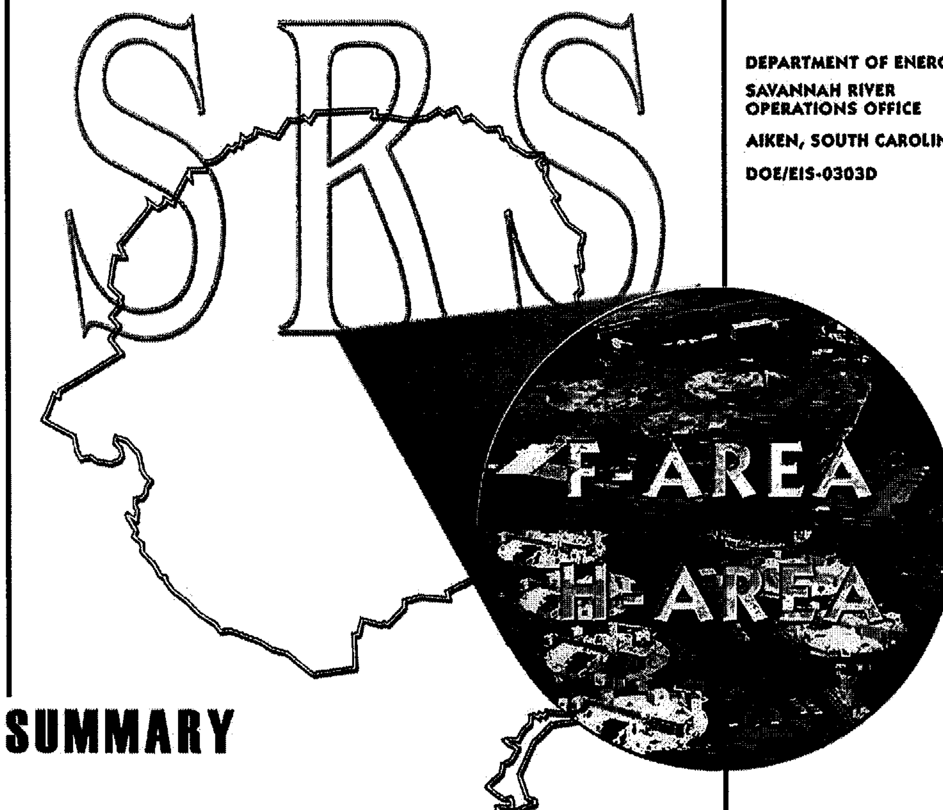
Savannah River Site

HIGH- LEVEL WASTE TANK CLOSURE

Draft Environmental Impact Statement



DEPARTMENT OF ENERGY
SAVANNAH RIVER OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA

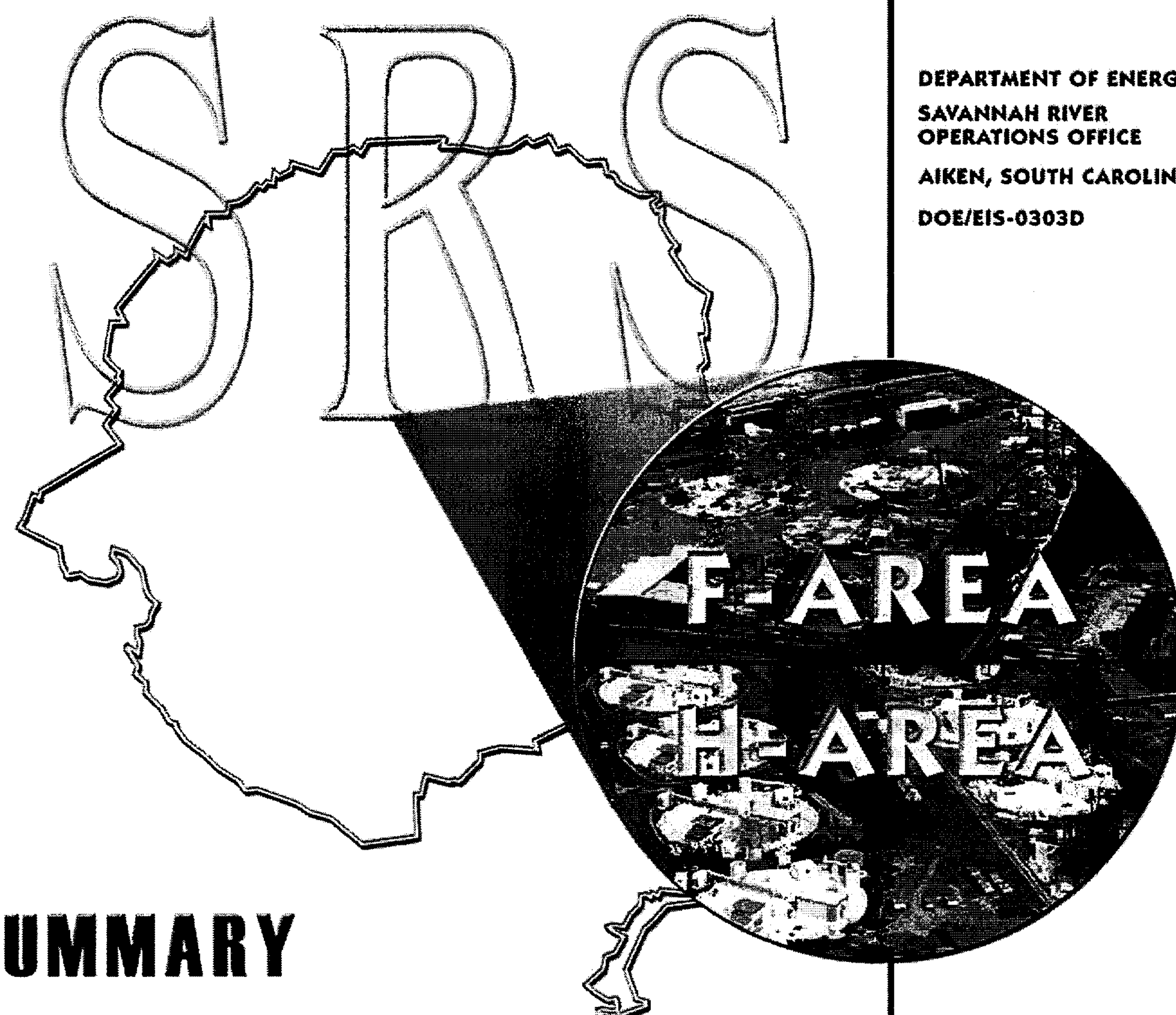
DOE/EIS-0303D

SUMMARY

November 2000

Savannah River Site

HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement



DEPARTMENT OF ENERGY
SAVANNAH RIVER OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA
DOE/EIS-0303D

SUMMARY

November 2000

COVER SHEET

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

TITLE: Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D), Aiken, SC.

CONTACT: For additional information or to submit comments on this environmental impact statement (EIS), write or call:

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

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

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

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

ABSTRACT: DOE proposes to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (approved by the South Carolina Department of Health and Environmental Control), which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed. This EIS evaluates three alternatives regarding the HLW tanks at the SRS. The three alternatives are the Clean and Stabilize Tanks Alternative, the Clean and Remove Tanks Alternative, and the No Action Alternative. The EIS considers three options for tank stabilization: Fill with Grout (Preferred Alternative); Fill with Sand; and Fill with Saltstone.

Under each alternative (except No Action), DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic impacts, and cumulative impacts.

PUBLIC INVOLVEMENT: In preparing this Draft EIS, DOE considered comments received by letter and voice mail and formal statements made at public scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999.

A 45-day comment period on the Draft High-Level Waste Tank Closure EIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft EIS will be held on December 11, 2000 at the North Augusta Community Center, North Augusta, South Carolina, and on December 12, 2000 at the Adams Mark Hotel, Columbia, South Carolina. Comments may be submitted at the public meeting and by voice mail, e-mail, and regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the final EIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

Table of Contents

List of Tables

List of Figures

ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

AAQS	ambient air quality standard
AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLSM	controlled low-strength material
CO	carbon monoxide
D&D	decontamination and decommissioning
DBE	design basis event
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
IMNM	Interim Management of Nuclear Material
INEEL	Idaho National Engineering and Environmental Laboratory
ISO	International Organization for Standardization
LCF	latent cancer fatality
LEU	low enriched uranium
LWC	lost workday cases

MCL	maximum contaminant level
MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_X	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O_3	ozone
OSHA	Occupational Safety and Health Administration
PM_{10}	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO_2	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

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

Use of Scientific Notation

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

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

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

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

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

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

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

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

Metric Conversion Chart

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

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^{9}
mega-	M	1 000 000 = 10^{6}
kilo-	k	1 000 = 10^{3}
centi-	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro-	μ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001 = 10^{-18}

S.1 Introduction

The U.S. Atomic Energy Commission, a U.S. Department of Energy (DOE) predecessor agency, established the Savannah River Site (SRS) near Aiken, South Carolina, in the early 1950s. The primary mission of SRS was to produce nuclear materials for national defense. With the end of the Cold War and the reduction in the size of the United States' stockpile of nuclear weapons, the SRS mission has changed. While national defense is still an important facet of the mission, SRS no longer produces nuclear materials and the mission is focused on material stabilization, environmental restoration, waste management, and decontamination and decommissioning of facilities that are no longer needed.

As a result of its nuclear materials production mission, SRS generated large quantities of highly corrosive and radioactive waste known as high-level waste (HLW). The HLW resulted from dissolving spent reactor fuel and nuclear targets to recover the valuable radioactive isotopes. DOE had stored the HLW in 51 large underground storage tanks located in the F- and H-Area Tank Farms at SRS. DOE has emptied and closed two of those tanks. DOE is treating the HLW using a process called vitrification. The highly radioactive portion of the waste is mixed with a glass-like material and stored in stainless steel canisters at SRS, pending shipment to a geologic repository for disposal. This process is currently underway at SRS, in the Defense Waste Processing Facility (DWPF).

The HLW tanks at SRS are of four different types, which provide varying degrees of protection to the environment due to different degrees of containment. The tanks are operated under the authority of the Atomic Energy Act of 1954 (AEA) and DOE Orders issued under the AEA. The tanks are permitted by the South Carolina Department of Environmental Control (SCDHEC) under the South Carolina wastewater regulations, which require permitted facilities to be closed after they are removed from service. DOE has entered into an agreement with the U.S. Environmental Protection Agency (EPA) and SCDHEC to close the HLW tanks after they have been removed from service. Closure of the HLW tanks will comply with DOE's responsibilities under the AEA and the South Carolina closure requirements, and be carried out under a schedule agreed to by DOE, EPA, and SCDHEC.

There are several ways to close the HLW tanks. DOE has prepared this Environmental Impact Statement to ensure that the public and DOE's decisionmakers have a thorough understanding of the potential environmental impacts of alternative means of closing the tanks before one method is chosen. This Summary provides a brief description of the HLW tanks and the closure process, describes the National Environmental Policy Act (NEPA) process that DOE is using to aid in decisionmaking, summarizes the alternatives for closing the HLW tanks and identifies DOE's preferred alternative, and outlines the major conclusions, areas of controversy, and issues that remain to be resolved as DOE proceeds with the HLW tank closure process.

S.2 High-Level Waste Storage and Tank Closure

S.2.1 HIGH-LEVEL WASTE

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "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 waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation."

S.2.2 HIGH-LEVEL WASTE MANAGEMENT AT THE SAVANNAH RIVER SITE

Currently, about 34 million gallons of HLW are stored in 49 underground tanks in two tank farms, the F-Area Tank Farm and the H-Area Tank Farm. Two additional tanks have been closed. The tank farms are in the central part of the SRS, about 5.5 miles from the SRS boundaries. Figure S-1 shows the locations of F- and H-Areas and the tank farms.

The HLW in the tanks is in three forms: sludge, salt, and liquid. The sludge is solid material that has precipitated and settled to the bottom of the tank. The salt is comprised of salt compounds[1] that have crystallized as a result of concentrating the liquid by evaporation. The liquid is a highly concentrated solution of salt compounds in water. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks, while others are considered salt tanks, containing both salt and liquid.

HLW management systems at SRS are designed to place the high-radioactivity fraction of the HLW in a form (borosilicate glass) that can be disposed of in a geologic repository, and to dispose of the low-radioactivity fraction in vaults at the SRS. The sludge portion of the HLW is being transferred to the DWPF for vitrification in borosilicate glass. The glass is poured into stainless steel canisters at the DWPF and the filled and sealed canisters are stored nearby, pending shipment to a geologic repository. Almost 1,000 canisters have been filled and stored.

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before treatment. As described in the *Defense Waste Processing Facility Supplemental Environmental Impact Statement* (DOE/EIS-0082S*)*, any In-Tank Precipitation Process would separate the salt and liquid portions of the HLW into high- and low-radioactivity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification along with the sludge portion. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed of in vaults at SRS. Since issuance of that EIS, 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, February 22, 1999). DOE is conducting research and development for a new technology for separating the salt and liquid portions of the HLW and is preparing an EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*, to evaluate the impacts of alternative technologies. Figure S-2 shows the current configuration of the SRS HLW management system.

S.2.3 HIGH-LEVEL WASTE TANKS AND TANK FARMS

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks (Tanks 17 and 20), 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure S-3 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site with 29 waste tanks, 3 evaporator systems (including the new Replacement High-Level Waste Evaporator), the In-Tank Precipitation Process, the Extended Sludge Processing Facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure S-4 shows the general layout of the H-Area Tank Farm.

The HLW tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. The major design features and dimensions of each tank design are shown in Figure S-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.

[1] A salt is a chemical compound formed when one or more hydrogen ions of an acid are replaced by metallic ions. Common salt, sodium chloride, is a well-known salt.

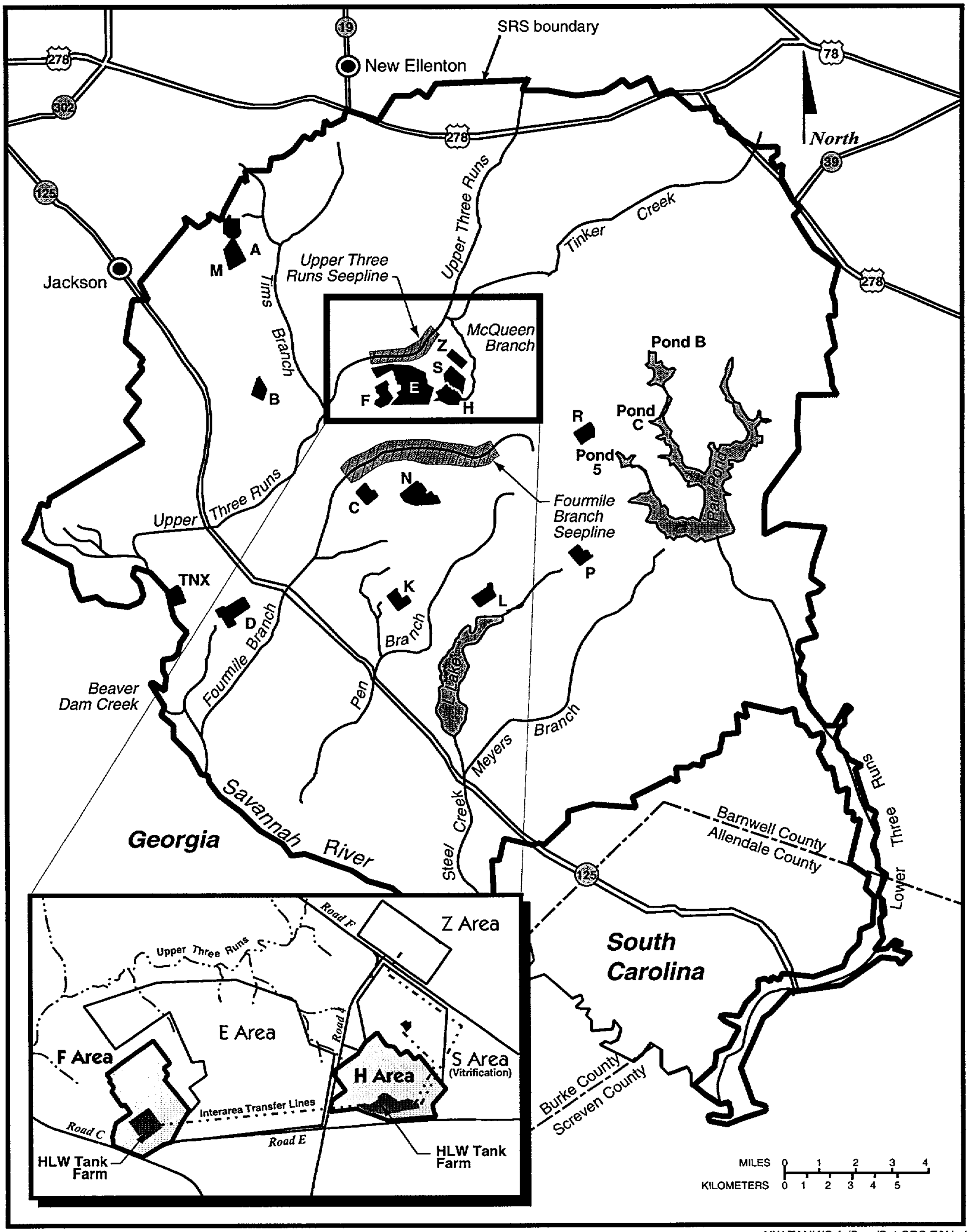
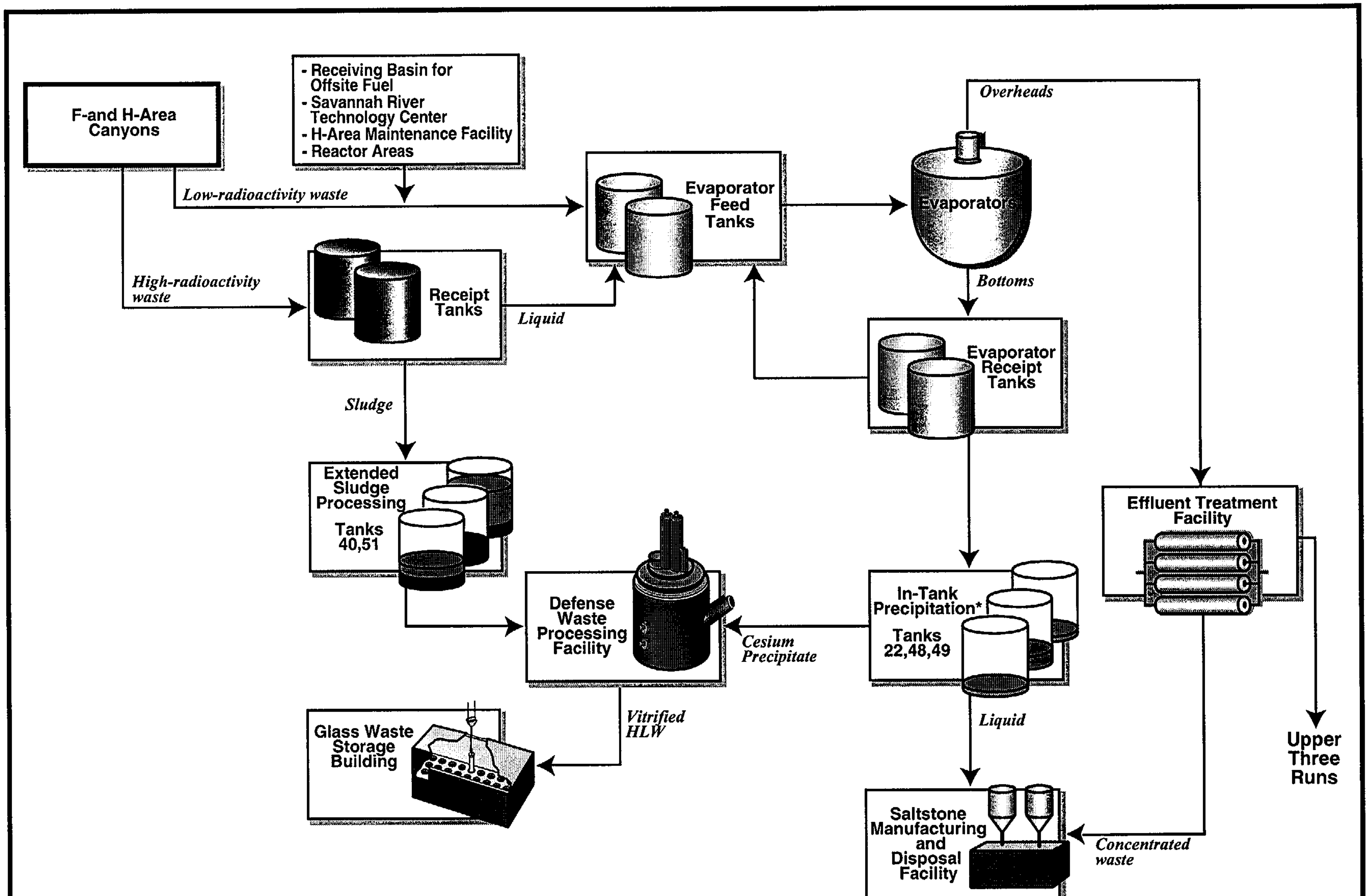


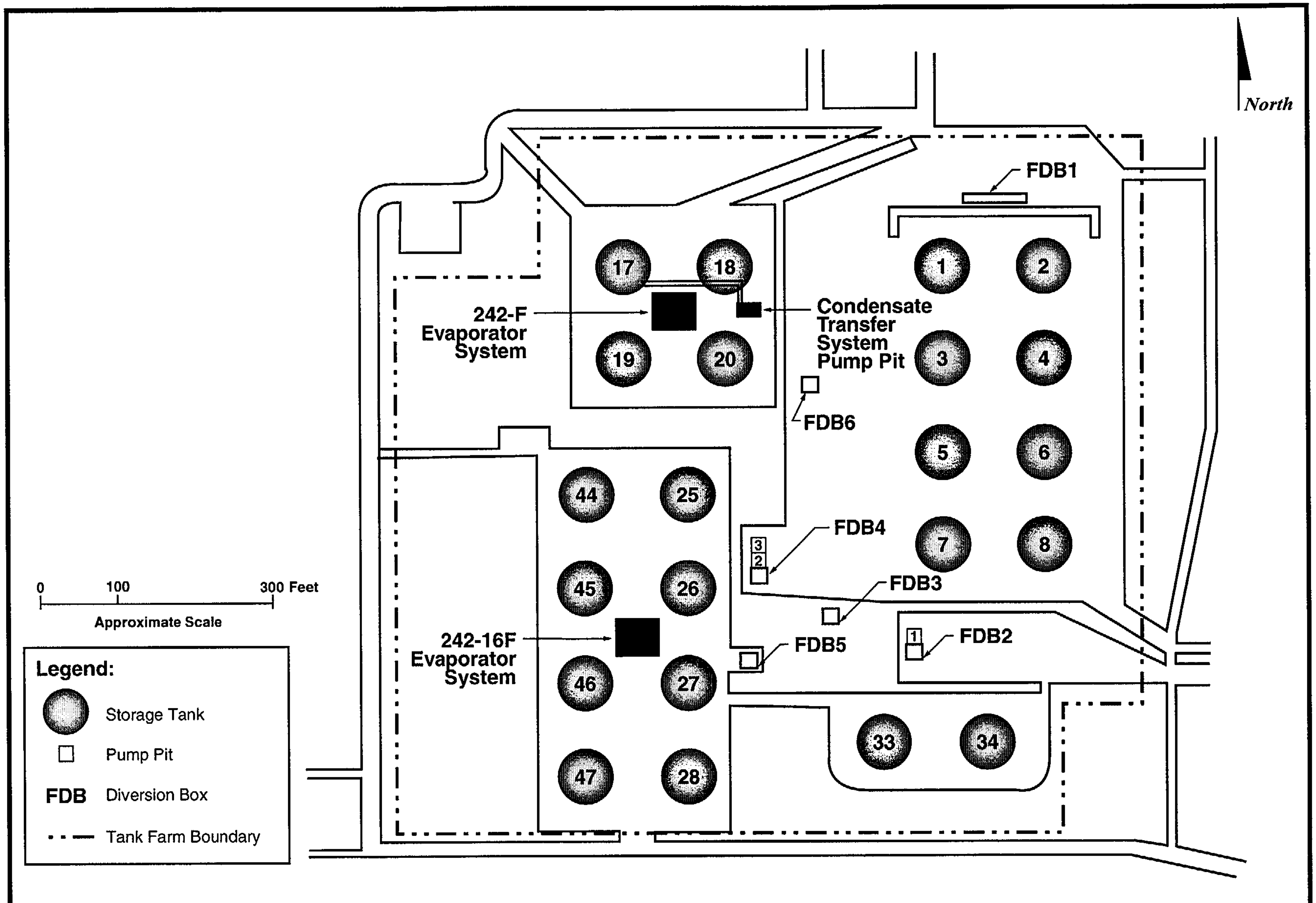
Figure S-1. Savannah River Site map with F- and H-Areas highlighted.



*This process will be replaced. DOE is evaluating alternatives to this process in a separate EIS (see 64 FR 8559).

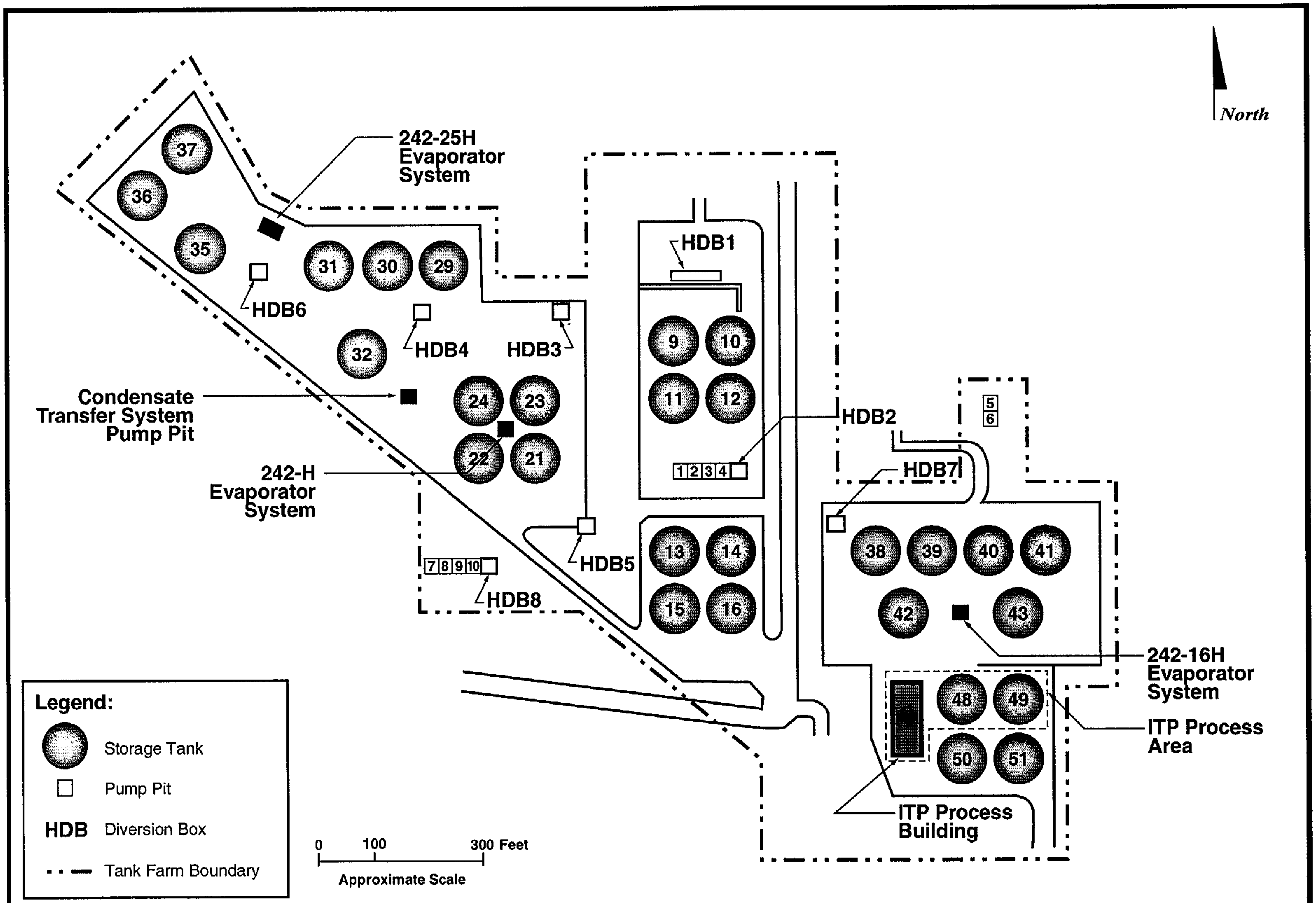
NW TANK/Grfx/Sum/S-2 HLW mgt syst.ai

Figure S-2. Process flows for Savannah River Site High-Level Waste Management System.



NW TANK/Grfx/Sum/S-3 F_Tank.ai

Figure S-3. General layout of F-Area Tank Farm.



NW TANK/Grfx/Sum/S-4 H_Tank.ai

Figure S-4. General layout of H-Area Tank Farm.

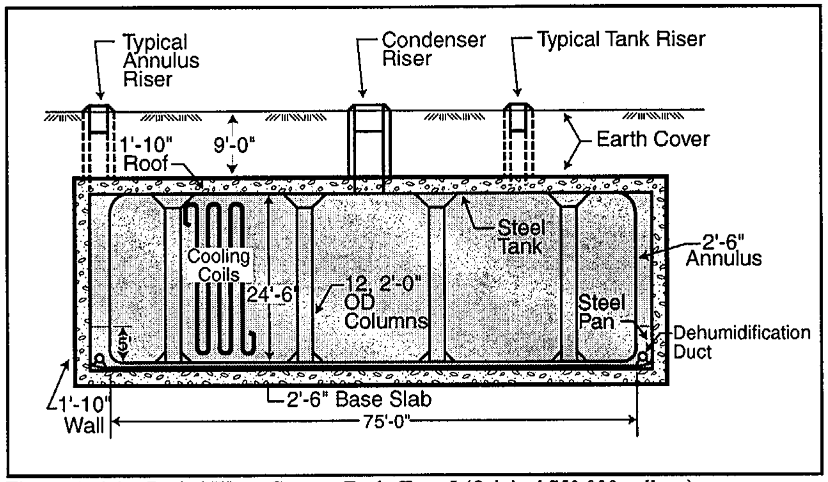


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

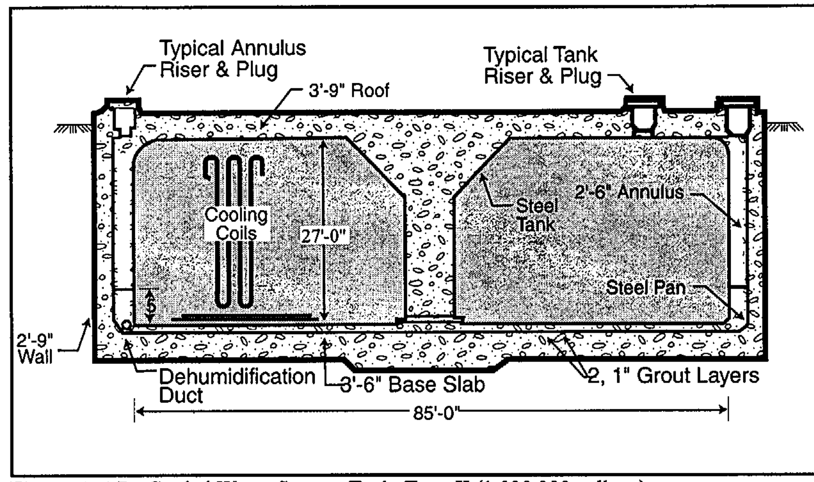


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

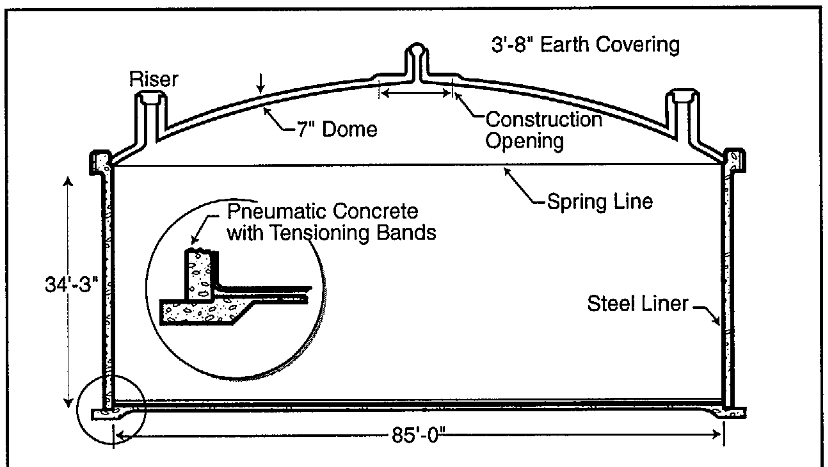


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

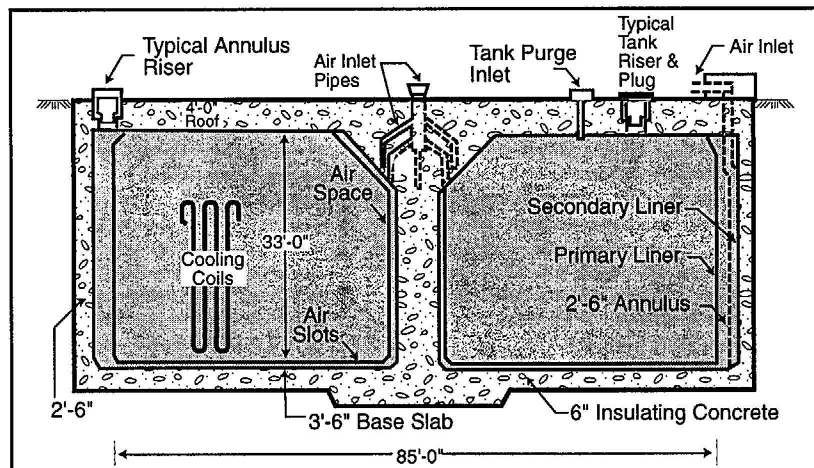


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

NW TANK/Grfx/Sum/S-5 Tank config.ai

Figure S-5. Tank configuration.

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 seasonal 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 this 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.

S.2.4 HIGH-LEVEL WASTE TANK CLOSURE

Tank closure would begin when bulk waste has been removed from an HLW tank system (a tank and its associated piping and equipment) for treatment and disposal.

DOE has reviewed bulk waste removal of waste 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.

In accordance with the SRS Federal Facility Agreement between DOE, EPA, and SCDHEC, DOE intends to remove the tanks from service as their storage missions are completed. DOE is obligated to close 24 tanks that do not meet the EPA's secondary containment standards under the Resource Conservation and Recovery Act (RCRA) by 2022. 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 them, which DOE currently anticipates would occur before the year 2030.

The HLW tank systems at SRS are operated in accordance with a permit issued by SCDHEC under the authority of the South Carolina Pollution Control Act as industrial wastewater treatment facilities. DOE is required to close the tank systems in accordance with AEA requirements (i.e., DOE Orders) and South Carolina Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This regulation requires that closures be carried out according to site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. DOE has adopted a general strategy for HLW tank system closure, set forth in the *Industrial Wastewater Closure Plan for the F- and H-Area High-Level Waste Tank Systems* (DOE 1996), known as the General Closure Plan. The General Closure Plan has been approved by SCDHEC.

The General Closure Plan identifies the resources (e.g., groundwater, air) 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 regulations and guidance that apply to the closures. It describes the use of fate and transport models to calculate potential environmental exposure concentrations or radiological dose rates from the residual waste left in the tank systems. The General Closure Plan describes the method DOE will use to make sure the impacts of closure of individual tank systems do not exceed the environmental standards that apply to the entire F - and H-Area Tank Farms. Chapter 7 of this EIS gives more detail on the development of the General Closure Plan and the environmental standards that apply to closure of the HLW tanks.

Performance Objective

Under the action alternatives, DOE will establish performance objectives for closure of each HLW tank. Each performance objective will correspond to an overall performance standard in the General Closure Plan and will ensure that the overall performance standard can be met. For example, if the performance standard for drinking water in the receiving stream is 4 millirem per year, the contribution from contaminants from all tanks will not exceed the 4-millirem-per-year-limit. DOE will evaluate closure options for specific tanks 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 (a tank-specific closure plan) for each HLW tank such that the performance objectives for the tank can be met. The Closure Module must be approved by SCDHEC before tank closure can begin.

Waste Incidental to Reprocessing

An important issue associated with tank closure, and a subject of controversy, is the determination of the regulatory classification of residual waste in the tanks. Before bulk waste removal, the content of the tanks is HLW. The goal of the bulk waste removal and subsequent cleaning of the tanks is to remove as much waste as can reasonably be removed.

In July 1999, DOE issued Order 435.1, Radioactive Waste Management, and the associated Manual and Implementation Guide. DOE Manual 435.1-1 prescribes two processes, by citation or by evaluation (see text box), for determining that waste resulting from reprocessing spent nuclear fuel can be considered "waste incidental to reprocessing."

Waste Incidental to Reprocessing Determination

The two processes for determining that waste can be considered incidental to reprocessing are "citation" and "evaluation." Waste incidental to reprocessing by "citation" includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission's Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as "waste incidental to reprocessing." 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).

Waste incidental to reprocessing by "evaluation" includes spent nuclear fuel processing plant wastes that meet the following three criteria: (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.

According to Order 435.1, waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed under DOE's regulatory authority in accordance with requirements for transuranic waste or low-level waste, as appropriate.[2] Section 7.1.3 of this EIS discusses the waste incidental to reprocessing process in more detail.

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17. If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

After spray water washing is complete, DOE could use oxalic acid cleaning. Hot oxalic acid would be sprayed through the spray nozzles that were used for spray water washing.

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 (See Table S-1). Use of oxalic acid in an HLW tank would require successfully demonstrating that dissolution of HLW sludge solids by the acid would not create a potential for a nuclear criticality.

On the basis of performance and historical data, DOE believes that waste removal meets the Criteria 2 and 3 requirements of the evaluation process for determining that waste can be considered "waste incidental to reprocessing" (see text box). In addition, waste removal followed by spray water washing, meets the Criterion 1 requirement for removal of key radionuclides to the extent "technically and economically practical" (DOE Order 435.1). If Criteria 2 or 3 could not be met, enhanced cleaning methods such as additional water washes or oxalic acid cleaning could be employed. However, DOE considers that oxalic acid cleaning beyond the extent needed to meet performance objectives is not "technically and economically practical" within the meaning of DOE Order 435.1, for reasons discussed below.

In general, the economic costs of oxalic acid cleaning are quite high. DOE estimates that oxalic acid cleaning (including disposal costs) per tank would cost approximately $1,050,000.

DOE considers that performance of bulk waste removal and spray washing, which together result in removal of 98% to 99% of the total curies and over 99% of the volume of waste, constitutes the limit of what is economically and technically practicable for waste removal (DOE Response to U.S. Nuclear Regulatory Commission Additional Questions on SRS HLW Cover Tank Closure, April 1999). However, DOE recognizes that enhanced waste removal operations may be required for some tanks and is committed to performing the actions necessary to meet "incidental waste" determination and performance objectives. DOE further recognizes that, if it could not clean the tank components sufficiently to meet the waste incidental to reprocessing criteria, it would need to examine alternative disposition strategies. Alternatives could include disposal in place as high-level waste (which is not contemplated in DOE Order 435.1), development of new cleaning technologies, or packaging the cleaned tank pieces and storing them until DOE could ship them to a geologic repository for disposal. A geologic

[2] The Natural Resources Defense Council (NRDC) has filed a Petition in the Court of Appeals for the Ninth Circuit asking the Court to review DOE Order 435.1 and claiming that the Order is "arbitrary, capricious, and contrary to law." The Nuclear Regulatory Commission, in responding recently to a separate petition from the NRDC, has concluded that DOE's commitments to (1) clean up the maximum extent technically and economically practical, and (2) meet performance objectives consistent with those required for disposal of low level waste, if satisfied, should serve to provide adequate protection of public health and safety (65 FR 62377, October 18, 2000).

Table S-1. Tank 16 waste removal process and curies removed with each sequential step.

Sequential Waste Removal Step	Curies Removed	% of Curies Removed	Cumulative Curies Removed	Cumulative Percent Curies Removed
Bulk Waste Removal	2.74×10^{6}	97%	2.74×10^{-6}	97
Spray Water Washing	2.78×10^{4}	0.98%	2.77×10^{-6}	97.98
Oxalic Acid Wash & Rinse	5.82×10^{4}	2%	2.83×10^{-6}	99.98

repository has not yet been approved and waste acceptance criteria have not yet been finalized.

The potential for nuclear criticality is one significant technical constraint on the practicality of oxalic acid cleaning. Also, extensive use of oxalic acid cleaning could affect downstream waste processing activities (DWPF and salt disposition). The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect the quality of the glass, and special batches of the salt disposition process could be required to control the sodium oxalate concentration.

Nine HLW tanks have leaked measurable amounts of waste from primary containment to secondary containment with only one leaking to the soil surrounding the tanks. For these tanks, the waste would be removed from the secondary containment using water and/or steam. Such cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only about 70 percent completed, because salts mixed with sand (from sandblasting of tank welds) made salt removal more difficult. Cleaning of the secondary containment is not a demonstrated technology and new techniques may need to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

S.3 NEPA Process

NEPA provides Federal decisionmakers with a process to use when considering the potential environmental impacts of proposed actions and alternatives. This process also provides several ways the public can be informed about and influence the selection of an alternative.

In 1995, DOE began preparations for closure of the HLW tanks. DOE prepared the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*. At the same time, DOE prepared the *Environmental Assessment for the Closure of the High-Level Waste Tanks in F- and H-Areas at the Savannah River Site*. In a Finding of No Significant Impact signed on July 31, 1996, DOE concluded that closure of the HLW tanks in accordance with the General Closure Plan would not result in significant environmental impacts. Since that time DOE has closed Tanks 17 and 20.

DOE re-examined the 1996 Tank Closure Environmental Assessment and has decided to prepare an EIS before any additional HLW tanks are closed at SRS. This decision was based on several factors, including a desire to explore the environmental impacts from closure and to open a new round of information sharing and dialogue with stakeholders. In the December 29, 1998, Federal Register, DOE published a Notice of Intent (NOI) to prepare an EIS on closure of the HLW tanks. Publication of the NOI began a 45-day public scoping period. DOE held public scoping meetings on January 14, 1999, in North Augusta, South Carolina, and on January 19, 1999, in Columbia, South Carolina. DOE considered comments received during the scoping period in preparing this Draft EIS. The comments, along with DOE's responses, are given in Appendix D of this EIS and briefly summarized here.

DOE received three comment letters, one E-mail, seven oral comments at the public scoping meetings, and one Recommendation from the

SRS Citizens Advisory Board. DOE identified 36 separate comments in these submittals and presentations.

Several comments related to the alternatives for closing the HLW tanks and suggested additional alternatives. One expressed the opinion that any alternative premised on "reclassification" of the residual waste in the tanks as waste incidental to reprocessing violated the Nuclear Waste Policy Act of 1982. DOE believes that the alternatives suggested by the commentors were substantially the same as the alternatives DOE proposed to evaluate. In regard to the waste incidental to reprocessing comment, it is within the scope of DOE's authority and responsibilities under the AEA to establish and carry out a procedure for determining if residual waste may be managed as transuranic or low-level waste. DOE's procedure is found in DOE Order 435.1 and the accompanying Manual 435.1-1.

Commentors suggested that certain data be included in the EIS, including the total volume of waste and the total amount of each chemical and radionuclide that DOE expected to remain in the tanks as residual waste. DOE has included this information in the EIS.

Several comments suggested evaluations to be performed. DOE has provided reasons for not using certain evaluation methods suggested by commentors (see Appendix D of the EIS).

Commentors were also concerned with the application of certain laws, regulations, and criteria, particularly the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), RCRA, the Nuclear Waste Policy Act, and South Carolina's regulations. DOE has provided responses to each of the comments in Appendix D of the EIS. In addition, Chapter 7 of the EIS provides a review of laws, regulations, and DOE Orders that apply to the closure of the HLW tanks.

Commentors were concerned about the EIS schedule and process as it relates to closure of the HLW tanks. DOE will complete the EIS process before closing any additional waste tanks at SRS. In addition, preparation of the EIS will not interfere with the established schedule for closure of the HLW tanks.

One commentor wanted to know if the tanks being considered for closure were the same tanks that have leaked in the past. All tanks that have leaked are inactive, meaning they do not receive fresh waste, and none of them are continuing to leak. Most of these tanks currently store sludge, salt, or both. In cases where liquid high-level waste is stored, the waste level is below the known leak sites. In accordance with the SRS Federal Facility Agreement, DOE is obligated to close all of these tanks by 2022. One of the tanks that already leaked, Tank 20, has already been closed.

One commentor was concerned about the process for removing sludges from the HLW tanks. The EIS describes the processes that were used for cleaning Tanks 17 and 20 and those that will be used in the future. DOE also acknowledges that new technologies may be useful in the future for removing sludges from the HLW tanks.

One commentor observed that new missions would add to the amount of HLW and prolong the closure process. 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.

S.4 Purpose and Need

DOE needs to reduce human health and safety risks at and near the HLW tanks, and to reduce the eventual introduction of contaminants into the environment. If DOE does not take action after bulk waste removal, the tanks would fail and contaminants would be released to the environment. Failed tanks would present the risk of accidents to individuals. Release of contaminants to the environment would present human health risks, particularly to individuals who might use contaminated water, in addition to adverse impacts to the environment.

S.5 Decisions to be Based on This EIS

This EIS provides an evaluation of the environmental impacts of several alternatives for closure of the HLW tanks at SRS. The closure process will take place over a period of up to 30 years. The EIS provides the decisionmaker with an assessment of the environmental, health and safety effects of each alternative. The selection of a tank closure alternative, following completion of this EIS, will guide the selection and implementation of a closure method for each HLW tank at SRS. Within the framework of the selected alternative, and the environmental impact of closure described in the EIS, DOE will select and implement a specific closure method for each tank.

In addition to the closure methods and impacts described in this EIS, the tank closure program will operate under a number of laws, regulations, and regulatory agreements described in Chapter 7 of this EIS. In addition to the General Closure Plan (a document prepared by DOE based on responsibilities under the AEA and other laws and regulations and approved by SCDHEC), the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. Each Closure Module will incorporate a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving each Closure Module, DOE will select a closure method that is consistent with the closure alternative selected after completion of this EIS. The selected closure method for each tank will result in the closure of all tanks with impact on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. DOE would conduct the appropriate NEPA review for any proposal to use a new technology.

S.6 Proposed Action and Alternatives

DOE proposes to close the HLW tanks at SRS in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* approved by SCDHEC, which specifies the management of residuals as waste incidental to reprocessing. The proposed action evaluated in this EIS would begin when bulk waste removal has been completed. Under each alternative except No Action, DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines.

DOE is evaluating three alternatives in this EIS.

Tank Closure Alternatives

Implementation of each alternative would start following bulk waste removal and SCDHEC approval of a tank-specific Closure Module that is protective of human health and the environment.

- Clean with water and fill the tanks with grout (Preferred Alternative). If necessary to meet the performance objectives, oxalic acid cleaning could be used. The use of sand or saltstone as fill material would also be considered.
- Clean and remove the tanks for disposal in the SRS waste management facilities
- No Action. Leave the tank systems in place without cleaning or stabilizing, following bulk waste removal.

S.6.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

Following bulk waste removal, DOE would clean the tanks to remove as much additional waste as can reasonably be removed and fill the tanks with a material that would bind up remaining residual waste and prevent future collapse of the tanks. DOE considers three options for tank stabilization under this alternative:

- Fill with Grout (Preferred Alternative)
- Fill with Sand
- Fill with Saltstone

In the evaluation and cleaning phase of tank closure each tank system or group of tank systems would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal and spray water washing. This information would be used to conduct a performance evaluation as part of the preparation of a Closure Module. In the evaluation DOE would consider: (1) the types of contamination in the tank and the configuration of the tank system, and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods, and comparing the modeling results with the performance objectives developed in the General Closure Plan. If the modeling shows that performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

If the modeling shows that the performance objectives would not be met, additional cleaning steps (such as additional water spray washing, oxalic acid cleaning, or other cleaning techniques) would be taken until enough waste had been removed that the performance objectives could be met. DOE estimates that oxalic acid cleaning could be required on as many as three-quarters of the tanks to meet performance objectives.

Tank Stabilization

After DOE would clean a tank and demonstrate that the performance objectives could be met, SCDHEC would approve a Closure Module. The tank stabilization process would then begin. Each tank system (including the secondary containment, for those that have one) would be filled with a pumpable, self-leveling backfill material. DOE's preferred option is to use grout, a concrete-like material, as backfill. The grout would be trucked to an area near the tank farm, batched if necessary, and pumped to the tank. The fill material would be high enough in pH to be compatible with the carbon steel walls of the waste tank. The grout would be formulated with chemical properties that would retard the movement of radionuclides in the residual waste in the closed tank. Therefore, the closure configuration for each tank or group of tanks would be determined on a case-by-case basis through development of the Closure Module.

Using the preferred option of grout as fill material, the grout would be poured in three distinct layers as illustrated in Figure S-6. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high-strength grout to deter inadvertent intrusion from drilling.

If DOE were to choose another fill material (sand or saltstone) for a tank system, all other aspects of the closure process would remain the same, as described above.

Sand is readily available and inexpensive. Its emplacement is more difficult than grout because it does not flow readily into voids. Any equipment or piping left on or inside the tank that might require filling (to eliminate voids inside the device) might not be adequately filled. Over time, the sand would tend to settle in the tank, creating additional void spaces. The dome of the tank would then become unsupported and would sag and crack. The sand would tend to

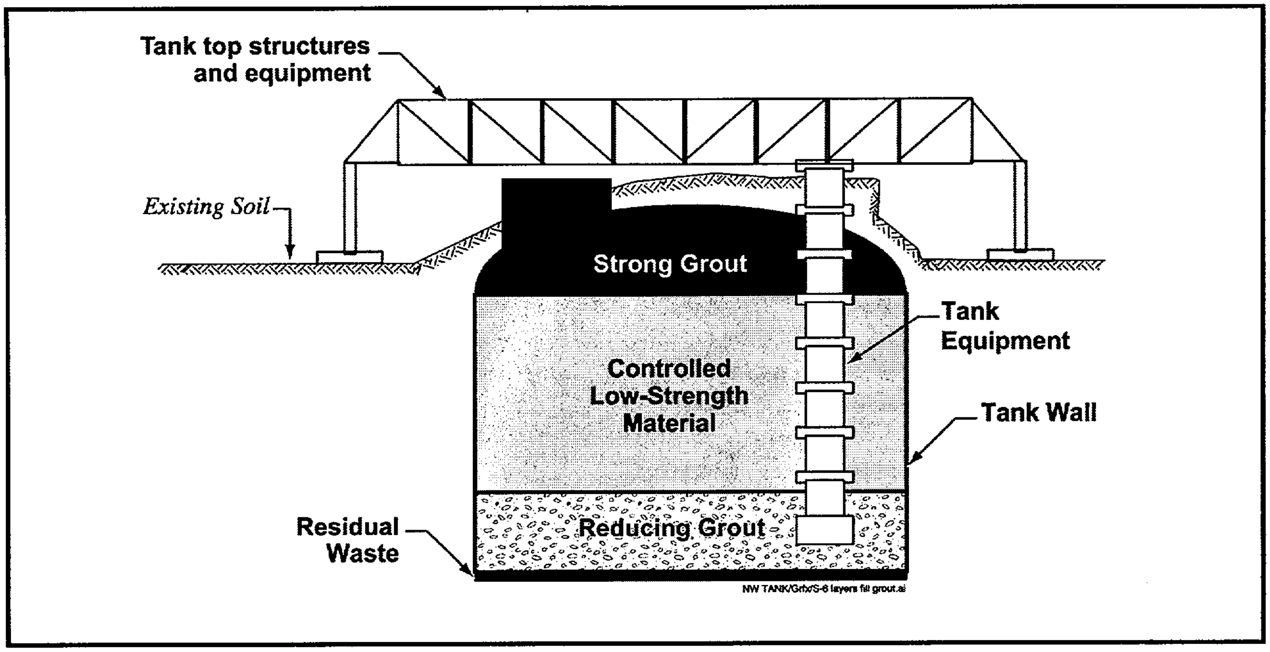


Figure S-6. Typical layers of the fill with grout option.

isolate the contamination from the environment to some extent, limit the amount of settling of the tank top after failure, and prevent wind from spreading the contaminants. Nevertheless, water would flow readily through the sand. Sand is relatively inert and could not be formulated to retard the migration of radionuclides. Thus, expected contamination levels in groundwater and surface water streams resulting from migration of residual contaminants would be higher than the levels for the preferred option.

Saltstone could also be used as fill material. Saltstone is the low-radioactivity fraction of HLW mixed with cement, flyash, and slag to form a concrete-like mixture. Saltstone is normally disposed of as low-level waste in the SRS Saltstone Disposal Facility. This alternative would have the advantage of reducing the amount of Saltstone Disposal Facility area that would be required. Filling the tank with a grout mixture that is contaminated with radionuclides, like saltstone, would considerably complicate the project and increase worker radiation exposure, which would increase risk to workers and add to the cost of closure. In addition, the saltstone would contain large quantities of nitrate that would not be present in the tank residual.

Because nitrates are very mobile in the environment, these large quantities of nitrate would adversely impact the groundwater near the tank farms over the long term.

Following the use of any of the stabilization options described above, 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 the tanks that could facilitate degradation of the tank structure.

S.6.2 CLEAN AND REMOVE TANKS ALTERNATIVE

The Clean and Remove Tanks Alternative would include cleaning the tanks, cutting them up in situ, removing them from the ground, and transporting tank components for disposal in an engineered disposal facility at another location on SRS. This alternative has not been demonstrated on HLW tanks.

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning beyond that contemplated for the other action alternatives, until tanks were clean enough to be safely removed and could meet waste acceptance criteria at SRS Low-Level Waste Disposal Facilities. Worker exposure would have to be As Low As Reasonably Achievable to ensure protection of the individuals required to perform the tank removal operations. This might require the use of cleaning technologies such as oxalic acid cleaning, mechanical cleaning, and additional steps as yet undefined on most of the tanks. DOE considers that these additional actions on so many tanks are not "technically and economically practical" within the meaning of DOE Order 435.1 because of criticality safety concerns associated with acidic cleaning solutions, potential interference with downstream waste processing activities, and high cost.

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal. During cutting and removal operations, steps would be taken and technologies employed to limit both emissions and exposure of workers to radiation. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the tank components. 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.

With removal of the tanks, backfilling of the excavations left after the removal would be required. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

S.6.3 NO ACTION ALTERNATIVE

For HLW tanks, the No Action Alternative would involve leaving the tank systems in place after bulk waste removal has taken place. Even after bulk waste removal, each tank would contain residual waste and, in those tanks that reside in the water table, ballast water. The tanks would not be backfilled.

After some period of time (probably hundreds of years), the reinforcing bar in the roof of the tank would rust and the roof would fail, causing the structural integrity to degrade. Similarly, the floor and walls of the tank would degrade over time. Rainwater would pour into the exposed tank, flushing contaminants from the residual waste in the tanks and eventually carrying these contaminants into the groundwater. Contamination of the groundwater would occur much more quickly than it would if the tank were backfilled and the residual waste bound with the backfill material.

S.7 Alternatives Considered, But Not Analyzed

S.7.1 MANAGEMENT OF TANK RESIDUALS AS HIGH-LEVEL WASTE

The alternative of managing the tank residuals as HLW is not preferred, in light of the requirements embodied in the State-approved General Closure Plan for a regulatory approach based on the designation of the residuals as waste incidental to reprocessing.

The waste incidental to reprocessing designation does not create a new radioactive waste type. The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying waste streams that might otherwise be considered HLW due to their origin, but are actually low-level or transuranic waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. The goal of the waste incidental to reprocessing determination process is to safely manage a limited number of reprocessing waste streams that do not warrant geologic repository disposal because of their low threat to human health or the environment. Although the technical alternatives of managing tank residuals under the General Closure Plan would likely be the same as those that would apply to managing residuals as HLW, the application of regulatory requirements would be different.

As described in the General Closure Plan, DOE will meet the waste incidental to reprocessing requirements of DOE Manual 435.1-1, which entail a step for removing key radionuclides to the extent that is technically and economically practical, a step for incorporating the residues into a solid form, and a process for demonstrating that appropriate disposal performance objectives are met. The technical alternatives evaluated in the EIS represent a range of tank cleaning and stabilization techniques. The radionuclides in residual waste would be the same whether the material is HLW, low-level waste, or transuranic waste; however, the regulatory regime would be different.

DOE must demonstrate its ability to meet certain performance objectives before SCDHEC will approve a Closure Module. Appendix C of the General Closure Plan describes the process DOE used to determine the performance objectives (dose limits and concentrations established to be protective of human health) incorporated in the General Closure Plan. As described in Chapter 7 of this EIS, DOE will establish performance standards for the closure of each HLW tank. In the General Closure Plan, DOE considered dose limits and concentrations found in current (40 CFR 191, 10 CFR 60) and proposed (40 CFR 197, 10 CFR 63) HLW management requirements in defining the performance standards. DOE considered the HLW management dose limits and concentrations as performance indicators of the ability to protect human health and the environment, even though the residual would not be considered HLW. That evaluation (described in Appendix C of the General Closure Plan) identified numerical performance standards (concentrations or dose limits for specific radiological or chemical constituents released to the environment) based on the requirements and guidance. Those numerical standards apply to all exposure pathways and to specific media (air, groundwater, and surface water), at different points of compliance, and over various periods during and after closure.

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be managed as HLW. The technical alternatives for managing the residues as HLW, however, would be the same as those for managing the residues under the LLW requirements. Thus, DOE expects that the potential environmental impacts that could result from managing the residues under the LLW requirements would be representative of the impacts if the HLW standards were applicable. For these reasons, this EIS does not present the management of tank residues as HLW as a separate alternative.

S.7.2 OTHER ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

DOE considered the alternative of delaying closure of additional tanks, pending the results of research. For the period of delay, the impacts of this approach would be the same as the No Action Alternative. DOE continues to conduct research and development efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of delaying closure.

DOE considered an alternative that would represent grouting of certain tanks and removal of others. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet performance requirements for a given tank, the decisionmakers may elect to remove a tank if it is not possible to meet the performance requirements by using another method. This EIS captures the environmental and health and safety impacts of both options.

S.8 Comparison of Environmental Impacts among Alternatives

Closure of the HLW tanks would affect the environment, as well as human health and safety, during the period of time when work is being done to close the tanks and after the tanks have been closed. For this EIS, DOE has defined the period of short-term impacts to be from the year 2000 through about 2030, or the period during which the HLW tanks would be closed. Long-term impacts would be those resulting from the eventual release of residual waste contaminants from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

S.8.1 SHORT-TERM IMPACTS

DOE evaluated short-term impacts of the tank closure alternatives (Note – the preferred alternative is one of the options) on a number of environmental media. DOE also characterized the employment required for each alternative and estimated the cost to close an HLW tank using each alternative and option.

DOE compared impacts in the following areas:

- Geologic and Water Resources
- Nonradiological Air Quality
- Radiological Air Quality
- Ecological Resources
- Land use
- Socioeconomics
- Cultural Resources
- Worker and Public Health Impacts
- Environmental Justice
- Transportation
- Waste Generation
- Utilities and Energy Consumption
- Accidents

In general, the No Action alternative has the least impact on the environment over the short term, the Clean and Remove Tanks alternative has the greatest, and the impacts of the Clean and Stabilize Tanks alternative fall in between. Table S-2 shows those areas in which there are notable differences in impacts among the alternatives.

For the short term, No Action means continuing normal tank farm operations, including waste transfers, but not closing any tanks. The impacts, in terms of radiological and nonradiological air and water emissions and human health and safety, are the least of the three alternatives and in all cases are very small.

The primary health effect of radiation is the increased incidence of cancer. Radiation impacts on workers and public health are expressed in terms of latent cancer fatalities. A radiation dose to a population is estimated to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The EPA has established dose-to-risk conversion factors of 0.0005 per person-rem for the general population and 0.0004 per person-rem for workers. The difference is due to the presence of children, who are believed to be more susceptible to radiation, in the general population.

DOE estimates the doses to the population and uses the conversion factor to estimate the number of cancer fatalities that might result from those doses. In most cases, the result is a small fraction of one. For these cases, DOE concludes that the action would very likely result in no additional cancer in the exposed population.

Over the short term, the Clean and Remove Tanks alternative has significantly greater impacts than the other alternatives. This is particularly notable in worker exposure to radiation and the resultant cancer fatalities, and in the numbers of on-the-job injuries. DOE's analysis estimates that implementation of the Clean and Remove Tanks alternative would result in about five cancer fatalities in the worker population, while the estimate for the Clean and Stabilize Tanks alternative is less than one, and the estimate for No Action is essentially zero. The Clean and Remove Tanks alternative would result in the generation of twice as much liquid radioactive waste and about 15 times as much low-level waste as the Clean and Stabilize Tanks alternative. The waste generation would be the result of the cleaning activities required to clean the tanks so they could be removed from the ground, and from disposal of the tanks as low-level waste at another location on the Savannah River Site.

