DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems

Savannah River Site

Construction Permit Numbers: 14,338
14,520
17,424-IW

EXECUTIVE SUMMARY

The Savannah River Site (SRS) is owned by the United States Department of Energy (DOE) and is currently operated and managed by the Westinghouse Savannah River Company (WSRC). Since beginning operations in the early 1950s, uranium and plutonium recovery processes have generated liquid high-level radioactive waste, which currently amounts to 34 million gallons stored in underground tanks in the F- and H-Areas at the site. DOE intends to remove from service the high-level waste (HLW) tanks that do not meet the standards established in Appendix B of the SRS Federal Facility Agreement entered into pursuant to Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). After the wastes are removed from the tanks, the residual contaminants will be stabilized and the tanks closed under the industrial wastewater permits that regulate their operation. This plan establishes the general protocol by which DOE intends to close F- and H-Area HLW tank systems at SRS to prevent health hazards and promote safety in and around the tank systems in accordance with South Carolina Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." In addition, closure of the HLW tanks by this process is intended to be consistent with the requirements of the Resource Conservation and Recovery Act (RCRA) and CERCLA, which will control the overall remediation of the F- and H-Area Tank Farms.

The F- and H-Area Tank Farms are located in the central portion of the SRS. The F-Area Tank Farm is located on 22 acres with 22 HLW tank systems, and the H-Area Tank Farm is located on 45 acres and contains 29 HLW tank systems. The tank systems include the tank structure and ancillary components such as transfer pipelines, evaporators, diversion boxes, pump pits, and stripper columns. The tanks are of four basic types, designated I, II, III, and IV, and are constructed of carbon steel and concrete with waste capacities ranging from 750,000 to 1,300,000 gallons. Type I and II tanks have 5-foot-high annular pans (secondary containment), while Type IV tanks have single-wall designs. The newest design (Type III) has a full-height secondary containment tank. Nine of the Type I and II tanks are known to have experienced leaks from primary to secondary containment; one tank (Tank 16) leaked a small amount into the surrounding soil. As described in the Waste Removal Plan and Schedule (WSRC 1993), DOE intends to remove from service by 2028 and close the 24 tanks (Types I, II, and IV) that do not meet the standards set forth in Appendix B of the FFA. Summary information on the F- and H-Area HLW tanks is presented in Table ES-1.

This plan describes the environmental setting for the HLW tanks and the human and environmental receptors potentially affected by the tank closures (i.e., land use and demographics, local geology, ground and surface waters, biota, and air quality). Most of the information was compiled from existing

Table ES-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	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 2028.

SRS documents (environmental impact statements, safety analysis reports, hydrogeologic studies, etc.) that address the F- and H-Areas.

Environmental requirements and guidance considered pertinent to closure of the F- and H-Area HLW tank systems have been identified, and performance objectives have been derived from them to ensure protection of human health and the environment and consistency with potential remedial actions in the F- and H-Area Tank Farms. In establishing the performance objectives for HLW tank system closure, DOE has assumed that the residual waste material remaining in the tank at closure will not be classified as high-level waste. In this regard, DOE intends to demonstrate that the residual waste will satisfy the criteria established by the U.S. Nuclear Regulatory Commission for classification as "incidental waste."

Before initiating the closure process for a tank, DOE will remove the HLW (salt, sludge, and supernate) by mechanical agitation (slurry pumps and eductor jets) and wash it with an inhibited water solution. Any waste not removed during this process will be residual waste. The residual waste in the tank will then be evaluated to determine the inventory of contaminants (radiological and nonradiological). The closure process described in this plan and shown in Figure ES-1 will be initiated with the following sequence of activities:

1. A method of stabilizing the residual contaminants in the tanks will be proposed.
2. The closure configuration (i.e., the combination of residual tank source terms and stabilization method) will be subjected to fate and transport modeling to evaluate compliance with the overall performance objectives determined from the applicable environmental regulations. Contributions from other nearby tanks and nontank sources will also be calculated and accounted for in comparison with the overall performance objectives.
3. The portion of the performance objectives remaining after subtracting the nontank sources will be apportioned between the HLW tanks to determine tank-specific performance objectives. Chapter 6 provides a more complete explanation of these steps.

The preferred alternative will be selected based on performance criteria and consistency with the overall remediation of the F- and H-Area Tank Farms. DOE will then prepare a detailed tank-specific closure module, which will be submitted to South Carolina Department of Health and Environmental Control (SCDHEC) for review. After SCDHEC approval of the module is granted, stabilization of the residual contaminants will be performed as the final step of the closure process. The tank will be turned over to the DOE Environmental Restoration group to manage as part of the overall remediation of the tank farm under RCRA/CERCLA requirements. Figure ES-1 summarizes the sequence of steps in the closure process.

REFERENCES

WSRC (Westinghouse Savannah River Company), 1993, *Waste Removal Plan and Schedule*, WSRC-RP-93-1477, Revision 0, Westinghouse Savannah River Company, Aiken, SC.

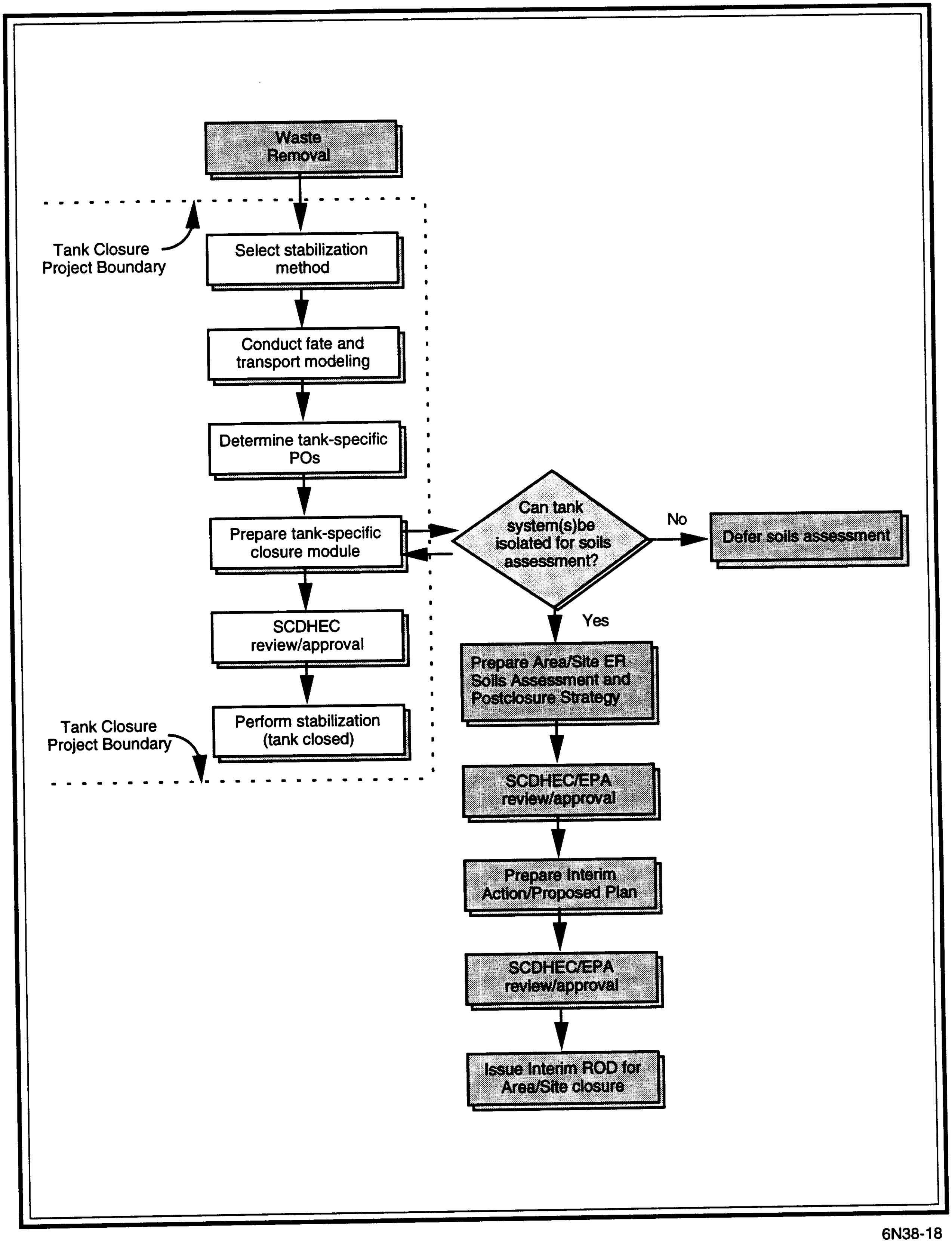

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Figure ES-1. Summary of HLW tank closure process.

ACRONYMS AND ABBREVIATIONS

ACL	alternate concentration limit
AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
AOC	area of concern
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
Bq	becquerel
CAA	Clean Air Act
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie
CLSM	controlled low-strength material
CMS/FS	Corrective Measures Study/Feasibility Study
CRC	cesium removal column
CWA	Clean Water Act
CZ	contaminated zone
DCF	dose conversion factor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ETF	F/H Effluent Treatment Facility
FFA	Federal Facility Agreement
g	gram
GSA	General Separations Area
GTCC	greater-than-class-C
GTS	groundwater transport segment
HHEM	Human Health Evaluation Manual
HHW	high heat waste
HLW	high-level waste
HQ	hazard quotient

HWMF	hazardous waste management facility
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ITP	In-Tank Precipitation Facility
l	liter
LDR	Land Disposal Restrictions
LHW	low heat waste
LLW	low-level waste
LOAEL	lowest-observed-adverse-effect-level
m^3	cubic meters
µCi	microcurie (10^{-6} Ci)
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MEPAS	Multimedia Environmental Pollutant Assessment System
µg	microgram (10^{-6} gram)
mg	milligram (10^{-3} gram)
mrem	10^{-3} rem
mSv	milliSievert (10^{-3} Sievert)
MW	mixed waste
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAEL	no-observed-adverse-effect-level
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PCB	polychlorinated biphenyl
pCi	picocurie (10^{-9} Ci)
PO	performance objective
ppm	parts per million
RAGS	Risk Assessment Guidance for Superfund
RBOF/RRF	Receiving Basin for Offsite Fuels/Resin Regeneration Facility
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RHLWE	Replacement High-Level Waste Evaporator
RI/FS	Remedial Investigation/Feasibility Study
RPA	radiological performance assessment

SAR	safety analysis report
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCHWMR	South Carolina Hazardous Waste Management Regulations
SCPCA	South Carolina Pollution Control Act
SDWA	Safe Drinking Water Act
SMDF	Saltstone Manufacturing and Disposal Facility
SRS	Savannah River Site
Sv	sievert
SWMU	solid waste management unit
TBC	to be considered
TEDE	total effective dose equivalent
TOC	total organic carbon
TSS	total suspended solids
UST	underground storage tanks
UTS	Universal Treatment Standards
VOC	volatile organic compound
WL	working level
WMEIS	Waste Management Environmental Impact Statement
WSRC	Westinghouse Savannah River Company

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CHAPTER 1. INTRODUCTION

The Savannah River Site (SRS) occupies approximately 300 square miles adjacent to the Savannah River, principally in Aiken, Barnwell, and Allendale Counties of South Carolina. The site is owned by the United States Department of Energy (DOE) and is operated by the Westinghouse Savannah River Company (WSRC). Environmental restoration is emphasized in the current site mission. However, since the early 1950s, the primary mission of the site has been to produce nuclear materials for national defense. The process used to recover uranium and plutonium from production reactor fuel and target assemblies in the chemical separations area at SRS generated liquid high-level radioactive waste. This waste, which now amounts to approximately 34 million gallons, is stored in underground tanks in the F- and H-Areas near the center of the site. DOE intends to remove from service by 2028 those high-level waste (HLW) tank systems that do not meet the standards set forth in Appendix B of the SRS Federal Facility Agreement (FFA) (EPA 1993). DOE, the U.S. Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control (SCDHEC) signed the FFA pursuant to Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the comprehensive environmental remediation of SRS; the agreement became effective in August 1993. After wastes are removed from individual tank systems, they will be closed under, then removed from, the industrial wastewater permits that regulate their operation.

1.1 Purpose and Objectives

The purpose of this document is to set forth the general protocol by which DOE intends to close the F- and H-Area HLW tank systems at SRS to protect public health and the environment in accordance with South Carolina Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This plan presents the environmental regulatory standards and guidelines pertinent to closure of the tanks and describes the process for evaluating and selecting the closure configuration (i.e., residual source term and method of stabilizing the tank system and residual waste material). The plan also describes the integration of HLW tank system closure activities with existing commitments to remove waste from the tanks before closure and ultimately to remediate the F- and H-Area Tank Farms.

The specific objectives of this plan are as follows:

- Identify the resources (e.g., human populations, land use, natural and cultural resources) potentially affected by contamination remaining in the tanks after waste removal.

- Describe the relationship between the HLW tank system closure activities and the SRS FFA (Section IX.E) and present the logistics for integrating tank closure activities with the requirements of the agreement.

- Describe the methods DOE will use to remove wastes from the tank systems and stabilize the tank systems and residual waste material.

- Identify the Federal and South Carolina environmental requirements and guidance that apply to the tank closure (e.g., groundwater, surface water, and air emission limits).

- Describe the methodology of using fate and transport modeling to calculate potential exposure concentrations or radiological dose rates from residual wastes in the tank systems.

- Provide the methodology for apportioning environmental standards, through the use of groundwater transport segments as an estimate of contaminate flow, to derive specific performance objectives and other criteria for individual tank systems such that the closure of all F- and H-Area tank systems will comply with environmental standards.

- Describe the methods by which DOE will use tank-specific performance objectives and other criteria to select appropriate options for waste removal and closure of individual tank systems and the method for obtaining regulatory approval for those options.

The process outlined in this plan is intended to comply with the requirements of South Carolina R.61-82, and be consistent with the requirements of the Resource Conservation and Recovery Act (RCRA) and CERCLA, under which the F- and H-Area Tank Farms will eventually be remediated. Thus, evaluation and selection of a proposed closure configuration by the process described in this plan will be consistent with evaluation against the following CERCLA criteria [40 CFR 300.430(e)(9)]: (1) overall protection of human health and the environment; (2) compliance with applicable or relevant and appropriate requirements (ARARs); (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance.

1.2 HLW Tank Systems Closure Plan

SCDHEC has issued three Industrial Wastewater Treatment System construction/operating permits associated with the F- and H-Area Tank Farms. SCDHEC Permit No. 17,424-IW addresses the entire tank farm with the exception of Tanks 16 and 50. Tank 50 and the H/Z interarea transfer pipeline are under permit Nos. 14,520 and 14,338, respectively. Due to past releases, Tank 16 was not included in the wastewater operating permits. However, because the application of a consistent closure methodology is appropriate for all HLW tank systems, Tank 16 will be closed under this plan. Figure 1-1 shows the sequence of steps in the closure process.

The remainder of this plan is organized as follows:

- Chapter 2 describes the F- and H-Area Tank Farm components of the HLW system and identifies the elements of the tank farms that this closure plan covers; Chapter 3 describes the environmental setting of the tank systems; Chapter 4 describes the waste removal and stabilization processes for the tank systems and the methods by which DOE will use tank-specific performance objectives and other factors (e.g., other environmental requirements, technical feasibility, cost) to select an appropriate closure option; Chapter 5 identifies the regulatory standards and guidance applicable to closure of the tank systems; and Chapter 6 describes the methodology for establishing tank-specific performance objectives for closure and dose apportionment through the use of groundwater transport segments including fate and transport modeling.

- Appendix A presents DOE's evaluation of major alternatives considered for removing wastes from the HLW tank systems, and for stabilizing the tank systems and associated residual wastes. Appendix B provides DOE's anticipated schedule for closure of HLW tank systems. Appendix C summarizes the process to identify pertinent environmental regulatory requirements and guidance and the resulting overall performance objectives for HLW tank system closures. Appendix D provides an example of the fate and transport modeling that could be used to determine tank-specific performance objectives. In this example, F-Area Tanks 17 through 20 were modeled. Appendix E presents an example of the process of apportioning overall performance objectives to determine tank-specific performance objectives and the calculation of residual contamination left in Tank 20 corresponding to the tank-specific performance objective.

1.3 References

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.

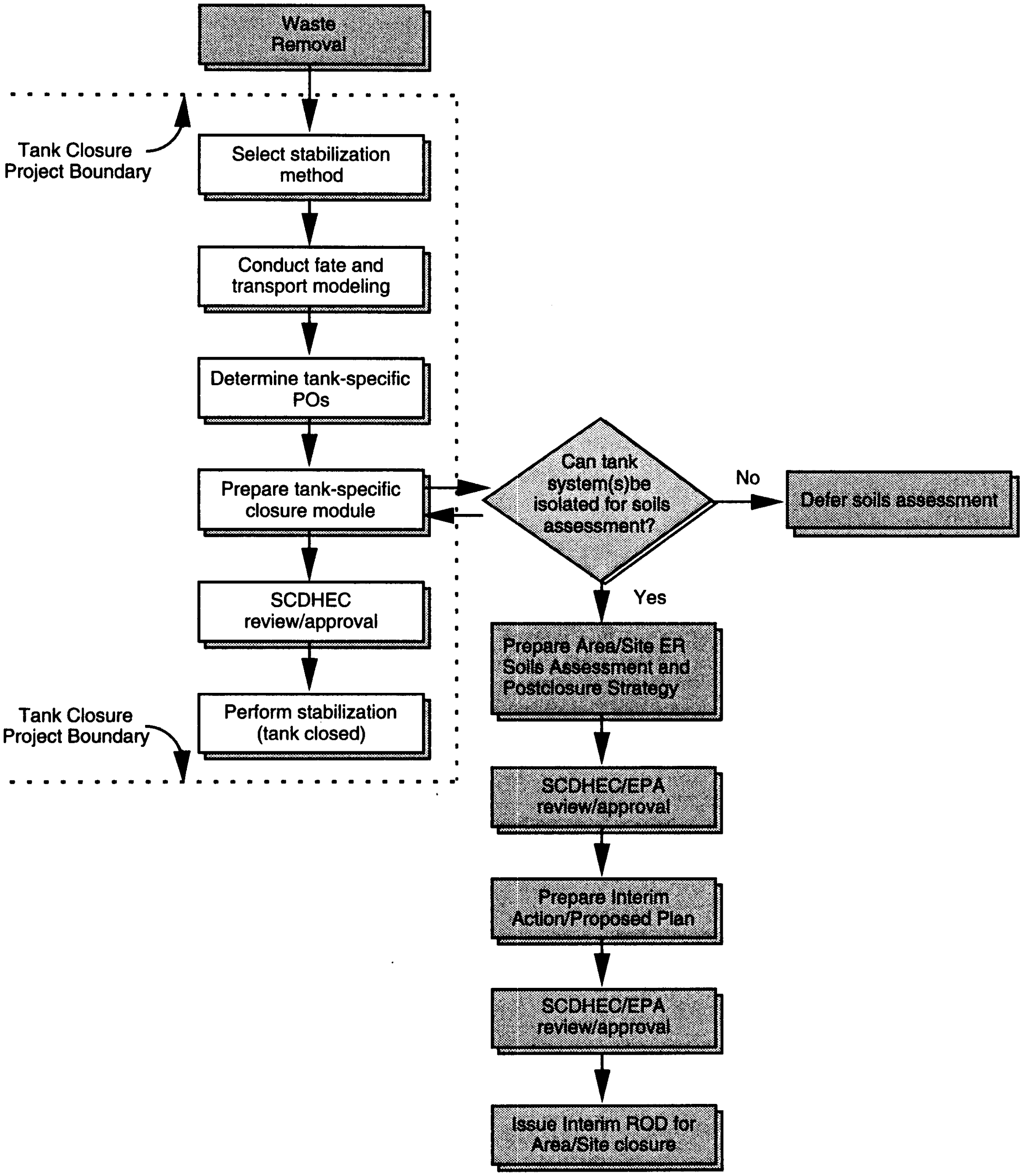

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Figure 1-1. Summary of HLW tank closure process.

CHAPTER 2. HIGH-LEVEL WASTE SYSTEM

A legacy of the SRS mission was the generation of high-level radioactive waste. Since the beginning of SRS operations, an integrated management system, the "High-Level Waste System," consisting of several facilities designed for the overall processing of liquid high-level radioactive waste has evolved. Two of the major components of this system are the F- and H-Area High-Level Waste (HLW) Tank Farms, which are (Figure 2-1), near the center of the site in F- and H-Areas where plutonium, uranium, and other radionuclides were separated from irradiated fuel and target assemblies using chemical separations processes. The tank farms, which store and process HLW from the chemical separations process, include the following facilities and structures: tank systems, evaporators, transfer systems, the In-Tank Precipitation (ITP) Facility, and sludge processing tanks.

The F- and H-Area Tank Farms are in the central portion of the SRS, as shown on Figure 2-1. The tank farm sites were chosen because of their favorable terrain, proximity to the F- and H-Area Separations Facilities (the major waste generating sources), and isolation distance (at least approximately 5.5 miles) from the SRS boundaries. Figure 2-2 shows the setting of the F- and H-Areas and associated tank farms.

The F-Area Tank Farm is a 22-acre site consisting of 22 waste tanks, 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure 2-3 shows the general layout of F-Area Tank Farm.

The H-Area Tank Farm is a 45-acre site consisting of 29 waste tanks, 2 evaporator systems and the Replacement High Level Waste Evaporator (RHLWE, under construction), the ITP process building and associated equipment, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure 2-4 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 or ion exchange. 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). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal.

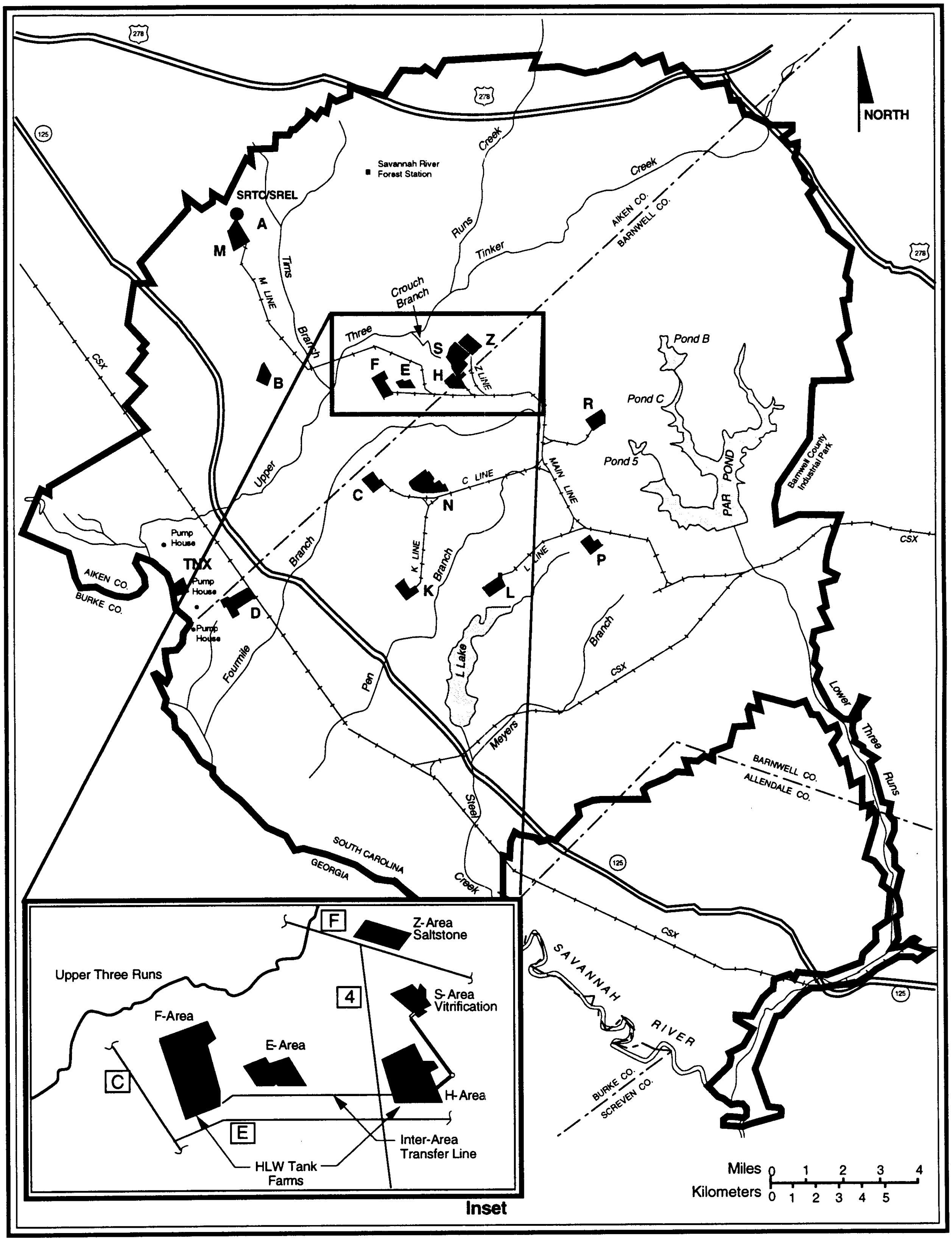

Figure 2-1. SRS map with F- and H-Areas highlighted.

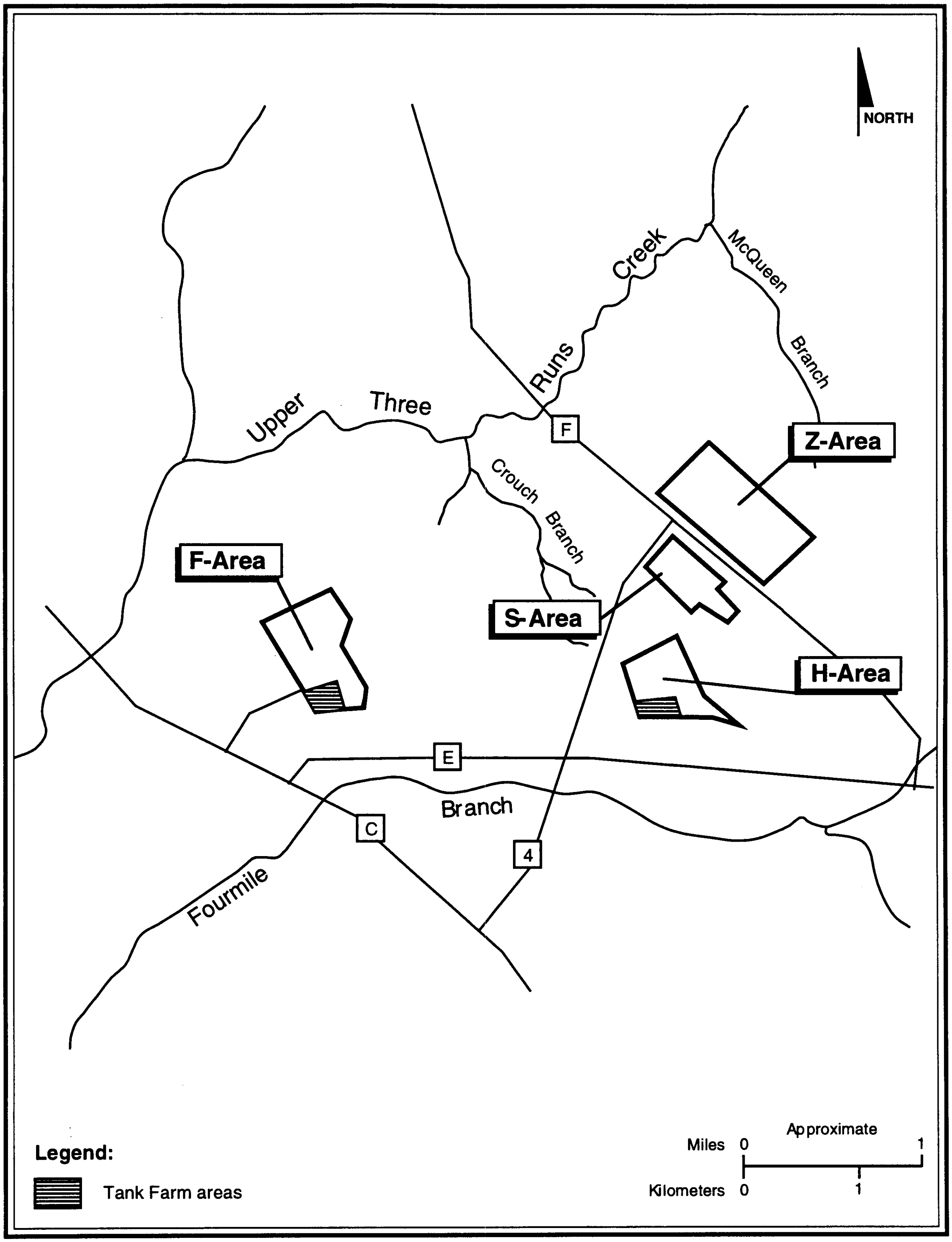

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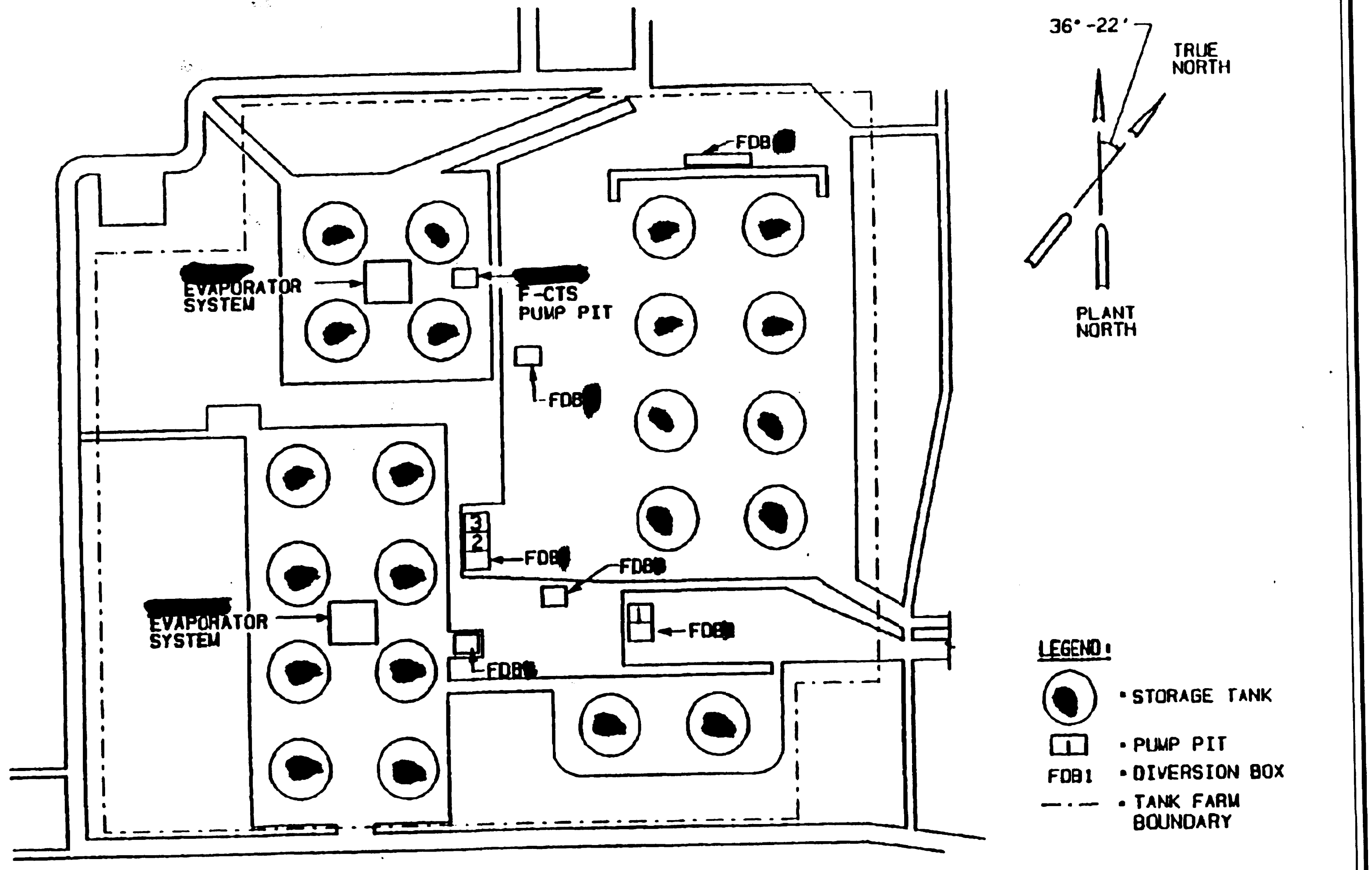
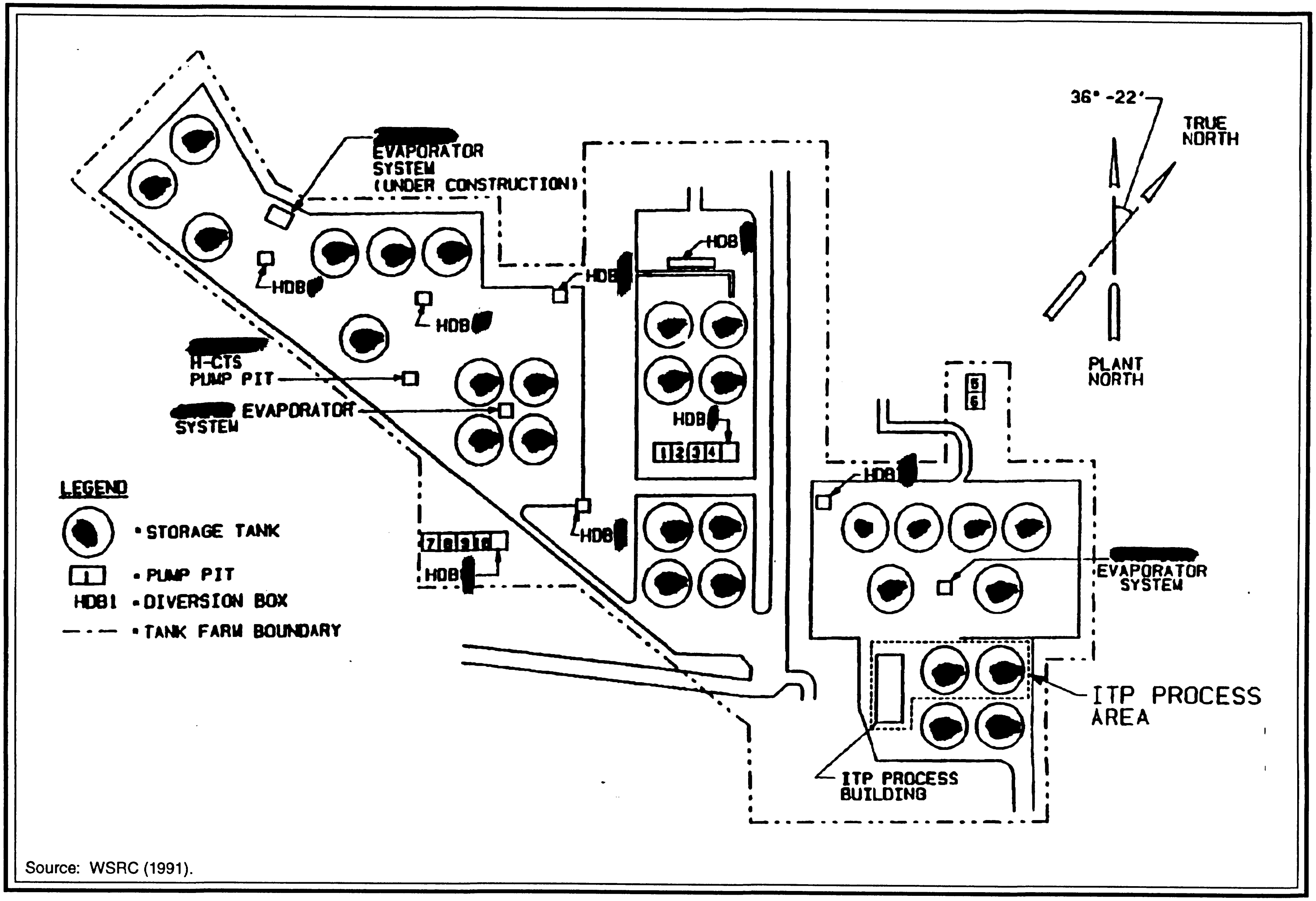
Figure 2-2. F- and H-Tank Farm areas.



