet below grade, and the bottoms of Tanks 1 through 8 in F-Area are above the seasonal high water table. The bottoms of Tanks 9 through 12 in H-Area are in the water table. Tanks 1 and 9 through 12 are known to have leak sites where waste has leaked from the primary to the secondary containment. There is no evidence that the waste has leaked from the secondary containment.

Four Type II tanks, Tanks 13 through 16, were built in 1956 in H-Area. These tanks have partial-height secondary containment and active cooling. These tanks are above the water table. All four tanks have known leak sites where waste has leaked from the primary to the secondary containment. In Tank 16, waste overflowed the annulus pan (secondary containment) and migrated into the surrounding soil. Waste removal from the Tank 16 primary vessel was completed in 1980, but waste that leaked into the annulus has not been removed.

Eight Type IV tanks, Tanks 17 through 24, were built between 1958 and 1962. These tanks have single steel walls and do not have active cooling. Tanks 17 through 20 in the F-Area Tank Farm are slightly above the water table. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank walls in the past. Small amounts of groundwater have leaked into these tanks, but there is no evidence that waste ever leaked out. Tanks 17 and 20 have been closed in the manner

described in the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative evaluated in the EIS. Tanks 21 through 24 in the H-Area Tank Farm are above the groundwater table, but are in a perched water table, caused by the original construction of the tank area.

The newest design, Type III tanks, have a full-height secondary tank and active cooling. These 27 tanks were placed in service between 1969 and 1986, with 10 in the F-Area and 17 in the H-Area Tank Farms. All Type III tanks are above the water table.

- There is a problem in getting the solidified material from the bottom of the tanks.

DOE Response: The Draft EIS discusses the difficulty of removing sludge from the bottom of the tanks, and it describes and evaluates the options for removing such materials and stabilizing the residue that remains after cleaning.

- New SRS missions will add to the amount of high-level waste and prolong the closure.

DOE Response: DOE has recently selected SRS as the site for several new missions. The Pit Disassembly and Conversion Facility, Mixed Oxide Fuel Facility, Immobilization Facility, and the Tritium Extraction Facility will not add HLW to the current SRS inventory. Stabilizing plutonium residues from the Rocky Flats Environmental Technology Site at SRS is expected to result in the equivalent of five DWPF canisters. The melt and dilute facility for management of spent nuclear fuel would add the equivalent of 17 DWPF canisters. These canisters are in addition to the approximately 6,000 canisters DOE expects to produce absent the new missions.

- It is not reasonable for the EIS to assume that groundwater remediation could compensate for radionuclide release to the environment.

DOE Response: DOE has not assumed in the Draft EIS that groundwater remediation could compensate for long-term releases of contamination to the groundwater after tank closure. The *Industrial Waste Water Closure Plan for F- and H-Area High-Level Waste Tank Systems* also does not make this assumption.

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TECHNICAL EXPERIENCE:	Seventeen years experience as fishery biologist and aquatic ecologist.
EIS RESPONSIBILITY:	Prepared Surface Water and Ecological sections of Chapters 3 and 4.

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TECHNICAL EXPERIENCE:	Eleven years experience in environmental and occupational radiological programs including management of an environmental monitoring laboratory, startup testing of nuclear instrumentation, training, and technical assessments of environmental and radiation protection programs.
EIS RESPONSIBILITY:	Prepared Health and Safety sections of Chapters 3 and 4; prepared Chapter 5.

NAME:	**JAMES L. OLIVER**
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EDUCATION:	B.S., Biology (Fisheries), 1971
TECHNICAL EXPERIENCE:	Twenty-three years experience in research and impact assessment projects for the U.S. Department of Interior and DOE. Reviews environmental and natural resource management issues and performs strategic planning for National Environmental Policy Act documentation for DOE.
EIS RESPONSIBILITY:	Prepared Chapter 6. Management Reviewer.