The labor and waste disposal requirements of the Clean and Remove Tanks alternative would result in a cost of more than $100 million per tank, compared to about $6.3 million for the most costly option (Clean and Fill with Saltstone) of the Clean and Stabilize Tanks alternative. While the Clean and Remove Tanks Alternative would

Table S-2. Comparison of short-term impacts by tank closure alternative.

Parameter	No Action Alternative	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
Geologic Resources **Soil backfill (m^3)**	None	170,000	170,000	170,000	356,000
Air Resources					
Nonradiological air emissions (tons/yr.):					
Particulate matter	None	4.5	3.1	3.6	None
Carbon monoxide	None	5.6	5.6	16.0	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$)[a]:					
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Annual radionuclide emissions (curies/year):					
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4[b]	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Occupational Health and Safety:					
Recordable injuries-closure	110[c]	120	120	190	400
Lost workday cases-closure	60[c]	62	62	96	210

Table S-2. (Continued).

Parameter	No Action Alternative	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
Transportation (offsite round-trip truckloads per tank)	0	654	653	19	5
Waste Generation					
Maximum annual waste generation:					
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Low-level waste (m^3)	0	60	60	60	900
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Low-level waste (m^3)	0	1,284	1,284	1,284	19,260
Mixed low-level waste (m^3)	0	257	257	257	428
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

a. No exceedances of air quality standards are expected.
b. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.
c. For the No Action Alternative, recordable injuries and lost workday cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.
NA = Not available.

effectively eliminate the future radiation dose at the seepline, under the Preferred Alternative this seepline dose would be within the 4 millirem per year drinking water standard, which would equate to 0.000002 latent cancer fatality. Thus, DOE would spend $4.9 billion (for all 49 HLW tanks) to reduce a projected dose that already would be less than 4 millirem. This alternative would result in about 12,000 person-rem (4.9 latent cancer fatalities) within the population of SRS workers performing these activities. DOE believes that the incremental benefits of oxalic acid cleaning do not warrant the high costs associated with using this cleaning method on all tanks.

There are some differences in impacts among the three options of the Clean and Stabilize Tanks alternative in the short term, but none are significant. The Clean and Fill with Grout option would use about four times as much water (from groundwater sources) than the other options. The Clean and Fill with Saltstone option would employ the most workers and result in more occupational injuries and a very slightly increased risk of cancer fatalities for workers. It would also be the most costly of the three options.

DOE evaluated the impacts of potential accidents related to each alternative. The highest consequence accidents would be transfer errors (spills) and seismic events during cleaning. Both of these accidents could happen during cleaning under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative, and there is no difference in the consequences.

S.8.2 LONG-TERM IMPACTS

In the long term, the important impact to consider is the effect on the environment and human health of residual waste contaminants that will eventually find their way to the accessible environment. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a period of 10,000 years to determine when certain impacts (e.g., radiation dose and the associated health effects) would reach their peak value. Table S-3 shows those areas in which there are notable differences in impacts among the alternatives.

Any waste that migrates through the groundwater and outcrops at a stream location (called a "seepline" in the EIS) would result in radiological doses and possible consequent health effects to individuals exposed to water containing the contaminants. For H-Area, the seepline along Upper Three Runs and Fourmile Branch is about 1,200 meters downgradient from the center of the tank farm while, for F-Area, the seepline is about 1,800 meters downgradient from the tank farm (see Figure S-1). Because of the long travel time from the closed and stabilized tank to the groundwater outcrop, the impacts would be substantially reduced compared to what they might have been if the contaminants came into the accessible environment more quickly. This can be seen clearly by comparing the long-term impacts of the No Action Alternative to the impacts of the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative. Figure S-7 graphically illustrates this.

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tank systems themselves would be removed and transported to SRS radioactive waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217).

The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are about one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health. Under this alternative, some land in E-Area would be permanently committed to disposal and would therefore be unavailable for other uses or for ecological habitat. After removal of the tanks and subsequent CERCLA actions, some land and habitats could become available for other uses or habitat.

Table S-3. Comparison of long-term impacts by tank closure alternative.[a]

Parameter	No Action Alternative	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
Surface Water	Limited movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters
Maximum dose from beta-gamma emitting radionuclides in surface water (millirem/year)				
Upper Three Runs	0.45	(b)	4.3×10^{-3}	9.6×10^{-3}
Fourmile Branch	2.3	9.8×10^{-3}	0.019	0.130
Groundwater				
Groundwater concentrations from contaminant transport – F-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline, Fourmile Branch (1,800 meters downgradient)	430	1.9	3.5	25
Groundwater concentrations from contaminant transport – H-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1×10^{5}
100-meter well	9.0×10^{4}	300	920	870
Seepline (1,200 meters downgradient): North of Groundwater Divide	2,500	2.5	25	46
South of Groundwater Divide	200	0.95	1.4	16
Maximum Groundwater Concentrations of Nitrates[c]				
1-meter well	270	21	22	440,000
100-meter well	69	4.7	4.9	180,000
Seepline	3.4	0.1	0.2	3,300

Table S-3. (Continued).

Parameter	No Action Alternative	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
Ecological Resources				
Maximum absorbed dose to aquatic and terrestrial organisms (in millirad per year):				
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265
Public Health				
Radiological contaminant transport from F-Area Tank Farm:				
Adult resident latent cancer fatality risk	2.2×10^{-4}	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}
Child resident latent cancer fatality risk	2.0×10^{-4}	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}
Seepline worker latent cancer fatality risk	2.2×10^{-7}	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}
Intruder latent cancer fatality risk	1.1×10^{-7}	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}
Adult resident maximum lifetime dose (millirem)[d]	430	1.9	3.6	26
Child resident maximum lifetime dose (millirem)[d]	400	1.7	3.3	24
Seepline worker maximum lifetime dose (millirem)[d]	0.54	0.002	0.004	0.03
Intruder maximum lifetime dose (millirem)[d]	0.27	0.001	0.002	0.02
Radiological contaminant transport from H-Area Tank Farm:				
Adult resident latent cancer fatality risk	8.5×10^{-5}	3.9×10^{-7}	5.5×10^{-7}	6.5×10^{-6}
Child resident latent cancer fatality risk	7.5×10^{-5}	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}
Seepline worker latent cancer fatality risk	8.4×10^{-8}	(e)	4.0×10^{-10}	6.8×10^{-9}
Intruder latent cancer fatality risk	4.4×10^{-8}	(e)	(e)	3.2×10^{-9}
Adult resident maximum lifetime dose (millirem)[d]	170	0.7	1.1	13
Child resident maximum lifetime dose (millirem)[d]	150	0.65	1.1	1.3
Seepline worker maximum lifetime dose (millirem)[d]	0.21	(b)	0.001	0.017
Intruder maximum lifetime dose (millirem)[d]	0.11	(b)	(b)	0.008

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the tank farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).
b. The radiation dose for this alternative is less than 1×10^{-3} millirem.
c. Given in percent of EPA Primary Drinking Water Maximum Contaminant Levels (MCL). A value of 100 is equivalent to the MCL concentration.
d. Calculated based on an assumed 70-year lifetime.
e. The risk for this alternative is less than 4.0×10^{-10}.

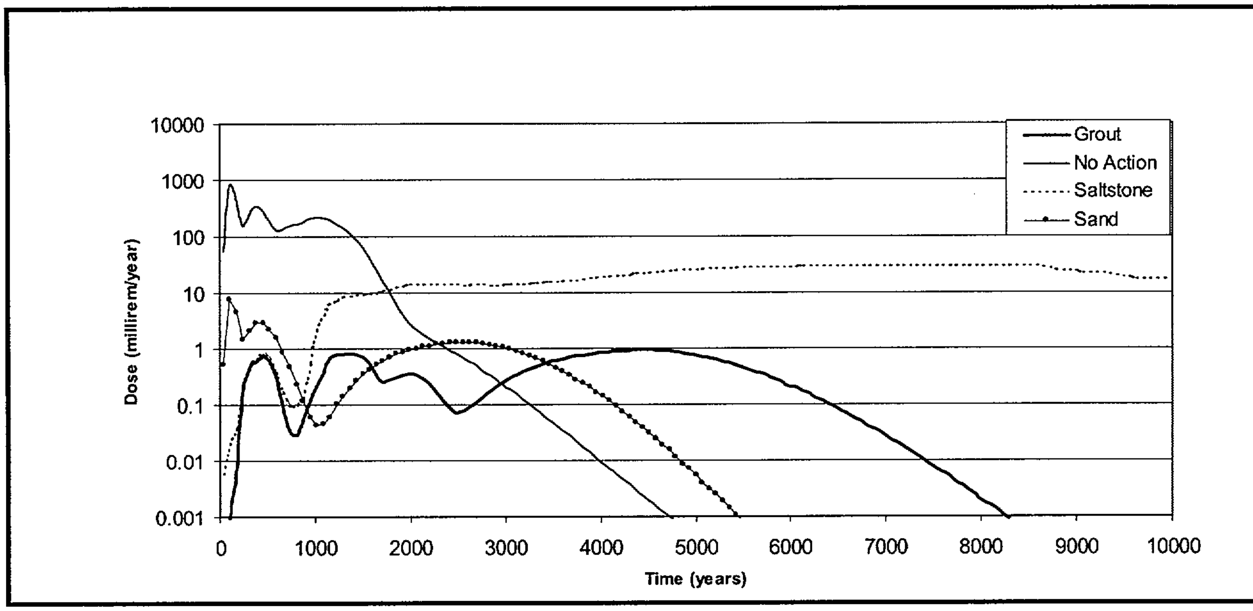


Figure S-7. Predicted Drinking Water Dose Over Time at the H-Area Seepline North of the Groundwater Divide in the Barnwell-McBean and Water Table Aquifers.

There are always uncertainties associated with the results of analyses, especially if the analyses attempt to predict impacts over a long period of time. These uncertainties could result from assumptions used, the complexity and variability of the process(es) being analyzed, the use of incomplete information, or lack of information.

The uncertainties involved in estimating impacts over the 10,000-year period analyzed in this EIS are described in Chapter 4 and Appendix C of the EIS. Over the long term, there would be limited movement of residual contaminants from the closed tanks to surface waters downgradient from the tanks under the No Action Alternative, and almost no such movement under the Clean and Fill with Grout Option under the Clean and Stabilize Tanks Alternative and an intermediate amount under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. The use of a stabilizing agent to retard the movement of residual contaminants under the Clean and Stabilize Alternative results in considerably lower long-term environmental impacts than the No Action Alternative, as described below.

Conservative modeling which exaggerates concentrations at wells close to the tank farms estimates that doses from groundwater at wells 1 meter and 100 meters distant from the tank farms, and at the seepline in Fourmile Branch, would be very large under the No Action Alternative. Under the Clean and Stabilize Tanks Alternative, doses would be much smaller, but incremental doses at the 100 meter well would still exceed the average annual dose a person living in South Carolina receives from natural and man-made sources. The same is true under all three options in the H-Area Tank Farm at the 100-meter well. The doses decrease substantially with distance from the tank farm.

The greatest long-term impacts occur under the No Action Alternative. For this alternative, the Maximum Contaminant Level for beta-gamma radionuclides is exceeded at all points of exposure. On the other hand, the Clean and Fill with Grout Option shows the lowest long-term impacts at all exposure points, and the Maximum Contaminant Level for beta-gamma radionuclides is met at the seepline for this alternative. Impacts for the Clean and Fill with Grout Option would occur later than under the No Action Alternative or the Clean and Fill with Sand Option. The Clean and Fill with Saltstone Option would delay the impacts at the seepline, but would. result in a higher peak dose than either the Clean and Fill with Grout or Clean and Fill with Sand Options

If, in the future, people were unaware of the presence of the closed waste tanks and chose to live in homes built over the tanks, they would have essentially no external radiation exposure under the Clean and Fill with Grout Option or the Clean and Fill with Sand Option. Residents could be exposed to external radiation under the Clean and Fill with Saltstone Option, due to the presence of radioactive saltstone near the ground surface. If it is conservatively assumed that all shielding material over the saltstone would be removed by erosion or excavation, at 1000 years after tank closure a resident living on top of a closed tank would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. For the No Action Alternative, external exposures to onsite residents would be expected to be unacceptably high, due to the potential for contact with residual waste.

The risk of incurring a fatal cancer as a result of radiation doses is also greater under the No Action Alternative than under any of the Options of the Clean and Stabilize Tanks Alternative. The preferred Option, Clean and Fill with Grout, would result in the least risk of a fatal cancer of all the Options under the Clean and Stabilize Tanks Alternative.

Effects on aquatic and terrestrial organisms are very large under the No Action Alternative, and two or three orders of magnitude less under the options of the Clean and Stabilize Tanks Alternative.

SRS personnel have prepared a report, referred to as the *Composite Analysis*, 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.

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. Any of these options under the Clean and Stabilize Tanks Alternative would render the tank farms areas least suitable for other uses, as the closed 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.

HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement

DEPARTMENT OF ENERGY
SAVANNAH RIVER OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA

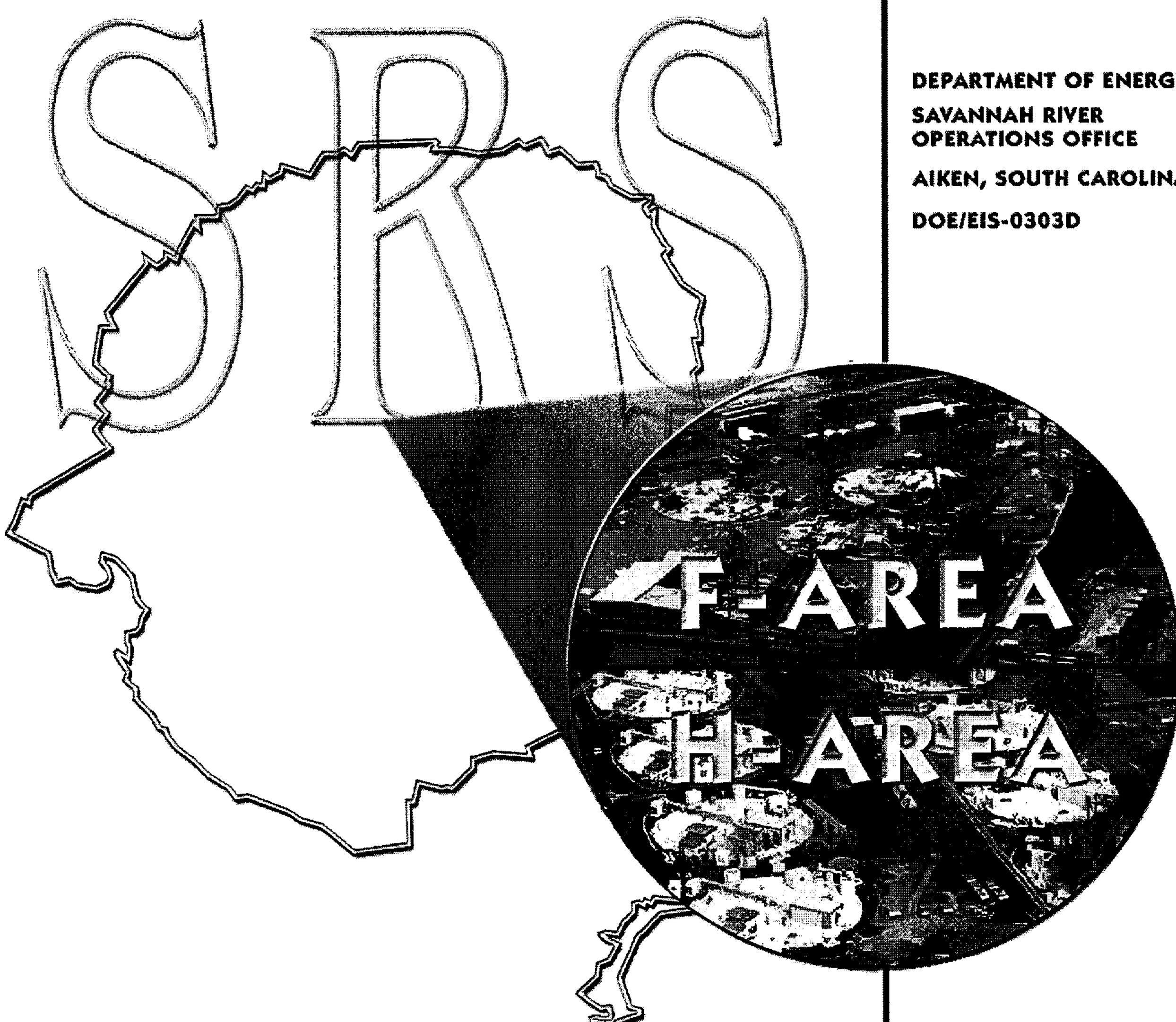
DOE/EIS-0303D

November 2000

DOE-SR
AIKEN, SC
DOE/EIS-0303D
Savannah River Site
Savannah River Site
HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement
November 2000

Savannah River Site

HIGH-LEVEL WASTE
TANK CLOSURE
Draft Environmental Impact Statement



DEPARTMENT OF ENERGY
SAVANNAH RIVER OPERATIONS OFFICE
AIKEN, SOUTH CAROLINA

DOE/EIS-0303D

November 2000

COVER SHEET

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

TITLE: Savannah River Site, High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE/EIS-0303D), Aiken, SC.

CONTACT: For additional information or to submit comments on this environmental impact statement (EIS), write or call:

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

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

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

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

ABSTRACT: DOE proposes to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (approved by the South Carolina Department of Health and Environmental Control), which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed. This EIS evaluates three alternatives regarding the HLW tanks at the SRS. The three alternatives are the Clean and Stabilize Tanks Alternative, the Clean and Remove Tanks Alternative, and the No Action Alternative. The EIS considers three options for tank stabilization: Fill with Grout (Preferred Alternative); Fill with Sand; and Fill with Saltstone.

Under each alternative (except No Action), DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines. Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic impacts, and cumulative impacts.

PUBLIC INVOLVEMENT: In preparing this Draft EIS, DOE considered comments received by letter and voice mail and formal statements made at public scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999.

A 45-day comment period on the Draft High-Level Waste Tank Closure EIS begins with the U.S. Environmental Protection Agency's publication of a Notice of Availability in the *Federal Register*. Public meetings to discuss and receive comments on the Draft EIS will be held on December 11, 2000 at the North Augusta Community Center, North Augusta, South Carolina, and on December 12, 2000 at the Adams Mark Hotel, Columbia, South Carolina. Comments may be submitted at the public meeting and by voice mail, e-mail, and regular mail to the first address above. Comments received or postmarked by the end of the comment period will be considered in the preparation of the final EIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

FOREWORD

The U.S. Department of Energy (DOE) published a Notice of Intent to prepare this environmental impact statement (EIS) on December 29, 1998 (63 FR 71628). As described in the Notice of Intent, DOE's proposed action described in this EIS is to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* approved by the South Carolina Department of Health and Environmental Control. This closure plan specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed and the tank system is turned over to the tank closure program. This EIS assesses the potential environmental impacts associated with alternatives for closing these tanks, as well as the potential environmental impacts of the residual radioactive and non-radioactive material remaining in the closed HLW tanks.

The Notice of Intent requested public comments and suggestions for DOE to consider in its determination of the scope of the EIS, and announced a public scoping period that ended on February 12, 1999. DOE held scoping meetings in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999. During the scoping period, individuals, organizations, and government agencies submitted 36 comments that DOE considered applicable to the SRS HLW tank closure program.

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

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

- Chapter 1 provides background information related to SRS HLW tank closures and describes the purpose and need for DOE action regarding HLW tank closure at the SRS.
- Chapter 2 identifies the proposed action and alternatives that DOE is considering for HLW tank closure at the SRS.
- Chapter 3 describes the existing SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives for both the short-term (from the year 2000 through final closure of the existing high-level waste tanks) and long-term (10,000 years post closure) timeframes.
- Chapter 5 discusses the cumulative impacts of HLW tank closure actions in relation to impacts of other past, present, and foreseeable future activities at the SRS.
- Chapter 6 identifies irreversible or irretrievable resource commitments.
- Chapter 7 discusses applicable statutory and regulatory requirements, DOE Orders, and agreements.
- Appendix A provides a description of the SRS HLW Tank Farms and the tank closure process.
- Appendix B provides detailed descriptions of accidents that could occur at SRS during HLW tank closure activities.

- Appendix C provides a detailed description of the fate and transport modeling used to estimate long-term environmental impacts.
- Appendix D describes public comments received during the scoping process and provides DOE responses.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Section | Page

TABLE OF CONTENTS (Continued)

List of Tables

TABLE OF CONTENTS (Continued)

List of Tables (Continued)

TABLE OF CONTENTS (Continued)

List of Tables (Continued)

TABLE OF CONTENTS (Continued)

List of Tables (Continued)

List of Figures

TABLE OF CONTENTS (Continued)

List of Figures (Continued)

ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

AAQS	ambient air quality standard
AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
CEQ	Council on E nvironmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLSM	controlled low-strength material
CO	carbon monoxide
D&D	decontamination and decommissioning
DBE	design basis event
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
IMNM	Interim Management of Nuclear Material
INEEL	Idaho National Engineering and Environmental Laboratory
ISO	International Organization for Standardization
LCF	latent cancer fatality
LEU	low enriched uranium
LWC	lost workday cases
MCL	maximum contaminant level

MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_X	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O_3	ozone
OSHA	Occupational Safety and Health Administration
PM_{10}	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO_2	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

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

Use of Scientific Notation

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

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

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

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

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

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

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

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

Metric Conversion Chart

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

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	$1\ 000\ 000\ 000\ 000\ 000\ 000 = 10^{18}$
peta-	P	$1\ 000\ 000\ 000\ 000\ 000 = 10^{15}$
tera-	T	$1\ 000\ 000\ 000\ 000 = 10^{12}$
giga-	G	$1\ 000\ 000\ 000 = 10^{9}$
mega-	M	$1\ 000\ 000 = 10^{6}$
kilo-	k	$1\ 000 = 10^{3}$
centi-	c	$0.01 = 10^{-2}$
milli	m	$0.001 = 10^{-3}$
micro-	μ	$0.000\ 001 = 10^{-6}$
nano-	n	$0.000\ 000\ 001 = 10^{-9}$
pico-	p	$0.000\ 000\ 000\ 001 = 10^{-12}$
femto-	f	$0.000\ 000\ 000\ 000\ 001 = 10^{-15}$
atto-	a	$0.000\ 000\ 000\ 000\ 000\ 001 = 10^{-18}$

CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

The Savannah River Site (SRS) occupies approximately 300 square miles adjacent to the Savannah River, primarily in Aiken and Barnwell Counties in South Carolina. It is approximately 25 miles southeast of Augusta, Georgia and 20 miles south of Aiken, South Carolina. The U.S. Atomic Energy Commission, a U.S. Department of Energy (DOE) predecessor agency, established SRS in the early 1950s. Until the early 1990s, the primary SRS mission was the production of special radioactive isotopes to support national programs. More recently, the SRS mission has emphasized waste management, environmental restoration, and decontamination and decommissioning of facilities that are no longer needed for SRS's traditional defense activities.

As a result of its nuclear materials production mission, SRS generated large quantities of highly corrosive and radioactive waste known as high-level waste (HLW). This waste resulted from dissolving spent reactor fuel and nuclear targets to recover the valuable isotopes.

1.1.1 HIGH-LEVEL WASTE DESCRIPTION

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "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 waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation." DOE M 435.1-1 also defines two processes for determining that a specific waste resulting from reprocessing spent nuclear fuel can be considered waste incidental to reprocessing (see Section 7.1.3). Waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing does not need to be managed as HLW, and shall be managed under DOE's regulatory authority in accordance with the requirements for transuranic waste or low-level waste, as appropriate.

1.1.2 HLW MANAGEMENT AT SRS

At the present time, approximately 34 million gallons of HLW are stored in 49 underground tanks in two tank farms, the F-Area Tank Farm and the H-Area Tank Farm. These tank farms are in the central portion of SRS. The sites were chosen in the early 1950s because of their proximity to the F- and H-Area Separations Facilities, and the distance (approximately 5.5 miles) from the SRS boundaries. Figure 1-1 shows the setting of the F and H Areas and associated tank farms.

The HLW in the tanks consists primarily of three physical forms: sludge, salt, and liquid. The sludge is solid material that precipitates and settles to the bottom of a tank. The salt is comprised of salt compounds[1] that have crystallized as a result of concentrating the liquid by evaporation. The liquid is highly concentrated salt solution. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks while others are considered salt tanks (containing both salt and salt solution).

The sludge portion of the HLW currently is being transferred to the Defense Waste Processing Facility (DWPF) for vitrification in borosilicate glass to immobilize the radioactive constituents as described in the *Defense Waste Processing Facility Supplemental Environmental Impact Statement* (DOE 1994). [The plan and schedule for managing tank space, mixing waste to create an appropriate feed for the DWPF, and remov-

[1] A salt is a chemical compound formed when one or more hydrogen ions of an acid are replaced by metallic ions. Common salt, sodium chloride, is a well-known salt.

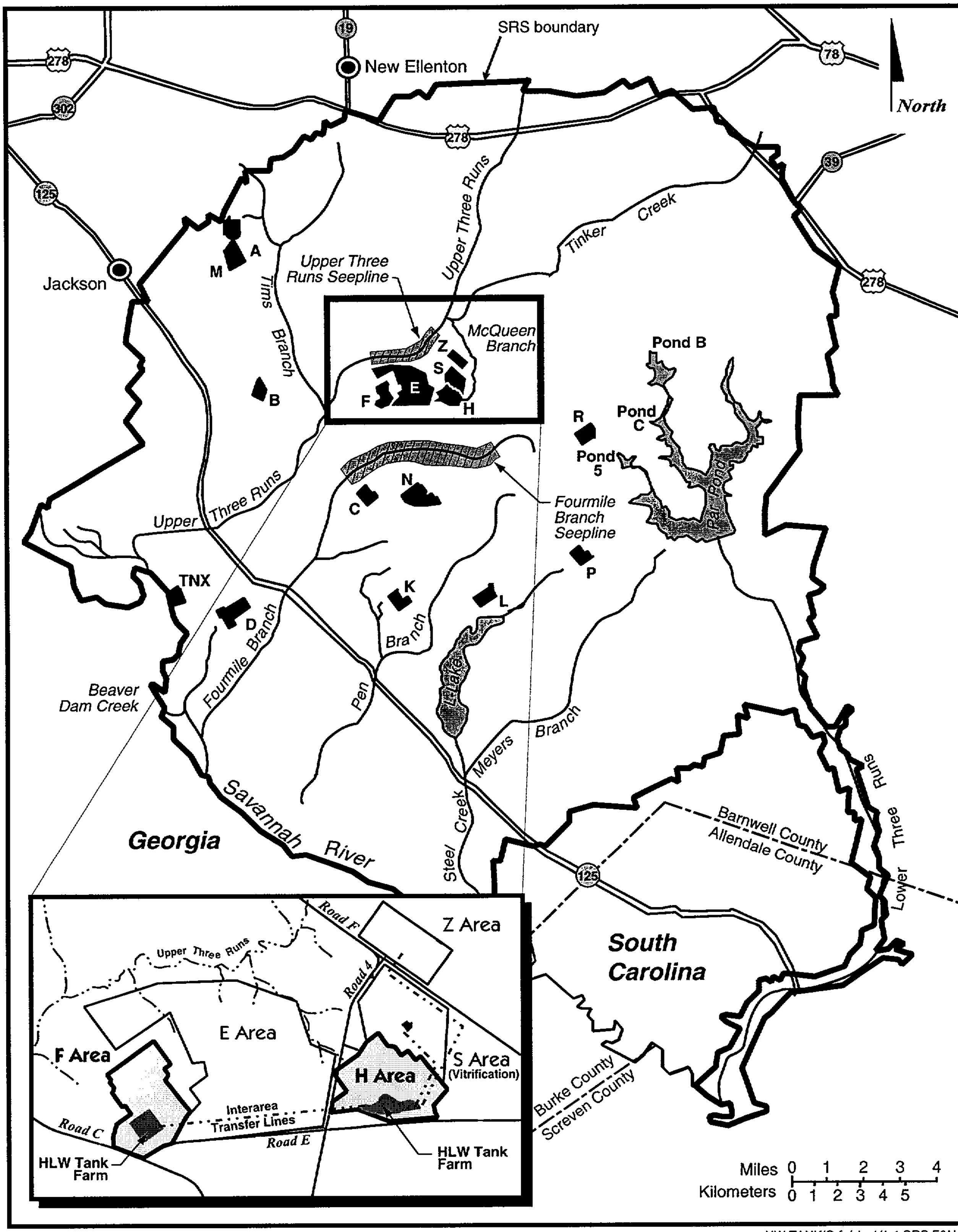


Figure 1-1. Savannah River Site map with F- and H-Areas highlighted.

ing bulk waste is contained in the *High Level Waste System Plan* (WSRC 1998 and subsequent revisions)]. The borosilicate glass is poured into stainless steel canisters that are stored in the Glass Waste Storage Building pending shipment to a geologic repository for disposal.

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. As described in DOE (1994), an In-Tank Precipitation process would separate the HLW into high- and low-activity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed in vaults at SRS. Since issuance of that EIS, 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; February 22, 1999). The process for separating the HLW is the subject of an on-going EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site.* Figure 1-2 shows the SRS HLW management system as currently configured.

1.1.3 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 (Tanks 17 and 20), 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure 1-3 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 Precipitation Process, the Extended Sludge Processing facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure 1-4 shows the general layout of the H-Area Tank Farm.

The F- and H-Area Tank Farms were constructed to receive high-level radioactive waste generated by various SRS production, processing, and laboratory facilities. The use of the tank farms isolates these wastes from the environment, SRS workers, and the public. In addition, the tank farms enable radioactive decay by aging the waste, clarification of waste by gravity settling, and removal of soluble salts from waste by evaporation. The tank farms also pretreat the accumulated sludge and salt solutions (supernate) to enable the management of these wastes at other SRS treatment facilities (i.e., Defense Waste Processing Facility (DWPF) and Z-Area Saltstone Manufacturing and Disposal Facility (SMDF). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal.

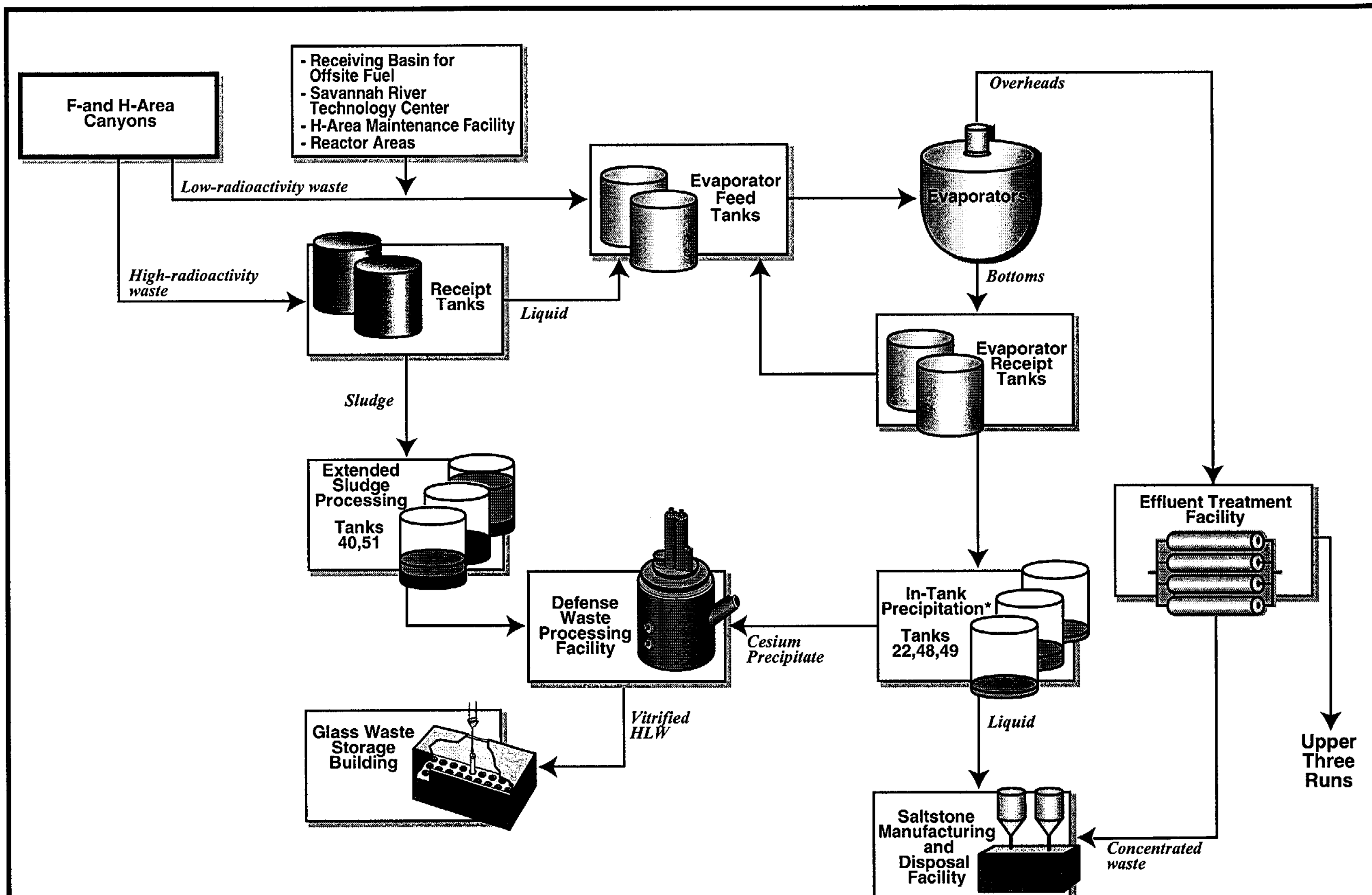
To accomplish the system operational objectives described above, the following units were assembled in the tank farms:

- Fifty-one large underground waste tanks to receive and age the waste, and allow it to settle

- Five existing evaporator systems to concentrate soluble salts and reduce the waste volume

- Transfer system (i.e., transfer lines, diversion boxes, and pump pits) to transfer supernate, sludge and other waste (e.g., evaporator condensate) between tanks and treatment facilities

- Precipitation/filtration system (i.e., ITP Facility) to separate the salt solution into high- and low-activity fractions for immobilization at the DWPF Vitrification Facility and Z-Area Saltstone Manufacturing and Disposal Facility, respectively [Operation of the ITP Facility was suspended in early 1998. DOE is currently evaluating alternate salt disposition technologies to replace the ITP process.]



*This process will be replaced. DOE is evaluating alternatives to this process in a separate EIS (see 64 FR 8559).

NW TANK/Grfx/1-2 Proc SRS HLW.ai

Figure 1-2. Process flows for Savannah River Site High-Level Waste Management System.

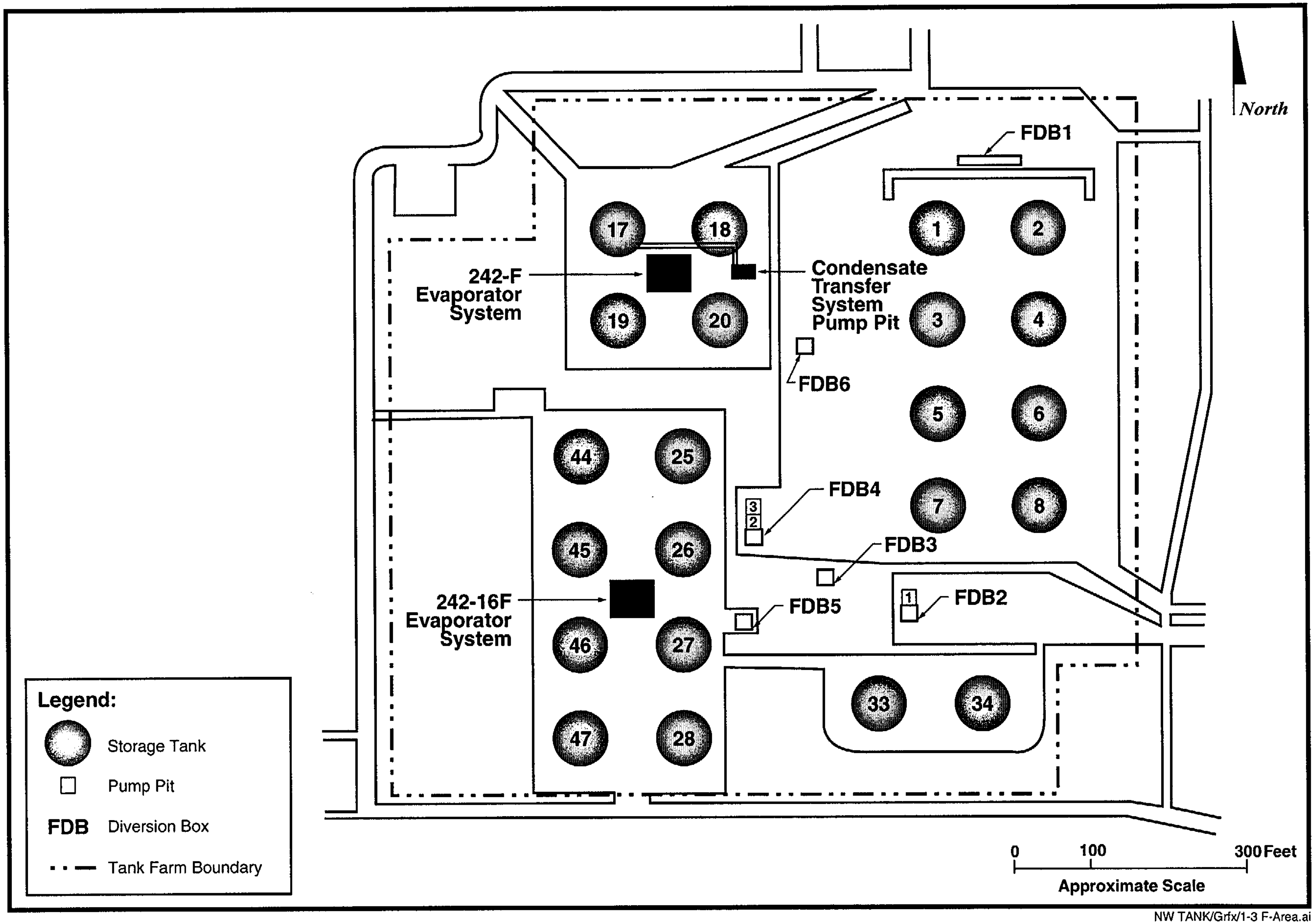
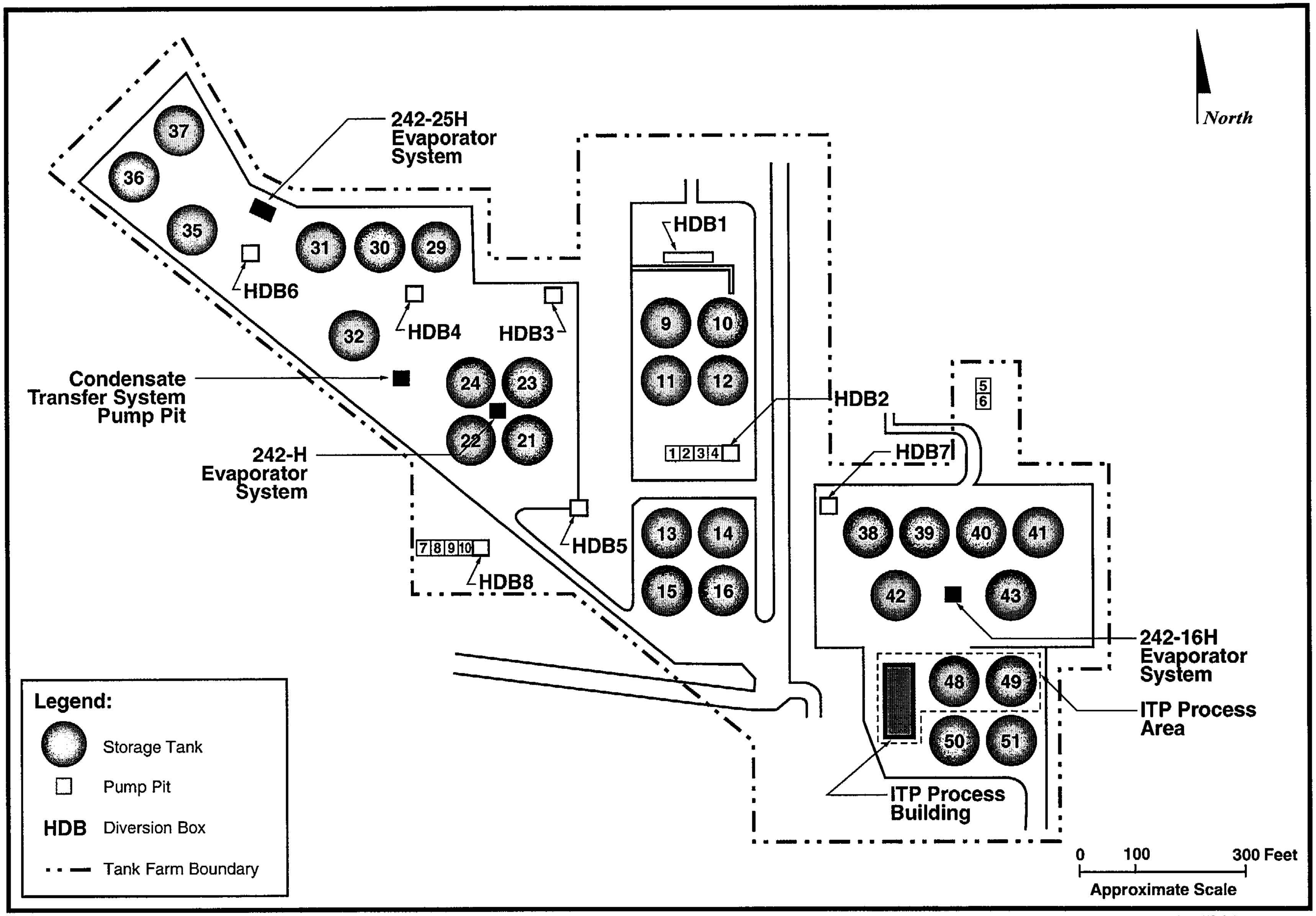


Figure 1-3. General layout of F-Area Tank Farm.



NW TANK/Grfx/1-4 H_Tank.ai

Figure 1-4. General layout of H-Area Tank Farm.

- Sludge washing system (i.e., Extended Sludge Processing) to pretreat the accumulated sludge prior to immobilization at the DWPF Vitrification Facility

Tanks

The F- and H-Area tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. Two designs (Types I and II) have 5-foot high secondary annulus "pans" and active cooling (Figure 1-5). (An "annulus" is the space between two walls of a double-walled tank.)

The 12 Type I Tanks (Tanks 1 through 12) were built in 1952 and 1953, five 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 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 1-5). All four have known leak sites in which waste leaked from primary to secondary containment. In Tank 16, the waste overflowed the annulus pan (secondary containment). 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. Much of the leaked waste was removed from the annulus during the period 1976 to 1978; however, several thousand gallons remain in the annulus. Waste removal from the Tank 16 primary vessel was completed in 1980. 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.

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 1-5). 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 corrosion of the tank wall from occasional groundwater inundation from fluctuation in the water table. 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 construction of the tank area. Tanks 17 and 20 have already been closed in a manner described in the Clean and Fill with Grout option of the Clean and Stabilize Tanks Alternative evaluated in this EIS (see Section 2.1.1).

The newest design (Type III) has a full-height secondary tank and active cooling (Figure 1-5). All of the Type III tanks (25 through 51) are above the water table. 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. None of them has known leak sites.

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. 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, which DOE currently anticipates would occur before the year 2030.

Summary information on the F-and H-Area HLW tanks is presented in Table 1-1.

Evaporator Systems

Each tank farm has two evaporators that concentrate waste following receipt from the canyons. At present, two evaporators are operating, one in each tank farm. Each operating evaporator is made of stainless steel and operates at near

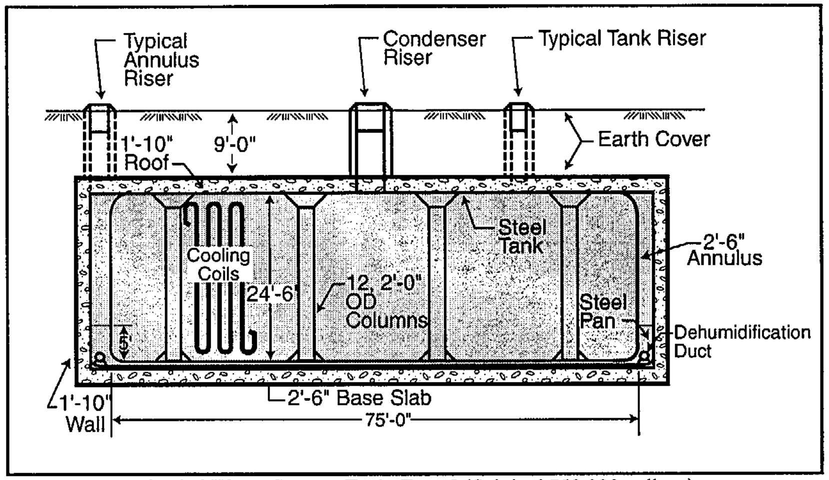


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

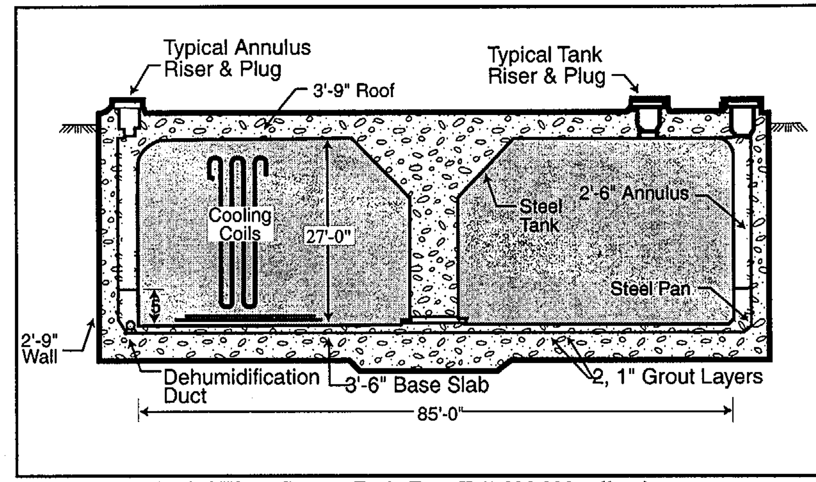


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

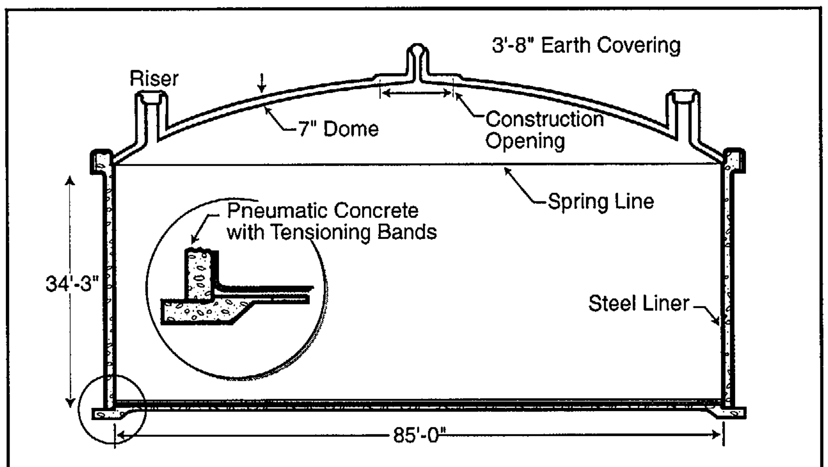


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

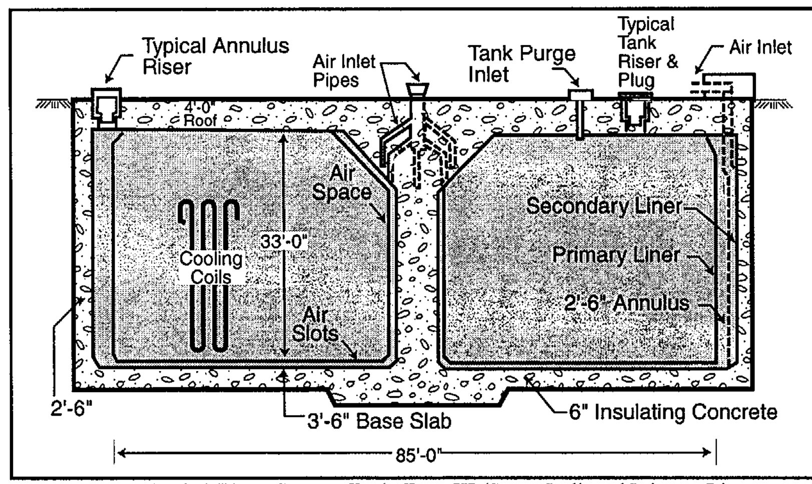


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

NW TANK/Grfx/1-5 Tank config.ai

Figure 1-5. Tank configuration.

Table 1-1. Summary of high-level waste tanks.

Tank type	Number of tanks	Volume (gallons)	Area	Tank numbers	Year constructed	Year first used
I[a]	12	750,000	F	1 - 8	1952	1954-64
			H	9 - 12	1953	1955-56
II[a]	4	1,030,000	H	13 - 16	1956	1957-60
III	27	1,300,000	F	25 - 28	1978	1980
				33 - 34	1969, 1972	1969, 1972
				44 - 47	1980	1980-82
			H	29 - 32	1970	1971-74
				35 - 43	1976-79	1977-86
				48 - 51	1981	1983-86
IV[a]	8	1,300,000	F	17 - 20[b]	1958	1958-61
			H	21 - 24	1961-62	1961-65

a. Twenty-four Type I, II, and IV HLW tanks will be removed from service by 2022.
b. Two tanks (Tanks 17 and 20) have been closed.

atmospheric pressure under alkaline conditions. The evaporators are 8 feet in diameter and have an operating capacity of approximately 1,800 gallons. An additional evaporator system, the Replacement High-Level Waste Evaporator, has been built in H-Area. The Replacement High-Level Waste Evaporator 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.

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.

1.1.4 HLW TANK CLOSURE

1.1.4.1 Closure Process

After the majority of the waste has been removed from the HLW tanks for treatment and disposal, the tank systems (including the tanks, evaporators, transfer lines, and other ancillary equipment) would become part of the HLW tank closure project, the potential environmental impacts of which are the subject of this EIS. In accordance with the SRS Federal Facility Agreement (EPA 1993), DOE intends to remove the tanks from service as their missions are completed. For 24 tanks that do not meet the U.S. Environmental Protection Agency's (EPA's) secondary containment standards under the Resource Conservation and Recovery Act, DOE is obligated to close the tanks by 2022. The proposed closure process specified by the Federal Facility Agreement is described in Appendix A beginning in Section A.4.

The process of preparing to close tanks began in 1995. DOE prepared the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996a) that describes the general protocol for closing the tanks. This document (referred to as the General Closure Plan) was developed with extensive interaction with the State of South Carolina and EPA. Concurrent with the General Closure Plan, DOE prepared the *Environmental Assessment for the Closure of the High Level Waste Tanks in F- and H-Areas at the Savannah River Site* (DOE 1996b). In a Finding of No Significant Impact published on July 31, 1996, DOE concluded that closure of the HLW tanks in accordance with the General Closure Plan would not result in significant environmental impacts.

Accordingly, DOE began to close Tank 20, from which the bulk waste had already been removed. In accordance with the General Closure Plan, DOE prepared a tank-specific closure plan (DOE 1997a) that outlined the specific steps for Tank 20 closure and presented the long-term environmental impacts of the closure. The State of South Carolina approved the Closure Module, and Tank 20 closure was completed on July 31, 1997. Later in 1997, following preparation and approval of a tank-specific Closure Module, Tank 17 was closed.

DOE has decided to prepare an EIS before any additional HLW tanks are closed at SRS. This decision is based on several factors, including the desire to further explore the environmental impacts from closure and to open a new round of information sharing and dialogue with stakeholders. SRS is committed in the Federal Facility Agreement to close another HLW tank by Fiscal Year 2003. DOE has reviewed bulk waste removal of waste 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.

The National Research Council released a study (National Research Council, 1999) examining the technical options for HLW treatment and tank closure at the Idaho National Engineering and Environmental Laboratory (INEEL). The Council concluded that clean closure is impractical, some residual radioactivity will remain, but with rational judgement and prudent management, that it is reasonable to expect all options will result in very low risks. Recommendations made by the NRC included: 1- establish closure criteria, 2-develop an innovative sampling plan based on risks, and 3-conduct testing to anticipate possible process failure. The SRS General Closure Plan had anticipated and includes points similar to those raised by the Council.

1.1.4.2 Waste Incidental to Reprocessing

An important issue associated with tank closure, and a subject of controversy, is the determination of the regulatory classification of residual waste in the tanks. Before bulk waste removal, the content of the tanks is HLW. The goal of the bulk waste removal and subsequent cleaning of the tanks is to remove as much waste as can reasonably be removed.

In July 1999, DOE issued Order 435.1, Radioactive Waste Management, and the associated Manual and Implementation Guide. DOE Manual 435.1-1 prescribes two processes, by citation or by evaluation (see text box), for determining that waste resulting from reprocessing spent nuclear fuel can be considered "waste incidental to reprocessing."

> **Waste Incidental to Reprocessing Determination**
>
> The two processes for determining that waste can be considered incidental to reprocessing are "citation" and "evaluation." Waste incidental to reprocessing by "citation" includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission's Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as "waste incidental to reprocessing." 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).
>
> Waste incidental to reprocessing by "evaluation" includes spent nuclear fuel processing plant wastes that meet the following three criteria: (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.

According to Order 435.1, waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed under DOE's regulatory authority in accordance with requirements for transuranic waste or low-level waste, as appropriate.[2] Section 7.1.3 of this EIS discusses the waste incidental to reprocessing process in more detail.

1.2 Purpose and Need for Action

DOE needs to reduce human health and safety risks at and near the HLW tanks, and to reduce the eventual introduction of contaminants into the environment. If DOE does not take action after bulk waste removal, the tanks would fail, and contaminants would be released to the environment. Failed tanks would present the risk of accidents to individuals. Release of contaminants to the environment would present human health risks, particularly to individuals who might use contaminated water, in addition to adverse impacts to the environment.

1.3 Decisions to be Based on this EIS

This EIS provides an evaluation of the environmental impacts of several alternatives for closure of the high-level waste tanks at the Savannah River Site. The closure process will take place over a period of up to 30 years. The EIS provides the decisionmaker with an assessment of the potential environmental, health and safety effects of each alternative. The selection of a tank closure alternative, following completion of this EIS, will guide the selection and imple-

[2] The Natural Resources Defense Council (NRDC) has filed a Petition in the Court of Appeals for the Ninth Circuit asking the Court to review DOE Order 435.1 and claiming the Order is "arbitrary, capricious, and contrary to law." The Nuclear Regulatory Commission, in responding recently to a separate petition from the NRDC, has concluded that DOE's commitments to (1) clean up the maximum extent technically and economically practical, and (2) meet performance objectives consistent with those required for disposal of low level waste, if satisfied, should serve to provide adequate protection of public health and safety (65 FR 62377, October 18, 2000).

mentation of a closure method for each high-level waste tank at the SRS. Within the framework of the selected alternative, and the environmental impact of closure described in the EIS, DOE will select and implement a closure method for each tank.

In addition to the closure methods and impacts described in this EIS, the tank closure program will operate under a number of laws, regulations, and regulatory agreements described in Chapter 7 of this EIS. In addition to the General Closure Plan (a document prepared by DOE based on responsibilities under the AEA and other laws and regulations and approved by SCDHEC), the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. Each Closure Module will incorporate a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving each Closure Module, DOE will select a closure method that is consistent with the closure alternative selected after completion of this EIS. The selected closure method for each tank will result in the closure of all tanks with impact on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. DOE would conduct the appropriate NEPA review for any proposal to use a new technology.

1.4 EIS Overview

1.4.1 SCOPE

This EIS analyzes the environmental impacts of cleaning, isolating, and stabilizing the HLW tanks and related systems such as evaporators, transfer piping, sumps, pump pits, diversion boxes, filtration systems, sludge washing equipment, valve boxes, and the condensate transfer system. Before tank closure can be accomplished, DOE must remove the waste stored in the tanks, a process called bulk waste removal. Bulk waste removal is discussed as part of the No Action Alternative (i.e., a continuation of the normal course of action) in the Savannah River Site Waste Management EIS (DOE/EIS-0217). In light of proposed changes in the bulk waste removal program, DOE will determine the need to supplement the Waste Management EIS. Bulk waste removal means pumping out all the waste that is possible with existing equipment. Bulk waste removal leaves residual contamination on the tank walls and internal hardware such as cooling coils. A heel of liquid, salt, sludge, or other material remains in the bottom of the tank and cannot be removed without using special means. Removal of this residual material is part of the cleaning stage of the proposed action.

Upon completion of closure activities for a group of tanks (and their related equipment) in a particular section of a tank farm, the tanks and associated equipment in the group would transition 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. DOE, however, 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 1996c). 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.

1.4.2 ORGANIZATION

This EIS has seven chapters supported by four appendices. Chapter 2 describes the proposed action and alternatives for carrying it out. Chapter 3 discusses the SRS and describes the site and the surrounding environment the alternatives could impact. Chapter 4 presents the estimated impacts from tank closure. Chapter 5 discusses the cumulative impacts of this project plus other existing or planned projects that affect the environment. Chapter 6 presents resource commitments. Chapter 7 discusses applicable laws, regulations, and permit requirements.

This EIS also contains four appendices. Appendix A describes HLW management at SRS with an emphasis on the tank farms and the closure alternatives. Appendix B provides information on accident scenarios. Appendix C describes long-term closure modeling, and Appendix D describes public input received during the scoping period and provides DOE responses.

1.4.3 STAKEHOLDER PARTICIPATION

On December 29, 1998, DOE announced in the *Federal Register* (63 FR 71628) its intent to prepare an EIS on the proposed closure of High-Level Waste Tanks at SRS near Aiken, South Carolina. DOE proposes to close the tanks to protect human health and the environment and to promote safety. With the Notice, DOE established a public comment period that lasted through February 12, 1999.

DOE invited SRS stakeholders and other interested parties to submit comments for consideration in the preparation of the EIS.

DOE held scoping meetings on the EIS in North Augusta, South Carolina, on January 14, 1999, and in Columbia, South Carolina, on January 19, 1999. Each meeting included presentations on the NEPA process in relation to the proposed action, on the plan for closure of the tanks and on the alternatives presented in this EIS. The meetings also offered opportunities for public comment and general questions and answers.

From the scoping process the Department identified about 25 separate comments. Six comments recommended changes or additions to the alternatives, three comments suggested data to be included, eleven comments suggested evaluations to be used or concerns about analyses, six comments dealt with concerns about criteria used or regulatory compliance, two comments dealt with schedule or EIS process, and four comments dealt with a variety of topics that do not fit in any of the areas given above. DOE considered all of these comments in preparing this EIS.

A summary of the comments received during the pubic scoping period and how they influenced the scope of this Draft EIS is included as Appendix D.

1.4.4 RELATED NEPA DOCUMENTS

This EIS makes use of information contained in other DOE NEPA documents related to HLW management and tank closure. It is also designed to be consistent with DOE's parallel effort to prepare an EIS on HLW Salt Disposition Alternatives, which is related to activities in the H-Area Tank Farm. The NEPA documents related to this HLW Tank Closure EIS are briefly described below.

Environmental Assessment for the Closure of the High-Level Waste Tanks in the F- and H-Areas at the Savannah River Site – DOE prepared an environmental assessment (DOE 1996b) to evaluate the impacts of closing HLW tanks at the SRS after removal of the bulk waste. The proposed action was to remove the residual waste from the tanks and fill them with a material to prevent future collapse and bind up residual waste, to decrease human health risks, and to increase safety in the area of the tank farms. After closure, the tank system would be turned over to the SRS environmental restoration program for environmental assessment and remedial actions as necessary. A Finding of No Significant Impact was determined based on the analyses in the environmental assessment, and DOE subsequently closed Tanks 17 and 20. DOE has now decided to prepare an EIS for proposal to close the remaining HLW tanks.

Final Defense Waste Processing Facility Supplemental Environmental Impact Statement – DOE prepared a Supplemental EIS to examine the impacts of completing construction and operating the DWPF at the SRS. This document (DOE 1994) assisted the Department in deciding whether and how to proceed with the DWPF project, given the changes to processes and facilities that had occurred since 1982, when it issued the original *Defense Waste Processing Facility EIS.*

The Record of Decision (60 FR 18589) announced that DOE would complete the construction and startup testing of DWPF and would operate the facility using the In-Tank Precipitation process after the satisfactory completion of startup tests.

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

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

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

Final Waste Management Programmatic Environmental Impact Statement for Managing, Treatment, Storage, and Disposal of Radioactive and Hazardous Waste – DOE published this EIS as a complex-wide study of the environmental impacts of managing five types of waste generated by past and future nuclear defense and research activities, including HLW at four sites (DOE 1997c). This NEPA analysis was the first time DOE had examined in an integrated fashion the impacts of complex-wide waste management alternatives and the cumulative impacts from all waste management activities at a specific site.