Source: WSRC (1991).

Figure 2-3. General layout of F-Area Tank Farm.



Source: WSRC (1991).

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Figure 2-4. General layout of H-Area Tank Farm.

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
- Four existing evaporator systems and one additional evaporator system currently under construction 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
- Sludge washing system (i.e., Extended Sludge Processing) to pretreat the accumulated sludge prior to immobilization at the DWPF Vitrification Facility

Sections 4.0 and 7.0 of the *As-Built Construction Permit Application for an Industrial Wastewater Treatment Facility for the F- and H-Area Radioactive Waste Tank Farms* (WSRC 1991) contain detailed descriptions and discussion of the tank farm equipment.

2.1 Tanks

The F- and H-Area tanks are of four different designs, all constructed of carbon-steel, inside of reinforced concrete containment vaults. Table 2-1 summarizes information about the tanks. Two designs (Types I and II) have 5-foot-high secondary annulus “pans” and forced cooling (Figure 2-5). The 12 Type I tanks (Tanks 1 through 12) were built in 1952 and 1953, 5 of which (Tanks 1, 9 through 12) have known leak sites in which waste leaked from the primary containment to the secondary containment. The leaked waste is kept dry by air circulation, and there is no evidence that the waste has leaked from the secondary containment. The 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.

Table 2-1. Waste tank usage.[a]

Tank number	Design type	Location	Year constructed	First used	Current usage
1[b]	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
2	I	F	1952	1955	Inactive, HHW/LHW salt cake tank
3	I	F	1952	1954	Inactive, HHW/LHW salt cake tank
4	I	F	1952	1961	Inactive, HHW sludge and salt cake tank
5	I	F	1952	1959	Inactive, HHW sludge tank
6	I	F	1952	1964	Inactive, HHW sludge tank
7	I	F	1952	1954	Occasional waste receipt (i.e., F-Area Catch Tank), HHW/LHW sludge tank
8	I	F	1952	1958	Inactive, LHW sludge tank
9[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
10[b]	I	H	1953	1955	Inactive, HHW/LHW salt cake tank
11[b]	I	H	1953	1955	Inactive, HHW sludge tank
12[b]	I	H	1953	1956	Inactive, HHW sludge tank
13[b]	II	H	1956	1959	HHW evaporator feed tank (contains HHW sludge)
14[b]	II	H	1956	1957	Inactive, HHW sludge and salt cake tank
15[b]	II	H	1956	1960	Inactive, HHW/LHW sludge tank
16[b]	II	H	1956	1960	Tank is empty, HHW supernate removed, tank interior cleaned out, initial annulus cleaning complete; this tank is not covered by the industrial wastewater permit
17	IV	F	1958	1961	Inactive, LHW supernate and salt removed, residual LHW remains
18	IV	F	1958	1958	Inactive, LHW supernate removed, residual LHW sludge remains
19	IV	F	1958	1961	Inactive, LHW supernate removed, residual LHW sludge and salt remains (most of the tank sludge consists of spent CRC ion exchange resin)
20[b]	IV	F	1958	1960	Inactive, LHW supernate and salt removed, residual LHW sludge remains
21	IV	H	1961	1961	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
22	IV	H	1962	1965	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters
23	IV	H	1962	1963	LHW supernate removed, residual LHW sludge remains; may be used to hold dilute solutions or recycle wastewaters

Table 2-1. (continued).

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

Table 2-1. (continued).

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

a. Source: WSRC (1991).
b. Has one or more known cracks in primary tank shell.

The four Type II Tanks (Tanks 13 through 16) were built in 1956 in the H-Area Tank Farm (Figure 2-5). 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) and migrated into the surrounding soil. Waste removal from the Tank 16 primary vessel was completed in 1980. However, the waste that leaked into the annulus has not been removed. These tanks are above the seasonal high water table.

The fourth design (Type IV) has a single steel wall and does not have forced cooling (Figure 2-5). The eight Type IV Tanks (Tanks 17 through 24) were built between 1958 and 1962. Tanks 17 through 20 are in the F-Area Tank Farm and Tanks 21 through 24 are in H-Area. Tank 20 has known cracks that are believed to have been caused by groundwater corrosion of the tank wall. Small amounts of groundwater have leaked into this tank; there is no evidence that waste has leaked out. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original basemat under the tank area.

The newest design (Type III) has a full-height secondary tank and forced water cooling (Figure 2-5). All of the Type III tanks (25 through 51) are above the water table. These tanks were placed in service between 1969 and 1986. None of them has known leak sites.

DOE intends to remove from service by 2028 and close all tank systems that have experienced leaks or do not have full-height secondary containment. Thus, the 24 Type I, II, and IV tanks will be removed from service while the 27 Type III tanks will remain in service until there is no further need for the tanks.

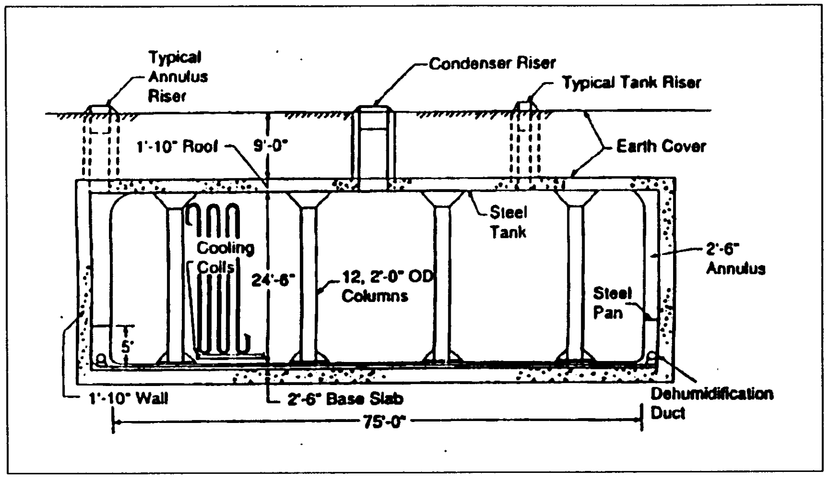

Figure 2-5.A. Cooled Waste Storage Tank, Type I (Original 750,000 Gallons)

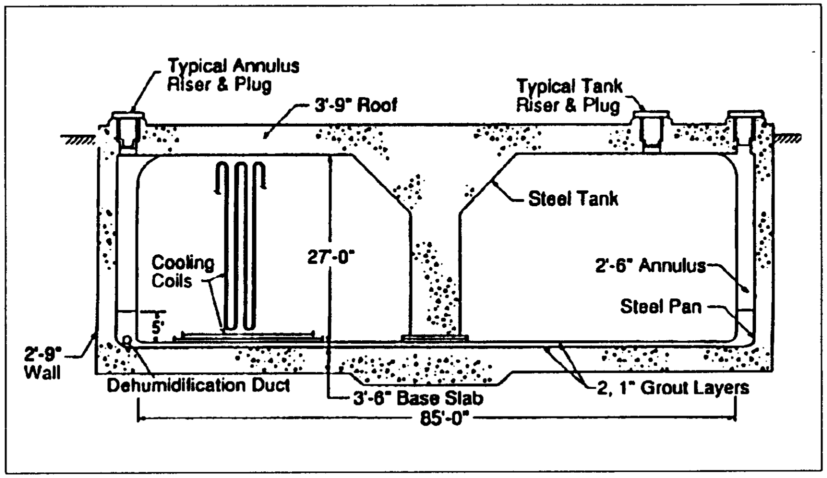

Figure 2-5.B. Cooled Waste Storage Tank, Type II (1,030,000 Gallons)

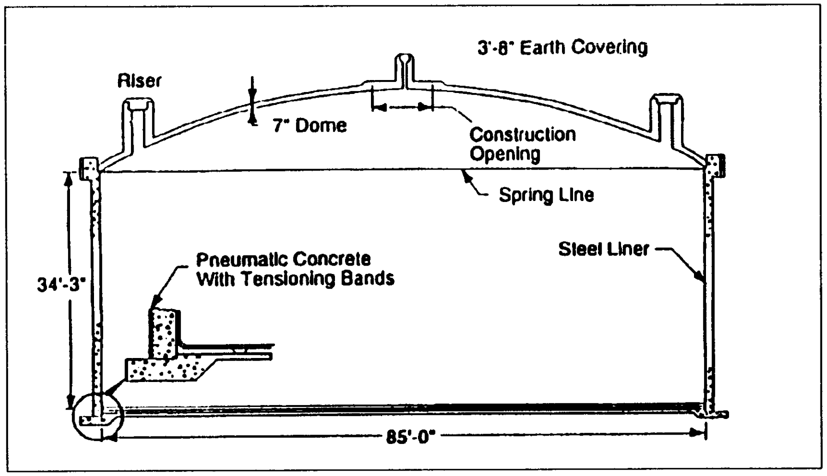

Figure 2-5.C. Uncooled Waste Storage Tank, Type IV (Prestressed Concrete Walls, 1,300,000 Gallons)

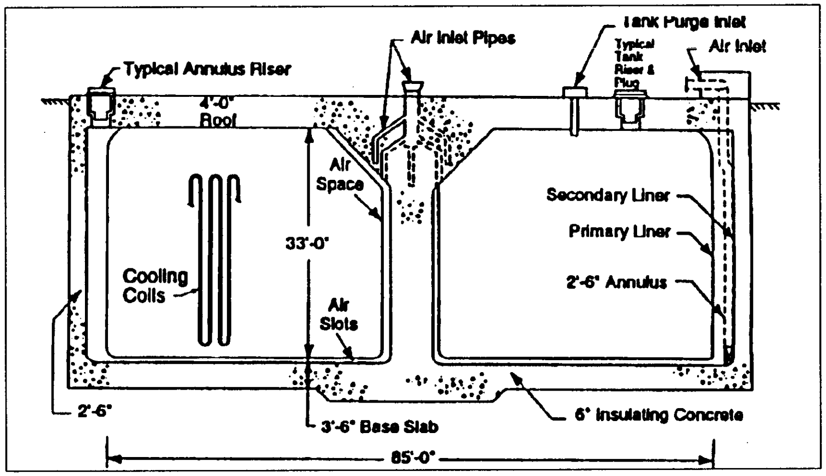

Figure 2-5.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 Gallons)

Source: WSRC (1991).

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Figure 2-5. Tank configurations.

2.2 Evaporator Systems

Each tank farm has two single-stage, bent-tube evaporators that concentrate waste following receipt from the canyons. At present, two evaporators are operating, one in each tank farm. An additional evaporator system, the Replacement High-Level Waste Evaporator (RHLWE), is being built in H-Area. Each operating evaporator is made of stainless steel and operates at near atmospheric pressure under alkaline conditions. The evaporators are 8 feet in diameter and have an operating capacity of approximately 1,800 gallons. The RHLWE is being fabricated of INCO alloy G3 to allow higher design temperatures; it will have 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 (ETF) for final treatment before being discharged to Upper Three Runs Creek. 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.

2.3 Transfer System

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

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

2.4 Precipitation/Filtration System

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

2.5 Sludge Washing System

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

2.6 References

WSRC (Westinghouse Savannah River Company), 1991, *As-Built Construction Permit Application for an Industrial Wastewater Treatment Facility for the F/H-Area High-Level Radioactive Waste Tank Farms*, Aiken, South Carolina, Rev. 0, April 16.

CHAPTER 3. ENVIRONMENTAL CONDITIONS

This chapter describes the affected environment of the F- and H-Area Tank Farms. The information emphasizes the environmental features of the F- and H-Areas that are important in the performance evaluation for the tank system closure discussed in Chapter 4. The affected environment is addressed in the following subsections: Land Use and Demographics, Geology and Soils, Groundwater, Surface Water, Biota, Air Quality, and Other Resources. Most of the information is from existing Savannah River Site (SRS) documents (EISs, SARs, hydrogeologic studies, etc.) that address the F- and H-Areas.

3.1 Land Use and Demographics

3.1.1 LAND USE

The SRS is in south-central South Carolina (Figure 3-1), 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 18 production, service, and research and development areas (Figure 3-2). The production facilities occupy less than 10 percent of the SRS area; the remainder of the site is undeveloped forest or wetlands (Parsons 1996).

As described in the Safety Analysis Report for the Savannah River Site (WSRC 1995a), the F- and H-Areas are in the north-central portion of the SRS, bounded by Upper Three Runs Creek to the north and Fourmile Branch to the south. The two separations areas, F and H (Figures 3-3 through 3-5), occupy 364 and 395 acres, respectively. Land use within the F-and H-Areas is classified as heavy industrial. All the land within a 5-mile radius of these areas is entirely inside the SRS boundaries and is either industrial or forest land (DOE 1994a).

DOE assumes that the SRS defense processing and environmental management areas (the area between Fourmile Branch and Upper Three Runs Creek) would continue to be under institutional control for the next 100 years and, after that, the area would be zoned industrial for an indefinite period with deed restrictions on the use of the groundwater (DOE 1996). For the purposes of this closure plan and the modeling used to support its conclusions, DOE assumes that the area directly on the opposite side (the south side) of Fourmile Branch would be available for residential use (DOE 1996).

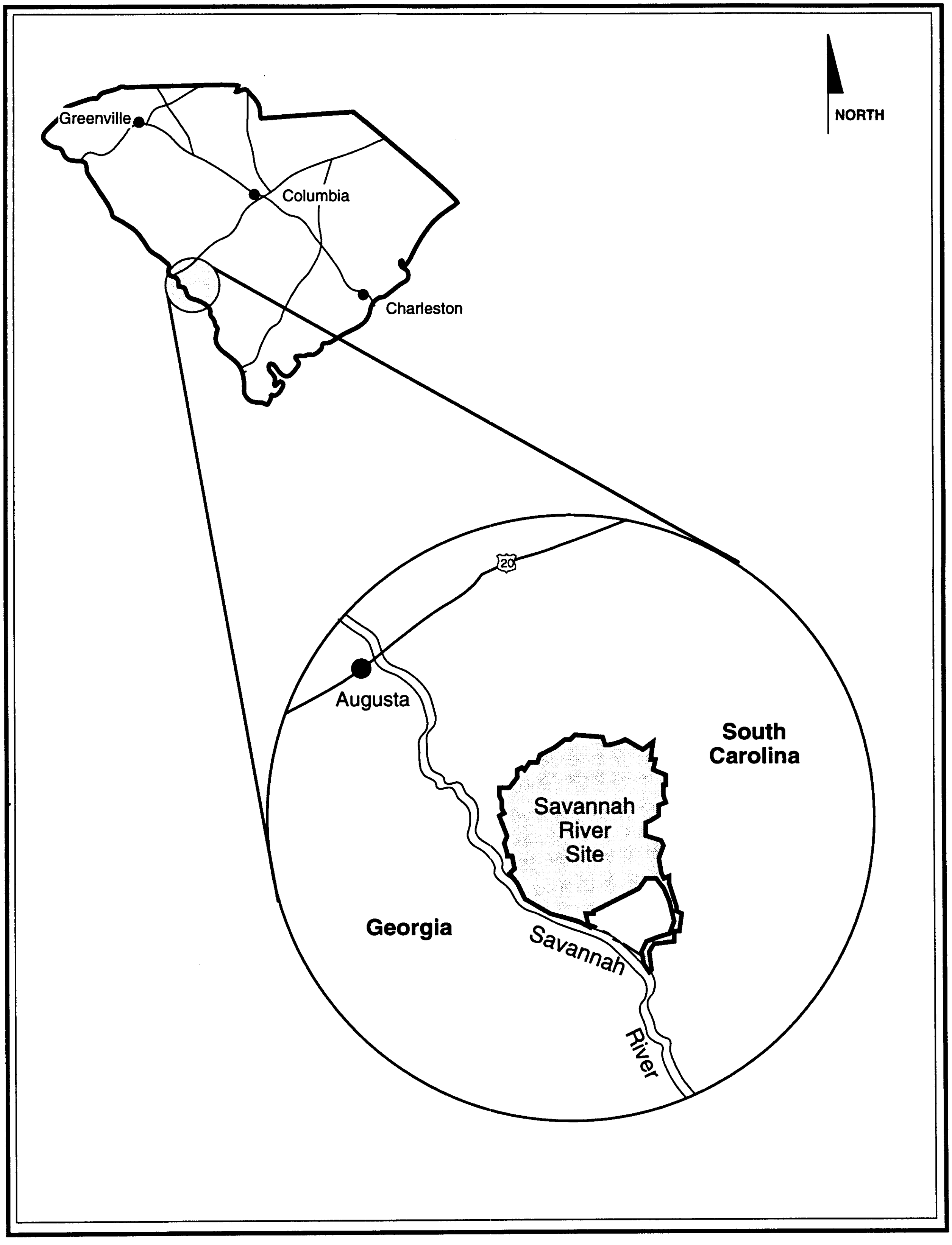

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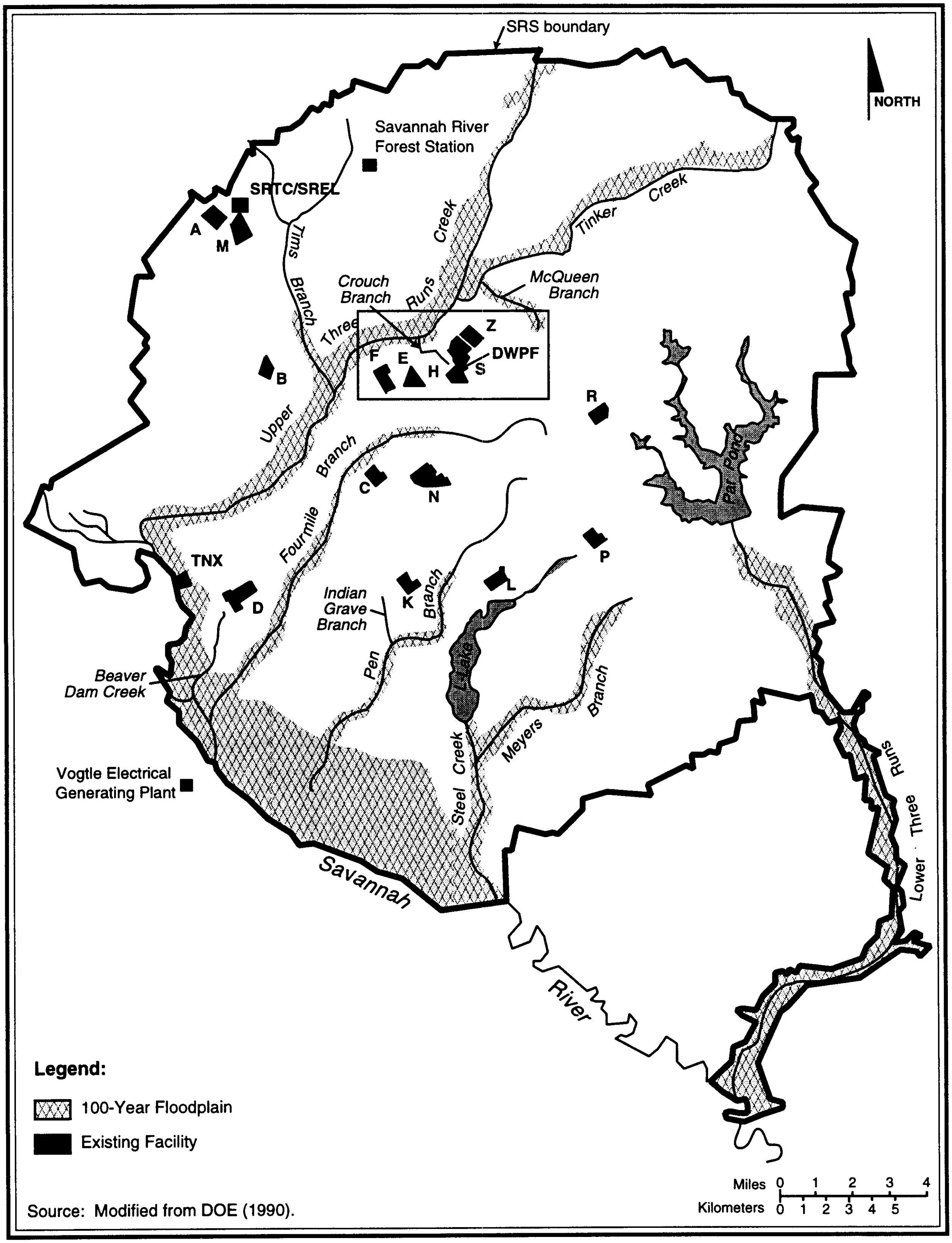
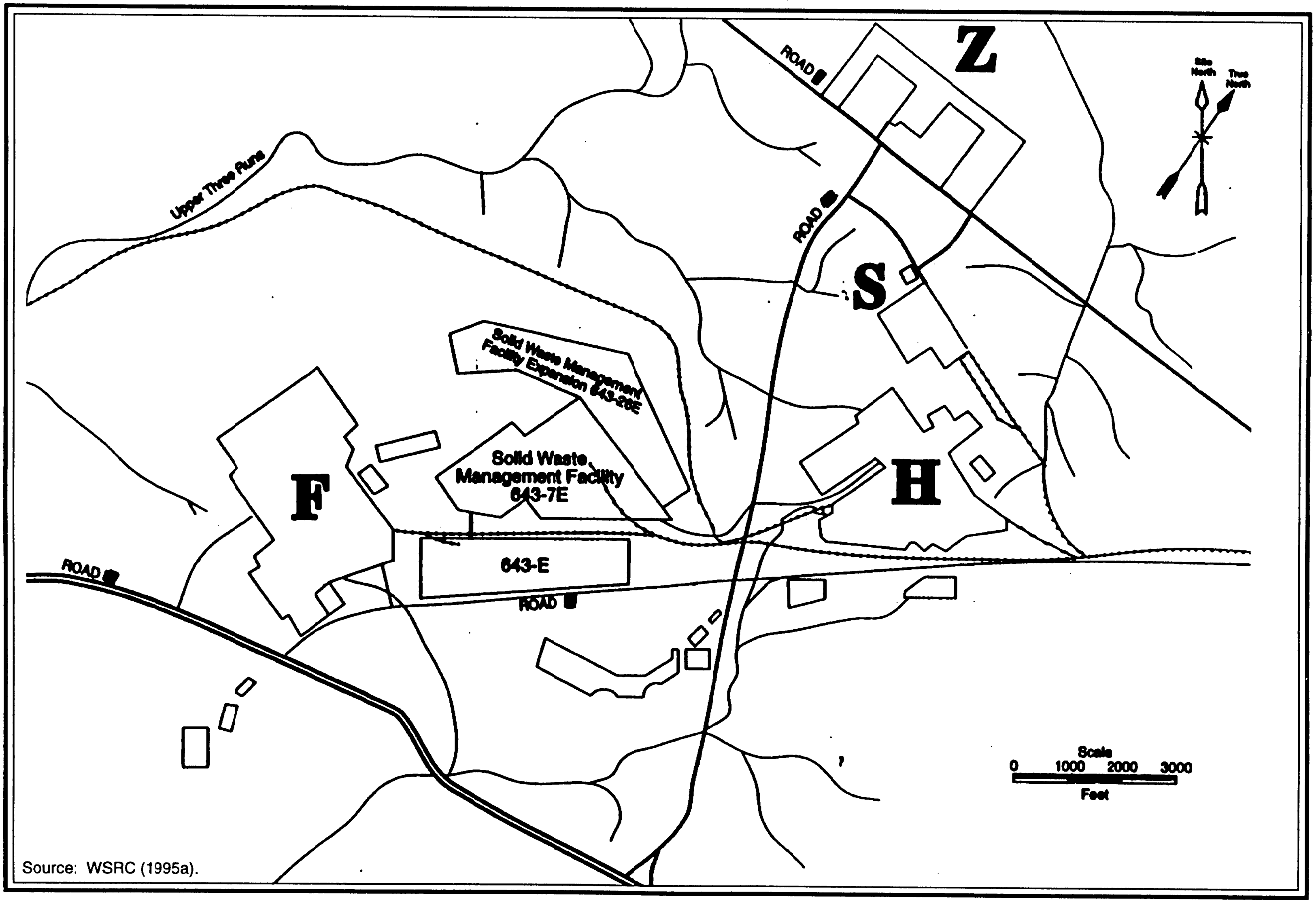
Figure 3-1. Savannah River Site location.



Source: Modified from DOE (1990).

Figure 3-2. Major facilities and stream systems at the Savannah River Site.



Source: WSRC (1995a).

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Figure 3-3. F-, H-, S-, and Z-Areas map.

3.1.2 DEMOGRAPHICS

There are no performance objectives for collective radiation dose (population dose) to members of the public pertinent to the HLW tank system closure. Therefore, demographic information is not used in the modeling to support this plan. However, if there were to be a performance objective limiting collective radiation dose, demographic data would be needed to assess compliance with this objective. Therefore, the following paragraphs present recent population information.

Within a 50-mile radius of the center of the SRS is a total resident population of approximately 730,000. One major urban center, Augusta, Georgia (1990 population of 44,639) (renamed Augusta-Richmond County in 1995 with a population greater than 150,000), is about 25 miles west-northwest of the site. Four other cities within the 50-mile radius had 1990 populations greater than 13,000: Aiken, South Carolina, about 20 miles north-northwest; Orangeburg, South Carolina, 48 miles east-northeast; North Augusta, South Carolina, 23 miles northwest; and Evans, Georgia, about 35 miles west-northwest of the site. All other cities and towns have populations less than 7,000, the largest being Belvedere, South Carolina, followed by Red Bank, South Carolina, Waynesboro, Georgia, and Barnwell, South Carolina (WSRC 1995a). Table 3-1 lists the sizes and locations of cities and towns within the 50-mile radius.

The industrial population, consisting primarily of the SRS work force, Vogtle Electric Generating Plant employees, and employees of 16 smaller industries located in or near Barnwell, Williston, New Ellenton, and Jackson, South Carolina, comprise a daily transient population of approximately 25,734. Most of this total population works Monday through Friday from about 8:00 a.m. to 4:00 p.m. These workers spend an average of about 45 hours per week at the worksite. The industrial population within a 5-mile radius of F- and H-Areas consists entirely of SRS employees at A-/M-, B-, C-, N-, E-, F-, H-, K-, R-, S-, and Z-Areas (WSRC 1995a). The November 1992 workforce, by area, is listed in Tables 3-2 and 3-3. Figure 3-6 shows the locations of these areas on the SRS.

3.2 Geology and Soils

3.2.1 GEOLOGY

SRS is on the Aiken Plateau, which is bounded by the Savannah and Congaree Rivers and extends from the fall line to the Orangeburg Scarp. The highly dissected surface of the Aiken Plateau is characterized by broad interfluvial areas with narrow, steep-sided valleys. Local relief is as much as 300 feet. The plateau is generally well drained, although many poorly drained sinks and depressions exist (WSRC 1995b).

Table 3-1. Incorporated cities and towns within 50 miles of the SRS center.

Population center	County	State	Distance	Sector	Population (1990)
Augusta	Richmond	GA	25.0	WNW	44,639
Aiken	Aiken	SC	19.5	NNW	20,386
North Augusta	Aiken/Edgefield	SC	23.4	NW	15,691
Orangeburg	Orangeburg	SC	47.5	ENE	13,772
Evans	Columbia	GA	33.0	NW	13,713
Belvedere	Aiken	SC			6,133
Red Bank	Lexington	SC			5,950
Waynesboro	Burke	GA	25.8	WSW	5,701
Brookdale	McCormick	SC			5,339
Barnwell	Barnwell	SC	16.4	ESE	5,255
Clearwater	Aiken	SC			4,731
Allendale	Allendale	SC	27.3	SE	4,410
Batesburg	Lexington/Saluda	SC	43.3	N	4,082
Bamberg	Bamberg	SC	35.2	E	3,843
Millen	Jenkins	GA	31.6	SW	3,808
Denmark	Bamberg	SC	28.9	E	3,762
Grovetown	Columbia	GA	34.2	WNW	3,596
Wilkinson Heights	Orangeburg	SC			3,394
Williston	Barnwell	SC	15.0	ENE	3,099
Hampton	Hampton	SC	41.3	SE	2,997
Sylvania	Screven	GA	37.0	S	2,871
Edisto	Orangeburg	SC			2,815
Saluda	Saluda	SC	49.7	N	2,798
Gloverville	Aiken	SC			2,753
Blackville	Barnwell	SC	22.2	ENE	2,688
Johnston	Edgefield	SC	38.9	NNW	2,688
New Ellenton	Aiken	SC	9.4	NNW	2,515
Edgefield	Edgefield	SC	38.8	NNW	2,563
Hephzibah	Richmond	GA	26.6	W	2,466
Louisville	Jefferson	GA	48.6	WSW	2,429
Wrens	Jefferson	GA	43.8	W	2,414
South Congaree	Lexington	SC			2,406
Estill	Hampton	SC	43.6	SSE	2,387
Fairfax	Allendale	SC	32.8	SE	2,312
Harlem	Columbia	GA	40.0	WNW	2,199
Leesville	Lexington	SC	44.8	N	2,025
Varnville	Hampton	SC	44.8	SE	1,970
Pineridge	Lexington	SC			1,731
Jackson	Aiken	SC	9.4	WNW	1,681
McCormick	McCormick	SC			1,659
Sardis	Burke	GA	22.7	SSW	1,116
Branchville	Orangeburg	SC	47.7	E	1,107
Gaston	Lexington	SC	48.4	NE	984
Ridge Spring	Saluda	SC	38.8	N	894

Table 3-1. (continued).

Population center	County	State	Distance	Sector	Population (1990)
North	Orangeburg	SC	38.8	NE	809
Wagener	Aiken	SC	30.0	NNE	731
Midville	Burke	GA	47.2	SW	620
Brunson	Hampton	SC	36.4	SE	587
Dearing	McDuffie	GA	44.1	WNW	547
Swansea	Lexington	SC	44.5	NE	527
Springfield	Orangeburg	SC	25.8	NE	523
Burnettown	Aiken	SC	25.0	NNW	493
Salley	Aiken	SC	27.5	NE	451
Ehrhardt	Bamberg	SC	38.8	ESE	442
Neeses	Orangeburg	SC	34.5	ENE	410
Hilltonia	Screven	GA	27.7	S	402
Norway	Orangeburg	SC	31.7	ENE	401
Olar	Bamberg	SC			391
Hilda	Barnwell	SC	23.0	E	342
Pelion	Lexington	SC	40.3	NE	336
Stapleton	Jefferson	GA	48.3	W	330
Gilbert	Lexington	SC	46.4	NNE	324
Rowesville	Orangeburg	SC	47.2	E	316
Trenton	Edgefield	SC	33.6	NNW	303
Newington	Screven	GA	48.9	S	319
Gifford	Hampton	SC	37.8	SE	313
Blythe	Burke	GA	32.3	W	297
Monetta	Aiken/Saluda	SC	39.4	N	285
Kline	Barnwell	SC	20.6	ESE	285
Furman	Hampton	SC	49.5	SSE	260
Summit	Lexington	SC	45.9	NNE	242
Perry	Aiken	SC	30.3	NE	241
Elko	Barnwell	SC	16.4	ENE	214
Sycamore	Allendale	SC			208
Woodford	Orangeburg	SC	40.6	NE	200
Rocky Ford	Screven	GA	43.9	SSW	197
Girard	Burke	GA	17.5	SSW	195
Parksville	McCormick	SC	48.1	NE	193
Williams	Colleton	SC	49.5	ESE	188
Scotia	Hampton	SC	48.0	SSE	182
Livingston	Orangeburg	SC	47.7	ENE	171
Lodge	Colleton	SC	42.7	ESE	147
Smoaks	Colleton	SC	50.0	ESE	142
Cordova	Orangeburg	SC	43.1	ENE	135
Ward	Saluda	SC	25.6	N	132
Snelling	Barnwell	SC	11.3	ESE	125
Cope	Orangeburg	SC	37.3	E	124

Table 3-2. Peak daytime onsite population within a 5-mile radius of F-Area.