NAME:	**JOSEPH W. RIVERS**
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TECHNICAL EXPERIENCE:	Three years experience in preparing NEPA documents; 16 years in commercial and DOE nuclear projects; design, systems engineering, safety and accident analysis, and regulatory compliance.
EIS RESPONSIBILITY:	Prepared Accident Analysis section of Chapter 4; prepared Appendix B.

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EDUCATION:	M.E., Nuclear Engineering, 1994 B.S., Nuclear Engineering Sciences, 1990
TECHNICAL EXPERIENCE:	Six years in air permitting, fate and transport modeling, human health impacts, environmental compliance, and health physics.
EIS RESPONSIBILITY:	Prepared Air Resources sections of Chapters 3 and 4; contributed to Appendix C.

NAME:	**THOMAS TEMPLES**
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EDUCATION:	Ph.D., Geology, 1996 M.S, Geology, 1978 B.S., Geology, 1976
TECHNICAL EXPERIENCE:	Four years preparing NEPA documents; 18 years as a geophysicist.
EIS RESPONSIBILITY:	Contributed to Chapter 3.

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EIS RESPONSIBILITY:	Contributed to Appendix C.

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EIS RESPONSIBILITY:	Project Manager; technical reviewer; contributed to Appendix C.

NEPA DISCLOSURE STATEMENT
FOR
PREPARATION OF THE
ENVIRONMENTAL IMPACT STATEMENT FOR CLOSURE OF HIGH-LEVEL WASTE TANKS AT THE SAVANNAH RIVER SITE, SOUTH CAROLINA

CEQ Regulations at 40 CFR 1506.5c, which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." See 46 FR 18026-18031.

In accordance with these requirements, the offeror and the proposed subcontractors hereby certify as follows: (check either (a) or (b) and list financial or other interest if (b) is checked).

(a) ☑ Contractor has no financial or other interest in the outcome of the project.

(b) ☐ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interest

1.

2.

3.

Certified by: [signature]
Signature

Daniel M. Evans
Name (Printed)

General Manager
Title

Tetra Tech NUS, Inc.
Company

June 10, 1999
Date

DISTRIBUTION LIST

DOE provided copies of the *Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement* EIS to Federal, state, and local elected and appointed officials and agencies of government; Native American groups; Federal, state, and local environmental and public interest groups; and other organizations and individuals listed below. Copies will be provided to other interested parties upon request as identified in the cover sheet of this EIS.

CONTENT

A. UNITED STATES CONGRESS

A.1 SENATORS FROM AFFECTED AND ADJOINING STATES

The Honorable Max Cleland
United States Senate

The Honorable Zell Miller
United States Senate

The Honorable Ernest F. Hollings
United States Senate

The Honorable Strom Thurmond
United States Senate

A.2 UNITED STATES SENATE COMMITTEES

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Committee on Armed Services

The Honorable Robert C. Byrd
Ranking Minority Member
Committee on Appropriations

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The Honorable Carl Levin
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The Honorable Harry Reid
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Committee on Appropriations

The Honorable Robert Smith
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The Honorable Ted Stevens
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The Honorable John Warner
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A.3 UNITED STATES HOUSE OF REPRESENTATIVES FROM AFFECTED AND ADJOINING STATES

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The Honorable Nathan Deal
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The Honorable Lindsey Graham
U.S. House of Representatives

The Honorable Jack Kingston
U.S. House of Representatives

The Honorable Cynthia McKinney
U.S. House of Representatives

The Honorable Charlie Norwood
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The Honorable Mark Sanford
U.S. House of Representatives

The Honorable Floyd Spence
U.S. House of Representatives

The Honorable John M. Spratt, Jr.
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A.4 UNITED STATES HOUSE OF REPRESENTATIVES COMMITTEES

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Subcommittee on Energy and Water Development
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The Honorable Duncan L. Hunter
Chairman
Subcommittee on Military Procurement
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The Honorable C. W. Bill Young
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C. STATE OF SOUTH CAROLINA