The EIS evaluated four alternatives, including the no action alternative, for managing immobilized HLW until such time as a geologic repository is available to receive it. The preferred alternative was for each site to store its immobilized waste onsite. The Record of Decision to proceed with DOE's preferred alternative of decentralized storage for immobilized HLW was issued August 26, 1999 (64 FR 46661).

Supplemental Environmental Impact Statement for High-Level Waste Salt Disposition Alternatives at the Savannah River Site – On February 22, 1999 DOE published a Notice of Intent to prepare a Supplemental EIS for alternatives to the In-Tank Precipitation process at

SRS (64 FR 8558). The In-Tank Precipitation process was intended to separate soluble, high-activity radionuclides from HLW before vitrifying the high-activity portion of the waste in the DWPF and disposing of the low-activity fraction as saltstone grout in vaults at SRS. However, the In-Tank Precipitation process as presently configured cannot achieve production goals and safety requirements for processing HLW. The Supplemental EIS will evaluate the impacts of alternatives to the In-Tank Precipitation process for separating the high- and low-activity fractions of the HLW currently stored in tanks at SRS. Although the *Salt Disposition Alternatives Supplemental EIS* addresses subject matter and some equipment in common with this EIS, the actions proposed in each EIS are independent and are thus appropriately considered in separate EISs.

References

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

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

DOE (U.S. Department of Energy), 1996a, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, July 10.

DOE (U.S. Department of Energy), 1996b, *Environmental Assessment for the Closure of the High Level Waste Tanks in F- and H-Areas at the Savannah River Site*, DOE/EA-1164, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996c, *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 20 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*, Rev. 1, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, April 30.

DOE (U.S. Department of Energy), 1997c, *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-F, Office of Environmental Management, Washington, D.C.

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

EPA (U.S. 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).

National Research Council, 1999, *Alternative High-Level Waste Treatments at the Idaho National Engineering and Environmental Laboratory*, National Academy Press, Washington, D.C.

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

CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action and Alternatives

DOE proposes to close the HLW tanks at SRS in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996) (the General Closure Plan) approved by SCDHEC, which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin when bulk waste removal has been completed. Under each alternative except No Action, DOE would close 49 HLW tanks and associated waste handling equipment including evaporators, pumps, diversion boxes, and transfer lines.

DOE is evaluating three alternatives in this EIS. As described above, all of the alternatives would start after bulk waste removal occurs.

- Clean and Stabilize Tanks Alternative. DOE considers three options for tank stabilization:
  - Fill with Grout (Preferred Alternative)
  - Fill with Sand
  - Fill with Saltstone
- Clean and Remove Tanks Alternative
- No Action Alternative (evaluation required by CEQ regulations)

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17 (du Pont 1980; WSRC 1995a). If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

After spray water washing is complete, DOE could use oxalic acid cleaning. Hot oxalic acid would be sprayed through the spray nozzles that were used for spray water washing.

Oxalic acid cleaning – In this process, after the spray washing is complete, hot oxalic acid (80°-90°C) would be sprayed through the spray nozzles that were used for water spray washing. This process has been demonstrated only on Tank 16. A number of potential cleaning agents for sludge removal were studied. Oxalic acid was chosen as the preferred cleaning agent because it dissolves sludge and is only moderately aggressive against carbon steel, the material used in the construction of the waste tanks.

Bradley and Hill (1977) describes the study that led to the selection of oxalic acid as the preferred chemical cleaning agent. The study examined cleaning agents that would not aggressively attack carbon steel and were compatible with high-level waste processes. The studies included tests with waste stimulants and also tests with actual Tank 16 sludge. The agents tested were disodium salt EDTA, glycolic acid, formic acid, sulfamic acid, citric acid, dilute sulfuric acid, alkaline permanganate, and oxalic acid. None of these agents completely dissolved the sludge, but oxalic acid was shown to dissolve about 70% of the sludge in a well-mixed sample at 25% C, which was the highest of any of the cleaning agents tested. (Concentrated mineral acids, such as nitric acid, hydrochloric acid, and concentrated sulfuric acid, will completely dissolve the sludge but also aggressively attack carbon steel.)

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 (see Table 2-1). Use of oxalic acid in an HLW tank would require a successful demonstration that it would not create a potential for a nuclear criticality. The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited. This prohibition was established because of concern that oxalic acid could dissolve a sufficient quantity of fissile materials to create the potential for nuclear criticality.

An earlier study (Nomm 1995) had concluded that criticality in the high-level waste tanks is "beyond extremely unlikely" because neutron-absorbing substances present in the sludge would prevent criticality. However, the study assumed the waste would remain alkaline and did not address the possibility that chemicals would be used that would dissolve sludge solids. Therefore, to ensure that no criticality could occur in tank cleaning, DOE would need to prepare a formal Nuclear Criticality Safety Evaluation (i.e., a study of the potential for criticality) before deciding to use oxalic acid in cleaning a tank. If the new evaluation found that oxalic acid could be used safely, the *Liquid Radioactive Waste Facility Safety Analysis Report* would be revised and DOE could permit its use. If not, DOE would need to investigate other cleaning technologies, such as mechanical cleaning.

If oxalic acid cleaning were performed infrequently, there would be minimal impact on the downstream waste processing operations (DWPF and salt disposition). The oxalic acid used to clean a tank would be neutralized with sodium hydroxide, forming sodium oxalate. The sodium oxalate would follow the same treatment path as other salts in the tank farm inventory.

Extensive use of oxalic acid cleaning may result in conditions that, if not addressed by checks within the DWPF feed preparation process, could allow carryover of sodium oxalate to the vitrification process. The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect the quality of the HLW glass produced at DWPF. To prevent that from occurring, special batches of the salt treatment process would be scheduled in which the sodium oxalate concentrations would be controlled to not exceed their solubility limit in the low-radioactivity fraction.

DOE expects that oxalic acid cleaning would be required on tanks that contain first-cycle wastes, the most highly radioactive waste in the tanks. High-level wastes were produced as a byproduct of SRS separations processes. During processing, materials from SRS reactors passed through several cycles of solvent extraction. In these cycles, the plutonium and other products were first separated from the waste and then purified. Most of the radionuclides were removed from the processing streams during the first cycle of solvent extraction, so wastes from this cycle have most of the radionuclides. Wastes from subsequent cycles have radionuclide concentrations that are one to two orders of magnitude lower. DOE anticipates that oxalic acid would be needed to clean tanks that contain the more radioactive first cycle wastes (about three fourths of the tanks).

On the basis of performance and historical data, DOE believes that waste removal meets the Criteria 2 and 3 requirements of the evaluation process for determining that waste can be considered "waste incidental to reprocessing" (see text box). In addition, waste removal followed by spray water washing, meets the Criterion 1 requirement for removal of key radionuclides to the extent "technically and economically practical" (DOE Order 435.1). If Criteria 2 or 3 could not be met, enhanced cleaning methods such as additional water washes or oxalic acid cleaning could be employed. However, DOE considers that oxalic acid cleaning beyond the extent needed to meet performance objectives is not "technically and economically practical" within the meaning of DOE Order 435.1, for reasons discussed below.

In general, the economic costs of oxalic acid cleaning are quite high. DOE estimates that oxalic acid cleaning (including disposal costs) per tank would cost approximately $1,050,000.

Table 2-1. Tank 16 waste removal process and curies removed with each sequential step.

Sequential Waste Removal Step	Curies Removed	% of Curies Removed	Cumulative Curies Removed	Cumulative Percent Curies Removed
Bulk Waste Removal	2.74×10^{6}	97%	2.74×10^{-6}	97
Spray Water Washing	2.78×10^{4}	0.98%	2.77×10^{-6}	97.98
Oxalic Acid Wash & Rinse	5.82×10^{4}	2%	2.83×10^{-6}	99.98

DOE considers that performance of bulk waste removal and spray washing, which together result in removal of 98% to 99% of the total curies and over 99% of the volume of waste, constitutes the limit of what is economically and technically practicable for waste removal (DOE Response to U.S. Nuclear Regulatory Commission Additional Questions on SRS HLW Cover Tank Closure, April 1999). However, DOE recognizes that enhanced waste removal operations may be required for some tanks and is committed to performing the actions necessary to meet "incidental waste" determination and performance objectives. DOE further recognizes that, if it could not clean the tank components sufficiently to meet the waste incidental to reprocessing criteria, it would need to examine alternative disposition strategies. Alternatives could include disposal in place as high-level waste (which is not contemplated in DOE Order 435.1), development of new cleaning technologies, or packaging the cleaned tank pieces and storing them until DOE could ship them to a geologic repository for disposal. A geologic repository has not yet been approved and waste acceptance criteria have not yet been finalized.

Nine HLW tanks have leaked measurable amounts of waste from primary containment to secondary containment with only one leaking to the soil surrounding the tanks. For these tanks, the waste would be removed from the secondary containment using water and/or steam. Such cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only about 70 percent completed, because salts mixed with sand (from sandblasting of tank welds) made salt removal more difficult. Cleaning of the secondary containment is not a demonstrated technology and new techniques may need to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

2.1.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

Following bulk waste removal, DOE would remove the majority of the waste from the tanks and fill the tanks with a material to prevent future collapse and to bind up residual waste. A detailed description of this alternative can be found in Appendix A.

Tank Closure Alternatives

Implementation of each alternative would start following bulk waste removal and SCDHEC approval of a tank-specific Closure Module that is protective of human health and the environment.

- Clean with water and fill the tanks with grout (Preferred Alternative). If necessary to meet the performance objectives, oxalic acid cleaning could be used. The use of sand or saltstone as fill material would also be considered.
- Clean and remove the tanks for disposal in the SRS waste management facilities.
- No Action. Leave the tank systems in place without cleaning or stabilizing following bulk waste removal.

In the evaluation and cleaning phase, each tank system or group of tank systems, as appropriate, would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal, and spray water washing. This information would be used to conduct a performance evaluation as part of the Preparation of a Closure Module. In this evaluation, DOE would consider (1) the types of contamination in the tank and the configuration of the tank system and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods and comparing the modeling results with the performance objectives developed in the General Closure Plan (DOE 1996). These performance objectives are described in Section 7.1.2 of this EIS. If the modeling shows that the performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

If the modeling shows that the performance objectives would not be met, additional cleaning steps, such as additional water spray washing, oxalic acid cleaning, or other cleaning techniques, would be taken until enough residual waste had been removed that the performance objectives could be met.

Tank Stabilization

After DOE would clean a tank and demonstrate that the performance objectives could be met, SCDHEC would approve a Closure Module. The tank stabilization process would then begin. Each tank system (including the secondary containment, for those that have one) would be filled with a pumpable, self-leveling backfill material.

DOE's Preferred Alternative is to use grout, a concrete-like material, as backfill. The grout would be trucked to an area near the tank farm, batched if necessary, and pumped to the tank. The grout would be high enough in pH to be compatible with the carbon steel walls of the waste tank. Although the details of each individual closure would vary, any tank system closure under this alternative would have the following characteristics:

- The grout would be pumpable, self-leveling, designed to prevent future subsidence of the tank, and able to fill voids to the extent practical, including equipment and secondary containment.
- The grout would be poured in three distinct layers as illustrated in Figure 2.1-1. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high strength grout to deter inadvertent intrusion from drilling.
- The final closure configuration would meet performance objectives established by SCDHEC and EPA.

If DOE were to choose another fill material (e.g., sand, saltstone) for a tank system, all other aspects of the closure process would remain the same, as described above.

Sand is readily available and inexpensive. However, its emplacement is more difficult than the grout because it does not flow readily into voids. Any equipment or piping left on or inside the tank that might require filling to eliminate voids inside the device might not be adequately filled. Over time, the sand would tend to settle in the tank, creating additional void spaces. The dome might then become unsupported and would sag and crack. The sand would tend to isolate the contamination from the environment to some extent, limit the amount of settling of the tank top after failure, and prevent winds from spreading the contaminants. Nevertheless, water would flow readily through the sand. Sand is relatively inert and could not be formulated to retard the migration of radionuclides. Thus, the expected contamination levels in groundwater and surface streams resulting from migration of residual contaminants would be higher than the levels for the preferred option.

Saltstone could also be used as fill material. Saltstone is the low-radioactivity fraction of HLW mixed with cement, flyash, and slag to form a concrete-like mixture. Saltstone is normally disposed of as low-level waste in the SRS

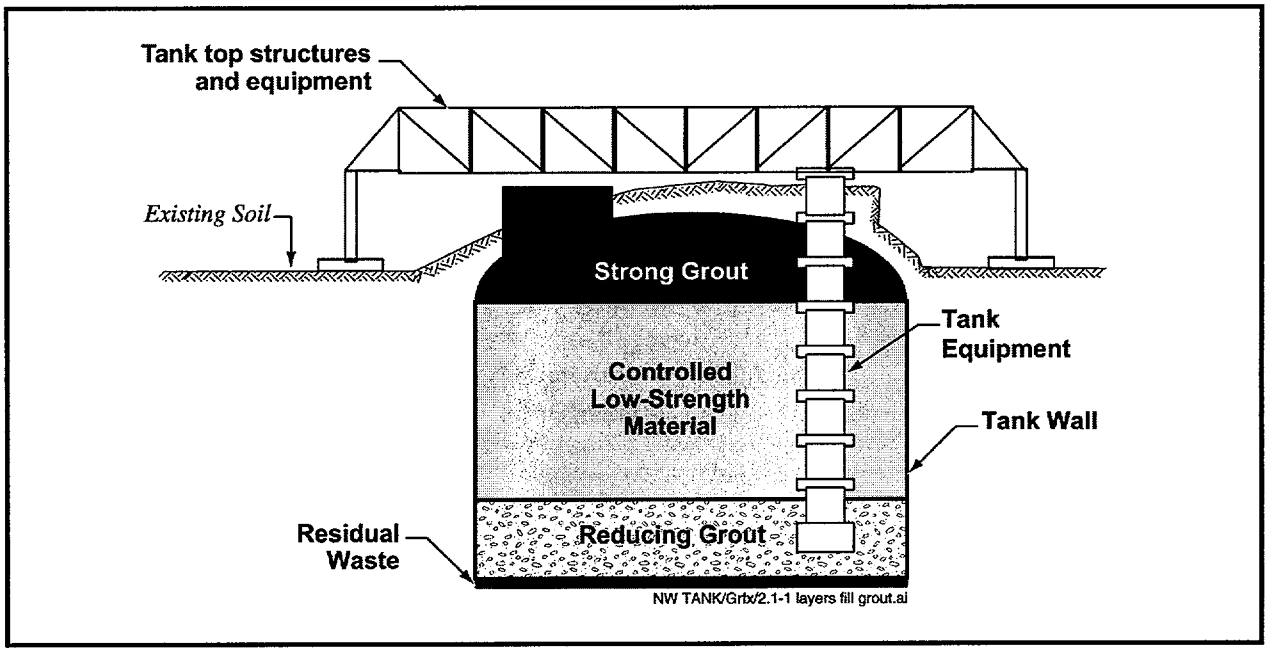


Figure 2.1-1. Typical layers of the fill with grout option.

Saltstone Disposal Facility. See Appendix A for a description of the Saltstone Manufacturing and Disposal Facility and its function within the HLW system.

This alternative would have the advantage of reducing the amount of Saltstone Disposal Facility area that would be required. Any saltstone sent to a waste tank would not require disposal space in the Saltstone Disposal Facility.

The total amount of saltstone required to stabilize the low-activity fraction of HLW would probably be greater than 160 million gallons, which is considerably in excess of the capacity of the HLW tanks. Therefore, disposal of saltstone in the Saltstone Disposal Facility would still be required. Because saltstone sets up quickly and is radioactive, it would be impractical to ship by truck or pump to the tank farms. Thus, a Saltstone Mixing Facility would need to be constructed in F-Area; another facility would be built in H-Area; and the existing Saltstone Manufacturing and Disposal Facility in Z-Area would still be operated.

Filling the tank with saltstone, which is contaminated with radionuclides would considerably complicate the project and increase worker radiation exposure, which would increase risk to workers and add to the cost of closure. In addition, the saltstone would contain large quantities of nitrate that would not be present in the tank residual. Because nitrates are very mobile in the environment, these large quantities of nitrate would adversely impact the groundwater near the tank farms in the long term.

One of the alternatives being evaluated in the Supplemental EIS for high-level waste salt disposition would not involve the manufacture of saltstone (64 FR 8558; February 22, 1999). If this alternative (known as the Direct Disposal in Grout Alternative) is selected, the option of using saltstone as a HLW tank stabilization material would no longer be applicable. The Direct Disposal in Grout Alternative involves the manufacture of a grout with substantially greater radioactive content than saltstone, which would be unsuitable for use as HLW tank stabilization material.

For any of the above options, 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.

2.1.2 CLEAN AND REMOVE TANKS ALTERNATIVE

The Clean and Remove Tanks alternative would include cleaning the tanks, cutting them up in situ, removing them from the ground, and transporting tank components for disposal in an engineered disposal facility at another location on the SRS. This alternative has not been demonstrated on HLW tanks.

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning beyond that contemplated for the other action alternatives, until tanks were clean enough to be safely removed and could meet waste acceptance criteria at SRS Low-Level Waste Disposal Facilities. Worker exposure would have to be As Low As Reasonably Achievable to ensure protection of the individuals required to perform the tank removal operations. This might require the use of cleaning technologies such as oxalic acid cleaning, mechanical cleaning, and additional steps as yet undefined on most of the tanks.

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal (assuming these components are considered waste incidental to reprocessing). During tank removal activities, the top of the tank would have HEPA-filtered enclosures or airlocks. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the low-level waste disposal boxes containing the tank components from all 49 tanks. This number of new low-activity waste vaults is within the range DOE previously analyzed in the *Savannah River Site Waste Management Final Environment Impact Statement* (DOE 1995). That EIS analyzed a range of waste treatment alternatives that resulted in the construction of up to 31 new low-activity waste vaults. The long-term impacts presented in that EIS for the low-activity waste vaults are approximately one-one thousandth of the long-term tank closure impacts presented in Section 4.2 of this EIS and are incorporated into this EIS by reference. 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.

With removal of all the tanks, backfilling of the excavations left after the removal would be required. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks.

2.1.3 NO ACTION

For HLW tanks, the No Action Alternative would involve leaving in place the tank systems after bulk waste removal from each tank has taken place and the storage space is no longer needed. Even after bulk waste removal, each tank would contain residual waste and in those tanks that reside in the water table, ballast water, which is required to prevent the tank from "floating" out of the ground. Tanks would not be backfilled.

After some period of time, the reinforcing bar in the roof of the tank would rust and the roof of the tank would fail, causing the structural integrity of the tank to degrade. Similarly, the floor and walls of the tank would degrade over time. Rainwater would readily pour into the exposed tank, flushing contaminants from the residual waste in the tank and eventually carrying these contaminants into the groundwater. Contamination of the groundwater would happen much more quickly than it would if the tank were backfilled and residual wastes were bound with the fill material.

No Action would be the least costly of the alternatives (less than $100,000 per tank), require the fewest worker hours and exposure to radiation (about two person-rem), and would require fewer workers per tank system than the Clean and Stabilize Tanks Alternative. There would be ongoing maintenance and no interruption of operations in the tank farm.

Future inhabitants of the area would be exposed to the contamination in a tank, and injuries or fatalities could occur if an intruder ventured into the area of the tank and the roof were to collapse due to structural failure. Also, movement of the contaminants into the groundwater would be more rapid compared to the other alternatives, and expected contamination levels in groundwater and surface streams would be higher than for the Clean and Stabilize Tanks Alternative because there would be no material to retard movement of the radionuclides. This alternative would be the least protective of human health and safety and of the environment.

2.1.4 ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

2.1.4.1 <u>Management of Tank Residuals as High-Level Waste</u>

The alternative of managing the tank residuals as HLW is not preferred, in light of the requirements embodied in the State-approved General Closure Plan for a regulatory approach based on the designation of the residuals as waste incidental to reprocessing.

The waste incidental to reprocessing designation does not create a new radioactive waste type. The terms "incidental waste" or "waste incidental to reprocessing" refer to a process for identifying waste streams that might otherwise be considered HLW due to their origin, but are actually low-level or transuranic waste, if the waste incidental to reprocessing requirements contained in DOE Manual 435.1-1 are met. The goal of the waste incidental to reprocessing determination process is to safely manage a limited number of reprocessing waste streams that do not warrant geologic repository disposal because of their low threat to human health or the environment. Although the technical alternatives of managing tank residuals under the General Closure Plan would likely be the same as those that would apply to managing residuals as HLW, the application of regulatory requirements would be different.

As described in the General Closure Plan, DOE will meet the waste incidental to reprocessing requirements of DOE Manual 435.1-1, which entail a step for removing key radionuclides to the extent that is technically and economically practical, a step for incorporating the residues into a solid form, and a process for demonstrating that appropriate disposal performance objectives are met. The technical alternatives evaluated in the EIS represent a range of tank cleaning and stabilization techniques. The radionuclides in residual waste would be the same whether the material is HLW, low-level waste, or transuranic waste; however, the regulatory regime would be different.

DOE must demonstrate its ability to meet certain performance objectives before SCDHEC will approve a Closure Module. Appendix C of the General Closure Plan describes the process DOE used to determine the performance objectives (dose limits and concentrations established to be protective of human health) incorporated in the General Closure Plan. As described in Chapter 7 of this EIS, DOE will establish performance standards for the closure of each HLW tank. In the General Closure Plan, DOE considered dose limits and concentrations found in current (40 CFR 191, 10 CFR 60) and proposed (40 CFR 197, 10 CFR 63) HLW management requirements in defining the performance standards. DOE considered the HLW management dose limits and concentrations as performance indicators of the ability to protect human health and the environment, even though the residual would not be considered HLW. That evaluation (described in Appendix C of the General Closure Plan) identified numerical performance standards (concentrations or dose limits for specific radiological or chemical constituents released to the environment) based on the requirements and guidance. Those numerical standards apply to all exposure pathways and to specific media (air, groundwater, and surface water), at different points of compliance, and over various periods during and after closure.

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be managed as HLW. The technical alternatives for managing the residues as HLW, however, would be the same as those for managing the residues under the LLW requirements. Thus, DOE expects that the potential environmental impacts that could result from managing the residues under the LLW requirements would be representative of the impacts if the HLW standards were applicable. For these reasons, this EIS does not present the management of tank residues as HLW as a separate alternative.

2.1.4.2 Other Alternatives Considered, but not Analyzed

DOE considered the alternative of delaying closure of additional tanks, pending the results of research. For the period of delay, the impacts of this approach would be the same as the No Action Alternative. DOE continues to conduct research and development efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of delaying closure.

DOE considered an alternative that would represent grouting of certain tanks and removal of others. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of cleaning to meet performance requirements for a given tank, the decisionmakers may elect to remove a tank if it is not possible to meet the performance requirements by using another method. This EIS captures the environmental and health and safety impacts of both options.

2.2 Other Cleaning Technologies

The approved General Closure Plan contemplates cleaning the tanks with hot water streams, as described in the Clean and Stabilize Tanks Alternative. Several cleaning technologies have been investigated but are not considered reasonable alternatives to hot water cleaning at this time. However, DOE continues to research cleaning methods and should a particular method prove practical and be required to meet the performance criteria for a specific tank, its use would be proposed in the Closure Module for that tank. DOE would conduct the appropriate NEPA review for any proposal to use such new technology.

Mechanical and chemical cleaning using advanced techniques has not been demonstrated in actual HLW tanks. A number of techniques have been studied involving such technologies as robotic arms, wet-dry vacuum cleaners, and remote cutters. However, none of these techniques have been demonstrated for this application. For example, no robotic arms have been demonstrated that could navigate through the cooling coils that are found in most SRS waste tanks. These techniques could be applied for specific tank closures based on the waste characteristics (e.g., presence of zeolite or insoluble materials) and other circumstances (e.g., cooling coils or other obstructions) for specific SRS tank closures.

There are more aggressive cleaning agents than oxalic acid (e.g., nitric acid). However, in addition to the same safety questions involving the use of oxalic acid (see Section 2.2.1), these cleaning agents have an unacceptable environmental risk because they attack the carbon steel wall of the waste tank, causing deterioration of the metal, and reducing the intact containment life of the tank. This would result in much more rapid release of contaminants to the environment.

2.3 Considerations in the Decision Process

This environmental impact statement evaluates the environmental impacts of several alternatives for closure of the high-level waste tanks at the Savannah River Site. The closure process would take place over a period of up to 30 years. The selection of a tank closure alternative following completion of this EIS would guide the selection and implementation of a closure method for each high-level waste tank at the SRS. Within the framework of the selected alternative, and the environmental impacts of closure described in the EIS, DOE will select and implement a closure method for each tank.

The tank closure program will operate under a number of laws, regulations and regulatory agreements, described in Chapter 7 of this EIS. In addition to the General Closure Plan, a document prepared by DOE based on responsibilities under the Atomic Energy Act and other laws and regulations, the closure of individual tanks will be performed in accordance with a tank-specific Closure Module. The Closure Module incorporates a specific plan for tank closure and modeling of impacts based on that plan. Through the process of preparing and approving the Closure Module, DOE will select a closure method that is consistent with the closure alternative selected following completion of this EIS. The selected closure method will result in a closure that has impacts on the environment equal to or less than those described in this EIS. If a tank closure that meets the performance objectives of the closure module cannot be accomplished using the selected alternative, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank.

During the expected 30-year period of tank closure activities, new technologies for tank cleaning or other aspects of the closure process may become available. If DOE elects to use such a technology, DOE would prepare the appropriate additional NEPA review prior to implementing closure of the tank using the new technology.

During scoping for this EIS, a commentor suggested that DOE should consider the alternative of delaying closure of additional tanks pending the results of research. For the period of delay, the impacts of this approach would be the same as the No-Action Alternative. DOE continues to conduct research and development (R&D) efforts aimed at improving closure techniques. DOE has evaluated the No Action Alternative, thereby evaluating the impacts of the alternative suggested by the commentor.

A comment was made that tank removal and grouting should be combined as an alternative. DOE has examined 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 EIS captures the environmental and health and safety impacts of both options. Additional discussion on these and other comments made during scoping is included in Appendix D.

As stewards of the Nation's financial resources, DOE decision-makers must also consider cost of the alternatives. DOE has prepared rough order-of-magnitude estimates of cost for each of the alternatives (DOE 1997). These costs, which are presented on a per tank basis, are as follows:

No Action Alternative – <$100,000

Clean and Stabilize Tanks Alternative

- Clean and Fill with Grout Option - $3.8-4.6 million
- Clean and Fill with Sand Option - $3.8 million
- Clean and Fill with Saltstone Option - $6.3 million
- Clean and Remove Tanks Alternative - >$100 million

2.4 Comparison of Environmental Impacts Among Alternatives

Closure of the HLW tanks would affect the environment, and human health and safety, during the period of time when work is being done to close the tanks and after the tanks have been closed. For purposes of analysis in this EIS, DOE has defined the period of short-term impacts to be from the year 2000 through about 2030, when all of the existing HLW tanks are proposed to be closed. Long-term impacts would be those resulting from the eventual release of residual waste contaminants from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

Chapter 4 presents estimates of the potential short-term and long-term environmental impacts associated with each tank closure alternative, as well as the No Action Alternative. Section 2.4.1 summarizes the short-term impacts and accident scenarios, while Section 2.4.2 summarizes the long-term impacts.

2.4.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (approximately the years 2000 to 2030) for each of the alternatives. These potential impacts are summarized in Table 2-2 and discussed in more detail in the sections that follow.

Geologic and water resources – Each of the tank stabilization options under the Clean and Stabilize Tanks Alternative would require an estimated 170,000 cubic meters of soil for backfill. The Clean and Remove Tank Alternative would require more, approximately 356,000 cubic meters. Short-term impacts to surface water and groundwater are expected to be negligible for any of the alternatives.

Nonradiological air quality – Tank closure activities would result in the release of regulated nonradiological pollutants to the surrounding air. The primary source of air pollutants for the Clean and Fill with Grout Option would be a portable concrete batch plant and three diesel generators. For the Clean and Fill with Sand Option, pollutants would be emitted from operation of a portable sand feed plant and three diesel generators. The Clean and Fill with Saltstone Option would require saltstone batching facilities in F- and H- Areas. Regulated nonradiological air pollutants released as a result of activities associated with the No Action Alternative and Clean and Remove Tanks Alternative would consist largely of emissions from vehicular traffic. All alternatives except the No Action Alternative include the cleaning of interior tank walls with oxalic acid. The acid would be transferred to the HLW tanks through a sealed pipeline. No releases are expected during this procedure. The cleaning process would consist of spraying hot (80-90°C) acid using remotely operated water sprayers.

The tanks would be ventilated with 300-400 cfm of air which would pass thorough a HEPA filter; acid releases from the ventilated air are expected to be minimal. Under all alternatives, the expected emission rate for each source would be less than the Prevention of Significant Deterioration Standards.

The maximum air concentrations at the SRS boundary associated with the release of regulated pollutants would be highest for the Clean and Fill with Saltstone Option. However, ambient concentrations for all the pollutants and alternatives would be less then 1 percent of the regulatory limits. The concentrations at the location of the hypothetical noninvolved worker would be highest for the Clean and Fill with Saltstone Option. All concentrations, however, would be below the Occupational Safety and Health Administration (OSHA) limits; all concentrations with the exception of nitrogen oxide (as NO_x) would be less than 1 percent of the regulatory limit. Nitrogen dioxide (NO_x) could reach 8 percent of the regulatory limit for the Clean and Fill with Grout and Clean and Fill with Sand Options, while NO_x levels under the Clean and Fill with Saltstone Option could reach about 16 percent of the OSHA limit. These emissions would be attributable to the diesel generators.

Radiological air quality – Radiation dose to the maximally-exposed offsite individual from air emissions during tank closure would be essentially the same for all alternatives and options, 2.5×10^{-5} to 2.6×10^{-5} millirem per year. Estimated dose to the offsite population would also be similar for all alternatives and options, from 1.4×10^{-3} to 1.5×10^{-3} person-rem per year.

Ecological resources – Construction-related disturbance under the Clean and Stabilize Tanks Alternative and Clean and Remove Tank Alternative would result in impacts to wildlife that are small, intermittent, and localized. Some individual animals could be displaced by construction noise and activity, but populations would not be affected.

Table 2-2. Summary comparison of short-term impacts by tank closure alternative.

Parameter	No Action Alternative	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
Geologic Resources					
Soil backfill (m^3)	None	170,000	170,000	170,000	356,000
Water Resources					
Surface Water	None	None	None	None	None
Groundwater		<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required	<0.6% of F-Area well production required
Air Resources					
Nonradiological air emissions (tons/yr.):					
Sulfur dioxide (as SO_x)	None	2.2	2.2	3.3	None
Total suspended particulates	None	(a)	(a)	3.0	None
Particulate matter	None	4.5	3.1	1.7	None
Carbon monoxide	None	5.6	5.6	8.0	None
Volatile organic compounds	None	2.3	2.3	3.3	None
Nitrogen dioxide (as NO_x)	None	33	33	38	None
Lead	None	9.0×10^{-4}	9.0×10^{-4}	1.5×10^{-3}	None
Beryllium	None	1.7×10^{-4}	1.7×10^{-4}	2.8×10^{-4}	None
Mercury	None	2.2×10^{-4}	2.2×10^{-4}	4.3×10^{-4}	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-$\mu g/m^3$):[b]					
Sulfur dioxide (as SO_x) – 3 hr.	None	0.2	0.0	0.6	None
Total suspended particulates – annual	None	(a)	(a)	0.005	None
Particulate matter – 24 hr.	None	0.08	0.06	0.06	None
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Nitrogen dioxide (as NO_x) - annual	None	0.03	0.03	0.07	None
Lead – max. quarterly	None	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-6}	None
Beryllium – 24 hr.	None	3.2×10^{-6}	3.2×10^{-6}	1.1×10^{-5}	None

Table 2-2. (Continued).

Parameter	No Action Alternative	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
Mercury – 24 hr.	None	4.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	None
Benzene	None	3.8×10^{-4}	3.8×10^{-4}	2.0×10^{-2}	None
Annual radionuclide emissions (curies/year):					
F-Area	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}
H-Area	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Annual dose from radiological air emissions:					
Noninvolved worker dose (mrem/yr.)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
Maximally Exposed Offsite Individual dose (mrem/yr.)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Offsite population dose (person-rem)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Ecological Resources	No change	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife
Land Use	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns	Zoned heavy industrial-no change in SRS land use patterns
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Cultural Resources	None	None	None	None	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Worker and Public Health					
Radiological dose and health impacts to the public and non-involved workers:					
Maximally-exposed offsite individual (mrem/yr.)	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Maximally exposed offsite individual estimated latent cancer fatality risk	6.1×10^{-10}	6.1×10^{-10}	6.1×10^{-10}	6.4×10^{-10}	6.1×10^{-10}
Noninvolved worker estimated latent cancer fatality risk	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}	5.1×10^{-5}
Estimated increase in number of latent cancer fatalities in population within 50 miles of SRS	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.7×10^{-5}	3.4×10^{-5}
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4[c]	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Nonradiological air pollutants at noninvolved worker location (max conc.):					
Sulfur dioxide (as SO_x) – 8 hr.	None	5.0×10^{-3}	5.0×10^{-3}	0.02	None
Total suspended particulates – 8 hr.	None	ND	ND	0.01	None
Particulate matter – 8 hr.	None	9.0×10^{-3}	6.0×10^{-3}	8.0×10^{-3}	None
Carbon monoxide – 8 hr.	None	0.01	0.01	0.04	None
Oxides of nitrogen (as NO_x) - ceiling	None	0.70	0.70	1.40	None
Lead – 8 hr.	None	2.1×10^{-6}	2.1×10^{-6}	6.5×10^{-6}	None

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Beryllium – 8 hr.	None	4.1×10^{-7}	4.1×10^{-7}	1.3×10^{-6}	None
Mercury - ceiling	None	4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-5}	None
Benzene – 8 hr.	None	4.8×10^{-5}	4.8×10^{-5}	1.0×10^{-3}	None
Occupational Health and Safety:					
Recordable injuries-closure	110[d]	120	120	190	400
Lost workday cases-closure	60[d]	62	62	96	210
Environmental Justice	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations	No disproportionately high and adverse environmental impacts expected for minority or low income populations
Transportation (offsite round-trip truckloads)	0	654	653	19	5
Waste Generation					
Maximum annual waste generation:					
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	60	60	60	900
Hazardous waste (m^3)	0	2	2	2	2
Mixed low-level waste (m^3)	0	12	12	12	20
Industrial waste (m^3)	0	20	20	20	20
Sanitary waste (m^3)	0	0	0	0	0

Table 2-2. (Continued).

Parameter	No Action Alternative	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
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (m^3)	0	0	0	0	0
Low-level waste (m^3)	0	1,284	1,284	1,284	19,260
Hazardous waste (m^3)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (m^3)	0	257	257	257	428
Industrial waste (m^3)	0	428	428	428	428
Sanitary waste (m^3)	0	0	0	0	0
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA	NA	NA	NA	NA
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

a. No data on TSP emissions for these sources is readily available and therefore is not reflected in the analysis.
b. No exceedences of air quality standards are expected.
c. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.
d. For the No Action Alternative, recordable injuries and lost work day cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.
NA = Not applicable; ND = Below detection limit.

Land use – From a land use perspective, the F- and H- Area Tank Farms are zoned Heavy Industrial and are within existing heavily industrialized areas. SRS land use patterns are not expected to change over the short term due to closure activities.

Socioeconomics – An annual average of 284 workers would be required for tank closure activities under the Clean and Remove Tanks Alternative. Fewer workers (85 to 131) would be required by the three tank stabilization options under the Clean and Stabilize Tanks Alternative. None of the alternatives or options is expected to measurably affect regional employment or population trends.

Cultural resources – There would be no impacts on cultural resources under any of the alternatives. The Tank Farms lie in a previously-disturbed, highly-industrialized area of the SRS.

Worker and public health impacts – All alternatives are expected to result in similar airborne radiological release levels. Public radiation doses and potential adverse health effects could occur from airborne releases only. Latent cancer fatality risk to the maximally-exposed offsite individual from air emissions during tank closure would be highest (6.4×10^{-10}) under the Clean and Fill with Saltstone Option due to the operation of the saltstone batch plant. Latent cancer fatality risk to the maximally-exposed offsite individual from other alternatives and options would be slightly lower, 6.1×10^{-10}. Estimated latent cancer fatalities to the offsite population of 620,000 people would also be highest under the Clean and Fill with Saltstone Option (3.7×10^{-5}), with other alternatives and options expected to result in a nominally-lower number of latent cancer fatalities of 3.4×10^{-5}.

Collective involved worker dose for closure of all 49 tanks would be highest under the Clean and Remove Tanks Alternative (12,000 person-rem), with the three stabilization options under the Clean and Stabilize Tanks Alternative ranging from 1,600 (Clean and Fill with Grout and Clean and Fill with Sand options) to 1,800 person-rem (Clean and Fill with Saltstone Option). Increased latent cancer fatalities attributable to these collective doses would be 4.9 (Clean and Remove Tanks Alternative), 0.72 (Clean and Fill with Saltstone Option), and 0.65 (Clean and Fill with Grout and Clean and Fill with Sand Options), respectively. The higher dose associated with the Clean and Remove Tanks Alternative relates to larger numbers of personnel required to implement the alternative.

The primary health effect of radiation is the incidence of cancer. Radiation impacts on workers and public health are expressed in terms of latent cancer fatalities. A radiation dose to a population is estimated to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The EPA has established dose-to-risk conversion factors of 0.0005 per person-rem for the general population and 0.0004 per person-rem for workers. The difference is due to the presence of children, who are believed to be more susceptible to radiation, in the general population.

DOE estimates the doses to the population and uses the conversion factor to estimate the number of cancer fatalities that might result from those doses. In most cases the result is a small fraction of one. For these cases, DOE concludes that the action would very likely result in no additional cancer in the exposed population.

Occupational Health and Safety – Recordable injuries and lost workday cases would be the lowest for the No Action Alternative and highest for the Clean and Remove Tanks Alternative. Of the three options under the Clean and Stabilize Tanks Alternative, the Fill with Saltstone option would have about 50% more recordable injuries and lost workday cases than the Fill with Grout and Fill with Sand options.

Environmental Justice – Because short-term impacts from tank closure activities would not significantly affect the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the tank closure alternatives.

Transportation – Offsite transportation of material by truck to clean and fill tanks would require from zero round-trips per tank for the No Action Alternative to 654 round trips per tank for the Clean and Fill with Grout Option. The amount of increased traffic expected under the proposed action and alternatives would be minimal. There would be no transportation of material under the No Action Alternative.

Waste generation – Tank cleaning activities under the Clean and Remove Tank Alternative would generate as much as 1.2 million gallons of radioactive liquid waste annually, while tank cleaning activities under the Clean and Stabilize Tanks Alternative (regardless of tank stabilization option) would generate as much as 600,000 gallons annually. This radioactive liquid waste would be managed as HLW. Small amounts of mixed low-level waste, hazardous waste, and industrial waste would be produced under both the Preferred Alternative and Clean and Remove Tanks Alternative. The amount of low-level radioactive waste generated by the Clean and Remove Tanks Alternative would be much higher than that generated by any of the other alternatives. No radioactive or hazardous wastes would be generated under the No Action Alternative.

Utilities and energy consumption – None of the alternatives would require electricity usage beyond that associated with current tank farm operations. Electrical power for field activities would be supplied by portable diesel generators. The Clean and Remove Tanks Alternative would require twice the fossil fuel use of the three options under the Clean and Stabilize Tanks Alternative. Total utility costs under the Clean and Remove Tanks Alternative would be approximately three times the costs of the options under the Clean and Stabilize Tanks Alternative. The increased costs are primarily associated with fossil fuel consumption and steam generation. Water consumption is not a substantial contributor to overall utility costs. The highest water usage would be expected for the Clean and Fill with Grout Option. The Clean and Remove Tanks Alternative would require the next highest water usage. The water required to clean tanks, mix tank fill material, or to be used as tank ballast would require less than 0.6 percent (or 0.006) of the annual production from F-Area wells.

Accidents – DOE evaluated the impacts of potential accidents related to each of the alternatives (Table 2-3). For the tank stabilization options, DOE considered transfers during cleaning, a design basis seismic event during cleaning, and failures of the salt solution hold tank. For the Clean and Remove Tanks Alternative, DOE considered transfer errors during cleaning and a seismic event.

For each accident, the impacts were evaluated as radiation dose and latent cancer fatalities (or increased risk of a latent cancer fatality) to the noninvolved workers, to the offsite maximally-exposed individual, and to the offsite population. For the Clean and Stabilize Tanks Alternative and the Clean and Remove Tank Alternative option, a design basis earthquake would result in the highest potential dose and the highest potential increase in latent cancer fatalities or increased risk of latent cancer for each of the receptor groups. The Clean and Fill with Saltstone Option was reviewed to identify potential accidents resulting from producing saltstone and using it to fill tanks. The highest consequence accident identified for saltstone production and use was the failure of the Salt Solution Hold Tank. This accident would result in lower dose and cancer impacts than the bounding accidents for other phases of the alternative.

2.4.2 LONG-TERM IMPACTS

Section 4.2 presents a discussion of impacts associated with residual radioactive and nonradioactive material remaining in the closed HLW tanks. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a long time span (10,000 years) to determine when certain measures of impacts (e.g., radiation dose) reach their peak value.

There is always uncertainty associated with the results of analyses, especially if the analyses attempt to predict impacts over a long period of

Table 2-3. Estimated accident consequences by alternative.

Alternative	Accident frequency	Consequences					
		Noninvolved worker (rem)	Latent cancer fatalities	Maximally exposed offsite individual (rem)	Latent cancer fatalities	Offsite population (person-rem)	Latent cancer fatalities
Clean and Stabilize Tanks Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5
Failure of Salt Solution Hold Tank (Saltstone option only)	0.005% per year (once in 20,000 years)	0.02	8.0×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	17	8.4×10^{-3}
Clean and Remove Tank Alternative							
Transfer errors during cleaning	0.1% per year (once in 1,000 years)	7.3	2.9×10^{-3}	0.12	4.8×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	0.0019% per year (once in 53,000 years)	15	6.0×10^{-3}	0.24	9.6×10^{-5}	11,000	5.5

time. The uncertainty could be the result of assumptions used, the complexity and variability of the process being analyzed, the use of incomplete information, or the unavailability of information. The uncertainties involved in estimating impacts over the 10,000 year period analyzed in this EIS are described in Section 4.2 and in Appendix C.

Because long-term impacts to certain resources were not anticipated, detailed analyses of impacts to these resources were not conducted. These included air resources, socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Therefore Section 4.2 (as summarized in Table 2-4) focuses on the following discipline areas: geologic resources, water resources, ecological resources, land use, and public health. Tables 2-5 through 2-7 present the long-term transport of nonradiological constituents in groundwater.

Geologic resources – Filling the closed-in-place tanks with ballast water (No Action), grout, sand, or saltstone (the three tank stabilization options under the Clean and Stabilize Tanks Alternative) could increase the infiltration of rainwater at some point in the future, allowing more percolation of water into the underlying geologic deposits. No detrimental effect on surface soils, topography, or to the structural or load-bearing properties of the geologic deposits would occur from these actions. With tank failure, the underlying soil could become contaminated for either the No Action Alternative or any of the options under the Clean and Stabilize Tanks Alternative. No long-term impacts to geologic resources are anticipated from the Clean and Remove Tanks Alternative.

Water resources/surface water – Based on modeling results, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the long-term movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in most cases several times below applicable standards. Concentrations of non-radiological contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

The fate and transport modeling indicates that movement of residual radiological contaminants from closed HLW tanks to nearby surface waters via groundwater would also be limited by the three stabilization options under the Clean and Stabilize Tanks Alternative. Based on the modeling results, all three stabilization options under the Clean and Stabilize Tanks Alternative would be more effective than the No Action Alternative. The Clean and Fill with Grout Option would be the most effective of the three tank stabilization options as far as minimizing long-term movement of residual radiological contaminants.

Water resources/groundwater – The highest concentrations of radionuclides in groundwater would occur under the No Action Alternative. For this alternative, the EPA primary drinking water maximum contaminant level of 4.0 millirem per year for beta-gamma emitting radionuclides would be exceeded at all points of exposure since essentially all of the drinking water dose is due to beta-gamma emitting radionuclides. The Clean and Fill with Grout Option shows the lowest groundwater concentrations of radionuclides at all exposure points. Only this option and the Clean and Fill with Sand Option would meet the maximum contaminant level at the seepline. The beta-gamma maximum contaminant level would be substantially exceeded at the 1-meter and 100-meter wells under all alternatives.

The results for alpha-emitting radionuclides also show that the highest concentrations would occur for the No Action Alternative. For this alternative, the maximum contaminant level of 15 picocuries per liter would be exceeded at the 1-meter and 100-meter wells for both tank farms

Table 2-4. Summary comparison of long-term impacts by tank closure alternative.[a]

Parameter	No Action Alternative	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
Geologic Resources	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated	With tank failure, underlying soil could become contaminated
Surface Water	Limited movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters	Almost no movement of residual contaminants in closed tanks to down-gradient surface waters
Nonradiological constituents in Upper Three Runs at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	3.7×10^{-5}	(b)	(b)	(b)
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.2×10^{-6}	(b)	(b)	(b)
Nonradiological constituents in Fourmile Branch at point of compliance (mg/L)				
Aluminum	(b)	(b)	(b)	(b)
Chromium IV	(b)	(b)	(b)	(b)
Copper	(b)	(b)	(b)	(b)
Iron	4.9×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}
Lead	(b)	(b)	(b)	(b)
Mercury	(b)	(b)	(b)	(b)
Nickel	(b)	(b)	(b)	(b)
Silver	1.1×10^{-4}	8.8×10^{-5}	6.5×10^{-6}	8.8×10^{-6}

Table 2-4. (Continued).

Parameter	No Action Alternative	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
Maximum dose from beta-gamma emitting radionuclides in surface water (millirem/year)				
Upper Three Runs	0.45	(b)	4.3×10^{-3}	9.6×10^{-3}
Fourmile Branch	2.3	9.8×10^{-3}	0.019	0.130
Groundwater				
Groundwater concentrations from contaminant transport – F-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline, Fourmile Branch (1,800 meters downgradient)	430	1.9	3.5	25
Alpha concentration (pCi/L)				
1-meter well	1,700	13	13	13
100-meter well	530	4.8	4.7	4.8
Seepline, Fourmile Branch (1,800 meters downgradient)	9.2	0.04	0.039	0.04
Groundwater concentrations from contaminant transport – H-Area Tank Farm:				
Drinking water dose (mrem/yr.)				
1-meter well	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1×10^{5}
100-meter well	9.0×10^{4}	300	920	870
Seepline (1,200 meters downgradient)				
North of Groundwater Divide	2,500	2.5	25	46
South of Groundwater Divide	200	0.95	1.4	16
Alpha concentration (pCi/L)				
1-meter well	13,000	24	290	24

Table 2-4. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative		
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
100-meter well	3,800	7.0	38	7.0
Seepline, North of Groundwater Divide	34	0.15	0.33	0.15
Seepline, South of Groundwater Divide	4.9	0.02	0.19	0.02
Ecological Resources				
Maximum hazard indices for aquatic environments	2.0	1.42	0.18	0.16
Maximum hazard quotients for terrestrial environments				
Aluminum	(c)	(c)	(c)	(c)
Barium	(c)	(c)	(c)	(c)
Chromium	0.04	0.02	(c)	(c)
Copper	(c)	(c)	(c)	(c)
Fluoride	0.19	0.08	0.01	0.01
Lead	(c)	(c)	(c)	(c)
Manganese	(c)	(c)	(c)	(c)
Mercury	(c)	(c)	(c)	(c)
Nickel	(c)	(c)	(c)	(c)
Silver	1.55	0.81	0.09	0.13
Uranium	(c)	(c)	(c)	(c)
Zinc	(c)	(c)	(c)	(c)
Maximum absorbed dose to aquatic and terrestrial organisms (in millirad per year):				
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265

Table 2-4. (Continued).

Parameter	No Action Alternative	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
Land Use	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS	Tank farms zoned heavy industrial; no residential areas allowed on SRS
Public Health				
Radiological contaminant transport from F-Tank Farm:				
Adult resident latent cancer fatality risk	2.2×10^{-4}	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}
Child resident latent cancer fatality risk	2.0×10^{-4}	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}
Seepline worker latent cancer fatality risk	2.2×10^{-7}	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}
Intruder latent cancer fatality risk	1.1×10^{-7}	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}
Adult resident maximum lifetime dose (millirem)[f]	430	1.9	3.6	26
Child resident maximum lifetime dose (millirem)[f]	400	1.7	3.3	24
Seepline worker maximum lifetime dose (millirem)[f]	0.54	0.002	0.004	0.03
Intruder maximum lifetime dose (millirem)[f]	0.27	0.001	0.002	0.02
1-meter well drinking water dose (millirem per year)	3.6×10^{5}	130	420	790
1-meter well alpha concentration (picocuries per liter)	1,700	13	13	13
100-meter well drinking water dose (mrem/yr)	1.4×10^{4}	51	190	510
100-meter well alpha concentration (picocuries per liter)	530	4.8	4.7	4.8
Seepline drinking water dose (millirem per year)	430	1.9	3.5	25
Seepline alpha concentration (picocuries per liter)	9.2	0.04	0.039	0.04
Radiological contaminant transport from H-Tank Farm:				
Adult resident latent cancer fatality risk	8.5×10^{-5}	2.0×10^{-6}	5.5×10^{-7}	6.5×10^{-6}
Child resident latent cancer fatality risk	7.5×10^{-5}	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}
Seepline worker latent cancer fatality risk	8.4×10^{-8}	(e)	4.0×10^{-10}	6.8×10^{-9}
Intruder latent cancer fatality risk	4.4×10^{-8}	(e)	(e)	3.2×10^{-9}

Table 2-4. (Continued).

Parameter	No Action Alternative	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
Adult resident maximum lifetime dose (millirem)[f]	170	4	1.1	13
Child resident maximum lifetime dose (millirem)[f]	150	0.65	1.1	1.3
Seepline worker maximum lifetime dose (millirem)[f]	0.21	(d)	0.001	0.017
Intruder maximum lifetime dose (millirem)[f]	0.11	(d)	(d)	0.008
1-meter well drinking water dose (millirem per year)	9.3×10^{6}	1×10^{5}	1.3×10^{5}	1.0×10^{5}
1-meter well alpha concentration (picocuries per liter)	13,000	24	290	24
100-meter well drinking water dose (millirem per year)	9.0×10^{4}	300	920	870
100-meter well alpha concentration (picocuries per liter)	3,800	7.0	38	7.0
Seepline drinking water dose (millirem per year)	2.5×10^{3}	2.5	25	46
Seepline alpha concentration (picocuries per liter)	34	0.15	0.33	0.15

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).

b. Radiation dose less than 1.0×10^{-6} or non-radiological concentration less than 1.0×10^{-6} mg/L.

c. Hazard quotient is less than ~ 1×10^{-2}.

d. The radiation dose for this alternative is less than 1×10^{-3} millirem.

e. The risk for this alternative is less than 4.0×10^{-10}.

f. Calculated based on an assumed 70-year lifetime.

Table 2-5. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 1-meter well.[a]

	Maximum concentration (percent of MCL)				
1-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	18.5	320	6,500	150
Barnwell McBean	0.0	47.5	380	0.0	270
Congaree	0.0	6.8	0.0	0.0	62
Grout Fill Option					
Water Table	0.0	0.3	21	70	2.3
Barnwell McBean	0.0	5	23	0.0	21
Congaree	0.0	0.1	0.0	0.0	0.5
Saltstone Fill Option					
Water Table	0.0	0.3	21	70	240,000
Barnwell McBean	0.0	5	23	0.0	440,000
Congaree	0.0	0.1	0.0	0.0	160,000
Sand Fill Option					
Water Table	0.0	1.6	8.5	37	6.7
Barnwell McBean	0.0	5.3	19	0.0	22
Congaree	0.0	0.1	0.0	0.0	0.7

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-6. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, 100-meter well.[a]

	Maximum concentration (percent of MCL)				
100-Meter well	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	8.3	74	265	69
Barnwell McBean	0.0	12.5	81	0.0	58
Congaree	0.0	1.2	0.0	0.0	11
Grout Fill Option					
Water Table	0.0	0.1	2.7	1.5	0.7
Barnwell McBean	0.0	1.1	4.4	0.0	4.7
Congaree	0.0	0.0	0.0	0.0	0.1
Saltstone Fill Option					
Water Table	0.0	0.1	2.7	1.5	68,000
Barnwell McBean	0.0	1.1	4.4	0.0	180,000
Congaree	0.0	0.0	0.0	0.0	21,000
Sand Fill Option					
Water Table	0.0	0.3	1.5	2.7	1.3
Barnwell McBean	0.0	1.2	3.7	0.0	4.9
Congaree	0.0	0.0	0.0	0.0	0.1

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

Table 2-7. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Tank Farm, seepline.[a]

	Maximum concentration (percent of MCL)				
Fourmile Branch seepline	Ba	F	Cr	Hg	Nitrate
No Action Alternative					
Water Table	0.0	0.4	1.0	0.0	3.4
Barnwell McBean	0.0	0.5	0.8	0.0	2.4
Congaree	0.0	0.0	0.0	0.0	0.1
Grout Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.0
Barnwell McBean	0.0	0.0	0.0	0.0	0.1
Congaree	0.0	0.0	0.0	0.0	0.0
Saltstone Fill Option					
Water Table	0.0	0.0	0.0	0.0	3,000
Barnwell McBean	0.0	0.0	0.0	0.0	3,300
Congaree	0.0	0.0	0.0	0.0	300
Sand Fill Option					
Water Table	0.0	0.0	0.0	0.0	0.1
Barnwell McBean	0.0	0.0	0.0	0.0	0.2
Congaree	0.0	0.0	0.0	0.0	0.0

Notes: Only those contaminants with current EPA primary drinking water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration. Values represent the highest concentration from either tank farm.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities.

and the seepline north of the groundwater divide for H-Tank Farm. The Grout, Sand, and Saltstone Options show similar concentrations at most locations. For these three options, the maximum contaminant level for alpha-emitting radionuclides would be exceeded only in H-Area at the 1-meter well (all three options) and at the 100-meter well (Sand Option).

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tank systems themselves would be removed and transported to SRS radioactive waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217). The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are about one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health.

For nonradiological constituents, the EPA primary drinking water maximum contaminant levels would be exceeded only for the No Action Alternative and Clean and Fill with Saltstone Option. The impacts would be greatest in terms of the variety of contaminants that exceed the maximum contaminant level for the No Action Alternative, but exceedances of the maximum contaminant levels only occur primarily at the 1-meter well, with mercury exceeding the MCL also at the 100-meter well. Impacts from the Clean and Fill with Saltstone Option would occur at all exposure points, including the seepline; however, nitrate is the only contaminant that would exceed its maximum contaminant level. The maximum contaminant levels would not be exceeded for any contaminant in any aquifer layer, at any point of exposure, for either the Grout or the Sand Options.

Ecological resources – Risks to aquatic organisms in Fourmile Branch and Upper Three Runs for non-radiological contaminants would be negligible under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. For the Clean and Fill with Grout Option and the No Action Alternative, there would be relatively low risk to aquatic organisms.

Risks to terrestrial organisms such as the shrew and mink (and other small mammalian carnivores with limited home range sites) from non-radiological contaminants would be negligible for all options under the Clean and Stabilize Tanks Alternative. For the No Action Alternative, there would be generally low risk to terrestrial organisms.

All calculated radiological doses to terrestrial and aquatic animal organisms were well below the limit of 365,000 millirad per year (1.0 rad per day) established in DOE Order 5400.5, including the No Action Alternative.

Land use – Long-term land use impacts at the tank farm areas are not expected because of DOE's established land use policy for the SRS. In the *Savannah River Site Future Use Plan*, DOE established a future use policy for the SRS. Several key elements of that policy would maintain the lands that are now part of the tank farm areas for heavy industrial use and exclude use from non-conforming land uses. Most notable are:

- Protection and safety of SRS workers and the public shall be a priority.
- The integrity of site security shall be maintained.
- A "restricted use" program shall be developed and followed for special areas (e.g., CERCLA and RCRA regulated units).
- SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government.
- Residential uses of all SRS land shall be prohibited in any area of the site.

As mentioned above, the tank farm areas will remain in an industrialized zone. In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. In the case of the Industrial-Heavy Nuclear zone, facilities included (1) produce, process, store and/or dispose of radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations.

Public health – DOE evaluated the impacts over a 10,000-year period. Structural collapse of the tanks would pose a safety hazard under the No Action Alternative, creating unstable ground conditions and forming 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. Airborne releases from the tanks are considered to be possible only under the No Action Alternative, and their likelihood is considered to be minimal for that alternative because the presence of moisture and the considerable depth of the tanks below grade would tend to discourage resuspension of tank contents. Therefore, the principal source of potential impacts to public health is leaching and groundwater transport of contaminants. DOE calculated risks to public health based on postulated release and transport scenarios.

The maximum calculated dose to the adult resident for either tank farm, as presented in Table 2-3, would be 430 mrem for a 70-year lifetime for the No Action Alternative. This dose is less than the 100 mrem per year public dose limit and represents only a marginal increase in the annual average exposure of individuals in the United States of approximately 360 mrem due to natural and manmade sources of radiation exposure. Based on this low dose, DOE would not expect any health effects if an individual were to receive this hypothetical dose.

At the one-meter well, the highest calculated peak drinking water dose under the No Action Alternative is 9,300,000 millirem per year (9,300 rem per year), which would lead to acute radiation health effects, including death. Peak doses at this well for the Clean and Stabilize Tanks Alternative are calculated to be in the range of 100,000 to 130,000 millirem per year (100 to 130 rem per year), which substantially exceeds all criteria for acceptable exposure, could result in acute health effects, and would give a significantly increased probability of a latent cancer fatality. Peak doses calculated at the 100-meter well range from 300 millirem (0.3 rem per year) per year for the Clean and Fill with Grout Option to 90,000 millirem per year (90 rem per year) for the No Action Alternative. Individuals exposed to 300 millirem per year would experience a lifetime increased risk of latent cancer fatality of less that 0.02 percent per year of exposure. The estimated doses at the 1- and 100-meter wells are extremely conservative (high) estimates because the analysis treated all of the tanks in a given group as being at the same physical location. Realistic doses at these close-in locations would be substantially smaller.

DOE considered the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radiation exposure was the only potentially significant pathway of potential radiological exposure other than groundwater use (WSRC 1992). For the Clean and Fill with Grout and Clean and Fill with Sand Options of the Clean and Stabilize Tanks Alternative, external radiation doses to onsite residents would be negligible because the thick layers of nonradioactive material between the waste (near the bottom of the tanks) and the ground surface would shield residents from any direct radiation emanating from the waste. External radiation exposures could occur under the Clean and Fill with Saltstone Option which would place radioactive saltstone near the ground surface. If it is conservatively assumed that all of the backfill soil is eroded or excavated away and there is no other cap over the saltstone, so that a home is built directly on the saltstone, analysis presented in WSRC (1992) indicates that 1000 years after tank closure a resident would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. Backfill soils or caps would eliminate or substantially reduce the potential external exposure. For example, with a 30-inch-thick intact concrete cap, the dose would be reduced to 0.1 mrem/year. For the No Action Alternative external exposures to onsite residents would be expected to be unacceptably high due to the potential for contact with the residual waste.

References

Bradley, R. F. and A. J. Hill, 1977, *Chemical Dissolving of Sludge from a High Level Waste Tank at the Savannah River Plant*, DP-1471, November.

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

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, July 10.

DOE (U.S. Department of Energy), 1997, *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), 1998, *Savannah River Site Future Use Plan*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

du Pont (E.I. du Pont de Nemours and Company, Inc.), 1980, *Tank 16 Demonstration, Water Wash and Chemical Cleaning Results*, DPSP 80-17-23, Savannah River Site, Aiken, South Carolina.

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.

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), 1995a, *High Level Waste Engineering Monthly Data Report (U)*, WSRC-RP-95-841-7, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1995b, *Annual Radioactive Waste Tank Inspection Program - 1994 (U)*, WSRC-TR-95-166, Westinghouse Savannah River Company, Aiken, South Carolina.

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

CHAPTER 3. AFFECTED ENVIRONMENT

Chapter 3 describes the existing SRS environment as it relates to the alternatives described in Chapter 2.

3.1 Geologic Setting and Seismicity

The SRS is in west-central South Carolina, approximately 100 miles from the Atlantic coast (Figure 3.1-1). It is on the Aiken Plateau of the Upper Atlantic Coastal Plain about 25 miles southeast of the Fall Line that separates the Atlantic Coastal Plain from the Piedmont.

3.1.1 GENERAL GEOLOGY

In South Carolina, the Atlantic Coastal Plain Province consists of a wedge of seaward-dipping and thickening unconsolidated and semiconsolidated sediments that extend from the Fall Line to the Continental Shelf. The Aiken Plateau is the subdivision of the Coastal Plain that includes the location of the SRS. The plateau extends from the Fall Line to the oldest of several scarps incised in the Coastal Plain sediment. The Plateau surface is highly dissected and characterized by broad interfluvial areas with narrow steep-sided valleys. Although it is generally well drained, poorly drained depressions (called Carolina bays) do occur (DOE 1995). At the Site, the plateau is underlain by 600 to 1,400 feet of sands, clays, and limestones of Tertiary and Cretaceous age. These sediments are underlain, in turn, by sandstones of Triassic age and older metamorphic and igneous rocks (Arnett and Mamatey 1996). Because of the proximity of the SRS to the Piedmont Province, it has more relief than areas that are nearer the coast, with onsite elevations ranging from 89 to 420 feet above mean sea level.