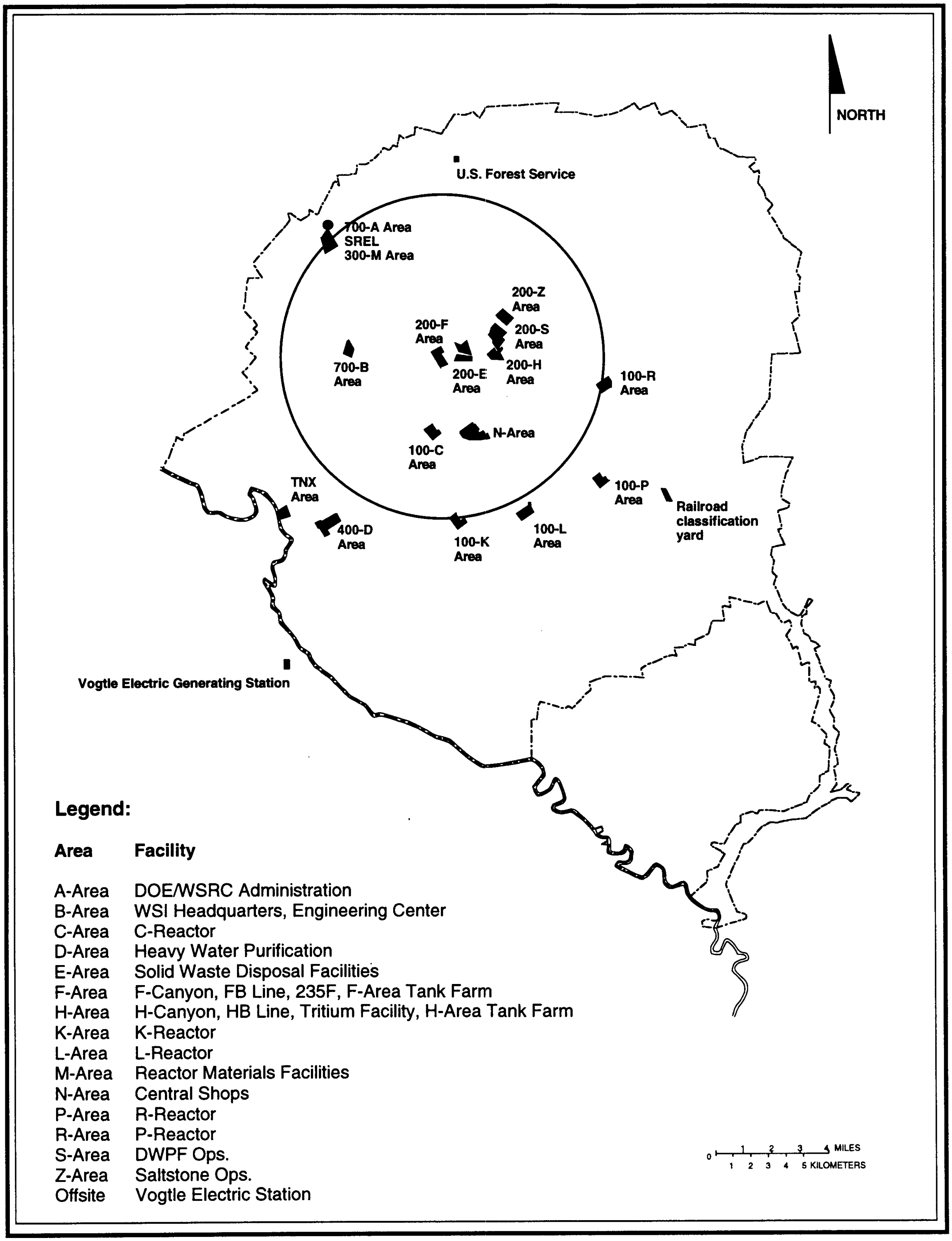
Location	November 1992 population
A- and M-Areas (including G-Area)	7,736
B-Area	612
C-Area	831
N-Area (Central Shops)	1,456
E-Area	66
F-Area	2,027
H-Area	3,044
K-Area	1,111
S-Area	1,192
Z-Area	245

Source: East (1993).

Table 3-3. Peak daytime onsite population within a 5-mile radius of H-Area.

Location	November 1992 population
B-Area	612
C-Area	831
N-Area (Central Shops)	1,456
E-Area	66
F-Area	2,027
H-Area	3,044
R-Area	0
S-Area	1,192
Z-Area	245

Source: East (1993).



Legend:

Area	Facility
A-Area	DOE/WSRC Administration
B-Area	WSI Headquarters, Engineering Center
C-Area	C-Reactor
D-Area	Heavy Water Purification
E-Area	Solid Waste Disposal Facilities
F-Area	F-Canyon, FB Line, 235F, F-Area Tank Farm
H-Area	H-Canyon, HB Line, Tritium Facility, H-Area Tank Farm
K-Area	K-Reactor
L-Area	L-Reactor
M-Area	Reactor Materials Facilities
N-Area	Central Shops
P-Area	R-Reactor
R-Area	P-Reactor
S-Area	DWPF Ops.
Z-Area	Saltstone Ops.
Offsite	Vogtle Electric Station

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Figure 3-6. SRS Areas within a 5-mile vicinity of F-Area.

The surface of the Upper Atlantic Coastal Plain Province, on which the Aiken Plateau is located, slopes gently seaward. This province is underlain by a southeastern dipping wedge of unconsolidated and semiconsolidated sediments that extends and progressively thickens from the fall line (separates the Piedmont Plateau from the Atlantic Coastal Plain) southeastward to the edge of the continental shelf. The stratigraphic section underlying SRS ranges from approximately 200 feet to more than 1,200 feet of mostly unconsolidated sands, clayey sands, sandy clays, and clays.

A more complete description of the geology and soils of the F- and H-Areas can be found *in Geology and Hydrogeology of the Savannah River Site* (WSRC 1993a) and in a report titled *Hydrogeologic Framework of West-Central South Carolina* (SCDNR 1995). The latter report, prepared by the State of South Carolina Department of Natural Resources, focuses on SRS and compares the chronostratigraphic, lithostratigraphic, and hydrostratigraphic units in the SRS region.

3.2.2 LOCAL GEOLOGY AND SOILS

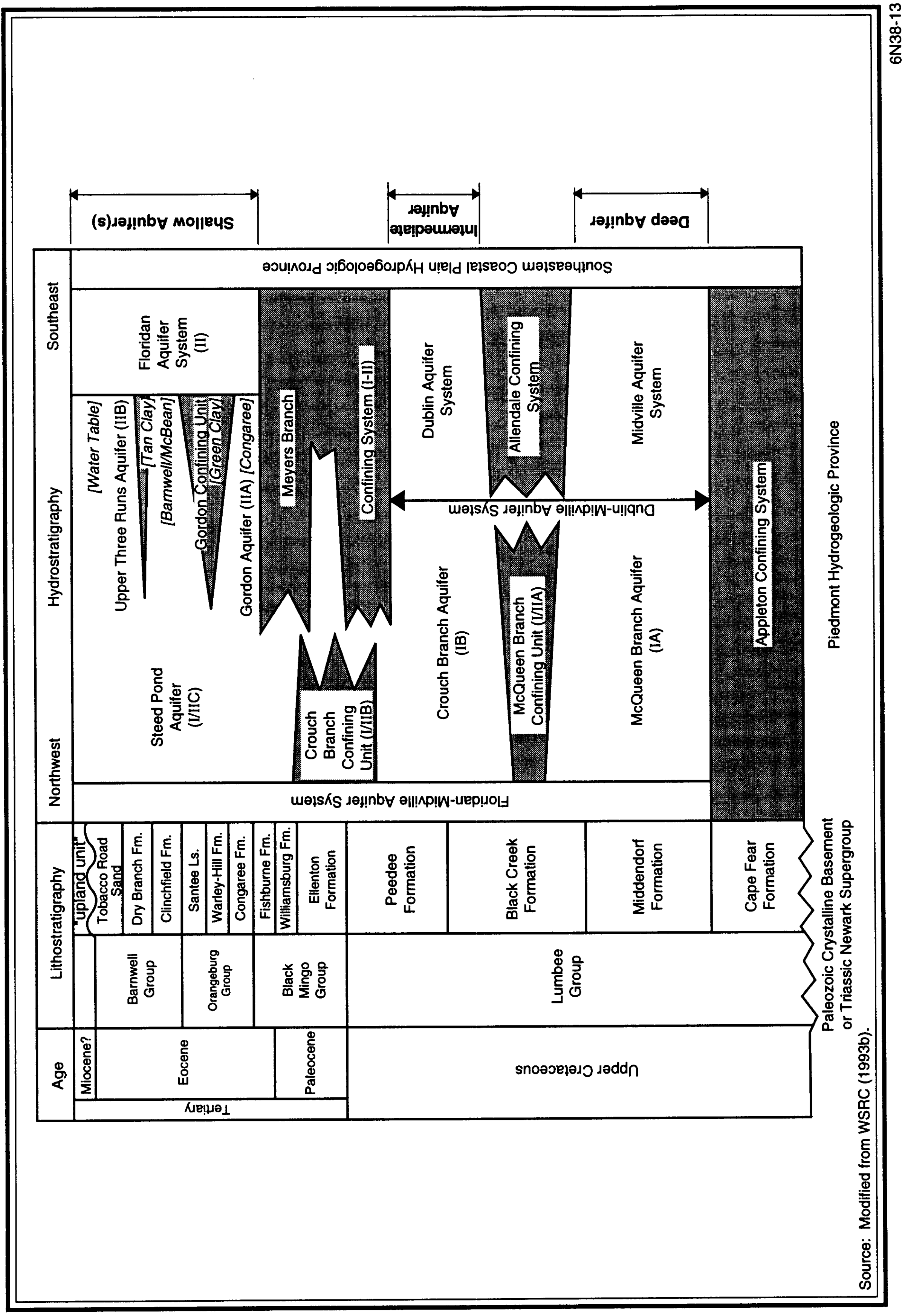
The principal surface and near-surface soils in F- and H-Areas are clayey sands averaging about one-third clay. These soils have demonstrated a good retention capacity for most radionuclides (Parsons 1996). A significant portion of the surface soils around the F- and H-Area Tank Farms are composed of backfill that resulted during excavation and construction activities. The vadose zone is comprised of the Upland Unit, which extends over much of SRS. This formation contains predominantly red-brown to yellow-orange, coarse to fine sand, and silty clay with localized gravel lenses. The thickness of the Upland Unit ranges from 16 feet to 40 feet in the vicinity of the F- and H-Area Seepage Basins (WSRC 1991), which are southwest and west of the F- and H-Area Tank Farms, respectively.

A notable feature of the Upland Unit sandy clay is its compositional variability (Figure 3-7). Lenses of clay, sand, and sandy clay occur throughout the layer. The unit is traversed by small-scale joints and fractures, both of which are commonly filled with sand or silt. The soils at F- and H-Areas are 20 to 40 percent clay. The dominant clay mineral is kaolinite, with small amounts of other clays and weathered mica (WSRC 1991).

3.3 Groundwater

3.3.1 AQUIFER UNITS

According to the SRS Waste Management EIS (DOE 1995), the most important hydrologic system underlying the site is the Southeastern Coastal Plain Hydrogeologic Province, which overlies the Piedmont Hydrogeologic Province, in which groundwater flows through porous sands and clays.



Source: Modified from WSRC (1993b).

Figure 3-7. Comparison of lithostratigraphy and hydrostratigraphy for the SRS region.

Figure 3-7 shows the names of geologic formations based on the physical character of the rocks (lithostratigraphy) and the corresponding names used to identify their water-bearing properties (hydrostratigraphy). This figure also shows the shallow, intermediate, and deep aquifers. More detailed discussions of SRS groundwater features are available in DOE (1987) and DOE (1990).

3.3.2 GROUNDWATER FLOW

Groundwater beneath SRS flows at rates ranging from a few centimeters per year to several hundred meters per year toward streams and swamps on the site and into the Savannah River (DOE 1995). All groundwater within the State, including those at the SRS, are classified as GB water for which the State of South Carolina has set standards. South Carolina Department of Health and Environmental Control (SCDHEC) recognizes that Class GB might not be suitable for some water and has two other classifications: GA (exceptionally valuable groundwater) and GC (groundwater with little potential for use as an underground source of drinking water). The quality standards that SCDHEC has set for GB water are in R.61-58.5 B (2), and R.61-58.5 D. (2) for inorganic and organic chemicals respectively.

According to R.61-68 G. (c), items such as manmade radionuclides, priority pollutant volatile organic compounds, pesticides, herbicides, polychlorinated biphenyls, any other synthetic organic compounds not specified above, treated wastes, thermal wastes, deleterious substances, colored wastes, or other wastes or constituents thereof are not to exceed concentrations or amounts that interfere with use, actual or intended, as determined by SCDHEC. The groundwater under the tank farm is classified as GB.

The Water Table Aquifer underlies the Upland Unit and is the shallow aquifer in F- and H-Areas. Beneath the Water Table Aquifer is what is commonly referred to as the Tan Clay Layer. The Barnwell-McBean Aquifer underlies the Tan Clay Layer and is above what is known as the Green Clay Layer. The Water Table Aquifer (see Figure 3-8) was used in the groundwater modeling simulations.

At SRS groundwater movement is controlled by the depths of the incisions of creeks and streams where water discharges to the surface. The valleys of the smaller perennial streams collect discharge from the shallow aquifers such as the Water Table and Barnwell/McBean Aquifers. Groundwater in the intermediate aquifer flows to Upper Three Runs Creek or to the Savannah River. Groundwater in the deep aquifer beneath SRS flows toward the Savannah River or to the southeast toward the coast. In many areas of the site, groundwater flow is upward, from the lower to the upper parts of the shallow aquifer and from the intermediate aquifer to the lower part of the shallow aquifer. This upward flow occurs in the Separations (F- and H-) Areas (DOE 1995). The F- and H-Area Tank Farms are on a

HYDROSTRATIGRAPHIC UNIT		THICKNESS RANGE (FEET)
AQUIFER UNIT II B	ZONE II B_2 (WATER TABLE AQUIFER)	0 - 110
	CONFINING ZONE II B_1 - II B_2 (TAN CLAY)	0 - 33
	ZONE II B_1 (BARNWELL/McBEAN AQUIFER)	39 - 81
CONFINING UNIT II A - II B (GREEN CLAY)		2 - 30
AQUIFER UNIT II A (CONGAREE AQUIFER)		52 - 107
TOP OF CONFINING SYSTEM I- II B (ELLENTON CLAYS)		>100

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Figure 3-8. Hydrostratigraphic Units of the General Separations Area.

surface-water and groundwater divide; shallow groundwater outcrops into Upper Three Runs Creek and Fourmile Branch.

According to the First Quarter 1993 groundwater monitoring data of the Water Table Aquifer and the map created from the monitoring results (GSA Water Table Surface, First Quarter 1993 Data), the F-Area Tank Farm is on a near-surface groundwater divide between Upper Three Runs Creek and Fourmile Branch. As a result, the Water Table Aquifer groundwater from the southern part of the F-Area Tank Farm is thought to discharge to Fourmile Branch, approximately 5,000 feet to the southwest. The Water Table Aquifer groundwater from the northern part of F-Area Tank Farm is thought to discharge to Upper Three Runs Creek, approximately 4,500 feet to the northwest.

H-Area is also on a near-surface groundwater divide between Upper Three Runs Creek and Fourmile Branch. The Water Table Aquifer groundwater from the northern part of the H-Area Tank Farm is thought to discharge to Upper Three Runs Creek, approximately 4,000 to 12,000 feet north to northeast of the H-Area Tank Farm. The Water Table Aquifer groundwater from the southern part of H-Area Tank Farm is thought to discharge to Fourmile Branch approximately 5,000 to 15,000 feet southwest of H-Area Tank Farm. Figure 3-9 is the First Quarter 1993 Map of the Water Table Aquifer monitoring data showing the direction of F- and H-Area Tank Farm groundwater flow.

3.4 Surface Water

The Savannah River, which forms the boundary between Georgia and South Carolina, is the principal surface-water system near SRS. The river adjoins the site along its southwestern boundary for a distance of about 20 miles, and the site is 140 river miles from the Atlantic Ocean (WSRC 1995a).

Five tributaries discharge directly to the Savannah River from SRS: Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs Creek (Figure 3-2). A sixth stream, Pen Branch, which does not flow directly into the river, joins Steel Creek in the Savannah River floodplain swamp. These tributaries drain all of SRS with the exception of a small area on the northeast side, which drains to a tributary of the Salkehatchie River. Each of these six streams originates on the Aiken Plateau in the Coastal Plain and descends 100 to 200 feet before discharging into the river (DOE 1995).

The source of most of the surface water on SRS is either natural rainfall, which averages 48 inches annually, water pumped from the Savannah River and used for cooling site facilities, or groundwater discharging to surface streams (WSRC 1995a). The streams, which historically have received varying

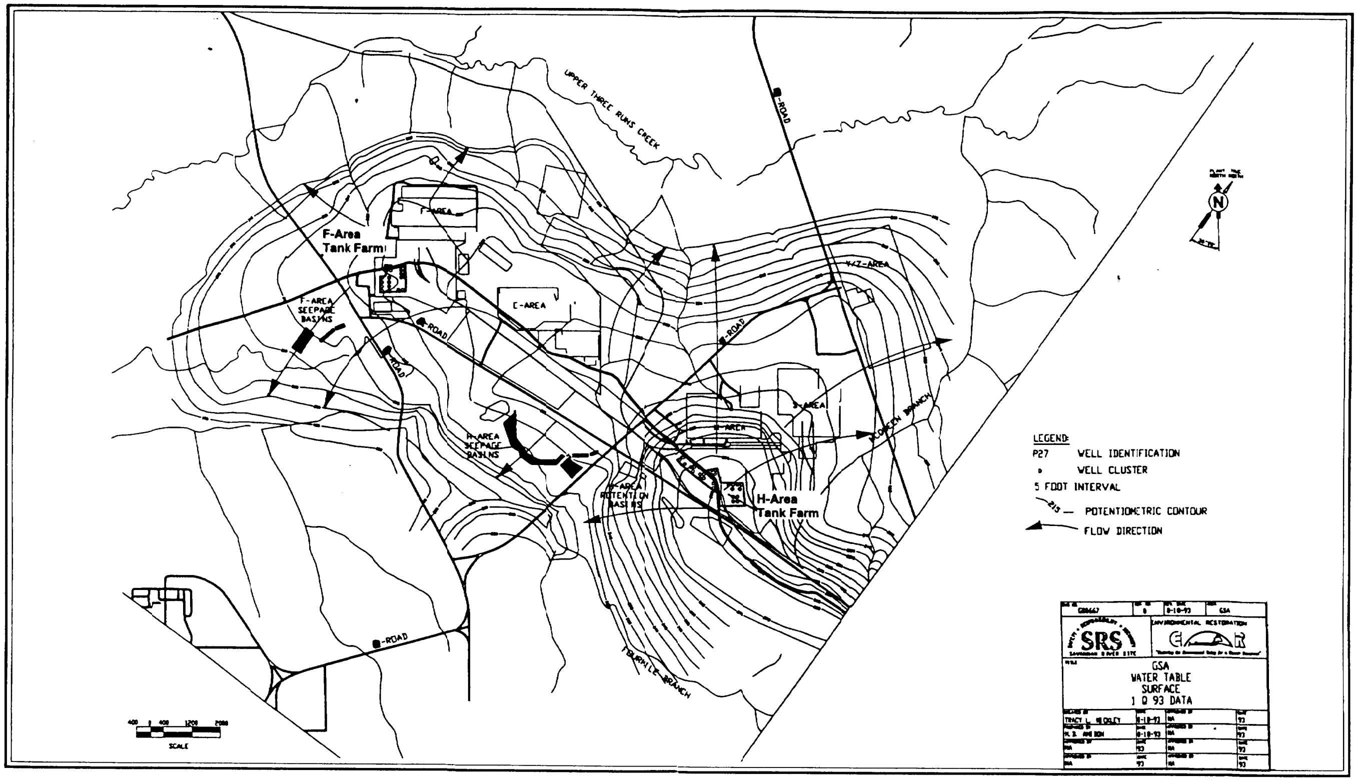


Figure 3-9. General Separations Area Water Table Aquifer surface data 1Q93.

amounts of effluent from SRS operations, are not commercial sources of water. Downstream of the SRS, the river supplies domestic and industrial water (DOE 1995).

The natural flow of SRS streams range from 11 cubic feet per second in smaller streams to 240 cubic feet per second in Upper Three Runs Creek. From 1974 to 1991, the mean flow of Upper Three Runs Creek at Road A was 239 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. The mean flow of Fourmile Branch southwest of SC Highway 125 from 1977 to 1991 was 208 cubic feet per second and the 7Q10 was 11.1 cubic feet per second (WSRC 1993b). The *SRS Ecology Environmental Information Document* (WSRC 1993b) and the *Safety Analysis Report Savannah River Site* (WSRC 1995a) contain specific information on flow rates and water quality of the Savannah River and SRS streams.

SCDHEC classifies the Savannah River and the SRS streams as "Freshwaters" in accordance with R.61-68.G(3), Water Classifications and Standards for Surface Waters (SCDHEC 1993). "Freshwaters" are described as suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with SCDHEC requirements. "Freshwaters" are suitable for fishing, for the survival and propagation of a balanced indigenous aquatic community of fauna and flora, and for industrial and agricultural uses. Associated water quality standards can be found in R.61-68.G(3) (SCDHEC 1993). Reviews of Savannah River water quality data upstream and downstream of SRS recorded during 1992 and described in the *Savannah River Site Environmental Report for 1993* (Arnett, Karapatakis, and Mamatey 1993) indicates that constituents of SRS discharges are within the guidelines for drinking water established by U.S. Environmental Protection Agency (EPA), SCDHEC, and DOE (DOE 1995).

F- and H-Areas are situated on the divide that separates the drainage into Upper Three Runs Creek (including McQueen Branch and Crouch Branch) and Fourmile Branch; approximately half of each area drains into each stream (DOE 1993). F- and H-Areas are relatively elevated areas of SRS and are centrally located inside the SRS boundary. Surface elevations range from approximately 200 to 320 and 270 to 315 feet above mean sea level for F- and H-Areas, respectively. The F- and H-Areas are drained by Upper Three Runs Creek 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 Creek.

Upper Three Runs Creek, 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 (WSRC 1993b). The Upper Three Runs Creek valley has meandering channels, especially in the lower reaches. It has a steep southeastern side and gently sloping northwestern sides (WSRC 1995a).

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 (WSRC 1993b). It drains an area of about 21 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 (WSRC 1995a). 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. 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 valley is V-shaped, with sides varying from fairly steep to gently sloping. The floodplain is up to 1,000 feet wide (WSRC 1995a).

There are various potential sources of contamination to the Upper Three Runs Creek 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 1996) and are listed in Table 3-4. These potential sources could contribute contaminants to the surface waters of Upper Three Runs Creek and Fourmile Branch in the same manner as the F- and H-Area Tank Farms.

3.5 Biota

This section describes the biota specific to both the general site area and the F- and H-Areas.

3.5.1 GENERAL SITE AREAS

The SRS represents one of the most intensively studied environmental systems in the United States. The area has a variety of habitats, ranging from well-drained upland forests to swamps, other wetlands, and river systems. The entire site has been designated as a National Environmental Research Park by DOE. 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 the SRS, and the artificial impoundments on two of the tributary systems (DOE 1995). The *SRS Ecology Environmental Information Document* (WSRC 1993b) describes the aquatic and terrestrial vegetation

Table 3-4. Potential F- and H-Area contributors of contamination to Upper Three Runs and Fourmile Branch (WSRC 1996).

Fourmile Branch Watershed	Upper Three Runs Watershed
Burial Ground Complex Groundwater[a]	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 Pu-239 Release, 081-F
H-Area Tank Farm Groundwater	
Mixed Waste Management Facility, 643-28E	
Warner's Pond, 685-23G	

a. Units located in more than one watershed.

cover types and wildlife species that are commonly found on SRS and evaluates the importance and sensitivity of the systems to site activities. In addition, several monographs; the eight volume comprehensive cooling water study; and three EISs describe the aquatic biota (fish and macroinvertebrates) and aquatic system of SRS (DOE 1995).

The diversity and abundance of wildlife inhabiting the SRS reflect the variety of habitats found on the site. SRS is near the transition between northern oak-hickory-pine forest and southern mixed forest. Species typical of both occur on the site (DOE 1995). Each of the six streams that drain SRS has floodplains with bottomland hardwood forests or scrub-shrub wetlands in varying stages of succession. Dominant bottomland hardwood species include red maple, box elder, bald cypress, water tupelo, sweetgum, and black willow (DOE 1994a). The mild climate and diversity of aquatic and terrestrial habitats on SRS support an abundant herpetofauna, including 31 species of snakes, 26 species of frogs and toads, 17 species of salamanders, 10 species of turtles, 9 species of lizards, and the American alligator. The Savannah River Ecology Laboratory has conducted extensive studies of reptiles and amphibians living in the SRS wetlands (DOE 1995).

More than 213 species of birds occur on the SRS. Large mammals inhabiting the site include white-tailed deer and feral hogs. Raccoon, beaver, and otter are relatively common throughout the wetlands of SRS. In addition, the gray fox, opossum, bobcat, gray squirrel, fox squirrel, eastern cottontail, mourning dove, northern bobwhite, and eastern wild turkey are common at SRS (DOE 1995). Diatoms and approximately 400 species of algae have been identified in the Savannah River. Aquatic macrophytes are limited to areas of reduced current and edges of the river's tributaries. Eight species of vascular plants have been identified in the river adjacent to SRS. A diverse aquatic invertebrate fauna is found in the shallow areas and quiet backwaters and marshes off the river. The river and associated marshes and tributaries support a diverse fish fauna (WSRC 1991).

Threatened, endangered, and candidate plant and animal species known to occur or that might occur on the SRS include the smooth coneflower, bald eagle, woodstork, red-cockaded woodpecker, and shortnose sturgeon. The U.S. Fish and Wildlife Service has not designated any critical habitats on the SRS (WSRC 1991).

3.5.2 F- AND H-AREAS

The F- and H-Areas are heavily industrialized with little natural vegetation inside the fenced areas. These areas are characterized by existing buildings, roads, paved and gravel parking areas, laydown yards, and other infrastructure. While some grassed areas occur around the administration buildings and some vegetation is present along the ditches that drain the areas, most of the developed areas have no vegetation. No wetland, floodplain, forest area, or fields occur in these areas. Wildlife is largely absent except for house sparrows, European starlings, and barn swallows around the buildings. In addition, highly mobile wildlife such as red-tailed hawks and turkey vultures may fly over the area. Pine plantations managed for timber production by the U.S. Forest Service (under an interagency agreement with DOE) occupy surrounding areas (DOE 1994a).

As mentioned in Section 3.3.2, F- and H-Areas are on a near-surface groundwater divide, and groundwater from these areas outcrops at seeplines at Fourmile Branch and Upper Three Runs Creek. 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 (Workman and McLeod 1990). A more precise description of the vegetative community surrounding the seepline is sweet gum-red maple-red bay community (Jones, VanLear, and Cox 1981). Immediately upslope of the seepline is an upland pine/hardwood forest. The upland forest is replaced by lowland forest vegetation at the seepline where the groundwater outcrops and feeds the emergent wetlands and the Fourmile Branch stream community (WSRC 1991). As implied by its name (sweet gum-red maple-red bay community), the upperstory in the forested wetland surrounding the seepage area is dominated by sweet gum, red maple, and red bay. Sweet bays are also common. The understory consists largely of saplings of these same species, as well as a herbaceous layer of smilax, dog hobble, giant cane, poison ivy, chain fern, and hepatica. At the wetland's upland edge, scattered American holly and white oak occur. Dominant along Fourmile Branch in this area are tag alder, willow, sweetgum, and wax myrtle.

The Fourmile Branch floodplain in the vicinity of the seepline provides habitat for a myriad of aquatic, semiaquatic, and terrestrial animal species. During a site visit on April 5, 1996, the following animals were identified in the vicinity of the seepage area by direct observation or by tracks, scat, and bird calls: white-tailed deer, rabbit, raccoon, beaver, mink, shrew, various small rodents, crayfish, gray rat snake, and several species of birds. For detailed lists of animals known or expected to occur in this area, see Hillestad and Bennett (1981), Gibbons et. al (1986), and Gibbons and Patterson (1978).

The Upper Three Runs Creek seepline is located in a bottomland hardwood forest community (Workman and McLeod 1990). The wildlife species in this area are expected to be similar to those described above.

According to summaries of studies on Upper Three Runs Creek documented in the *SRS Ecology Environmental Information Document* (WSRC 1993b), the macroinvertebrate communities of Upper Three Runs Creek drainage are unusual. They include many rare species and contain species not often found living together in the same freshwater system. Upper Three Runs Creek is a spring-fed stream and is colder and generally clearer than most surface water at its low elevation, typical of unpolluted streams in northern North America or high in the Appalachian Mountains.

Based on studies conducted in 1984 and 1985, the dominant taxa of fish was spotted sucker. Other abundant taxa were darters, crappie, minnows, blueback herring, and American shad. Larvae of spotted sucker observed in abundance suggest that Upper Three Runs Creek is an important spawning site for spotted sucker. The smaller tributary sample stations on Upper Three Runs Creek have been dominated by shiners followed by pirate perch, madtoms, and darters. Densities of fish at sampling stations downstream from F- and H-Areas were within the range or higher than numbers at stations upstream of F- and H-Areas (WSRC 1993b).

After the shutdown of C-Reactor in June 1985, macroinvertebrates recolonized Fourmile Branch. Within 2 months, macroinvertebrate richness was comparable to other nonthermal SRS streams sampled. For certain groups of insects, recolonization was rapid. In the vicinity of the outcropping zone at Fourmile

Branch, dominant fish included shiners (dusky, yellowfin, and taillight) and sunfishes (dollar, spotted, or redbreast) (WSRC 1993b).

No endangered or threatened fish or wildlife species have been recorded near the Fourmile Branch and Upper Three Runs Creek 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.

While not listed by Federal or state agencies, four populations of rare plants in the northwest part of F-Area were located during Savannah River Forest Station botanical surveys in 1992 and 1994. One population of *Nestronia* and three populations of Oconee azalea were located on the steep slopes adjacent to the Upper Three Runs Creek floodplain (DOE 1995).

3.6 Air Quality

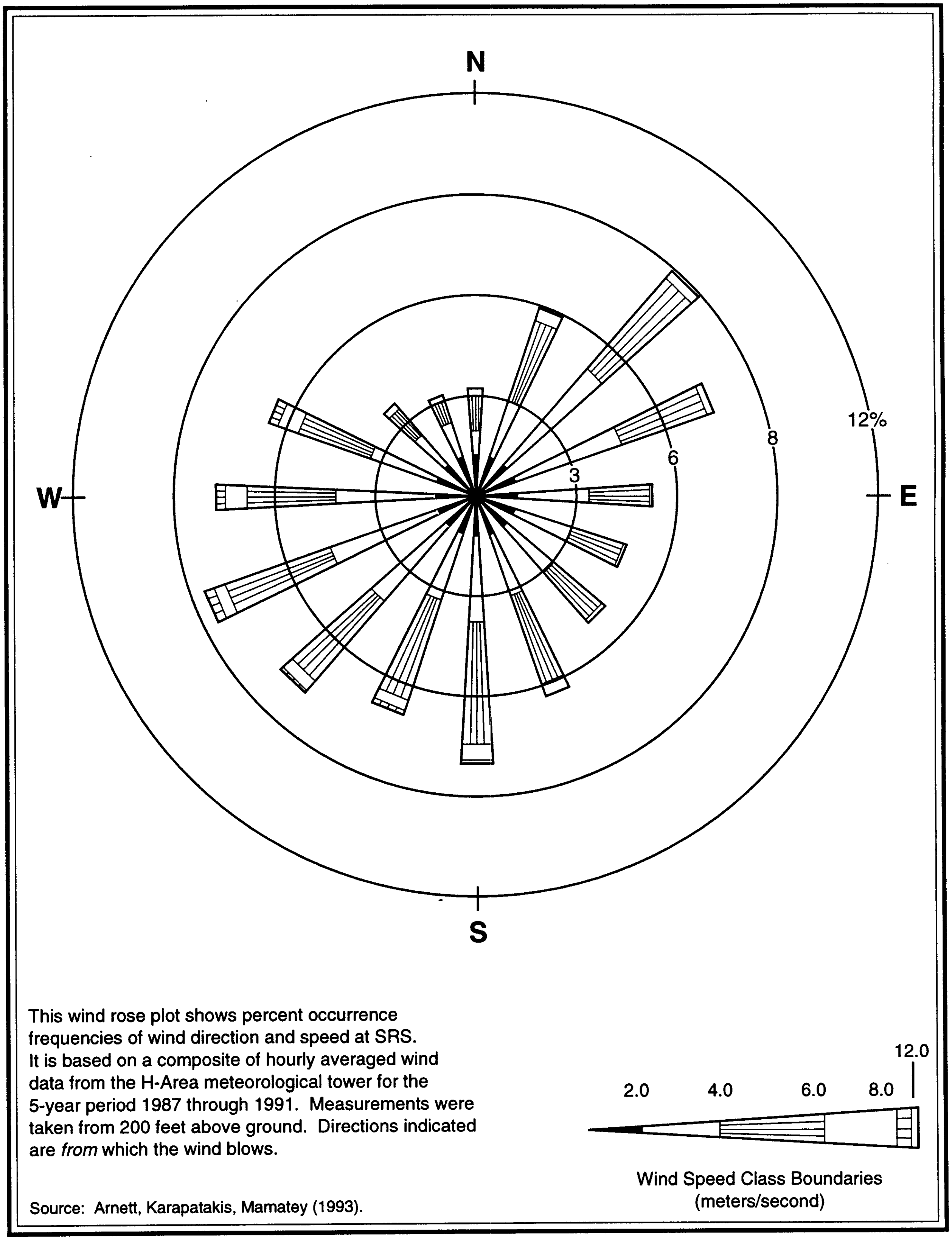
This section describes the climate, meteorology, and ambient air quality at SRS.

3.6.1 CLIMATE AND METEOROLOGY

The climate at SRS is temperate with short mild winters and long humid summers. Throughout the year, the weather is affected by warm, moist maritime air masses (DOE 1995). Climatological records indicate that the annual average temperature for the Augusta, Georgia area is 63.2°F (NOAA 1994). Monthly and annual normals, means, and extremes are listed in *Local Climatological Data Annual Summaries for 1993 Part II - Southern Region* published by the National Oceanic and Atmospheric Administration (NOAA).

The annual average precipitation value for Augusta, Georgia, is 44.7 inches (NOAA 1994). Precipitation is fairly well distributed throughout the year. Hourly observations at Augusta indicate that rainfall rates are usually less than 0.5 inch per hour, although rainfall rates as high as 2 inches per hour can occur during summer thunderstorms (WSRC 1995a). The maximum monthly snow, ice pellets, and hail were 14 inches in 1973 (NOAA 1994).

Figure 3-10 is a joint frequency summary (wind rose) of hourly averaged wind speeds and directions collected from the H-Area meteorological towers at a height of 200 feet during the 5-year period through 1987 to 1991. This figure indicates that prevailing wind directions are from the southwest and northeast. Winds from the south, southwest, and west directions occurred approximately 35 percent of the monitoring period (DOE 1995).



This wind rose plot shows percent occurrence frequencies of wind direction and speed at SRS. It is based on a composite of hourly averaged wind data from the H-Area meteorological tower for the 5-year period 1987 through 1991. Measurements were taken from 200 feet above ground. Directions indicated are *from* which the wind blows.

Source: Arnett, Karapatakis, Mamatey (1993).

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Figure 3-10. Wind rose for SRS, 1987 through 1991.

The average wind speed for the 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. The average wind speed for 1993 was 6.5 miles per hour (NOAA 1994).

The local SRS terrain has little effect on meteorological parameters at SRS. During stable atmospheric conditions, some channeling or flow stagnation could occur in some more pronounced valleys (WSRC 1995a).