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Mr. W. Lee Poe

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Mr. Donald J. Skinner

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Mr. Mel Woods

Dr. Abe Zeitoun
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I. READING ROOMS AND LIBRARIES

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U.S. Department of Energy
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Chatham-Effingham-Liberty Regional Library
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Parsons Brinckerhoff Library
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Savannah River Site Library
Savannah River Technology Center
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Public Reading Room
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GLOSSARY

Terms in this glossary are defined based on the context in which they are to be used in this EIS.

accident
: An unplanned sequence of events that results in undesirable consequences.

alpha-emitter
: A radioactive substance that decays by releasing an alpha particle.

alpha particle
: A positively charged particle consisting of two protons and two neutrons, that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

alpha waste
: Waste containing alpha-emitting transuranic radionuclides with activities between 10 and 100 nanocuries per gram.

alternative
: A major choice or strategy to address the EIS "Purpose and Need" statement, as opposed to the engineering options available to achieve the goal of an alternative.

annulus
: The space between the two walls of a double-wall tank.

applicable or relevant and appropriate requirements (ARARs)
: Requirements, including cleanup standards, standards of control, and other substantive environmental protection requirements and criteria for hazardous substances as specified under Federal and State law and regulations, that must be met when complying with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

aquifer
: A body of permeable rock, rock fragments, or soil through which groundwater moves.

as low as reasonably achievable (ALARA)
: A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment at a rate that is as far below applicable limits as reasonably achievable.

atomic number
: The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

background radiation
: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

backfill

Material such as soil or sand used in refilling an excavation.

basemat

The concrete and steel portion of the tank below the residual material and above the vadose zone.

beta-emitter

A radioactive substance that decays by releasing a beta particle.

beta particle

A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

beyond design basis accident (BDBA)

An accident with an annual frequency of occurring between 1 in 1,000,000 and 1 in 10,000,000 ($1.0\times^{-6}$ and 1.0×10^{-7}).

biodiversity

Pertains to the variety of life (e.g., plants, animals and other organisms) that inhabits a particular area or region.

blackwater stream

Water in coastal plains, creeks, swamp, and/or rivers that has been imparted a dark or black coloration due to dissolution of naturally occurring organic matter from soils and decaying vegetation.

borosilicate

A form of glass with silica sand, boric oxide, and soda ash.

borrow material

Material such as soil or sand that is removed from one location and used as fill material in another location.

bounding accident

A postulated accident that is defines to encompass the range of anticipated accidents and used to evaluate the consequences of accidents at facilities. The most conservative parameters (e.g., source terms, and meteorology) applied to a conservative accident resulting in a bounding accident analysis.

cancer

The name given to a group of diseases characterized by uncontrolled cellular growth.

canister

A container (generally stainless steel) into which immobilized radioactive waste is placed and sealed.

capable fault

In part, a capable fault is one that may have had movement at or near the ground surface at least once within the past 35,000 years, or has had recurring movement within the past 500,000 years. Further definition can be found in 10 CFR 100, Appendix A.

carcinogen
: A radionuclide or nonradiological chemical that has been proven or suspected to be either a promoter or initiator of cancer in humans or animals.

characterization
: The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

chronic exposure
: The absorption of hazardous material (or intake of hazardous materials) over a long period of time (for example, over a lifetime).

Code of Federal Regulations (CFR)
: A document containing the regulations of Federal executive departments and agencies.

collective effective dose equivalent
: Sum of the effective dose equivalents for individuals composing a defined population. The units for this are person-rem or person-sievert.

committed dose equivalent
: Total dose equivalent accumulated in an organ or tissue in the 50 years following a single intake of radioactive materials into the body.

committed effective dose equivalent
: The sum of committed radiological dose equivalents to various tissues in the body, each multiplied by the appropriate weighing factor and expressed units of rem.

condensate
: Liquid that results from condensing a gas by cooling below its saturation temperature.