The sediments of the Atlantic Coastal Plain (Figure 3.1-2) dip gently seaward from the Fall Line and range in age from Late Cretaceous to Recent. The sedimentary sequence thickens from essentially 0 feet at the Fall Line to more than 4,000 feet at the coast. Regional dip is to the southeast. Coastal Plain sediments underlying the SRS consist of sandy clays and clayey sands, although occasional beds of clean sand, gravel, clay, or carbonate occur (DOE 1995). The formations of interest in F- and H-Areas (General Separations Area) are part of the shallow (Floridan) aquifer system (Figure 3.1-2 and Table 3.1-1). Contaminants released to these formations could be transported by groundwater to local SRS streams.

3.1.2 LOCAL GEOLOGY AND SOILS

The principal surface and near-surface soils in F- and H- Areas consist of cross-bedded, poorly sorted sands and pebbly sands with lenses and layers of silts and clays. The surface and near surface soils contain a grater percentage of clay which has demonstrated a good retention capacity for most radionuclides. A significant portion of the surface soils around the F- and H- Area Tank Farms are composed of backfill material resulting from previous excavation and construction activities.

The vadose zone is comprised of the middle to late Miocene-age "Upland Unit," which extends over much of SRS. The term "Upland Unit" is an informal name used to describe sediments at higher elevations located in the Upper Coastal Plain in southwestern South Carolina. This area has also been referred to as the Aiken Plateau which is bounded by the Savannah and Congaree Rivers and extends from the Fall Line to the Orangeburg escarpment. This unit is highly dissected and is characterized by broad interfluvial areas with narrow, steep-sided valleys (SCDNR, 1995). Erosion in these dissected, steep-sided valley areas expose older, underlying deposits.

The occurrence of cross-bedded, poorly sorted sands with clay lenses indicate fluvial deposition (high-energy channel deposits to channel-fill deposits) with occasional transitional marine influence. This depositional environment results in wide differences in lithology and presents a very complex system of transmissive and confining beds or zones (SCDNR, 1995). The lower surface of the "Upland Unit" is very irregular due to erosion of the underlying

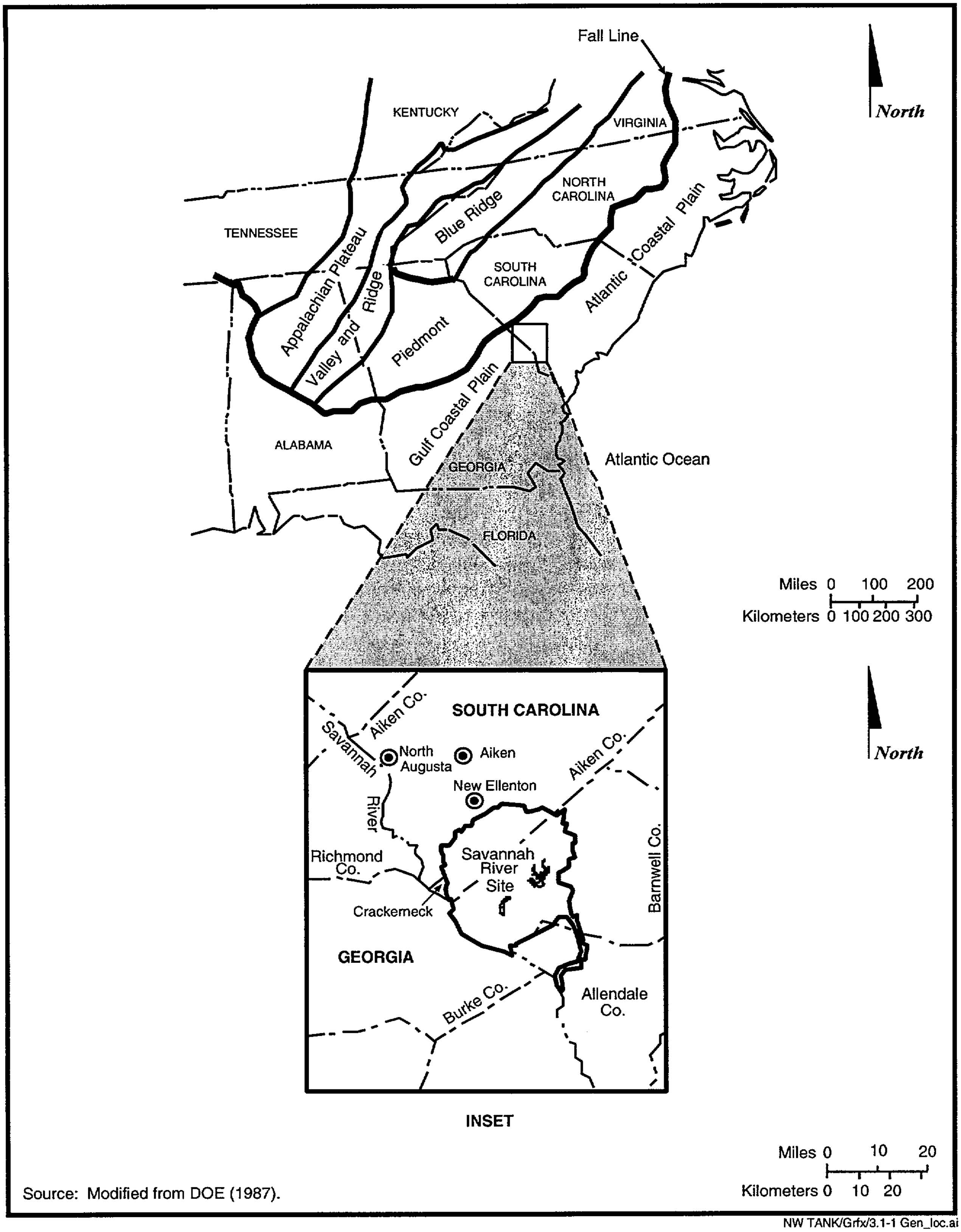
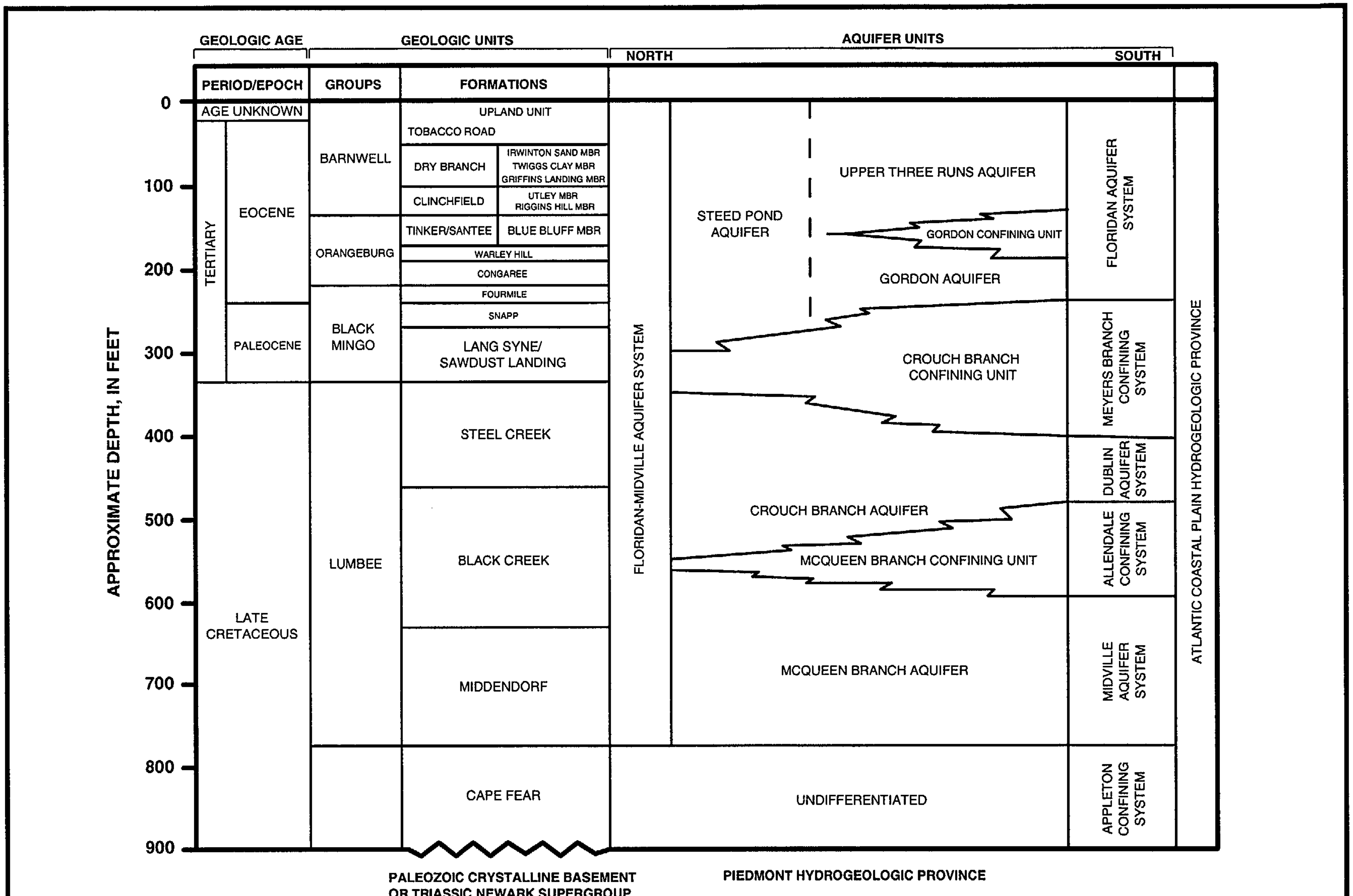


Figure 3.1-1. Generalized location of Savannah River Site and its relationship to physiographic provinces of southeastern United States.



Source: Aadland, Gellici, and Thayer (1995).

NW TANK/Grfx/3.1-2 Geo_Aqu Units.ai

Figure 3.1-2. Generalized geologic and aquifer units in SRS region.

Table 3.1-1. Formations of the Floridan aquifer system in F- and H-Areas.[a]

Aquifer unit	Formation	Description
Upper Three Runs Aquifer -upper zone [Water Table]	"Upland Unit"	Poorly sorted, clayey-to-silty sands, with lenses and layers of conglomerates, pebbly sands, and clays. Clay clasts are abundant, and cross-bedding and flecks of weathered feldspar are locally common.
	Tobacco Road Formation	Moderately to poorly sorted, variably colored, fine-to-coarse grained sand, pebbly sand, and minor clay beds.
"Tan Clay" Confining Zone	Dry Branch Formation -Twiggs Clay Member	Variably colored, poorly sorted to well sorted sand with the interbedded tan to gray clay ("Tan Clay") of the Twiggs Clay Member. The Tan Clay where present divides the Upper Three Runs Aquifer into an upper and lower zone.
Upper Three Runs Aquifer -lower zone [Barnwell/McBean]	-Griffins Landing Member -Irwinton Sand Member	
	Clinchfield Formation	Light colored basal quartz sand and glauconitic, biomoldic limestone, calcareous sand and clay. Sand beds of the formation constitute Riggins Mill Member and consist of medium to coarse, poorly to well sorted, loose and slightly indurated, tan, gray, and green quartz. The carbonate sequence of the Clinchfield consists of Utley Member -- sandy, glauconitic limestone and calcareous sand with indurated biomoldic facies.
	Tinker/Santee Formation	Unconsolidated, moderately sorted, subangular, lower coarse-to-medium grained, slightly gravely, immature yellow and tan quartz sand and clayey sand; calcareous sands and clays and limestone also occur in F- and H-Areas.
Gordon Confining Unit [Green Clay]	Blue Bluff Member of Santee Limestone	Micritic limestone
	Warley Hill Formation	Fine grained, glauconitic, clayey sand, and clay that thicken, thin, and pinch out abruptly.
Gordon Aquifer [Congaree]	Congaree Formation	Yellow, orange, tan, gray, and greenish gray, well-sorted, fine-to-coarse-grained quartz sands. Thin clay laminae occur throughout the section, with pebbly layers, clay clasts, and glauconite in places. In some places on SRS, upper part of Congaree Formation is cemented with silica; in other places it is slightly calcareous. Glauconitic clay, encountered in some borings on SRS near the base of this formation, indicates that basal contact is unconformable.
	Fourmile Formation	Tan, yellow-orange, brown, and white, moderately to well-sorted sand, with clay beds near middle and top of unit. The sand is very coarse to fine-grained, with pebbly zones common. Glauconite and dinoflagellate fossils occur.
	Snapp Formation	Silty, medium- to course-grained quartz sand interbedded with clay. Dark, micaceous, lignitic sand also occurs. In northwestern part of SRS, this Formation is less silty and better sorted, with thinner clay interbeds.

a. Source: Aadland, Gellici, and Thayer (1995).

formations (Fallow and Price, 1992). The thickness of the "Upland Unit" ranges from 16 feet to 40 feet in the vicinity of the F-and H- Area Seepline Basins (WSRC, 1991), but may be as thick as 70 feet in the Central Savannah River Area (Fallow and Price, 1992). The F- and H- Area Seepage Basins are located southwest and west of the F- and H- Area Tank farms, respectively.

A notable feature of the "Upland Unit" is its compositional variability (Figure 3.1.2). This formation predominantly consists of red-brown to yellow-orange, gray, and tan colored, coarse to fine grained sand, pebbly and with lenses and beds of sandy clay and clay. Generally vertically upward through the unit, sorting of grains becomes poorer, clay beds become more abundant and thicker, and sands become more argilaceous and indurated (Fallow and Price, 1992). In some areas, small-scale joints and fractures, both of which are commonly filled with sand or silt, traverse the unit. The mineralogy of the sands and pebbles primarily consists of quarts, with some feldspars. In areas to the east-southeast, sediments may become more phosphatic and dolomitic. The mineralogy of the clays consists of kaolinite, resulting from highly weathered feldspars, and muscovite (Nystrom et al., 1991). The soils at F- and H- Areas may contain as much as 20 to 40 percent clay (WSRC, 1991).

3.1.3 SEISMICITY

There are several fault systems off the Site northwest of the Fall Line (DOE 1990). A recent study of geophysical evidence (Wike et al. 1996) and an earlier study (Stephenson and Stieve 1992) also identified the onsite faults indicated on Figure 3.1-3. The earlier study identified the following faults – Pen Branch, Steel Creek, Advanced Tactical Training Area, Crackerneck, Ellenton, and Upper Three Runs – under SRS. The more recent study (Wike et al. 1996) identifies a previously unknown fault that passes through the southeastern corner of H-Area and passes approximately one-half mile south of F-Area between F-Area and Fourmile Branch. The Upper Three Runs Fault, which is a Paleozoic fault that does not cut Coastal Plain sediments, passes approximately 1 mile north and west of F Area. The lines shown on Figure 3.1-3 represent the projection of faults to the ground surface. The actual faults do not reach the surface but stop several hundred feet below.

Based on available information, none of the faults discussed in this section is capable, which means that none of the faults has moved at or near the ground surface within the past 35,000 years or is associated with another fault that has moved in the past 35,000 years. The regulation 10 CFR 100 contains a more detailed definition of a capable fault. Two major earthquakes have occurred within 186 miles of SRS.

- According to URS/Blume (1982), the Charleston, South Carolina earthquake of 1886 had an estimated Richter scale magnitude of 6.8; it occurred approximately 90 miles from the SRS area, which experienced an estimated peak horizontal acceleration of 10 percent of gravity (0.10*g*). Lee et al. (1997) reevaluated the data determined the magnitude to have been 7.5.

- The Union County, South Carolina earthquake of 1913 had, according to Bollinger (1973), an estimated Richter scale magnitude of 6.0 and occurred about 99 miles from the Site. The magnitude has since been revised downward to 4.5 based on a re-evaluation of the duration data (Geomatrix 1991).

These earthquakes are not associated conclusively with a specific fault.

In recent years, three earthquakes occurred inside the SRS boundary.

- On May 17, 1997, with a duration magnitude of 2.3 and a focal depth of 3.38 miles; its epicenter was southeast of K Area.

- On August 5, 1988, with a duration magnitude of 2.0 and a focal depth of 1.66 miles; its epicenter was northeast of K Area.

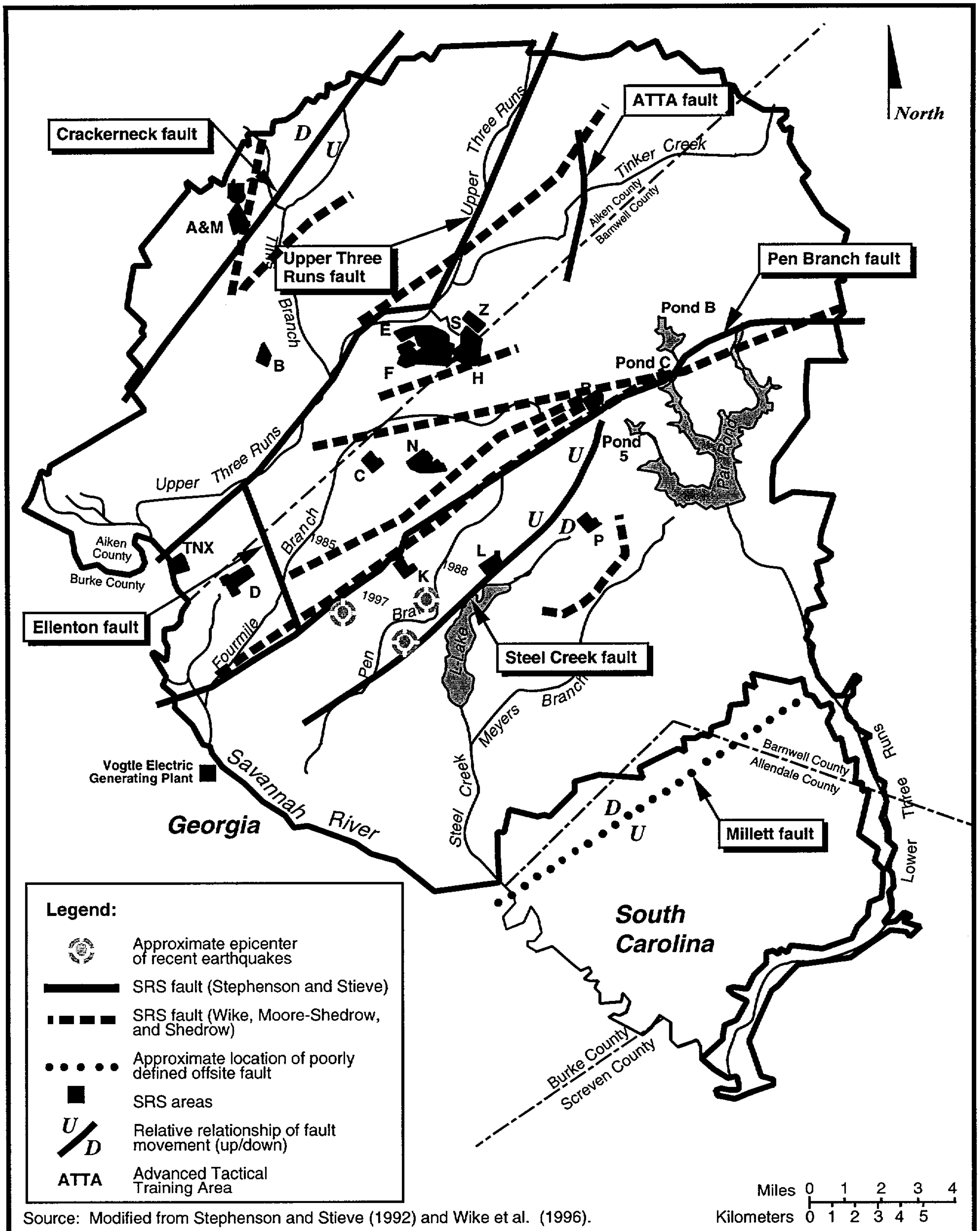


Figure 3.1-3. Savannah River Site, showing seismic fault lines and locations of onsite earthquakes and their year of occurrence.

- On June 8, 1985, with a duration magnitude of 2.6 and a focal depth of 0.59 mile; its epicenter was south of C Area and west of K Area.

Existing information does not relate these earthquakes conclusively with known faults under the Site. In addition, the focal depth of these earthquakes is currently being evaluated. Figure 3.1-3 shows the locations of the epicenters of these earthquakes.

Outside the SRS boundary, an earthquake with a Richter scale magnitude of 3.2 occurred on August 8, 1993, approximately 10 miles east of the City of Aiken near Couchton, South Carolina. People reported feeling this earthquake in Aiken, New Ellenton (immediately north of SRS), North Augusta (approximately 25 miles northwest of the SRS), and on the Site.

3.2 Water Resources

3.2.1 SURFACE WATER

The Savannah River bounds SRS on its southwestern border for about 20 miles, approximately 160 river miles from the Atlantic Ocean. Five upstream reservoirs -- Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond – reduce the variability of flow downstream, in the area of SRS. River flow averages about 10,000 cubic feet per second at SRS (DOE 1995).

Upstream of SRS, the river supplies domestic and industrial water for Augusta, Georgia, and North Augusta, South Carolina. Approximately 130 river miles downstream of SRS, the river supplies domestic and industrial water for Savannah, Georgia, and Beaufort and Jasper Counties in South Carolina through intakes at about River Mile 29 and River Mile 39, respectively (DOE 1995).

Five tributaries discharge directly to the Savannah River from SRS: Upper Three Runs, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs (Figure 3.2-1). A sixth stream, Pen Branch, which does not flow directly into the river, joins Steel Creek in the Savannah River floodplain swamp. Each of these six streams originates on the Aiken Plateau in the Coastal Plain and descends 50 to 200 feet before discharging into the river (DOE 1995). The streams, which historically have received varying amounts of effluent from SRS operations, are not commercial sources of water.

F- and H-Areas are situated on the divide that separates the drainage into Upper Three Runs (including McQueen Branch and Crouch Branch) and Fourmile Branch; approximately half of each area drains into each stream (DOE 1997b). F- and H-Areas are relatively elevated areas of SRS and are centrally located inside the SRS boundary. Surface elevations range from approximately 270 to 320 feet above mean sea level for both F- and H-Areas. The F- and H-Areas are drained by Upper Three Runs to the north and west and by Fourmile Branch to the south. In addition, the Water Table Aquifer for both F- and H-Areas outcrops at the seeplines along both Fourmile Branch and Upper Three Runs.

Upper Three Runs, the longest of the SRS streams, is a large blackwater stream in the northern part of SRS that discharges to the Savannah River. It drains an area of over 195 square miles and is approximately 25 miles long, with its lower 17 miles within SRS boundaries. This creek receives more water from underground sources than other SRS streams and is the only stream with headwaters arising outside the site. It is the only major tributary on SRS that has not received thermal discharges (Halverson et al. 1997).

Fourmile Branch is a blackwater stream that originates near the center of SRS and flows southwest for 15 miles before emptying into the Savannah River (Halverson et al. 1997). It drains an area of about 22 square miles inside SRS, including much of F-, H-, and C-Areas. Fourmile Branch flows parallel to the Savannah River behind natural levees and enters the river through a breach downriver from Beaver Dam Creek. In its lower reaches, Fourmile Branch broadens and flows via braided channels through a delta formed by the deposition of sediments eroded from upstream during high flows.

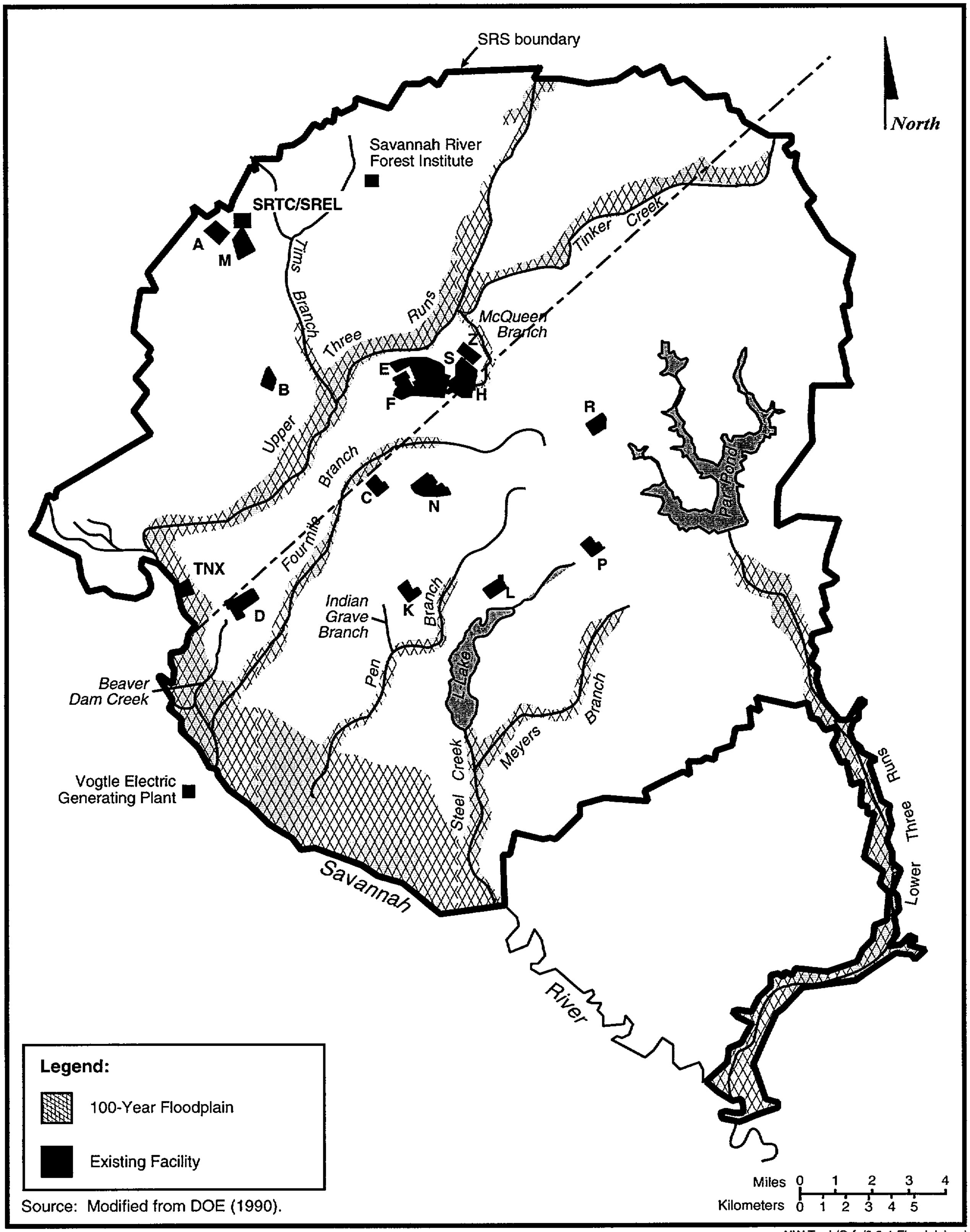


Figure 3.2-1. Savannah River Site, showing 100-year floodplain and major stream systems.

Downstream from the delta, the channels rejoin into one main channel. Most of the flow discharges into the Savannah River while a small portion flows west and enters Beaver Dam Creek (DOE 1995).

The natural flow of SRS streams ranges from about 10 cubic feet per second in smaller streams to 245 cubic feet per second in Upper Three Runs. From 1974 to 1995, the mean flow of Upper Three Runs at Road A was 245 cubic feet per second, and the 7Q10 (minimum 7-day average flow rate that occurs with an average frequency of once in 10 years) was 100 cubic feet per second (Halverson et al. 1997). The mean flow of Fourmile Branch southwest of SC Highway 125 from 1976 to 1995 was 113 cubic feet per second, and the 7Q10 was 7.6 cubic feet per second (Halverson et al. 1997). The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) contain detailed information on flow rates and water quality of the Savannah River and SRS streams.

There are various potential sources of contamination to the Upper Three Runs and Fourmile Branch watersheds in and around the F- and H-Areas. These potential sources have been identified in the SRS Federal Facility Agreement, Appendix C, RCRA/CERCLA Units (WSRC 1993) and are listed in Table 3.2-1. These potential sources could contribute contaminants to the surface waters of Upper Three Runs and Fourmile Branch in the same manner as the F- and H-Area Tank Farms.

SCDHEC regulates the physical properties and concentrations of chemicals and metals in SRS effluents under the National Pollutant Discharge Elimination System (NPDES) program. SCDHEC, which also regulates biological water quality standards for SRS waters, has classified the Savannah River and SRS streams as "Freshwaters." In 1998, 99.3 percent of the NPDES water quality analyses on SRS effluents were in compliance with the SRS NPDES permit; only 42 of 5,790 analyses exceeded permit limits (Arnett and Mamatey 1999a). The 1998 exceedances were higher than in previous years. Repeat exceedances at 4 outfalls accounted for a majority of the exceedances; some of which can be attributed to ongoing heavy rainfall. In particular, heavy rainfall caused groundwater levels to rise significantly at outfall D-1A which had a total of 18 exceedances. A comparison of 1998 Savannah River water quality analyses showed no significant differences between up- and downstream SRS stations (Arnett and Mamatey 1999a). Table 3.2-2 summarizes the water quality of Fourmile Branch and Upper Three Runs for 1998.

3.2.2 GROUNDWATER RESOURCES

3.2.2.1 <u>Groundwater Features</u>

In the SRS region, the subsurface contains two hydrogeologic provinces. The uppermost, consisting of a wedge of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age, is the Atlantic Coastal Plain Hydrogeologic Province. Beneath the sediments of the Atlantic Coastal Plain Hydrogeologic Province are rocks of the Piedmont Hydrogeologic Province. These rocks consist of Paleozoic igneous and metamorphic basement rocks and lithified mudstone, sandstone, and conglomerates of the Dunbarton basin of the Upper Triassic. Sediments of the Atlantic Coastal Plain Hydrogeologic Province are divided into three main aquifer systems, the Floridan Aquifer System, the Dublin Aquifer System, and the Midville Aquifer System as shown in Figure 3.1-2 (Aadland et al. 1995). The Meyers Branch Confining System and/or the Allendale Confining System, as shown in Figure 3.1-2, separate the aquifer systems of interest.

Groundwater within the Floridan System (the shallow aquifer beneath the Site) flows slowly toward SRS streams and swamps and into the Savannah River at rates ranging from inches to several hundred feet per year. The depth to which onsite streams cut into sediments, the lithology of the sediments, and the orientation of the sediment formations control the horizontal and vertical movement of the groundwater. The valleys of smaller perennial streams allow dis-

Table 3.2-1. Potential F- and H-Area contributors of contamination to Upper Three Runs and Fourmile Branch.[a]

Fourmile Branch Watershed	Upper Three Runs Watershed
Burial Ground Complex Groundwater[b]	Burial Ground Complex Groundwater[a]
Burial Ground Complex [the Old Radioactive Waste Burial Ground (643-E) and Solvent Tanks S01-S22 portions]	Burial Ground Complex [the Low-Level Radioactive Waste Disposal Facility (643-7E) portion]
F-Area Coal Pile Runoff Basin, 289-F	Burma Road Rubble Pit, 231-4F
F-Area Hazardous Waste Management Facility, 904-41G, -42G, -43G	F-Area Burning/Rubble Pits, 231-F, -1F, -2F
F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F	F-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-1F
F-Area Retention Basin, 281-3F	
F-Area Seepage Basin Groundwater Operable Unit	H-Area Coal Pile Runoff Basin, 289-H
H-Area Hazardous Waste Management Facility, 904-44G, -45G, -46G, -56G	H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H
H-Area Inactive Process Sewer Lines from Building to the Security Fence[a], 081-H	
H-Area Retention Basin, 281-3H	Old F-Area Seepage Basin, 904-49G
H-Area Seepage Basin Groundwater Operable Unit	211-FB Plutonium-239 Release, 081-F
H-Area Tank Farm Groundwater	
Mixed Waste Management Facility, 643-28E	
Warner's Pond, 685-23G	

a. Source: WSRC (1993).
Units located in more than one watershed.

charge from the shallow saturated geologic formations. The valleys of major tributaries of the Savannah River (e.g., Upper Three Runs) drain formations of intermediate depth, and the river valley drains deep formations. With the release of water to the streams, the hydraulic head of the aquifer unit releasing the water can become less than that of the underlying unit. If this occurs, groundwater has the potential to migrate upward from the lower unit to the overlying unit.

Groundwater flow in the shallow aquifer (Floridan) system is generally horizontal but may have a vertically downward component. In the divide areas between surface water drainages the vertical component of groundwater flow is downward due to the decreasing hydraulic head with increasing depth. In areas along the lower reaches of most of the Site streams, groundwater moves generally in a horizontal direction and has vertically upward potential from deeper aquifers to the shallow aquifers. In these areas, hydraulic heads increase with depth. In the vicinity of these streams, the potential for vertically upward flow occurs across a confining unit where the underlying aquifer has not been incised by an overlying stream (Aadland et al. 1995). For example, in the area south of H-Area where Fourmile Branch cuts into the Upper Three Runs Aquifer but does not cut into the Gordon Aquifer, the hydraulic head is greater in the Gordon Aquifer than the overlying Upper Three Runs Aquifer that discharges to Fourmile Branch. At these locations any contaminants in the overlying aquifer system are prevented from migrating into deeper aquifers by the prevailing hydraulic gradient and the low permeability of the confining unit. Groundwater flow in the General Separations Area, which includes F- and H-Areas, is toward Upper Three Runs and its tributaries to the north and Fourmile Branch to the south.

Table 3.2-2. SRS stream water quality (onsite downstream locations).[a]

Parameter[b]	Units	Fourmile Branch (FM-6) average	Upper Three Runs (U3R-4) average	Water Quality Criterion[c], MCL[d], or DCG[e]
Aluminum	mg/L	0.285[f]	0.294[f]	0.087
Cadmium	mg/L	NR[g]	NR	0.00066
Calcium	mg/L	NR	NR	NA[h]
Cesium-137	pCi/L	4.74	0.67	120[e]
Chromium	mg/L	ND[i]	ND	0.011
Copper	mg/L	0.006	ND	0.0065
Dissolved oxygen	mg/L	8.31	6.3	≥5
Iron	mg/L	0.717	0.547	1
Lead	mg/L	0.18	0.011	0.0013
Magnesium	mg/L	NR	NR	0.3
Manganese	mg/L	0.045	0.026	1
Mercury	mg/L	0.0002	ND	0.000012
Nickel	mg/L	ND	ND	0.088
Nitrate (as nitrogen)	mg/L	1.29	0.26	10[d1]
pH	pH	6.4	5.8	6-8.5
Plutonium-238	pCi/L	0.003	ND	1.6[e]
Plutonium-239	pCi/L	0.001	0.005	1.2[e]
Strontium-89,90	pCi/L	6.79	0.04	8[d2]
Suspended solids	mg/L	3.9	5.9	NA
Temperature[j]	°C	20.2	18.8	32.2
Tritium	pCi/L	1.9×10^5	4.2×10^3	20,000[d2]
Uranium-234	pCi/L	0.69	0.093	20[e]
Uranium-235	pCi/L	0.053	0.046	24[e]
Uranium-238	pCi/L	0.84	0.11	24[e]
Zinc	mg/L	0.019	0.02	0.059

a. Source: Arnett and Mamatey (1999b).
b. Parameters DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.
c. Water Quality Criterion (WQC) is Aquatic Chronic Toxicity unless otherwise indicated.
d. MCL = Maximum Contaminant Level; State Primary Drinking Water Regulations [d1 = Chapter 61-58.5 (b)(2)h; d2= Chapter 61-585(h(2)b].
e. DCG = DOE Derived Concentration Guides for Water (DOE Order 5400.5). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, value listed is 4 percent of DCG.
f. Concentration exceeded WQC; however, these criteria are for comparison only. WQCs are not legally enforceable.
g. ND = Not detected.
h. NA = Not applicable.
i. Shall not be increased more than 2.8°C (5°F) above natural temperature conditions or exceed a maximum of 32.2°C (90°F) as a result of the discharge of heated liquids unless appropriate temperature criterion mixing zone has been established.

3.2.2.2 Groundwater Use

Groundwater is a domestic, municipal, and industrial water source throughout the Upper Coastal Plain. Regional domestic water supplies come primarily from the shallow aquifers including the Gordon Aquifer and the Upper Three Runs Aquifer (water-table aquifer). Most municipal and industrial water supplies in Aiken County are from the Crouch Branch and McQueen Branch Aquifers, formerly the Black Creek and Middendorf, respectively. In Barnwell and Allendale Counties some municipal water supplies are from the Gordon Aquifer and overlying units that thicken to the southeast. At SRS, most groundwater production for domestic and process water comes from the Crouch Branch and McQueen Branch, with a few lower-capacity domestic waterwells pumping from the shallower Gordon (Congaree) Aquifer and the lower zone of the Upper Three Runs (McBean) Aquifer. These wells are located away from the main operations areas in outlying areas including guard barricades and operations offices/ laboratories (DOE 1998).

The domestic water requirements for the General Separations Area are supplied from groundwater wells located in A Area (Arnett and Mamatey 1997). From January to December 1998, the total groundwater withdrawal rate in the General Separations Area for industrial use, including groundwater from process production wells and former domestic wells, now used as process wells in F-, H-, and S-Areas, was approximately 2.1 million gallons per day. These wells are installed in the deeper Crouch Branch and McQueen Branch Aquifers. Groundwater in F-Area is pumped from four process production and two former domestic wells currently being used for process production. The total F-Area groundwater production rate in 1998 was approximately 1.01 million gallons per day. During the same period, wells in H- and S-Areas produced approximately 1.02 million gallons per day and 49,000 gallons per day, respectively. H-Area has two former domestic wells and three process production wells (Wells 1997; WSRC 1999). S-Area's groundwater production is from three process/former domestic wells (WSRC 1995).

3.2.2.3 Hydrogeology

The aquifers of interest for F- and H-Areas within the General Separations Area are the Upper Three Runs and Gordon Aquifers. The Upper Three Runs Aquifer (formerly Water Table and Barnwell-McBean Aquifers) is defined by the hydrogeologic properties of the Tinker/Santee Formation, the Dry Branch Formation, and the Tobacco Road Formation (DOE 1997a). Table 3.1-1 provides descriptions of these formations. The Twiggs Clay Member of the Dry Branch Formation acts as a confining unit (Tan Clay) that separates the Upper Three Runs Aquifer into an upper and lower zone. The horizontal hydraulic conductivity for the upper zone of the Upper Three Runs Aquifer ranges between 5 to 13 feet per day with localized areas as high as 40 feet per day (Aadland et al. 1995). The horizontal hydraulic conductivity for the lower zone of the Upper Three Runs Aquifer is approximately 2.5 to 10 feet per day (Aadland et al. 1995). The vertical conductivity of the Upper Three Runs Aquifer (upper and lower zones) is generally assumed to be about $1/10^{th}$ to $1/100^{th}$ of the horizontal conductivity based on its lithology and stratified nature. The vertical hydraulic conductivity of the Tan Clay unit is generally taken to be on the order of 5×10^{-3} to 8×10^{-4} feet per day to support groundwater flow modeling calibration (Flach 1994).

Groundwater flow in the Upper Three Runs Aquifer is generally horizontal but may have a vertically downward component. In the groundwater divide areas generally located between surface water drainages a component of groundwater flow is downward due to the decreasing hydraulic head with increasing depth. Because the F- and H- Area Tank Farms lie near the groundwater divide the groundwater flow direction may be toward either Upper Three Runs and its tributaries to the north or Fourmile Branch to the south. In areas along Fourmile Branch shallow groundwater moves generally in a horizontal direction and deeper groundwater has vertically upward potential to the shallow aquifers. In these areas, hydraulic heads increase with depth. Therefore, along Fourmile Branch any contaminants in the Upper Three Runs Aquifer are prevented from migrating into deeper aquifers by the prevailing hydraulic gradient and the low permeability of the Tan and Green Clay confining units. To the north of the tank farms, however the rising elevation of the Upper Three Runs Aquifer and the deep incision of Upper Three Runs Creek result in truncation of the entire aquifer. In these areas shallow groundwater may seep out along the major tributaries to Upper Three Runs Creek above the valley floor or may seep downward to the next underlying aquifer zone and discharge along the stream valley.

The Gordon Confining Unit (green clay), which separates the Upper Three Runs and Gordon Aquifers, consists of the Warley Hill Formation and the Blue Bluff Member of the Santee Limestone (Table 3.1-1). It is not a continuous clay unit but consists of several superimposed lenses of green and gray clay that thicken, thin, and pinch out abruptly. Locally, beds of calcareous mud add to the thickness of the unit with minor interbeds of clayey sand or sand (Aadland et al. 1995). The vertical hydraulic conductivity is generally taken to be on the order of 1×10^{-4} to 1×10^{-5} foot per day to support groundwater flow modeling calibration (Flach 1994).

The Gordon Aquifer consists of the Congaree, Fourmile, and Snapp Formations. Table 3.1-1 provides soil descriptions for these formations. The Gordon Aquifer is partially eroded near the Savannah River and along Upper Three Runs. This aquifer is recharged directly by precipitation in the outcrop area, at interstream drainage divides in and near the outcrop area, and by leakage from overlying and underlying aquifers. The southeast-to-northwest hydraulic gradient across SRS is consistent and averages 4.8 feet per mile. The horizontal hydraulic conductivity ranges between approximately 30 to 40 feet per day (Aadland et al. 1995). The vertical hydraulic conductivity is generally assumed to be about 1/10th to 1/100th of the horizontal conductivity based on its lithology and stratified nature (Flach 1994).

Figures 3.2-2 through 3.2-4 show the approximate groundwater flow paths for F- and H-Area Tank Farms for the Water Table, Barnwell-McBean, and Congaree aquifers.

3.2.2.4 Groundwater Quality

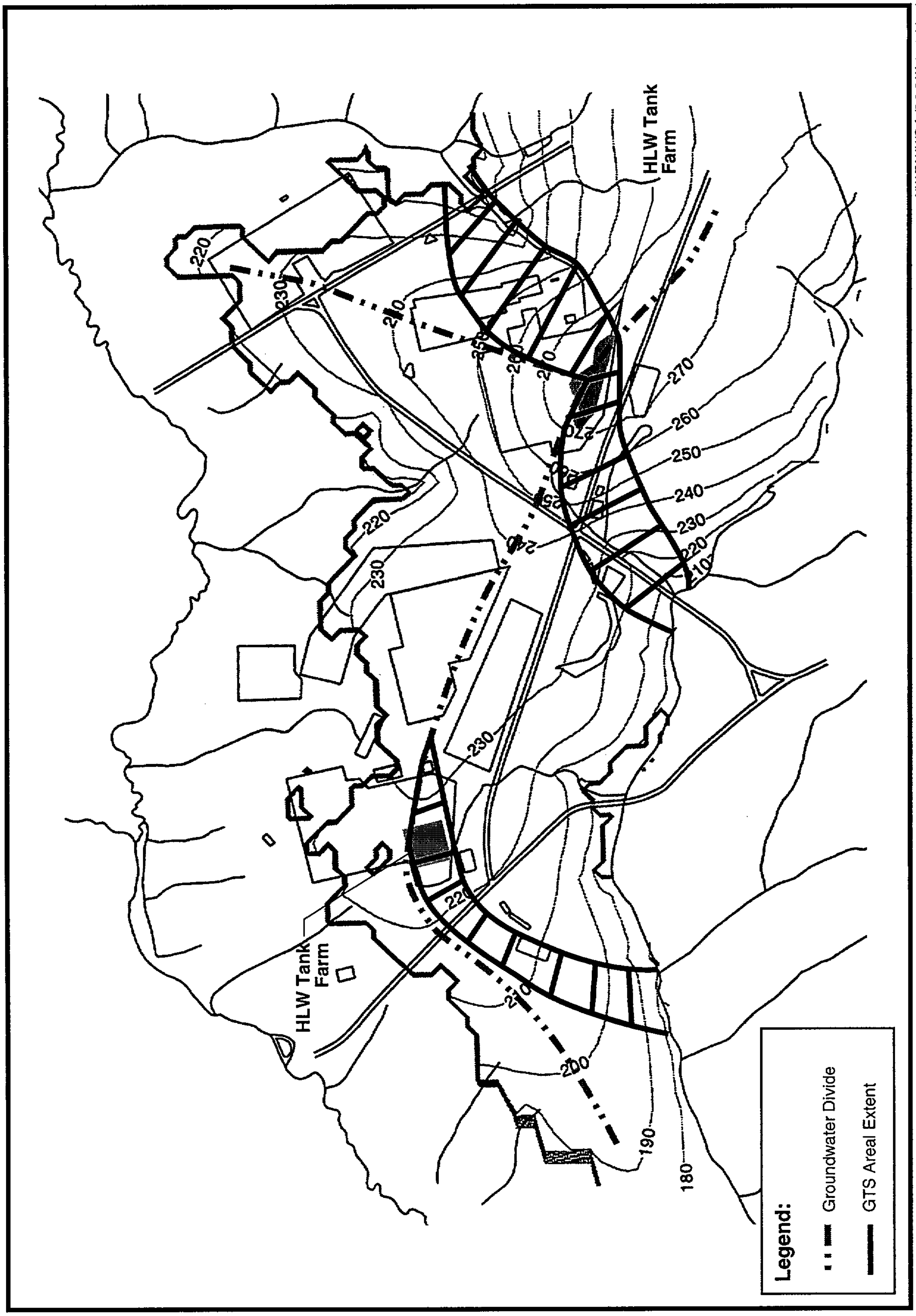
Industrial solvents, metals, tritium, and other constituents used or generated on SRS have contaminated the shallow aquifers beneath the industrial areas that make up 5 to 10 percent of the Site. In general, DOE does not use these aquifers for SRS process operations or drinking water, although there are a few low-yield wells in the Gordon Aquifer and in the lower zone of the Upper Three Runs Aquifer (formerly known as the McBean and Barnwell-McBean) in remote locations. The shallow aquifer units of the Floridan System discharge to SRS streams and eventually the Savannah River (Arnett and Mamatey 1997).

Most contaminated groundwater at SRS occurs beneath the industrial facilities; the contaminants reflect the operations and chemical processes performed at those facilities. In the General Separations Area, contaminants above regulatory and DOE guidelines include tritium and other radionuclides, metals, nitrates, sulfates, and chlorinated and volatile organics. Tables 3.2-3 through 3.2-7 list concentrations of individual analytes above regulatory or SRS guidelines for the period from fourth quarter 1997 through third quarter 1998 for the General Separations Area that includes E-, F-, H-, S-, and Z-Areas, respectively (WSRC 1997; WSRC 1998a,b,c). Figure 3.2-5 shows generalized groundwater contamination maximum values for analytes at or above regulatory or established SRS guidelines for the areas of concern.

3.3 Air Resources

3.3.1 METEOROLOGY

The southeastern U.S. has a humid subtropical climate characterized by relatively short, mild winters and long, warm, and humid summers. Summer-like weather typically lasts from May through September, when the area is subject to the persistent presence of the Atlantic subtropical anticyclone (i.e., the "Bermuda" high). The humid conditions often result in scattered afternoon thunderstorms. Average seasonal rainfall is usually lowest during the fall.



NW TANK/Grfx/3.2-2 Water table.ai

Figure 3.2-2. Calibrated potentiometric surface (ft) for the Water Table aquifer.

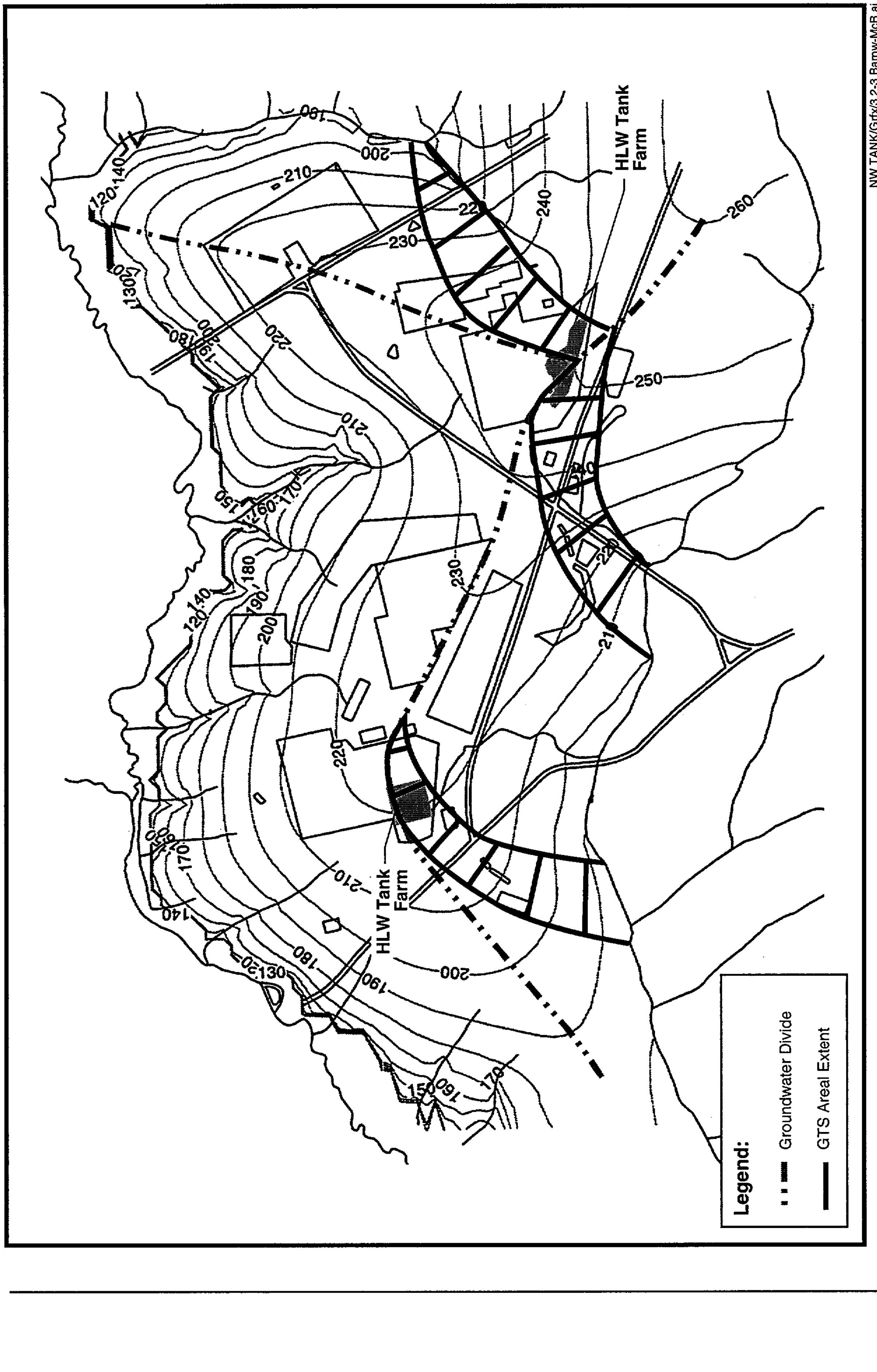
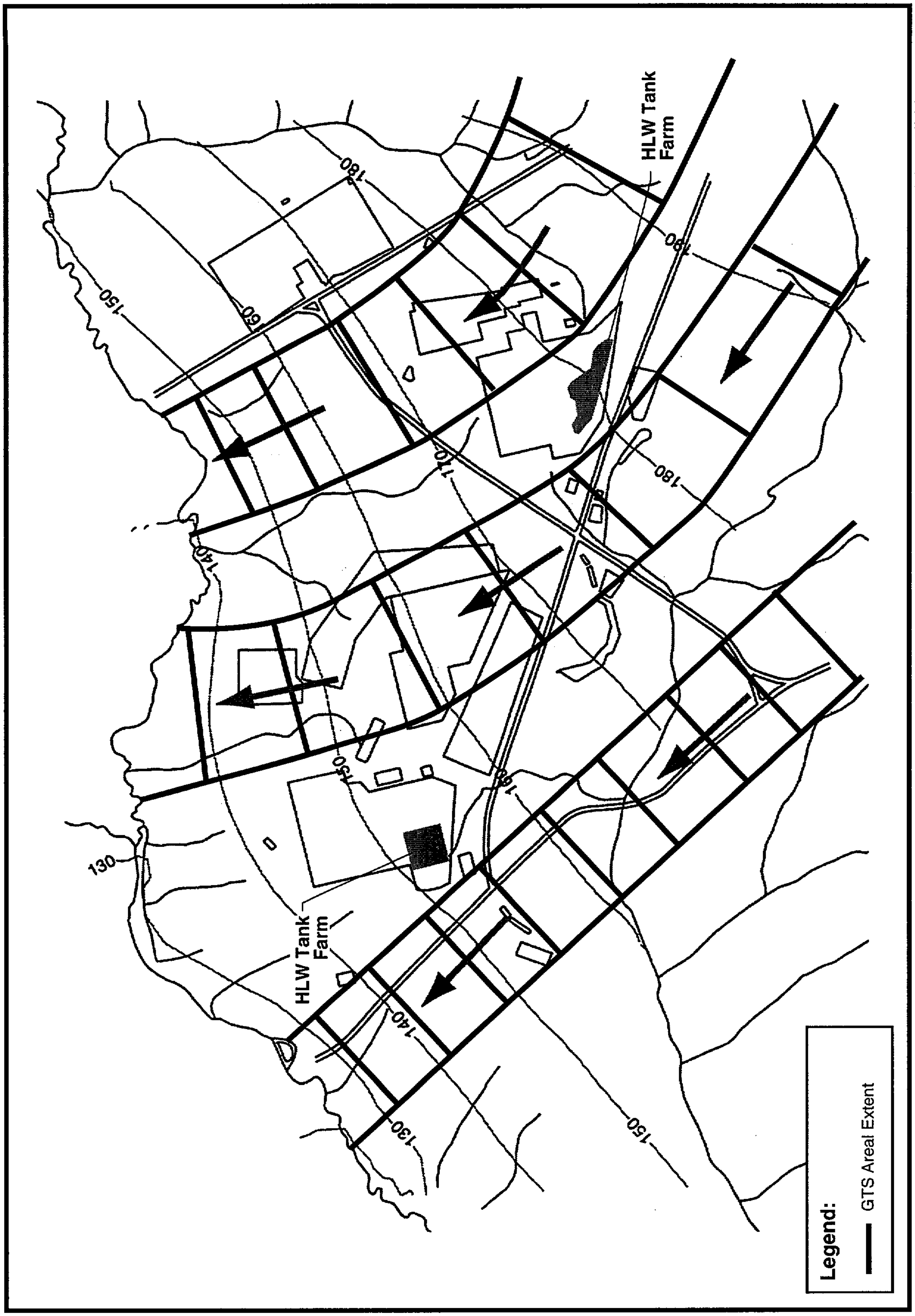


Figure 3.2-3. Calibrated potentiometric surface (ft) for the Barnwell/McBean aquifer.



NW TANK/Grfx/3.2-4 Congaree.ai

Figure 3.2-4. Calibrated potentiometric surface (ft) for the Congaree aquifer.

Table 3.2-3. E-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	3,670 µg/L	50 µg/L[c]
Antimony[b]	10.2 µg/L	6.0 µg/L[d]
Bromomethane	20.0 µ/L	20 µg/L[e]
Cadmium[b]	9.48 µg/L	5.0 µg/L[d]
Carbon-14	5.29×10^{-5} µCi/mL	2.0×10^{-6} µCi/mL[f]
Carbon tetrachloride	11.4 µg/L	5.0 µg/L[d]
Chloroethene (vinyl chloride)	24.9 µg/L	2.0 µg/L[d]
Chloroform	163 µg/L	100 µg/L[d]
Chromium[b]	117 µg/L	100 µg/L[d]
1,1-Dichloroethane	60.8 µg/L	5.0 µg/L[e]
1,1-Dichloroethylene	25.6 µg/L	7.0 µg/L[d]
Dichloromethane	150 µg/L	5.0 µg/L[d]
Gross alpha	3.27×10^{-8} µCi/mL	1.5×10^{-8} µCi/mL[d]
Iron[b]	13,500 µg/L	300 µg/L[c]
Lead[b]	116.0 µg/L	50 µg/L[g]
Lithium[b]	1,510 µg/L	250 µg/L[e]
Manganese[b]	309 µg/L	50 µg/L[c]
Mercury[b]	6.67 µg/L	2.0 µg/L[d]
Nickel[b]	134 µg/L	100 µg/L[d]
Nonvolatile beta	1.05×10^{-7} µCi/mL	5.0×10^{-8} µCi/mL[f]
Radium, total alpha emitting	6.90×10^{-9} µCi/mL	5.0×10^{-9} µCi/mL[f]
Strontium-90	6.44×10^{-8} µCi/mL	8.0×10^{-9} µCi/mL[d]
Tetrachloroethylene	50.2 µg/L	5 µg/L[d]
Thallium[b]	8.30 µg/L	2 µg/L[d]
Total organic halogens	559 µg/L	50 µg/L[e]
Trichloroethylene	1,160 µg/L	5 µg/L[d]
Trichlorofluoromethane	35.1 µg/L	20 µg/L[e]
Tritium	2.96×10^{-1} µCi/mL	2.0×10^{-5} µCi/mL[d]

a. µg/L = micrograms per liter; µCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997; 1998a,b,c). EPA Final Primary Drinking Water Standards (WSRC 1997; 1998a,b,c).
d. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997; 1998a,b,c).
e. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
g. SCDHEC Final Primary Drinking Water Standards (WSRC 1997; 1998a,b,c), Chapter 61-58.6E(7)(d).

Measurable snowfall is rare. Spring is characterized by mild temperatures, relatively low humidity, and a higher frequency of tornadoes and severe thunderstorms.

3.3.1.1 Local Climatology

Sources of data used to characterize the climatology of SRS consist of a standard instrument shelter in A-Area (temperature, humidity, and precipitation for 1961 to 1994), the Central Climatology Meteorological Facility near N-Area (temperature, humidity, and precipitation for 1995 to 1996), and seven meteorological towers (winds and atmospheric stability). The average annual temperature at SRS is 64.7°F. July is the warmest month of the year with an average daily maximum of 92°F and an average daily minimum near 72°F; January is the coldest month with an average daily high around 56°F and an average daily low of 36°F. Temperature extremes recorded at SRS since 1961 range from a

Table 3.2-4. F-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	37,100 μg/L	50 μg/L[c]
Americium-241	5.27×10^{-8} μCi/mL	6.34×10^{-9} μCi/mL[d]
Antimony[b]	27.0 μg/L	6.0 μg/L[e]
Beryllium[b]	16.6 μg/L	4.0 μg/L[e]
Bis (2-ethylhexyl) phthalate	160 μg/L	6 μg/L[e]
Cadmium[b]	36.3 μg/L	5.0 μg/L[e]
Carbon-14	1.97×10^{-5} μCi/mL	2.0×10^{-6} μCi/mL[f]
Cesium-137	2.58×10^{-7} μCi/mL	2.0×10^{-7} μCi/mL[f]
Cobalt[b]	863 μg/L	100 μg/L[g]
Copper[b]	1,530 μg/L	1,000 μg/L[h1]
Curium-243/244	1.08×10^{-7} μCi/mL	8.30×10^{-9} μCi/mL[d]
Dichloromethane	11.3 μg/L	5 μg/L[e]
Gross alpha	2.32×10^{-6} μCi/mL	1.5×10^{-8} μCi/mL[e]
Iodine-129	8.14×10^{-7} μCi/mL	1.0×10^{-9} μCi/mL[f]
Iron[b]	15,200 μg/L	300 μg/L[c]
Lead[b]	548 μg/L	50 μg/L[h2]
Manganese[b]	63.5 μg/L	50 μg/L[c]
Mercury[b]	8.38 μg/L	2.0 μg/L[e]
Nickel[b]	156 μg/L	100 μg/L[e]
Nickel-63	5.58×10^{-8} μCi/mL	5.0×10^{-8} μCi/mL[f]
Nitrate-nitrite as nitrogen	324,000 μg/L	10,000 μg/L[e]
Nonvolatile beta	3.06×10^{-6} μCi/mL	5.0×10^{-8} μCi/mL[f]
Radium-226	1.31×10^{-7} μCi/mL	5.0×10^{-9} μCi/mL[f,i]
Radium-228	6.19×10^{-7} μCi/mL	5.0×10^{-9} μCi/mL[f,i]
Ruthenium-106	5.41×10^{-8} μCi/mL	3.0×10^{-8} μCi/mL[f]
Strontium-89/90	2.46×10^{-5} μCi/mL	8.0×10^{-9} μCi/mL[e]
Strontium-90	9.07×10^{-7} μCi/mL	8.0×10^{-9} μCi/mL[e]
Technicium-99	1.32×10^{-6} μCi/mL	9.0×10^{-7} μCi/mL[f]
Tetrachloroethylene	15.7 μg/L	5 μg/L[e]
Thallium[b]	145 μg/L	2 μg/L[e]
Trichloroethylene	88.3 μg/L	5 μg/L[e]
Trichlorofluoromethane	55.8 μg/L	20μg/L[g]
Tritium	1.55×10^{-2} μCi/mL	2.0×10^{-5} μCi/mL[e]
Uranium-233/234	4.48×10^{-7} μCi/mL	1.38×10^{-8} μCi/mL[d]
Uranium-234	4.71×10^{-7} μCi/mL	1.39×10^{-8} μCi/mL[d]
Uranium-235	3.48×10^{-8} μCi/mL	1.45×10^{-8} μCi/mL[d]
Uranium-238	8.79×10^{-7} μCi/mL	1.46×10^{-8} μCi/mL[d]
Zinc[b]	8,430 μg/L	5,000 μg/L[c]

a. μg/L = micrograms per liter; μCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997, 1998a,b,c).
d. EPA Proposed Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
e. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
f. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
g. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997, 1998a,b,c).
h. SCDHEC Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c) [h1 = Chapter 61-58.5 0(2); h2 = Chapter 61-58.6 F(7)(d)].
i. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

Table 3.2-5. H-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Aluminum[b]	13,000 μg/L	50 μg/L[c]
Bis (2-ethylhexyl) phthalate	142 μg/L	6 μg/L[d]
Dichloromethane	8.45 μg/L	5 μg/L[d]
Gross alpha	9.74×10^{-8} μCi/mL	1.5×10^{-8} μCi/mL[d]
Iodine-129	1.09×10^{-7} μCi/mL	1.0×10^{-9} μCi/mL[e]
Iron[b]	17,100 μg/L	300 μg/L[c]
Lead[b]	417 μg/L	50 μg/L[f]
Manganese[b]	1,650 μg/L	50 μg/L[c]
Mercury[b]	18.5 μg/L	2.0 μg/L[d]
Nickel-63	4.79×10^{-7} μCi/mL	5.0×10^{-8} μCi/mL[e]
Nitrate-nitrite as nitrogen	52,800 μg/L	10,000 μg/L[d]
Nonvolatile beta	3.37×10^{-6} μCi/mL	5.0×10^{-8} μCi/mL[e]
Phorate	2.28 μg/L	1.7 μg/L[g]
Radium-226	6.52×10^{-8} μCi/mL	5.0×10^{-9} μCi/mL[e, h]
Radium-228	6.98×10^{-8} μCi/mL	5.0×10^{-9} μCi/mL[e,h]
Radium, total alpha emitting	6.70×10^{-9} μCi/mL	5.0×10^{-9} μCi/mL[e]
Ruthenium-106	3.81×10^{-8} μCi/mL	3.0×10^{-8} μCi/mL[e]
Strontium-89/90	1.01×10^{-8} μCi/mL	8.0×10^{-9} μCi/mL[d]
Strontium-90	1.24×10^{-6} μCi/mL	8.0×10^{-9} μCi/mL[d]
Thallium[b]	1,060 μg/L	2 μg/L[d]
Trichloroethylene	14.7 μg/L	5 μg/L[d]
Tetrachloroethylene	12.6 μg/L	5 μg/L[d]
Tritium	1.02×10^{-2} μCi/mL	2.0×10^{-5} μCi/mL[d]
Uranium-233/234	4.28×10^{-8} μCi/mL	1.38×10^{-8} μCi/mL[i]
Uranium-238	4.20×10^{-8} μCi/mL	1.46×10^{-8} μCi/mL[i]
Vanadium[b]	139 μg/L	133 μg/L[g]

a. μg/L = micrograms per liter; μCi/mL = microcuries per milliliter.
b. Total recoverable.
c. EPA National Secondary Drinking Water Standards (WSRC 1997, 1998a,b,c).
d. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
e. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
f. SCDHEC Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c) [Chapter 61-58.6 F(7)(d).
g. Drinking Water Standards do not apply. Criterion 10 times a recently published 90th percentile detection limit was used (WSRC 1997, 1998a,b,c).
h. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.
i. EPA Proposed Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).

maximum of 107°F in July 1986 to -3°F in January 1985.