The SRS area experiences an average of 55 thunderstorms per year, half of which occur during the summer months of June, July, and August. On average, lightning flashes will strike six times per year on 0.39 square mile of ground. Thunderstorms can generate wind speeds as high as 40 miles per hour and even stronger gusts. The highest 1-minute wind speed recorded at Bush Field in Augusta, Georgia, between 1950 and 1990 was 62 miles per hour (DOE 1995).

Since SRS operations began, nine confirmed tornadoes have occurred on or close to SRS. Eight caused light to moderate damage. No tornado-related damage has occurred to SRS production facilities.

Based on tornado statistics for the SRS area, the estimated average frequency of a tornado striking any given location in South Carolina is 7.11×10^{-5} per year. This means that a tornado could strike any given location about once every 14,000 years (DOE 1995).

A total of 36 hurricanes caused damage in South Carolina between 1700 and 1989. The average frequency of occurrence of a hurricane in the state is once every 8 years; however, the observed interval between hurricanes has ranged from as short as 2 months to as long as 27 years. Eighty percent of these hurricanes occurred in August and September.

Winds produced by Hurricane Gracie, which passed to the north of SRS on September 29, 1959, were as high as 75 miles per hour in F-Area. No other hurricane-force wind has been measured on SRS. Heavy rainfall and tornadoes, which frequently accompany tropical weather systems, usually have the greatest hurricane-related impact on SRS operations (DOE 1995).

3.6.2 AMBIENT AIR QUALITY

SCDHEC has air quality regulatory authority at SRS and determines compliance based on pollutant emission rates and estimates of ambient concentrations at the SRS facility boundary based on air dispersion modeling results. DOE complies with National Ambient Air Quality Standards and the gaseous fluoride and total suspended particulate standards, as required by SCDHEC Regulation R.61-62.5, Standard 2 ("Ambient Air Quality Standards"). DOE has identified emission sources for 139 of the 257 SCDHEC Standard No. 8 air toxics; the modeling results indicate that SRS complies with SCDHEC air quality standards (DOE 1995).

3.6.3 EXISTING RADIOLOGICAL CONDITIONS

Background and Baseline Radiological Conditions

Ambient air concentrations of radionuclides at SRS include nuclides of natural origins, such as radon from uranium in soils; manmade radionuclides, such as fallout from testing of nuclear weapons; and emissions from coal-fired and nuclear powerplants. DOE operates a 35-station atmospheric surveillance program; the stations are inside the SRS perimeter, on the perimeter, and as far as 100 miles from SRS (DOE 1995).

Routine SRS operations result in releases of quantities of alpha- and beta-gamma-emitting radioactive materials in the form of gases and particulates. Gross alpha and nonvolatile beta measurements are used as a screening method for determining the concentration of all radionuclides in the air.

The average 1990 to 1993 gross alpha radioactivity and nonvolatile beta radioactivity measured at SRS and at distances of 25 miles to 100 miles from SRS are listed in Table 3-5. The maximum levels of onsite gross alpha and nonvolatile beta radioactivity were found near production or processing areas. For each year, average onsite gross alpha and nonvolatile beta radioactivity concentrations were similar to the average concentrations measured in offsite air (DOE 1995). Nonvolatile beta concentrations do not include tritium (which accounts for more than 99 percent of the airborne radioactivity released from SRS) or carbon-14.

Table 3-5. Average concentrations of gross alpha and nonvolatile beta radioactivity measured in air (1991 to 1993) (microcuries per milliliter of air).[a]

Location	Number of locations	Average gross alpha radioactivity			Average nonvolatile beta radioactivity		
		1991	1992	1993	1991	1992	1993
Onsite	5	2.5×10^{-15}	1.8×10^{-15}	1.9×10^{-15}	1.8×10^{-14}	1.9×10^{-14}	1.8×10^{-14}
SRS perimeter	14	2.6×10^{-15}	1.8×10^{-15}	1.8×10^{-15}	1.8×10^{-14}	1.9×10^{-14}	1.9×10^{-14}
40-km[b] radius	12	2.5×10^{-15}	1.7×10^{-15}	1.8×10^{-15}	1.8×10^{-14}	1.8×10^{-14}	1.8×10^{-14}
161-km radius	4	2.6×10^{-15}	1.7×10^{-15}	2.0×10^{-15}	1.8×10^{-14}	1.7×10^{-14}	2.0×10^{-14}

a. Source: WSRC (1995a).
b. To convert kilometers to miles, multiply by 0.621.

Tritium levels in 1993 are not directly comparable to those observed in previous years because the protocol for atmospheric tritium oxide was changed in 1993. For 1993, the highest annual average concentration of tritium in the air over SRS was 1.06×10^{-9} microcuries per milliliter. The maximum offsite tritium concentration was slightly higher than the 1992 level of 5.3×10^{-11} microcuries per milliliter (DOE 1995).

3.7 Other Resources

DOE uses a memorandum of agreement, ratified on August 24, 1990, on the management of cultural resources at the SRS to identify cultural resources, assess them in terms of eligibility for the National Register of Historic Places, and develop mitigation plans for affected resources in consultation with the State Historic Preservation Officer.

If any historic or archaeological resources are threatened by HLW tank system closure activities under this plan, DOE would take appropriate steps to identify the resource and to contact the appropriate agency (i.e., the Savannah River Archaeological Research Program and the South Carolina Institute of Archaeology and Anthropology at the University of South Carolina).

3.8 References

Arnett, M. W., L. K. Karapatakis, and A. R. Mamatey, 1993, Savannah River Site Environmental Report for 1992, WSRC-TR-93-075, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

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

DOE (U.S. Department of Energy), 1993, *Preliminary Draft Environmental Impact Statement, Upgrade of Canyon Exhaust Systems, Savannah River Site, Aiken, South Carolina*, DOE/EIS, Savannah River Operations Office, Aiken, South Carolina.

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

DOE (U.S. Department of Energy), 1994b, *Final F-Canyon Plutonium Solutions Environmental Impact Statement, Savannah River Plant, Aiken, South Carolina*, DOE/EIS-0219, Savannah River Operations Office, Aiken, South Carolina.

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

DOE (U.S. Department of Energy), 1996, *Savannah River Site Future Use Project Report Stakeholder Recommendations for SRS Land and Facilities, Aiken, South Carolina*, Savannah River Operations Office, Aiken, South Carolina.

East, J. M., 1993, *1992 Onsite Worker Population for PRA Applications (U)*, WSRC-RP-93-197, January.

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.

Gibbons, J. W. and K. K. Patterson, 1978, *The Reptiles and Amphibians of the Savannah River Plant*, SRO-NERP-2, Savannah River Plant National Environmental Research Park Publication, Aiken, South Carolina.

Gibbons, J. W., W. D. McCort, J. L. Knight, and S. S. Novak, 1986, *Semi-Aquatic Vertebrates of the Savannah River Plant, Comprehensive Cooling Water Study, Final Report*, Savannah River Ecology Laboratory, Aiken, South Carolina.

Hillestad, H. O., and S. H. Bennett, 1981, *Set-Aside Areas*, National Environmental Research Park, Aiken, South Carolina, Savannah River Ecology Laboratory, Aiken, South Carolina.

Jones, S. M., D. H. Van Lear, and S. K. Cox, 1981, *Major Forest Community Types of the Savannah River Plant: A Field Guide*, SRO-NERP-9, Savannah River Plant National Environmental Research Park Publication, Aiken, South Carolina.

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

Parsons, A. M., Gruebel, M. M., 1996, *Hydrogeology of the F-Area at the Savannah River Site*, Rev. 0, Sandia National Laboratories, Albuquerque, New Mexico.

SCDHEC (South Carolina Department of Health and Environmental Control), 1993, Water Classifications and Standards, Regulation 61-68.

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

Workman, S. W., and K. W. McLeod, 1990, *Vegetation of the Savannah River Site: Major Community Types*, SRO-NERP-19, Savannah River Plant National Environmental Research Park Publication, Aiken, South Carolina.

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.

WSRC (Westinghouse Savannah River Company), 1993a, *Draft Environmental Information Document: Geology and Hydrogeology of the Savannah River Site*, WSRC-TR-93-147, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993b, *SRS Ecology Environmental Information Document*, WSRC-TR-93-496, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1995a, *Safety Analysis Report Savannah River Site*, WSRC-SA-19, Rev. 0, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1995b, *RCRA Part B Permit Renewal Application*, Volume IV, Book 1 of 7, WSRC-IM-91-53, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1996, *Federal Facility Compliance Agreement, Savannah River Site, Aiken, South Carolina*, WSRC-OS-94-42, Aiken, South Carolina, Version: March 1996.

CHAPTER 4. WASTE REMOVAL/CLOSURE STRATEGY

This closure plan sets forth the general protocol by which U.S. Department of Energy (DOE) will close the F- and H-Area high-level waste (HLW) tank systems at SRS to ensure protection of human health and the environment while being cost effective and prudent. The scope of the Tank Closure Project (Figure 4-1) encompasses the general strategy for HLW tank systems closure, including the general methods for selection and implementation of appropriately protective methods for decontamination of tank systems and stabilization of residual contaminants left in individual tank systems. Appendix A provides DOE's analysis of a range of major alternatives for closing the HLW tank systems and DOE's selected closure configuration alternatives. The selected closure alternative for the HLW tank systems consists of removing the waste from the tanks using hydraulic slurrying techniques or other cleaning techniques of comparable effectiveness. After waste removal, each tank will be filled with pumpable, self-leveling backfill material(s) (e.g., grout). The fill material will be high enough in pH to be compatible with the carbon-steel walls of the waste tank. The fill material formula will include chemical properties that will retard the movement of radionuclides and chemical constituents from the closed tank. This chapter describes the methods DOE will use to evaluate the selected configuration with respect to performance objectives and refine the closure configuration, as appropriate, and documents DOE's plans for closure of individual HLW tank systems in specific modules for approval by South Carolina Department of Health and Environmental Control (SCDHEC).

With respect to interfacing programs, industrial wastewater facility closure activities under this plan are those activities that occur after waste removal is complete and before turnover of the HLW tank systems to the SRS Environmental Restoration Program for subsequent evaluation and, if necessary, source control or remediation of contaminant releases as part of the overall remediation of the F- and H-Area tank farms. DOE's anticipated schedule for closure of HLW tank systems is provided in Appendix B.

4.1 Waste Removal

Before turning an HLW tank system over to the tank closure project, DOE will remove waste from the tanks. The waste removal process will use the following techniques or other techniques of comparable effectiveness:

- Bulk waste removal - Slurry pumps, transfer pumps, and transfer jets will be used to remove as much HLW as practical from the tank systems.

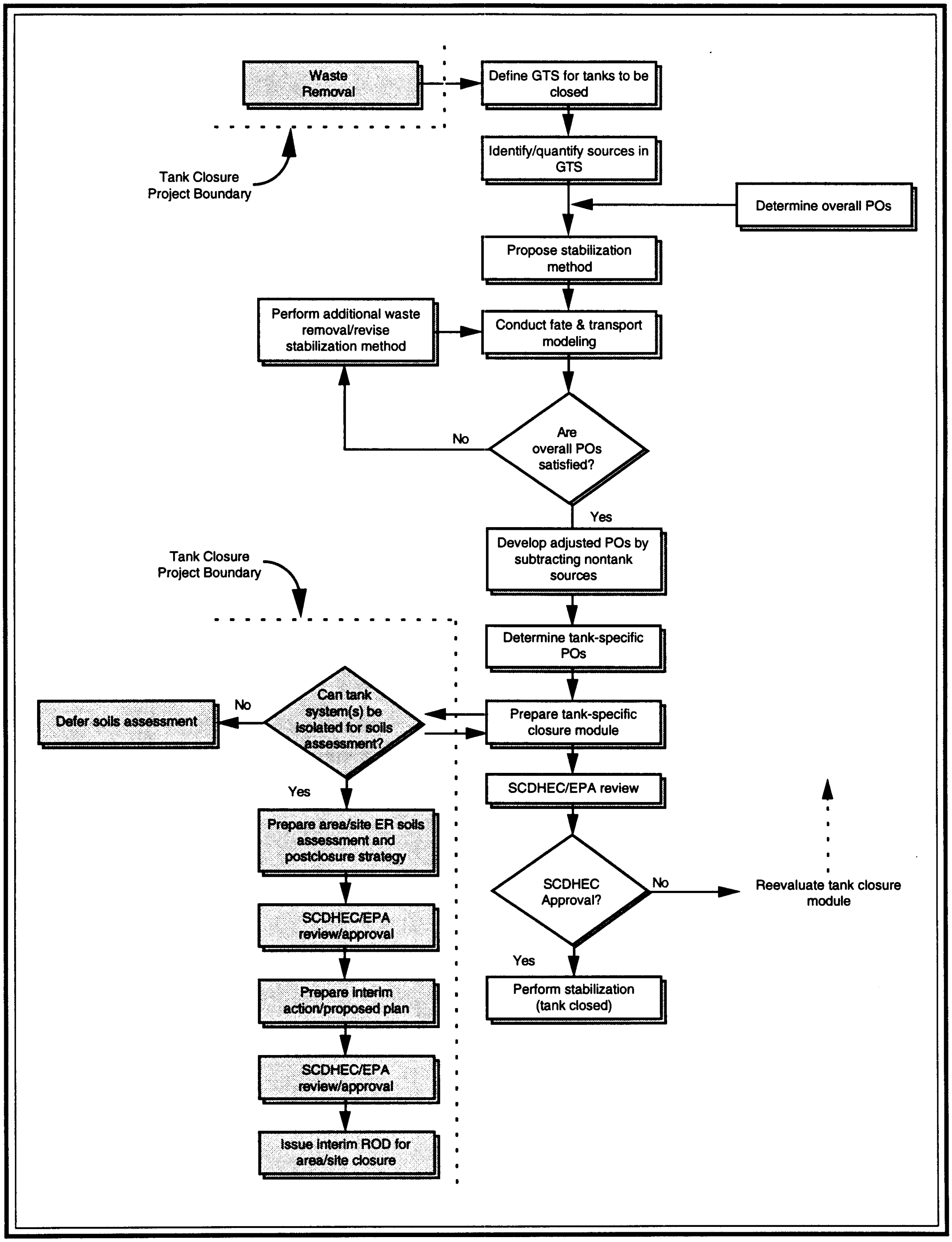

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Figure 4-1. HLW tank closure project.

- Spray washing - The interior of the tank will be sprayed with jets of hot water to dislodge contamination that was not removed during bulk waste removal.

- Annulus cleaning - On tanks that have leaked waste from primary to secondary containment, as much waste as is practical will be removed from the annulus.

If it is determined that additional cleaning of a particular sludge tank is necessary to meet the performance objectives, acid washing will be performed as follows:

- Acid washing - The interior of the sludge tank will be sprayed with jets of oxalic acid to remove contamination that remains after water washing.

4.2 Determination of Performance Objectives

DOE has identified pertinent substantive requirements with which it will comply and guidance it will consider to ensure that closure of the tank systems will be protective of human health and the environment. DOE will use these requirements and guidance to develop tank system closure performance objectives that provide a basis for comparison of different closure configurations. The performance objectives that are applicable to specific environmental media (e.g., the receiving groundwater) must be apportioned to the tank systems proposed for closure.

Groundwater transport segments (GTS) will be defined for the tanks to be closed to apportion the performance objectives to the target tank system and other sources of contaminants that may impact the same point of exposure. A GTS represents the advective contaminant plume from the tank system considered for closure and all other sources within the segment. In general, a GTS will run from the groundwater divide to the point of exposure. Chapter 6 discusses the establishment and use of GTSs.

4.3 Waste Removal and Stabilization Selection

Each tank system or group of tank systems will be evaluated to determine the inventory of contaminants (radiological and nonradiological) that exists after waste removal. This information will be used to conduct a performance evaluation. The performance evaluation includes modeling the projected contamination pathways for selected closure configurations and comparing the results with the performance objectives. If the performance objectives are met, closure will continue. If performance objectives cannot be met, additional waste removal steps could be taken or the stabilization method could be revised to comply with the performance objectives.

4.4 Closure Module Preparation and Approval

On completion of bulk waste removal and water washing, a tank-specific closure module will be submitted to SCDHEC for review and approval. In addition, the closure module will be provided to the U.S. Environmental Protection Agency (EPA) Region IV and SCDHEC Federal Facility Agreement (FFA) project managers for review to ensure consistency with the FFA requirements for overall remediation of the Tank Farms. The module will contain characterization information and analyses necessary to show that the proposed closure configuration (i.e., combination of source removal/reduction and stabilization options) is protective of human health and the environment. The module will describe the end-state of the tank (e.g., type and characteristics of fill material, residual volume and contamination level; cap requirements), modeling calculations to demonstrate that the performance of the closure configuration will meet the applicable performance objectives, and details (e.g., methods, schedule) for implementing the closure. The module will also include protocol and forecast schedule for transferring the tank systems to the SRS Environmental Restoration program. If necessary, additional individual modules will be written for the evaporators, diversion boxes and pump pits, transfer lines, and the In-Tank Precipitation Facility (ITP) filter and stripper building.

A postclosure monitoring and inspection plan will be developed and submitted as part of the tank-specific closure module based on the selected closure configuration. The objective of the monitoring and inspections will be to identify any changes in and to monitor the effectiveness of the HLW tank system closure configuration. SRS procedures detailing the inspection protocols, inspection reporting, and corrective action process will be developed and implemented based on the selected closure configuration.

4.5 Tank Stabilization

The HLW tanks at SRS contain different quantities of contaminants and different configurations of cooling coils and equipment and hydrogeologic setting, such as the distance from the water table and the distance to nearby streams. DOE will determine the closure configuration for each tank or group of tanks on a case-by-case basis, although all closures will incorporate a number of important features. Examples of anticipated closure configurations are shown in Figure 4-2 for an individual waste tank system and Figure 4-3 for groups of tank systems based on the closure options described in Appendix A.

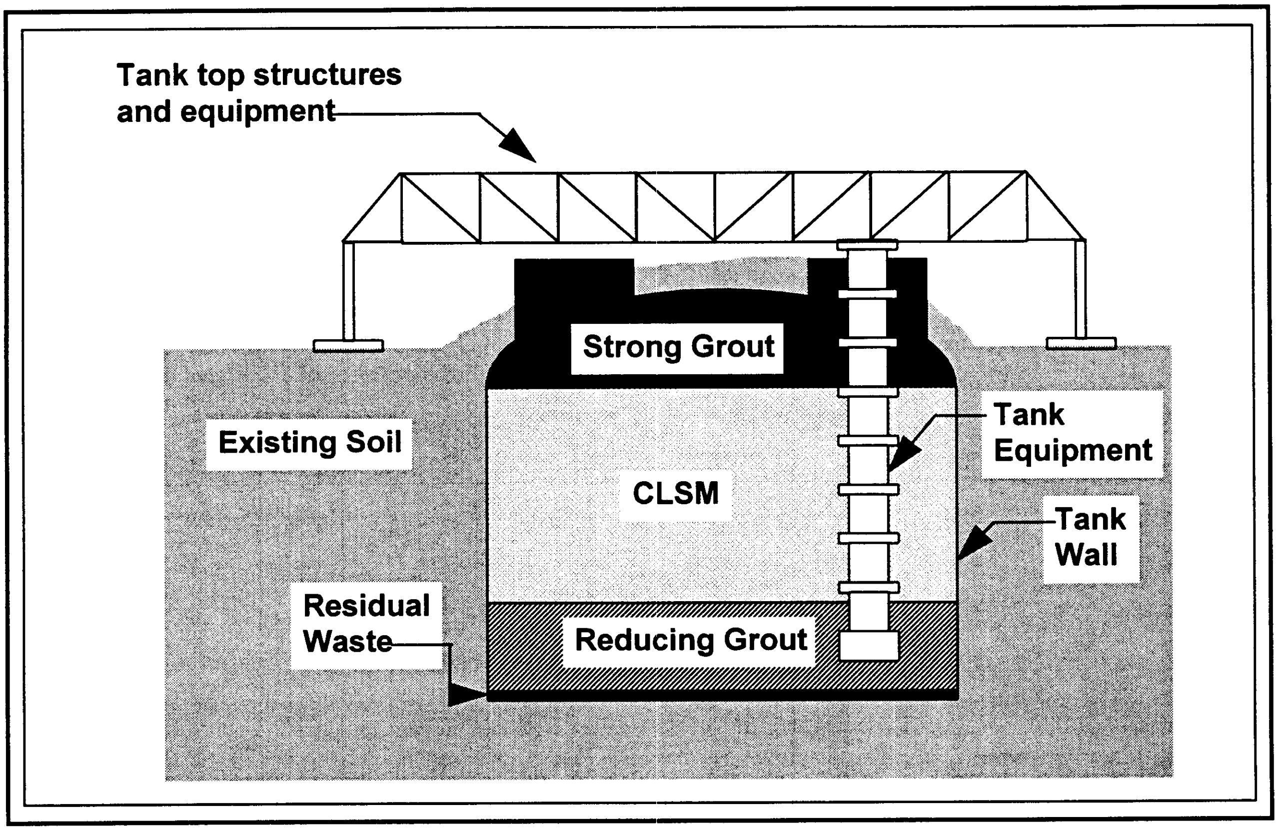

Figure 4-2. Tank closure example.

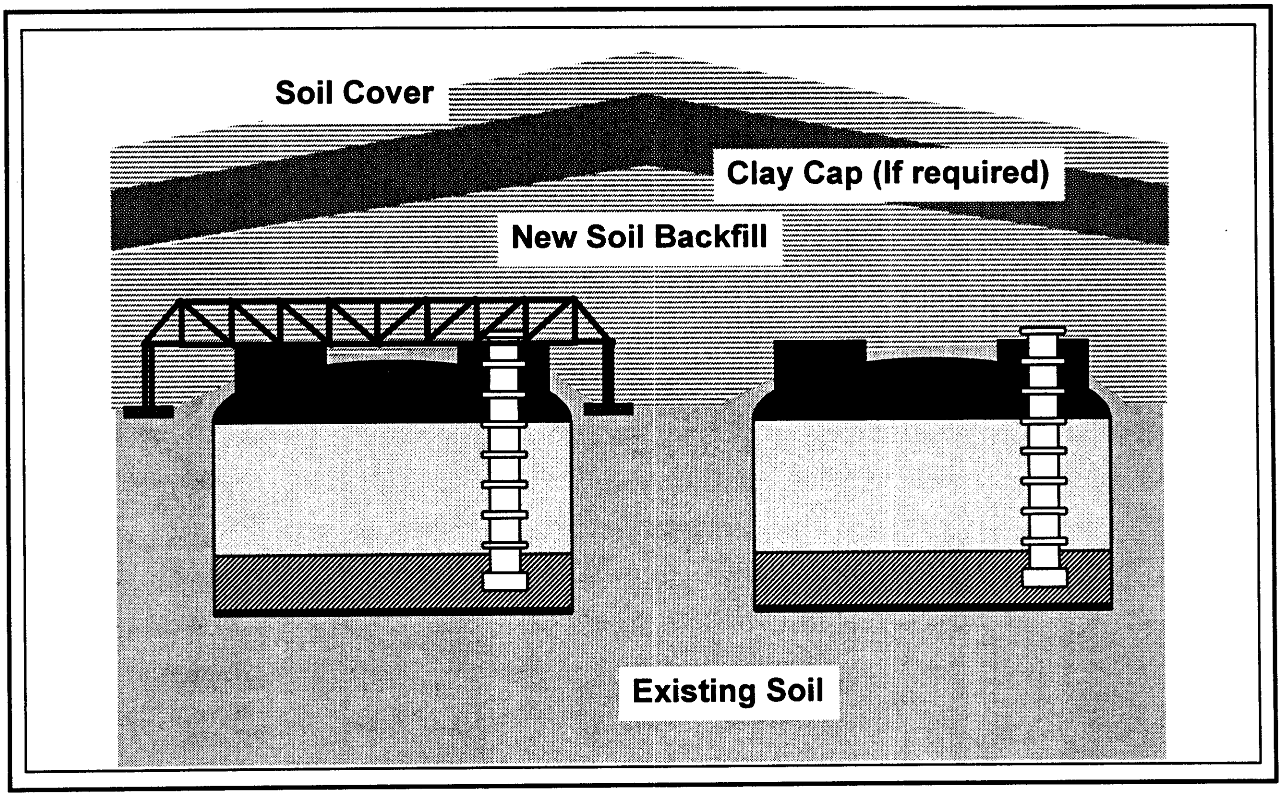

Figure 4-3. Area closure example.

The layers in and above the tank, from bottom to top, are as follows:

- The residual waste at the bottom of the tank is the waste that remains in place after selected waste removal techniques have been applied.

- Fill material composed of a combination of pumpable, self-leveling backfill materials specifically formulated for each tank system closure. The following fill materials are being considered:

  - Reducing grout composed of primarily cement, flyash, and blast furnace slag. The chemical properties of liquid that leaches through this backfill material will reduce the mobility of certain radionuclides and chemical constituents.

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

  - Strong grout is a pumpable grout with compressive strengths in the normal concrete range. This material is used to fill voids near the top of the tank created around risers and tank equipment.

- The necessity for a low-permeability cap, such as a clay cap, to reduce rainwater infiltration will be established in the HLW tank system-specific closure module. Figure 4-3 shows a conceptual cap design in which the area around the tank would be backfilled with soil to cover risers, equipment, and other protuberances. The cap construction would ensure that rain falling on the area drains away from the closed tank(s). A soil cover could be placed over the cap and seeded to prevent erosion.

In addition to the residual waste at the bottom of the tank, which is the major focus of closure activities, there will be residual contamination on equipment inside and near the tank (e.g., slurry pumps used for waste removal, cooling coils inside the tank, transfer piping in and out of the tank, and the secondary containment system and leak detection system for the tank). In addition, the tank farms include other equipment for processing the waste, such as evaporators, diversion boxes, pump tanks, and interarea transfer lines from F- to H-Area and from H-Area to Defense Waste Processing Facility (DWPF) and Saltstone. DOE anticipates that the amount of contamination left on this equipment will be small compared to the amount of contamination in the tanks, so closure of this equipment will have a relatively small environmental impact in comparison to closure of the tanks.

4.6 HLW Tank System Turnover to Environmental Restoration Program

Development of the postclosure strategy for the closed HLW tank systems depends on completion of the HLW Tank System Closure Program Plan (scheduled for completion in December 1996), which will set forth the anticipated sequence and schedule for closure of specific tank systems. DOE will identify areas and sites in the tank farms (e.g., tank system groupings) that are appropriate for transition to the Environmental Restoration Program based on the HLW Tank System Closure Program Plan.

On completion of closure activities, the HLW tank farms would transition to the Environmental Restoration Program. To the extent possible, environmental restoration activities will be concurrent with individual HLW tank system closure activities. Figure 4-1 shows the general strategy for integration of tank-specific closure module development with DOE's soil assessment, remedial action, and postclosure activities pursuant to the FFA.

Concurrent with the preparation of tank-specific closure modules, the Environmental Restoration Program will evaluate the ability to conduct an area/site soils assessment. As indicated in Figure 4-1, DOE will decide if it is appropriate to proceed at that time with a soils assessment for the specific tank system or systems. If DOE determines that it is not appropriate to proceed, it will provide supporting rationale for the deferral [e.g., the need to limit intrusive characterization efforts while HLW tank system components, such as underground transfer lines, remain in service; the tank system(s) are not isolated from other ongoing operational activities in that location].

The soils assessment and postclosure strategy will identify any additional characterization required; however, it might not be possible to undertake field investigations to determine the nature and extent of soil contamination until the closure of all tank systems in a location and cessation of operational activities in that location. Personnel radiation exposure considerations and the potential for future releases after the completion of soil characterization will be considered. DOE anticipates that the postclosure strategy will address such items as the need for capping and postclosure maintenance and security measures. Groundwater monitoring is being addressed in accordance with the FFA (e.g., H-Area Tank Farm Groundwater Operable Unit).

Investigation, determination of remediation requirements, and implementation of remedial action for any soil contamination in the tank farm area and ultimate tank farm area closure will be conducted. Any historic releases from the HLW tank system(s) in an area will be assessed along with those from other units in the same area. Environmental restoration activities for the tank farms will consider requirements for capping that were part of individual tank system-specific modules under this plan.

CHAPTER 5. CLOSURE STANDARDS

This section summarizes the regulatory framework for closure of the Savannah River Site (SRS) high-level waste (HLW) tank systems as determined through consultation with South Carolina Department of Health and Environmental Control (SCDHEC) and U.S. Environmental Protection Agency (EPA) Region V. It also discusses the U.S. Nuclear Regulatory Commission's (NRC's) "incidental waste" determination as it relates to the identification of pertinent, substantive environmental requirements and guidance for HLW tank system closures.

DOE will close the HLW tank systems, which are permitted by SCDHEC under authority of the South Carolina Pollution Control Act (SCPCA) as wastewater treatment facilities, in accordance with South Carolina Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This regulation requires that such closures be performed in accordance with site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. To facilitate compliance with this requirement and in recognition of the necessity for consistency with ultimate remedial action of the SRS under the Federal Facility Agreement (FFA), U.S. Department of Energy (DOE) has adopted a general strategy for HLW tank system closure that includes evaluation of an appropriate range of closure alternatives with respect to pertinent, substantive environmental requirements and guidance and other appropriate criteria (e.g., technical feasibility, cost). The general strategy for HLW tank system closure is thus consistent in its substance with comparative analyses performed as part of a Resource Conservation and Recovery Act (RCRA) corrective measures study/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility study under the FFA.

DOE has identified the environmental requirements and guidance applicable to the closure of the F- and H-Area HLW tank systems (Appendix C). Compliance with these requirements will ensure that closure of the HLW tank systems will be protective of human health and the environment and consistent with final remedial action for SRS as implemented under the FFA. Details of these requirements and guidance, the process used to identify them, and their intended use in the HLW tank systems closure plan are described in Appendix C.

DOE will review the list of requirements and guidance in Appendix C when it develops each tank system-specific closure module to determine if any changes to substantive provisions of the regulations and guidance have occurred that are pertinent to HLW tank system closure activities. If so, DOE will revise Appendix C to reflect the changes and incorporate them into the performance standards for HLW tank-specific closure modules.

5.1 Performance Standards

The performance standards for HLW tank system closure are generally numerical standards, such as concentration or dose limits for specific radiological or chemical constituents released to the environment. These numerical standards apply to various environmental media, at different points of compliance, at various periods during or after closure. They will be used to develop performance objectives that provide a basis for comparison of different tank system closure configurations. The performance objectives for HLW tank system closure will be the groundwater protection standards applied at the point where groundwater discharges to the surface (seepline) and the surface-water quality standards applied in the receiving stream. Closure options will be evaluated to show conformance with the performance objectives as part of the overall evaluation [similar to compliance with applicable or relevant and appropriate requirements (ARARs) as one of the nine CERCLA criteria]. In a manner similar to CERCLA requirements, appropriate justification will be necessary to select a nonconforming closure option.

The performance evaluation will focus on the exposure pathways and contaminants of most concern for a specific HLW tank system. DOE anticipates that the limiting exposure pathway for the HLW tank system closures will be via contaminant releases to groundwater and migration of those contaminants to onsite surface waters. The contaminants of most concern in that exposure pathway will be those constituents subject to the most stringent performance standards for points of compliance in that pathway. The tables in Appendix C are organized to enable comparison of the various performance standards to aid in identifying the most stringent limit that would be applicable at a specific point of compliance. The lowest concentration limit for a specific constituent would become the performance objective for that constituent in the specific media (i.e., air, groundwater, or surface water for nonradiological constituents) and the lowest dose or concentration limit for a specified exposure pathway (i.e., air, soil, groundwater, multipathway) would become the performance objective for the radiological constituents.

5.2 Incidental Waste Determination

To identify HLW tank system closure performance standards, DOE has determined that the residual remaining in any tank system when closure occurs will no longer be classified as high-level waste. In conjunction with the development of this closure plan, DOE will demonstrate that the material remaining in the tank systems at closure satisfies criteria established by the NRC for its classification as "incidental waste."

For these wastes to be classified as "incidental waste," DOE must separate for disposal as much of the radioactivity as possible, using processes that are technically and economically practicable. The NRC has suggested that DOE use a material balance to demonstrate that it has segregated most of the activity associated with the wastes for disposal as HLW, and provided examples of the types of incidental wastes (e.g., waste generated from the further treatment of HLW such as salt residues or miscellaneous trash from waste glass processing). The NRC concluded that the wastes would be classified as incidental wastes provided they:

- Have been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical

- Will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste or alternative site-specific classification limits as set forth at 10 CFR 61

- Are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR 61 are satisfied

DOE will provide analyses for NRC review and concurrence that will demonstrate that the residuals remaining in the tank systems at closure conform to the performance objectives for Class C low-level waste under 10 CFR 61, Subpart C. DOE anticipates NRC concurrence with the "incidental waste" determination for the SRS tank residuals.

CHAPTER 6. DETERMINATION OF TANK-SPECIFIC PERFORMANCE OBJECTIVES

This chapter describes methods for determining if specific tank closures satisfy the performance objectives discussed in Chapter 5. A major component of the decision process involves fate and transport modeling to evaluate compliance of alternative closure configurations with those performance objectives.

The 51 tanks in the F- and H-Area Tank Farms will be closed at various times over a period of decades. The 24 tanks that do not meet the standards established in Appendix B of the Federal Facility Agreement (FFA) will be removed from service by 2028 and subsequently closed. The *Waste Removal Plan and Schedule* (WSRC 1993) provides start and end dates, in years, for removing these tanks from service. The remaining 27 tanks will remain in service until there is no further need for them. Thus, for the tanks that remain in service, U.S. Department of Energy (DOE) can provide only estimates about the condition of the tank systems and the wastes in the tanks at the time of closure. In addition, potential impacts from the closure of an high-level waste (HLW) tank must be projected for a period that extends thousands of years into the future. The process described in this section has been developed to allow closure of individual tanks to proceed, while recognizing and considering the unquantified source terms of the tanks remaining in service.

6.1 Summary of the Technical Approach

To close a tank, overall performance objectives have been selected from the performance standards as described in Appendix C. Tank-specific performance objectives will be developed. In the F- and H-Area Tank Farms, the major sources of potential contamination are the HLW tank systems, but the approach must consider other sources outside the tanks farms. Thus, potential impacts from other tanks and other nontank sources up- and downgradient from the tank system to be closed are considered in the development of specific performance objectives for the tank system to be closed. Fate and transport modeling of alternative closure configurations is the primary tool used to develop tank-specific performance objectives. The groundwater pathway is considered the limiting exposure pathway for determining conformance of a closure configuration to the performance objectives. If the approach determined, however, that an exposure pathway other than groundwater is limiting for a particular HLW tank system, the tank-specific closure module would address that pathway.

Figure 6-1 shows the overall process for closing the HLW tank system. The shaded blocks in the figure show the sequence of steps involved in establishing tank-specific performance objectives.