confining (unit)
: A rock layer (or stratum) having very low hydraulic conductivity (or permeability) that restricts the movement of groundwater either into or out of adjacent aquifers.

contaminant
: Any gaseous, chemical or organic material that contaminates (pollutes) air, soil, or water. This term also refers to any hazardous substance that does not occur naturally or that occurs at levels greater than those naturally occurring in the surrounding environment (background).

contamination
: The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

critical
: A condition where in uranium, plutonium or tritium is capable of sustaining a nuclear chain reaction.

criticality
: State of being critical. Refers to a self-sustaining nuclear chain reaction in which there is an exact balance between the production of neutrons and the losses on neutrons in the absence of extraneous neutron sources.

curie (CI)
The basic unit used to describe the intensity of radioactivity in a sample of material. he curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

decay, radioactive
The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation (see half-life, radioactive).

decommissioning
The process of removing a facility from operation followed by decontamination, entombment, dismantlement, or conversion to another use.

decontamination
The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

design basis accident (DBA)
For nuclear facilities, a postulated abnormal event that is used to establish the performance requirements of structures, systems, and components that are necessary to maintain them in a safe shutdown condition indefinitely or to prevent or mitigate the consequences so that the general public and operating staff are not exposed to radiation in excess of appropriate guideline values.

design basis earthquake
The maximum intensity earthquake that might occur along the nearest fault to a structure. Structures are built to withstand a design basis earthquake.

DOE Orders
Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

dosage
The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose)
A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dose equivalent
Product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem. A millirem is one one-thousandth of a rem.

effective dose equivalent (EDE)
: The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. It includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem. The International Commission on Radiation Protection defines this as the effective dose.

effluent
: Liquid or gaseous waste streams released from a facility.

effluent monitoring
: Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

endemic
: Native to a particular area or region.

environmental restoration
: Cleanup and restoration of sites and decontamination and decommissioning of facilities contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

environmental restoration program
: A DOE subprogram concerned with all aspects of assessment and cleanup of both contaminated facilities in use and of sites that are no longer a part of active operations. Remedial actions, most often concerned with contaminated soil and groundwater, and decontamination and decommissioning are responsibilities of this program.

evaporator
: A facility that mechanically reduces the water contents in tank waste to concentrate the waste and reduce storage space needs.

exposure pathways
: The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a release site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium such as air or water is also included.

external accident (or initiator)
: An accident that is initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

facility basemat
: For this purposes of this EIS, basemat is defined as the concrete pad beneath the HLW tank.

fissile material
: Any material fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

floodplain
: The level area adjoining a river or stream that is sometimes covered by flood water.

gamma-emitter
: A radioactive substance that decays by releasing gamma radiation.

gamma ray (gamma radiation)
: High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to x-rays, but are usually more energetic.

geologic repository
: A deep (on the order of 600 meter [1,928 feet] or more) underground mined array of tunnels used for permanent disposal of radioactive waste.

groundwater
: Water occurring beneath the earth's surface in the intervals between soil grains, in fractures, and in porous formations.

grout
: A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation, immobilization, and stabilization purposes.

habitat
: The sum of environmental conditions in a specific place occupied by animals, plants, and other organisms.

half-life
: The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazard index
: The sum of several hazard quotients for multiple chemicals and/or multiple exposure pathways. A hazard index of greater than 1.0 is indicative of potential adverse health effects. Health effect could be minor temporary effects or fatal, depending on the chemical and amount of exposure.

hazard quotient
: The ratio of an exposure level to a substance to a toxicity reference value selected for risk assessment purposes.

hazardous chemical
: A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical that is a physical hazard or a health hazard.

hazardous material
: A substance or material, including a hazardous substance, which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance

Any substance that when released to the environment in an uncontrolled or unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

hazardous waste

Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heavy metals

Metallic elements with high atomic weights (for example, mercury, chromium, cadmium, arsenic, and lead) that can damage living things at low concentrations and tend to accumulate in the food chain.