Annual precipitation averages 49.5 inches. Summer is the wettest season of the year with an average monthly rainfall of 5.2 inches. Fall is the driest season with a monthly average rainfall of 3.3 inches. Relative humidity averages 70 percent annually with an average daily maximum of 91 percent and an average daily minimum of 45 percent.

Wind directions frequently observed at SRS show that there is no prevailing wind at SRS, which is typical for the lower Midlands of South Carolina. According to wind data collected from 1992 through 1996, winds are most fre-

Table 3.2-6. S-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Trichloroethylene	49.2 μg/L	5 μg/L[b]

a. μg/L = micrograms per liter; μCi/mL = microcuries per milliliter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).

Table 3.2-7. Z-Area maximum reported groundwater parameters in excess of regulatory and SRS limits.[a]

Analyte	Concentration	Regulatory limit
Gross alpha	9.77×10^{-8} μCi/mL	1.5×10^{-8} μCi/mL[b]
Nonvolatile beta	5.26×10^{-8} μCi/mL	5.0×10^{-8} μCi/mL[c]
Radium-226	7.78×10^{-9} μCi/mL	5.0×10^{-9} μCi/mL[c, d]
Radium-228	8.09×10^{-9} μCi/mL	5.0×10^{-9} μCi/mL[c, d]
Radium, total alpha emitting	5.55×10^{-8} μCi/mL	5.0×10^{-9} μCi/mL[c]
Ruthenium-106	3.08×10^{-8} μCi/mL	3.0×10^{-8} μCi/mL[c]

a. μg/L = micrograms per liter; μCi/mL = microcuries per milliliter.
b. EPA Final Primary Drinking Water Standards (WSRC 1997, 1998a,b,c).
c. EPA Interim Final Primary Drinking Water Standard (WSRC 1997, 1998a,b,c).
d. Radium 226/228 Combined Proposed Maximum Contaminant Level of 5.0×10^{-8} microcuries per milliliter.

quently from the southwest sector (9.7 percent) (Arnett and Mamatey 1998a). Measurements of turbulence are used to determine whether the atmosphere has relatively high, moderate, or low potential to disperse airborne pollutants (commonly identified as unstable, neutral, or stable atmospheric conditions, respectively). Generally, SRS atmospheric conditions were categorized as unstable 56 percent of the time (DOE 1997).

The average wind speed for a measured 5-year period was 8.5 miles per hour. Average hourly wind speeds of less than 4.5 miles per hour occur approximately 10 percent of the time (NOAA 1994).

3.3.1.2 Severe Weather

An average of 54 thunderstorm days per year were observed at the National Weather Service in Augusta, Georgia office during the period 1951 to 1995. About half of the thunderstorms occurred during the summer. Since operations began at SRS, 10 confirmed tornadoes have occurred on or in close proximity to the Site. Several of these tornadoes, which were estimated to have winds up to 150 miles per hour, did considerable damage to forested areas of SRS. None caused damage to structures. Tornado statistics indicate that the average frequency of a tornado striking any single point on the Site is 2×10^{-4} per year or about once every 5,000 years (Weber 1998).

The highest sustained wind (fastest-mile) recorded at the Augusta National Weather Service Office is 82 miles per hour. Hurricanes struck South Carolina 36 times during the period 1700 to 1992, which equates to an average recurrence frequency of once every 8 years. A hurricane force wind of 75 miles per hour has been observed at SRS only once, during Hurricane Gracie in 1959.

3.3.2 AIR QUALITY

3.3.2.1 Nonradiological Air Quality

The SRS is located in the Augusta-Aiken Interstate Air Quality Control Region (AQCR). All areas within this region are classified as achieving attainment with the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). Ambient air is defined as that portion of the atmos-

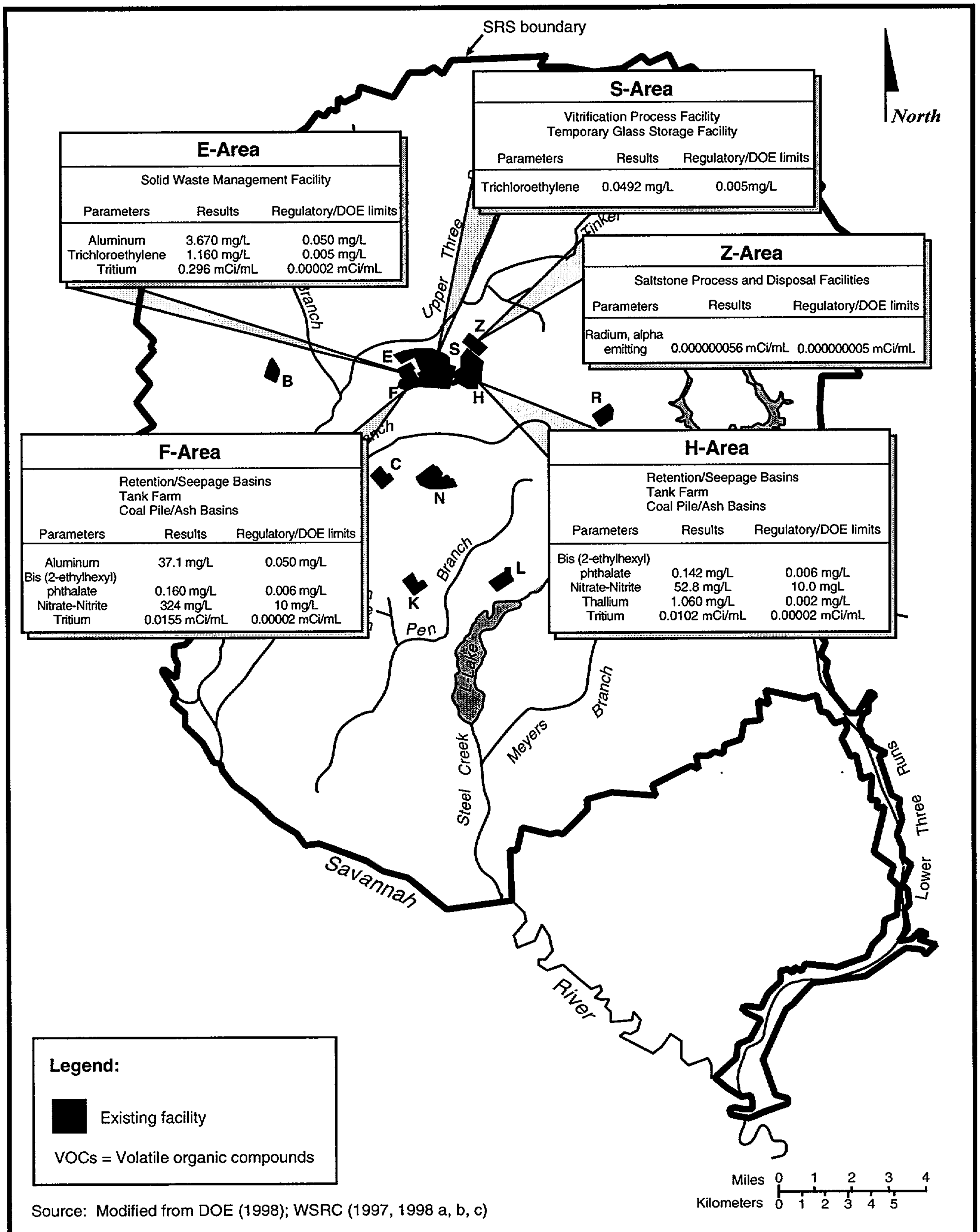


Figure 3.2-5. Maximum reported groundwater contamination in excess of regulatory/DOE limits at Savannah River Site.

phere, external to buildings, to which the general public has access. The NAAQS define ambient concentration criteria or limits for sulfur dioxide (SO_2), particulate matter equal to or less than 10 microns in aerodynamic diameter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb). These pollutants are generally referred to as "criteria pollutants." The nearest area not in attainment with the NAAQS is Atlanta, Georgia, which is approximately 150 miles west of SRS.

All of the Aiken-Augusta AQCR is designated a Class II area with respect to the Clean Air Act's Prevention of Significant Deterioration (PSD) regulations (40 CFR 51.166). The PSD regulations provide a framework for managing the existing clean air resources in areas that meet the NAAQS. Areas designated PSD Class II have sufficient air resources available to support moderate industrial growth. A Class I PSD designation is assigned to areas that are to remain pristine, such as national parks and wildlife refuges. Little additional impact to the existing air quality is allowed with a Class I PSD designation. Industries located within 100 kilometers (62 miles) of Class I Areas are subject to very strict Federal air pollution control standards. There are no Class I areas within 62 miles of SRS. The only Class 1 Area in South Carolina is the Cape Romain National Wildlife Refuge located in Charleston County.

The EPA approved more restrictive ambient standards for ground-level ozone and particulate matter that became effective on September 16, 1997 (62 FR 138). The new primary standard for ground-level ozone is based on an 8-hour averaging interval with a limit of 0.08 parts-per-million (ppm). Monitoring data from 1993 to 1997 indicate that ozone concentrations in the urban areas of Greenville-Spartanburg-Anderson, Columbia-Lexington, Rock Hill, Aiken, and Florence may approach or exceed the new standard. Monitoring data from 1997, 1998, and 1999 will be used to determine compliance with the new ozone standard (SCDHEC 1998).

Based on review of available scientific data on all particulate matter, the EPA determined that fine particulate matter less than 2.5 microns in diameter or $PM_{2.5}$ present greater health concerns than larger sized particulates. As a result, in addition to keeping the current PM_{10} regulations, EPA issued a daily (24-hour) $PM_{2.5}$ standard of 65 $\mu g/m^3$ and an annual limit of 15.0 $\mu g/m^3$. Limited data collected in several rural and urban areas in South Carolina, along with estimates derived from PM_{10} and TSP sampling around the State, indicate that many areas of South Carolina may exceed or have the potential to exceed the new annual standard for $PM_{2.5}$. SCDHEC expects that Aiken County will likely comply with the new standards. States will collect 3 years of monitoring data beginning in 1998 and will make attainment demonstrations beginning in 2002 (SCDHEC 1998).

On May 14, 1999, in response to challenges filed by industry and others, a 3-judge panel of the U.S. Court of Appeals for the District of Columbia Circuit issued a split opinion (2 to 1) on the new clean air standards. The Court vacated the new particulate standard and directed EPA to develop a new standard meanwhile reverting back to the previous PM_{10} standard. The revised ozone standard was not nullified, however, the judges ruled that the standard "cannot be enforced" (EPA 1999). On June 28, 1999, the EPA filed a petition for rehearing key aspects of the case in the U.S. Court of Appeals for the D.C. Circuit. The EPA has asked the U.S. Department of Justice to appeal this decision and take all judicial steps necessary to overturn the decision.

SCDHEC has been delegated authority to implement and enforce requirements of the Clean Air Act for the State of South Carolina. SCDHEC Air Pollution Regulation 62.5, Standard 2, enforces the NAAQS and sets ambient limits for two additional pollutants: total suspended particulates (TSP) and gaseous fluorides (as hydrogen fluoride, HF). The latter is not expected to be emitted as result of tank closure activities and is not included in subsequent discussions. In addition, SCDHEC Standard 8, Section II, Paragraph E) establishes ambient standards for 256 toxic air pollutants.

Significant sources of regulated air pollutants at SRS include coal-fired boilers for steam production, diesel generators, chemical storage tanks, the DWPF, groundwater air strippers, and various other process facilities. Another source of criteria pollutant emissions at SRS is the prescribed burning of forested areas across the Site by the U.S. Forest Service (Arnett and Mamatey 1998a). Table 3.3-1 shows the actual atmospheric emissions from all SRS sources in 1997.

Prior to 1991, ambient monitoring of SO_2, NO_2, TSP, CO, and O_3 was conducted at five sites across SRS. Because there is no regulatory requirement to conduct air quality monitoring at SRS, all of these stations have been decommissioned. Ambient air quality data collected during 1997 from monitoring stations operated by SCDHEC in Aiken County and Barnwell County, South Carolina, are summarized in Table 3.3-2. These data indicate that ambient concentrations of the measured criteria pollutants are generally much less than the standards.

SCDHEC also requires dispersion modeling as a means of evaluating local air quality. Periodically, all permitted sources of regulated air emissions at SRS must be modeled to determine estimates of ambient air pollution concentrations at the SRS boundary. (The ambient limits found under Standards 2 and 8 are enforceable at or beyond the Site boundary.) The results are used to demonstrate compliance with ambient standards and to define a baseline from which to assess the impacts of any new or modified sources. Additionally, a site-wide inventory of air emissions is developed every year as part of an annual emissions inventory required by SCDHEC regulation 61-62.1, Section III, "Emissions Inventory." Table 3.3-3 provides a summary of the most recent regulatory compliance modeling for SRS emissions. These calculations were performed with EPA's Industrial Source Complex (ISC3) air dispersion model (EPA 1995) and site-wide maximum potential emissions data from the annual air emissions inventory for 1998. Site boundary concentrations for the eight South Carolina ambient air pollutants include background concentrations of these pollutants, as observed at SCDHEC monitoring stations. Background concentrations of toxic/hazardous air pollutants are assumed to be zero. As Table 3.3-3 shows, estimated ambient SRS boundary concentrations are within the ambient standards for all regulated air pollutants emitted at SRS.

3.3.2.2 Radiological Air Quality

In the SRS region, airborne radionuclides originate from natural (i.e., terrestrial and cosmic) sources, worldwide fallout, and SRS operations. DOE maintains a network of 23 air sampling stations on and around SRS to determine concentrations of radioactive particulates and aerosols in the air (Arnett and Mamatey 1999a). Table 3.3-4 lists average and maximum atmospheric concentrations of radioactivity at the SRS boundary and at 25-mile radius monitoring locations during 1998.

DOE provides detailed summaries of radiological releases to the atmosphere from SRS operations, along with resulting concentrations and doses, in a series of annual environmental data reports. Table 3.3-5 lists 1998 radionuclide releases from each major operational group of SRS facilities.

Atmospheric emissions of radionuclides from DOE facilities are limited under the EPA regulation "National Emission Standards for Hazardous Air Pollutants (NESHAP)," 40 CFR Part 61, Subpart H. The EPA annual effective dose equivalent limit of 10 millirem per year to members of the public for the atmospheric pathway is also incorporated in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." To demonstrate compliance with the NESHAP regulations, DOE annually calculates maximally exposed offsite individual (MEI) and collective doses and a percentage of dose contribution from each radionuclide using the CAP88 computer code. The dose to the maximally exposed individual (MEI) from 1998 SRS emissions (Table 3.3-5) was estimated at 0.08 millirem which is 0.8 percent of the 10 millirem per year EPA standard. The population dose was calculated, by pathway and radionuclide, using the POPGASP computer code which is discussed later in this section. The POPGASP

Table 3.3-1. Criteria and toxic/hazardous air pollutant emissions from SRS (1997).[a]

Pollutant	Actual tons/year
Criteria pollutants[b]	
Sulfur dioxide (as SO_x)	490
Total suspended particulates	2,000
Particulate matter (≤10 μm)	1,500
Carbon monoxide	5,200
Ozone (as Volatile Organic Components)	290
Nitrogen dioxide (as NO_x)	430
Lead	0.019
Toxic/Hazardous Air Pollutants[c]	
Benzene	13
Beryllium	0.0013
Mercury	0.039

a. Sources: Mamatey (1999). Based on 1997 annual air emissions inventory from all SRS sources (permitted and unpermitted).
b. Includes an additional pollutant, PM-10, regulated under SCDHEC Regulation 61-62.5, Standard 2. Note: gaseous fluoride is also regulated under this standard but is not expected to be emitted as a result of tank closure activities.
c. Pollutants listed only include air toxics of interest to tank closure activities. A complete list of 1997 toxic air pollutant emissions for SRS can be found in Mamatey (1999).

Table 3.3-2. SCDHEC ambient air monitoring data for 1997.[a]

Pollutant	Averaging time	SC Standard (μg/m³)	Aiken Co. (μg/m³)	Barnwell Co. (μg/m³)
Sulfur dioxide (as SO_x)	3-hr[d]	1,300	60	44
	24[d]	365	21	10
	Annual[e]	80	5	3
Total suspended particulates[c]	Annual geometric mean	75	36	--
Particulate matter (≤10 μm)	24-hr[d]	150	45	44
	Annual[e]	50	21	19
Carbon monoxide	1-hr[d]	40,000	5,100[b]	--
	8-hr[d]	10,000	3,300[b]	--
Ozone[c]	1-hr	235	200	210
Nitrogen dioxide (as NO_x)	Annual[c]	100	9	8
Lead	Calendar quarterly mean	1.5	0.01	--

a. Source: SCDHEC (1998).
b. Richland County in Columbia, South Carolina (nearest monitoring station to SRS).
c. New standards may be applicable in the future; see discussion in text.
d. Second highest maximum concentration observed.
e. Arthmetic mean of observed concentrations.

Table 3.3-3. SRS baseline air quality for maximum potential emissions and observed ambient concentrations.

Pollutant	Averaging time	SCDHEC ambient standard (μg/m³)[a]	Estimated SRS baseline concentration (μg/m³)[b]
Criteria pollutants			
Sulfur dioxide (as SO_x)[c]	3-hr	1,300	1,200
	24-hr	365	350
	Annual	80	34
Total suspended particulates	Annual geometric mean	75	67
Particulate matter (≤10 μm)[d]	24-hr	150	130
	Annual	50	25
Carbon monoxide	1-hr	40,000	10,000
	8-hr	10,000	6,900
Nitrogen Dioxides (as NO_x)[e]	Annual	100	26
Lead	Calendar quarterly mean	1.5	0.03
Ozone	1-hr	235	200[f]
Toxic/hazardous air pollutants			
Benzene	24-hr	150	4.6
Beryllium	24-hr	0.01	0.009
Mercury	24-hr	0.25	0.03

Source: SCDHEC Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards," and Regulation 61-62.5, Standard 8, Section II, Paragraph E, "Toxic Air Pollutants" (SCDHEC 1976).

a. Source: Hunter (1999). Concentration is the sum of Industrial Source Complex (ISC3) modeled air concentrations using the maximum potential emissions from the 1998 air emissions inventory for all SRS sources not exempted by Clean Air Act Title V requirements and observed concentrations from nearby ambient air monitoring stations.

b. Based on emissions for all oxides of sulfur (SO_x).

c. New NAAQS for particulate matter ≤2.5 microns (24-hour limit of 65 μg/m³ and an annual average limit of 15 μg/m³) may become enforceable during the life of this project.

d. Based on emissions for all oxides of nitrogen (NO_x).

e. Source: SCDHEC (1998). Observed concentration of ozone at SCDHEC ambient monitoring station for Aiken County. Ambient concentration of ozone from SRS emissions is not available.

g. New NAAQS for ozone (8-hour limit of 0.08 parts per million) may become enforceable during the life of this project.

collective (population) dose was estimated at 3.5 person-rem. Tritium oxide accounts for 94 and 77 percent of the MEI and the population dose, respectively. Plutonium-239 is the second highest contributor to dose with 3 percent of both the collective and MEI doses (Arnett and Mamatey 1999b). The contributions to dose from other radionuclides can be found in *SRS Environmental Data for 1998* (Arnett and Mamatey 1999a).

SRS-specific computer dispersion models such as MAXIGASP and POPGASP (see discussion of these models in Section 4.1.3.2) are also used to calculate radiological doses to members of the public from SRS annual releases. Whereas the CAP88 code assumes that all releases occur from one point (for SRS, at the center of the site), MAXIGASP can model multiple release locations which is truer to actual conditions.

Table 3.3-4. Radioactivity in air at the SRS boundary and at a 25-mile radius during 1998 (picocuries per cubic meter).[a]

Location	Tritium	Gross alpha	Gross beta	Cobalt-60	Cesium-137	Strontium-89,90	Plutonium-238	Plutonium-239
Site boundary								
Average[b]	11.3	1.4×10^{-3}	0.017	1.3×10^{-3}	2.6×10^{-4}	1.1×10^{-5}	7×10^{-7}	(c)
Maximum[d]	79.6	5.91×10^{-3}	0.061	0.021	0.011	1.1×10^{-4}	4.1×10^{-6}	7.4×10^{-7}
Background (25-mile radius)								
Average	6.7	0.0015	0.019	1.48	2.8×10^{-4}	(c)	(c)	(c)
Maximum	54	0.0036	0.003	0.011	0.0079	5.1×10^{-4}	8.6×10^{-6}	2.9×10^{-6}

a. Source: Arnett and Mamatey (1999b).
b. The average value is the average of the arithmetic means reported for the site perimeter sampling locations.
c. Below background levels.
d. The maximum value is the highest value of the maximum reported for the site perimeter sampling locations.

3.4 Ecological Resources

3.4.1 NATURAL COMMUNITIES OF THE SAVANNAH RIVER SITE

The SRS comprises a variety of diverse habitat types that support terrestrial and semi-aquatic wildlife species. These habitat types include upland pine forests, mixed hardwood forests, bottomland hardwood forests, swamp forests, and Carolina bays. Since the early 1950s, the site has changed from 60 percent forest and 40 percent agriculture to 90 percent forest, with the remainder in aquatic habitats and developed (facility) areas (Halverson et al. 1997). The wildlife correspondingly shifted from forest-farm edge species to a predominance of forest-dwelling species. The SRS now supports 44 species of amphibians, 59 species of reptiles, 255 species of birds, and 54 species of mammals (Halverson et al. 1997). Comprehensive descriptions of the SRS's ecological resources and wildlife can be found in documents such as *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a).

SRS has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, or impoundments. In addition, approximately 200 Carolina bays occur on SRS (DOE 1995). Carolina bays are unique wetland features of the southeastern United States. They are isolated wetland habitats dispersed throughout the uplands of SRS. The approximately 200 Carolina bays on SRS exhibit extremely variable hydrology and a range of plant communities from herbaceous marsh to forested wetland (DOE 1995).

The Savannah River bounds SRS to the southwest for approximately 20 miles. The river floodplain supports an extensive swamp, covering about 15 square miles of SRS; a natural levee separates the swamp from the river (Halverson et al. 1997).

Timber was cut in the swamp from the turn of the century until 1951, when the Atomic Energy Commission assumed control of the area. At present, the swamp forest is comprised of two kinds of forested wetland communities (Halverson et al. 1997). Areas that are slightly elevated and well drained are characterized by a mixture of oak species (*Quercus nigra, Q. laurifolia, Q. michauxii,* and *Q. lyrata*) as well as red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and other hardwood species. Low-lying areas that are continuously flooded are dominated by second-growth bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*).

Table 3.3-5. 1998 Radioactive atmospheric releases by source.[a]

	Curies[b]						
Radionuclide	Reactors	Separations[c]	Reactor materials	Heavy water	SRTC[d]	Diffuse and fugitive[e]	Total
			Gases and vapors				
H-3(oxide)	2.28×10^{4}	3.45×10^{4}		4.04×10^{2}		9.31×10^{2}	5.86×10^{4}
H-3(elem.)		2.41×10^{4}					2.41×10^{4}
H-3 Total	2.28×10^{4}	5.86×10^{4}		4.04×10^{2}		9.31×10^{2}	8.27×10^{4}
C-14		7.01×10^{-2}				9.68×10^{-5}	7.02×10^{-2}
Kr-85		1.70×10^{4}					1.70×10^{4}
Xe-135		4.95×10^{-2}					4.95×10^{-2}
I-129		1.25×10^{-2}				1.29×10^{-5}	1.25×10^{-2}
I-131		5.92×10^{-5}			8.29×10^{-6}		6.75×10^{-5}
I-133					1.59×10^{-4}		1.59×10^{-4}
			Particulates				
Na-22						7.76×10^{-11}	7.76×10^{-11}
Cr-51						1.21×10^{-4}	1.21×10^{-4}
Fe-55						3.90×10^{-4}	3.90×10^{-4}
Co-57						9.40×10^{-11}	9.40×10^{-11}
Co-58						1.27×10^{-4}	1.27×10^{-4}
Co-60					2.65×10^{-7}	1.38×10^{-4}	1.38×10^{-4}
Ni-59						8.33×10^{-13}	8.33×10^{-13}
Ni-63						8.21×10^{-6}	8.21×10^{-6}
Zn-65						2.23×10^{-5}	2.23×10^{-5}
Se-79						1.85×10^{-11}	1.85×10^{-11}
Sr-89,90[F,6]	1.62×10^{-3}	3.22×10^{-4}	5.50×10^{-4}	2.61×10^{-4}	2.66×10^{-5}	2.58×10^{-2}	2.85×10^{-2}
Zr-95						1.71×10^{-5}	1.71×10^{-5}
Nb-95						1.13×10^{-4}	1.13×10^{-4}
Tc-99						2.82×10^{-5}	2.82×10^{-5}
Ru-103						2.26×10^{-5}	2.26×10^{-5}
Ru-106		1.80×10^{-5}				2.26×10^{-5}	3.34×10^{-5}
Sn-126						1.29×10^{-13}	1.29×10^{-13}
Sb-125		1.79×10^{-7}				5.27×10^{-5}	5.29×10^{-5}
Cs-134		2.32×10^{-7}				1.31×10^{-4}	1.31×10^{-4}
Cs-137	3.50×10^{-5}	3.77×10^{-4}			2.30×10^{-6}	4.89×10^{-3}	5.30×10^{-3}
Ce-141						4.16×10^{-5}	4.16×10^{-5}
Ce-144						1.45×10^{-4}	1.45×10^{-4}
Pm-147						9.79×10^{-10}	9.79×10^{-10}
Eu-152						4.19×10^{-8}	4.19×10^{-8}
Eu-154						5.74×10^{-6}	5.74×10^{-6}

Table 3.3-5. (Continued).

Radionuclide	Reactors	Separations[c]	Reactor materials	Heavy water	SRTC[d]	Diffuse and fugitive[e]	Total
Eu-155						1.10×10^{-6}	1.10×10^{-6}
Ra-226						8.64×10^{-6}	8.64×10^{-6}
Ra-228						2.13×10^{-5}	2.13×10^{-5}
Th-228						9.44×10^{-6}	9.44×10^{-6}
Th-230						1.02×10^{-5}	1.02×10^{-5}
Th-232						7.51×10^{-7}	7.51×10^{-7}
Pa-231						1.00×10^{-9}	1.00×10^{-9}
U-232			1.20×10^{-6}				1.20×10^{-6}
U-233						2.35×10^{-6}	2.35×10^{-6}
U-234		2.62×10^{-5}	3.39×10^{-5}			1.83×10^{-5}	7.84×10^{-5}
U-235		1.57×10^{-6}	6.21×10^{-6}			2.10×10^{-6}	9.88×10^{-6}
U-236						2.39×10^{-9}	2.39×10^{-9}
U-238		6.92×10^{-5}	6.32×10^{-5}			5.12×10^{-5}	1.84×10^{-4}
Np-237						1.01×10^{-9}	1.01×10^{-9}
Pu-238		1.15×10^{-4}	4.76×10^{-8}			3.28×10^{-4}	4.43×10^{-4}
Pu-239[h]	2.19×10^{-4}	1.12×10^{-4}	5.09×10^{-5}	2.98×10^{-5}	6.71×10^{-6}	1.41×10^{-3}	1.83×10^{-3}
Pu-240						1.12×10^{-6}	1.12×10^{-6}
Pu-241						6.02×10^{-5}	6.02×10^{-5}
Pu-242						1.59×10^{-7}	1.59×10^{-7}
Am-241		3.31×10^{-5}	2.17×10^{-8}			5.75×10^{-6}	3.89×10^{-5}
Am-243						1.89×10^{-5}	1.89×10^{-5}
Cm-242						1.58×10^{-7}	1.58×10^{-7}
Cm-244		3.67×10^{-6}	4.90×10^{-9}			1.30×10^{-4}	1.34×10^{-4}
Cm-245						2.08×10^{-13}	2.08×10^{-13}
Cm-246						9.37×10^{-7}	9.37×10^{-7}
Cf-249						5.27×10^{-16}	5.27×10^{-16}
Cf-251						2.17×10^{-14}	2.17×10^{-14}

Note: Blank spaces indicate no quantifiable activity.
a. Source: Arnett and Mamatey (1999b).
b. One curie equals 3.7×10^{10} Becquerels.
c. Includes separations, waste management, and tritium facilities.
d. Savannah River Technology Center.
e. Estimated releases from minor unmonitored diffuse and fugitive sources.
f. Includes unidentified beta emissions.
g. Includes SR-89.
h. Includes unidentified alpha emissions.

The aquatic resources of SRS have been the subject of intensive study for more than 30 years. Research has focused on the flora and fauna of the Savannah River, the tributaries of the river that drain SRS, and the artificial impoundments (Par Pond and L-Lake) on two of the tributary systems. Several monographs (Britton and Fuller 1979; Bennett and McFarlane 1983), the eight-volume comprehensive cooling water study (du Pont 1987), and a number of EISs (DOE 1987, 1990, 1997a) describe the aquatic biota (fish and macroinvertebrates) and aquatic systems of SRS. The *SRS Ecology Environmental Information Document* (Halverson et al. 1997) and the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a) review ecological research and monitoring studies conducted in SRS streams and impoundments over several decades.

The Savannah River site was designated as the first National Environmental Research Park (NERP) by the Atomic Energy Commission in 1972. Especially significant components of the NERP are DOE Research Set-Aside Areas, representative habitats that DOE has preserved for ecological research and that are protected from public intrusion and most site-related activities. Set-Aside Areas protect major plant communities and habitats indigenous to the SRS, preserve habitats for endangered species, and also serve as controls against which to measure potential environmental impacts of SRS operations. These ecological Set-Aside Areas total 14,005 acres, approximately 7 percent of the Site's total area. Descriptions of the 30 tracts that have been set aside to date can be found in Davis and Janacek (1997).

Under the Endangered Species Act of 1973, the Federal government provides protection to six species that occur on the SRS: American alligator (*Alligator mississippiensis*; threatened due to similarity of appearance to the endangered American crocodile), shortnose sturgeon (*Acipenser brevirostrum*; endangered), bald eagle (*Haliaeetus leucocephalus*; threatened), wood stork (*Mycteria americana*; endangered), red-cockaded woodpecker (*Picoides borealis*; endangered), and smooth purple coneflower (*Echinacea laevigata*; endangered) (SRFS 1994; Halverson et al. 1997). None of these species is known to occur on or near the F- and H-Area Tank Farms, which are intensively developed industrial areas surrounded by roads, parking lots, construction shops, and construction laydown areas and are continually exposed to high levels of human disturbance.

3.4.2 ECOLOGICAL COMMUNITIES POTENTIALLY AFFECTED BY TANK FARM CLOSURE ACTIVITIES

F- and H-Area Biota

The F- and H-Area Tank Farms are located within a densely developed, industrialized area of SRS. The immediate area provides habitat for only those animal species typically classified as urban wildlife (Mayer and Wike 1997). Species commonly encountered in this type of urban landscape include the Southern toad, green anole, rat snake, rock dove, European starling, house mouse, opossum, and feral cats and dogs (Mayer and Wike 1997). Lawns and landscaped areas within F- and H-Area also provide some marginal terrestrial wildlife habitat. A number of ground-foraging bird species (e.g., American robin, killdeer, and mourning dove) and small mammals (e.g., cotton mouse, cotton rat, and Eastern cottontail) that use lawns and landscaped areas around buildings may be present at certain times of the year, depending on the level of human activity (e.g., frequency of mowing) (Mayer and Wike 1997). Pine plantations managed for timber production by the U.S. Forest Service (under an interagency agreement with DOE) occupy surrounding areas (DOE 1994).

Wildlife characteristically found in SRS pine plantations include toads (i.e., the southern toad), lizards (e.g., the eastern fence lizard), snakes (e.g., the black racer), songbirds (e.g., the brown-headed nuthatch, and the pine warbler), birds of prey (e.g., the sharp-shinned hawk), and a number of mammal species (e.g., the cotton mouse), the gray squirrel, the opossum, and the white-tailed deer) (Sprunt and Chamberlain 1970; Cothran et al. 1991; Gibbons and Semlitsch 1991; Halverson et al. 1997).

Several populations of rare plants have been found in undeveloped areas adjacent to F- and H-Areas. One population of Nestronia *(Nestronia umbellula)* and three populations of Oconee azalea (*Rhododendron flammeum*) were located on the steep slopes adjacent to the Upper Three Runs floodplain approximately one mile north of the F-Area Tank Farm (DOE 1995: SRFS 1999). Populations of two additional rare plants, Elliott's croton (*Croton elliotti*) and spathulate seedbox (*Ludwigia spathulata*) were found in the pine forest southeast of H-Area, approximately one-half mile from the H-Area Tank Farm (SRFS 1999).

Seeplines and Associated Riparian Communities

As mentioned in Section 3.2, F- and H-Areas are on a near-surface groundwater divide, and groundwater from these areas discharges at seeplines adjacent to Upper Three Runs and Fourmile Branch. The biota associated with the seepage areas are discussed in the following paragraphs.

The Fourmile Branch seepline area is located in a bottomland hardwood forest community (DOE 1997b). The canopy layer of this bottomland forest is dominated by sweetgum (*Liquidambar styraciflua)*, red maple (*Acer rubrum*), and red bay (*Persea borbonia*). Sweet bay (*Magnolia virginiana)* is also common. The understory consists largely of saplings of these same species, as well as a herbaceous layer of greenbrier (*Smilax* sp), dog hobble (*Leucothoe axillaris*), giant cane (*Arundinaria gigantea*), poison ivy (*Rhus radicans*), chain fern (*Woodwardia virginica*), and hepatica (*Hepatica americana*). At the seepline's upland edge, scattered American holly and white oak occur. Upslope of the seepline area is an upland pine/hardwood forest. Tag alder (*Alnus serrulata*), willow (*Salix nigra)*, sweetgum, and wax myrtle (*Myrica cerifera)* are found along the margins of the Fourmile Branch in this area. The Upper Three Runs seepline is located in a similar bottom land hardwood forest community (DOE 1997b).

The floodplains of both streams in the general vicinity of the seeplines provide habitat for a variety of aquatic, semi-aquatic, and terrestrial animals including amphibians (e.g., leopard frogs), reptiles (e.g., box turtles), songbirds (e.g., wood warblers), birds of prey (e.g., barred owls), semi-aquatic mammals (e.g., beaver), and terrestrial mammals (white-tailed deer). For detailed lists of species known or expected to occur in the riparian forests and wetlands of SRS, see Gibbons et al. (1986), duPont (1987), Cothran et al. (1991), DOE (1997a), and Halverson et al. (1997).

No endangered or threatened fish or wildlife species have been recorded near the Upper Three Runs and Fourmile Branch seeplines. The seeplines and associated bottomland community do not provide habitat favored by endangered or threatened fish and wildlife species known to occur at SRS. The American alligator is the only Federally-protected species that could potentially occur in the area of the seeplines. Fourmile Branch does support a small population of American alligator in its lower reaches, where the stream enters the Savannah River swamp (Halverson et al. 1997). Alligators have been infrequently observed in man-made waterbodies (e.g., stormwater retention basins) in the vicinity of H-Area (Mayer and Wike 1997).

Aquatic Communities Downstream of F- and H-Areas

Upper Three Runs

According to summaries of studies on Upper Three Runs documented in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the macroinvertebrate communities of Upper Three Runs are characterized by unusually high measures of taxa richness and diversity. Upper Three Runs is a spring-fed stream and is colder and generally clearer than most streams in the upper Coastal Plain. As a result, species normally found in the Northern U.S. and southern Appalachians are found here along with endemic lowland (Atlantic Coastal Plain) species (Halverson et al. 1997).

A study conducted from 1976 to 1977 identified 551 species of aquatic insects within this stream system, including a number of species and genera new to science (Halverson et al. 1997). A 1993 study found more than 650 species in Upper Three Runs, including more than 100 caddisfly species. Although no threatened or endangered species have been found in Upper Three Runs, there are several environmentally sensitive species. Davis and Mulvey (Halverson et al. 1997) identified a rare clam species (*Elliptio hepatica*) in this drainage. Also, in 1997 the U.S. Fish and Wildlife Service listed the American sand-burrowing mayfly (*Dolania americana*), a mayfly relatively common in Upper Three Runs, as a species of special concern. Between 1987 and 1991, the density and variety of insects collected from Upper Three Runs decreased for unknown reasons. More recent data, however, indicate that insect communities are recovering (Halverson et al. 1997).

The fish community of Upper Three Runs is typical of third- and higher-order streams on SRS that have not been greatly affected by industrial operations, with shiners and sunfish dominating collections. The smaller tributaries to Upper Three Runs are dominated by shiners and other small-bodied species (i.e., pirate perch, madtoms, and darters) indicative of unimpacted streams in the Atlantic Coastal Plain (Halverson et al. 1997). In the 1970s, the U.S. Geological Service designated Upper Three Runs as a National Hydrological Benchmark Stream due to its high water quality and rich fauna. However, this designation was rescinded in 1992 due to increased development of the Upper Three Runs watershed north of the SRS (Halverson et al. 1997).

Fourmile Branch

Until C-Reactor was shut down in 1985, the distribution and abundance of aquatic biota in Fourmile Branch were strongly influenced by reactor operations (high water temperatures and flows downstream of the reactor discharge). Following the shutdown of C-Reactor, macroinvertebrate communities began to recover, and in some reaches of the stream began to resemble those in nonthermal and unimpacted streams of the SRS (Halverson et al. 1997). Surveys of macroinvertebrates in more recent years showed that some reaches of Fourmile Branch had healthy macroinvertebrate communities (high measures of taxa richness) while others had depauperate macroinvertebrate communities (low measures of diversity or communities dominated by pollution-tolerant forms). Differences appeared to be related to variations in dissolved oxygen levels in different portions of the stream. In general, macroinvertebrate communities of Fourmile Branch show more diversity (taxa richness) in downstream reaches than upstream reaches (Halverson et al. 1997).

Studies of fish populations in Fourmile Branch conducted in the 1980s, when C-Reactor was operating, revealed that very few fish were present downstream of the reactor outfall (Halverson et al. 1997). Water temperatures exceeded 140°F at the point where the discharge entered Fourmile Branch and were as high as 100°F where the stream flowed into the Savannah River Swamp, approximately 10 miles downstream. Following the shutdown of C-Reactor in 1985, Fourmile Branch was rapidly recolonized by fish from the Savannah River swamp system. Centrarchids (sunfish) and cyprinids (minnows) were the most common taxa.

To assess potential impacts of groundwater outcropping to Fourmile Branch, WSRC in 1990 surveyed fish populations in Fourmile Branch up- and downstream of F- and H-Area seepage basins (Halverson et al. 1997). Upstream stations were dominated by pirate perch, creek chubsucker, yellow bullhead, and several sunfish species (redbreast sunfish, dollar sunfish, spotted sunfish). Downstream stations were dominated by shiners (yellowfin shiner, dusky shiner, and taillight shiner) and sunfish (redbreast sunfish and spotted sunfish), with pirate perch and creek chubsucker present but in lower numbers. Differences in species composition were believed to be due to habitat differences rather than the effect of contaminants in groundwater.

Savannah River

An extensive information base is available regarding the aquatic ecology of the Savannah River in the vicinity of SRS. The most recent water quality data available from environmental monitoring conducted on the river in the vicinity of SRS and its downstream reaches can be found in *Savannah River Site Environmental Data for 1998* (Arnett and Mamatey 1999b). These data demonstrate that the Savannah River is not adversely impacted by SRS wastewater discharges to its tributary streams. A full description of the ecology of the Savannah River in the vicinity of SRS can be found in the *SRS Ecology Environmental Information Document* (Halverson et al. 1997), the *Final Environmental Impact Statement for the Shutdown of the River Water System at the Savannah River Site* (DOE 1997a), and the EIS for *Accelerator Production of Tritium at the Savannah River Site* (DOE 1997c).

3.5 Land Use

The SRS is in south central South Carolina (Figure 3.1-1) approximately 100 miles from the Atlantic Coast. The major physical feature at SRS is the Savannah River, about 20 miles of which serve as the southwestern boundary of the Site and the South Carolina-Georgia border. The SRS includes portions of Aiken, Barnwell, and Allendale counties in South Carolina.

The SRS occupies an almost circular area of approximately 300 square miles or 192,000 acres and contains production, service, and research and development areas (Figure 3.2-1). The production facilities occupy less than 10 percent of the SRS; the remainder of the site is undeveloped forest or wetlands (DOE 1997).

The site is a significant large-scale facility available for wildlife management and research activities. SRS is a desirable location for landscape scale studies and externally funded studies conducted as a part of DOE's National Environmental Research Park. Public use of the site's natural resources is presently limited to controlled hunts and to various science literacy programs encompassing elementary through graduate school levels.

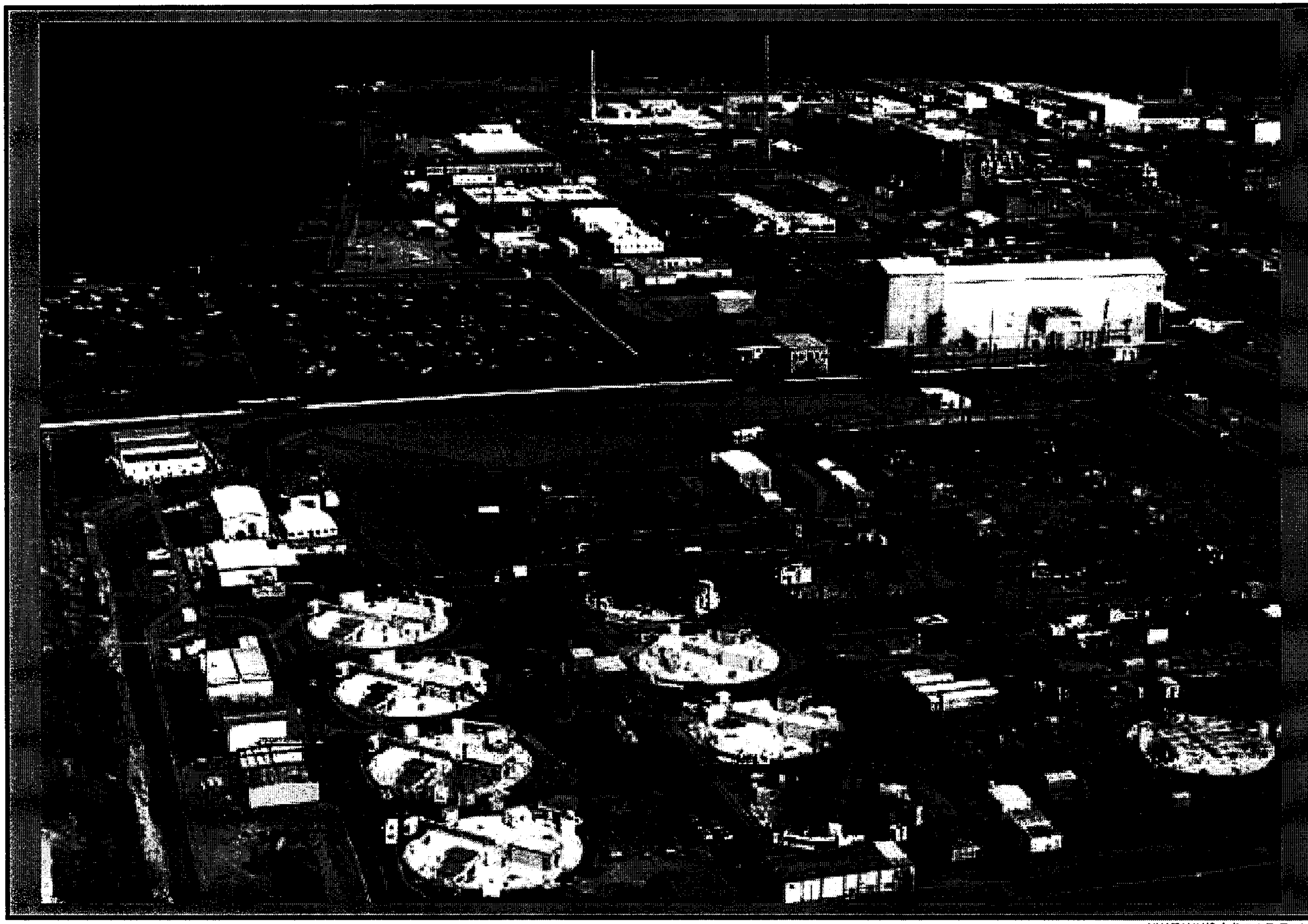
The F- and H-Areas, of which the tank farms are a part, are in the north-central portion of the SRS, bounded by Upper Three Runs to the north and Fourmile Branch to the South. The F-Area occupies about 364 acres while the H-Area occupies 395 acres (DOE 1997). Land within a 5-mile radius of these areas lies entirely within the SRS boundaries and is used for either industrial purposes or as forested land (DOE 1997).

Figures 3.5-1 and 3.5-2 are aerial photographs of the tank farm areas and give an indication of the industrial character of each location.

In March of 1998, the *Savannah River Future Use Plan* was formally issued. It was developed in partnership with all major site contractors, support agencies, and Headquarters counterparts with the input of stakeholders, and defines the future use for the site. The plan states as policy the following important points: (1) SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government, consistent with the site's designation as a National Environmental Research Park; (2) residential uses of all SRS land shall be prohibited; and (3) an Integral Site Model that incorporates three planning zones (industrial, industrial support, and restricted public uses) will be utilized. The land around the F- and H-Areas (i.e., between Upper Three Runs and Fourmile Branch) will be considered in the industrial use category (DOE 1998). Consequently, DOE's plan is to continue active institutional control for those areas as long as necessary to protect the public and the environment (DOE 1998). For purposes of analysis, however, DOE assumes institutional control for the next 100 years. After that, the area would be zoned as industrial for an indefinite period with deed restrictions on the use of groundwater. This was the basis for the analysis in the *Industrial Wastewater Closure Plan for F- and H- Area High-Level Waste Tank Systems* (DOE 1997).

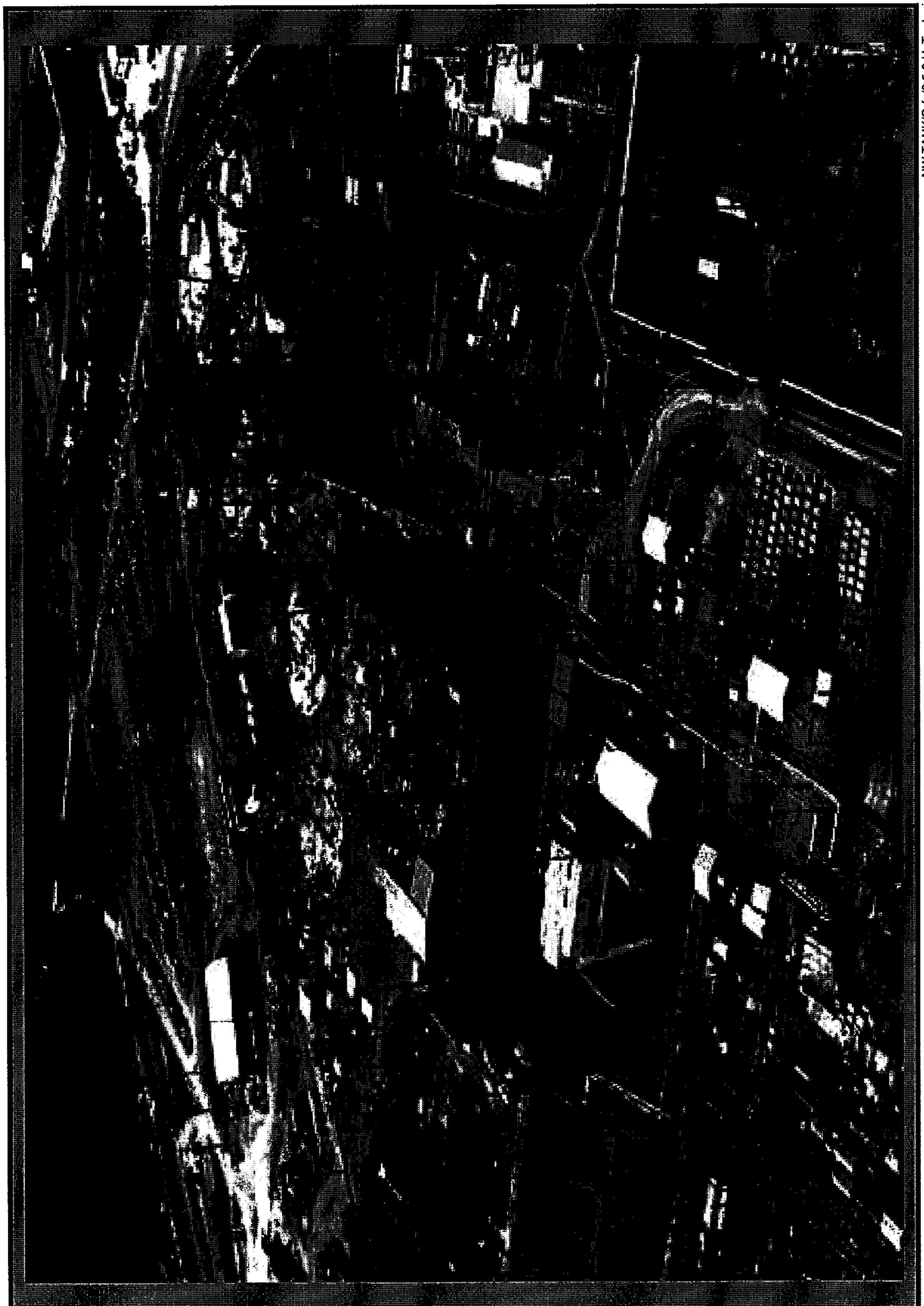
3.6 Socioeconomics and Environmental Justice

This section describes the economic and demographic baseline for the area around SRS. The purpose of this information is to assist in understanding the potential impacts HLW tank closure could have on population and employment income and to identify any potential disproportionately high and adverse impacts the actions could have on minority and low-income populations.



NW TANK/Grfx/3.5-1 F_Tank.ai

Figure 3.5-1. F-Area Tank Farm (view toward the north, with 21 of the 22 F-Area liquid high-level waste tanks).



NW TANK/Grfx/3.5-2 H_Tank.ai

Figure 3.5-2. H-Area Tank Farm (view toward the south, with 11 of the 29 H-Area liquid high-level waste tanks).

3.6.1 SOCIOECONOMICS

The socioeconomic region of influence for the proposed action is a six-county area around the SRS where the majority of Site workers reside and where socioeconomic impacts are most likely to occur. The six counties are Aiken, Allendale, Barnwell, and Bamberg in South Carolina, and Columbia and Richmond in Georgia. *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site* (HNUS 1997) contains details on the region of influence, as well as most of the information discussed in this section. The study includes full discussions of regional fiscal conditions, housing, community services and infrastructure, social services and institutions, and educational services. This section will, however, focus on population and employment estimates that have been updated to reflect the most recently available data.

Population

Based on state and Federal agency surveys and trends, the estimated 1998 population that live in the region of influence was 466,222. About 90 percent lived in the following counties: Aiken (29 percent), Columbia (20 percent), and Richmond (41 percent). The population in the region grew at an annual growth rate of about 6.5 percent between 1990 and 1998 (Bureau of the Census 1999). Columbia County, and to a lesser extent Aiken County, contributed to most of the growth due to inmigration from other region of influence counties and states. Over the same period Bamberg and Barnwell counties experienced net outmigration.

Population projections indicate that the overall population in the region should continue to grow less than 1 percent until about 2040, except Columbia County, which could experience 2 percent to 3 percent annual growth. Table 3.6-1 presents projections by county through 2040.

Based on the most recent information available (1992), the estimated median age of the population in the region was 31.8 years, somewhat higher than 1980, when the estimated median age was 28. Median ages in the region are generally lower than those of the nation and the two states. The region had slightly higher percentages of persons in younger age groups (under 5 and 5 to 19) than the U.S., while for all other age groups, the region was comparable to U.S. percentages. The only exception to this was Columbia County, with only 6 percent of its population 65 years or older while the other counties and the U.S. were 10 percent or greater in this age group. The proportion of persons younger than 20 is expected to decrease, while the proportion of persons older than 64 is expected to increase (DOE 1997).

Employment

In 1994, the latest year consistently developed information is available for all counties in the region of influence, the total civilian labor force for the region of influence was 206,518, with 6.9 percent unemployment. The unemployment rate for the U.S. for the same period was 6.1 percent. For the Augusta-Aiken Metropolitan Statistical Area which does not exactly coincide with the counties in the region of influence, the 1996 labor force totaled 202,400 with an unemployment rate of 6.7 percent. The most recent unemployment rate for the Augusta-Aiken Metropolitan Statistical Area issued for February 1999 was 5.0 percent.

In 1994, total employment according to Standard Industrial Code sectors ranged from 479 workers in the mining sector (e.g., clay and gravel pits) to 58,415 workers in the services sector (e.g., health care and education). Average per capita personal income in 1993 (adjusted to 1995 dollars) was $18,867, in comparison to the U.S. figure of $21,937.

Based on a detailed workforce survey completed in the fall of 1995, the SRS had 16,625 workers (including contractors, permanent and temporary workers, and persons affiliated with Federal agencies and universities who work on the Site) with a total payroll of slightly over $634 million. In September 1997, DOE had reduced the total workforce to 15,112 (DOE 1998).

Table 3.6-1. Population projections and percent of region of influence.[a]

	2000		2010		2020	
Jurisdiction	Population	% ROI	Population	% ROI	Population	% ROI
South Carolina						
Aiken County	135,126	28.7	143,774	27.9	152,975	26.9
Allendale County	11,255	2.4	11,514	2.2	11,778	2.1
Bamberg County	16,366	3.5	17,528	3.4	18,773	3.3
Barnwell County	21,897	4.6	23,517	4.6	25,257	4.5
Georgia						
Columbia County	97,608	20.7	120,448	23.3	148,633	26.9
Richmond County	189,040	40.1	199,059	38.6	209,609	37.0
Six-county total	471,292	100	515,840	100	567,025	100

	2030		2040	
Jurisdiction	Population	% ROI	Population	% ROI
South Carolina				
Aiken County	162,766	26.0	173,182	24.9
Allendale County	12,049	1.9	12,326	1.8
Bamberg County	20,106	3.2	21,533	3.1
Barnwell County	27,126	4.5	29,134	4.2
Georgia				
Columbia County	184,413	29.4	226,332	32.6
Richmond County	220,718	35.2	232,417	33.4
Six-county total	627,178	100	694,924	100

a. Source: Scaled from HNUS (1997) and Bureau of the Census (1999).
ROI = region of influence.

3.6.2 ENVIRONMENTAL JUSTICE

DOE completed an analysis of the economic and racial characteristics of the population in areas affected by SRS operations for the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE 1995). That EIS evaluated whether minority communities or low-income communities could receive disproportionately high and adverse human health and environmental impacts from the alternatives included in that EIS. Geographically, it examined the population within a 50-mile radius of the SRS plus areas downstream of the Site that withdraw drinking water from the Savannah River. The area encompasses a total of 147 census tracts, resulting in a total potentially affected population of 993,667. Of that population, 618,000 (62 percent) are white. In the minority population, approximately 94 percent are African American; the remainder consists of small percentages of Asian, Hispanic, and Native American persons (see Table 3.6-2).

It should be noted that the Interim Management of Nuclear Materials EIS used data on minority and low-income populations from the 1990 census. Although the Bureau of Census publishes county- and state-level population estimates and projections in odd (inter-census) years, census-tract-level statistics on minority and low-income populations are only collected for decennial censuses. Updated census tract information is expected to be published by the Bureau of Census in 2001.

The analysis determined that, of the 147 census tracts in the combined region, 80 contain populations of 50 percent or more minorities. An additional 50 tracts contain between 35 and 50 percent minorities. These tracts are well dis-

Table 3.6-2. General racial characteristics of population in the Savannah River Site region of influence.[a]

State	Total population	Total White	Total Minority	African American	Hispanic	Asian	Native American	Other	Percent minorities
South Carolina ROI	418,685	267,639	151,046	144,147	3,899	1,734	911	355	36.1%
Georgia ROI	574,982	350,233	224,749	208,017	7,245	7,463	1,546	478	39.1%
Total	993,667	617,872	375,795	352,164	11,144	9,197	2,457	833	37.8%

a. Source: DOE (1995).
ROI = region of influence.

tributed throughout the region, although there are more toward the south and in the immediate vicinities of Augusta and Savannah (see Figure 3.6-1).

Low-income communities [25 percent or more of the population living in poverty (i.e., income of $8,076 for a family of two)] occur in 72 census tracts distributed throughout the region of influence but primarily to the south and west of SRS (see Figure 3.6-2.). This represents more than 169,000 persons or about 17 percent of the total population (see Table 3.6-3).

3.7 Cultural Resources

Through a cooperative agreement, DOE and the South Carolina Institute of Archaeology and Anthropology of the University of South Carolina conduct the Savannah River Archaeological Research Program to provide the services required by Federal law for the protection and management of archaeological resources. Ongoing research programs work in conjunction with the South Carolina State Historic Preservation Office. They provide theoretical, methodological, and empirical bases for assessing site significance using the compliance process specified by law. Archaeological investigations usually begin through the Site Use Program, which requires a permit for clearing land on SRS.

The archaeological research has provided considerable information about the distribution and content of archaeological and historic sites on SRS. Savannah River archaeologists have examined SRS land since 1974. To date they have examined 60 percent of the 300-square-mile area and recorded more than 1,200 archaeological sites (HNUS 1997). Most (approximately 75 percent) of these sites are prehistoric. To facilitate the management of these resources, SRS is divided into three archaeological zones based upon an area's potential for containing sites of historical or archaeological significance (DOE 1995). Zone 1 represents areas with the greatest potential for having significant resources; Zone 2 areas possess sites with moderate potential; Zone 3 has areas of low archaeological significance.

Studies of F- and H-Areas in a previous EIS (DOE 1994) noted that activities associated with the construction of F- and H-Areas during the 1950s could have destroyed historic and archaeological resources present in this area. As mentioned in Chapter 2, F- and H-Areas are heavily industrialized sites. They are surrounded by Zone 2 and Zone 3 lands outside of the facilities' secure parameters.