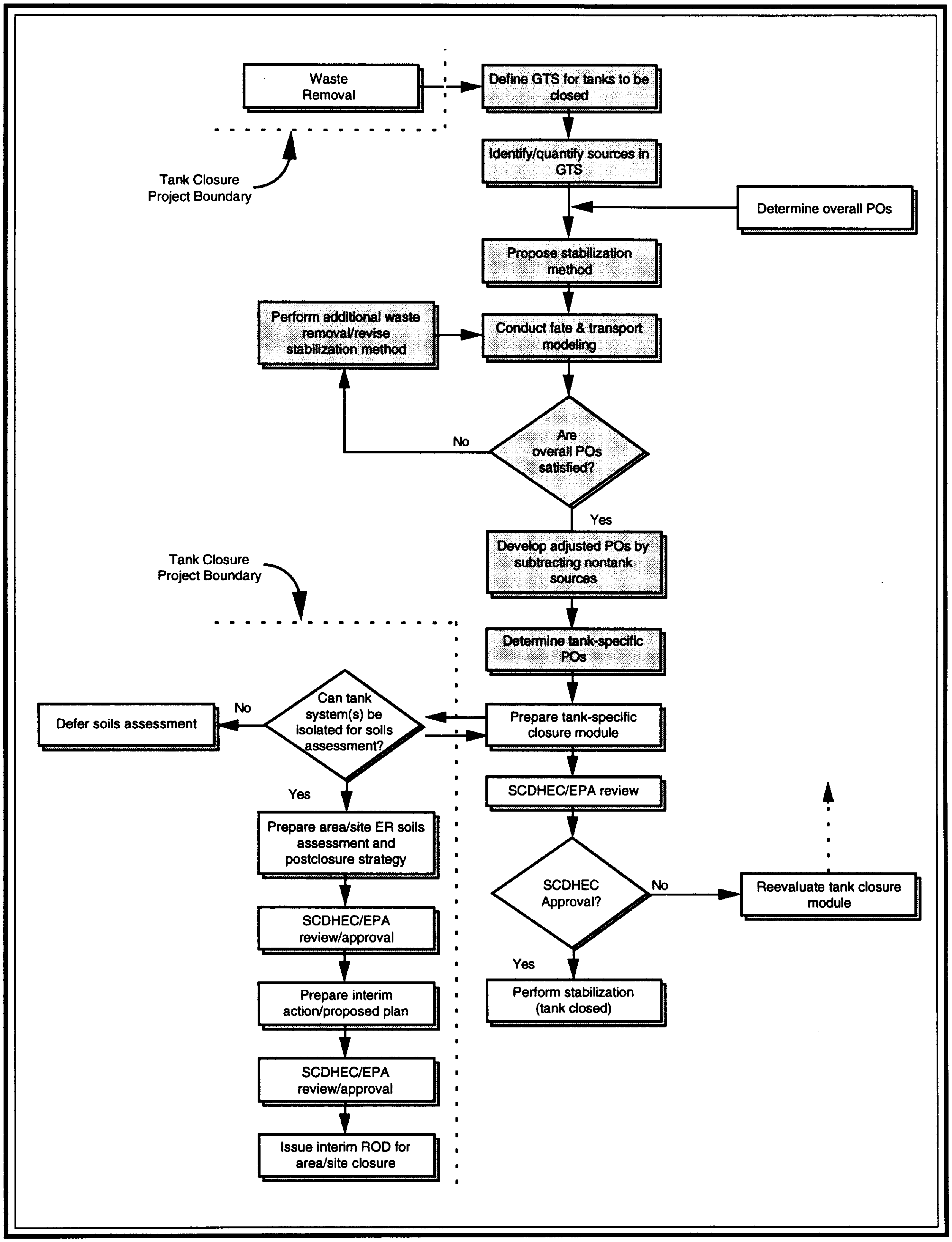

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Figure 6-1. HLW tank closure; shaded blocks show steps in determining tank-specific performance objectives.

These steps consist of: (1) defining a groundwater transport segment (GTS) for the tank system to be closed; (2) identifying and quantifying sources within the GTS; (3) conducting fate and transport modeling to determine if overall performance objectives in the GTS are satisfied; (4) developing "adjusted POs" to account for nontank sources in the GTS; and (5) apportioning the adjusted POs between tanks to determine tank-specific POs. As shown in Figure 6-1, if the initial closure configuration (i.e., the combination of residual source term in the tank system and the method of stabilization) do not meet the overall POs, the closure configuration can be revised and modeled again to achieve compliance. Each of these steps is described in detail in the following sections. Appendix D presents an example of fate and transport modeling that could be used to support this process. Appendix E provides an example of the process itself.

6.2 Definition of Groundwater Transport Segment

The performance objectives discussed in Chapter 5 apply to all of the contaminant sources in the general separations area, including all 51 tanks, the closed F- and H-Area Seepage Basins, the solid waste disposal facilities, and any other potential sources. However, it would be inappropriate to apportion the performance objectives to all the sources simultaneously. For example, the groundwater at any point could only be contaminated by those sources upgradient or near upgradient to the point of measurement. No single receptor could simultaneously obtain drinking water or eat food from land contaminated by both the F- and H-Area tanks farms or even from widely separated tanks with a given tank farm. Therefore, DOE has established an interpretive construct known as a GTS, in order to identify which sources of contamination could collectively contribute to impacts to realistic receptors.

The GTS represents an advective contaminant plume from the tank system considered for closure and all the other sources within the segment (see Figure 6-2 for an example). The combined impact of all these sources at the point of exposure is then determined. Making the assumption that advective transport is the only mode of contaminant migration (diffusion is not considered) is reasonable because advective transport is the major transport mode and conservatively "concentrates" the environmental impacts within the GTS. There will, of course, be diffusive transport from the GTS in the crossgradient direction but this process will be counteracted somewhat by the diffusive transport of contaminants into the GTS from adjacent plumes emanating from other tank systems. However, contributions from future adjacent groundwater transport segments due to transverse dispersitivity will be considered on a case-by-case basis as tank closure data become further refined.

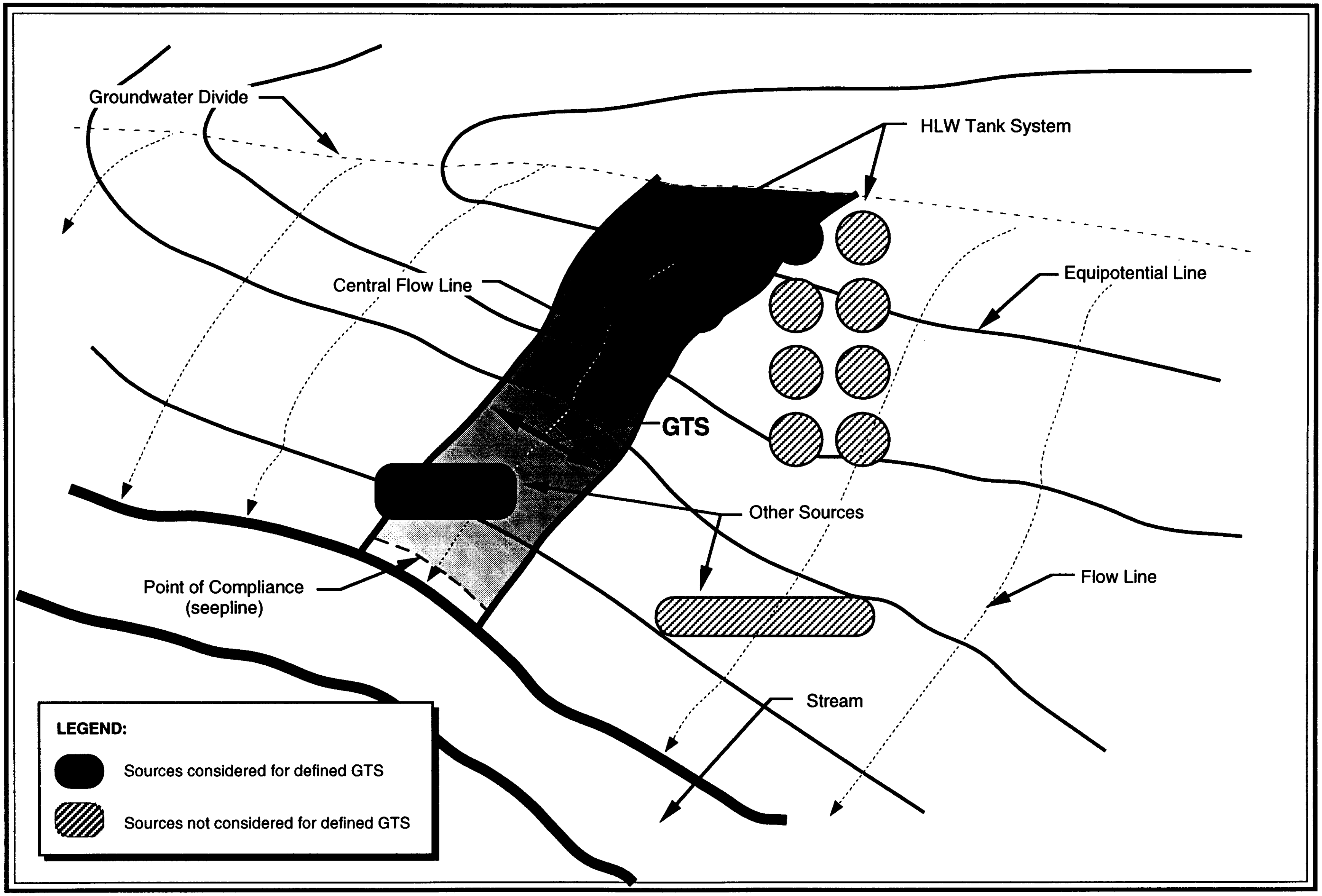

Figure 6-2. Groundwater transport segment.

To locate the GTS, groundwater flow lines will be constructed from the HLW tank systems being considered for closure using groundwater gauging data. These flow lines will be extended both upgradient to the groundwater divide and downgradient to the receiving stream. Each flow line simulates the trace of a particle released into the groundwater. Two flow lines will be constructed to encompass the entirety of the tank systems being evaluated, thereby forming the lateral boundaries of the GTS. Future GTSs for nearby tanks will be bound on one side by the adjacent, previously established GTS and on the other by a groundwater flow line tangent to the tank systems being evaluated.

Several simplifying assumptions will be made when defining a GTS and when performing fate and transport modeling of contaminants affecting the GTS. These include (1) assuming homogeneous, isotropic conditions when modeling groundwater flow, (2) assuming that there are no contributions from adjacent GTSs (i.e., there is no overlap of contamination from different GTSs), (3) assuming all contaminants remain in the Water Table Aquifer, and (4) assuming current environmental conditions (i.e., meteorology, hydrology) will remain throughout the period of analysis. While these assumptions represent inherent simplifications of actual environmental conditions, they enable the modeling of environmental effects using standard fate and transport modeling techniques to obtain concentration or dose levels for comparison to regulatory standards. These assumptions also lead to increased conservatism in modeling by overestimating the predicted individual maximum dose at the seepline. In addition, historic characterization data from the SRS general separations area (Fenimore and Horton 1972, Looney et al. 1993) indicate the existence of narrow flow paths for contaminants in groundwater, thus supporting the assumption that there are no contributions from adjacent GTSs.

DOE recognizes that this method does not specifically account for the temporal variability of the distribution of contaminants in the groundwater (which could cause localized heterogeneities). However, the computer program, Multimedia Environmental Pollutant Assembly System (MEPAS), calculates 70-year average concentrations over a 10,000-year period; thus, any temporal inhomogeneities that might be short-lived in nature (a few years at isolated times) would affect the 70-year averages only minimally. In addition, the GTS method does include the conservative assumption that centerline concentrations are representative of the concentration along the entire width of the GTS.

As modules are developed, the appropriateness of assumptions will be reevaluated and adjusted as necessary to represent actual conditions. If, for instance, groundwater transport characterization for the entire F- and H-Area Tank Farms were performed, the GTS methodology could be replaced by a more sophisticated methodology.

6.3 Source Identification and Quantification

After defining the GTS, DOE will identify all tank systems and other nontank sources contributing to environmental impacts in the GTS and quantify the source term. If an entire tank system or other source is located partially in the GTS for the tank system to be closed, that portion of the source in the GTS will be included in calculating the environmental impact. The remaining portion of the source will be included in the adjacent GTS during the closure process for another tank system. For instance, if one half of a tank system is within the defined GTS, one half of its total contribution will be included for the GTS in question. There is considerable judgment involved in defining the width of a GTS, but a properly defined segment should encompass all the sources in or very near the flowpath of the tank system to be closed.

6.4 Fate and Transport Modeling

6.4.1 MODELING CLOSURE CONFIGURATIONS

To close a specific tank, DOE would specify a closure configuration (residual source term and stabilization method) or range of configurations for evaluation. These configurations would be used to establish analysis scenarios (refer to Appendix D, Section D.2). Fate and transport modeling would then determine if the closure scenarios can satisfy the overall POs (Chapter 5).

The process for evaluating tank closure against the overall POs involves modeling the transport of residual contaminants through the environment and calculating concentrations and doses at the point of compliance. If modeling determines that concentrations and doses are less than those prescribed by the POs, then the tank closure process will proceed with the steps to determine tank-specific POs. As shown in Figure 6-1, however, the selection of the closure configuration can be an iterative process requiring several modeling cycles to test revised configurations. For example, if initial modeling fails to demonstrate compliance with POs, DOE could consider additional waste removal steps to reduce the source term, or the construction of a high performance cap could reduce hypothetical contaminant migration, thereby achieving compliance with POs.

6.4.2 MODELING CONSIDERATIONS

Before actual modeling can begin, DOE must determine the future use of the closure site and its environs. For modeling purposes, the tank farms in F- and H-Areas will be under institutional control for

100 years after closure and an area surrounding the tank farms will be restricted to commercial and industrial use. The future use scenario forms the basis for many of the parameters in the model.

Another consideration in modeling is the identification of potential receptors and estimation of their living requirements (e.g., food and water consumption). The performance objectives determine the types of receptors or points of compliance that must be specified. An example of a human receptor identified in current regulations is the resident-farmer who lives and farms near the closure site.

Because the concentration of released contaminants at a point in the environment is directly proportional to the amount of material released, DOE must characterize the contents of the tank and nontank sources as accurately as practicable. In addition, the structural design and integrity of the tank must be known to determine the amount of contamination that will be released. A compounding problem is the fact that releases would occur over time and the rate of release generally increases with time as the containment degrades.

The residual contamination released from the sources is transported through the environment by geological and meteorological processes. Many parameters characterize environmental transport that must be determined. Because the HLW tanks are in the ground, geohydrological transport is the dominant mechanism.

In cases where there is uncertainty in the value of any parameter, values are selected that are believed to be conservative (i.e., they result in relatively higher calculated rates of contaminant transport and, therefore, greater environmental impact). The same is true of equations and algorithms used in the computer codes. Equations and constants are as accurate as possible; however, when uncertainty exists, choices are made so the results are not underestimated. The compounding of a large number of such conservative inputs leads to modeled results generally that are considerably greater than actual results.

When all the parameters describing release, transport, and exposure of receptors have been determined, they must be entered in an appropriate computer model. DOE will use the U.S. Environmental Protection Agency (EPA)-recognized MEPAS computer code because it is designed to accept the primary assumptions discussed in Section 6.2, or an equivalent code appropriate for this application. Because the HLW tanks will be removed from service and closed over a period of decades, other codes or methods could be selected in the future. Appendix D of this plan contains an example of how modeling could be performed for tanks 17 to 20 in the F-Area Tank Farm.

6.5 Contributions from Nontank Sources

To determine an appropriate performance objective for the tank to be closed, contributions from other sources (HLW tank systems and nontank sources) must be subtracted from the overall performance objectives discussed in Chapter 5 and identified in Appendix C. The nontank sources are considered initially because the source terms are likely to be better quantified and, in many cases, considerably less significant than the HLW tanks.

Accounting for the nontank sources will result in an "adjusted" Performance Objective defined as follows for each contaminant:

$$PO_a = PO - C_{os}$$

where: PO_a = Adjusted Performance Objective
PO = Overall Performance Objective for the tank farm (refer to Chapter 5)
C_{os} = Contribution of other nontank sources at peak contribution from the HLW tank system

The value for C_{os} will be determined for each contaminant with the fate and transport modeling described in the previous section. The value for PO_a represents the PO for all tank systems in the GTS. Appendix E provides an example of the use of this process.

6.6 Determination of Tank-Specific Performance Objectives

After subtracting the impacts from nontank sources, the resulting value for PO_a must be apportioned among the HLW tanks within a particular GTS. The apportionment will be based on the relative contributions to potential impacts expected from the various tanks at closure. Thus, in principle, the apportionment will be governed by the following equation:

$$PO_i = PO_a \text{ x } {}^{Q_i}\!/\!_{Q_T}$$

where: PO_i = a tank-specific performance objective for tank i
Q_i = contribution from tank i
Q_T = contribution from all tanks in the GTS

DOE recognizes that, in practice, application of the above equation is not always straightforward since Q_i and Q_T result from several contaminants that must be considered together. However, the modeling results presented in Appendix D indicate that usually only one contaminant dominates at a given time because the different contaminants have varying transport rates. This leads to a simple application of the equation for each performance objective. The results and conclusions presented in Appendix D include the effects of all contaminants contributing to a given exposure point at all times during the period of analysis. Appendix E provides an example of the use of this process.

6.7 References

Fenimore, J. W., and J. H. Horton, 1972, *Operating History and Environmental Effects of Seepage Basins in Chemical Separations Areas of the Savannah River Plant*, DPST-72-548, E. I. duPont de Nemours and Company, Inc., Savannah River Laboratory, Aiken, South Carolina.

Looney, B. B., J. S. Haselow, C. M. Lewis, M. K. Harris, D. E. Wyatt, and C. S. Hetrick, 1993, *Projected Tritium Releases from F & H Area Seepage Basins and the Solid Waste Disposal Facilities to Fourmile Branch* (U), WSRC-RP-93-459, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993, *Waste Removal Plan and Schedule*, WSRC-RP-93-1477, Revision 0, Westinghouse Savannah River Company, Aiken, South Carolina.

APPENDIX A.

ANALYSIS OF HIGH-LEVEL WASTE TANK SYSTEM CLOSURE ALTERNATIVES

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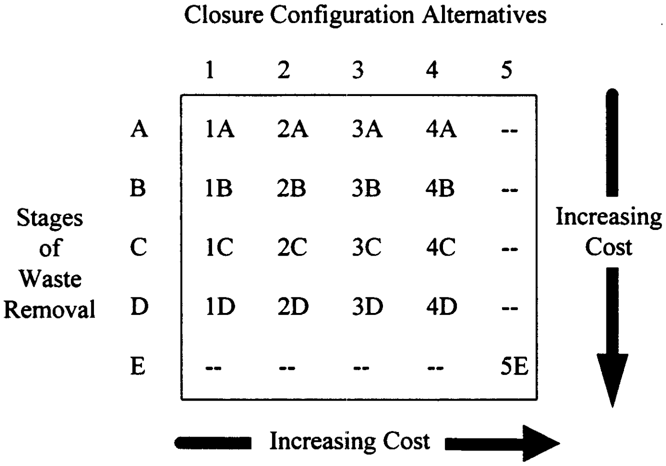
APPENDIX A. ANALYSIS OF HIGH-LEVEL WASTE TANK SYSTEM CLOSURE ALTERNATIVES

DOE evaluated a number of high-level waste tank system closure alternatives. Most of the alternatives involve removing the waste from the tank followed by filling the tank with a backfill material to leave it in a stable condition.

The chart below shows the waste removal and closure configuration alternatives that were considered:



Closure Configuration Alternatives

Stages of Waste Removal

	1	2	3	4	5
A	1A	2A	3A	4A	--
B	1B	2B	3B	4B	--
C	1C	2C	3C	4C	--
D	1D	2D	3D	4D	--
E	--	--	--	--	5E

Closure Configuration Alternatives

1. No fill material in tank (no action)
2. Fill with sand
3. Fill with grout
4. Fill with saltstone
5. Remove tanks from ground

Stages of Waste Removal

A. Bulk waste removal
B. Bulk waste removal
    + Spray washing
C. Bulk waste removal
    + Spray washing
    + Oxalic acid cleaning
D. Bulk waste removal
    + Mechanical and chemical cleaning involving advanced techniques
E. Clean tanks to extent allowing removal of tank from ground

A.1 Closure Configuration Alternatives

A.1.1 SELECTED ALTERNATIVE—FILL TANKS WITH PUMPABLE BACKFILL MATERIAL

The selected closure alternative for the HLW tank systems consists of removing the waste from the tanks using hydraulic slurrying techniques or other cleaning techniques of comparable effectiveness. After waste removal, each tank will be filled with pumpable, self-leveling backfill material(s) (e.g., grout). The fill material will be high enough in pH to be compatible with the carbon-steel walls of the waste tank. The fill material will be formulated with chemical properties that will retard the movement of radionuclides and chemical constituents from the closed tank.

A.1.1.1 Example Closure Configuration

The HLW tanks at SRS differ in the quantities of contaminants, configurations of cooling coils and equipment, and hydrogeologic setting (e.g., distance from the water table and distance to nearby streams). The closure configuration for each tank or group of tanks will be determined case by case, although all closures will incorporate a number of important features. The sections that follow describe an anticipated closure configuration under the selected alternative. The first section describes the closure state for each waste tank. The second section describes the closure state for groups of tanks.

A.1.1.1.1 Tank Stabilization

The first step of closing the HLW tanks at SRS would be to close each tank individually. Figure A-1 shows the anticipated closure configuration for a single tank closure.

The various layers in and above the tank, from bottom to top, are as follows:

- The residual waste at the bottom of the tank is the waste that remains after waste removal techniques have been applied (see Section A.2).

- Reducing grout is a pumpable, self-leveling backfill material similar in composition to that used at the SRS Saltstone Manufacturing and Disposal Facility (SMDF), composed primarily of cement, flyash, and blast furnace slag. The chemical properties of liquid that leaches through this backfill material will reduce the mobility of selected radionuclides and chemical constituents. The formulation of the backfill material for each waste tank will be adjusted based

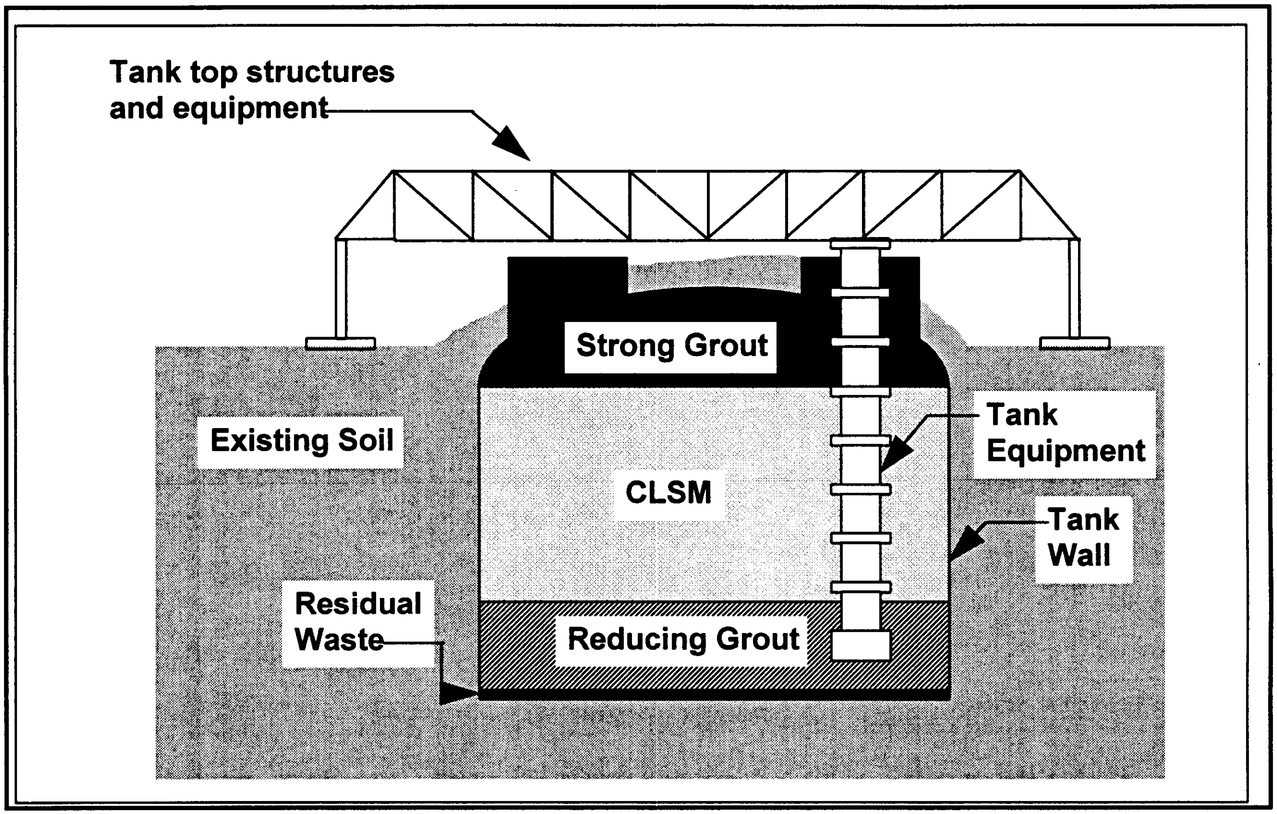


Figure A-1. Tank closure example.

on specific circumstances for each tank. The material is pumped into the waste tank through an available opening (e.g., tank riser).

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

  - The compressive strength of the material can be controlled so that it will provide adequate strength for the overbearing strata and yet could be potentially excavated with conventional excavation equipment. Although excavation of the tank is not anticipated, filling the tank with low-strength material would enhance the opportunity for future removal of tank contaminants or perhaps the tank itself, if future generations were to decide that excavation is desirable.

  - CLSM has a low heat of hydration, which allows large or continuous pours. The heat of hydration in ordinary grout limits the rate at which the material can be placed because the high temperatures generated by thick pours prevent proper curing of the grout. Thus, large pours of grout are usually made in layers, allowing the grout from each layer to cool before the next layer is poured.

    - CLSM is relatively inexpensive.

    - CLSM is widely used at SRS, so there is considerable experience with its formulation and placement, and in controlling the composition to provide the required properties.

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

    - The runny consistency of the grout is advantageous for filling voids near the top of the tank created around risers and tank equipment. The grout would be injected in such a manner to ensure that voids were filled to the extent practicable. This may involve several injection points, each with a vent.

    - A relatively strong grout will discourage an intruder from accidentally accessing the waste after institutional control of the area is discontinued.

A.1.1.1.2 Area Closure

The necessity for a low-permeability cap, such as a clay cap, to reduce rainwater infiltration will be established in HLW tank system-specific closure modules. However, the design and installation of such a cap probably would address an entire tank farm or portions thereof containing several HLW tank systems, and would therefore be addressed under the SRS Environmental Restoration program.

Figure A-2 shows an anticipated closure configuration for a group of tanks in one area. The area around the tanks would be backfilled with soil to cover all risers, equipment, and other protuberances. If needed, a cap could be placed over the group of tanks. The cap would then be placed so that rain falling on the area will drain away from the closed tanks. Because the tank systems are in close groupings, a cap would probably be placed over an entire group of tank systems in one area rather than over each tank individually. If it were anticipated that a long period of time would elapse between the time a particular tank system in a group was closed and the time when the area cap was installed, the tank system would be covered in some manner to prevent rainwater intrusion during this interim period. The need for an interim cover will be addressed in the tank-specific closure module.

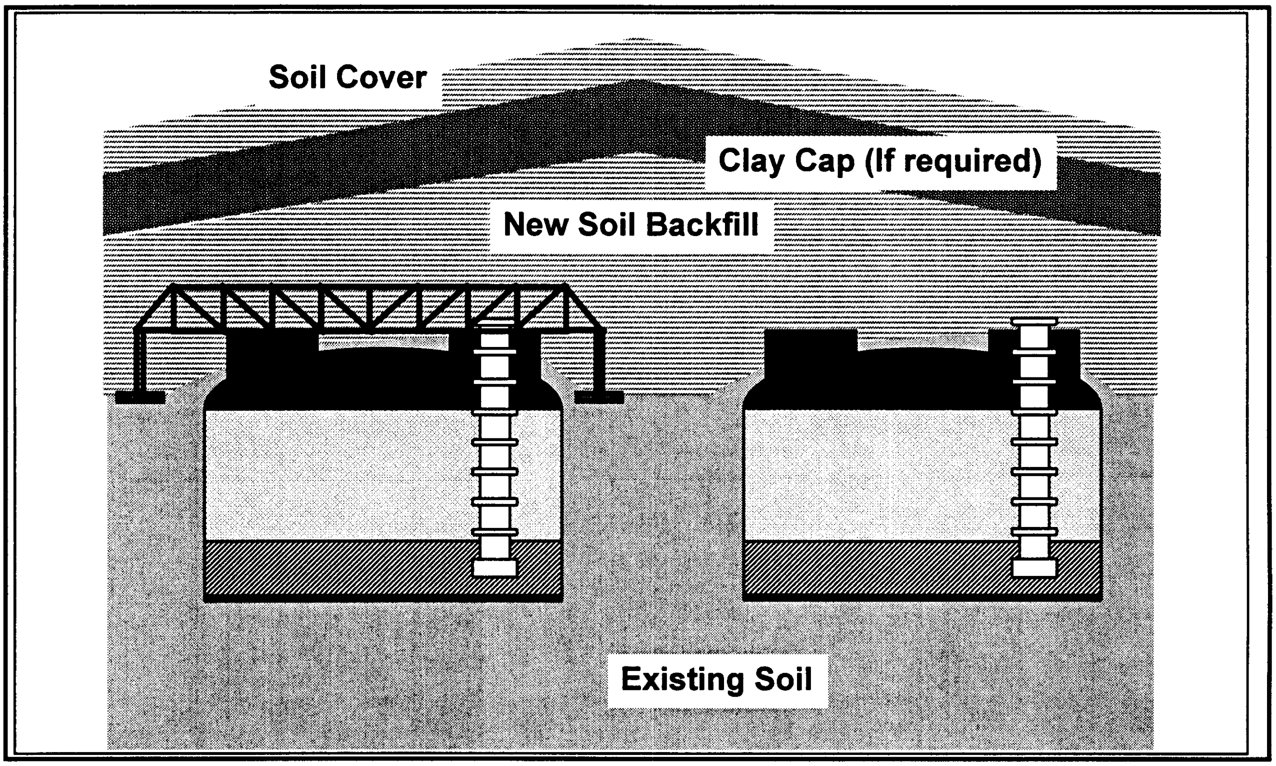


Figure A-2. Area closure example.

A.1.1.2 Essential Features of the Selected Alternative

Figure A-1 is an example of a tank system closure under the Selected Alternative. Although the details of each individual closure will probably vary, any sludge tank closure under this alternative would have the following characteristics:

- The tank is cleaned by bulk waste removal followed by spray washing with hot water. If new cleaning techniques are developed, the tank will be cleaned by newly developed techniques with comparable or greater cleaning effectiveness.

- The fill material is pumpable and self-leveling, is designed to prevent future subsidence of the tank, and will fill voids to the extent practical, including equipment and secondary containment.

- The fill material is formulated to reduce the migration of radionuclides and chemical constituents.

- The fill configuration discourages inadvertent intrusion after institutional control is discontinued but will be designed to allow potential future excavation of the tank to the extent practical, consistent with the need for preventing subsidence and migration of the radionuclides and chemical constituents.

- The final closure configuration meets performance objectives approved by SCDHEC and EPA.

A.1.2 OTHER STABILIZATION ALTERNATIVES

Alternatives to the Selected Alternative consist of the following:

- Waste removal - no fill material
- Waste removal - fill tanks with sand
- Waste removal - fill tanks with saltstone
- Clean tanks to extent allowing removal of tanks

These alternatives were rejected for various reasons discussed in this section. Table A-1 lists the relative costs of the various closure alternatives.

Table A-1. Costs of the closure alternatives.[a]

	Closure alternative	Cost per tank	Truck traffic per tank (concrete trucks of 9 cubic yards)	Worker exposure (rem)
1.	No fill material in tank	$56,000	NA	2 person-rem
2.	Fill with sand	$2,500,000	800 trucks[b]	10.2 person-rem
3.	Fill with grout	$2,500,000	800 trucks[b]	10.2 person-rem
4.	Fill with saltstone	$5,000,000	800 trucks	10.5 person-rem[c]
5.	Remove tanks from ground	$50,000,000	780 trucks[d]	93 person-rem

a. Estimates are for comparison purposes only, not of budget quality. All costs in FY1996 dollars.
b. Assume 1.4 million gallons at 9 cubic yards of concrete per truck. An anticipated schedule would be about 10 trucks per day for three months.
c. Based on dose estimated for grout filling (Option 3) plus <300 mrem per year total annual dose from operation of the saltstone facility.
d. Assumes 3,900 B-25 boxes, 5 boxes to a truck.

A.1.2.1 Waste Removal - No Fill Material (No Action)

After waste removal, no action would be taken to fill the tank with backfill material. After some period of time, the reinforcing bar in the roof of the tank would rust, and the roof of the tank would fail. Rainwater would readily pour into the exposed hole, flushing contaminants from the residual waste in the tank and carrying these contaminants into groundwater.

This alternative involves the least expense and the least amount of field work. There is no impact on surrounding tanks and no interruption of ongoing operations in the tank farm. However, there is no real control over the tank. Future inhabitants of the area would be potentially exposed to the contamination in the tank. The depth of the tank bottom and infiltration rate make it unlikely that the contaminants could be carried out of the tank; however, a limited potential exists for releases to the atmosphere by high winds or during storms. Also, movement of the contaminants into the groundwater is most rapid with this alternative, and expected contamination levels in groundwater and surface streams would be higher than for the selected alternative. Modeling results (see Appendix D) indicate a 34-percent decrease in total radiation dose at the seepline for grout fill versus no fill material.

A.1.2.2 Waste Removal - Fill Tanks with Sand

This alternative is similar to backfilling with a pumpable backfill material, except sand would be used instead of grout. The sand would be carried by truck to an area near the tank farm and conveyed to the tank to be closed.

Sand is readily available and is inexpensive. However, its emplacement is more difficult than grout as it does not flow readily into voids. Over time, sand will settle in the tank, creating additional void spaces. The dome would then become unsupported and would sag and crack, although there would not be the catastrophic collapse that would be anticipated in the no-action case. Also, the sand would tend to protect the contamination to some extent and prevent winds from spreading the contaminants. However, sand is highly porous and rainwater infiltrates rapidly and does not run off. Also, sand is relatively inert and could not be formulated to retard the migration of radionuclides and chemical constituents. Thus, the expected contamination levels in groundwater would be higher than for the selected alternative. Modeling results (see Appendix D) indicate a 24-percent decrease in total radiation dose at the seepline for grout fill versus sand.