high-efficiency particulate air (HEPA) Filter

A filter with an efficiency of at least 99.95 percent used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level waste

As defined by the Nuclear Waste Policy Act [42 U.S. C. 10101], High Level Waste means (a) the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid that contains [a combination of transuranic and] fission products [nuclides] in sufficient concentrations; and (b) other highly radioactive material that the [U.S. Nuclear Regulatory] Commission, consistent with existing law, determines by rule requires permanent isolation.

hydrology

The study of water, including groundwater, surface water, and rainfall.

immobilization

A process (e.g., grouting or vitrification) used to stabilized waste. Stabilizing the waste inhibits the release of waste to the environment.

inadvertent intrusion

The inadvertent disturbance of a disposal facility or its immediate environment by a potential future occupant that could result in loss of containment of the waste or exposure of personnel. Inadvertent intrusion is a significant consideration that shall be included either in the design requirements or waste acceptance criteria of a waste disposal facility.

incidental waste

Wastes that are not defined as high-level waste (i.e., originating from nuclear fuel processing).

inhibited water

Water to which sodium hydroxide has been added to inhibit corrosion.

in situ

A Latin term meaning "in place."

institutional control

The control of waste disposal sites or other contaminated sites by human institutions in order to prevent or limit exposures to hazardous materials. Institutional control may be accomplished by (1) active control measures, such as employing security guards and maintaining security fences to restrict site access, and (2) passive control measures, such as using physical markers, deed restrictions, government regulations, and public records and archives to preserve knowledge of the site and prevent inappropriate uses.

internal accidents

Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, criticalities, and so forth.

involved worker

Workers that would be involved in a proposed action as opposed to workers that would be on the site of a proposed action but not involved in the action.

isotope

One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

latent cancer fatality

A fatality resulting from cancer caused by an exposure to a known or suspected radionuclide or carcinogenic chemical.

low-level waste (LLW)

Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or byproduct tailings containing uranium or thorium from processed ore (as defined in Section II e(2) of the Atomic Energy Act).

low-level mixed waste (LLMW)

Waste that contains both hazardous waste under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic energy Act of 1954 (42 USC 2011, *et seq.*).

macroinvertebrate

Small animal, such as a larval aquatic insect, that is visible to the naked eye and has no vertebral column.

maximally exposed individual (MEI)

A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question.

millirad

One thousandth of a rad (see rad).

millirem

One thousandth of a rem (see rem).

mixed waste
: Waste that contains both hazardous wastes under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

nanocurie
: One billionth of a curie (see curie).

natural phenomena accidents
: Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

noninvolved workers
: Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located a specific distance (often 100 meters) from the reference facility area.

nuclear criticality
: A self-sustaining nuclear chain reaction.

nuclide
: A general term referring to all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

offsite
: Away from the SRS site.

offsite population
: For facility accident analyses, the collective sum of individuals located within an 80-kilometer (50-mile) radius of a facility and within the path of the plume with the wind blowing in the most populous direction.

oxalic acid
: A water soluble organic acid, $H_2C_2O_4$, being considered as a cleaning agent to use in spray-washing tanks because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in the construction of the waste tanks.

particulate
: Pertains to minute, separate particles. An example of dry particulate is dust.

performance objectives
: Parameters within which a facility must perform to be considered acceptable.

permanent disposal
: For high level waste the term means emplacement in a repository for high-level radioactive waste, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste.

permeability
: The degree of ease with which water can pass through a rock or soil.

person-rem

A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent (measured in rems) to a given organ or tissue by the number of persons in the population of interest.

pH

A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have a pH of less than 7, and bases have a pH of greater than 7.

picocurie

One trillionth of a curie (see curie).

pollutant migration

The movement of a contaminant away from its initial source.

population

For risk assessment purposes, population consists of the total potential members of the public or workforce who could be exposed to a possible radiation or chemical dose from an exposure to radionuclides or carcinogenic chemicals.