3.8 Public and Worker Health

3.8.1 PUBLIC RADIOLOGICAL HEALTH

Because there are many sources of radiation in the human environment, evaluations of radioactive releases from nuclear facilities must consider all ionizing radiation to which people are routinely exposed.

Doses of radiation are expressed as millirem, rem (1,000 millirem), and person-rem (sum of dose to all individual in population).

An individual's radiation exposure in the vicinity of SRS amounts to approximately

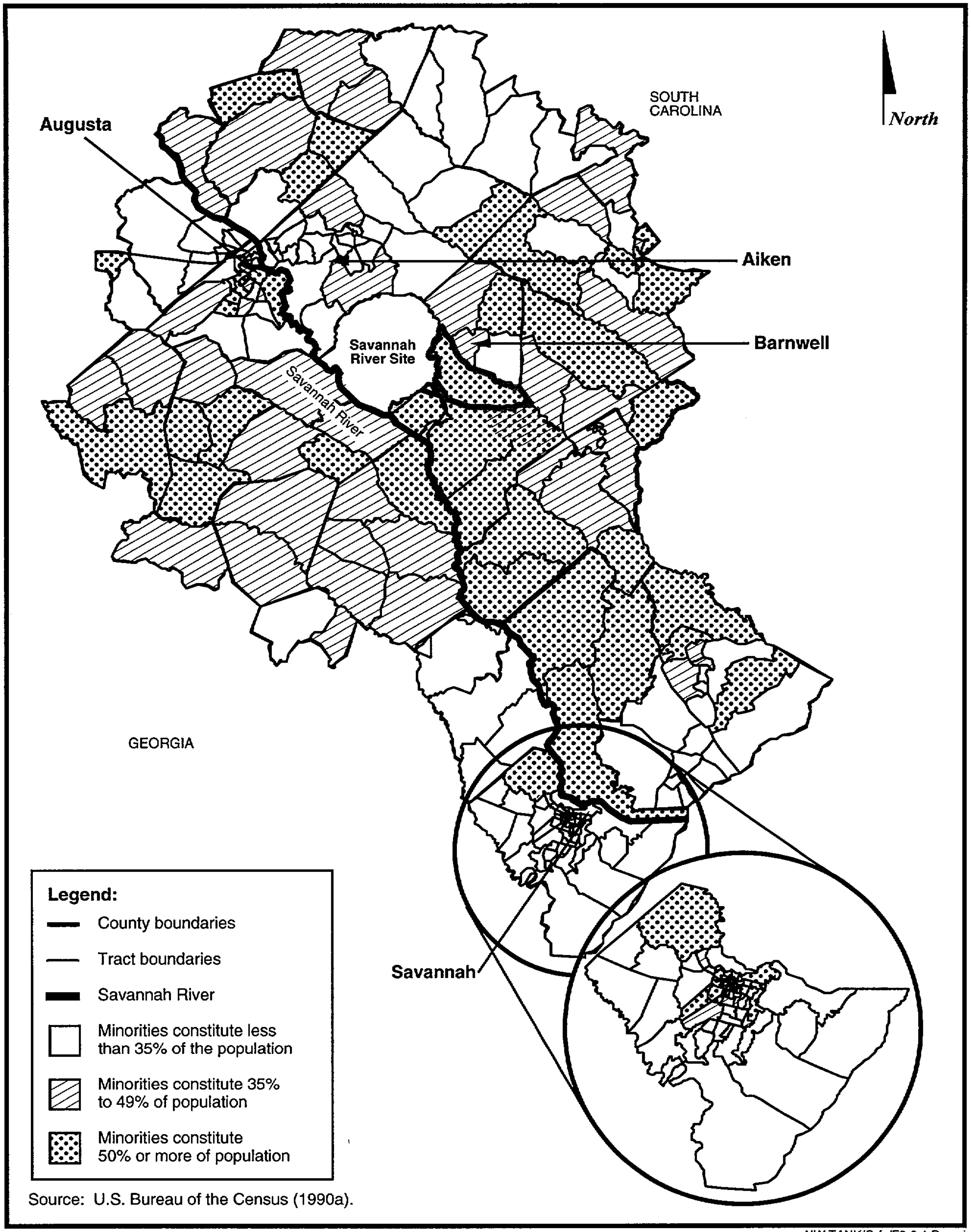
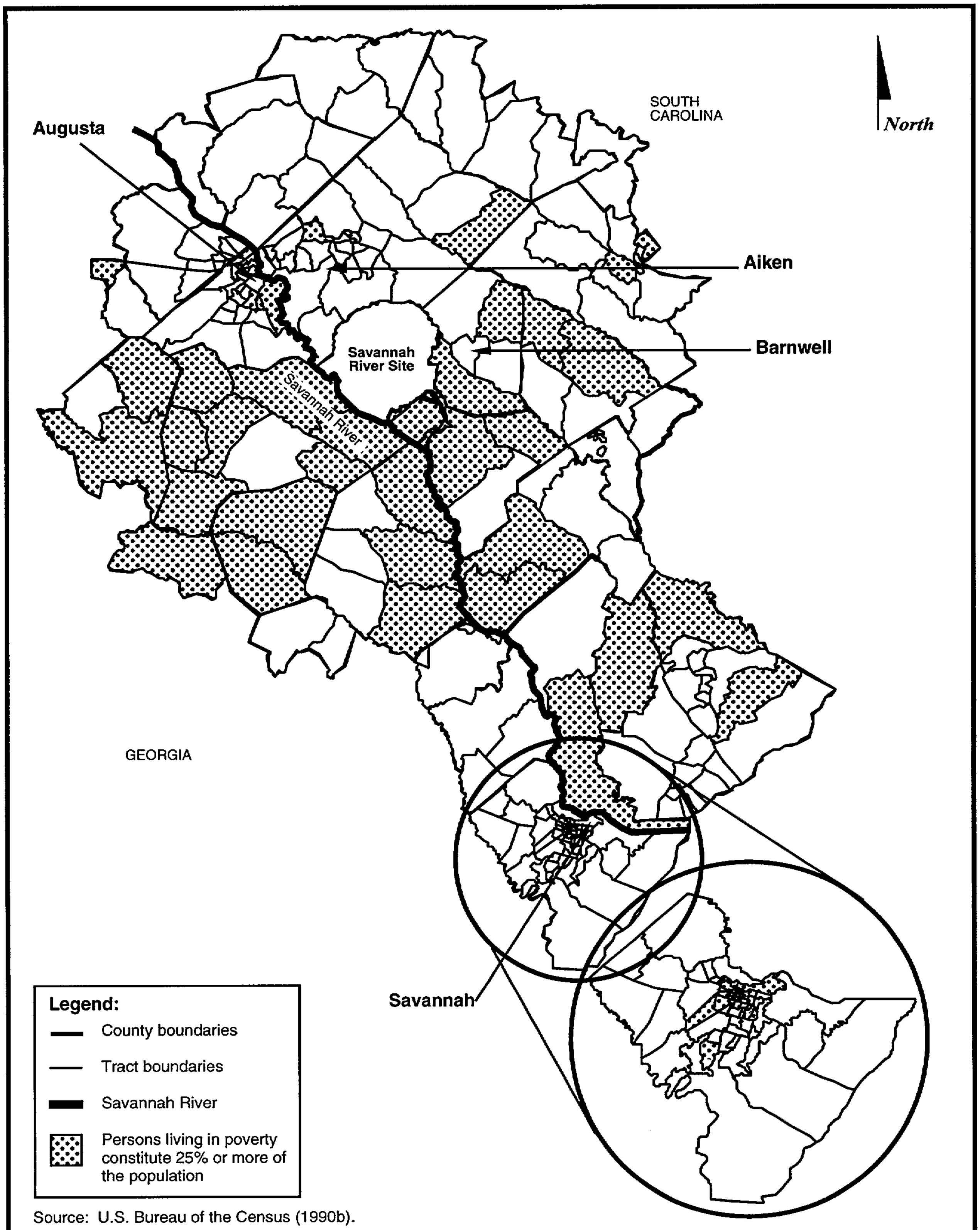


Figure 3.6-1. Distribution of minority population by census tracts in the SRS region of analysis.



NW Tank/Grfx/3-6-2 Income.ai

Figure 3.6-2. Low income census tracts in the SRS region of analysis.

Table 3.6-3. General poverty characteristics of population in the Savannah River Site region of interest.

Area	Total population	Persons living in poverty[a]	Percent living in poverty
South Carolina	418,685	72,345	17.3%
Georgia	574,982	96,672	16.8%
Total	993,667	169,017	17.0%

a. Families with income less than the statistical poverty threshold, which in 1990 was 1989 income of $8,076 for a family of two [U.S Bureau of the Census (1990b)].

357 millirem per year, which is comprised of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; weapons test fallout; consumer and industrial products, and nuclear facilities. Figure 3.8-1 shows the relative contribution of each of these sources to the dose an individual living near SRS would receive. All radiation doses mentioned in this EIS are effective dose equivalents. Effective dose equivalents include the dose from internal deposition of radionuclides and the dose attributable to sources external to the body.

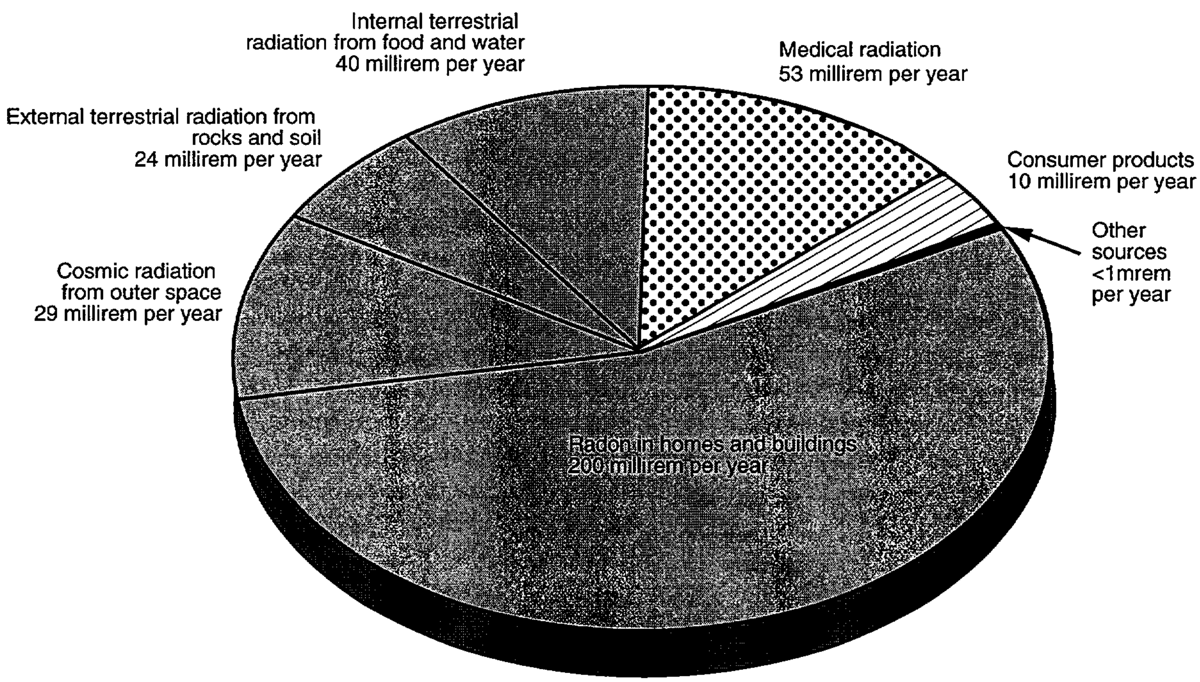
Releases of radioactivity to the environment from SRS account for less than 0.1 percent of the total annual average environmental radiation dose to individuals within 50 miles of the Site. Natural background radiation contributes about 293 millirem per year, or 82 percent of the annual dose of 357 millirem received by an average member of the population within 50 miles of the Site. Based on national averages, medical exposure accounts for an additional 15 percent of the annual dose, and combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 3 percent (NCRP 1987a).

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

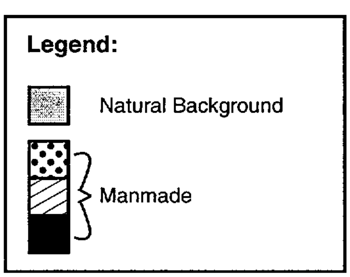
The *South Carolina Department of Health and Environmental Control Annual Report* (SCDHEC 1995) indicates that the Chem-Nuclear and Starmet CMI facilities do not influence radioactivity levels in the air, precipitation, groundwater, soil, or vegetation. Plant Vogtle began commercial operation in 1987: 1992 re leases produced an annual dose of 0.054 millirem to the maximally exposed individual at the plant boundary and a total population dose within a 50-mile radius of 0.045 person-rem (NRC 1996).

In 1997, releases of radioactive material to the environment from SRS operations resulted in a maximum individual dose of 0.07 millirem in the west-southwest sector of the Site boundary from atmospheric releases, and a maximum dose from liquid releases of 0.12 millirem for a maximum total annual dose at the boundary of 0.19 millirem. The maximum dose to downstream consumers of Savannah River water – 0.05 millirem – occurred to users of the Port Wentworth and the Beaufort-Jasper public water supplies (Arnett and Mamatey 1999a).

In 1990 the population within 50 miles of the Site was approximately 620,100. The collective effective dose equivalent to that population in 1998 was 3.5 person-rem from atmospheric releases. The 1998 population of 10,000 people using water from the Cherokee Hill Water Treatment Plant near Port Wentworth, Georgia, and 60,000 people using water from the Beaufort-Jasper Water Treatment Plant near Beaufort, South Carolina, received a collective dose equivalent of 1.8 person-rem in 1998 (Arnett and Mamatey 1999a). Population statistics indicate that cancer caused 23.2 percent of the



Notes:
1. Values are effective dose equivalents from NCRP (1987a) unless noted otherwise.
2. Cosmic: NCRP (1987a) reports 26 millirem per year for sea level. Multiplying value by a factor of 1.1 to correct for the altitude of 300 meters above sea level gives 29 millirem per year.
3. External terrestrial: NCRP (1987b) reports an absorbed dose rate for Augusta, Georgia of 4 microrad per hour, which is 35 millirad per year. NCRP (1987b) uses a factor of 0.7 to convert absorbed dose in air to effective dose equivalent, so 35 x 0.7 = 24 millirem per year.
4. Other sources include SRS operations (0.19 millirem per year; Arnett and Mamatey (1999a)), commercial nuclear facilities (nationwide), occupational exposure, air travel, and fallout.



NW TANK/Grfx/3.8-1 Radiation.ai

Figure 3.8-1. Major sources of radiation exposure in the vicinity of the Savannah River Site.

deaths in the United States in 1997 (CDC 1998). If this percentage of deaths from cancer continues, 23.2 percent of the U.S. population would contract a fatal cancer from all causes. Thus, in the population of 620,100 within 50 miles of SRS, 143,863 persons would be likely to contract fatal cancers from all causes. The total population dose from SRS of 5.3 person-rem (3.5 person-rem from atmospheric pathways plus 1.8 person-rem from water pathways) could result in 0.0027 additional latent cancer death in the same population [based on 0.0005 cancer death per person-rem (NCRP 1993)].

3.8.2 PUBLIC NONRADIOLOGICAL HEALTH

The hazards associated with the alternatives described in this EIS include exposure to nonradiological chemicals in the form of water and air pollution (see Sections 3.2 and 3.3). Table 3.3-2 lists ambient air quality standards and concentrations for selected pollutants. The purpose of these standards is to protect the public health and welfare. The concentrations of pollutants from SRS sources, listed in Table 3.3-3, are lower than the standards. Section 3.2 discusses water quality in the SRS vicinity.

3.8.3 WORKER RADIOLOGICAL HEALTH

One of the major goals of the SRS Health Protection Program is to keep worker exposures to radiation and radioactive material as low as reasonably achievable. Such a program must evaluate both external and internal exposures with the goal to minimize the total effective dose equivalent. An effective as low as reasonably achievable program to keep doses as low as reasonably achievable must also balance minimizing individual worker doses with minimizing the collective dose of workers in a group. For example, using many workers to perform small portions of a task would reduce the individual worker dose to low levels. However, frequent worker changes would make the work inefficient, resulting in a significantly higher collective dose to all the workers than if fewer had received slightly higher individual doses.

SRS worker doses have typically been well below DOE worker exposure limits. DOE set administrative exposure guidelines at a fraction of the exposure limits to help enforce doses that are as low as reasonably achievable. For example, the current DOE worker exposure limit is 5,000 millirem per year, and the 1998 SRS as low as reasonably achievable administrative control level for the whole body is 500 millirem per year. Every year DOE evaluates the SRS as low as reasonably achievable administrative control levels and adjusts them as needed.

Table 3.8-1 lists average individual doses and SRS collective doses from 1988 to 1998.

3.8.4 WORKER NONRADIOLOGICAL HEALTH

Industrial hygiene and occupational health programs at the SRS deal with all aspects of worker health and relationship of the worker to the work environment. The objective of an effective occupational health program is to protect employees from hazards in their work environment. To evaluate these hazards, DOE uses routine monitoring to determine employee exposure levels to hazardous chemicals.

Exposure limit values are the basis of most occupational health codes and standards. If an overexposure to a harmful agent does not exist, that agent generally does not create a health problem.

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

Table 3.8-2 lists OSHA-regulated workplace pollutants likely to be generated by HLW tank closure activities and the applicable OSHA limit.

Table 3.8-1. SRS annual individual and collective radiation doses.[a]

Year	Average individual worker dose (rem)[b]	Site worker collective dose (person-rem)
1988	0.070	864
1989	0.056	754
1990	0.056	661
1991	0.038	392
1992	0.049	316
1993	0.051	263
1994	0.022	311
1995	0.018	247
1996	0.019	237
1997	0.013	164
1998	0.015	163

a. Sources: DuPont (1989), Petty (1993), WSRC (1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999).
b. The average dose includes only workers who received a measurable dose during the year.

Table 3.8-2. Potential occupational safety and health hazards and associated exposure limits.

Pollutant	OSHA PEL[a] (mg/m^3)	Time period
Carbon monoxide	55	8 hours
Oxides of nitrogen	9	Ceiling limit
Total particulates	15	8 hours
Particulate matter (<10 microns)	150 50	24 hours Annual
Oxides of sulfur	13	8 hours

a. PEL = Permissible Exposure Limits. The OSHA PEL listed in Table Z-1-A or Z-2 of the OSHA General Industry Air Contaminants Standard (29 CFR 1910.1000) provided if appropriate. These limits, unless otherwise noted (e.g., ceiling), must not be exceeded during any 8-hour work shift of a 40-hour work week.

A well-defined worker protection program is in place at the SRS to protect the occupational health of DOE and contractor employees. To prevent occupational illnesses and injuries and to preserve the health of the SRS workforce, contractors involved in the construction and operations programs have implemented DOE-approved health and safety programs. Tables 3.8-3 and 3.8-4 indicated that these health and safety programs have resulted in lower incidences of injury and illness than those that occur in the general industry construction and manufacturing workforces.

3.9 Waste and Materials

3.9.1 WASTE MANAGEMENT

This section describes the waste generation baseline that DOE uses in Chapter 4 to gauge the relative impact of each tank closure alternative on the overall waste generation at SRS and on DOE's capability to manage such waste. In 1995 DOE prepared an EIS on the management of wastes projected to be generated by SRS for the next 40 years (DOE 1995).

Table 3.8-3. Comparison of 1997 rates for SRS construction to general industry construction.

Incident rate	SRS construction department[a]	Construction industry[b]
Total recordable cases	4.6	8.70
Total lost workday cases	2.3	4.09

a. Source: Hill (1999).
b. Source: Bureau of Labor Statistics (1998).

Table 3.8-4. Comparison of 1997 rates for SRS operations to private industry and manufacturing.

Incident rate	SRS operations[a]	Private industry[b]	Manufacturing[b]
Total recordable cases	1.08	6.05	10.30
Total lost workday cases	0.44	2.82	4.83

a. Source: Hill (1999).
b. Source: Bureau of Labor Statistics (1998).

DOE generates six basic types of waste – HLW, low-level radioactive, hazardous, mixed (low-level radioactive and hazardous), transuranic (including alpha-contaminated), and sanitary (nonhazardous, nonradioactive) – which this EIS considers because they are possible by products of the SRS tank closure activities. The following sections describe the waste types. Table 3.9-1 lists projected total waste generation volumes for fiscal years 1999 through 2029 (a time period that encompasses the expected duration of the tank closure activities addressed in this EIS). The assumptions and uncertainties applicable to SRS waste management plans and waste generation estimates are described in Halverson (1999). These estimates do not include wastes that would be generated as a result of closure of the SRS HLW tank systems.

Tables 3.9-2 through 3.9-4 provide an overview of the existing and planned facilities that DOE expects to use in the storage, treatment, and disposal of the various waste classes.

3.9.1.1 Low-Level Radioactive Waste

DOE (1999) defines low-level radioactive waste as radioactive waste that cannot be classified as HLW, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material.

At present, DOE uses a number of methods for treating and disposing of low-level waste at SRS, depending on the waste form and activity. Approximately 41 percent of this waste is low in radioactivity and can be treated at the Consolidated Incineration Facility. In addition, DOE could volume-reduce these wastes by compaction, supercompaction, smelting, or repackaging (DOE 1995). After volume reduction, DOE would package the remaining low-activity waste and place it in either shallow land disposal or vault disposal in E-Area.

DOE places low-level wastes of intermediate activity and some tritiated low-level wastes in E Area intermediate activity vaults and will store long-lived low-level waste (e.g., spent deionizer resins) in the long-lived waste storage buildings in E-Area, where they will remain until DOE determines their final disposition.

3.9.1.2 Mixed Low-Level Waste

Mixed low-level waste is radioactive waste that contains material that is listed as hazardous waste under RCRA or that exhibits one or more of the following hazardous waste characteristics: ignitability, corrosivity, reactivity, or toxicity. It includes such materials as tritiated mercury, tritiated oil contaminated with mercury, other mer-

Table 3.9-1. Total waste generation forecast for SRS (cubic meters).[a]

Inclusive dates	Low-level	HLW	Hazardous	Mixed low-level	Transuranic and alpha
	Waste class				
1999 to 2029	180,299	14,129	6,315	3,720	6,012

a. Source: Halverson (1999).

cury-contaminated compounds, radioactively contaminated lead shielding, equipment from the tritium facilities in H-Area, and filter paper takeup rolls from the M-Area Liquid Effluent Treatment Facility.

As described in the *Approved Site Treatment Plan* (WSRC 1999a), storage facilities for mixed low-level waste are in several different SRS areas. These facilities are dedicated to solid, containerized, or bulk liquid waste and all are approved for this storage under RCRA as interim status or permitted facilities or as Clean Water Act-permitted tank systems. Several treatment processes described in WSRC (1999a) exist or are planned for mixed low-level waste. These facilities, which are listed in Table 3.9-3, include the Consolidated Incineration Facility, the M-Area Vendor Treatment Facility, and the Hazardous Waste/Mixed Waste Containment Building.

Depending on the nature of the waste residues remaining after treatment, DOE plans to use either shallow land disposal or RCRA-permitted hazardous waste/mixed waste vaults for disposal.

3.9.1.3 High-Level Waste

HLW is highly radioactive material, resulting from the reprocessing of spent nuclear fuel, that contains a combination of transuranic waste and fission products in concentrations that require permanent isolation. It includes both liquid waste produced by reprocessing and any solid waste derived from that liquid (DOE 1999).

At present, DOE stores HLW in carbon steel and reinforced concrete underground tanks in the F- and H-Area Tank Farms. The HLW in the tanks consists of three physical forms: sludge, saltcake, and liquid. The sludge is solid material that precipitates or settles to the bottom of a tank. The saltcake is comprised of salt compounds that have crystallized as a result of concentrating the liquid by evaporation. The liquid is highly concentrated salt solution. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks while others are considered salt tanks (containing both saltcake and liquid salt solution).

The sludge portion of the HLW is currently being transferred to the DWPF for immobilization in borosilicate glass. The saltcake and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. The process for separating HLW is the subject of an ongoing supplemental EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site.* The high-radioactivity fraction would be transferred to the DWPF for vitrification. The low-radioactivity fraction would be treated and disposed at the Saltstone Manufacturing and Disposal Facility. Both treatment processes are described in the *Final Supplemental Environmental Impact Statement for the Defense Waste Processing Facility* (DOE 1994).

DOE has committed to complete closure by 2022 of the 24 high-level waste tank systems that do not meet the secondary containment requirements in the Federal Facility Agreement (WSRC 1998). During waste removal, DOE will retrieve as much of the stored HLW as can be removed using the existing waste transfer equipment. The retrieved waste will be processed through the remaining tank systems and treated at either the DWPF Vitrification Facility or the Saltstone Manufacturing and Disposal

Table 3.9-2. Planned and existing waste storage facilities.[a]

Storage facility	Location	Capacity	Original waste stream[b] Low-level	HLW	Transuranic	Alpha[c]	Hazardous	Mixed Low-level	Status
Long-lived waste storage buildings	E-Area	140 m^3/ bldg	X						One exists; DOE plans to construct additional buildings, as necessary.
Containerized mixed waste storage	Buildings 645-2N, 643-29E, 643-43E, 316-M, and Pad 315-4M	4,237 m^3						X	DOE plans to construct additional storage buildings, similar to 643-43E, as necessary.
Liquid mixed waste storage	DWPF Organic Waste Storage Tank (S-Area) SRTC Mixed Waste Tanks Liquid Waste Solvent Tanks (H-Area) Process Waste Interim Treatment/Storage Facility Tanks (M-Area)	9,586 m^3						X	The Process Waste Interim Treatment/Storage Facility ceased operation under RCRA in March 1996 and now operates under the Clean Water Act.
HLW Tank Farms	F- and H-Areas	(d)		X					51 underground tanks; one (16H) has been removed from service and two (17F, 20F) have been closed.[e]
Failed equipment storage vaults	Defense Waste Processing Facility (S-Area)	300 m^3		X					Two exist; DOE plans approximately 12 additional vaults.
Glass waste storage buildings	Defense Waste Processing Facility (S-Area)	2,286 canisters[f]		X					One exists and is expected to reach capacity in 2005; a second is planned to accommodate canister production from 2005 to 2015.
Hazardous waste storage facility	Building 710-B Building 645-N Building 645-4N Waste Pad 1 (between 645-2N and 645-4N) Waste Pad 2 (between 645-4N and 645-N) Waste Pad 3 (east of 645-N)	4,557 m^3					X		Currently in use. No additional facilities are planned, as existing space is expected to adequately support the short-term storage of hazardous wastes awaiting treatment and disposal.
Transuranic waste storage pads	E-Area	(g)			X	X		X	19 pads exists; additional pads will be constructed as necessary.

m^3 = cubic meters, SRTC = Savannah River Technology Center.
a. Sources: DOE (1994; 1995), WSRC (1998; 1999a).
b. Sanitary waste is not stored at SRS, thus it is not addressed in this table.
c. Currently, alpha waste is handled and stored as transuranic waste.
d. As of April 1998, there were approximately 660,00 gallons of space available in each of the HLW Tank Farms.
e. Twenty-four of these tanks do not meet secondary containment requirements and have been scheduled for closure.
f. Usable storage capacity of 2,159 canisters due to floor plug problems.
g. Transuranic waste storage capacities depend on the packaging of the waste and the configuration of packages on the pads.

Table 3.9-3. Planned and existing waste treatment processes and facilities.[a]

Waste Treatment Facility	Waste Treatment Process	Waste type: Low-level	High-level	Transuranic	Alpha[b]	Hazardous	Mixed Low-level	Sanitary	Status
Consolidated Incineration Facility	Incineration	X				X	X		Began treating waste in 1997.
Offsite facility[c]	Incineration	X				X	X		Currently operational.
Offsite facility	Compaction	X							Currently operational.
Offsite facility	Supercompaction	X							Currently operational.
Offsite facility	Smelting	X							Currently operational.
Offsite facility	Repackaging	X							Currently operational.
Defense Waste Processing Facility	Vitrification		X						Currently operational.
Saltstone Manufacturing and Disposal Facility	Stabilization						X		Currently operational.
Replacement High-Level Waste Evaporator[d]	Volume Reduction		X						Planned to replace existing evaporators in December 1999.
M-Area Vendor Treatment Facility	Vitrification						X		Treatment of design basis wastes completed in February 1999.
Hazardous Waste/Mixed Waste Containment Building	Macroencapsulation					X	X		Plan to begin operations in 2006.
Treatment at point of waste stream origin	Decontamination Macroencapsulation						X		As feasible based on waste and location.
Non-Alpha Vitrification Facility	Vitrification	X				X	X		Under evaluation as a potential process.
DOE Broad Spectrum Contractor	Amalgamation/ Stabilization/ Macroencapsulation						X		DOE is considering use of the Broad Spectrum Contract.
Offsite facility	Offsite Treatment and Disposal					X			Currently operational.
Offsite facility	Decontamination						X		Begin treating waste onsite in December 1998. Plan to pursue treatment offsite in 2000, if necessary.
Various onsite and offsite facilities[e]	Recycle/Reuse	X				X	X	X	Currently operational.
High-activity mixed transuranic waste facility	Repackaging/size reduction			X	X				Planned to begin operations in 2012.
Low-activity mixed transuranic waste facility	Repackaging/size reduction/ supercompaction			X	X				Planned to begin operations in 2002.
Existing DOE facilities	Repackaging/ Treatment			X					Transuranic waste strategies are still being finalized.
F- and H-Area Effluent Treatment Facility	Wastewater Treatment	X					X		Currently operational.

a. Sources: DOE (1994, 1995); Sessions (1999); WSRC (1998; 1999a).
b. Currently, alpha waste is handled as transuranic waste. After it is surveyed and separated, most will be treated and disposed of as low-level or mixed low-level waste.
c. An offsite incinerator may be used as a back-up to the Consolidated Incineration Facility.
d. Evaporation precedes treatment at the DWPF and is used to maximize HLW storage capacity.
e. Various waste streams have components (e.g., silver, lead, freon, paper) that might be recycled or reused. Some recycling activities might occur onsite, while other waste streams are directed offsite for recycling. Some of the recycled products are released for public sale, while others are reused onsite.

Table 3.9-4. Planned and existing waste disposal facilities.[a]

Disposal facility	Location	Capacity (m^3)	Original waste stream[b] Low-level	High-level	Transuranic	Hazardous	Mixed Low-level	Sanitary	Status
Shallow land disposal trenches	E-Area	(c)	X						Four have been filled; up to 58 more may be constructed.
Low-activity vaults	E-Area	30,500/vault	X						One vault exists and one additional is planned.
Intermediate-activity vaults	E-Area	5,300/vault	X						Two vaults exist and five more may be constructed.
Hazardous waste/mixed waste vaults	NE of F-Area	2,300/vault				X	X		RCRA permit application submitted for 10 vaults. At least 11 additional vaults may be needed.
Saltstone Manufacturing and Disposal Facility	Z-Area	80,000/vault[d]	X						Two vaults exist and approximately 13 more are planned.
Three Rivers Landfill	SRS Intersection of SC 125 and Rd. 2	NA						X	Current destination for SRS sanitary waste.
Burma Road Cellulosic and Construction Waste Landfill	SRS Intersection of C Rd. and Burma Rd	NA						X	Current destination for demolition/construction debris. DOE expects to reach permit capacity in 2008.
Waste Isolation Pilot Plant	New Mexico	175,600			X				EPA certification of WIPP completed in April 1998. RCRA permit expected to be finalized in fall of 1999.[e]
Federal repository	See Status	NA		X					Proposed Yucca Mountain, Nevada site is currently under investigation.

NA = Not Available, WIPP = Waste Isolation Pilot Plant.

a. Sources: DOE (1994, 1995, 1997); WSRC (1998; 1999a,b).

b. After alpha waste is assayed and separated from the transuranic waste, DOE plans to dispose of it as low-level or mixed low-level waste so it is not addressed separately here.

c. Various types of trenches exist including engineered low-level trenches, greater confinement disposal boreholes and engineered trenches, and slit trenches. The different trenches are designed for different waste types, are constructed differently, and have different capacities.

d. This is the approximate capacity of a double vault. One single vault and one double vault have been constructed. Future vaults are currently planned as double vaults.

e. SRS is scheduled for WIPP certification audit in summer 1999, after which WIPP could begin receiving SRS waste.

Facility. The tank closure activities described in this EIS would occur after waste removal is completed.

3.9.1.4 Sanitary Waste

Sanitary waste is solid waste that is neither hazardous, as defined by the Resource Conservation and Recovery Act (RCRA) nor radioactive. It consists of salvageable material and material that is suitable for disposition in a municipal sanitary landfill. Sanitary waste streams include such items as paper, glass, discarded office material, and construction debris (DOE 1994).

Sanitary waste volumes have declined due to recycling and the decreasing SRS workforce. DOE sends sanitary waste that is not recycled or reused to the Three Rivers Landfill on SRS. The SRS also continues to operate the Burma Road Cellulosic and Construction Waste Landfill to dispose of demolition and construction debris.

3.9.1.5 Hazardous Waste

Hazardous waste is nonradioactive waste that SCDHEC regulates under RCRA and corresponding state regulations. Waste is hazardous if the EPA lists it is as such or if it exhibits the characteristic(s) of ignitability, corrosivity, reactivity, or toxicity. SRS hazardous waste streams consist of a variety of materials, including mercury, chromate, lead, paint solvents, and various laboratory chemicals.

At present, DOE stores hazardous wastes in three buildings and on three solid waste storage pads that have RCRA permits. Hazardous waste is sent to offsite treatment and disposal facilities and is also treated at the Consolidated Incineration Facility. DOE also plans to continue to recycle, reuse, or recover certain hazardous wastes, including metals, excess chemicals, solvents, and chlorofluorocarbons. Wastes remaining after treatment might be suitable for either shallow land disposal or disposal in the Hazardous/Mixed Waste Disposal Vaults (DOE 1995).

3.9.1.6 Transuranic and Alpha Waste

Transuranic waste contains alpha-emitting transuranic radionuclides (those with atomic weights greater than 92) that have half-lives greater than 20 years at activities exceeding 100 nanocuries per gram (DOE 1999). At present, DOE manages low-level alpha-emitting waste with activities between 10 and 100 nanocuries per gram, referred to as alpha waste, as transuranic waste at SRS.

WSRC (1999a) defines the future handling, treatment, and disposal of the SRS transuranic and alpha waste stream. Current SRS efforts consist primarily of providing continued safe storage until treatment and disposal facilities are available. Eventually, DOE plans to ship the SRS retrievably stored transuranic and mixed transuranic waste to the Waste Isolation Pilot Plant in New Mexico for disposal.

Before disposition, DOE plans to measure the radioactivity levels of the wastes stored on the transuranic waste storage pads and segregate the alpha waste. A high-activity mixed transuranic waste facility could be constructed to process the higher activity SRS waste in preparation for shipment to the Waste Isolation Pilot Plant. This facility would use repackaging, sorting, and size reduction technologies. A low-activity mixed transuranic waste facility could also be constructed to process the lower activity SRS waste. The technology to process low-activity SRS waste is currently under development. A compactor could also be used to process lower activity mixed transuranic waste in preparation for shipment to the Waste Isolation Pilot Plant. After segregation and repackaging, DOE could dispose of much of the alpha waste as either mixed low-level or low-level waste.

3.9.2 HAZARDOUS MATERIALS

The *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report* for 1998 (WSRC 1999c) lists more than 79 hazardous chemicals that were present at SRS at some time during the year in amounts that exceeded the minimum reporting thresholds [generally 10,000 pounds for hazardous chemicals and 500 pounds for extremely hazardous substances]. Four of the 79 hazardous chemicals are considered extremely hazardous substances under the Emergency Planning and Community Right-to-Know Act of 1986. The actual number and quantity of hazardous chemicals present on the Site and at individual facilities changes daily as a function of use and demand.

References

SECTION 3.1

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.

Arnett, M. W., and A. R. Mamatey, 1996, *Savannah River Site Environmental Report for 1995*, WSRC-TR-96-0077, Westinghouse Savannah River Company, Aiken, South Carolina.

Bollinger, G. A., 1973, "Seismicity of the Southeastern United States," Bulletin of the Seismological Society of American, 63, 5, pp. 1785-1800.

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

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

DOE (U.S. Department of Energy), 1995, *Final Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement*, DOE/EIS-0203, Idaho Operations Office, Idaho Falls, Idaho.

Fallow, Wallace and Price, Van, *Geological Investigations of the Central Savannah River Area, South Carolina and Georgia*, Carolina Geological Society Field Trip Guidebook, 1992.

Geomatrix, 1991, *Ground Motion Following Selection of SRS Design Basis Earthquake and Associated Deterministic Approach,* Geomatrix Consultants, March.

Lee, R. C., M. E. Maryak, and M. D. McHood, 1997, SRS Seismic Response Analysis and Design Basis Guidelines, WSRC-TR-97-0085, Rev. 0., Savannah River Company, Aiken, South Carolina.

Nystrom, Paul, Widoughby, Ralph, Price, Lucille Kite, "Cretaceous and Tertiary Stratigraphy of the Upper Coastal Plain, South Carolina," *The Geology of the Carolinas*, Carolina Geological Society, TheUniversity of Tennessee Press, 1991.

Stephenson, D. E. and A. L. Stieve, 1992, *Structured Model of the Basement in the Central Savannah River Area, South Carolina and Georgia*, WSRC-TR-92-120, Westinghouse Savannah River Company, Aiken, South Carolina.

SCDNR (South Carolina Department of Natural Resources), 1995, *Hydrogeologic Frameword of West Central, South Carolina*, Water Resources Division Reports.

URS/Blume (URS/John Blume and Associates, Engineers), 1982, Update of Seismic Criteria for the Savannah River Plant, Volume I: Geotechnical, DPE-3699, prepared for E. I. du Pont de Nemours and Company, Inc., Savannah River Plant, Aiken, South Carolina.

Wike, L. D., D. B. Moore-Shedrow, and C. B. Shedrow, 1996, *Site Selection for the Accelerator for Production of Tritium at the Savannah River Site*, WSRC-TR-96-0279 Rev. 1, Westinghouse Savannah River Company, Aiken, South Carolina, October 9.

WSRC (Westinghouse Savannah River Company), 1991, *Baseline Risk Assessment For The F- and H-Area Seepage Basins Groundwater Unit, Draft Final*, WSRC-RP-91-950, Aiken, South Carolina.

SECTION 3.2

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.

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

Arnett, M. W., and A. R. Mamatey, 1999a, *Savannah River Site Environmental Report for 1998*, WSRC-TR-98-00312, Westinghouse Savannah River Company, Aiken, South Carolina.

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

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

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.

DOE (U.S. Department of Energy), 1997a, *Final Environmental Impact Statement Shutdown of the River Waste System at the Savannah River Site*, DOE/EIS-0268, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1998, *Spent Nuclear Fuel Management Draft Environmental Impact Statement*, DOE/EIS-0279D, Savannah River Operations Office, Aiken, South Carolina, December.

Flach, G., WSRC (Westinghouse Savannah River Company), 1994, *E-7 Procedure Document Q-CLC-H00005*, Revision 0, Westinghouse Savannah River Company, Savannah River Technical Center, Aiken, South Carolina, August.

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.

Wells, D., 1997, personal communication with G. Gunter (Tetra-Tech NUS), Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, February 6.

WSRC (Westinghouse Savannah River Company), 1993, *Federal Facility Compliance Agreement, Savannah River Site, Aiken, South Carolina*, WSRC-OS-94-42, Aiken, South Carolina. (Available at http://www.srs.gov/general/srenviro/erd/ffa/ffaa.pdf).

WSRC (Westinghouse Savannah River Company), 1995, *Environmental Protection Department's Well Inventory*, ESH-EMS-950419, Aiken, South Carolina, October.

WSRC (Westinghouse Savannah River Company), 1997, *The Savannah River Site's Groundwater Monitoring Program*, Fourth Quarter 1997, ESH-EMS-970491, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998a, *The Savannah River Site's Groundwater Monitoring Program*, First Quarter 1998, ESH-EMS-980568, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998b, *The Savannah River Site's Groundwater Monitoring Program*, Second Quarter 1998, ESH-EMS-980569, Aiken, South Carolina

WSRC (Westinghouse Savannah River Company), 1998c, *The Savannah River Site's Groundwater Monitoring Program*, Third Quarter 1998, ESH-EMS-980570, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999, *South Carolina Department of Health and Environmental Control Water Use Report – January through December, 1998*, January 22.

SECTION 3.3

Arnett, M. W. and A. R. Mamatey, 1998a, *Savannah River Site Environmental Data for 1997*, WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W. and A. R. Mamatey, 1998b, *Savannah River Site Environmental Report 1997*, WSRC-TR-97-00322, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1999a, *Savannah River Site Environmental Report for 1998*, WSRC-TR-98-00312, Westinghouse Savannah River Company, Aiken, South Carolina.

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

DOE (U.S. Department of Energy), 1997, *Draft Environmental Impact Statement, Accelerator Production of Tritium at the Savannah River Site*, DOE/EIS-0270D, Savannah River Operations Office, Aiken, South Carolina.

EPA (Environmental Protection Agency), 1995, User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume I – Users Instructions, EPA-454/B-95-003a, September. (Available at http://www.epa.gov/scram001/userg/regmod/isc3v1.pdf).

EPA (Environmental Protection Agency), 1999, June 28, 1999 EPA Summary of the Court's Decision, July 19. (Available at http://www.epa.gov/ttn/oarpg/gen/courtsum.pdf).

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

Mamatey, A., 1999, electronic message to L. Wike, "Nonrad Air Emissions Data," Westinghouse Savannah River Company, Aiken, South Carolina, July 6.

NOAA (National Oceanic and Atmospheric Administration), 1994, *Local Climatological Data Annual Summaries For 1993 Part II – Southern Region, Natinal Climatic Data Center, Asheville, North Carolina.*

SCDHEC (South Carolina Department of Health and Environmental Control), 1976, *Air Pollution Control Regulations and Standards*, South Carolina Code of Laws, Regulations 61-62, Columbia, South Carolina. (Available at http://www.lpitr.state.sc.us/coderegs/61b.htm).

SCDHEC (South Carolina Department of Health and Environmental Control), 1998, *South Carolina Air Quality Annual Report*, Vol. XVIII 1997, Bureau of Air Quality, Columbia, South Carolina.

Weber, A. H., J. H. Weber, M. J. Parker, C. H. Hunter, C. O. Minyard, 1998, *Tornado, Maximum Wind Gust, and Extreme Rainfall Event Recurrence Frequencies at the Savannah River Site (U)*, WSRC-TR-98-00329, Westinghouse Savannah River Company, Aiken, South Carolina.

SECTION 3.4

Arnett, M. W. and A. R. Mamatey, 1998, *Savannah River Site Environmental Data for 1997*, WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1999a, *Savannah River Site Environmental Report for 1998*, WSRC-TR-98-00312, Westinghouse Savannah River Company, Aiken, South Carolina.

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

Bennett, D. H. and R. W. McFarlane, 1983, *The Fishes of the Savannah River Plant: National Environmental Research Park*, SRO-NERP-12, Savannah River Ecology Laboratory, Aiken, South Carolina.

Britton, J. C. and S. L. H. Fuller, 1979, *The Freshwater Bivalve Mollusca of the Savannah River Plant*, SRO-NERP-3, Savannah River Ecology Laboratory, Aiken, South Carolina.

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, June.

Davis, C. E. and L. L. Janacek, 1997, DOE Research Set-Aside Areas of the Savannah River Site, Savannah River Ecology Laboratory, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1987, *Final Environmental Impact Statement, Alternative Cooling Water Systems*, DOE/EIS-0121, Savannah River Field Office, Aiken, South Carolina.

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

DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement for the 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.

DOE (U.S. Department of Energy), 1997a, *Final Environmental Impact Statement Shutdown for the River Water System at the Savannah River Site*, DOE/EIS-0268, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997c, *Draft Environmental Impact Statement, Accelerator Production of Tritium at the Savannah River Site*, DOE/EIS-0270D, Savannah River Operations Office, Aiken, South Carolina.

duPont, (E. I. du Pont de Nemours and Company, Inc.), 1987, *Comprehensive Cooling Water Study Final Report,* Volumes I - VIII, DP-1739, Savannah River Laboratory, Aiken, South Carolina.

Gibbons, J. W. and R. D. Semlitsch, 1991, *Guide to the Reptiles and Amphibians of the Savannah River Site*, University of Georgia Press, Athens, Georgia.

Gibbons, J. W., W. D. McCort, J. L. Knight, and S. S. Novak, 1986, *Semi-aquatic Mammals and Herpetefauna of the Savannah River Plant*, SREL-29, Savannah River Ecology Laboratory, Aiken, South Carolina, June.

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.

Mayer, J. J. and L. D. Wike, 1997, *SRS Urban Wildlife Environmental Information Document*, WSRC-TR-97-0093, Westinghouse Savannah River Company, Aiken, South Carolina.

Sprunt, A. and E. B. Chamberlain, 1970, *South Carolina Bird Life*, University of South Carolina Press, Columbia, South Carolina.

SRFS (Savannah River Forest Station), 1994, *Savannah River Site Proposed, Threatened, Endangered, and Sensitive Plants and Animals*, U.S. Department of Agriculture Forest Service, Aiken, South Carolina, August.

SRFS (Savannah River Forest Station), 1999, *Savannah River Site Threatened, Endangered, and Sensitive Flora and Fauna*, map, compiled by SRFS-GIS, New Ellenton, South Carolina, July.

SECTION 3.5

DOE (U.S. Department of Energy), 1997, *Industrial Wastewater Closure Plan for F- and H- Area High-Level Waste Tank Systems*, PD Rev. 2, August 15.

DOE (U.S. Department of Energy), 1998, *Responses to U.S. Nuclear Regulatory Commission Comments on SRS HLW Tank Closure*, Savannah River Operations Office, Aiken, South Carolina.

SECTION 3.6

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

DOE (U.S. Department of Energy), 1997, *Environment Impact Statement, Accelerator Production of Tritium at the Savannah River Site*, DOE/EIS-0270D, Savannah River Operations Office, Aiken, South Carolina, December.

DOE (U.S. Department of Energy), 1998, *Workforce Restructuring.* (Available at http://www.srs.gov/general/ aboutsrs/pub_rel/factsheets/workforce.htm).

HNUS (Halliburton NUS Corporation), 1997, *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site*, Aiken, South Carolina.

U.S. Bureau of the Census, 1990a, Summary Tape File 1B, Table P8, Washington, D.C.

U.S. Bureau of the Census, 1990b, Summary Tape File 1B, Table P117, Washington, D.C.

U.S. Bureau of the Census, 1999, *County Population Estimates.* (Available at http://www.census.gov/population/estimates/county/).

SECTION 3.7

HNUS (U.S. Halliburton NUS Corporation), 1997, *Socioeconomic Characteristics of Selected Counties and Communities Adjacent to the Savannah River Site*, Aiken, South Carolina.

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

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.

SECTION 3.8

Arnett, M. W. and A. R. Mamatey, 1997, *Savannah River Site Environmental Report for 1996*, WSRC-TR-97-0171), Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W. and A. R. Mamatey, 1998, *Savannah River Site Environmental Report for 1997*, WSRC-TR-97-00322), Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1999a, *Savannah River Site Environmental Report for 1998*, WSRC-TR-98-00312, Westinghouse Savannah River Company, Aiken, South Carolina.

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

Bureau of Labor Statistics, 1998, Number of nonfatal occupational injuries and illnesses by industry and selected case types, 1997, U.S. Department of Labor, Washington, D.C.

CDC (Centers for Disease Control and Prevention), 1998, National Vital Statistics Report, Volume 47, Number 4, October 7, 1998.

Du Pont (E.I. du Pont de Nemours and Company, Inc.), 1989, Radiation Exposure Report, Annual Report for 1988, DPSPU-89-11-1, Savannah River Plant, Aiken, South Carolina.

Hill, B.A., 1999, interoffice memorandum to A. S. Morrison, "SRS Occupational and Construction Injury and Illness Trending Data," Tetra-Tech NUS Corporation, Aiken, South Carolina.

NCRP (National Council on Radiation Protection and Measurements), 1987a, *Ionizing Radiation Exposure of the Population of the United States*, Report No. 93, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 1987b, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, Report No. 94, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitation of Exposure to Ionizing Radiation*, Report 116, Washington, D.C.

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.

Petty, K. R., 1993, "Health Protection Department 1992 Annual Report," interoffice memorandum to Distribution, Westinghouse Savannah River Company, WSRC-ESH-HPD-9200-035, Aiken, South Carolina.

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), 1991, *Radiation Protection and Industrial Hygiene Annual Report*, 1989, ESH-QIS-910027, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1992, 1990 *Health Protection Annual Report*, ESH-HPD-920072, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993, *Radiological Control Procedure Manual*, 5Q, Chapter 1, Part 1, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1994, *Savannah River Site Radiological Performance (U)*, Fourth Quarter 1993, ESH-PAS-94-0018, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1995, *Savannah River Site Radiological Performance (U)*, Fourth Quarter 1994, ESH-RCD-95-0016, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1996, *Savannah River Site Radiological Performance (U)*, Fourth Quarter 1995, ESH-RCO-96-0002, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1997, *WSRC Radiological Performance (U)*, Fourth Quarter 1996, WSRC-SHP-970012, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1998, *WSRC Radiological Performance (U)*, Fourth Quarter CY97, ESH-SHP-980007, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999, *WSRC Radiological Performance Indicators* (U), Fourth Quarter CY98, ESH-HPT-99-0017, Aiken, South Carolina.

SECTION 3.9

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), 1995, *Savannah River Site Waste Management Final Environmental Impact Statement*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2, Carlsbad Area Office, Carlsbad, New Mexico.

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

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

Sessions, J., 1999, Westinghouse Savannah River Company, Aiken, South Carolina, "Replacement High-level Waste Evaporator Startup," memorandum to L. A. Matis, Tetra Tech NUS, Aiken, South Carolina, August 24.

WSRC (Westinghouse Savannah River Company), 1998, *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), 1999a, *Savannah River Site Approved Site Treatment Plan, 1999 Annual Update*, WSRC-TR-94-0608, Revision 7, Savannah River Operations Office, Aiken, South Carolina. (Available at https://www.osti.gov/servlets/purl/6111-tB4S5C/webviewable/6111.pdf).

WSRC (Westinghouse Savannah River Company), 1999b, *Waste Isolation Pilot Plant Progress Report April 1999*, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999c, *Savannah River Site Tier II Emergency and Hazardous Chemical Inventory Report*, Aiken, South Carolina, March.

CHAPTER 4. ENVIRONMENTAL IMPACTS

Chapter 4 describes the potential environmental consequences to the SRS and the surrounding region of implementing each of the alternatives described in Chapter 2. As discussed in Chapter 2, DOE has identified three alternatives and three tank stabilization options:

- 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

Environmental consequences of actions could include direct physical disturbance of resources, consumption of affected resources, and degradation of resources caused by effluents and emissions. Resources include air, water, soils, plants, animals, cultural artifacts, and people, including SRS workers and people in nearby communities. Consequences may be detrimental (e.g., increased airborne emissions of hazardous chemicals) or beneficial (e.g., jobs created by new construction).

Section 4.1 describes the short-term impacts associated with each alternative within the scope of this EIS. For purposes of the analyses in the EIS, the short-term impacts span from the year 2000 through final closure of the existing HLW tanks associated with operation of the DWPF (approximately 2030). Section 4.2 describes the long-term impacts of the residual radioactive and non-radioactive material in the closed HLW tanks. Long-term assessment involves a 10,000-year performance evaluation beginning with a 100-year period of institutional control and continuing through an extended period during which it is assumed that residents and intruders could be present.

The impact assessments in this EIS have generally been performed in such a way that the magnitude and intensity of estimated impacts are unlikely to be exceeded during either normal operations or in the event of an accident. For routine operations, the results of monitoring the impacts from actual operations provide realistic predictions of impacts. For accidents there is more uncertainty because the impacts are based on events that have not occurred. In this EIS, DOE selected hypothetical accidents that would produce impacts as severe or more severe than any reasonably foreseeable accidents, which bounds the impacts of all reasonably foreseeable accidents for each alternative. The use of this methodology ensures that all of the alternatives have been evaluated using the same methods and data, allowing a non-biased comparison of impacts.

To ensure that small potential impacts are not over-analyzed and large potential impacts are not under-analyzed, analysts have assessed potential impacts based on their significance. This methodology follows the recommendation for the use of a "sliding scale" approach to analysis described in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993). The sliding scale approach uses a determination of significance by the analyst (and, in some cases, peer reviewers) for each potential impact. Potential impacts determined to be insignificant are not analyzed further, while potential impacts that may be significant are analyzed at a level of detail commensurate with the magnitude of the impacts.

4.1 Short-Term Impacts

Section 4.1 describes the short-term impacts associated with each alternative. For purposes of the analyses in the EIS, the short-term impacts span from year 2000 through final closure of the existing HLW tanks associated with operation of the DWPF (approximately 2030). The structure of Section 4.1 closely parallels that of Chapter 3, Affected Environment, with the addition of sections on utilities and energy consumption and accidents. The sections discuss methodology and present the potential impacts of each alternative evaluated. More details on the methodology for accident analysis are provided in Appendix B.

4.1.1 GEOLOGIC RESOURCES

No geologic deposits within F- and H-Areas have been economically or industrially developed, and none are known to have significant potential for development. There are, however, four tanks in F-Area and four tanks in H-Area that would require backfill soil to be placed over the top of the tanks for the Clean and Stabilize Tanks Alternative. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent surface water from collecting in the surface depressions. This action would prevent ponded conditions over these tanks that could facilitate the degradation of the tank structure. DOE currently estimates that 170,000 cubic meters of soil would be required to fill the depressions to grade.

Under the Clean and Remove Tanks Alternative, the tanks would be cleaned as appropriate and removed from the subsurface. This would require the backfilling of the excavations left by the removal of the tanks. The backfill material would consist of a soil type similar to the soils currently surrounding the tanks. DOE currently estimates that 356,000 cubic meters of soil would be required to backfill the voids left by the removal of the tanks.

The backfill soils would be excavated from an onsite borrow area(s) as determined by DOE. The excavation of borrow soils would be performed under Best Management Practices to limit impact to geologic resources that may be present. As a result, there would be no short-term impacts at the individual tank locations to geologic resources from any of the proposed alternatives discussed in Chapter 2.

4.1.2 WATER RESOURCES

4.1.2.1 <u>Surface Water</u>

Surface runoff in F- and H-Area Tank Farms flows to established storm sewer systems that may be used to block, divert, re-route, or hold up flow as necessary. During periods of earth moving or soil excavating, surface water runoff can be routed to area stormwater basins to prevent sediment from moving into down-gradient streams. During phases of the operation when the potential for a contaminant spill exists, specific storm sewer zones (or "flowpaths") can be secured, ensuring that contaminated water or cleaning chemicals inadvertently spilled would be routed to a lined retention basin via paved ditches and underground drainage lines.

The retention basins are flat-bottomed, slope-walled, earthen basins lined with rubber (H-Area Retention Basin) or polyethylene (F-Area Retention Basin). Both basins have a capacity of 6,000,000 gallons. Stormwater in the retention basins may be sent to Fourmile Branch (if uncontaminated rainwater), to the Effluent Treatment Facility for removal of contaminants, or re-routed to the tank farms for temporary storage prior to treatment. Because any construction site runoff or spills would be controlled by the tank farm storm sewer system, DOE does not anticipate impacts to down-gradient surface waters. Activities would be confined to developed areas and discharges would be in compliance with existing stormwater permits.

Small (approximately one acre) lay-down areas would be established just outside of the F- and H-Area Tank Farms to serve as equipment storage and staging areas. Development of these lay-down areas would require little or no construction or land disturbance; therefore, the potential for erosion and sedimentation under any of the alternatives would be negligible.

Prior to construction, DOE would review and augment (if necessary) its existing erosion and sedimentation plans, ensuring that they were in compliance with State regulations on stormwater discharges and approved by SCDHEC.

4.1.2.2 Groundwater

The only direct impact to groundwater resources during the short-term activities associated with tank closure would be the use of groundwater for cleaning, for tank ballast, and for mixing grout, saltstone, or sand fill. Of the alternatives described in Chapter 2, only the No Action Alternative involves using water as ballast; however, this alternative does not use water for tank cleaning. The Grout and Saltstone Options under the Clean and Stabilize Tanks Alternative include water use for tank cleaning and for mixing with the grout and saltstone backfill. The Clean and Fill with Sand Option uses water for tank cleaning and a relatively small amount of water to prepare the sand slurry for tank filling. The Clean and Remove Tanks Alternative only uses water for cleaning, although the higher degree of cleaning required for tank removal would use more water than cleaning for in-place tank closure alternatives.

An accounting of the volumes of water required for each of the closure alternatives (as described in Section 4.1.11) shows that the largest volume of water would be used during the Clean and Stabilize Tanks Alternative (Grout Option). The largest volume on a per tank basis would be consumed during closure of Type III tanks. Based on the anticipated closure schedule, closure of two Type III tanks in any given year would consume approximately 2.3 million gallons of water. This water would come from the groundwater production wells located at various operating areas at SRS. As a comparison, the total groundwater production from the F-Area industrial wells from January through December 1998 was approximately 1.01 million gallons per day (370 millions gallons per year) (Johnson 1999). This water was pumped from the intermediate and deep aquifers that have been widely used as an industrial and municipal groundwater source for many years across Aiken County. The tank closure water requirements represent less than 0.6 percent of the F-Area annual production alone. Based on these projections, there would be no significant impact to groundwater resources for any of the tank closure alternatives.

The tank farms are situated in highly developed industrial areas. Some of the tank groups were constructed in pits substantially lower in elevation than the surrounding terrain. The existing tank farm sites include facilities and structures designed to prevent surface ponding and to manage precipitation runoff in a controlled manner. Reclamation of the tank farms after closure would require backfilling and grading to provide a suitable site for future industrial/commercial development, to prevent future ponding of water at the surface, and to promote non-erosional surface water runoff. Backfilling and grading would be performed using borrow material derived from local areas at the SRS; borrow material is assumed to be physically similar to the in-place materials. Therefore, there should be little or no impact to short-term groundwater recharge as a result of the surface reclamation activities.

The in-place tank closure alternatives would result in residual waste being left in the tanks. The residual waste has the potential to contaminate groundwater at some point in the future due to leaching and water-borne transport of contaminants. This is not expected to occur, however, until several hundred years after tank closure when the tank, tank contents, and underlying basemat are anticipated to fail due to deterioration. Under all closure alternatives, construction and/or demolition activities have the potential to result in soil, wastewater, or direct groundwater contamination through spills of fuels or chemicals or construction by-products and wastes. By following safe work practices and implementing good engineering methodologies, concentrations in soil, wastewater, and groundwater should be kept well within applicable standards and guidelines to protect groundwater resources.

4.1.3 AIR RESOURCES

This section discusses nonradiological and radiological air quality impacts that would result from actions related to tank closure activities. To determine the impacts on air quality, DOE estimated the emission rates associated with processes used in each alternative. This included an identification of potential emission sources and any methods by which air would be filtered before being released to the environment. These emissions were entered into air dispersion models to determine potential maximum concentrations at onsite and offsite locations. The estimated emissions and air concentrations of nonradiological and radiological pollutants are discussed and compared to the pertinent SCDHEC and Federal regulatory limits in the following two sections. Any human health effects resulting from increased air concentrations are discussed in the Worker and Public Health Section (4.1.8).

4.1.3.1 Nonradiological Air Quality

Tank closure activities would result in the release of regulated nonradiological pollutants to the surrounding air. The estimated emission rates (tons per year) for each emitted regulated pollutant and each alternative/option are presented in Table 4.1.3-1. These emission rates can be compared against emission rates defined in SCDHEC Standard 7, "Prevention of Significant Deterioration (PSD)." The PSD limits are included in Table 4.1.3-1 and are discussed in this section.

The primary sources of nonradiological air pollutants for the Grout Option under the Clean and Stabilize Tanks Alternative would be a concrete batch plant located next to each of the F- and H-Area Tank Farms and three diesel generators that would provide electrical power for each of these batch plants. The batch plants and generators were assumed to be identical to those used during the two previous tank closures and were conservatively assumed to run continuously. The diesel generators account for a majority of the pollutants emitted; however, the batch plants' emissions would account for 77 percent of the total PM_{10} (particulate matter with an aerodynamic diameter ≤ 10 μm) emitted. Additional nonradiological pollutants would be expected from the exhaust from trucks delivering raw materials to the batch plant every few days. Since these emissions would only occur occasionally, they were considered very small relative to batch plant emission and were not included in the emissions calculations for this option or any other option under the Clean and Stabilize Tanks Alternative.

For the Sand Option of the Clean and Stabilize Tanks Alternative, nonradiological pollutants would be emitted from operation of the sand conveyance (feed) plants, one at H-Area and a second at F-Area, and three diesel generators providing electric power for each of the sand conveyance plants. The sand feed plants would emit 67 percent of the total PM_{10} that would be emitted under this option. The diesel generators and sand conveyance plants were assumed to operate continuously.

The option of filling the cleaned tanks with saltstone would require saltstone batching facilities to be located at F- and H-Areas. The total amount of saltstone that would be made from the stabilization of all the low-activity fraction of HLW would probably be greater than the capacity of the waste tanks (DOE 1996). Therefore, each of the two new facilities for producing the saltstone necessary to fill the tanks was assumed to be one-half the size of the existing facility and was assumed to have identical sources of air pollution (Hunter 1999). The diesel generator emissions were based on the permitted emissions for the three generators at the Saltstone Manufacturing and Disposal Facility.