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

A.1.2.3 Waste Removal - Fill Tanks with Saltstone

This alternative is the same as filling with uncontaminated grout, except the fill material used would be saltstone, the stabilized low-activity fraction of HLW that results from treatment at the In-Tank Precipitation Facility. This alternative has the advantage of reducing the amount of saltstone landfill space that would be required at SRS (i.e., saltstone sent to a waste tank would not need to be sent to the Saltstone Landfill). However, this alternative has several significant disadvantages that caused it to be rejected:

- The cost of this alternative is higher than the selected alternative. The amount of saltstone to be made is projected to be greater than 160 million gallons, which is considerably in excess of the capacity of the waste tanks. Thus, to implement this alternative either (1) two new saltstone mixing facilities would have to be constructed, one in F-Area and another in H-Area or (2) saltstone transport lines would have to be constructed from the existing saltstone facility in Z-Area to F- and H-Areas. Either alternative would involve a large capital project.

- Filling the tank with a grout mixture that is contaminated with radionuclides would considerably complicate the project, further adding to the expense.

- Saltstone grout cannot be poured as fast as CLSM because of its relatively high heat of hydration. Saltstone grout would have to be poured in discrete pours, allowing sufficient time between pours for the grout to cool.

A.1.2.4 Clean Tanks to the Extent Allowing Removal of Tanks

After bulk waste removal, each tank would undergo additional cleaning, perhaps including oxalic acid cleaning and additional cleaning steps, yet to be defined, until it is clean enough to remove. It is also possible that the tank could be removed from the ground after only a few cleaning steps, although the cost would be higher because of the risk of radiation exposure and contamination. The steel components would be sectioned, removed, placed in burial boxes for disposal, and transported to the SRS low-level waste disposal facilities. Some components could require treatment prior to disposal or disposal at planned SRS mixed waste disposal facilities.

The advantages of this option are:

- There is the potential to dispose of the contaminated components of the tank in a waste disposal facility that has better barriers to the migration of contamination than the current location of the waste tanks.
- This option exposes the surrounding soils such that they could be exhumed. This is the only option that has the potential to leave the waste tank area as an unrestricted area for future uses.

The disadvantages include:

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

A.2 Waste Removal Alternatives

A.2.1 SELECTED ALTERNATIVE - BULK WASTE REMOVAL PLUS SPRAY WASHING

The selected alternative for HLW tank system is bulk waste removal followed by spray washing with hot water. For tanks in which waste has leaked from primary containment into the annulus, the annulus will also be cleaned.

A.2.1.1 Bulk Waste Removal

Bulk waste removal uses long-shafted slurry pumps to agitate the liquid contents of the tank. The processes are slightly different for sludge and salt tanks. Each is described below:

Sludge Removal

While the sludge is still suspended, the sludge slurry is removed from the tank using a pump. DOE has used this process to remove sludge from six tanks, although only two sludge removal operations were continued to the bottom of the tank. The estimated amount of sludge remaining in these two tanks after bulk sludge removal was 5,000 gallons in Tank 16 and 9,000 gallons in Tank 17. In most tanks, it is anticipated that the amount of sludge remaining will be less than 10,000 gallons.

Salt Removal

DOE has used hydraulic salt removal at SRS to remove the salt from four waste tanks. The process is similar to Bulk Sludge Removal but with the following differences:

- Salt is dissolved rather than suspended by the mechanical action of the pumps.
- The salt solution is removed from the tank by a jet rather than a pump. Jets are less expensive and more reliable than pumps, but jets cannot pump significant quantities of solids, which is why pumps are used for bulk sludge removal.

In the two tanks in which hydraulic salt removal was continued to the bottom of the tank (Tanks 20 and 24), there was no observable salt at the bottom of the tank at the end of hydraulic salt removal. (However, Tank 24 still has some zeolite solids, which may require further waste removal.)

A.2.1.2 Spray Washing

The tank is spray washed using rotary spray jets with hot water. The spray nozzles can remove sludge near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank are then agitated with slurry pumps and pumped out of the tank.

Spray washing has been demonstrated to be effective in sludge tanks. The amounts of sludge left after spray washing were estimated at 3,500 gallons in Tank 16 and 4,000 gallons in Tank 17.

The effectiveness of spray washing has not been conclusively demonstrated in salt tanks. Since salt is soluble in water, bulk waste removal should be effective at removing most of the contamination, and spray washing of tanks might not be necessary. However, some insoluble particles exist even in salt tanks, and spray washing might be necessary to remove these residual insoluble particles, which is why spray washing is currently planned for all salt tanks.

Only one salt tank has been spray washed at SRS (Tank 20). Inspections of this tank after bulk waste removal showed no indication of residual waste, and no residual waste was noted after spray washing. At the time of the photographic inspection after waste removal, the tank contained at least 3.5 inches of residual liquid (about 12,000 gallons) so there has been no opportunity to inspect the bottom of the tank for residual waste. The tank currently contains 6 inches of water to prevent uplift of the tank bottom. The need for spray washing of salt tanks will be reassessed after more experience is gained in salt tanks.

A.2.1.3 Annulus Cleaning

Nine tanks have leaked detectable amounts of wastes from primary to secondary containment. On these tanks, the waste will be removed from the annulus using water or steam. Annulus cleaning has been attempted at SRS on only one tank (Tank 16), and the operation was only partially completed. Thus, annulus cleaning is not demonstrated technology. Also, there may be some cases where it is impractical and new techniques might have to be developed. The amount of waste in secondary containment is small, so the environmental risk of this waste is small in relation to the amount of waste inside the tanks.

A.2.2 WASTE REMOVAL ALTERNATIVES

Various waste removal alternatives were considered. The waste removal alternatives in order of increasing cost are:

A. Bulk waste removal
B. Bulk waste removal + spray washing
C. Bulk waste removal + spray washing + oxalic acid cleaning
D. Bulk waste removal + mechanical and chemical cleaning involving advanced techniques
E. Clean tanks to extent allowing removal of tank from ground

Options A, B, and C have been demonstrated at SRS. First, bulk waste removal is performed on every tank. Current plans are then to perform spray washing on every sludge tank because it has been demonstrated to be effective at removing contamination. For salt tanks, the current plan is also to spray wash. However, as mentioned previously, these plans may be changed if further experience shows that bulk waste removal is sufficiently effective.

The last demonstrated waste removal process is oxalic acid cleaning. In this process, hot oxalic acid is sprayed through the spray nozzles that were used for spray washing. A number of potential cleaning agents for waste removal have been studied. Oxalic acid was chosen as the preferred cleaning agent because:

- Oxalic acid dissolves sludge, allowing the removal of sludge deposits that are difficult to mobilize using water sprays alone.

- Oxalic acid is only moderately aggressive against carbon steel, the material of construction of the waste tanks. Corrosion rates of oxalic acid on carbon steel are on the order of 0.001 inch per week. These corrosion rates are acceptable for a short-term process such as oxalic cleaning. There are more aggressive cleaning agents such as nitric acid that could remove sludge more effectively but these cleaning agents would cause rapid deterioration of the carbon steel wall of the tank, which could potentially cause the release of contaminants to the environment in a mobile (acid) form. This is contrary to the goal of the tank system closure, which is to mobilize most of the contaminants briefly so they can be removed from the tank but then leave the remaining contaminants in immobile form inside the tank.

Oxalic acid cleaning has been demonstrated to provide better cleaning than bulk waste removal or spray washing. In Tank 16, the estimated inventory of sludge after oxalic acid cleaning was less than 1,000 gallons. However, oxalic acid cleaning generates large quantities of sodium oxalate that must be disposed of in the Z-Area SMDF. Sodium oxalate precipitates at the high sodium concentrations in SRS wastes. If large quantities of sodium oxalate are generated during tank cleaning, it will be necessary to modify the processing plans for the In-Tank Precipitation Facility.

Therefore, the selected alternative is B, bulk waste removal plus spray washing. Oxalic acid cleaning may be used on some tanks in order to meet performance standards. Table A-2 lists the relative costs of the various waste removal alternatives. Although the costs of options D and E cannot be accurately estimated at this time because there is no experience with conducting them, all indications are that these technologies would be considerably more expensive than options A, B, and C.

Table A-2. Costs of the waste removal alternatives.[a]

	Waste removal option	Cost per tank[a]	Disposal costs of liquid waste per tank	Worker exposure (rem)
A	Bulk sludge removal or hydraulic salt removal	$9,000,000	$134,000,000[b]	2
B	Spray washing (incremental costs after bulk removal)	$1,200,000	$100,000	less than 1
C	Oxalic acid cleaning (incremental costs after spray washing)	$300,000	$500,000[c]	less than 1
D	Mechanical and chemical cleaning (incremental costs after oxalic acid cleaning)	Unknown but believed to be greater than $50 million per tank		
E	Clean tanks to extent allowing removal of tank from ground (incremental costs after oxalic acid cleaning)	Unknown but believed to be greater than $50 million per tank		

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a. Estimates are for comparison purposes only, not of budget quality. All costs in FY1996 dollars. Costs are total estimated cost only.

b. Based on estimated cost of DWPF at $2.4 billion capital plus $4.3 billion operation expenses over 25 years. $6.7 billion divided by 50 tanks equals $134 million per tank.

c. Based on 150,000 gallons of spent sodium oxalate solution to be disposed of in SMDF at $3 per gallon.

Options D and E have 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 can be considered viable options at this time. For example, no robotic arms have been demonstrated that could navigate through the forest of cooling coils that are found in most SRS waste tanks. Also, as mentioned previously, there are more aggressive cleaning agents than oxalic acid, for example, nitric acid. However, these cleaning agents have an unacceptable environmental risk because they attack the carbon steel wall of the waste tank. Laboratory studies indicate that oxalic acid is the most aggressive cleaning agent that can be safely used on carbon steel for the long periods of time (days to weeks) that are needed for spraying and slurrying of the cleaning agent.

Therefore, advanced cleaning techniques focus aggressive cleaning techniques on a small portion of the tank. For example, a high pressure jet could be focused on a small portion of the tank wall, or the tank could be scrubbed by mechanical means. Alternatively, the tank could be cut into steel plates and disposed of elsewhere. Each of these techniques requires either (1) developing robotic techniques that can navigate through the forest of cooling coils found in most SRS high-level waste tanks, or (2) cutting the cooling coils. Such cleaning techniques would require large costs to develop using today's technologies and would require a long time to carry out because they focus on small areas of the tank at a time.

DOE is actively sponsoring research into improved cleaning methods. If improved cleaning methods are developed that provide equal or superior cleaning effectiveness to the preferred alternative, these cleaning methods could be substituted for oxalic acid cleaning in SRS sludge tanks. For example, it would be beneficial to develop a cleaning method that does not generate large quantities of sodium oxalate.

A.3 Ancillary Equipment

In addition to the residual waste at the bottom of the tank, which is the major focus of closure activities, there will be residual contamination on equipment inside and near the tank (e.g., slurry pumps used for waste removal, cooling coils inside the tank, transfer piping into and out of the tank, and the secondary containment system and leak detection system for the tank). Also, the tank farms include other equipment for processing the waste (e.g., evaporators, diversion boxes, pump tanks, and interarea transfer lines from F- to H-Area and from H-Area to DWPF and the Z-Area SMDF). DOE anticipates that the amount of contamination left on this equipment will be small compared to the amount of contamination in the tanks, so closure of this equipment will have a smaller environmental impact.

The disposition of equipment associated with each tank or group of tanks will be addressed at the same time as closure of the tank or group of tanks. For each piece of equipment, the decision will be made as to whether the equipment will be left in place or removed. Reasons for removing a piece of equipment might include that it can be used elsewhere or that the materials of construction can be used beneficially. Also, consideration will be given to the amount of contaminants left in the piece of equipment, although, as mentioned above, the amount of contamination in equipment will be small in relation to the amount of contamination in the tanks. DOE anticipates that most of the equipment on the tanks will be left in place because much of the equipment would have to be disposed of elsewhere. Thus, removing the equipment would be a significant cost with small environmental benefit. However, in some cases disposition of equipment or media (e.g., contaminated soil) by placement in the tank might prove beneficial in the future. If costs/benefits analysis demonstrates the disposition of such materials in the tanks to be advantageous, this option will be considered in the tank-specific closure module.

If the decision is made to leave a particular piece of equipment in place, then the closure configuration for that piece of equipment must be addressed. Similar to the tanks, two separate decisions need to be made: (1) how the equipment will be decontaminated and (2) how the equipment will be closed. The disposition of each piece of equipment in a tank system will be addressed in the closure module for that tank system.

A.3.1 DECONTAMINATION OF EQUIPMENT

The options for decontamination of equipment are similar to the options for cleaning the tank, although there are some differences:

- No Action
- Flushing with water (similar to bulk waste removal)
- Flushing with oxalic acid (similar to oxalic acid cleaning)
- Mechanical and chemical cleaning involving advanced techniques
- Remove the equipment

One significant difference between equipment and the tank is that No Action is a viable option for many pieces of equipment. Much equipment located on the tank top is not contaminated because it does not come in contact with the waste. In addtion, some equipment that does regularly contact the waste is flushed regularly, so the amount of contamination normally left in the equipment is small, and no additional cleaning is needed for closure.

On any particular tank system, a combination of strategies will probably be used (i.e., some equipment will be removed, some will be left in place, some will be flushed).

A.3.2 CLOSURE OF EQUIPMENT

The options for closure of equipment are also similar to those for closure of the tanks:

- No fill material (no action)
- Fill with sand
- Fill with grout
- Fill with saltstone
- Remove equipment

The No-Action case is a viable alternative for small pieces of equipment. Some equipment has very little void space and filling the voids would be impractical. If the number of voids is small and would not present a concern for settling after the closure, the voids could be left unfilled.

Filling with sand has the same disadvantages as those discussed for backfilling tanks. In addition, tank equipment has many small void spaces, each of which would need to be filled separately. Thus, filling with sand is particularly undesirable for small equipment.

Filling with grout is a viable option for large equipment, such as evaporator cells, diversion boxes, and pump pits, and could be used for other pieces of equipment, such as transfer lines. The backfill material would have similar properties to that discussed for tank closure. Some sort of fill on large equipment will probably be required to prevent settling of the area after the closure.

Filling with saltstone has the same disadvantages as those discussed for filling the tanks with saltstone.

As discussed above, removing equipment is a viable option for small pieces, especially those that could be reused elsewhere.

APPENDIX B.

ANTICIPATED CLOSURE SCHEDULE

APPENDIX B. ANTICIPATED CLOSURE SCHEDULE

In November 1993, DOE submitted the Waste Removal Plan and Schedule (WSRC 1993) to the South Carolina Department of Health and Environmental Control (SCDHEC) in accordance with Section IX.E of the Federal Facility Agreement (FFA; EPA 1993). This Plan and Schedule addresses only those high-level waste (HLW) tank systems that do not meet standards set forth in Appendix B of the FFA. DOE subsequently determined that it would accelerate the anticipated schedule to complete waste removal and commence closure of all the HLW tank systems in accordance with this closure plan. It is DOE's intention to meet or exceed the dates as defined in the Waste Removal Plan and Schedule.

A generalized schedule for closure of HLW tank systems is provided in Figure B-1. Figure B-1 is based on the Waste Removal Plan and Schedule and also includes the schedule for closure of the Type III tanks. Within approximately 6 months after waste removal and cleaning are completed, DOE expects to commence characterization of the tank residual, treatability studies to formulate the appropriate backfill material, performance evaluation of potential closure configurations, and development of a tank-specific closure module.

Due to operational constraints, the tank systems selected for closure first will be those Type IV systems whose closure least impacts the operations of the SRS HLW facilities. Therefore, DOE's anticipated near term schedule for specific HLW tank systems is as follows:

- Closure of Tank 20 by the end of calendar year 1996.
- Closure of two additional HLW tank systems by the end of fiscal year 1997 (September 1997). The two tanks will be selected from Tanks 17, 19, 16, or 24.
- Closure of at least five HLW tank systems by the end of fiscal year 2000 (September 2000). The tanks will be identified primarily in accordance with Figure B-1.

The order of subsequent tank closure will generally follow the order set forth in Figure B-1. Where possible and practicable, groups of tank systems within a geographic area, such as Tanks 17 through 20, will be closed together to facilitate final CERCLA remediation of the tank farms.

Closure of the HLW tank systems in accordance with the anticipated near-term schedule above is contingent upon SCDHEC review and approval of the tank-specific closure modules, adequate funding, resolution of technical issues, and assurance that there is adequate feedstock to support commitments regarding the Defense Waste Processing Facility in the Site Treatment Plan (WSRC 1996).

DOE is currently preparing a HLW Tank System Program Plan, which will be DOE's planning tool for managing HLW tank system closures. The Program Plan will address in greater detail the upcoming tank systems to be closed and their closure schedule, which will reflect DOE's current budget. The Program Plan will describe the role of the tank-specific closure modules and the process and schedule for transition of the closed HLW tank systems to the SRS Environmental Restoration Program. The Program Plan will also delineate all the Groundwater Transport Segments, which are interpretive constructs used to apportion closure performance objectives across all 51 tanks and other potential sources of contamination in the tank farm area. Finally, the Waste Removal Plan and Schedule will be attached to the Program Plan.

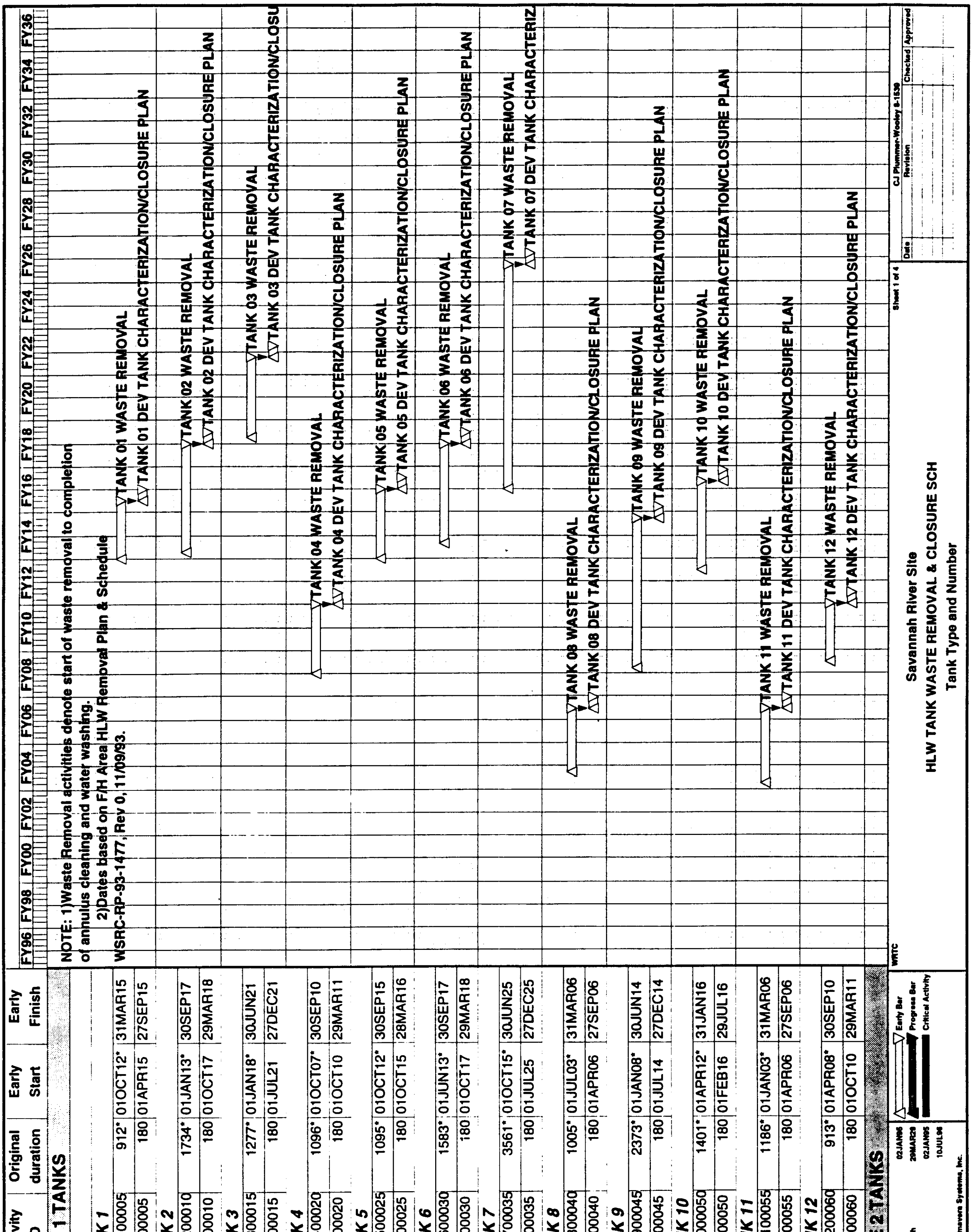
DOE expects to complete the Program Plan by December of 1996 and intends to revise the Program Plan at least annually or when significant perturbations occur that would adversely affect the tank closure program. All modifications to the Program Plan would be provided to SCDHEC in a timely manner.

Concurrent with the submission of the tank-specific closure modules, the DOE-Environmental Restoration Division will submit an evaluation of tank-specific activities required for remediation of the tank farm environs. This evaluation will facilitate full integration of the Environmental Restoration Soils Assessment program into the tank closure schedule. The evaluation will be consistent with the requirements set forth in the FFA.

References

WSRC (Westinghouse Savannah River Company), 1993, *Waste Removal Plan and Schedule*, WSRC-RP-93-1477, Revision 0, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1996, *Savannah River Site Mixed Waste Approved Site Treatment Plan (STP) (U)*, WSRC-TR-94-0608, Westinghouse Savannah River Company, Aiken, South Carolina.

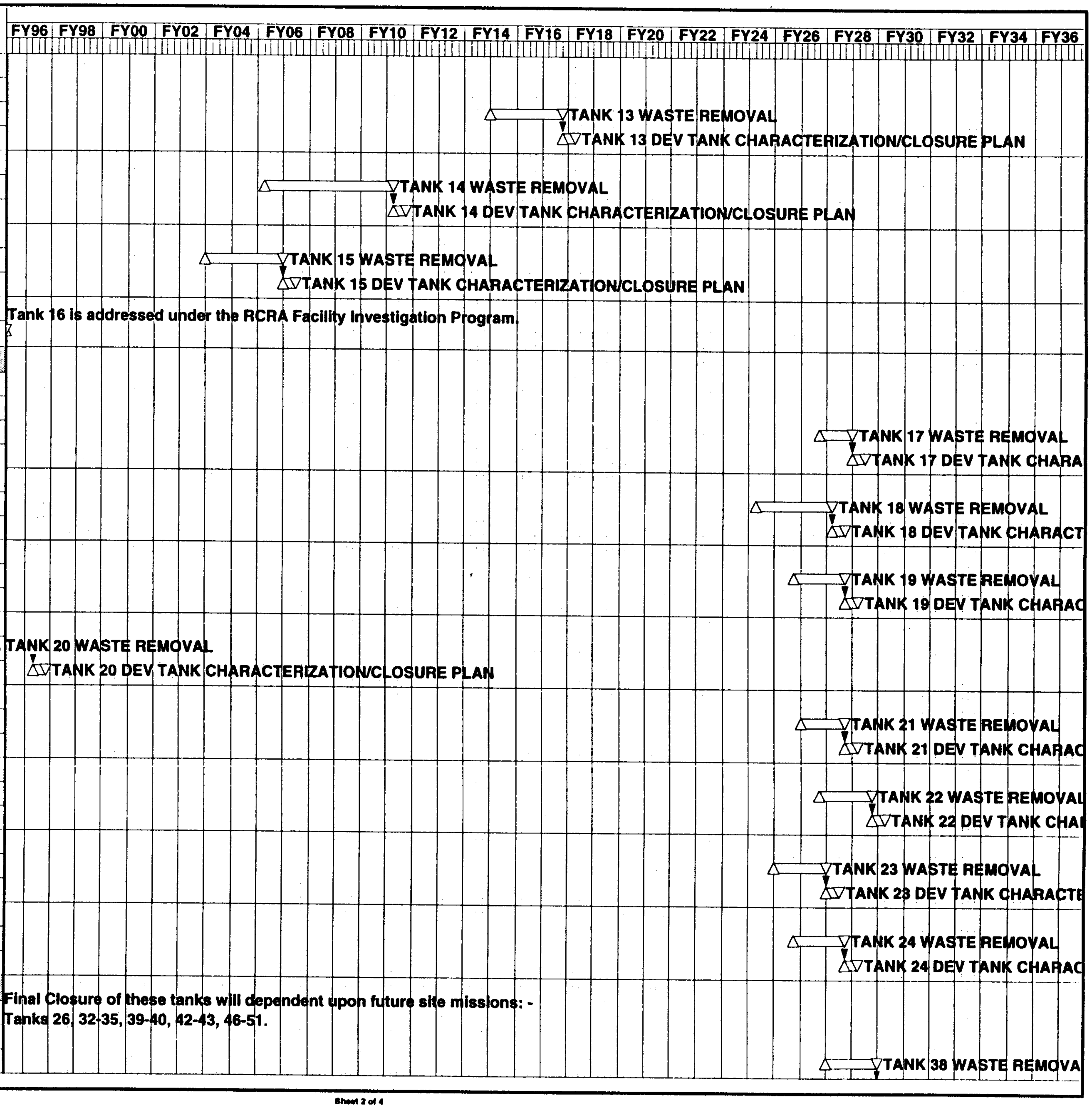


Activity ID	Original duration	Early Start	Early Finish
TYPE 1 TANKS			
TANK 1			
WR0100005	912*	01OCT12*	31MAR15
TC0100005	180	01APR15	27SEP15
TANK 2			
WR0200010	1734*	01JAN13*	30SEP17
TC0200010	180	01OCT17	29MAR18
TANK 3			
WR0300015	1277*	01JAN18*	30JUN21
TC0300015	180	01JUL21	27DEC21
TANK 4			
WR0400020	1096*	01OCT07*	30SEP10
TC0400020	180	01OCT10	29MAR11
TANK 5			
WR0500025	1095*	01OCT12*	30SEP15
TC0500025	180	01OCT15	28MAR16
TANK 6			
WR0600030	1583*	01JUN13*	30SEP17
TC0600030	180	01OCT17	29MAR18
TANK 7			
WR0700035	3561*	01OCT15*	30JUN25
TC0700035	180	01JUL25	27DEC25
TANK 8			
WR0800040	1005*	01JUL03*	31MAR06
TC0800040	180	01APR06	27SEP06
TANK 9			
WR0900045	2373*	01JAN08*	30JUN14
TC0900045	180	01JUL14	27DEC14
TANK 10			
WR1000050	1401*	01APR12*	31JAN16
TC1000050	180	01FEB16	29JUL16
TANK 11			
WR1100055	1186*	01JAN03*	31MAR06
TC1100055	180	01APR06	27SEP06
TANK 12			
WR1200060	913*	01APR08*	30SEP10
TC1200060	180	01OCT10	29MAR11
TYPE 2 TANKS			

NOTE: 1)Waste Removal activities denote start of waste removal to completion of annulus cleaning and water washing.
2)Dates based on F/H Area HLW Removal Plan & Schedule WSRC-RP-93-1477, Rev 0, 11/09/93.

Figure B-1. HLW Tank System Closure Schedule

Activity ID	Original duration	Early Start	Early Finish
TANK 13			
WR1300065	1004*	01OCT13*	30JUN16
TC1300065	180	01JUL16	27DEC16
TANK 14			
WR1400070	1825*	01JAN05*	30DEC09
TC1400070	180	31DEC09	28JUN10
TANK 15			
WR1500075	1096*	01OCT02*	30SEP05
TC1500075	180	01OCT05	29MAR06
TANK 16			
WR1600080	0		
TYPE 4 TANKS			
TANK 17			
WR1700085	457*	01JUL26*	30SEP27
TC1700085	180	01OCT27	28MAR28
TANK 18			
WR1800090	1096*	01JAN24*	31DEC26
TC1800090	180	01JAN27	29JUN27
TANK 19			
WR1900095	730*	01JUL25*	30JUN27
TC1900095	180	01JUL27	27DEC27
TANK 20			
WR2000100	729		01OCT94A
TC2000015	180	01FEB96*	29JUL96
TANK 21			
WR2100105	638*	01OCT25*	30JUN27
TC2100105	180	01JUL27	27DEC27
TANK 22			
WR2200110	731*	01JUL26*	30JUN28
TC2200110	180	01JUL28	27DEC28
TANK 23			
WR2300115	730*	01OCT24*	30SEP26
TC2300115	180	01OCT26	29MAR27
TANK 24			
WR2400120	730*	01JUL25*	30JUN27
TC2400120	180	01JUL27	27DEC27
TYPE 3 TANKS			
2H EVAPORATOR			
TANK 38			
WR3800190	731*	01OCT26*	30SEP28

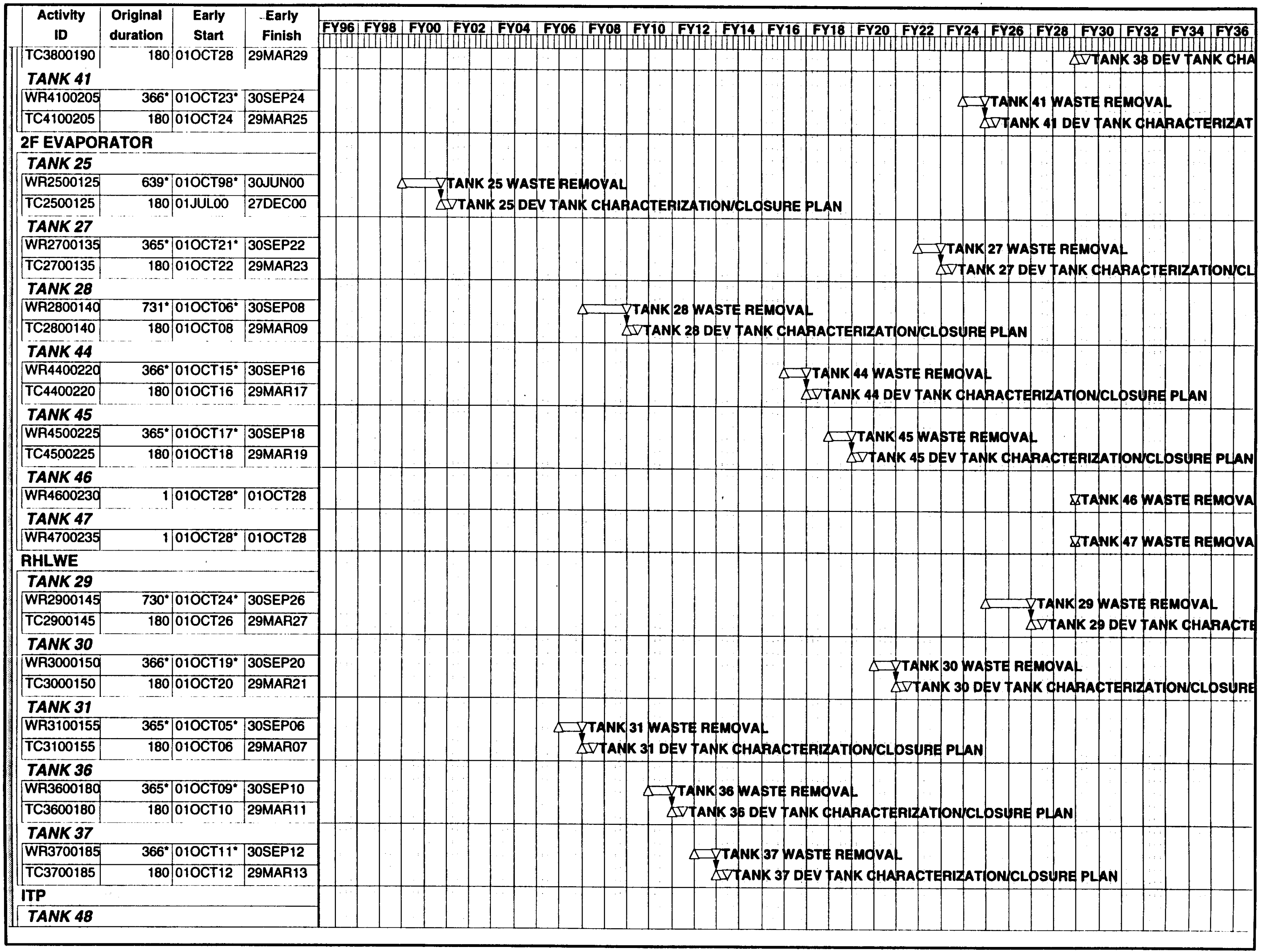


Tank 16 is addressed under the RCRA Facility Investigation Program.

Final Closure of these tanks will dependent upon future site missions: -
Tanks 26, 32-35, 39-40, 42-43, 46-51.