population dose

The overall dose to the offsite population.

rad

The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation)

Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include nonionizing radiation such as radio- or microwaves, or visible, infrared, or ultraviolet light.

radiation worker

A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive waste

Waste that is managed for its radioactive content.

radioactivity

The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).

radioisotope

An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. approximately 5,000 natural and artificial radioisotopes have been identified.

radionuclide

The radioisotopes that together comprise 95 percent of the total curie content of a waste package by volume and have a half-life of at least 1 week. Radionuclides that are important to a facility's radiological performance assessment and/or a safety analysis and are listed in the facility's waste acceptance criteria are considered major radionuclides.

Record of Decision (ROD)

A public document that records the final decision(s) concerning a proposed action.

reducing grout

A grout formulated to behave as a chemical reducing agent. A chemical reducing agent is a substance that reduces other substances (i.e., decreases their positive charge or valence) by supplying electrons. The purpose of a reducing grout in closure of the high-level waste tanks would be to provide long-term chemical durability against leaching of the residual waste by water. Reducing grout would be com

posed primarily of cement, blast furnace slag, masonry sand, and silica fume.

rem

A unit of radiation dose that reflects the ability of different types of radiation to damage human tissues and the susceptibility of different tissues to the damage. Rems are a measure of effective dose equivalent.

risk

Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

Safety Analysis Report (SAR)

A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarize the hazards associated with the operation of a particular facility and defines minimum safety requirements.

saltcake

Salt compounds that have crystallized as a result of concentrating the liquid.

saltstone

Concrete-like substance formed when the low-activity fraction of high-level waste is mixed with cement, flyash, and slag.

seepline

An area where subsurface water or groundwater emerges from the earth and slowly flows overland.

segregation

The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment and storage or disposal.

seismicity

The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

sludge

Solid material that precipitates or settles to the bottom of a tank.

solvent

Substance (usually liquid) capable of dissolving one or more other substances.

source material

(a) Uranium, thorium, or any other material that is determined by the U.S. Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the U.S. Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under to Resource Conservation and Recovery Act.

source term (Q)

the quantity of radioactive material released by an accident or operation that causes exposure after transmission or deposition. Specifically, it is that fraction of respirable material at risk (MAR) that is released to the atmosphere from a specific location. The source term defines the initial condition for subsequent dispersion and consequence evaluations. Q = material at risk (MAR) damage ration (DR) x airborne release fraction (ARF) x respirable fraction (RF) x leak path factor (LPF). The units of Q are quantity at risk averaged over the specified time duration.

spent nuclear fuel

Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

stabilization

Treatment of waste to protect the environment from contamination. This includes rendering a waste immobile or safe for handling and disposal.

subsurface

The area below the land surface (including the vadose zone and aquifers).

tank farm

An installation of multiple adjacent tanks, usually interconnected for storage of liquid radioactive waste.

total effective dose equivalent

The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transuranic waste

Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

treatment

Any activity that alters the chemical or physical nature of a hazardous waste to reduce its toxicity, volume, mobility or to render it amenable for transport, storage or disposal.

vadose zone

The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification

A method of immobilizing waste (e.g., radioactive, hazardous, and mixed). This involves adding frit and waste to a joule-heated vessel and melting the mixture into a glass. The purpose of this process is to permanently immobilize the waste and to isolate it from the environment.

volatile organic compound (VOC)

Compounds that readily evaporate and vaporize at normal temperatures and pressures.

waste minimization

An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

waste stream

A waste or group of wastes with similar physical form, radiological properties, U. S. Environmental Protection Agency waste codes, or associated land disposal restriction treatment standards. It may be the result of one or more processes or operations.

wetlands

Area that are inundated or saturated by surface water or groundwater and that typically support vegetation adapted for life in saturated soils. Wetlands generally include swamps, marshes, bogs, and similar areas.

wind rose

A star-shaped diagram showing how often winds of various speeds blow from different directions. This is usually based on yearly average.