Regulated nonradiological air pollutants released as a result of activities associated with the No Action Alternative would consist primarily of emissions from vehicular traffic operating during waste removal. Relatively few vehicles would be required and would not run continuously; therefore, the emissions would be very small.

Regulated nonradiological air pollutants released as a result of activities associated with the Clean and Remove Tanks Alternative would consist of emissions from cutting the carbon steel tanks and emissions from vehicular traffic operating during cleaning and removal. The tank cutting would produce particulates, but not air toxics, and these particulates would be heavier and deposited to the ground much quicker than for welding. The cutting operations would be intermittent and short term (a day or two every few weeks). Also, a hut would be erected around the cutting operation to control the particulates; therefore the emissions would be very

Table 4.1.3-1. Nonradiological air emissions (tons per year) for tank closure alternatives.[a]

			Diesel Generators			Batch/Feed Plant			
Air pollutant	PSD significant emissions rate[b]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tank Alternative
Sulfur dioxide (as SO_x)	40	-[c]	2.2	2.2	6.6				-[c]
Total suspended particulates	25	-[c]	-[d]	-[d]	5.2				-[c]
Particulate matter (≤10 μm)	15	-[c]	1.0	1.0	3.3	3.5	2.1	0.3	-[c]
Carbon monoxide	100	-[c]	5.6	5.6	16.0				-[c]
VOCs	40	-[c]	2.3	2.3	4.9			0.8	-[c]
Nitrogen dioxide (as NO_x)	40	-[c]	33	33	77				-[c]
Lead	0.6	-[c]	9.0×10^{-4}	9.0×10^{-4}	2.9×10^{-3}				-[c]
Beryllium	4.0×10^{-4}	-[c]	1.7×10^{-4}	1.7×10^{-4}	5.6×10^{-4}				-[c]
Mercury	0.1	-[c]	2.2×10^{-4}	2.2×10^{-4}	7.0×10^{-4}			8.4×10^{-5}	-[c]
Benzene	NA	-[c]	0.02	0.02	0.04			0.84	-[c]

NA = Not applicable; no regulatory limit for this pollutant.
Source: Hunter (1999).
b. SCDHEC, Regulation 61-62.5, Standard 7, "Prevention of Significant Deterioration (PSD), Part V(1)."
c. Emissions from these alternatives have not been quantified, but would be small in relation to the clean and Stabilize Tanks Alternative.
d. No data on TSP emissions for these sources are readily available and therefore are not reflected in this analysis.
e. VOCs = volatile organic compounds, includes benzene.

small. Relatively few vehicles would be required and would not run continuously.

Additionally, all but one alternative includes the possibility of cleaning the interior tank walls with oxalic acid, a toxic air pollutant regulated under SCDHEC Standard 8. Oxalic acid would likely be stored in aboveground storage tanks. Tank ventilation would result in the release of small amounts of vapor to the atmosphere. A review of emissions data from two oxalic acid tanks currently used at SRS shows that the emissions from these sources are less than 3.5×10^{-9} tons per year. This resulting concentration in the vented air would be much less than any ambient air limit and would therefore be considered to be very small for purposes of assessing impacts to air quality (Hunter 1999).

The oxalic acid would be stored as a 4-8% (by weight) solution in tank trucks and driven to the tank to be cleaned. The acid would be transferred to the HLW tanks through a sealed pipeline. No releases are expected during this procedure. The cleaning process would consist of spraying hot (80-90°C) acid using remotely operated water sprayers. The tanks would be ventilated with 300-400 cfm of air, which would pass through a HEPA filter. The acid has a very low vapor pressure (as demonstrated by the very low tank emissions), releases from the ventilated air will be minimal. After its use in the tank, the acid is pumped and neutralized. Although no specific monitoring for oxalic acid fumes was performed during the cleaning of Tank 16 (see Sect. 2.1.1), no deleterious effects of using the acid were noted at the time.

The expected emission rates from the identified sources for each alternative/option were compared to the emission rates listed in SCDHEC Standard 7, "Prevention of Significant Deterioration (PSD)," to determine if the emission would result in an exceedance of this standard or a significant emission increase. Facilities such as SRS that are located in attainment areas and are classified as major facilities may trigger a PSD permit review under the new source review requirements of the Clean Air Act when they construct a major stationary source or make a major modification to a major source. A major source is defined as a source with the potential to emit any air pollutant regulated under the Clean Air Act in amounts equal to or exceeding specified thresholds. A PSD permit review is required if that modification or addition to the major facility results in a significant net emissions increase of any regulated pollutant. However, as can be seen in Table 4.1.3-1, the expected nonradiological emissions would be below the PSD significant emission rates listed in Standard 7 for most pollutants. The estimated emission rate for oxides of nitrogen under each alternative (33, 33, and 77 tons per year) are close to or exceed the PSD limit of 40 tons per year. However, the estimated emission rates were based on the assumption that batch operations at both F-Area and H-Area are running at the same time and continuously throughout the year. In all likelihood, tanks would be closed one at a time and there would be time between each closure when equipment is not in operation. Therefore, the estimated emission rates in Table 4.1.3-1 are conservative and none would be expected to exceed the PSD limits in Standard 7. In addition, the estimated emission rate for beryllium from diesel generators for the Clean and Fill with Saltstone Option would slightly exceed the PSD significant emissions rate.

Using the emission rates from Table 4.1.3-1, maximum concentrations of released regulated pollutants were determined using the EPA's Industrial Source Complex – Short Term (ISC3) air dispersion model (EPA 1995). The one-year meteorological data set collected onsite at SRS for 1996 was used as input into the model. Maximum concentrations were estimated at: (1) the SRS boundary where members of the public potentially could receive the highest exposure, and (2) at the location of a hypothetical noninvolved site worker. For the location of the noninvolved worker, the analysis used a generic location 2,100 feet from the release point in the direction of the greatest concentration. This location is the standard distance for assessing consequences from facility accidents and is used here for normal operations for consistency. Concentrations at the receptor locations were calculated at an elevation of 2 meters above ground to approximate the breathing height of a typical adult. The maximum air concentrations (micrograms per cubic meter) at the SRS boundary associated with the release of regulated nonradiological pollutants are listed in Tables 4.1.3 2 and 4.1.3-3. As can be expected, the Clean and Fill with Saltstone Option, which has slightly higher emissions, results in higher concentrations at the site boundary. However, ambient concentrations for all the pollutants and alternatives/options would increase by less than 1 percent of the regulatory limits. Therefore, no proposed tank closure activities would result in an exceedance of standards.

The air quality impacts at the location of a hypothetical noninvolved worker in the vicinity of F- and H-Areas are presented in Table 4.1.3-4. As with the modeled concentrations at the Site boundary, ambient concentrations of the OSHA-regulated pollutants (milligrams per cubic meter) at the location of the noninvolved worker would be highest for the Clean and Fill with Saltstone Option. All concentrations would be below OSHA limits; all concentrations with the exception of nitrogen dioxide (as NO_x) would be less than 1 percent of the regulatory limit. Nitrogen dioxide (as NO_x) could reach 8 percent of the regulatory limit for the Clean and Fill with Grout and Clean and Fill with Sand Options while nitrogen dioxide levels under the Clean and Fill with Saltstone Option could reach approximately 16 percent of the OSHA limit. All emissions of nitrogen dioxide are attributable to the operation of the diesel generators.

Emissions of regulated nonradiological air pollutants resulting from tank closure activities would not exceed PSD limits enforced under SCDHEC Standard 7. Likewise, air concentrations at the SRS boundary of the emitted pollutants under all options would not exceed SCDHEC or Clean Air Act regulatory limits. Any impacts to human health from these pollutants are discussed in Section 4.1.8.2 – Nonradiological Health Effects.

Table 4.1.3-2. Estimated maximum concentrations (in micrograms per cubic meter) at the SRS boundary for SCDHEC Standard 2 Air Pollutants.[a]

				Maximum concentration increment				
					Clean and Stabilize Tanks Alternative			
Air pollutant	Averaging time	South Carolina Standard[b]	SRS baseline[c]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Sulfur dioxide (as SO_x)	3-hr	1,300	1,200	(d)	0.2	0.2	0.6	(d)
	24-hr	365	350	(d)	0.04	0.04	0.12	(d)
	Annual	80	34	(d)	0.002	0.002	0.006	(d)
Total suspended particulates	Annual Geometric Mean	75	67	(d)	ND	ND	0.005	(d)
Particulate matter ($\leq$10 μm)	24-hr	150 (65)[e]	130	(d)	0.08	0.06	0.06	(d)
	Annual	50 (15)[e]	25	(d)	0.004	0.003	0.003	(d)
Carbon monoxide	1-hr	40,000	10,000	(d)	1.2	1.2	3.4	(d)
	8-hr	10,000	6,900	(d)	0.3	0.3	0.8	(d)
VOCs	1-hr	(f)	(f)	(d)	0.5	0.5	2.0	(d)
Ozone	1-hr	235	NA	(d)	(g)	(g)	(g)	(d)
Nitrogen dioxide (as NO_x)	Annual	100	26	(d)	0.03	0.03	0.07	(d)
Lead	Calendar Quarter Mean	1.5	0.03	(d)	1.2×10^{-6}	1.2×10^{-6}	4.1×10^{-6}	(d)

NA = Not applicable; ND = Not detectable; maximum concentration below detectable limit; VOC = volatile organic compounds.

a. Source: Hunter (1999).

b. Source: SCDHEC Air Pollution Regulation 61-62.5, Standard 2, "Ambient Air Quality Standards."

c. Sum of (1) an estimated maximum site boundary concentration from modeling all sources of the indicated pollutant at SRS not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory data base) and (2) observed concentrations from nearby ambient air monitoring stations.

d. No emissions of this pollutant are expected.

e. New NAAQS for particulate matter $\leq$2.5 microns (24-hour limit of 65 $\mu g/m^3$ and an annual average limit of 15 $\mu g/m^3$) may become enforceable during the life of this project.

f. There is no standard for ambient concentrations of volatile organic compounds, but their concentrations are relevant to estimating ozone concentrations.

g. Ozone is a regional pollutant resulting from complex photochemical reactions involving oxides of nitrogen (NO_x) and volatile organic compounds (VOCs). Because estimated NO_x and VOCs emissions are below Prevention of Significant Deterioration (PSD) significant emissions rates, corresponding ozone increases are expected to be insignificant.

Table 4.1.3-3. Estimated maximum concentrations (in micrograms per cubic meter) at the SRS boundary for SCDHEC Standard 8 Toxic Air Pollutants.

				Maximum concentration increment				
					Clean and Stabilize Tanks Alternative			
Air pollutant	Averaging time	South Carolina Standard[a]	SRS baseline[b]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Beryllium	24-hr	0.01	0.009	(c)	3.2×10^{-6}	3.2×10^{-6}	1.1×10^{-5}	(c)
Mercury	24-hr	0.25	0.03	(c)	4.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	(c)
Benzene	24-hr	150	4.6	(c)	3.8×10^{-4}	3.8×10^{-4}	2.0×10^{-2}	(c)

a. From SCDHEC Air Pollution Regulation 61-62.5, Standard 8, Part II, Paragraph E, "Toxic Air Pollutants."
b. Estimated maximum site boundary concentrations from modeling all sources of the indicated pollutant at SRS not exempt from Clean Air Act Title V modeling requirements (maximum potential emissions from the 1998 Air Emissions Inventory database).
c. No emissions of this pollutant are expected.

Table 4.1.3-4. Estimated maximum concentrations (in milligrams/cubic meter) of OSHA-regulated nonradiological air pollutants at hypothetical noninvolved worker location.

			Maximum concentration[b]				
			Clean and Stabilize Tanks Alternative				
Air pollutant	Averaging time	OSHA Standard[a]	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Sulfur dioxide (as SO_x)	8-hr TWA	13	-	5.0×10^{-3}	5.0×10^{-3}	0.02	-
Total suspended particulates	8-hr TWA	15	-	ND	ND	0.01	-
Particulate matter ($\leq$10 μm)	8-hr TWA	5	-	9.0×10^{-3}	6.0×10^{-3}	8.0×10^{-3}	-
Carbon monoxide	8-hr TWA	55	-	0.01	0.01	0.04	-
Oxides of nitrogen (as NO_x)	Ceiling	9	-	0.7	0.7	1.4	-
Lead	8-hr TWA	0.05	-	2.1×10^{-6}	2.1×10^{-6}	6.5×10^{-6}	-
Beryllium	8-hr TWA	2.0×10^{-3}	-	4.1×10^{-7}	4.1×10^{-7}	1.3×10^{-6}	-
	Ceiling	5.0×10^{-3}	-	3.4×10^{-6}	3.4×10^{-6}	1.1×10^{-5}	-
Mercury	Ceiling	1.0		4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-5}	-
Benzene	8-hr TWA	3.1	-	4.8×10^{-5}	4.8×10^{-5}	1.0×10^{-3}	-
	Ceiling	15.5	-	3.9×10^{-4}	3.9×10^{-4}	3.3×10^{-3}	-

ND = Not detectable; maximum concentration below detectable limit.

a. Air pollutants regulated under 29 CFR 1910.1000. Averaging values listed are 8-hour time-weighted averages (TWA) except for oxides of nitrogen, mercury, benzene, and beryllium which also include not-to-be exceeded ceiling (29 CFR 1910.1000 values).

b. Hunter (1999). Maximum estimated concentrations for a noninvolved worker at a distance of 2,100 feet from source and a breathing height of 2 meters.

4.1.3.2 Radiological Air Quality

Routine radiological air emissions that would be associated with tank closure activities were assumed to be equivalent to the current level of releases from the F- and H-Area Tank Farms. Annual emissions were based on the previous 5 years measured data for the tank farms (predominantly Cs-137). For No Action and each of the fill alternatives, all the air exiting the tanks would be filtered through high efficiency particulate air (HEPA) filters. For the Clean and Remove Tanks Alternative, the top of the tank would have HEPA-filtered enclosures or airlocks during removal of the metal from the tank. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration (Johnson 1999). Therefore, emissions from the tanks in F-Area and H-Area would not vary substantially among alternatives. The Saltstone Option under the Clean and Stabilize Tanks Alternative would require two new saltstone mixing facilities that would result in additional radionuclide emissions. The estimated Saltstone Manufacturing and Disposal Facility radionuclide emission rates presented in the *DWPF Supplemental EIS* (DOE 1994) were assumed to bound the emissions from both saltstone mixing facilities. The total estimated radiological air emissions for each alternative are shown in Table 4.1.3-5. The relevance to human health of these emissions are presented in Section 4.1.8 – Worker and Public Health.

After determining routine emission rates, DOE used the MAXIGASP and POPGASP computer codes to estimate radiological doses to the maximally exposed individual, the hypothetical noninvolved worker, and the offsite population surrounding SRS. Both codes utilize the GASPAR (Eckerman et al. 1980) and XOQDOQ (Sagendorf et al. 1982) modules that have been adapted and verified for use at SRS (Hamby 1992 and Bauer 1991, respectively). MAXIGASP and POPGASP are both site-specific computer programs that have SRS-specific meteorological parameters (e.g., wind speeds and directions) and population distribution parameters (e.g., number of people in sectors around the Site). The 1990 census population database was used to represent the population living within a 50-mile radius of the center of SRS.

Table 4.1.3-6 presents the calculated maximum radiological doses associated with tank closure activities for all the analyzed alternatives and options. Based on the dispersion modeling, the maximally exposed individual was identified as being located in the northern sector at the SRS boundary (Simpkins 1996). The maximum committed effective dose equivalent for the maximally exposed individual would be 2.6×10^{-5} millirem per year for the Clean and Fill with Saltstone Option, which is slightly higher than the other alternatives due to the additional emissions from operation of the saltstone batch plants. A majority of the dose to the maximally exposed individual, 70 percent, is associated with emissions from the tanks in H-Area. The annual maximally exposed individual dose under all the alternatives is well below the established annual dose limit of 10 millirem for SRS atmospheric releases (40 CFR 61.92). The maximum estimated dose to the offsite population residing within a 50-mile radius is calculated as 1.5×10^{-3} person-rem per year for the Clean and Fill with Saltstone Option. As with the maximally exposed individual dose, the tank farm emissions from H-Area comprise a majority (71 percent) of the total dose.

Table 4.1.3-6 also reports a dose to the hypothetical onsite worker from the estimated annual radiological emissions. The Clean and Fill with Saltstone Option is slightly higher than the other alternatives, 2.64×10^{-3} versus 2.57×10^{-3} millirem per year, with 74 percent of the total dose due to emissions from the H-Area Tank Farm.

Radionuclide doses from tank closure activities for all alternatives and options considered would not exceed any regulatory limit. Potential human health impacts from these doses are presented in Section 4.1.8.

Table 4.1.3-5. Annual radionuclide emissions (curies/year) resulting from tank closure activities.

	Annual emission rate				
		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
F-Area[a]	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}	3.9×10^{-5}
H-Area[a]	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Saltstone Facility[b]	NA	NA	NA	0.46	NA
Total	1.5×10^{-4}	1.5×10^{-4}	1.5×10^{-4}	0.46	1.5×10^{-4}

a. Source: Arnett and Mamatey (1997 and 1998), Arnett (1994, 1995, and 1996).
b. Source: DOE (1994).

Table 4.1.3-6. Annual doses from radiological air emissions from tank closure activities.[a]

	Maximum dose				
		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Noninvolved worker dose (millirem/year)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}
Maximally exposed individual dose (millirem/year)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Offsite population dose (person-rem/year)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}

a. Source: Based on emissions values listed in Table 4.1.3-5 and Simpkins (1996).

4.1.4 ECOLOGICAL RESOURCES

Most of the closure activities described in Chapter 2 (e.g., excavation and removal of transfer lines) would take place within the fenced boundaries of the F- and H-Area Tank Farms, heavily industrialized areas that provide limited wildlife habitat (see Figures 3.5-1 and 3.5-2). However, wildlife in undeveloped woodland areas adjacent to the F- and H-Area Tank Farms could be intermittently disturbed by construction activity and noise over the approximately 30-year period when 49 HLW tanks would be emptied (under all alternatives, including No Action), cleaned and stabilized (under the Clean and Stabilize Tanks Alternative), or cleaned and removed (under the Clean and Remove Tanks Alternative).

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

Table 4.1.4-1 shows the attenuation of construction noise over relatively short distances. At

Table 4.1.4-1. Peak and attenuated noise (in dBA) levels expected from operation of construction equipment.[a]

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

a. Source: Golden et al. (1980).

400 feet from the construction sites, construction noises would range from approximately 60 to 80 dBA. Golden et al. (1980) suggest that noise levels higher than 80 to 85 dBA are sufficient to startle or frighten birds and small mammals. Thus, there would be minimal potential for disturbing birds and small mammals outside a 400-foot radius of the construction sites.

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 (e.g., songbirds and small mammals) that forage, feed, nest, rest, or den in the woodlands to the south and west of the F-Area Tank Farm and to the south of the H-Area Tank Farm. Construction-related disturbances are likely to create impacts to wildlife that would be small, intermittent, and localized. Some animals could be driven from the area permanently, while others could become accustomed to the increased noise and activity and return to the area. Species likely to be affected (e.g., gray squirrel, opossum, white-tailed deer) are common to ubiquitous in these areas.

Lay-down areas (approximately one to three acres in size) would be established in previously-disturbed areas immediately adjacent to the F- and H-Area Tank Farms to support construction activities under the Clean and Stabilize Tanks Alternative and the Clean and Remove Tanks Alternative. These lay-down areas would serve as staging and equipment storage areas. The specialized equipment required for handling and conveying fill material under the Clean and Stabilize Tanks Alternative (e.g., the batch plants and diesel generators) would also be placed in these lay-down areas. Creating these lay-down areas would have the effect of extending the zone of potential noise impact several hundred feet, but noise-related impacts would still be limited to a relatively small area (less than 20 acres) adjacent to the F- and H-Area Tank Farms.

As noted in Section 3.4.1, no threatened or endangered species, or critical habitat occurs in or near the F- and H-Area Tank Farms, which are heavy-industrial sites surrounded by roads, parking lots, construction shops, and construction laydown areas and are continually exposed to high levels of human disturbance. DOE will continue to monitor the tank farm area, and all of the SRS, for the presence of threatened or endangered species. If a listed species is found, DOE will determine if tank closure activities would affect that species. If DOE were to determine that adverse impacts may occur, DOE would initiate consultation with the U.S. Fish and Wildlife Service under Section 7 of the ESA.

DOE has not selected a location for the onsite borrow area, but suitability of a potential sites would be based on proximity to F- and H-Area, topography, characteristics of soil in an area, accessibility (whether or not access roads are present), and the presence/absence of sensitive resources such as wetlands and archaeological sites. DOE would attempt to locate a source of soil in a previously-developed area (or adjacent to a previously-developed area) in order to minimize disturbance to plant and animal communities. Representative impacts from borrow pit development would include the physical alteration of 7 to 14 acres of land (and attendant loss of potential wildlife habitat) and noise disturbances to nearby wildlife.

DOE would require approximately 51 acres of land in E-Area for use as low-activity waste storage vaults under the Clean and Remove Tanks Alternative. A total of 70 acres of developed land in E-Area was identified as available for waste management activities in the SRS Waste Management EIS. Currently only one low-activity waste storage vault has been constructed. The analysis in SRS Waste Management EIS found that the construction and operation of storage and disposal facilities within the previously cleared and graded portions of E-Area (i.e., developed) would have little effect on terrestrial wildlife. Wildlife habitat in these areas is poor and characterized by mowed grassy areas with few animals. Birds and mammals that use these areas, mostly for feeding, would be displaced by construction activities, but it is unlikely that they would be physically harmed or killed.

4.1.5 LAND USE

As can be see from Figures 3.5-1 and 3.5-2, the tank farms are in a highly industrialized portion of the SRS. Since bulk material removal would continue until completed, the transition of tanks to the HLW tank closure project would be phased over an approximately 30-year period. Consequently, closure activities would not result in short-term changes to the land use patterns of the SRS or alter the use or character of the tank farm areas.

As noted in Section 4.1.1, a substantial volume of soil (6 to 12.5 million cubic feet) could be required for backfill under the Clean and Stabilize Tanks Alternative or the Clean and Remove Tanks Alternative. DOE would obtain this soil from an onsite borrow area. Assuming an average depth of 20 feet for the borrow pit, the borrow area would be approximately 7 to 14 acres in surface area.

DOE has not selected a location for the onsite borrow area, but suitability of potential sites would be based on proximity to F- and H-Area, topography (ridges and hilltops would be avoided to limit erosion), characteristics of soil in an area, accessibility (whether or not access roads are present), and the presence/absence of sensitive resources such as wetlands and archaeological sites. DOE would attempt to locate a source of soil in a previously-developed area (or adjacent to a previously-developed area) in order to minimize the amount of undeveloped land converted to industrial use. Consistent with SRS long-term land use plans, any site selected would be within the central developed core of the SRS, which is dedicated to industrial facilities (DOE 1998). There would be no change in overall land use patterns on the SRS.

As discussed in Section 2.1.2, this amount of solid low-level waste generated under the Clean and Remove Tanks Alternative would require about 16 new low-activity waste vaults (650 feet by 150 feet). The land use impacts of constructing and operating the required low-activity-waste vaults were described and presented in the SRS Waste Management EIS (DOE/EIS-0217) and was based on constructing up to 31 low-activity waste vaults. Based on design information presented in the Waste Management EIS, the 16 vaults under the Clean and Remove Tanks Alternative would require just over 51 acres of land. In the SRS Waste Management EIS, DOE identified 70 acres of previously developed land in E-Area that is available for waste storage use. Since completion of the

SRS Waste Management EIS in July 1995, DOE has not identified the remaining land as a potential site for other activities therefore, there are no conflicting land uses and the analysis presented in the SRS Waste Management EIS is still valid. However, should future land uses change these changes would be made by DOE through the site development, land-use, and future-use planning processes, including public input through various avenues such as the Citizens Advisory Board. Finally any land use changes would be in accordance with the current Future Use Plan (DOE 1998).

4.1.6 SOCIOECONOMIC IMPACTS

Table 4.1.6-1 presents the estimated employment levels associated with each tank closure alternative.

For the No Action Alternative, operators, supervisors, technical staff and maintenance personnel would be required to monitor the tanks and maintain equipment and instruments. These activities are estimated to require about 40 personnel from the existing work force to cover shift and day operations (Johnson 1999).

As seen in Table 4.1.6-1, approximately 85 employees, on average, would be required to perform closure activities for the Clean and Fill with Grout and Sand Options under the Clean and Stabilize Tanks Alternative. The Clean and Fill with Saltstone Option would require approximately 130 employees (Caldwell 1999). The Clean and Remove Tanks Alternative would require, on average, over 280 employees. In each case, it is assumed two tanks will be closed per year. The employment estimates includes all employee classifications: operations, engineering, design, construction, support, and project management.

The maximum peak annual employment would occur under the Clean and Remove Tanks Alternative. This alternative would require less than 2 percent of the existing SRS workforce. All options under the Clean and Stabilize Tanks Alternative would require less than 1 percent of the existing SRS workforce.

Given the size of the economy in the six-county region of influence (described in Section 3.6), the estimated SRS workforce, and the size of the regional population and workforce, tank closure activities are not expected to result in any measurable socioeconomic impacts for any of the alternatives. Likewise, impacts to low-income or minority areas (as described in Section 3.6) are also not expected.

4.1.7 CULTURAL RESOURCES

As discussed in Chapter 2, activities associated with the tank closure alternatives at SRS would occur within the current F- and H-Area Tank Farms. Although there may have been prior human occupation at or near the F- and H-Area

Table 4.1.6-1. Estimated HLW tank closure employment.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Annual employment (Full-time equivalent employees)[a,b]	40	85	85	131	284
Life of project employment (Full-time equivalent employees – years)[c]	980	2,078	2,078	3,210	6,963

a. Source: Caldwell (1999).
b. Assumes two tanks closed per year.
c. Total for all 49 tanks.

Tank Farms, the likelihood of historic resources surviving the construction of the tank farms in the early 1950s, before the enactment of regulations to protect such resources, would be small. The potential for the presence of prehistoric site in the candidate locations also is limited. As with any historic sites, tank farm construction activities probably destroyed or severely damaged prehistoric deposits. Therefore, tank closure activities would not be expected to further impact historic or prehistoric resources.

Under the Clean and Remove Tanks Alternative, 16 new low-activity waste vaults would be constructed in E-Area. As with the Tank Farm areas, previous DOE activities in E-Area probably destroyed or severely damaged any historic or prehistoric resources. Therefore, construction of these low-activity waste vaults would not be expected to further impact historic or prehistoric resources.

If any historic or archaeological resources should become threatened, however, DOE would take appropriate steps to identify the resources and contact the Savannah River Archaeological Research Program, the South Carolina Institute of Archaeology and Anthropology at the University of South Carolina and the State Historic Preservation Officer to comply with Section 106 of the National Historic Preservation Act.

4.1.8 WORKER AND PUBLIC HEALTH

This section discusses potential radiological and nonradiological health effects to SRS workers and the surrounding public from the HLW tank closure alternatives; it does not include impacts of potential accidents, which are discussed in Section 4.1.12. DOE based its calculations of health effects from the airborne radiological releases on (1) the dose to the hypothetical maximally exposed offsite individual; (2) the dose to the maximally exposed noninvolved worker (i.e., SRS employees who may work in the vicinity of the HLW tank closure facilities but are not directly involved in tank closure work); (3) the collective dose to the population within a 50-mile radius around the SRS (approximately 620,000 people); and (4) the collective dose to workers involved in implementing a given alternative (i.e., the workers involved in tank closure activities). All radiation doses mentioned in this EIS are effective dose equivalents; internal exposures are committed effective dose equivalents. This discussion characterizes health effects as additional lifetime latent cancer fatalities likely to occur in the general population around SRS and in the population of workers who would be associated with the alternatives.

Nonradiological health effects discussed in this section include health effects from nonradiological air emissions. In addition, occupational health impacts are presented in terms of estimated work-related illness and injury rates associated with each of the tank closure alternatives.

4.1.8.1 Radiological Health Effects

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

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

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

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

Vital statistics on mortality rates for 1997 (CDC 1998) indicate that the overall lifetime fatality rate in the United States from all forms of cancer is about 23.4 percent (23,400 fatal cancers per 100,000 deaths).

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation; these include nonfatal cancers among the exposed population and genetic effects in subsequent generations. Previous studies have concluded that these effects are less probable than fatal cancers as consequences of radiation exposure (NCRP 1993). Dose-to-risk conversion factors for nonfatal cancers and hereditary genetic effects (0.0001 per person-rem and 0.00013 per person-rem, respectively) are substantially lower than those for fatal cancers. This EIS presents estimated effects of radiation only in terms of latent cancer fatalities because that is the major potential health effect from exposure to radiation. Estimates of nonfatal cancers and hereditary genetic effects can be estimated by multiplying the radiation doses by the appropriate dose-to-risk conversion factors for these effects.

DOE expects minimal worker and public health impacts from the radiological consequences of tank closure activities under any of the closure alternatives. All closure alternatives are expected to result in similar radiological release levels in the near-term. Public radiation doses would likely occur from airborne releases only (Section 4.1.3). Table 4.1.8-1 lists incremental radiation doses estimated for the noninvolved worker [a worker not directly involved with implementing the option but located 2,100 feet (a standard distance used for consistency with other SRS for NEPA evaluations) from the HLW tank farm] and the public (maximally exposed offsite individual and collective population dose) and corresponding incremental latent cancer fatalities, for each closure alternative. DOE based estimated worker doses on past HLW tank operating experience and the projected number of employees associated with each action (Newman 1999a; Johnson 1999). For the maximally exposed worker, DOE assumed that no worker would receive an annual dose greater than 500 millirem from any alternative because SRS uses the 500 millirem value as an administrative limit for normal operations: that is, an employee who receives an annual dose approaching the administrative limit normally is reassigned to duties in a nonradiation area. Table 4.1.8-2 estimates radiation doses for the collective population of workers who would be directly involved in implementing the options. This estimation was derived by assigning a specific number of workers for each tank closure task and then combining the tasks for each option/alternative. An average collective dose was then assigned for the closure of all 49 HLW tanks. Latent cancer fatalities likely attributable to the doses are also listed in this table. Individual worker doses were not calculated or assigned by this method. Total dose to the involved worker population was not evaluated by DOE due to the speculative nature of worker locations at the site. As expected, the Clean and Remove Tanks Alternative would result in larger radiological dose and health impacts due to larger manpower needs. However, impacts are well within the administrative control limit for SRS workers.

As shown in Table 4.1.8-2, post-closure activities would result in minimal radiological worker impacts. The Clean and Stabilize Tanks Alternative as well as the Clean and Remove Tanks Alternative would result in a smaller collective worker dose than the No Action Alternative. The lower dose is due to the reduced number of employees that would be needed once the tank closure activities are completed.

The estimated number of latent cancer fatalities in the public listed in Table 4.1.8-1 from airborne emissions for each alternative and/or options can be compared to the projected number of fatal cancers (143,863) in the public around the SRS from all causes (as discussed in Section 3.8.1). In all cases, the incremental impacts from the options would be small.

Table 4.1.8-1. Estimated radiological dose and health impacts to the public and noninvolved worker from SRS airborne emissions.

	F-Tank[a]					H-Tank[a]				
		Clean and Stabilize Tanks Alternative					Clean and Stabilize Tanks Alternative			
Receptor	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Maximally exposed offsite individual dose (millirem/year)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	2.6×10^{-5}	2.5×10^{-5}
Maximally exposed offsite individual dose over entire period of analysis (millirem)	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.4×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.1×10^{-4}	6.4×10^{-4}	6.1×10^{-4}
Maximally exposed offsite individual estimated latent cancer fatality risk	3.1×10^{-10}	3.1×10^{-10}	3.1×10^{10}	3.2×10^{10}	3.1×10^{10}	3.1×10^{10}	3.1×10^{10}	3.1×10^{10}	3.2×10^{10}	3.1×10^{10}
Noninvolved worker dose (millirem/year)	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.7×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.6×10^{-3}	2.7×10^{-3}	2.6×10^{-3}
Noninvolved worker individual dose over entire period of analysis (millirem)	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.6×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.4×10^{-2}	6.6×10^{-2}	6.4×10^{-2}
Noninvolved worker estimated latent cancer fatality risk	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.6×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.5×10^{-8}	2.6×10^{-8}	2.5×10^{-8}
Dose to population within 50 miles of SRS (person-rem/year)	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.5×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.4×10^{-3}	1.40×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Dose to population within 50 miles of SRS over entire period of analysis (person-rem)	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.7×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.4×10^{-2}	3.7×10^{-2}	3.4×10^{-2}
Estimated increase in number of latent cancer fatalities in population within 50 miles of SRS	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.8×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.8×10^{-5}	1.7×10^{-5}

a. Estimated annual dose levels based on tank emissions in F-Area and H-Area.

Table 4.1.8-2. Estimated radiological dose and health impacts to involved workers by alternative.

	No Action Alternative[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
Total workload per tank closure (person-year)[b]	NA	2.8	2.8	3.1	11.0
Collective involved worker dose (person-rem)[c]	29.4[d]	1,600	1,600	1,800	12,000
Estimated increase in number of latent cancer fatalities	0.012	0.65	0.65	0.72	4.9

NA = Not applicable.

a. For the No Action Alternative, a work level of 40 persons would be required per year for both tank farms. Source: Newman (1999a).

b. Source: Caldwell (1999).

c. Collective dose is for closure of all 49 tanks.

d. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.

4.1.8.2 Nonradiological Health Effects

DOE evaluated the range of chemicals to which the public and workers would be exposed due to HLW tank closure activities and expects minimal health impacts from nonradiological exposures. The onsite and offsite chemical concentrations from air emissions were discussed in Section 4.1.3. DOE estimated noninvolved worker impacts and site boundary concentrations to which a maximally exposed member of the public could be exposed.

OSHA limits (29 CFR Part 1910.1000) are time-weighted average concentrations that a facility cannot exceed in any 8-hour work shift of a 40-hour week. In addition, there are OSHA ceiling concentrations that may not be exceeded during any part of the workday. These exposure limits refer to airborne concentrations of substances and represent conditions under which nearly all workers could be exposed day after day without adverse health effects. However, because of the wide variation in individual susceptibility, a small percentage of workers could experience discomfort from concentrations of some substances at or below the permissible limit.

After analysis of expected activities during tank closure, DOE expects little possibility of involved workers in the tank farms and associated facilities being exposed to anything other than incidental concentrations of airborne nonradiological materials. Transfer of oxalic acid to and from the HLW tanks will be by sealed pipeline. Tank cleaning will be performed remotely. Normal industrial practices (e.g., wearing acid aprons and goggles) will be followed for all workers involved in acid handling. For routine operations, no exposure of personnel to oxalic acid would be expected. Therefore, health effects from exposure to nonradiological material inside the facilities or directly around the waste tanks would be small for all options.

The noninvolved worker concentrations were compared to OSHA permissible exposure limits or ceiling limits for protecting worker health, and DOE concluded that all pollutant concentrations were negligible compared to the OSHA standards except for oxides of nitrogen (NO_X).

The NO_X emissions result in ambient concentrations that are about 10 to 15 percent of the standard for all three options within the Clean and Stabilize Tanks Alternative.

Estimated pollutant releases for beryllium, benzene, and mercury are also expected to be within OSHA guidelines. The maximum excess lifetime cancer risk to the noninvolved worker from exposure to beryllium emissions was estimated to be 3.1×10^{-9}, based on the EPA's Integrated Risk Information System (IRIS) database unit risk factor for beryllium of 2.4×10^{-3} excess cancer risk per microgram per cubic meter. The maximum excess lifetime cancer risk to the noninvolved worker from benzene was estimated to be 8.3×10^{-9}, based on a unit risk factor for benzene of 8.3×10^{-6} excess cancer risk per microgram per cubic meter. These values are less than 1% of the 1.0×10^{-6} risk value that EPA typically uses as the threshold of concern. For mercury, there are inconclusive data relating to cancer studies. Therefore, EPA does not report unit risk factors for mercury. However, the mercury concentrations for the noninvolved worker and at the site boundary are less than 1% of their respective OSHA and SCDHEC standards respectively, for all options. The pollutant values are for the maximum option presented, which is Clean and Fill with Saltstone. All other options are expected to have lower impact values. See Table 4.1.3-4 for nonradiological pollutant concentrations discussed above.

Exposure to nonradiological contaminants such as beryllium and mercury could also result in adverse health effects other than cancer. For example, exposure to beryllium could result in the development of a scarring lung disease, chronic beryllium disease (also known as berylliosis). However, the beryllium and mercury concentrations at the noninvolved worker locations would be so low that adverse health effects would not be expected.

Likewise, site boundary concentrations were compared to the SCDHEC standards for ambient concentrations, and DOE concluded that all air emission concentrations were below the applicable standard. See Section 4.1.3 for comparison of estimated concentrations at the site boundary with SCDHEC standards.

4.1.8.3 Occupational Health and Safety

Table 4.1.8-3 provides estimates of the number of total recordable cases (TRCs) and lost workday cases (LWCs) that could occur during the entire tank closure process. The projected injury rates are based on historic SRS injury rates over a 5-year period from 1994 through 1998 multiplied by the employment levels for each alternative.

The TRC value includes work-related death, illness, or injury that resulted in loss of consciousness, restriction from work or motion, transfer to another job, or required medical treatment beyond first aid. The data for LWCs represent the number of workdays beyond the day of injury or onset of illness that the employee was away from work or limited to restricted work activity because of an occupational injury or illness.

The results that are presented in Table 4.1.8-3 show that the Clean and Remove Tanks Alternative has the highest number of total TRCs and LWCs (400 and 200, respectively because it would require the largest number of workers). The injury rate for the No Action Alternative is caused by the number of workers that are needed to continue to conduct operations if no action is taken in regard to tank closure activities.

4.1.8.4 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs each Federal agency to "make...achieving environmental justice part of its mission" and to identify and address "...disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations." The Presidential Memorandum that accompanied Executive Order 12898 emphasized the importance of using existing laws, including the National Environmental Policy Act, to identify and address environmental justice concerns, "including human health, economic, and social effects, of Federal actions."

The Council on Environmental Quality, which oversees the Federal government's compliance with Executive Order 12898 and the National Environmental Policy Act, subsequently developed guidelines to assist Federal agencies in incorporating the goals of Executive Order 12898

Table 4.1.8-3. Estimated Occupational Safety impacts to involved workers by alternative.

		Clean and Stabilize Tanks Alternative			
	No Action Alternative[a]	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Total workload per tank closure (person-years)[b]	40	42	42	66	140
Total recordable cases of accident or injury[c]	110	120	120	190	400
Lost workday cases[c]	60	62	62	96	210

a. For the No Action Alternative, workload, TRC, and LWC estimates are for the period of closure activities for the other alternatives. These would continue indefinitely. Workload source: Johnson (1999).
b. Total manpower estimates are per tank. Source: Caldwell (1999).
c. TRC and LWC rates basis source: Newman (1999b).

in the NEPA process. This guidance, published in 1997, was intended to "...assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed."

As part of this process, DOE identified (in Section 3.6.2) minority and low-income populations within a 50-mile radius of the SRS (plus areas downstream of the Site that withdraw drinking water from the Savannah River), which was defined as the region of influence for the environmental justice analysis. The section that follows discusses whether implementing the alternatives described in Chapter 2 would result in disproportionately high or adverse impacts to minority and low-income populations.

Methodology

The Council Environmental Quality guidance (CEQ 1997) does not provide a standard approach or formula for identifying and addressing environmental justice issues. Instead, it offers Federal agencies general principles for conducting and environmental analysis under NEPA:

- Federal agencies should consider the population structure in the region of influence to determine whether minority populations, low-income populations, or Indian tribes are present, and if so, whether there may be disproportionately high and adverse human health or environmental effects on any of these groups.
- Federal agencies should consider relevant public health and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards, to the extent such information is available.
- Federal agencies should recognize the interrelated cultural social, occupational, historical, or economic factors that may amplify the effects of the proposed agency action. These would include the physical sensitivity of the community or population to particular impacts.
- Federal agencies should develop effective public participation strategies that seek to overcome linguistic, cultural, institutional, and geographic barriers to meaningful participation, and should incorporate active outreach to affected groups.

- Federal agencies should assure meaningful community representation in the process, recognizing that diverse constituencies may be present.

- Federal agencies should seek tribal representation in the process in a manner that is consistent with the government-to-government relationship between the United States and trial governments, the Federal government's trust responsibility to Federally-recognized tribes, and any treaty rights.

First, DOE assessed the impacts of the proposed action and alternatives to the general population, which near the Savannah River Site includes minority and low-income populations. No special considerations, such as unique exposure pathways or cultural practices, contribute to any discernible disproportionate impacts. The only identified cultural practice (or unusual pathway) potentially associated with minority and low-income populations is use of the Savannah River for subsistence fishing. For the Draft and Final Accelerator Production of Tritium EIS (issued in 1999) DOE reviewed the limited body of literature available on subsistence activities in the region. DOE concluded that because the identified communities downstream from the SRS are widely distributed, and the potential impact to the general population is not discernible, there would be no potential for disproportionate impacts among minority or low-income populations. Second, having concluded that the potential off-site consequences to the general public of the proposed action and the alternatives would be small, DOE concluded there would be no disproportionately high and adverse impacts to minority or low-income populations.

The above stated conclusions are based on the comparison of HLW actions to past actions for which environmental justice issues were evaluated in detail. In 1995, DOE conducted an analysis of economic and racial characteristics of the population potentially affected by SRS operations within a 50-mile radius of the site Reference Interim Management EIS (DOE 1995). In addition, DOE examined the population downstream of the site that withdraws drinking water from the Savannah River. The economic and racial characterization was based on 1990 census tract data from the U.S. Census Bureau. More recent census tract data are not available. The nearest minority and low-income populations to SRS are to the south of Augusta, Georgia, northwest of the site.

This environmental justice analysis was based on the assessment of potential impacts associated with the various tank closure alternatives to determine if there would be high and adverse human health or environmental impacts. In this assessment, DOE reviewed potential impacts arising under the major disciplines and resource areas including socioeconomics, cultural resources, air resources, water resources, ecological resources, and public and worker health over the short term (approximately the years 2000 to 2030) and long term (approximately 10,000 years after HLW tanks are closed). Regarding health effects, both normal facility operations and postulated accident conditions were analyzed, with accident scenarios evaluated in terms of risk to workers and the public.

Although no high and adverse impacts were predicted for the activities analyzed in this EIS, DOE nevertheless considered whether there were any means for minority or low-income populations to experience disproportionately high and adverse impacts. The basis for making this determination would be a comparison of areas predicted to experience human health or environmental impacts with areas in the region of influence known to contain high percentages of minority or low-income populations.

The environmental justice analysis for the tank closure alternatives was assessed for a 50-mile area surrounding SRS (plus downstream areas) as discussed in Section 3.6.2.

Short-Term Impacts

For environmental justice concerns to be implicated, high and adverse human health or environmental impacts must disproportionately affect minority populations or low-income populations.

None of the proposed tank closure alternatives would produce significant short-term impacts to surface water (see Section 4.1.2.1) or groundwater (see Section 4.1.2.2). Emissions of nonradiological and radiological air pollutants from tank closure activities would be below regulatory limits (see Section 4.1.3) and would result in minimal impacts to workers (see Section 4.1.8.1) and the public (see Section 4.1.8.2). The estimated radiological doses and health impacts to the noninvolved worker and the public are very small (highest dose is 0.0026 millirem per year to the noninvolved worker, under the Saltstone Option of the Clean and Stabilize Tanks Alternative).

Because all tank closure activities would take place in an area that has been dedicated to industrial use for more than 40 years, no short-term impacts to ecological resources (see Section 4.1.4), existing land uses (see Section 4.1.5) or cultural resources (see Section 4.1.7) are expected.

Relatively small numbers of workers would be required to carry out tank closure activities regardless of the alternative selected (see Section 4.1.6); as a result, none of the tank closure alternatives would affect socioeconomic trends (i.e., unemployment, wages, housing) in the region of influence.

As noted in Section 4.2, no long-term environmental justice impacts are anticipated.

Because short-term impacts would not significantly impact the surrounding population, and no means were identified for minority or low-income populations to be disproportionately affected, no disproportionately high and adverse impacts would be expected for minority or low-income populations under any of the alternatives.

Subsistence Consumption of Fish, Wildlife, and Game

Section 4-4 of Executive Order 12898 directs Federal agencies "whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence and that Federal governments communicate to the public the risks of these consumption patterns." There is no evidence to suggest that minority or low-income populations in the SRS region of influence are dependent on subsistence fishing, hunting, or gathering. DOE nevertheless considered whether there were any means for minority or low-income populations to be disproportionately affected by examining levels for contaminants in vegetables, fruit, livestock, and game animals collected from the SRS and from adjacent lands. In addition, DOE assessed concentrations of contaminants in fish collected from SRS waterbodies and from the Savannah River up- and downstream of the Site.

Based on recent monitoring results, concentrations of radiological and nonradiological contaminants in vegetables, fruit, livestock, game animals, and fish from the SRS and surrounding areas are generally low, in virtually all instances below applicable DOE standards (Arnett and Mamatey 1999). Consequently, no disproportionately high and adverse human health impacts would be expected in minority or low-income populations in the region that rely on subsistence consumption of fish, wildlife, or native plants.

It should be noted that mercury, which is present in relatively high concentrations in fish collected from SRS and the middle reaches of the Savannah River, could pose a potential threat to individuals and populations that rely on subsistence fishing. This mercury in fish has been attributed to upstream (non-DOE) industrial sources and natural sources (DOE 1997). The tank closure alternatives under consideration would not affect mercury concentrations in SRS waterbodies or the Savannah River.

4.1.9 TRANSPORTATION

SRS is served by more than 199 miles of primary roads and more than 995 miles of unpaved secondary roads. The primary highways used by SRS commuters are State Routes 19, 64, and 125; 40, 10, and 50 percent of the workers use these routes, respectively. Significant congestion can occur during peak traffic periods onsite on SRS Road 1-A, State Routes 19 and 125, and

U.S. Route 278 at SRS access points. Construction vehicles associated with this action would use these same routes and access points.

Cement (grout), saltstone, and sand are the different materials that could be used to fill the tanks. The trucks could come to the site with premixed fill material batched at the vendor's facility. If the Grout Option under the Clean and Stabilize Tanks Alternative were used, approximately 654 truckloads would be required to fill each waste tank, which would result in 654 round trips. The total trips for all 49 tanks would be 32,046. The Clean and Fill with Sand Option would require approximately 653 truckloads; therefore, 653 round trips would be necessary. The total trips for all 49 tanks would be 31,997. The Clean and Fill with Saltstone Option would result in approximately 19 truck loads and 19 round trips leading to 931 total trips for all the tanks. The No Action Alternative would not require any truckloads of material. Lastly, the Clean and Remove Tanks Alternative would require 5 truckloads of material, which would result in 5 round trips and 245 trips for all the tanks because only oxalic acid would be transported from offsite. See Table 4.1.9-1 for summary of data used to obtain the above information.

Assuming that the material is supplied by vendor facilities in Jackson and New Ellenton (i.e., a round-trip distance of 18 miles), closure of the tanks using each alternative would result in approximately 576,828 miles traveled for the grout fill option under the Clean and Stabilize Tanks Alternative, 575,946 miles for the sand fill option, 16,758 miles for the saltstone fill option, 0 miles for the No Action Alternative, and 4,410 miles for the Clean and Remove Tanks Alternative. Using Federal Aid Primary Highway System statistics for South Carolina for the 1986 to 1988 DOE calculated the impacts of potential transportation accidents for each alternative, which are presented in Table 4.1.9-2.

Regardless of the alternative chosen, it is anticipated that one tank would be closed at a time; therefore, the existing transportation structure would be adequate to accommodate this projected traffic volume. None of the routes associated with this transportation would require additional traffic controls and/or highway modifications. The surrounding area already has a certain volume of truck and car traffic associated with SRS logging, agriculture, and industrial activity. The amount of traffic associated with the proposed action would increase traffic volume by 0.025 percent based on traffic counts from the South Carolina Highway Department.

Table 4.1.9-1. Estimated maximum volumes of materials consumed and round trips per tank during tank closure.

		Clean and Stabilize Tanks Alternative			
Materials	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Oxalic acid (4 weight percent) (gallons)	-	225,000	225,000	225,000	500,000
Soil (cubic meters)[a]	-	170,000	170,000	170,000	356,000
Sand (gallons)	-	-	2,640,000	-	-
Cement (gallons)	-	2,640,000	-	52,800	-
Fly ash (gallons)	-	-	-	Included in	-
Boiler slag (gallons)	-	-	-	saltstone	-
Additives (grout) (gallons)	-	500	-	-	-
Saltstone (gallons)	-	-	-	2,640,000	-
Round trips/tank	-	654	653	19	5

a. Soil values represent the total volume needed for the eight tanks requiring backfill under the Clean and Stabilize Tanks Alternative and the voids for all 49 tanks under the Clean and Remove Tanks Alternative.
- = not used in that option/alternative.

Table 4.1.9-2. Estimated transportation accidents, fatalities, and injuries during tank closure.

	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Accidents	NA	0.6	0.6	0.02	0.005
Fatalities	NA	0.08	0.08	0.002	0.0006
Injuries	NA	0.6	0.6	0.02	0.005

NA = Not applicable.

4.1.10 WASTE GENERATION AND DISPOSAL CAPACITY

This section describes impacts to the existing or planned SRS waste management systems resulting from closure of the HLW tank systems. Waste generation estimates are provided for each tank closure alternative that DOE considered in this EIS. Impacts are described in terms of increases in waste generation beyond that expected from other SRS activities during the same period and the potential requirements for new waste management facilities or expanded capacity at existing or planned facilities.

The SRS HLW tank systems include four tank designs (Types I, II, III, and IV). Estimates were developed for the volume of waste generated from closure of a single Type III tank system. Closure of a Type III tank system represents the maximum waste generation 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. Table 4.1.10-1 provides estimates of the maximum annual waste generation. These annual values assume that two Type III tanks would be closed in one year. Table 4.1.10-2 provides the total waste volumes that would be generated from closure of the 49 remaining SRS HLW tank systems for each of the alternatives.

4.1.10.1 Liquid Waste

Radioactive liquid wastes would be generated as a result of tank cleaning activities under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternative. The waste consists of the spent oxalic acid cleaning solutions and water rinses. This material would be managed as part of ongoing operations in the SRS HLW management system (e.g., evaporation and treatment of the evaporator overheads in the Effluent Treatment Facility). The projected volume of radioactive liquid waste under the Clean and Stabilize Tanks Alternative is 3.4 times the forecasted SRS HLW generation through 2029 (see Section 3.9, Table 3.9-1). The projected volume under the Clean and Remove Tanks Alternative is 6.9 times the forecasted SRS HLW generation for that period. This liquid waste would contain substantially less radioactivity than HLW and would not affect the environmental impacts of tank farm operations (i.e., there would be no increase in airborne emissions or worker radiation exposure).

DOE would need to evaluate the current schedule for closure of the HLW tank systems to ensure that adequate capacity remained in the Tank Farms to manage the amount of radioactive liquid waste generated from tank cleaning activities. A *High Level Waste System Plan* (WSRC 1998) has been developed to present the integrated operating strategy for the various components (Tank Farms, DWPF, salt disposition) comprising the HLW system. The *High Level Waste System Plan* integrates budgetary information, regulatory considerations (including waste removal and closure schedules), and production planning data (e.g., projected Tank Farm influents and effluents, evaporator operations, DWPF canister production). DOE uses computer simulations to model the operation of the HLW system. The amount of available Tank Farm storage space is an important parameter in those simulations. Other elements in the HLW

Table 4.1.10-1. Maximum annual generation for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Radioactive liquid waste (gallons)	0	600,000	600,000	600,000	1,200,000
Nonradioactive liquid waste (gallons)	0	20,000	20,000	20,000	0
Transuranic waste (cubic meters)	0	0	0	0	0
Low-level waste (cubic meters)	0	60	60	60	900
Hazardous waste (cubic meters)	0	2	2	2	2
Mixed low-level waste (cubic meters)	0	12	12	12	20
Industrial waste (cubic meters)	0	20	20	20	20
Sanitary waste (cubic meters)	0	0	0	0	0

a. Source: Johnson (1999a,b).

Table 4.1.10-2. Total estimated waste generation for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (cubic meters)	0	0	0	0	0
Low-level waste (cubic meters)	0	1,284	1,284	1,284	19,260
Hazardous waste (cubic meters)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (cubic meters)	0	257	257	257	428
Industrial waste (cubic meters)	0	428	428	428	428
Sanitary waste (cubic meters)	0	0	0	0	0

a. Source: Johnson (1999a,b).

system are adjusted to ensure the Tank Farms will have adequate waste storage capacity to support operations. The *High Level Waste System Plan* assumes that a salt disposition process will be operational by the year 2010. However, if the salt disposition process startup is delayed, the tank closure schedule may need to be extended because there would not be sufficient space in the tank farms to manage the large amounts of dilute liquid wastes generated by waste removal activities. The volume of this dilute waste can readily be reduced using the tank farm evaporators. The salt disposition process should be adequate to handle the additional radioactive liquid waste volume for the most water-intensive of the HLW tank closure alternatives (Clean and Remove Tanks) without schedule delays. The bulk of this wastewater would be generated at a time when other contributors to the tank farm inventory have stopped producing waste or dramatically reduced their generation rates. Delaying startup of the salt disposition process would result in about a year-for-year slip in the current waste removal schedule with a corresponding delay in tank closures. The need for any schedule modification would be identified through the *High Level Waste System Plan.*

Nonradioactive liquid wastes would be generated under the Clean and Stabilize Tanks Alternative as a result of flushing activities associated with the preparation and transport of all the fill material. This wastewater would be managed in existing SRS treatment facilities.

4.1.10.2 Transuranic Waste

DOE does not expect to generate transuranic wastes as a result of the proposed HLW tank system closure activities.

4.1.10.3 Low-Level Waste

Under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives, approximately 30 cubic meters of solid low-level waste would be generated per Type III tank closure. This would consists of job control wastes (e.g., personnel protective equipment) generated from activities performed in the area of the tank top. Under the Clean and Remove Tanks Alternative, an additional 420 cubic meters of solid low-level waste would be generated as a result of each Type III tank removal. DOE assumed that any steel in direct contact with the waste would be removed (e.g., primary tank walls, cooling coils). The concrete shell and secondary containment liner would be left in place and the void space filled with soil. The steel components that are removed would be cut to a size that would fit into standard SRS low-level waste disposal boxes. The low-level waste would be disposed at existing SRS disposal facilities. The projected volume of low-level waste under the Clean and Stabilize Tanks Alternative is less than 1 percent of the forecasted SRS low-level waste generation through 2035. The projected volume under the Clean and Remove Tanks Alternative is about 11 percent of the forecasted SRS low-level waste generation for that period.

4.1.10.4 Hazardous Waste

Under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives, a small amount (about 1 cubic meter) of nonradioactive lead waste would be generated from each Type III tank closure. The projected volume represents less than 1 percent of the forecasted SRS hazardous waste generation through 2035.

4.1.10.5 Mixed Low-Level Waste

Under the Clean and Stabilize Tanks Alternative, about 6 cubic meters of radioactive lead waste would be generated for each Type III tank closure. A slightly larger volume (10 cubic meters) would be generated from each Type III tank closure under the Clean and Remove Tanks Alternative. These projected volumes represent 7 and 12 percent, respectively, of the forecasted SRS mixed low-level waste generation through 2035.

4.1.10.6 Industrial Waste

DOE estimates that about 10 cubic meters of industrial (nonhazardous, nonradioactive) waste would be generated for each Type III tank closure under the Clean and Stabilize Tanks Alternative and Clean and Remove Tanks Alternatives.

4.1.10.7 Sanitary Waste

DOE does not expect to generate sanitary wastes as a result of the proposed HLW tank system closure activities.

4.1.11 UTILITIES AND ENERGY

This section describes the estimated utility and energy impacts associated with each of the HLW tank system closure alternatives that DOE considered in this EIS. Water, steam, and diesel fuel would be required to support many of the alternatives. Estimates of water use include preparation of cleaning solutions and rinsing of the tank systems. Steam is used primarily to operate the ventilation systems and to heat the cleaning solutions prior to use. Fuel consumption is based on use of diesel-powered equipment during tank closure activities. Total utility costs are also provided. The utility costs are primarily associated with fossil fuel consumption and steam generation. Water consumption is not a substantial contributor to the overall utility costs.

Table 4.1.11-1 lists the total estimated utility and energy requirements for each tank closure alternative. DOE used applicable past SRS operations or engineering judgements to estimate the utility consumption for new closure methods. The following paragraphs describe estimated utility requirements for the alternatives.

4.1.11.1 Water Use

Under the Clean and Stabilize Tanks Alternative, the estimated quantities of water are based on an assumption that three oxalic acid flushes (75,000 gallons each) and one water rinse (75,000 gallons) would be required to clean the tanks to the extent technically and economically feasible. Oxalic acid would be purchased in bulk and diluted with water to the desired strength (about 4 weight percent) prior to use in the tank farms. Under the Clean and Remove Tanks Alternative, DOE assumed that the quantities of cleaning solutions required to clean the HLW tank systems sufficiently to allow removal would be twice that required under the Clean and Stabilize Tanks Alternative. No water usage would be required under the No Action Alternative except for ballast water in those tanks that reside in the water table.

Additional water would be required for the Grout Option under the Clean and Stabilize Tanks Alternative. Water would be used to produce the reducing grout, controlled low-strength material (known as CLSM), and strong (high compressive strength) grout used to backfill the tank after cleaning is completed. Assuming a closure configuration of 5 percent reducing grout, 80 percent CLSM, and 15 percent strong grout, about 840,000 gallons of water would be required per Type III tank system (Johnson 1999c).

The largest annual water consumption, approximately 2.3 million gallons, would occur for closure of two Type III tanks in a given year. This volume represents less than 1 percent of current SRS groundwater production from industrial wells in the Tank Farms area (see Section 4.1.2.2).

Table 4.1.11-1. Total estimated utility and energy usage for the HLW tank closure alternatives.[a]

		Clean and Stabilize Tanks Alternative			
	No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	Clean and Remove Tanks Alternative
Water (gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA[b]	NA	NA	NA	NA
Steam (pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (gallons)	NA	214,000	214,000	214,000	428,000
Total utility cost	NA	$4,280,000	$4,280,000	$4,280,000	$12,840,000

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.

4.1.11.2 Electricity Use

DOE assumed that there would be no significant additional electrical usage beyond that associated with current tank farm operations. This assumption is supported by DOE's closure of Tanks 17 and 20. Major power requirements associated with the HLW tank closure activities would be met by the use of diesel-powered equipment. Fuel consumption to power the equipment is addressed in Section 4.1.11.4.

4.1.11.3 Steam Use

The two main uses for steam are operation of the ventilation systems on the waste tanks during closure operations and heating of the cleaning solutions prior to use. Operation of the ventilation system uses about 100,000 pounds of 15 psig (pounds per square inch above atmospheric pressure) steam per year. The ventilation system operates as part of current tank farm operations. Thus, steam usage by the ventilation system was not included in this evaluation of tank closure alternatives.

Under the Clean and Stabilize Tanks Alternative, heating of the oxalic acid cleaning solution would use about 200,000 pounds of 150 psig steam per Type III tank system. The Clean and Remove Tanks Alternative would require twice as much oxalic acid cleaning solution and therefore would use twice (400,000 pounds per Type III tank system) as much steam as the Clean and Stabilize Tanks Alternative. There would be no additional steam requirements for the No Action Alternative (Johnson 1999c).

4.1.11.4 Diesel Fuel Use

Major power requirements would be covered by the use of diesel-powered equipment. Approximately 5,000 gallons of diesel fuel would be required for each Type III tank system closure under the Clean and Stabilize Tanks Alternative. The Clean and Remove Tanks Alternative would have twice the number of equipment operating hours as the Clean and Stabilize Tanks Alternative and would use 10,000 gallons of diesel fuel per Type III tank system closure. There would be no additional diesel fuel requirements for the No Action Alternative (Johnson 1999c,d).

4.1.12 ACCIDENT ANALYSIS

This section summarizes risks to the public and workers from potential accidents associated with the various alternatives for HLW tank closure at the SRS.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as a human error, 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.

Table 4.1.12-1 summarizes the estimated impacts to workers and the public from potential accidents for each HLW tank closure alternative. Appendix B contains details of each accident, including the scenario description, probability, source term, and consequence. Table 4.1.12-1 lists potential accident consequences as latent cancer fatalities, without consideration of the accident's probability. Accidents involving nonradiological, hazardous materials were evaluated in Appendix B; however, these other accidents were shown to result in no significant impacts to the onsite or offsite receptors. Therefore, the accidents contained in Table 4.1.12-1 are limited to those involving the release of radiological materials.

DOE estimated impacts to three receptors: (1) a noninvolved worker 2,100 feet from the accident location, (2) the maximally exposed individual at the SRS boundary, and (3) the offsite population within 50 miles. DOE did not evaluate total dose to noninvolved worker population due the speculative nature of worker locations at the site.

DOE identified potential accidents in Yeung (1999) and estimated impacts using the AXAIRQ computer model (Simpkins 1995a,b), as discussed in Appendix B.