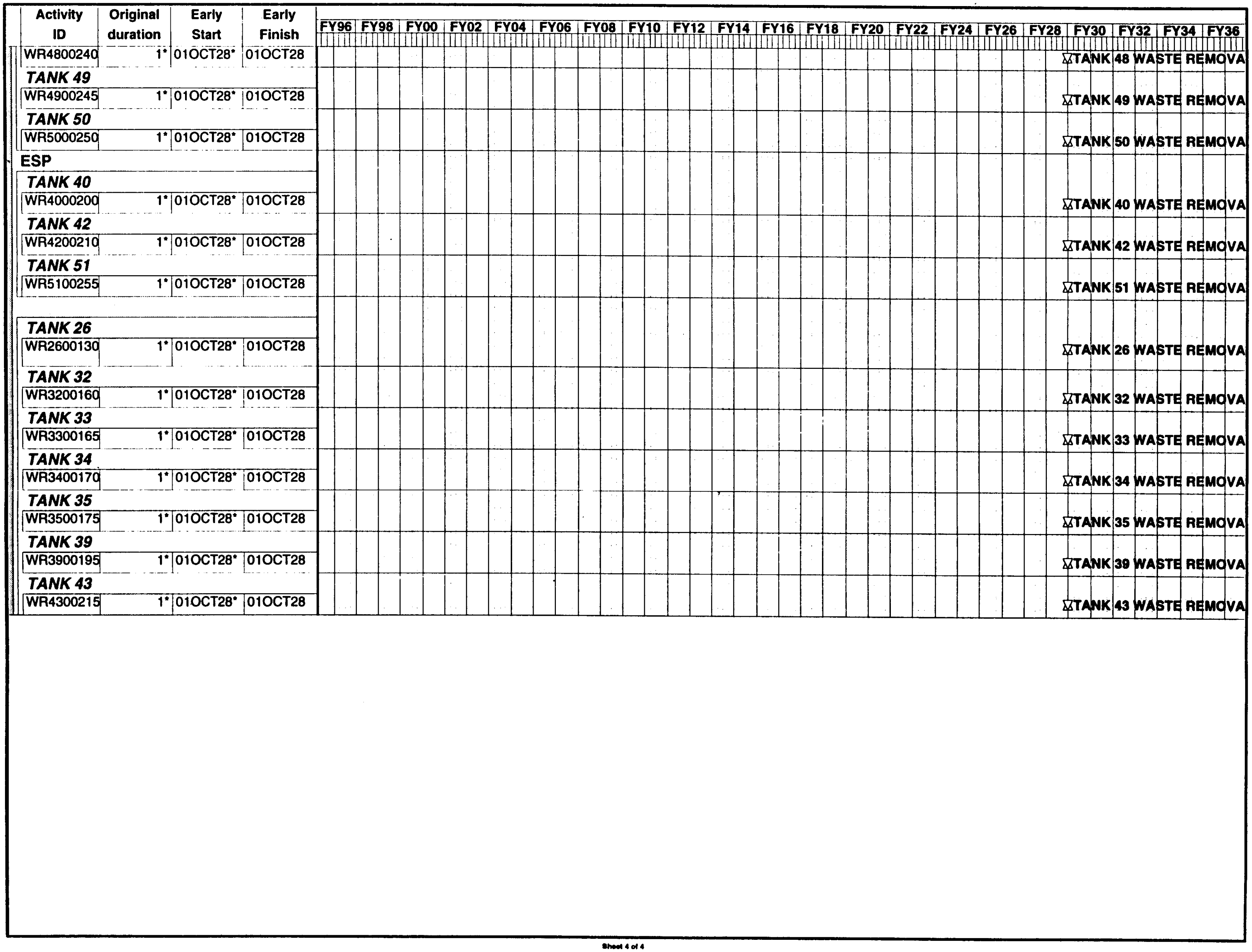
Sheet 2 of 4

Figure B-1. (Continued)



Activity ID	Original duration	Early Start	Early Finish
TC3800190	180	01OCT28	29MAR29
TANK 41			
WR4100205	366*	01OCT23*	30SEP24
TC4100205	180	01OCT24	29MAR25
2F EVAPORATOR			
TANK 25			
WR2500125	639*	01OCT98*	30JUN00
TC2500125	180	01JUL00	27DEC00
TANK 27			
WR2700135	365*	01OCT21*	30SEP22
TC2700135	180	01OCT22	29MAR23
TANK 28			
WR2800140	731*	01OCT06*	30SEP08
TC2800140	180	01OCT08	29MAR09
TANK 44			
WR4400220	366*	01OCT15*	30SEP16
TC4400220	180	01OCT16	29MAR17
TANK 45			
WR4500225	365*	01OCT17*	30SEP18
TC4500225	180	01OCT18	29MAR19
TANK 46			
WR4600230	1	01OCT28*	01OCT28
TANK 47			
WR4700235	1	01OCT28*	01OCT28
RHLWE			
TANK 29			
WR2900145	730*	01OCT24*	30SEP26
TC2900145	180	01OCT26	29MAR27
TANK 30			
WR3000150	366*	01OCT19*	30SEP20
TC3000150	180	01OCT20	29MAR21
TANK 31			
WR3100155	365*	01OCT05*	30SEP06
TC3100155	180	01OCT06	29MAR07
TANK 36			
WR3600180	365*	01OCT09*	30SEP10
TC3600180	180	01OCT10	29MAR11
TANK 37			
WR3700185	366*	01OCT11*	30SEP12
TC3700185	180	01OCT12	29MAR13
ITP			
TANK 48			

Figure B-1. HLW Tank System Closure Schedule



Activity ID	Original duration	Early Start	Early Finish	
WR4800240	1*	01OCT28*	01OCT28	⧗TANK 48 WASTE REMOVA
TANK 49				
WR4900245	1*	01OCT28*	01OCT28	⧗TANK 49 WASTE REMOVA
TANK 50				
WR5000250	1*	01OCT28*	01OCT28	⧗TANK 50 WASTE REMOVA
ESP				
TANK 40				
WR4000200	1*	01OCT28*	01OCT28	⧗TANK 40 WASTE REMOVA
TANK 42				
WR4200210	1*	01OCT28*	01OCT28	⧗TANK 42 WASTE REMOVA
TANK 51				
WR5100255	1*	01OCT28*	01OCT28	⧗TANK 51 WASTE REMOVA
TANK 26				
WR2600130	1*	01OCT28*	01OCT28	⧗TANK 26 WASTE REMOVA
TANK 32				
WR3200160	1*	01OCT28*	01OCT28	⧗TANK 32 WASTE REMOVA
TANK 33				
WR3300165	1*	01OCT28*	01OCT28	⧗TANK 33 WASTE REMOVA
TANK 34				
WR3400170	1*	01OCT28*	01OCT28	⧗TANK 34 WASTE REMOVA
TANK 35				
WR3500175	1*	01OCT28*	01OCT28	⧗TANK 35 WASTE REMOVA
TANK 39				
WR3900195	1*	01OCT28*	01OCT28	⧗TANK 39 WASTE REMOVA
TANK 43				
WR4300215	1*	01OCT28*	01OCT28	⧗TANK 43 WASTE REMOVA

Figure B-1. (Continued)

APPENDIX C.

HLW TANK SYSTEM CLOSURE ENVIRONMENTAL REQUIREMENTS, GUIDANCE, AND PERFORMANCE STANDARDS

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APPENDIX C. HLW TANK SYSTEM CLOSURE ENVIRONMENTAL REQUIREMENTS, GUIDANCE, AND PERFORMANCE STANDARDS

C.1. Identification of Requirements and Guidance

C.1.1 INTRODUCTION

The U.S. Department of Energy (DOE) has identified pertinent substantive requirements and guidance it will comply with and consider, respectively, to ensure that closure of the F- and H-Area high-level waste (HLW) tank systems at the Savannah River Site (SRS) will be protective of human health and the environment and consistent with overall remediation of the SRS as implemented under the Federal Facility Agreement (FFA). These requirements and guidance, the process DOE used to identify them, and their intended use in the HLW tank closure strategy and plan are described in this appendix.

C.1.2 TECHNICAL APPROACH

DOE will close the HLW tank systems, which are permitted by the South Carolina Department of Health and Environmental Control (SCDHEC) under authority of the South Carolina Pollution Control Act (SCPCA) as wastewater treatment facilities, in accordance with SC Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This regulation requires the performance of such closures be carried out in accordance with site-specific guidelines established by SCDHEC to prevent health hazards and to promote safety in and around the tank systems. To facilitate compliance with this requirement and recognizing the necessity for consistency with overall remediation of the SRS under the FFA, DOE has adopted a general strategy for HLW tank system closure that includes evaluation of an appropriate range of closure alternatives with respect to pertinent, substantive environmental requirements and guidance and other appropriate criteria (e.g., technical feasibility, cost). The general strategy for HLW tank system closure is thus consistent in its substance with comparative analyses performed as part of a Resource Conservation and Recovery Act (RCRA) corrective measures study/Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility study (CMS/FS) under the FFA.

DOE will close all HLW tank systems in the F- and H-Area Tank Farms in accordance with this strategy, including Tank 16, which is no longer operational and hence was not permitted as part of the industrial wastewater treatment facility. However, with respect to closure of the tank system, Tank 16 is subject to the same considerations that determine acceptable closure alternatives for the other 50 HLW tank systems. The past release from Tank 16 that resulted in its removal from service will be addressed along with the release from the Tank 37 condensate transfer system as the H-Area Tank Farm Groundwater Operable Unit (Appendix C of the FFA) in accordance with provisions of the FFA.

In developing this plan, DOE sought to identify, in consultation with SCDHEC and EPA Region IV, those substantive environmental requirements and guidance documents most pertinent to selection and implementation of appropriate closure option(s). These requirements and guidance are comparable to those established as applicable or relevant and appropriate requirements (ARARs) and to-be-considered materials (TBCs) in the context of a CMS/FS under the FFA. These terms, with comparable definitions to those used in CERCLA, were adopted for use in this closure plan.

The initial step in this process involved compiling and evaluating potential "ARARs" documents listed in Appendix A of the FFA (Federal and South Carolina statutes and, by reference, implementing regulations), additional laws and regulations (including potentially useful proposed regulations), DOE Orders implementing the Atomic Energy Act, SRS environmental permits, environmental enforcement documents (e.g., consent orders, settlement agreements) currently in force for SRS, and selected EPA guidance. These documents were screened with respect to applicability, relevance and appropriateness, or usefulness as TBCs in general accord with pertinent EPA guidance for determination of "ARARs" for CERCLA remedial actions (EPA 1988, 1989a, 1989b, 1990a, 1990b, 1990c, and 1991) using the following definitions:

> Applicable - Substantive Federal or State environmental protection requirements, criteria, or limits that directly apply to SRS high-level waste tank system closure operations.
>
> Relevant and Appropriate - Substantive Federal and State environmental protection requirements, criteria, or limits that, while not directly applicable, are judged to be well suited for use for SRS high-level waste tank system closure operations based on their applicability to similar operations.
>
> To-be-Considered Materials - Advisories, guidance, proposed rules and the like issued by Federal or State government that are not legally binding, but that are judged to be useful in establishing environmental protection protocols and performance objectives or in evaluating closure options with respect to protection of human health and the environment.

The results of this initial screening process are listed in Table C-1.

Documents determined to constitute or contain "ARARs" or TBCs based on this initial screening were subjected to more detailed evaluation, and substantive requirements and guidance were extracted or summarized, tabulated, and sorted by category (i.e., Applicable, Relevant and Appropriate, and To-be-Considered). The tabulated results were reviewed by the regulatory agencies (SCDHEC and EPA Region IV). The requirements and guidance were subsequently evaluated to identify redundancies (e.g., common standards for environmental protection that are invoked by more than one regulatory program or authority) and confounding or conflicting requirements. Annotations were included in the "Rationale for Use" column explain why certain requirements and guidance should be carried forward to identify specific environmental regulatory standards while others could be dropped from consideration. In general, a requirement or guidance in the Relevant and Appropriate or To-be-Considered Materials categories was included if it is more stringent than the corresponding requirement or guidance in the Applicable category, and excluded if it is less stringent than a requirement or guidance in the Applicable category or if compliance is met by adherence to general provisions of this Closure Plan. The results of this effort are listed in Table C-2.

In the next step, redundancies in the requirements and guidance were eliminated to develop a shortened, but no less comprehensive, list from which to identify specific environmental regulatory standards. All the requirements and guidance listed as Applicable in Table C-2 were retained. Of the requirements and guidance denoted as Relevant and Appropriate or TBC Materials, only those that provide more stringent or more specific standards than those listed as Applicable were retained. Those Relevant and Appropriate or TBC requirements and guidance listed in Table C-2 that are fulfilled by compliance with a standard that is more applicable to the HLW tank system closure activities or that is met by adherence to general provisions of this closure plan were deleted. The results of this effort are listed in Table C-3.

C.2. Performance Standards

Performance standards for HLW tank closure were identified based on the requirements and guidance listed in Table C-3. These performance standards are generally numerical, such as concentration or dose limits for specific radiological or chemical constituents in releases to the environment, which are set forth in the requirements and guidance. The numerical standards apply at different points of compliance and at various periods during or after closure. Summaries of the performance standards for HLW tank closure are presented in Tables C-4 (nonradiological air quality standards), C-5 (nonradiological groundwater and surface-water standards), and C-6 (radiological standards).

The performance objectives that will be used in the evaluations performed for tank system-specific closure modules are a subset of these environmental performance standards. The performance objectives for the HLW tank system closures will be the groundwater protection standards applied at the point where groundwater discharges to the surface (seepline) and the surface-water quality standards applied in the receiving stream.

The performance standards provide a basis for comparison of different closure configurations. Closure options will be evaluated with respect to conformance with specific performance objectives based on these performance standards, and conformance of the closure configuration option selected with the requirements and guidance listed in Table C-3 as part of the overall evaluation (similar to compliance with ARARs as one of the nine CERCLA criteria). In a manner substantially similar to CERCLA requirements, appropriate justification will be necessary to select a nonconforming closure option.

Table C-1. Initial screening of potential requirements and guidance for high-level waste tank system closure.

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Administrative Procedures Act, 5 U.S.C. 551 et seq.	None	Imposes no substantive requirements for HLW tank closure.
Atomic Energy Act, 42 U.S.C. 7401 et seq., as implemented by the U.S Department of Energy:		
• DOE Order 5400.5, "Radiation Protection of the Public and the Environment"	Applicable	Chapter II, "Requirements for Radiation Protection of the Public and the Environment," and Chapter IV, "Residual Radioactive Material," include substantive requirements implementing provisions of the Atomic Energy Act that are applicable to SRS HLW tank closure. The remainder of the order consists primarily of administrative requirements, which would not be as useful discriminators for tank closure options.
• 10 CFR 834, "Radiation Protection of the Public and the Environment" (Proposed Rule)	To-be-Considered Materials	Proposed by DOE to replace DOE Order 5400.5; includes similar, in many cases identical, requirements.
• DOE Order 5820.2A, "Radioactive Waste Management"	Applicable	Establishes policies, guidelines, and minimum requirements by which DOE manages radioactive and mixed waste and contaminated facilities. Chapter I includes requirements applicable to management of high-level radioactive waste, including waste removed from HLW tanks and wastes remaining in the tanks that NRC determines to be high-level waste. Chapter III includes requirements applicable to low-level radioactive waste, including LLW generated as a result of HLW tank closure (e.g., job control waste, partially decontaminated tank ancillary equipment meeting the LLW definition) and residual waste remaining in the HLW tanks determined by NRC to be LLW. Chapter V includes requirements applicable to decommissioning of DOE radioactively contaminated facilities. The remaining requirements are not either applicable or relevant and appropriate, because they address requirements for transuranic waste, uranium and thorium ore processing byproduct material, and naturally occurring and accelerator produced radioactive material, none of which are associated with the HLW tank closure project.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Atomic Energy Act, 42 U.S.C. 7401 et seq., as implemented by the U.S Department of Energy: (cont.)		
• 10 CFR 835, "Radiation Protection for Occupational Workers"	None	Requirements to protect worker health and safety are applicable to all SRS radiological operations, including HLW tank closure. However, requirements do not specifically address closure of waste management facilities and would not be useful discriminators for tank closure options.
Atomic Energy Act, 42 U.S.C. 7401 et seq., as implemented by the Nuclear Regulatory Commission:		
• 10 CFR 20, "Standards for Protection Against Radiation," Subpart E, "Radiological Criteria for Decommissioning" (Proposed Rule)	To-be-Considered Materials	When promulgated, will provide specific radiological criteria for the decommissioning of lands and structures licensed by or subject to jurisdiction of the NRC. The rule would not be applicable to HLW tank closure, but could be considered relevant and appropriate in that the HLW tank closure is closely analogous and could provide meaningful performance objectives and criteria for tank closure options. Because the rule is not yet promulgated it is categorized as TBC material. The remainder of the regulation provides requirements to protect worker health and safety, for which DOE has applicable requirements in place.
• 10 CFR 20, "Standards for Protection Against Radiation," "Permissible Doses, Levels, and Concentrations" and Subpart D, "Radiation Dose Limits for Individual Members of the Public"	Relevant and Appropriate	Not applicable to HLW tank closure, but potentially relevant and appropriate because requirements are well suited for use as indicators of protection of human health and the environment and are similar in scope and content to DOE Orders and other Federal requirements that are applicable or are being considered as relevant and appropriate to the HLW tank closure.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Atomic Energy Act, 42 U.S.C. 7401 et seq., as implemented by the U.S. Environmental Protection Agency:		
• 40 CFR 191, "Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"	Relevant and Appropriate	Requirements of Subpart B, "Environmental Standards for Disposal," are applicable to disposal of any waste associated with HLW tank closure determined to be HLW and therefore subject to NRC licensing requirements per requirements of the Energy Reorganization Act of 1974. For waste that is not considered high-level waste, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. The remaining subparts of 40 CFR 191, which address management of spent fuel, high-level, and transuranic waste, are neither applicable nor relevant and appropriate because they apply only to facilities regulated by the NRC or Agreement States. (AEA requirements for nondisposal facilities associated with the HLW tank closure project would continue under the jurisdiction of DOE, which has its own AEA implementing requirements.)
• 40 CFR 193, "Environmental Radiation Protection Standards for the Management, Storage and Disposal of Low-Level Radioactive Waste" (Preproposal Draft, November 30, 1994)	To-be-Considered Materials	When promulgated, these requirements would be applicable to DOE LLW disposal facilities. Subpart B, "Environmental Standards for Disposal," and Subpart C, "Environmental Standards for the Protection of Underground Sources of Drinking Water," are well suited for use as indicators of protection of human health and the environment for the HLW tank closure project and could be considered at that time to be relevant and appropriate requirements; they are classified TBC material at this time because the rule has not yet been promulgated. The remainder of this rule addresses management and storage of low-level waste for which DOE has applicable standards.
• 40 CFR 196, "Radiation Site Cleanup Regulations" (Preproposal Draft, May 11, 1994)		This draft proposed EPA Federal regulation, when promulgated, will be applicable to activities resulting in residual radioactive material, including SRS HLW tank closure. These requirements are well suited for use as indicators of protection of human health and the environment for the HLW tank closure project. They are classified as TBC material at this time because the rule has not been promulgated.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Clean Air Act, 42 U.S.C. 2011 et seq., South Carolina Pollution Control Act, and associated Federal and State regulations related to air quality: • 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" • 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards" • SC R.61-62, "Air Pollution Control Regulations and Standards"	Applicable	Include requirements applicable to all SRS operations, including HLW tank closure, and provide criteria that might be useful for discriminating among tank closure options. 40 CFR 61, Subpart H regulates emissions of radionuclides to the ambient air from DOE facilities. 40 CFR 50 and R.61-62, Standard No. 2 provide ambient air quality standards for criteria pollutants. R.61-62, Standard No. 8, includes ambient air quality standards for toxic air pollutants. R.61-62.6 provides requirements for control of fugitive particulate matter.
Clean Water Act, 33 U.S.C. 1251 et seq., South Carolina Pollution Control Act, South Carolina Stormwater Management and Reduction Act, and implementing regulations for discharge of wastewater and stormwater to surface waters: • 40 CFR 125, "Criteria and Standards for the National Pollutant Discharge Elimination System" • SC R.61-9, "The National Pollutant Discharge Elimination System"	Applicable	Requirements for process wastewater discharges are applicable to F-/H-Area Effluent Treatment Facility and other facilities that would process waste from HLW tank closure activities, but are not directly applicable to HLW tank closure *per se*. Requirements for stormwater management and discharge from HLW tank operations (e.g., routing of potentially contaminated stormwater to retention basins; discharge limits for stormwater outfalls) would be applicable to HLW tank waste removal operations, but would not be useful discriminators for tank closure options. Requirements for stormwater management from construction-type activities associated with HLW tank closure (e.g., tank exhumation, cap installation) would be applicable and probably would require development of stormwater pollution prevention plans.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Clean Water Act, 33 U.S.C. 1251 et seq., South Carolina Pollution Control Act, South Carolina Stormwater Management and Reduction Act, and implementing regulations for discharge of wastewater and stormwater to surface waters (cont.):		
• SC R.61-76, "Effluent Standards and Guidelines for Wastewater Treatment Facilities"		
• SRS NPDES Permits: Nos. SCR100000 (Stormwater Discharges from Construction Activities), SCR000000 (Stormwater Discharges from Industrial Activities), SC0000175 (Process Wastewater and Stormwater Discharges)		
• SC R.72-300, SC Land Resources Conservation Commission (LRCC), "Standards for Stormwater Management and Sediment Reduction"		
• LRCC General Permit for Stormwater Management and Sediment Reduction at the Savannah River Site		

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Clean Water Act, 33 U.S.C. 1251 et seq., South Carolina Pollution Control Act, and implementing regulations for wastewater treatment facility permitting and closure: • SC R.61-67, "Preparation and Submission of Engineering Reports and Environmental Impact Statements" • SC R.61-82, "Proper Closeout of Wastewater Treatment Facilities" • F-/H-Area High-Level Radioactive Waste Tank Farms Permit No. 17,424-IW • Tank 50 Permit No. 14520 • H-Z Area Interarea Transfer Line Permit No. 14338	Applicable	Include requirements that are directly applicable to HLW tank closure. SC R.61-82 provides closure requirements for wastewater treatment facilities, and is invoked by the FFA (Section IX.E.4) and SRS Waste Removal Plan and Schedule submitted on November 9, 1993, in response to requirements of the FFA (Section IX.E.1) as applicable, with some exceptions (e.g., Tank 16; tanks that are impracticable to decontaminate). [These documents would require revision if HLW tank closure proceeds as currently envisioned.] F- and H-Area Tank Farm system modifications made as part of or as a result of closure activities might necessitate changes to Permit No. 17,424-IW, supported by engineering reports prepared in accordance with SC R.61-67.
Clean Water Act, 33 U.S.C. 1251 et seq.; South Carolina Pollution Control Act, and implementing regulations related to water quality standards for surface water and groundwater: • 40 CFR 131, "Water Quality Standards" • SC R.61-68, "Water Classifications and Standards" • SC R.61-69, "Classified Waters"	Applicable	Include generally applicable standards for maintaining quality of surface water and groundwater and provide criteria useful as discriminators for HLW tank closure options. 40 CFR, Section 131 includes requirements for states to establish water quality standards.
Coastal Zone Management Act and Corresponding SC Statutes and Regulations	None	Not applicable because SRS is outside the coastal zone. Not appropriate to tank closure project, because statute addresses land use planning and associated public involvement, both of which are being addressed at SRS in the broader context of SRS environmental restoration and future site missions.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance^a Potential	Rationale
Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9601 et seq.:		
• 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan" [The NCP implements CERCLA oil and hazardous substance release response requirements.]	Relevant and Appropriate	The extent to which CERCLA requirements are applicable to HLW tank closure is specified in the SRS FFA, which specifies that tanks that cannot practicably be decontaminated be remediated in accordance with CERCLA remedial action protocols (i.e., Remedial Investigation/Feasibility Study process as described in the 40 CFR 300.400 series regulations, part of the NCP). However, the HLW project assumes that, if necessary, the FFA will be modified to reflect the approach DOE is taking to close all HLW tanks in accordance with R.61-82, "Proper Closeout of Wastewater Treatment Facilities." Certain CERCLA requirements, particularly those setting forth the process, criteria, and performance objectives for evaluation of remedial alternatives, are considered to be relevant and appropriate to HLW tank closure, because: (a) this process is indicated as an appropriate process in DOE Order 5820.2A and, (b) releases, if any, from the closed HLW tanks would be addressed by the SRS environmental restoration program in accordance with CERCLA remedial action requirements under the FFA; tank closure should therefore be consistent with the final remedial action under that program, as would be required if tank closure were to be conducted as a CERCLA interim action. Remaining CERCLA requirements, which address such activities as release reporting, are applicable to all SRS operations, including the HLW tank project, but would not be useful discriminators for evaluation of tank closure options.
SRS Federal Facility Agreement [Entered into pursuant to Section 120 of CERCLA to implement CERCLA remedial action and RCRA Section 3004(u) and 3004(v) corrective action requirements at SRS.]	Applicable	Section IX and Appendix B of the FFA include requirements applicable to the HLW tank closure project, including removal of HLW from the tanks, stabilization, and turnover of the closed tanks to the SRS environmental restoration program. These requirements would need to be revised to accommodate closure of all SRS HLW tanks under authority of R.61-82. Section XXIII, "Permits," and Section XXIV, "Creation of Danger," are applicable to activities undertaken pursuant to the FFA, including HLW tank closure.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9601 et seq.: (cont.)		
F-/H-Area High Level Waste Removal Plan and Schedule as Required by the Federal Facility Agreement for the Savannah River Site (WSRC-RP-93-1477, Rev. 0, November 1993)	Applicable	Includes a plan and schedule for removing from service (including waste removal and decontamination) those SRS HLW tanks, except Tank 16, that do not meet secondary containment standards in the FFA or that leak or have leaked. Made applicable by Section IX.E of the FFA. This document would have to be revised to accommodate the SRS HLW Tank Closure Plan as currently envisioned.
Decommissioning Handbook, DOE/EM-0142P, U.S. Department of Energy Office of Environmental Restoration March 1994	To-be-Considered Materials	Technical guidance for the decommissioning of nuclear facilities, including removal of radioactive and hazardous materials to levels protective of human health and the environment. Chapter 13 identifies standards for air, surface water, and groundwater quality during decommissioning including the National Ambient Air Water Quality Standards, DOE Order 5400.5, "National Emissions Standards for Hazardous Air Pollutants," and Safe Drinking Water Act maximum contaminant levels.
Emergency Planning and Community Right-to Know Act, 42 U.S.C. 11001 et seq.	None	Includes requirements applicable to all SRS operations, including tank closure, with respect to such activities as release reporting and chemical inventories. However, requirements do not specifically address closure of waste management facilities and would not provide useful discriminators for tank closure options.
Executive Orders 11990, "Protection of Wetlands," and 11988, "Floodplain Management," as implemented by 10 CFR 1022	To-be Considered Materials	Includes requirements to avoid adverse impacts to wetlands when practicable alternative exists. Applicable to the extent that water quality of riparian wetlands and surface streams (e.g., Fourmile Branch) could be affected by HLW tank closure options. No tank closure activities are anticipated in wetlands or floodplains.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Endangered Species Act, 16 U.S.C. 531 et seq. and related statutes (Fish and Wildlife Coordination Act, Anadromous Fish Conservation Act, Migratory Bird Treaty Act, Bald Eagle Protection Act, South Carolina Nongame and Endangered Species Conservation Act)	Applicable	Requirements to evaluate potential impact to protected species is applicable to all SRS projects. Differential impact potential of HLW tank closure options would be formally evaluated in the context of NEPA and ecological risk assessment for HLW tank closure.
Federal Insecticide, Fungicide and Rodenticide Act, 7 U.S.C. 136 et seq.:	None	HLW tanks do not contain pesticides and closure will not involve their use.
Hazardous Materials Transportation Act	None	Includes requirements applicable to all SRS operations, including tank closure, with respect to any offsite transport of hazardous materials. However, requirements do not specifically address closure of waste management facilities and would not be useful discriminators for tank closure options.
National Environmental Policy Act, 42 U.S.C. 4321 et seq.: • 10 CFR 1021, "Compliance with NEPA"	Applicable	Requirements of NEPA to evaluate SRS HLW tank closure options are applicable and would be fulfilled in accordance with DOE's implementing regulations (10 CFR 1021). NEPA evaluation will address impacts, including occupational exposure to site personnel, associated with the various closure alternatives.
National Historic Preservation Act, 16 U.S.C. 470 et seq. and related legislation (e.g., Antiquities Act, Historic Sites Act, Archeological and Historic Preservation Act, Archaeological Resources Protection Act, American Indian Religious Freedom Act)	Applicable	Requirements to evaluate potential impacts to cultural resources is applicable to all SRS projects. Impact potential on cultural resources for HLW tank closure options, if any, would be formally evaluated in the context of NEPA.
Occupational Safety and Health Act, 29 U.S.C. 651 et seq.:	None	Requirements to protect worker health and safety are applicable to all SRS operations, including HLW tank closure. However, requirements do not specifically address closure of waste management facilities and would not be useful discriminators for tank closure options.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
River and Harbors Act of 1989	None	Requirements are applicable only to work in waterways, which is not anticipated for HLW tank closure. No analogous activities associated with tank closure would make requirements relevant and appropriate.
Safe Drinking Water Act (Public Health Service Act), 42 U.S.C. 300(f) et seq.: • 40 CFR 141, "National Primary Drinking Water Standards" • SC R.61-58.5, "Maximum Contaminant Levels"	Applicable	Maximum contaminant levels (MCLs) promulgated in 40 CFR 141 and in the corresponding SC regulations are applicable to the HLW closure in that they are invoked as groundwater protection standards in applicable requirements (e.g., DOE Orders 5820.2A, 5400.5).

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance^a Potential	Rationale
Solid Waste Disposal Act (as amended by the Resource Conservation and Recovery Act and the Federal Facility Compliance Act), 42 U.S.C. 6901 et seq.:		
• 40 CFR 260-270 "Hazardous Waste Management Regulations" (and corresponding portions of the SC Hazardous Waste Management Regulations) [Implement Subtitle C of RCRA.]	Applicable/ Relevant and Appropriate	RCRA regulatory requirements, most notably generator standards (Part 262), treatment, storage and disposal standards (Parts 264 and 265), and land disposal restriction treatment requirements (Part 268) would be variously applicable to hazardous waste removed from the HLW tanks as part of the closure process (e.g., tank rinsewater and solids meeting the definition of hazardous waste; HLW), generated during the closure process (e.g., job control waste, contaminated debris meeting the definition of hazardous waste), and hazardous waste remaining in the HLW tanks (if any). The operation and closure of the HLW tanks are regulated by SCDHEC as wastewater treatment units and thus are exempted from RCRA operating and closure standards (Parts 264 and 265) and permit requirements (Part 270). Parts 264 and 265, Subpart G, include requirements that are potentially relevant and appropriate to closure of the HLW tanks, because they are applicable to closure of hazardous waste tank systems that are not subject to the wastewater treatment unit exemption. Certain RCRA requirements, particularly those setting forth the process, criteria, and performance objectives for evaluation of corrective action alternatives, are relevant and appropriate to HLW tank closure, because: (a) this process is indicated as an appropriate process in DOE Order 5820.2A and, (b) releases, if any, from the closed HLW tanks would be addressed by the SRS environmental restoration program in accordance with the RCRA corrective action requirements for solid waste management units (SWMUs) under the FFA; tank closure should therefore be consistent with any corrective action under that program.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Consent Order 95-22-HW [Issued in conformance with requirements of the Federal Facility Compliance Act to enforce compliance with requirements of the SRS Approved Site Treatment Plan.]	Applicable	Includes applicable requirements for identification and treatment of SRS radioactive mixed waste (MW) streams, including HLW removed from HLW tanks and MW generated as a result of HLW tank closure operations.
40 CFR 280, "Underground Storage Tank Regulations" (including SC Underground Storage Tank Regulations R.61-92) [Implements Subtitle I of RCRA.]	None	Not applicable. Although these regulations provide requirements applicable to management standards for underground storage tanks (USTs) for oil and hazardous substances, including requirements for closure and corrective action, USTs for hazardous waste (e.g., SRS HLW tanks) are regulated under RCRA Subtitle C unless exempted (e.g., as wastewater treatment units subject to regulation, including closure, under authority of the Clean Water Act, as is the case with the SRS HLW tanks). Not relevant and appropriate, because UST regulations (i.e., R.61-92.3.I(1)) do not apply to tanks that contain hazardous waste (see Memorandum of Agreement between DOE and SCDHEC dated April 8, 1985, as amended May 5, 1988).
40 CFR 258, "Criteria for Municipal Solid Waste Landfills" (Final Rule) and 40 CFR 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (Proposed Rule for industrial nonhazardous solid waste landfills) and corresponding state regulations (R.61-107) [Implements Subtitle D of RCRA.]	None	RCRA Subtitle D requirements as applied under the corresponding SC program include requirements applicable to all SRS operations, including HLW tank closure, with respect to such operations as recycling and disposal of nonhazardous solid waste; however, these requirements do not specifically address closure of waste management facilities and would not be useful discriminators for HLW tank closure options. Title 40 CFR 258 and proposed 40 CFR 257 include groundwater protection standards (SDWA MCLs at a point of compliance as far as 150 meters from a landfill). However these groundwater protection standards are not appreciably different than those considered applicable to the HLW project.
South Carolina Administrative Procedures Act, 1-23-10	None	Imposes no substantive requirements for HLW tank closure.

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
South Carolina Atomic Energy and Radiation Control Act, 13-7-10: • R.61-63, "Radioactive Materials"	Relevant and Appropriate	Not applicable to HLW tank closure, but considered potentially relevant and appropriate because requirements are well suited for use as indicators of protection of human health and the environment and are similar in scope and content to DOE Orders and other Federal requirements that are applicable or relevant and appropriate to the HLW tank closure.
South Carolina Hazardous Waste Management Act, S.C. Code Ann. 44-56-10, et seq.	Applicable/ Relevant and Appropriate	See entry for Solid Waste Disposal Act as amended by RCRA. [Implements Subtitle C of RCRA in SC.]
South Carolina Oil and Gas Exploration, Drilling, and Transportation Act, 48-43-10	None	Not applicable because requirements address operations that affect or involve oil and gas exploration, extraction, and transportation. No oil or gas resources are known to exist in areas potentially affected by HLW tank closure operations. Not relevant and appropriate because tank closure operations are not analogous to regulated operations.
South Carolina Pollution Control Act, S.C. Code An. 48-1-10 et seq.	Applicable	SCPCA and implementing regulations include some substantive requirements that are applicable or relevant and appropriate to HLW tank closure, including R.61-82, "Proper Closeout of Wastewater Treatment Facilities," a directly applicable requirement for closure of HLW tanks, which are permitted as wastewater treatment units.
South Carolina Safe Drinking Water Act, 44-55-10, et seq.: • SC R.61-58.5, "Maximum Contaminant Levels in Drinking Water"	Applicable	See entry for Safe Drinking Water Act. [Implements SDWA in SC.]
South Carolina Solid Waste Policy and Management Act, 44-96-10, et seq.	None	See entry for Solid Waste Disposal Act as amended by RCRA. [Implements Subtitle D of RCRA in SC.]

Table C-1. (Continued).

Statute/Regulation	Requirements/ Guidance[a] Potential	Rationale
Toxic Substances Control Act, 15 U.S.C. 2601 et seq.	None	Some TSCA requirements, particularly those that address management of PCB items and significant new uses of toxic chemicals, are applicable to all SRS operations and could be applicable to HLW tank closure (e.g., disposition of PCB containing electrical insulation, hydraulic oil, if any). However, requirements do not specifically address closure of waste management facilities and would not be useful discriminators for tank closure options.
Uranium Mill Tailings Radiation Control Act, 42 U.S.C. 7910 et seq.	None	Not applicable because requirements address operations involving uranium and thorium mill tailings, none of which are associated with HLW tank closure. Not relevant and appropriate in that health and safety standards exist that are applicable or more clearly relevant and appropriate to HLW tank closure (see entries for Atomic Energy Act).
Wild and Scenic Rivers Act	None	No designated scenic rivers exist in areas potentially affected by HLW tank closure activities.
Wilderness Act	None	No designated wilderness areas exist in areas potentially affected by HLW tank closure activities.

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a. Categories are defined as follows:
- Applicable - Substantive Federal and State environmental protection requirements, criteria, or limits that apply directly to SRS high-level waste tank system closure operations.
- Relevant and Appropriate - Substantive Federal and State environmental protection requirements, criteria, or limits that, while not directly applicable, are judged to be well suited for use for SRS high-level waste tank system closure operations based on their applicability to similar operations.
- To-be-Considered Materials - Advisories, guidance, proposed rules, and the like issued by Federal or State government that are not legally binding, but that are judged to be useful in establishing environmental protection protocols and performance objectives or in evaluating closure options with respect to protectiveness of human health and the environment.