For all of the accidents, there is a potential for injury or death to involved workers in the vicinity of the accident. In some cases, the impacts to the involved worker would be greater than to the noninvolved worker. However, prediction of latent potential health effects becomes increasingly difficult to quantify as the distance between the accident location and the receptor decreases because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The worker also may be acutely injured or killed by physical effects of the accident itself.

Table 4.1.12-1. Estimated accident consequences by alternative.

		Consequences					
Alternative	Accident frequency	Noninvolved worker (rem)	Latent cancer fatalities	Maximally exposed offsite individual (rem)	Latent cancer fatalities	Offsite population (person-rem)	Latent cancer fatalities
Clean and Stabilize Tanks Alternative							
Transfer errors during cleaning	Once in 1,000 years	7.3	2.9×10^{-3}	0.12	6.0×10^{-5}	5,500	2.8
Seismic event (DBE)[a] during cleaning	Once in 53,000 years	15	6.0×10^{-3}	0.24	1.2×10^{-4}	11,000	5.5
Failure of Salt Solution Hold Tank (Clean and Fill with Saltstone Option only)	Once in 20,000 years	0.02	8.0×10^{-6}	2.1	2.1×10^{-7}	17	8.4×10^{-3}
Clean and Remove Tanks Alternative							
Transfer errors during cleaning	Once in 1,000 years	7.3	2.9×10^{-3}	0.12	6.0×10^{-5}	5,500	2.8
Seismic event (DBE) during cleaning	Once in 53,000 years	15	6.0×10^{-3}	0.24	1.2×10^{-4}	11,000	5.5

a. DBE = Design basis earthquake.

4.2 Long-Term Impacts

Section 4.2 presents a discussion of impacts associated with residual radioactive and non-radioactive material remaining in the closed HLW tanks. DOE has estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a long time span (10,000 years) to determine when certain measures of impacts (e.g., radiation dose) reach their peak value. More details on the methodology for long-term closure modeling analysis, and the uncertainties associated with this long-term modeling, are provided in Appendix C. The overall methodology for this long-term closure modeling is the same as the modeling used in the closure modules for Tanks 17 and 20 (DOE 1997a,b), which have been approved by SCDHEC and EPA Region IV. DOE intends to restrict the area around the tank farms from residential use for the entire 10,000-year period of analysis but has also assessed the potential impacts if institutional controls are lost and residents move into or intruders enter the tank farm areas.

Certain resources involve no long-term impacts and therefore are not included in the long-term analysis. These include air resources, socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, and utilities and energy. Therefore, Section 4.2 presents impacts only for the following discipline areas: geologic resources, water resources, ecological resources, land use, and public health.

If the Clean and Remove Tanks Alternative were chosen, residual waste would be removed from the tanks and the tanks systems themselves would be removed and transported to SRS waste disposal facilities. Long-term impacts at these facilities are evaluated in the Savannah River Site Waste Management EIS (DOE/EIS-0217) (DOE 1995). The long-term impacts of low-level waste disposal in low-activity vaults presented in the SRS Waste Management EIS are approximately one-one thousandth of the long-term tank closure impacts presented in this EIS for water resources and public health and are incorporated into Section 4.2 of this EIS by reference.

4.2.1 GEOLOGIC RESOURCES

No geologic deposits within F- and H-Areas have been economically or industrially developed, and none are known to have significant potential for development. The Clean and Remove Tanks Alternative would result in backfilling the tank excavations. Because the backfill material would be locally derived from borrow pits at SRS (see Section 4.1.1), it is assumed to be similar to the natural soils and sediments encountered in the excavations; therefore, no long-term impacts to geologic deposits would occur.

The other tank closure alternatives include closing the tanks in place, which would result in residual waste remaining in the tanks. Upon failure of the tanks as determined by each of the alternatives described in Appendix C, the waste in the tanks would have the potential to contaminate the surrounding soils. The inventory and concentration of the residual waste is expected to be less than that listed in Appendix C, Tables C.3.1-1 and C.3.1-2, which are based on conservative assumptions for the waste that would remain in the tanks after waste removal and washing. The residual waste has the potential to contaminate percolating groundwater at some point in the future due to leaching. The water-borne transport of contaminants would contaminate geologic deposits that lie below the tanks. The contamination would not result in any significant physical alteration of the geologic deposits. Filling the closed-in-place tanks with ballast water, sand, saltstone, or grout may also increase the infiltration of precipitation at some point in the future, allowing a greater percolation of water into the underlying geologic deposits. No detrimental effect on surface soils, topography, or to the structural or load-bearing properties of geologic deposits would occur from these actions. There are no anticipated long-term impacts to geologic resources from the Clean and Remove Tanks Alternative. The No Action Alternative and all options under the Clean and Stabilize Tanks Alternative would allow the soils in the vicinity of the tanks to be impacted.

4.2.2 WATER RESOURCES

4.2.2.1 Surface Water

Because the No Action Alternative and Clean and Stabilize Tanks Alternative would leave some residual radioactive and non-radioactive material in waste tanks, the potential would exist for long-term impacts to groundwater. Contaminants in groundwater could then be transported through the Water Table, Barnwell-McBean, or Congaree Aquifers to the seeplines along Fourmile Branch and Upper Three Runs, respectively (see Section 4.2.2.2 for a more detailed discussion). The factors governing the movement of contaminants through groundwater (i.e., the hydraulic conductivity, hydraulic gradient, and effective porosity of aquifers in the area) and the processes resulting in attenuation of radiological and non-radiological contaminants (i.e., radioactive decay, ion exchange in the soil, and adsorption to soil particles) would be expected to mitigate subsequent impacts to surface water resources.

DOE used the Multimedia Environmental Pollution Assessment System (MEPAS) computer code (Buck et at. 1995) to model the fate and transport of contaminants in groundwater and subsequent flux to surface waters. Maximum annual concentrations of contaminants at various locations) were estimated and compared to appropriate water quality criteria for the protection of aquatic life.

EPA periodically publishes water quality criteria, which are concentrations of substances that are known to affect "diversity, productivity, and stability" of aquatic communities including "plankton, fish, shellfish, and wildlife" (EPA 1986, 1999). These recommended criteria provide guidance for state regulatory agencies in the development of location-specific water quality standards to protect aquatic life (SCDHEC 1999). Such standards are used in implementing a number of environmental programs, including setting discharge limits in NPDES permits. Water quality criteria and standards are generally not legally enforceable; however, NPDES discharge limits based on these criteria and standards are legally binding and are enforced by SCDHEC.

The results of the fate and transport modeling of non-radiological contaminants are presented in Tables 4.2.2-1 (Upper Three Runs) and 4.2.2-2 (Fourmile Branch). Based on the modeling, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in all cases several times lower than applicable standards. Concentrations of non-radiological contaminants reaching Fourmile Branch via the Fourmile Branch seepline would also be low under the Clean and Stabilize Tanks Alternative. Concentrations of contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted concentrations of non-radiological contaminants were well below applicable water quality standards.

Based on the modeling results, all three stabilization options under the Clean and Stabilize Tanks Alternative would be more effective than the No Action Alternative. The Clean and Fill with Grout Option would be most effective of the three tank stabilization options under the Clean and Stabilize Tanks Alternative for reducing contaminant migration to surface water.

Table 4.2.2-3 shows maximum radiation doses to humans in surface (drinking) water at the points of compliance for Upper Three Runs and Fourmile Branch. Doses are low under all three tank stabilization options, and are well below the drinking water standard of 4 millirem per year (40 CFR 141.16). The 4 millirem per year standard applies only to beta- and gamma-emitting radionuclides, but since the total dose is less than 4 millirem per year, then the standard is met. The DOE dose limit for native aquatic animals is 1 rad per day from exposure to radio-

Table 4.2.2-1. Maximum concentrations of non-radiological constituents of concern in Upper Three Runs (milligrams/liter).

	Clean and Stabilize Tanks Alternative					
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Water Quality Criteria[a] Acute	Water Quality Criteria[a] Chronic
Aluminum	(b)	(b)	(b)	(b)	0.750	0.087
Chromium IV	(b)	(b)	(b)	(b)	0.016	0.011
Copper	(b)	(b)	(b)	(b)	0.0092	0.0065
Iron	(b)	(b)	(b)	3.7×10^{-5}	2.000	1.000
Lead	(b)	(b)	(b)	(b)	0.034	0.0013
Mercury	(b)	(b)	(b)	(b)	0.0024	1.2×10^{-5}
Nickel	(b)	(b)	(b)	(b)	0.790	0.088
Silver	(b)	(b)	(b)	1.2×10^{-6}	0.0012	-----

a. Criteria to Protect Aquatic Life (SCR. 61-68, Appendix 1).
b. Concentration less than 1.0×10^{-6} milligrams/liter.

Table 4.2.2-2. Maximum concentrations of non-radiological constituents of concern in Fourmile Branch (milligram/liter).

	Clean and Stabilize Tanks Alternative					
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative	Water Quality Criteria[a] Acute	Water Quality Criteria[a] Chronic
Aluminum	(b)	(b)	(b)	(b)	0.750	0.087
Chromium IV	(b)	(b)	(b)	(b)	0.016	0.011
Copper	(b)	(b)	(b)	(b)	0.0092	0.0065
Iron	3.0×10^{-5}	3.0×10^{-5}	3.0×10^{-5}	4.9×10^{-4}	2.000	1.000
Lead	(b)	(b)	(b)	(b)	0.034	0.0013
Mercury	(b)	(b)	(b)	(b)	0.0024	1.2×10^{-5}
Nickel	(b)	(b)	(b)	(b)	0.790	0.088
Silver	8.8×10^{-6}	6.5×10^{-6}	8.8×10^{-6}	1.1×10^{-4}	0.0012	-----

a. Criteria to Protect Aquatic Life (SC R. 61-68, Appendix 1).
b. Concentration less than 1.0×10^{-6} milligram/liter.

Table 4.2.2-3. Maximum drinking water dose from radionuclides in surface water (millirem/year).

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Upper Three Runs	(a)	4.3×10^{-3}	9.6×10^{-3}	0.45
Fourmile Branch	9.8×10^{-3}	0.019	0.130	2.3

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

active materials in liquid wastes discharged to natural waterways (DOE Order 5400.5). The absorbed dose (see Table 4.2.3-3) from surface water would be a small fraction of the DOE dose limit under any of the alternatives, including No Action.

4.2.2.2 Groundwater

Contamination Source

Waste remaining in tanks as a result of the closure alternatives has been identified as the primary source for long-term impacts to groundwater quality. The physical configurations of the waste after closure and the chemical parameters associated with the resulting contamination source zone would, however, vary between the closure alternatives. The in-place closure alternatives consist of the following:

- No Action Alternative (bulk waste removal and fill with ballast water)
- 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

For the No Action Alternative, the contaminant inventory would be the highest because this alternative would not provide for tank cleaning following bulk waste removal. In addition, filling the tanks with ballast water would allow for the immediate generation of a large volume of contaminated leachate. For the three tank stabilization options under the Clean and Stabilize Tanks Alternative, cleaning of the tanks would result in lower initial volume and inventory of contaminants in the residual waste prior to filling. The Clean and Fill with Grout Option would produce a source zone that consists of the residual waste covered by a low-permeability reducing grout. The grout fill would lower the water infiltration until failure and would reduce the leach rate of chemicals compared to the other options. The source zone for this option, therefore, would have more time to undergo radioactive decay prior to tank failure compared to the other alternatives. The Clean and Fill with Sand Option would result in little physical alteration of the residual waste in the tanks other than some mixing and an overall increase in the volume of contaminated material. This option also would result in a higher leaching rate than the Clean and Fill with Grout or Saltstone Options. The Clean and Fill with Saltstone Option would bind the residual waste and create a low-permeability zone compared to natural soils; however, the overall magnitude of the source term would be increased due to the presence of background contamination in the saltstone medium.

The evaluation and comparison of the in-place closure alternatives uses the results of long-term groundwater fate and transport modeling to interpret the potential impacts to groundwater resources beneath the F- and H-Area Tank Farms for each of the alternatives. Areas within the groundwater migration pathway to the downgradient point of compliance (the seepline along Upper Three Runs and Fourmile Branch, located approximately 1,200 meters downgradient of F-Area Tank Farm and approximately 1,800 meters downgradient of H-Area Tank Farm) are also included in the evaluation. The analysis also presents the impacts to groundwater at 1 meter and 100 meters downgradient of the tank farm. Impacts are presented in tables in the following sections that compare the predicted (i.e., modeled) groundwater concentrations to regulatory limits or established SRS guidelines for the various contaminants of interest.

The tank farms were modeled assuming conditions that would exist after tank closure for each of the alternatives that included closure of the tanks in place. The identity and level of residual contaminants in each tank were derived from data provided by Johnson (1999).

Each of the closure alternatives proposed in Chapter 2 except for tank removal includes actions that may result in potential long-term impacts to groundwater beneath the tank farms. Because groundwater is in a state of constant flux, impacts that occur directly above or below the tank farms may propagate to areas hydraulically downgradient of the tank farms. The primary action that would result in long-term impacts to groundwater is in-place tank closure that would result in some quantity of residual waste material remaining in the tanks. The residual waste has the potential to contaminate groundwater at some point in the future due to leaching and water-borne transport of contaminants.

The tank farms are situated in highly developed industrial areas. Some of the tank groups were constructed in pits substantially lower in elevation than the surrounding terrain. The existing tank farm sites, therefore, include facilities and structures designed to prevent surface ponding and to manage precipitation runoff in a controlled manner. Reclamation of the tank farms after closure would require backfilling and grading to provide a suitable site for future industrial/commercial development, to prevent future ponding of water at the surface, and to promote non-erosional surface water runoff. Backfilling and grading would be performed using borrow material derived from local areas at the SRS (see Section 4.1.1). The material is assumed to be physically similar to the in-place materials. Therefore, there should be little or no impact to long-term groundwater recharge or quality as a result of the surface reclamation activities. Because the tanks would be completely removed from service at closure, there are no other long-term operations at the tank farms that could potentially impact groundwater resources.

Modeling Methodology

The modeling results are used to predict whether each closure alternative and option would meet the identified regulatory and SRS water quality criteria at the point of compliance. This process addresses the cumulative effect of all the tanks in a tank farm whose plumes may intersect. Because of the physical separation of the F- and H-Area Tank Farms and the hydrogeologic setting, no overlapping of plumes from the two tank farms is anticipated. The presence of a groundwater divide that runs through the H-Area Tank Farm required a separation of the tank groups in the H-Area. This separation was necessary to identify impacts at various locations that are separated in both space and time as a result of the various groundwater flow directions and paths that leave different areas of the H-Area Tank Farm. Therefore the analysis and presentation of results are provided on a tank-farm or tank-grouping basis for each alternative.

Modeling the fate and transport of contaminants was performed using the Multimedia Environmental Pollutant Assessment System (MEPAS) computer model (Buck et al. 1995). The program is EPA-recognized and uses analytical methods to model the transport of contaminants from a source unit to any point at which the user desires to calculate the concentration. The modeling effort requires certain assumptions about the contaminant source term, source configuration, and hydrogeologic structure of the area between each of the tank farms, or tank groups, and the point where impacts are evaluated. Appendix C presents the major assumptions and inputs used in modeling concentrations of contaminants.

To account for overlapping of the contaminant plumes from separate tank groups that discharge to the same location, the modeled groundwater concentrations were summed as if the various tank groups were at the same initial physical location. Because of the size of the tank groups and the length of the groundwater flow paths, sensitivity analyses showed that the actual location of the contaminant source within the tank group had little impact at the point of analysis at the seepline. The impact analysis also summed the centerline concentrations from each tank-group plume at the point of analysis to ensure that the highest concentration was reported. Therefore, although the plumes from different tank groups may not overlap entirely, the calculation methodology provides an upper estimate for the predicted groundwater impacts. The simplification of treating all the tanks in a group as if they are at the same physical location has the effect of greatly exaggerating estimated groundwater concentrations and doses at close-in locations, including 1-meter and 100-meter wells.

For all of the tank groups in F-Area and for several groups in H-Area, the historical water level data showed that the tank bottoms are elevated above the zone of groundwater saturation. For these tanks, the modeling simulated leaching of contaminants from the waste zone and vertical migration to the water table. It was observed that some tank groups in the H-Area tank farm, due to their installation depth and the presence of a local high in the water table, lie partially or nearly entirely in the zone of groundwater saturation. The modeling simulation was adjusted for these sites to account for submergence of the contamination source zone.

Groundwater Quality Impacts

As described in detail in Appendix C, groundwater flowing beneath the tank farms flows in different directions and includes vertical flow components. In the analyzed alternatives, the mobile contaminants in the tanks would gradually migrate downward through unsaturated soil to the hydrogeologic units comprising the shallow aquifers underlying the tank farms. As identified above, 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.

The first hydrogeologic unit impacted would be the Water Table Aquifer formally known as the upper zone of the Upper Three Runs Aquifer (Aadland et al. 1995). Some contaminants from each tank farm would be transported by groundwater through the Water Table Aquifer 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 Aquifer may discharge to unnamed tributaries of Upper Three Runs or migrate downward to underlying aquifers. Previous DOE modeling results for this portion of H-Area, (GeoTrans 1993), from which the model inputs were based, showed that approximately 73 percent of the contaminant mass released from these tanks would remain in the Water Table and Barnwell-McBean Aquifers and 27 percent would migrate to the Congaree Aquifer (i.e., Gordon Aquifer) to a point of discharge along Upper Three Runs.

For tank groups located in the F-Area and for tank groups located south of the groundwater divide in H-Area, the contaminant mass released was simulated to migrate both laterally and vertically based on the hydrogeologic setting. Previous DOE modeling results for F-Area (GeoTrans 1993), from which the model inputs were derived, showed that approximately 96 percent of the contaminant mass released from the F-Area tanks would remain in the Water Table and Barnwell-McBean Aquifers and would discharge at the seepline along lower Fourmile Branch. Previous DOE modeling results for H-Area (GeoTrans 1993) showed that approximately 78 percent of the released contaminant mass would remain in the Water Table and Barnwell-McBean Aquifers and would discharge at the seepline along upper Fourmile Branch. The remaining 22 percent of contaminant mass released from the H-Area tanks was simulated as migrating downward and laterally through the Congaree Aquifer to a point of discharge at the seepline along Upper Three Runs.

Summary of Estimated Concentrations

The results of the groundwater fate and transport modeling for radiological and non-radiological contaminants for each tank farm are presented in Tables 4.2.2-4 through 4.2.2-8. The modeling calculated impacts for each aquifer layer. Because the concentrations in groundwater from the various aquifers are not additive, only the maximum value is presented in the tables. The results are presented for each alternative for the 1-meter and 100-meter wells, and for the seepline. Figure 4.2.2-1 illustrates some of the same results graphically. This figure shows the predicted concentrations over time at the Three Runs seepline (north of the groundwater divide) resulting from contamination transported from the H-Area Tank Farm through the Water Table and Barnwell-McBean Aquifers. Results at the other modeled exposure locations show similar patterns over time. The pattern of the peaks in the graph results from the simplified and conservative approach used in modeling, such as the simplifying assumption that the tanks would release their entire inventories simultaneously and completely. The specific concentrations for each radiological and nonradiological contami-

Table 4.2.2-4. Maximum radiological groundwater concentrations from contaminant transport from F-Area Tank Farm.[a]

Radiological emitter - exposure point	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Drinking water dose (millirem/yr)				
1-meter well	35,000	130	420	790
100-meter well	14,000	51	190	510
Seepline	430	1.9	3.5	25
Maximum Contaminant Level (millirem/yr)	4	4	4	4
Alpha concentration (picocuries per liter)				
1-meter well	1,700	13	13	13
100-meter well	530	4.8	4.7	4.8
Seepline	9.2	0.04	0.039	0.04
Maximum Contaminant Level (pCi/liter)	15	15	15	15

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-5. Maximum radiological groundwater concentrations from contaminant transport from H-Area Tank Farm.[a]

Radiological emitter - exposure point	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Drinking water dose (millirem/yr)				
1-meter well	9.3×10^6	1×10^5	1.3×10^5	1×10^5
100-meter well	9.0×10^4	300	920	870
Seepline, North of Groundwater Divide	2,500	2.5	25	46
Seepline, South of Groundwater Divide	200	0.95	1.4	16
Maximum Contaminant Level (millirem/yr)	4	4	4	4
Alpha Concentration (picocuries per liter)				
1-meter well	13,000	24	290	24
100-meter well	3,800	7.0	38	7.0
Seepline, North of Groundwater Divide	34	0.15	0.33	0.15
Seepline, South of Groundwater Divide	4.9	0.02	0.019	0.02
Maximum Contaminant Level (pCi/liter)	15	15	15	15

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Management EIS (DOE 1995).

Table 4.2.2-6. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, 1-meter well.[a]

	Maximum concentration (percent of MCL)				
	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	18.5	320	6,500	150
Barnwell McBean	0.0	47.5	380	0.0	270
Congaree	0.0	6.8	0.0	0.0	62
Clean and Fill with Grout Option					
Water Table	0.0	0.3	21	70	2.3
Barnwell McBean	0.0	5	23	0.0	21
Congaree	0.0	0.1	0.0	0.0	0.5
Clean and Fill with Sand Option					
Water Table	0.0	1.6	8.5	37	6.7
Barnwell McBean	0.0	5.3	19	0.0	22
Congaree	0.0	0.1	0.0	0.0	0.7
Clean and Fill with Saltstone Option					
Water Table	0.0	0.3	21	70	240,000
Barnwell McBean	0.0	5	23	0.0	440,000
Congaree	0.0	0.1	0.0	0.0	160,000

Notes: MCL = Maximum Contaminant Level. Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-7. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, 100-meter well.[a]

	Maximum concentration (percent of MCL)				
100-Meter well	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	8.3	74	265	69
Barnwell McBean	0.0	12.5	81	0.0	58
Congaree	0.0	1.2	0.0	0.0	11
Clean and Fill with Grout Option					
Water Table	0.0	0.1	2.7	1.5	0.7
Barnwell McBean	0.0	1.1	4.4	0.0	4.7
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Sand Option					
Water Table	0.0	0.3	1.5	2.7	1.3
Barnwell McBean	0.0	1.2	3.7	0.0	4.9
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Saltstone Option					
Water Table	0.0	0.1	2.7	1.5	68,000
Barnwell McBean	0.0	1.1	4.4	0.0	180,000
Congaree	0.0	0.0	0.0	0.0	21,000

Notes: MCL = Maximum Contaminant Level. Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

Table 4.2.2-8. Maximum nonradiological groundwater concentrations from contaminant transport from F- and H-Area Tank Farm, seepline.[a]

Fourmile Branch seepline	Maximum concentration (percent of MCL)				
	Barium	Fluoride	Chromium	Mercury	Nitrate
No Action Alternative					
Water Table	0.0	0.4	1.0	0.0	3.4
Barnwell McBean	0.0	0.5	0.8	0.0	2.4
Congaree	0.0	0.0	0.0	0.0	0.1
Clean and Fill with Grout Option					
Water Table	0.0	0.0	0.0	0.0	0.0
Barnwell McBean	0.0	0.0	0.0	0.0	0.1
Congaree	0.0	0.0	0.0	0.0	0.0
Clean and Fill with Sand Option					
Water Table	0.0	0.0	0.0	0.0	0.1
Barnwell McBean	0.0	0.0	0.0	0.0	0.2
Congaree	0.0	0.0	0.0	0.0	0.0
Clean and Fill with Saltstone Option					
Water Table	0.0	0.0	0.0	0.0	3,000
Barnwell McBean	0.0	0.0	0.0	0.0	3,300
Congaree	0.0	0.0	0.0	0.0	300

Notes: Only those contaminants with current EPA Primary Drinking Water MCLs are included in table. A value of "100" for a given contaminant is equivalent to the MCL concentration.

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995).

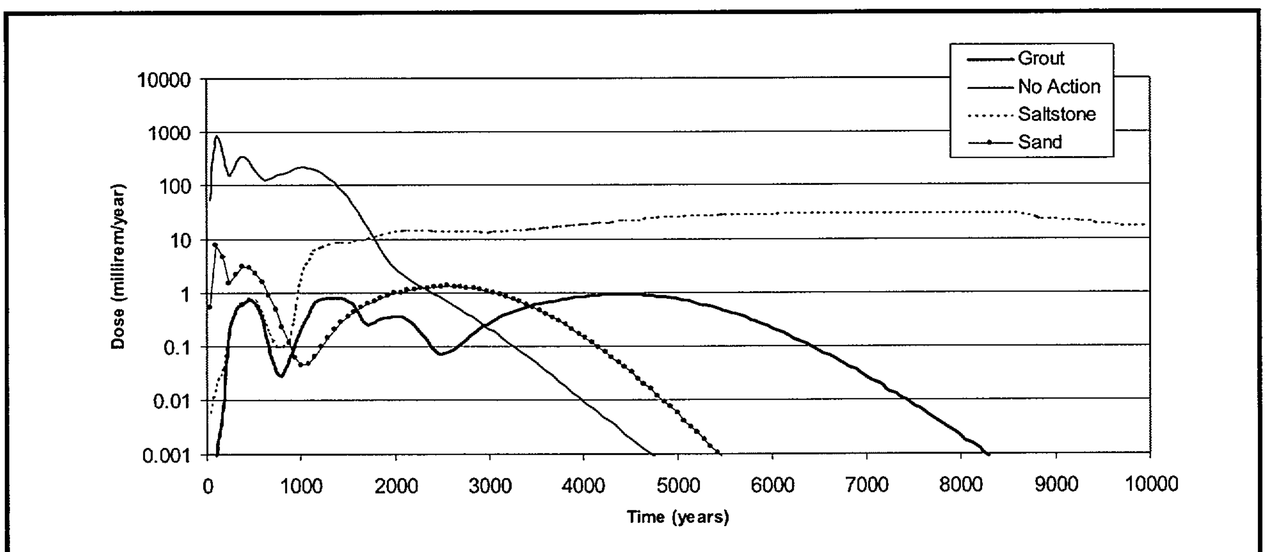


Figure 4.2.2-1 Predicted Drinking Water Dose Over Time at the H-Area Seepline North of the Groundwater Divide in the Barnwell-McBean and Water Table Aquifers.

nant for each aquifer layer and each exposure point are presented in Appendix C. For radiological contaminants, the dose in millirem per year from all radionuclides or the concentration of all alpha-emitting radionuclides are considered additive for any given aquifer layer at any exposure point. The maximum radiation dose (millirem per year) and maximum alpha concentration (picocuries per liter) regardless of the aquifer layer, therefore, are presented in the tables for each exposure point. This data represents the increment in time when the sum of all beta-gamma or alpha emitters is greatest but not necessarily when each species is at its maximum concentration. This method of data presentation shows the overall maximum dose or concentration that occurs at each exposure point.

For nonradiological contaminants the effects of the contaminants are not considered to be additive. The maximum concentration of each nonradiological contaminant, regardless of time, was determined for each aquifer layer and for each exposure point. Only those contaminants with current EPA Drinking Water Standard Maximum Contaminant Levels are shown on the tables. For comparison between the different alternatives the maximum value for each nonradiological contaminant was converted to its percentage of the Maximum Contaminant Level. This value provides a streamlined, quantitative method of comparing the impacts of the maximum concentrations for each alternative.

Comparison of Alternatives

The radiological results provided in Tables 4.2.2-4 through 4.2.2-5 and illustrated in Figure 4.2.2-1 consistently show that the greatest long-term impacts occur under the No Action Alternative. For this alternative, the Maximum Contaminant Level for beta-gamma radionuclides is exceeded at all points of exposure. On the other hand, the Clean and Fill with Grout Option shows the lowest-long term impacts at all exposure points, and the Maximum Contaminant Level for beta-gamma radionuclides is met at the seepline for this alternative. Also, Figure 4.2.2-1 shows that impacts would occur later than under the No-Action Alternative or the Clean and Fill with Sand Option. Peak dose under the Clean and Fill with Sand Alternative would be less than under the No-Action Alternative and the Maximum Contaminant Level would be met at the seepline, but doses would be greater than under the Clean and Fill with Grout Option and would occur sooner. Like the Clean and Fill with Sand Option, the Clean and Fill with Saltstone Option would delay the impacts at the seepline, but it would result in a higher peak dose than either the Clean and Fill with Grout or Clean and Fill with Sand Options (the peak dose under this alternative would exceed the Maximum Contaminant Level at the seepline) and the peak doses would persist for a very long time due to the release of other radiological constituents from the saltstone.

The results for alpha-emitting radionuclides shown in Tables 4.2.2-4 through 4.2.2-5 also show that the greatest long-term impacts would occur for the No Action Alternative. For this alternative, the Maximum Contaminant Level is exceeded at the 1-meter and 100-meter wells. The grout, sand, and saltstone fill options show similar impacts at all most locations. For these three options, the Maximum Contaminant Level for alpha-emitting radionuclides would be exceeded only at the 1-meter well (all three options) and at the 100-meter well (Clean and Fill with Sand Option).

The non-radiological results presented in Tables 4.2.2-6 through 4.2.2-8 show a consistent trend for all points of exposure. Unlike the radiological results, however, the data show exceedances of the Maximum Contaminant Levels only for the No Action Alternative and Clean and Fill with Saltstone Option. The impacts are greatest in terms of the variety of contaminants that exceed the Maximum Contaminant Level for the No Action Alternative, but exceedances of the Maximum Contaminant Levels primarily occur at the 1-meter well. Impacts from the Clean and Fill with Saltstone Option occur at all exposure points, including the seepline; however, nitrate is the only contaminant that exceeds the Maximum Contaminant Level. This occurs because the saltstone would contain large quantities of nitrate that would not be present in the tank residual. The Maximum Contaminant Levels are not exceeded for any contaminant in any aquifer layer, at any point of exposure, for either the Clean and Fill with Grout or the Clean and Fill with Sand Options.

4.2.3 ECOLOGICAL RESOURCES

This section presents an evaluation of the potential long-term impacts of F- and H-Area Tank Farm closure to ecological receptors. DOE assessed the potential risks to ecological receptors at groundwater points of discharge (seeplines) to Upper Three Runs and Fourmile Branch, and the risks to ecological receptors in these streams downstream of the seeplines. This section presents a summary of this analysis; the detailed assessment is provided in Appendix C.

Groundwater-to-surface water discharge of tank farm-related contaminants was the only migration pathway evaluated because the closed tanks would be 4 to 7 meters underground, precluding overland runoff of contaminants and associated terrestrial risks. As a result, only aquatic and semi-aquatic receptors and associated risks were evaluated.

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.

The estimated 1.24 acre seepage areas are small, (DOE 1997a), 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.

4.2.3.1 Non-radiological Contaminants

Exposure for aquatic receptors (e.g., fish, aquatic invertebrates) is expressed as the concentration of contaminants in the water surrounding them. 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 seeplines. For aquatic receptors, risks were evaluated by comparing concentrations of contaminants in surface water downgradient of seeps with ecological screening guidelines indicative of potential risks to aquatic receptors. Guidelines used are presented in Appendix C. If the ratio of the surface water concentration to the guideline (called the "hazard quotient") exceeded 1.0, risks to aquatic receptors were considered possible.

Exposure for terrestrial (semi-aquatic) receptors is based on dose, expressed as milligrams of contaminant absorbed per kilogram of body mass per day. For this evaluation, the southern short-tailed shrew and mink were selected as representative receptors (see Appendix C). The exposure routes used for estimating dose were ingestion of food and water. 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 and Upper Three Runs (mink); ingested in aquatic prey (mink); and transferred to soil, soil invertebrates, shrews, and to mink through a simple terrestrial food chain. The short-tailed shrew was assumed to receive exposure at the seepline only, and 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. The bioaccumulation factor for soil and soil invertebrates is 1.0 for all inorganics, as is the factor for accumulation in shrew tissue. Literature-based bioconcentration factors were used to estimate chemical concentrations in aquatic prey for the mink (see Appendix C).

For the short-tailed shrew and the mink, 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 (Appendix C). Usually the endpoints are adverse effects on reproduction or development. 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. Similar to the ratio used for the aquatic receptors, risks were considered possible when the ratio of the estimated dose to the toxicity threshold (hazard quotient) exceeded 1.0.

Potential risks were evaluated for all of the analyzed scenarios, which are described in Appendix C. Each of the scenarios 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). Comprehensive lists of all hazard quotients for each analyzed scenario are presented in Appendix C. Table 4.2.3-1 presents a summary of the maximum hazard indices (HIs) for aquatic receptors by tank stabilization method. Hazard quotients for individual aquatic contaminants were summed to obtain HIs. All HI values for the Clean and Fill with Sand and Saltstone Options were less than 1.0, indicating negligible risks to aquatic receptors in Fourmile Branch and Upper Three Runs. The maximum HIs for the Clean and Fill with Grout Option and No Action Alternative were slightly greater than 1.0. As a result, risks to aquatic receptors are possible. However, the relatively low HI values indicate that although risks are present, they are somewhat low. Although no guidance exists regarding the interpretation of the magnitude of HI values, given the conservation inherent in all aspects of the assessment single-digit HI values are most likely associated with low risks.

Table 4.2.3-2 presents a summary of the hazard quotients for the short-tailed shrew and mink by tank stabilization method. All terrestrial HQs were less than 1.0 for the grout, sand, and saltstone options, suggesting negligible risks to the shrew and mink (and similar species). The maximum HQ for silver for the No Action Alternative was slightly greater than 1.0. Hence, some risks are possible. Nevertheless, the relatively low maximum HQ suggests generally low risks.

As noted in Section 3.4, no Federally – listed species are known to occur in the vicinity of the F- and H-Area Tank Farms, and none have been recorded near the Upper Three Runs and Fourmile Branch seeplines. The American alligator (threatened due to similarity of appearance to the American crocodile) is the only Federally – protected species that could potentially occur in the area of the seeplines. Given that no Federally – listed species are believed to be present and ecological risks to terrestrial and aquatic receptors are low, DOE does not expect any long-term impacts as a result of the proposed actions and alternatives.

4.2.3.2 <u>Radionuclides</u>

DOE calculated peak radiation dose to aquatic and terrestrial receptors at the seepline and receiving surface water from the tank closure alternatives. These radiation doses are compared to the limit of 1,000 millirad per day (365,000 millirad per year).

The following exposure pathways were chosen for calculating absorbed radiation dose to the terrestrial mammals of interest (shrew and mink) located on or near the seepline: 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 pathways 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 parameters such as mass, food ingestion rate, water ingestion rate, soil ingestion rate, and bioaccumulation factors were used. Appendix C provides more details on the methodology and parameters used in this analysis.

Table 4.2.3-1. Summary of maximum hazard indices for the aquatic assessment by tank closure alternative.

No Action Alternative	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Max. HI	Max. HI	Max. HI	Max. HI
2.0	1.42	0.18	0.16

Calculated absorbed doses to the referenced organisms are listed in Table 4.2.3-3. All calculated doses are below the regulatory limit of 365,000 millirad per year.

4.2.4 LAND USE

DOE's primary planning document for land use at SRS is the *Savannah River Site Future Land Use Plan* (DOE 1998). This plan (DOE 1998) analyzed several future use options, including residential future use. The residential use option would call for all of SRS, except for existing waste units with clean up decisions under RCRA or CERCLA that preclude residential use, to be cleaned up to levels consistent with residential land use. Clean up of SRS to levels required for residential use would result in enormous costs and considerable time commitment. Many areas at the site are contaminated at low levels with various contaminants and it is probably not feasible with current technology to remediate these areas to standards acceptable for residential development. An integral site future-use model that assumes no residential uses would be permitted in any area of the site was identified as the basis for SRS future-use planning.

The General Separations Area includes several nuclear material processing and waste management areas. In addition to the Tank Farms, this area includes the F- and H-Area canyon buildings, radioactive waste storage and disposal facilities, and the DWPF vitrification and salt processing facilities. This area also contains numerous as yet unremediated waste sites (basins, pits, piles, tanks, contaminated groundwater plumes). Soils and groundwater within the General Separations Area are contaminated with radionuclides and hazardous chemicals as a result of 40 years of site operations. As described in Section 3.2.2.4, several contaminants in groundwater (tritium and other radionuclides, metals, nitrates, sulfates, and chlorinated and volatile organics) currently exceed the applicable regulatory or DOE guidelines. This area of the SRS is least amenable to remediation to the levels that would enable future residential use.

Section 4.2.5 discusses impacts to humans using the land in or near the Tank Farms. DOE does not envision relinquishing control of this area. However, DOE recognizes that there is uncertainty in projecting future land use and effectiveness of institutional controls considered in this EIS. For purposes of analysis, DOE assumes direct physical control in the General Separations Area only for the next 100 years. In accordance with agreements with the State of South Carolina and as reflected in the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996), DOE has calculated human health impacts based on doses that would be received over time at a point of compliance that is at the seepline, about a mile from the tank farms. However, recognizing the potential for exposure to groundwater and the fact that DOE's land use assumptions may be incorrect, DOE has also provided estimates of human health implications of doses that would be received directly adjacent to the boundary of the tank farm. This location is much closer to the tank farm than the point of compliance and the projected doses and consequent health effects are greater.

With respect to the 100-years of physical control, the land use plan establishes a future use policy for the SRS. Several key elements of that policy would maintain the tank farm area and exclude its future use from non-conforming land uses (see Figure 4.2.4-1). The most notable elements are the following:

- Protection and safety of SRS workers and the public shall be a priority.

Table 4.2.3-2. Summary of maximum hazard quotients for the terrestrial assessment by tank closure alternative.

	No Action Alternative		Clean and Stabilize Tanks Alternative					
			Clean and Fill with Grout Option		Clean Fill with Sand Option		Clean Fill with Saltstone Option	
	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]	Max. HQ	Time of maximum exposure[a]
Aluminum	b	NA	b	NA	b	NA	b	NA
Barium	b	NA	b	NA	b	NA	b	NA
Chromium	0.04	4,235	0.02	3,955	b	NA	b	NA
Copper	b	NA	b	NA	b	NA	b	NA
Fluoride	0.20	105	0.08	105	0.01	105	0.01	1,015
Lead	b	NA	b	NA	b	NA	b	NA
Manganese	b	NA	b	NA	b	NA	b	NA
Mercury	b	NA	b	NA	b	NA	b	NA
Nickel	b	NA	b	NA	b	NA	b	NA
Silver	1.55	455	0.81	245	0.09	525	0.13	1,365
Uranium	b	NA	b	NA	b	NA	b	NA
Zinc	b	NA	b	NA	b	NA	b	NA

a. Years after closure.
b. HQ is less than 0.01
NA = Not applicable.

Table 4.2.3-3. Calculated maximum absorbed radiation dose to aquatic and terrestrial organisms by tank stabilization method (millirad/year).[a]

	No Action Alternative	Clean and Stabilize Tanks Alternative: Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option
Sunfish dose	0.89	0.0038	0.0072	0.053
Shrew dose	24,450	24.8	244.5	460.5
Mink dose	2,560	3.3	25.6	265

a. DOE limit is 365,000 millirad per year.

- The integrity of site security shall be maintained.
- A "restricted use" program shall be developed and followed for special areas (e.g., CERCLA and RCRA regulated units).
- SRS boundaries shall remain unchanged, and the land shall remain under the ownership of the Federal government.
- Residential uses of all SRS land shall be prohibited in any area of the site.

In principle, industrial zones are ones in which the facilities pose either a potentially significant nuclear or non-nuclear hazard to employees or the general public. In the case of the Industrial-Heavy Nuclear zone, the facilities included (1) produce, process, store and/or dispose of radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations (DOE 1998).

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.

4.2.5 PUBLIC HEALTH

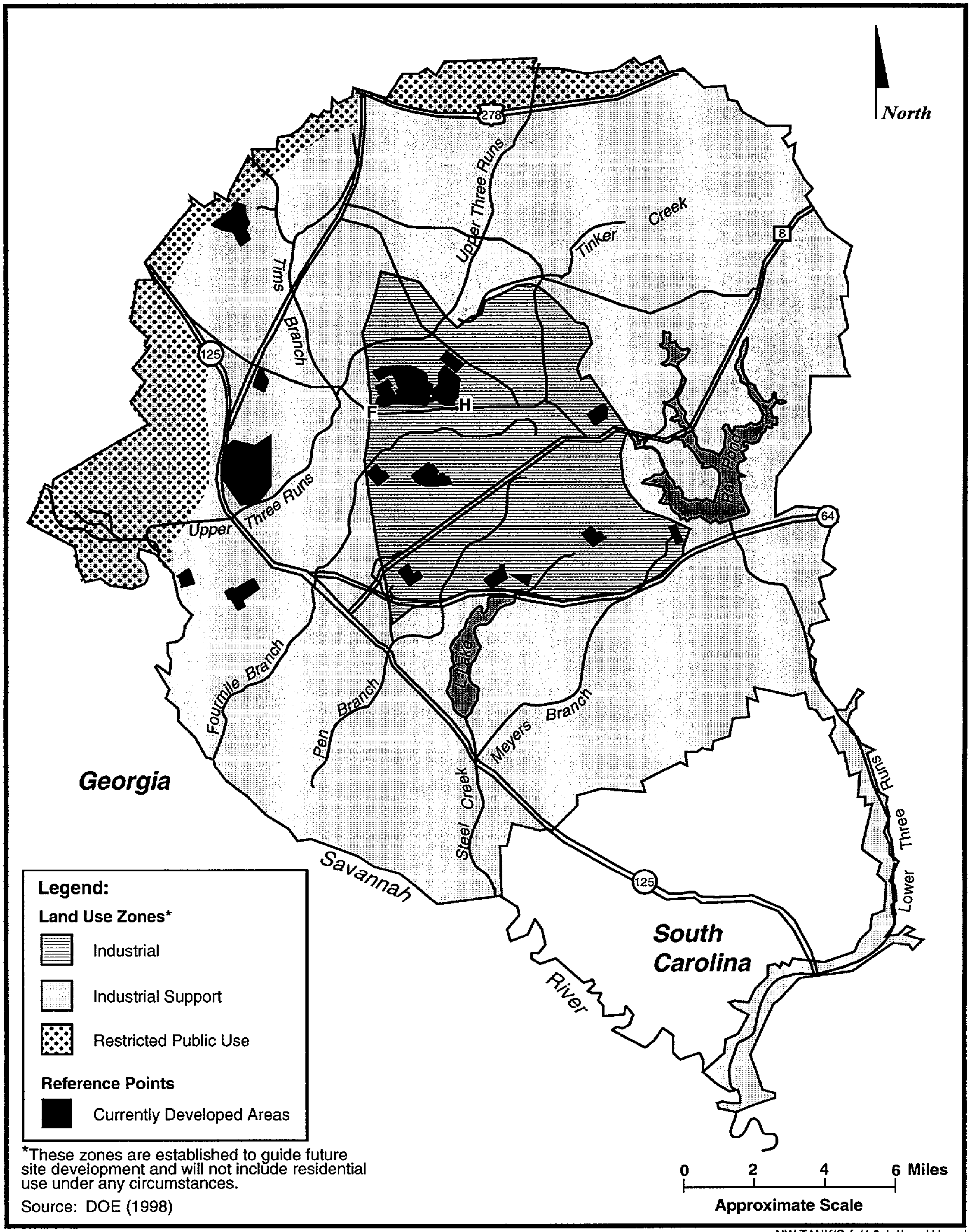
This section presents the potential impacts on human health from residual contaminants remaining in the HLW tanks after closure following the period of institutional control of the H-Area and F-Area Tank Farms.

To determine the long-term impacts, DOE has reviewed data for both tank farms, including the following:

- Expected source inventory that would remain in the tanks
- Existing technical information on geological and hydrogeological parameters in the vicinity of the tank farms

Use of the land around the tank farms

- Arrangement of the tanks within the stratigraphy
- Actions to be completed under each of the alternatives



NW TANK/Grfx/4.2.4-1Land Use.ai

Figure 4.2.4-1. Savannah River Site land use zones.

In its evaluation, DOE has reviewed the human populations who could be exposed to contaminants from the tank farms and has identified the following hypothetical individuals:

- *Worker*: an adult who has authorized access to, and works at, the tank farm and surrounding areas. This analysis assumes that the worker remains on the shores of Fourmile Branch or Upper Three Runs during working hours. This assumption maximizes the hypothetical worker's exposure to contaminants that might emerge at the seepline.

- *Intruder*: a person 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.

- *Downstream resident*: a person who lives in a downstream community where residents get their household water from the Savannah River. Effects are estimated for an average individual in the downstream communities and for the entire population in these communities.

DOE has based the assessment of population health effects on present-day populations because estimation of future populations is very speculative. The analysis based on present-day populations is useful for the purpose of understanding the potential impacts of the proposed action on future residents of the region.

DOE evaluated the impacts over a 10,000-year period, which is consistent with the time period used previously in the *Industrial Wastewater Closure Plan for F- and H-Area High Level Waste Tank System*. Because the tanks are located below the grade of the surrounding topography, DOE does not expect any long-term airborne releases to occur from the tanks. Therefore, DOE based its calculations on postulated release scenarios whereby contaminants in the tanks would be leached from the tank structures and transported to the groundwater. However, the holes formed by the collapsed tanks under the No Action Alternative would pose a long-term safety hazard.

As discussed in Section 4.2.2, the aquifers in the vicinity of F-Area Tank Farm and H-Area Tank Farm outcrop along both Fourmile Branch and Upper Three Runs. Because the locations where these aquifers outcrop from the tank farms do not overlap, DOE has chosen to calculate and present the impacts for these hypothetical individuals separately for F-Area Tank Farm and H-Area Tank Farm.

In addition to the hypothetical individuals and population listed above, DOE also calculated the concentration of contaminants in groundwater at the location where the groundwater outcrops into the environment (i.e., the seepline) and at 1 meter and 100 meters downgradient from each of the tank farms. Discussion of these results is provided in Section 4.2.2, along with an estimate of the impacts from pathways at these locations.

For non-radiological constituents, DOE compared the water concentrations directly to the concentrations listed as Maximum Contaminant Levels in 40 CFR 141. Appendix C lists concentrations for all the nonradiological constituents. As discussed in Section 4.2.2, DOE has chosen to present the fractions of Maximum Contaminant Level for non-radiological constituents to enable quantitative comparison among the alternatives.

As discussed in Appendix C, DOE performed its calculations for the three uppermost aquifers underneath the General Separations Area; however, in this section, DOE presents only the maximum results for the two tank farms. In addition, the maximum results for H-Area Tank Farm are reported, independent of which seepline (Upper Three Runs or Fourmile Branch) receives the highest level of contaminants. Downstream Savannah River users are assumed to be exposed to contemporaneous releases from all aquifers and seeplines. Further details on aquifer-specific results can be found in Appendix C.

Tables 4.2.5-1, 4.2.5-2, and 4.2.5-3 show the radiological results for the F- and H-Area Tank Farms. The maximum annual dose to the adult resident for either tank farm is 6.2 millirem per year for the No Action Alternative. This dose is less than the annual 100 millirem public dose limit and represents only a marginal increase in the annual average exposure of individuals in the United States of approximately 360 mrem due to natural sources of radiation exposure, as discussed in Section 3.8. Based on this low dose, DOE would not expect any health effects if an individual were to receive the dose calculated for the hypothetical adult.

DOE considered, but did not model, the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radiation exposure was the only potentially significant pathway of potential radiological exposure other than groundwater use (WSRC 1992). Tables 4.2.2-4 and 4.2.2-5 present estimates of the radiological doses from drinking water from the close-in wells where onsite residents might obtain their water. DOE also projected the contribution of other water-related environmental pathways to one set of model output and concluded that the dose to a future resident from these other pathways would not exceed the drinking water dose by more than 20 percent. For the Clean and Fill with Grout and Clean and Fill with Sand Options of the Clean and Stabilize Tanks Alternative, external radiation doses to onsite residents would be negligible because the thick layers of nonradioactive material between the waste (near the bottom of the tanks) and the ground surface would shield residents from any direct radiation emanating from the waste. External radiation exposures could occur under the Clean and Fill with Saltstone Option which would place radioactive saltstone near the ground surface. If it is conservatively assumed that all of the backfill soil is eroded or excavated away and there is no other cap over the saltstone, so that a home is built directly on the saltstone, analysis presented in WSRC (1992) indicates that 1000 years after tank closure a resident would be exposed to an effective dose equivalent of 390 mrem/year, resulting in an estimated 1 percent increase in risk of latent cancer fatality from a 70-year lifetime of exposure. Backfill soils or caps would eliminate or substantially reduce the potential external exposure. For example, with a 30-inch-thick intact concrete cap, the dose would be reduced to 0.1 mrem/year. For the No Action Alternative external exposures to onsite residents would be expected to be unacceptably high due to the potential for contact with the residual waste.

At the one-meter well, the highest calculate peak drinking water dose under the No Action Alternative is 9,300,000 millirem per year (9,300 rem per year), which would lead to acute radiation health effects, including death. Peak doses at this well for the Clean and Stabilize Tanks Alternative are calculated to be in the range of 100,000 to 130,000 millirem per year (100 to 130 rem per year), which substantially exceeds all criteria for acceptable exposure, could result in acute health effects, and would give a significantly increased probability of a latent cancer fatality. Peak doses calculated at the 100-meter well range from 300 millirem (0.3 rem per year) per year for the Clean and Fill with Grout Option to 90,000 millirem per year (90 rem per year) for the No Action Alternative. Individuals exposed to 300 millirem per year would experience a lifetime increased risk of latent cancer fatality of less that 0.02 percent per year of exposure. The estimated doses at the 1- and 100-meter wells are extremely conservative (high) estimates because the analysis treated all of the tanks in a given group as being at the same physical location. Realistic doses at these close-in locations would be substantially smaller. As noted above, land-use controls and other institutional control measures would be employed to prevent exposure at these locations.

Table 4.2.5-1. Radiological results from contaminant transport from F-Area Tank Farm.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident maximum annual dose (millirem per year)	0.027	0.051	0.37	6.2
Child resident maximum annual dose (millirem per year)	0.024	0.047	0.34	5.7
Seepline worker maximum annual dose (millirem per year)	(c)	(c)	0.001	0.018
Intruder maximum annual dose (millirem per year)	(c)	(c)	(c)	9.0×10^{-3}
Adult resident maximum lifetime dose (millirem)[b]	1.9	3.6	26	430
Child resident maximum lifetime dose (millirem)[b]	1.7	3.3	24	400
Seepline worker maximum lifetime dose (millirem)[d]	0.002	0.004	0.03	0.54
Intruder maximum lifetime dose (millirem)[d]	0.001	0.002	0.02	0.27
Adult resident latent cancer fatality risk	9.5×10^{-7}	1.8×10^{-6}	1.3×10^{-5}	2.2×10^{-4}
Child resident latent cancer fatality risk	8.5×10^{-7}	1.7×10^{-6}	1.2×10^{-5}	2.0×10^{-4}
Seepline worker latent cancer fatality risk	8.0×10^{-10}	1.6×10^{-9}	1.2×10^{-8}	2.2×10^{-7}
Intruder latent cancer fatality risk	4.0×10^{-10}	8.0×10^{-10}	8.0×10^{-9}	1.1×10^{-7}
1-meter well drinking water dose (millirem per year)	130	420	790	3.6×10^{5}
1-meter well alpha concentration (picocuries per liter)	13	13	13	1,700
100-meter well drinking water dose (millirem per year)	51	190	510	1.4×10^{4}
100-meter well alpha concentration (picocuries per liter)	4.8	4.7	4.8	530
Seepline drinking water dose (millirem per year)	1.9	3.5	25	430
Seepline alpha concentration (picocuries per liter)	0.04	0.039	0.04	9.2
Surface water drinking water dose (millirem per year)	9.8×10^{-3}	0.019	0.13	2.3

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.
b. Lifetime of 70 years assumed for this individual.
c. The radiation dose for this alternative is less than 1×10^{-3} millirem.
d. Lifetime of 30 years assumed for this individual.

Table 4.2.5-2. Radiological results from contaminant transport from H-Area Tank Farm.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Adult resident maximum annual dose (millirem per year)	0.010	0.016	0.19	2.4
Child resident maximum annual dose (millirem per year)	9.3×10^{-3}	0.015	0.18	2.2
Seepline worker maximum annual dose (millirem per year)	(c)	(c)	(c)	7×10^{-3}
Intruder maximum annual dose (millirem per year)	(c)	(c)	(c)	3.5×10^{-3}
Adult resident maximum lifetime dose (millirem)[b]	0.7	1.1	13	170
Child resident maximum lifetime dose (millirem)[b]	0.65	1.1	1.3	150
Seepline worker maximum lifetime dose (millirem)[d]	(c)	0.001	0.017	0.21
Intruder maximum lifetime dose (millirem)[d]	(c)	(c)	0.008	0.11
Adult resident latent cancer fatality risk	3.9×10^{-7}	5.5×10^{-7}	6.5×10^{-6}	8.5×10^{-5}
Child resident latent cancer fatality risk	3.3×10^{-7}	5.5×10^{-7}	6.5×10^{-7}	7.5×10^{-5}
Seepline worker latent cancer fatality risk	(e)	4.0×10^{-10}	6.8×10^{-9}	8.4×10^{-8}
Intruder latent cancer fatality risk	(e)	(e)	3.2×10^{-9}	4.4×10^{-8}
1-meter well drinking water dose (millirem per year)	1×10^{5}	1.3×10^{5}	1.0×10^{5}	9.3×10^{6}
1-meter well alpha concentration (picocuries per liter)	24	290	24	13,000
100-meter well drinking water dose (millirem per year)	300	920	870	9.0×10^{4}
100-meter well alpha concentration (picocuries per liter)	7.0	38	7.0	3,800
Seepline drinking water dose (millirem per year)	2.5	25	46	2.5×10^{3}
Seepline alpha concentration (picocuries per liter)	0.15	0.33	0.15	34
Surface water drinking water dose (millirem per year)	3.7×10^{-3}	6.0×10^{-3}	0.071	0.90

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.
b. Lifetime of 70 years assumed for this individual.
c. The radiation dose for this alternative is less than 1×10^{-3} millirem.
d. Lifetime of 30 years assumed for this individual.

Table 4.2.5-3. Radiological results to downstream resident from contaminant transport from F- and H-Area Tank Farms.[a]

	Clean and Stabilize Tanks Alternative			
	Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	No Action Alternative
Downstream maximum individual annual dose (millirem per year)	(b)	(b)	(b)	(b)
Downstream maximum individual lifetime dose (millirem)	(b)	(b)	3.4×10^{-3}	4.1×10^{-2}
Downstream maximum individual latent cancer fatality risk	(c)	(c)	1.8×10^{-9}	2.1×10^{-8}
Population dose (person-rem per year)	8.6×10^{-5}	3.3×10^{-4}	3.4×10^{-3}	4.1×10^{-2}
Population latent cancer fatality risk (incidents per year)	4.3×10^{-8}	1.7×10^{-7}	1.8×10^{-6}	2.1×10^{-5}

a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities. The environmental impacts of these disposal facilities were analyzed in the SRS Waste Management EIS (DOE 1995), Section 4.2.3.
b. The radiation dose for this alternative is less than 1×10^{-3} millirem.
c. The risk for this alternative is very low, less than 10^{-9}.

References

SECTION 4.0

DOE (U.S. Department of Energy), 1993, NEPA Guidance Document, *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*, Office of NEPA Oversight, May.

SECTION 4.1.2.

Johnson, G., 1999, Westinghouse Savannah River Company, to P. Young, Tetra Tech NUS, electronic message, *Draft Input to Tank Closure EIS*, April 8.

SECTION 4.1.3

Arnett, M. W., 1994, *Savannah River Site Environmental Data for 1993*, WSRC-TR-94-0077, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., 1995, *Savannah River Site Environmental Data for 1994*, WSRC-TR-95-0077, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., 1996, *Savannah River Site Environmental Data for 1995*, WSRC-TR-96-0077, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1997, *Savannah River Site Environmental Data for 1996*, WSRC-TR-97-0077, Westinghouse Savannah River Company, Aiken, South Carolina.

Arnett, M. W., and A. R. Mamatey, 1998, *Savannah River Site Environmental Data for 1997*, WSRC-TR-97-00324, Westinghouse Savannah River Company, Aiken, South Carolina.

Bauer, L. R., 1991, Modeling Chronic Atmospheric Releases at the SRS: Evaluation and Verification of XOQDOQ, WSRC-RP-91-320, Savannah River Laboratory, Aiken, South Carolina.

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.

DOE (U.S. Department of Energy), 1996, *Environmental Assessment for the Closure of High-Level Waste Tanks in F- & H-Areas at the Savannah River Site*, DOE/EA-1164, Savannah River Operations Office, Aiken, South Carolina, July.

Eckerman, K. F., F. J. Congel, A. K. Roecklein, and W. J. Pasciak, 1980, *Users Guide to GASPAR Code*, NUREG-0597, U.S. Nuclear Regulatory Commission, Washington, D.C.

EPA (Environmental Protection Agency), 1995, User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume I – Users Instructions, EPA-454/B-95-003a, September. (Available at http://www.epa.gov/scram001/userg/regmod/isc3v1.pdf).

Hamby, D. M., 1992, *Verification of GASPAR Dose Assessment Module Used in MAXIGASP and POPGASP*, WSRC-RP-92-418, Savannah River Laboratory, Aiken, South Carolina.

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., 1999, electronic message "Response to 4/20/99 Questions for Tank Closure EIS," correspondence to J. Newman, Westinghouse Savannah River Company, Aiken, South Carolina.

Sagendorf, J. F., J. T. Croll, and W. F. Sandusky, 1976, *XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations*, NUREG/CR-2919, U.S. Nuclear Regulatory Commission, Washington, D.C.

Simpkins, A. A., 1996, "Spent Nuclear Fuel EIS Routine Release Environmental Dosimetry Calculations," SRT-ETS-960149, interoffice memorandum to C. B. Shedrow, Westinghouse Savannah River Company, Aiken, South Carolina.

SECTION 4.1.4

Golden, J., R. P. Duellette, S. Saari, and P. N. Cheremisinoff, 1980, Environmental Impact Data Book, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan.

SECTION 4.1.6

Caldwell, T., Westinghouse Savannah River Company, "Manpower Estimates for EIS Options," memorandum to P. Young, Tetra Tech NUS, June 10.

Johnson, G., 1999, Westinghouse Savannah River Company, "Draft Input to Tank Closure EIS," electronic message to P. Young, Tetra Tech NUS, April 8.

SECTION 4.1.8

Arnett, M. W. and A. R. Mamatey, 1999, *Savannah River Site Environmental Report for 1998* (WSRC-TR-98-00312), Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

Caldwell, T., Westinghouse Savannah River Company, "Manpower Estimates for EIS Options," memorandum to P. Young, Tetra Tech NUS, June 10.

CDC (Centers for Disease Control and Prevention), 1998 National Vital Statistics Report, Volume 47, No. 4, *Births and Deaths: Preliminary Data for 1997*, October 7, 1998, U.S. Department of Health and Human Services, Washington D.C.

CEQ (Council on Environmental Quality), 1997, Environmental Justice Guidance Under the National Environmental Policy Act, Executive Office of the President, Washington, D.C., March. (Available at http://ceq.eh.doe.gov/nepa/regs/ej/justice.pdf).

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

DOE (U.S. Department of Energy), 1997, *Final Environmental Impact Statement Shutdown of the River Water System at the Savannah River Site* (DOE/EIS-0268), Department of Energy Savannah River Operations Office, Aiken, South Carolina.

Hunter, C. H. to C. B. Shedrow, Interoffice Memorandum, Non-Radiological Air Quality Modeling for the High-Level Waste Tank Closure Environmental Impact Statement (EIS), SRT-NTS-990067, March 26, 1999.

Johnson, G., 1999, Westinghouse Savannah River Company, "Draft Input to Tank Closure EIS," electronic message to P. Young, Tetra Tech NUS, April 8.

Newman, J., 1999a, Westinghouse Savannah River Company, "Requested Information," electronic message to P. Young, Tetra Tech NUS, April 19.

Newman, J., 1999b, Westinghouse Savannah River Company, *Westinghouse Savannah River Company Safety Statistics 1994 through 1998*, electronic message to P. Young, Tetra Tech NUS, April 19.

NCRP (National Council on Radiation Protection and Measurements), 1993, *Limitations of Exposure to Ionizing Radiation*, Report Number 116, Washington, D.C.

SECTION 4.1.9

Saricks, C., and T. Kvitek, *Trends in State-Level Freight Accident Rates: An Enhancement of Risk Factor Development for RADTRAN.* Center for Transportation Research, Energy Systems Division, Argonne National Laboratory.

SECTION 4.1.10

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.

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

SECTION 4.1.11

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.

SECTION 4.1.12

Simpkins, A. A., 1995a, *AXAIRQ User's Manual*, 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.

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.

SECTION 4.2

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.

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.

DOE (U.S. Department of Energy), 1995, *Final Environmental Impacts Statement Waste Management,* DOE/EIS-0217, Savannah River site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina, July 10.

DOE (U.S. Department of Energy), 1997a, *Industrial Wastewater Closure Module for the High-Level Waste Tank 20 System*, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1997b, *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), 1998, *Savannah River Site Future Use Plan*, Savannah River Operations office, Savannah River Site, Aiken, South Carolina.

EPA (U.S. Environmental Protection Agency), 1986, Quality Criteria for Water.

EPA (U.S. Environmental Protection Agency), 1999, National Recommended Water Quality Criteria-Correction. (Available at http://www.epa.gov/ostwater/pc/revcom.pdf).

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.

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

SCDHEC (South Carolina Department of Health and Environmental Control), 1999, Water Classifications and Standards (R.61-68) and Classified Waters (R.61-69), Bureau of Water, Columbia, South Carolina. (Available at http://www.lpitr.state.sc.us/coderegs/61c.htm).

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.