Table C-2. Potential requirements and guidance detail for SRS high-level waste tank system closure.

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SCPCA R.61-82, Section IV	Proper Closeout of Waste Treatment Facilities Not Defined As Lagoons or Package Plants - Waste treatment units shall be closed in accordance with guidelines issued by SCDHEC on an individual basis. These guidelines shall be designed to prevent health hazards and to promote safety in and around the abandoned sites.	Applicable to SRS HLW tanks that are permitted by SCDHEC as industrial wastewater treatment facilities (FFA, Section IX.E.4). Made applicable to all SRS HLW tanks except Tank 16 by DOE's commitment in its November 9, 1993, Waste Removal Plan and Schedule (FFA, Section IX.E.1,2). Applicability extended to all SRS HLW tank systems pursuant to discussions with SCDHEC and EPA.	A
CWA R.61-68.E(7)	Water Quality Criteria to Protect Aquatic Life - Numeric criteria for all class surface waters are adopted for toxic pollutants for which the EPA has published national criteria to protect aquatic life pursuant to Section 304(a) for the Federal CWA and for ammonia and chlorine. No numeric criteria are listed in this regulation; however, the national numeric criteria developed and published by EPA are hereby adopted by reference. Compounds with national criteria to protect aquatic life listed in this regulation include: Arsenic Mercury Cadmium Nickel Chromium (+3 and +6) Selenium (+4) Copper Silver Lead Zinc [Additional standards are included for pesticides and PCBs.]	Generally applicable standards for maintaining quality of surface water.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA NPDES Permit Limitations and Rationale Guidance	Water Quality Criteria - SCDHEC guidance (spreadsheet) that identifies ambient water quality criteria (concentration limits for individual constituents) for deriving NPDES permit limits.	SCDHEC guidance to be considered in the identification of appropriate ambient water quality criteria for protection of aquatic life and human health.	TBC
CWA R.61-68.E(8)(b)	Water Quality Standards to Protect Human Health - State ambient water quality standards to protect human health are listed in Appendix 2 of this regulation. These standards will be applicable to surface waters at average annual flow conditions or at average tidal dilution conditions, whichever is appropriate. The substances and their standards (µg/l) are: Antimony 4,308 Arsenic 1.4 Beryllium 1.17 Cadmium 5 Chromium (+3) 673,077 Chromium (+6) 50 Lead 50 Mercury 0.153 Nickel 4,584 Selenium 10 Silver 50 Thallium 48 [Additional standards are included for cyanide, asbestos, and organics.]	Generally applicable standards for maintaining quality of surface water.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA R.61-68.E(8)(e)	Water Quality Standards to Protect Human Health - A list of water quality standards based on organoleptic data (prevention of undesirable taste and odor) are adopted herein. For substances that have both human health standards and organoleptic standards, the more stringent of the two will be used to derive effluent limits. The substances and their standards (µg/l) are: Copper 1,000 Zinc 5,000 Chlorobenzene 20 2-chlorophenol 0.1 2,4-dichlorophenol 0.3 2,4-dimethylphenol 400 3-methyl-4-chlorophenol 3,000 Pentachlorophenol 30 Phenol 300 Acenaphthene 20 Hexachlorocyclopentadiene 1	Generally applicable standards for maintaining quality of surface water.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA R.61-68.G(3)(c)	Class Descriptions and Specific Standards for Surface Waters - Freshwaters shall meet standards for toxic pollutants listed in Section 307 of the Federal CWA and for which EPA has developed national criteria for ammonia and chlorine. Standards for these substances are prescribed in Sections E(7) and E(8) of this regulation. [The surface waters potentially affected by HLW tank closure activities, Fourmile Branch and Upper Three Runs, are classified as "freshwaters" under R.61-68.G.]	Generally applicable standards for maintaining quality of surface water.	A
CWA R.61-68.H	Class Descriptions and Specific Standards for Ground Waters - All South Carolina groundwater is classified GB effective June 28, 1995. Quality standards for Class GB groundwaters are: • Inorganic chemicals shall meet standards set forth in the State Primary Drinking Water Regulations, R.61-58.5.B(2). • Organic chemicals shall meet standards set forth in the State Primary Drinking Water Regulations, R.61-58.5.D(2). • Manmade radionuclides shall not exceed concentrations or amounts such as to interfere with use, actual or intended, as determined by the Department. [This standard also includes primary pollutant VOCs, pesticides, herbicides, PCBs, synthetic organic compounds, and various wastes.]	Generally applicable standards for maintaining quality of groundwater.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.15 (Subpart B) R.61-58.5(J)(2)	<u>Maximum Contaminant Levels</u> - The following are the maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity: (a) Combined radium-226 and radium-228 - 5 pCi/L. (b) Gross alpha particle activity (including radium-226 but excluding radon and uranium) - 15 pCi/L.	EPA Federal regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A
SDWA 40 CFR 141.16(a) (Subpart B) R.61-58.5(L)(2)(a)	<u>Maximum Contaminant Levels</u> - The average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/year.	EPA Federal regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.16(b) (Subpart B) R.61.58.5(L)(2)(b)	Maximum Contaminant Levels - Except for the radionuclides listed in Table A, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalents shall be calculated on the basis of a 2-liter per day drinking water intake using the 168-hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure" (NBS Handbook 69 as amended August 1963, U.S. Department of Commerce). If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or any organ shall not exceed 4 mrem/year.	EPA Federal regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A

Table A - Average Annual Concentrations Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr

Radionuclide	Critical Organ	pCi per liter
Tritium	Total body	20,000
Strontium-90	Bone marrow	8

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.51 (Subpart F)	Maximum Contaminant Levels Goals - The MCLGs for inorganic constituents are: Contaminant — Milligrams per liter Antimony — 0.006 Barium — 2 Beryllium — 0.004 Cadmium — 0.005 Chromium — 0.1 Copper — 1.3 Fluoride — 4 Lead — zero[1] Mercury — 0.002 Nitrate — 10 (as N) Nitrite — 1 (as N) Total nitrate & nitrite — 10 (as N) Selenium — 0.05 Thallium — 0.0005 [1] action level for lead is 0.015 mg/l	EPA Federal regulation applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. [Provides relevant and appropriate groundwater quality standards for copper and lead.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.62(b) (Subpart G) R.61-58.5(B)(2)	Maximum Contaminant Levels - The MCLs for inorganic constituents are: Contaminant — Milligrams per liter Fluoride 4.0 Arsenic 0.05 Barium 2.0 Cadmium 0.005 Chromium 0.1 Mercury 0.002 Nitrate 10 (as N) Nitrite 1 (as N) Total nitrate & nitrite 10 (as N) Selenium 0.05 Antimony 0.006 Beryllium 0.004 Cyanide (as free cyanide) 0.2 Nickel 0.1[1] Thallium 0.002 [1] nickel standard is in R.61-58.5(B)(2) only [Standard also includes asbestos fiber limit.]	EPA Federal regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Made applicable by R.61-68.H.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA SRS FFA WSRC-05-94-42 - DOE, EPA & SCDHEC, 8/16/93	The agreement directs the comprehensive remediation of SRS and also delineates the relationship between its requirements and the requirements for corrective measures being conducted under RCRA Sections 3004 (u) and (v) according to the conditions of the Federal and State RCRA permit. Section IX - High-Level Radioactive Waste Tank System(s) Section IX.E.1 - DOE has submitted a waste removal plan and schedule for the waste tank systems. DOE shall remove the tanks from service according to the approved plan(s) and schedule(s). Waste tanks deemed unsuitable by SCDHEC shall not receive additional waste prior to schedule approval for such receipt and only if waste receipt is approved as part of the plan associated with such a schedule. Section IX.E.2 - The DOE waste tank system(s) removal plan(s) shall provide for the removal or decontamination of all residues, contaminated containment systems components (liners, etc.), contaminated soils and structures and equipment contaminated with hazardous and/or radioactive substances. If DOE demonstrates that it cannot practicably remove or decontaminate soils or structures and equipment, then DOE shall conduct all necessary response actions under Section XI through XVI of this Agreement for those waste tank system(s). Section IX.E.3 - DOE will submit to EPA and SCDHEC an annual report on the status of the tanks being removed from service under Subsection E.1.	Standards for SRS HLW tank systems set forth in Section IX and Appendix B of the FFA apply to tank operations, including closure activities. Section XXIII, "Permits," and Section XXIV, "Creation of Danger," are applicable to activities undertaken pursuant to the FFA, including HLW tank closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA SRS FFA WSRC-05-94-42 - DOE, EPA & SCDHEC, 8/16/93 (cont.)	Section IX.E.4 - For waste tank system(s) that DOE decides to remove from service that have been issued an industrial wastewater permit under the SC Pollution Control Act (SCPCA): DOE shall remove such waste tank system(s) from service in accordance with the SCPCA and all applicable regulations promulgated pursuant to the SCPCA. For any waste tank systems(s) for which closure or removal from service is or has been conducted under the SCPCA, DOE shall conduct Site Evaluation in accordance with Section X of the FFA.		

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA Waste Removal Plan and Schedule for the HLW Tank Farms, WSRC-RP-93-1477, Rev. 0, 11/9/93	Waste removal plan and schedule for the HLW tank system(s) and/or component(s) that do not meet secondary containment standards or that leak or have leaked as required by Section IX.E of the SRS FFA. III. HLW Facility Descriptions and Operating Plans - Tank Farm Waste Tanks & Waste Removal Operations: (1) Type III tanks will be reused while the Type I, II, and IV tanks will be removed from service. (2) The tanks to be removed will undergo a water washing operation in the primary vessel and an annulus cleaning if waste is present in the annulus. (3) Salt will be removed from the new style tanks first, and these tanks will be reused to support Tank Farm evaporator operations and processing of DWPF recycle. (4) The first sludge tanks to be emptied will be old-style tanks, which will be removed from service. Operating Plans: Each waste tank will be fitted with special waste removal equipment. (1) Tanks containing sludge will have four slurry pumps and one transfer pump installed to suspend the settled sludge into a pumpable slurry for transfer to ESP. (2) Tanks containing salt will have three slurry pumps and one transfer jet installed to dissolve the salt and transfer it to ITP. IV. Assumptions - Waste Removal: (1) Each tank's waste removal schedule is based upon a typical construction-through-startup authorization task duration of 22-30 months. (2) As waste removal and water washing/annulus cleaning operations are completed for each old-style tank, that tank will be transitioned to SRS's Environmental Restoration Division for decommissioning and closure in accordance with applicable permits and other regulatory requirements.	Applicable to the removal of SRS HLW tanks from service in accordance with Section IX.E.1 of the FFA. To the extent that the proposed closure activities differ from those described in the Waste Removal Plan and Schedule, modifications to the plan may be required.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
	VI. Waste Removal Description/Definition: For the purposes of this plan, "removal from service" is defined as: (1) As much high level waste (salt, sludge and/or supernate) as practical is removed from the tank primaries and any annulus that had received waste via mechanical agitation (slurry pumps and eductor jets). (2) All tanks primaries and any annulus that received waste will be washed with inhibited water and as much waste as practical removed via installed systems (eductor jets and pumps). (1) Upon further evaluation, it may be decided that an additional chemical cleaning step may occur on some tanks as necessary. (2) A closure plan will be developed per SC Regulation R.61-82, Proper Closeout of Wastewater Treatment Facilities and submitted to SCDHEC for review and approval. (3) Upon approval, it is anticipated that the tank system/component will be turned over to the RCRA/CERCLA Program for decommissioning. (4) It may also be necessary to maintain a heel of inhibited water in some of the tanks to prevent structural damage to the tank bottom caused by upward groundwater pressure.		
CAA 40 CFR 61.92 (NESHAP)	Standard - Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	EPA Federal regulation that is applicable to all SRS operations, including HLW tank closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CAA SC R.61-62.5 Air Pollution Control Standard No. 2	Ambient Air Quality Standard - The following table constitutes the ambient air quality standards for the State of South Carolina. The analytical methods to be used will be those applicable Federal Reference Methods published in 40 CFR 50, Appendices A-H as revised July 1, 1986. In the case of fluorides either the double paper tape sampler methods (ASTM D-3266-79) or the sodium bicarbonate-coated glass tube and particulate filter method (ASTM D3268-78) may be used.	SC standards which implement national primary and secondary ambient air quality standards. Standards are applicable to all SRS operations, including HLW tank closure and provide standards for evaluation of criteria pollutant emissions and impacts.	

Pollutant	Measuring Interval	Standard ($\mu g/m^3$ unless noted otherwise) (1)(2)
Sulfur dioxide	3 hour	1,300(4)
	24 hours	365(4)
	annual	80
Total suspended particulates	Annual geometric mean	75
PM_{10}	24 hours	150(3)
	annual	50(3)
Carbon monoxide	1 hour	40 mg/m^3
	8 hour	10 mg/m^3
Ozone	1 hour	0.12 ppm (3)
Gaseous fluorides (as HF)	12 hr. avg.	3.7
	24 hr. avg.	2.9
	1 wk. avg.	1.6
	1 mo. avg.	0.8

Table C-2. (Continued).

Citation	Requirement/Guidance Summary			Rationale for Use[a]	Requirements/ Guidance Category[b]
CAA SC R.61-62.5 Air Pollution Control Standard No. 2 (cont.)	Nitrogen dioxide	annual	100		
	Lead	Calendar quarterly mean	1.5		

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(1) Arithmetic average except in case of total suspended particulate matter.

(2) At 25°C and 760 mm Hg.

(3) Attainment determinations will be made based on the criteria contained in Appendixes H and K, 40 CFR 50, July 1, 1987.

(4) Not to be exceeded more than once a year.

Table C-2. (Continued).

<table>
<tr><th>Citation</th><th>Requirement/Guidance Summary</th><th>Rationale for Use[a]</th><th>Requirements/ Guidance Category[b]</th></tr>
<tr><td>CAA
SC R.61-62.5
Air Pollution Control Standard No. 8, Toxic Air Pollutants</td><td><u>II. Toxic Air Emissions</u> - B. The allowable ambient air concentrations of a toxic air pollutant at the plant property line as determined by modeling under Part A shall be limited to the value listed in the following table in this section, which include:
<table>
<tr><th>Chemical Name</th><th>CAS No.</th><th>Maximum Allowable Concentration (µg/m^3)[a]</th></tr>
<tr><td></td><td><u>Category I: Low Toxicity</u></td><td></td></tr>
<tr><td>None</td><td></td><td></td></tr>
<tr><td></td><td><u>Category II: Moderate Toxicity</u></td><td></td></tr>
<tr><td>Oxalic acid</td><td>144627</td><td>10.00</td></tr>
<tr><td></td><td><u>Category III: High Toxicity</u></td><td></td></tr>
<tr><td>Benzene</td><td>71423</td><td>150.00</td></tr>
<tr><td>Chromium(+6) compounds</td><td>None</td><td>2.50</td></tr>
<tr><td>Manganese compounds</td><td>None</td><td>25.00</td></tr>
<tr><td>Mercury</td><td>7439976</td><td>0.25</td></tr>
<tr><td>Nickel</td><td>7440020</td><td>0.50</td></tr>
<tr><td>Selenium compounds</td><td>None</td><td>1.00</td></tr>
</table>
[a] For the purpose of this standard, these values shall be rounded to the nearest hundredth of a µg/m^3. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01 but values less than 0.005 would be rounded to 0.00.

[Note: See SC R.61-62.5 for a complete list of pollutants and corresponding standards.]</td><td>SC Standards that implement Federal air toxic control program requirements. Standards are applicable to all SRS operations, including HLW tank closure and provide standards for evaluation of toxic pollutant emissions and impact.</td><td>A</td></tr>
</table>

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
National Environmental Policy Act, 42 U.S.C. 4321 et seq., 10 CFR 1021	Requirements of NEPA to evaluate SRS HLW tank closure options would be fulfilled in accordance with DOE implementing regulations (10 CFR 1021). NEPA evaluation will address impacts, including occupational exposure to site personnel, associated with various closure alternatives.	Environmental assessment requirements of NEPA are applicable to all SRS operations, including HLW tank closure.	A
Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.); 50 CFR 402 and related statutes (Anadromous Fish Conservation Act, Bald Eagle Protection Act, South Carolina Nongame and Endangered Species Conservation Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act)	Prohibits Federally authorized actions that probably would jeopardize the existence of any threatened or endangered or otherwise protected species or result in the destruction or adverse modification of a critical habitat.	Applicable if threatened or endangered or otherwise protected species or habitats exist on or near the site, or could be affected by the proposed action.	A
National Historic Preservation Act, 16 U.S.C. 470 et seq. and related legislation (e.g., Antiquities Act, Historic Sites Act, Archeological and Historic Preservation Act, Archaeological Resources Protection Act, American Indian Religious Freedom Act)	Impact potential on cultural resources for HLW tank closure options, if any, would be formally evaluated in the context of NEPA.	Requirements to evaluate potential impact to cultural resources is applicable to all SRS projects.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use^a	Requirements/ Guidance Category^b
Executive Orders 11990 "Protection of Wetlands" and 11988 "Floodplain Management" as implemented by 10 CFR 1022	Includes requirements to avoid adverse impacts to wetlands when practicable alternative exists.	Applicable to the extent that water quality of riparian wetlands and surface streams (e.g., Fourmile Branch) could be affected by HLW tank closure options. No tank closure operations are anticipated in wetlands or floodplains. [Requirement met by compliance with R.61-68.]	TBC
CERCLA 42 U.S.C. 9621 Section 121(d) (Cleanup Standards)	Degree of Cleanup - Remedial actions shall attain a degree of (1) cleanup of hazardous substances, pollutants, or contaminants released into the environment and (2) control future releases which assures protection of human health and the environment. Section 121(d) of CERCLA requires that remedial action attain a level or standard of control for any hazardous constituent, pollutant, or contaminant which at least attains: • Any legally applicable or relevant and appropriate standard, requirement, criterion, or limitation under Federal environmental law • Any promulgated standard, requirement, criteria, or limitation under a state environmental or facility siting law that is more stringent that any Federal standard, requirement, or limitation and that has been identified by the state in a timely manner Such remedial action shall require a level or standard of control which attains MCL goals established under the SDWA and water quality criteria under section 304 or 303 of the CWA, where such goals are relevant and appropriate under the circumstances of the release or threatened release.	Potentially relevant and appropriate to ensure that HLW tank closure activities are consistent with final remedial actions for the F- and H-Area Tank Farms pursuant to the FFA. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA 40 CFR 300.400(g)	Identification of applicable or relevant and appropriate requirements - The lead and support agencies shall identify requirements applicable to the release or remedial action contemplated based upon an objective determination of whether the requirement specifically addressees a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. If it is determined that a requirement is not applicable to a specific release, the requirement may still be relevant and appropriate to the circumstances of the release. In evaluating relevance and appropriateness, the factors in paragraphs (g)(2)(i) through (viii) of this section shall be examined, where pertinent, to determine whether a requirement addresses problems or situations sufficiently similar to the circumstances of the release or remedial action contemplated, and whether the requirement is well suited to the site, and is therefore both relevant and appropriate.	Potentially relevant and appropriate to ensure that HLW tank closure activities are consistent with final remedial action for the F- and H-Area Tank Farms pursuant to the FFA. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA 40 CFR 300.430(e)(2)(i)	The remediation goals establish acceptable exposure levels that are protective of human health and the environment and are developed by considering ARARs (e.g., chemical-specific ARARs) under Federal or state environmental or facility siting laws, if available, and the following factors: For systemic toxicants, acceptable exposure levels represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect, during a lifetime or part of a lifetime, incorporating an adequate margin of safety. For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}. The 10^{-6} risk level is the point of departure for determining remediation goals for alternatives where ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple exposure pathways.	Potentially relevant and appropriate to ensure that HLW tank closure activities are consistent with final remedial action for the F- and H-Area Tank Farms pursuant to the FFA. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA 40 CFR 300.430(e)(9)	Nine Criteria for Evaluation - The analysis of remedial alternatives under CERCLA shall consider nine criteria: (1) Overall protection of human health and the environment (2) Compliance with applicable, or relevant and appropriate requirements (ARARs) (3) Long-term effectiveness and permanence including the magnitude of the residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities and the adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste (4) Reduction of toxicity, mobility, or volume through treatment (5) Short-term effectiveness (6) Implementability including technical feasibility, administrative feasibility, and availability of services and materials (e.g., treatment, storage, or disposal capacity, prospective technologies) (7) Cost (8) State acceptance (9) Community acceptance The first two, overall protection of human health and the environment and compliance with ARARs, are threshold requirements that must be met by each alternative to be eligible for selection. The next five are the primary balancing criteria and state and community acceptance are the modifying criteria to be considered in remedy selection.	Potentially relevant and appropriate to ensure that HLW tank closure activities are consistent with final remedial action for the F- and H-Area Tank Farms pursuant to the FFA. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA 40 CFR 300.430(f)(1)(ii)(C)	An alternative may be selected that does not meet an ARAR under Federal environmental law or state environmental or facility siting laws under the following circumstances: (1) The alternative selected is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate Federal or state requirement (2) Compliance with such requirements will result in greater risk to human health and the environment than alternative options (3) Compliance with the requirements is technically impracticable from an engineering perspective (4) The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation, through use of another method or approach (5) With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state	Potentially relevant and appropriate to ensure that HLW tank closure activities are consistent with final remedial action for the F- and H-Area Tank Farms pursuant to the FFA. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 262 R.61-79.262	<u>Standards Applicable to Generators of Hazardous Waste</u> - Generators of hazardous waste are required to do the following: • Determine if the waste is hazardous waste and identify requirements for management of hazardous waste as set forth in Parts 264, 265, and 268; obtain an EPA identification number (Subpart A) • Comply with manifest requirements for transport of hazardous waste off the site (Subpart B) • Comply with pretransport requirements for hazardous waste packaging, labeling, marking, placarding, and accumulation; comply with storage facility requirements of Parts 264, 265, and 270 if hazardous waste is stored for more than 90 days (Subpart C) • Comply with recordkeeping and reporting requirements for hazardous waste generation, offsite transport, treatment, storage, and disposal (Subpart D)	Applicable to any hazardous waste generated as a result of SRS HLW tank closure activities. Hazardous wastes that are managed in wastewater treatment units (e.g., wastes transferred to other HLW tank systems) can be excluded from RCRA permitting and operating standards.	A
RCRA 40 CFR 265 (Subpart G) R.61-79.265 (Subpart G)	<u>Closure and Postclosure</u> - Includes closure standards applicable to all HWMFs (Section 265.111-115) and postclosure standards (Section 265.116-120) applicable to postclosure care of tank systems required under Section 265.197 to meet the requirement for landfills.	Administrative closure and postclosure requirements of Subpart G are not considered as ARARs, because applicable administrative requirements are provided by R.61-82. Substantive closure requirements of Subpart G are generally relevant and appropriate to closure of HLW tank systems, because these tank systems contain or have contained RCRA hazardous waste. These closure requirements are relevant and appropriate in individual tank closure decisions made under this plan to the extent that individual closures must be consistent with overall closure of the F- and H-Area Tank Farms to be planned and implemented as part of the SRS Environmental Restoration Program under the FFA.	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 265 (Subpart G) R.61-79.265 (Subpart G) (cont.)		Similarly, postclosure requirements of Subpart G are relevant and appropriate to the extent that individual HLW tank closure activities must be consistent with a reasonable postclosure program to be planned and implemented as part of the SRS ER Program under the FFA. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensures that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	
RCRA 40 CFR 265.111 (Subpart G) R.61-79.265.111 (Subpart G)	Closure Performance Standard for HWMFs - The owner/operator must close the facility in a manner that: (1) Minimizes the need for further maintenance (2) Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere (3) Complies with the closure requirements of Part 265 (e.g., Section 265.197 for tank systems)	Provides relevant and appropriate general performance standards for closure of tank systems that have been used to manage RCRA hazardous waste. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 265.114 (Subpart G) R.61-79.265.114 (Subpart G)	Closure of HWMFs: Disposal or Decontamination of Equipment, Structures, and Soils - During partial and final closure periods, all contaminated equipment, structures, and soils must be properly disposed of or decontaminated, unless otherwise specified (e.g., under Section 265.197 for tank systems). By removing any hazardous wastes or hazardous constituents during partial or final closure, the owner/operator can become a generator of hazardous waste and must handle that waste in accordance with all applicable requirements of 40 CFR 262.	Provides relevant and appropriate standards for the disposition of structures or environmental media contaminated with hazardous waste or hazardous constituents. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 265.117 (Subpart G) R.61-79.265.117 (Subpart G)	Closure of HWMFs: Postclosure Care and Use of Property Postclosure care of each hazardous waste management unit subject to the requirements of Section 265.117-120 must begin after completion of closure of the unit and continue for 30 years after that date. It must consist of at least the following: (1) Monitoring and reporting in accordance with requirements of subparts F, K, L, M, and N of this part. (2) Maintenance and monitoring of waste containment systems in accordance with the requirements of subparts F, K, L, M, and N. The Department may extend the postclosure care period applicable to the unit if it finds that the extended period is necessary to protect human health and the environment (e.g., leachate or groundwater monitoring results indicate a potential for migration of hazardous wastes at levels that may be harmful to human health or the environment). The Department may require continuation of any of the security requirements of Section 265.14 during part or all of the postclosure period. Postclosure use of the property on or in which hazardous wastes remain after closure must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of the containment system, or the function of the facility's monitoring systems, unless the Department finds that the disturbance is necessary to the proposed use of the property and will not increase the potential hazard to human health or the environment or is necessary to reduce a threat to human health or the environment.	Provides relevant and appropriate standards for postclosure care and use of property contaminated with hazardous waste or hazardous constituents. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 265.197 (Subpart J) R.61-79.265.197 (Subpart J)	Tank System Closure and Postclosure Care - At closure of a tank system, the owner/operator must remove or decontaminate all waste residues, contaminated containment system components, contaminated soils, and structures or equipment contaminated with waste, and manage them as hazardous waste (unless they no longer meet the definition of hazardous waste). If the owner/operator demonstrates that not all contaminated soils can be practicably removed or decontaminated, he must close the tank system and perform postclosure care in accordance with the closure and postclosure care requirements that apply to landfills (Section 265.310). Such a tank system is considered to be a landfill and must meet the requirements for landfills in Part 265, Subpart G.	Provides relevant and appropriate standards for the disposition of structures or environmental media contaminated with hazardous waste or hazardous constituents. [Requirement to manage contaminated components, structures, equipment, and hazardous waste/constituents removed during closure met through compliance with 40 CFR and SCHWMR R.61-79, Parts 262, 264/265, and 268. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 265.310(a) (Subpart N) R.61-79.265.310(a) (Subpart N)	Landfill Closure - At final closure of the landfill or upon closure of any cell, the owner/operator must cover the landfill or cell with a final cover designed to: (1) Provide long-term minimization of migration of liquids through the closed landfill. (2) Function with minimal maintenance. (3) Promote drainage and minimize erosion or abrasion of the cover. (4) Accommodate settling and subsidence so that the cover's integrity is maintained. (5) Have permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.	Provides relevant and appropriate standards for the closure of HWMFs from which hazardous waste or hazardous constituents cannot be removed at the time of closure. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA
RCRA 40 CFR 265.310(b) (Subpart N) R.61-79.265.310(b) (Subpart N)	Landfill Postclosure Care - After final closure, the owner/operator is also required to comply with postclosure care requirements in Section 265.117-120 and: (1) Maintain the integrity and effectiveness of the final cover. (2) Continue to operate the leachate collection and removal system until leachate is no longer detected. (3) Maintain and monitor the leak detection system. (4) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of Part 265 Subpart F. (5) Prevent runoff from eroding or otherwise damaging the final cover. (6) Protect and maintain surveyed benchmarks.	Provides relevant and appropriate standards for the postclosure care and monitoring of HWMFs from which hazardous waste or hazardous constituents cannot be removed at the time of closure. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264 (Subpart F) R.61-79.264 (Subpart F)	Releases from Solid Waste Management Units - Subpart F requires: (a) for all solid waste management units at facilities seeking a RCRA permit, corrective action as necessary to protect human health and the environment from all releases of hazardous waste or hazardous constituents, and (b) for surface impoundments, waste piles, land treatment units, and landfills that have received hazardous waste after July 26, 1982, establishment of a groundwater protection standard, monitoring with respect to the standard, and corrective action program if the standard is exceeded.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.91 (Subpart F)	Required Programs - Owners/operators subject to this subpart must conduct a monitoring and response program as follows:	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection.	RA
R.61-79.264.91 (Subpart F)	(1) Whenever hazardous constituents under Section 264.93 from a regulated unit are detected at a compliance point under Section 264.95, the owner/operator must institute a compliance monitoring program under Section 264.99. Detected is defined as statistically significant evidence of contamination as described in Section 264.98(f). (2) Whenever the groundwater protection standard under Section 264.92 is exceeded, the owner/operator must institute a corrective action program under Section 264.100. Exceeded is defined as statistically significant evidence of increased contamination as described in Section 264.99(d). (3) Whenever hazardous constituents under Section 264.93 from a regulated unit exceed concentration limits under Section 264.94 in groundwater between the compliance point under Section 264.95 and the downgradient facility property boundary, the owner/operator must institute a corrective action program under Section 264.11. (4) In all cases, the owner/operator must institute a detection monitoring program under Section 264.98.	[Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.92 (Subpart F) R.61-79.264.92 (Subpart F)	Groundwater Protection Standard - The owner/operator must comply with conditions specified in the facility's permit that are designed to ensure that hazardous constituents under Section 264.93 detected in the groundwater from a regulated unit do not exceed the concentration limits under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance under Section 264.95 during the compliance period under Section 264.96. SCDHEC will establish the groundwater protection standard in the facility permit when hazardous constituents have been detected in the groundwater.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA
RCRA 40 CFR 264.93 (Subpart F) R.61-79.264.93 (Subpart F)	Hazardous Constituents - Hazardous constituents are those constituents identified in Appendix VIII of R.61-79.261 that have been detected in groundwater in the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit, unless SCDHEC has granted an exclusion of a constituent or constituents under paragraph (b) of this section. Paragraph (b) allows for the exclusion of an Appendix VIII constituent from the groundwater protection standard if the owner/operator can demonstrate that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. Criteria to be considered in such demonstrations or set forth in paragraph (b) include assessing potential adverse effects on groundwater quality and hydraulically connected surface waters.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.94 (Subpart F) R.61-79.264.94 (Subpart F)	Concentration Limits - The concentration of a hazardous constituent must not exceed: (1) The background level of that constituent in the groundwater at the time the limit is specified in the permit. (2) The respective MCL value for that constituent if the background level is below the MCL level. (3) An ACL established by the SCDHEC under paragraph (b). Paragraph (b) establishes criteria for establishing an ACL. The owner operator must demonstrate that the constituent will not pose a substantial threat to human health or the environment as long as the ACL is not exceeded.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA
RCRA 40 CFR 264.95 (Subpart F) R.61-79.264.95 (Subpart F)	Point of Compliance - The owner/operator must specify the point of compliance at which the groundwater protection standard of Section 264.92 applies and at which groundwater monitoring must be performed. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated unit(s). The waste management area is the limit, projected in the horizontal plane, of the area on which waste will be placed during the active life of the regulated unit, including horizontal space taken up by any liner, dike, or other barrier to contain waste in a regulated unit. If the facility contains more than one regulated unit, the waste management area is described by an imaginary line circumscribing the several regulated units.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.96 (Subpart F) R.61-79.264.96 (Subpart F)	Compliance Period - The owner/operator will specify the compliance period during which the groundwater protection standard of Section 264.92 applies. The compliance period is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period). If the owner/operator is engaged in a corrective action program at the end of the compliance period, the period is extended until the owner/operator can demonstrate that the groundwater protection standard of Section 264.92 has not been exceeded for a period of 3 consecutive years.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.97 (Subpart F) R.61-79.264.97 (Subpart F)	General Groundwater Monitoring Requirements - The owner/operator must comply with the following requirements for any groundwater monitoring program developed to satisfy Sections 264.98, 264.99, or 264.100. The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that: (1) Represent the quality of background water that has not been affected by leakage from a regulated unit (2) Represent the quality of groundwater passing the point of compliance (3) Allow for detection of contamination when hazardous waste or hazardous constituents have migrated from the waste management area to the uppermost aquifer This section also sets forth standards for groundwater monitoring systems at a facility that contains more than one regulated unit; standards for construction of monitoring wells; requirements for groundwater sampling and analysis procedures; requirements for the determination of groundwater surface elevation; sampling, monitoring, and statistical analysis requirements for background wells and compliance points; and groundwater monitoring data recordkeeping requirements.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.98 (Subpart F)	Detection Monitoring Program - The owner/operator required to establish a detection monitoring program under this subpart must:	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection.	RA
R.61-79.264.98 (Subpart F)	(a) Monitor for indicator parameters, waste constituents, and reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater. (b) Install a groundwater monitoring system at the compliance point as specified under Section 264.95. The groundwater monitoring system must comply with Sections 264.97(a)(2), (b), and (c). (c) Conduct a groundwater monitoring program using sampling procedures and statistical methods appropriate for the facility as specified in the permit. Maintain a record of groundwater analytical data as measured and in a form necessary for the determination of statistical significance. (d) Collect samples and conduct tests at the specified frequency to determine whether there is statistically significant evidence of contamination for any parameter or hazardous constituent. (e) Determine groundwater flow rate and direction in the uppermost aquifer at least annually. This section also specifies requirements for responding to a determination that statistically significant evidence of groundwater contamination exists.	[Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use^a	Requirements/ Guidance Category^b
RCRA 40 CFR 264.99 (Subpart F) R.61-79.264.99 (Subpart F)	Compliance Monitoring Program - The owner/operator must establish a compliance monitoring program to: (a) Monitor the groundwater to determine whether regulated units are in compliance with the groundwater protection standard under Section 264.92. (b) Install a groundwater monitoring system at the compliance point as specified under Section 264.95. The groundwater monitoring system must comply with Sections 264.97(a)(2), (b), and (c). (c) Conduct a groundwater monitoring program for each chemical parameter and hazardous constituent specified in the permit. Maintain a record of groundwater analytical data as measured and in a form necessary for the determination of statistical significance. (d) Collect samples and conduct tests at the specified frequency to determine whether there is statistically significant evidence of contamination for any parameter or hazardous constituent. (e) Determine groundwater flow rate and direction in the uppermost aquifer at least annually. At least annually, the owner/operator must analyze samples from all monitoring wells at the compliance point for all constituents contained in Appendix IX of Part 264 to determine whether additional hazardous constituents are present in the uppermost aquifer and, if so, at what concentration. This section sets forth requirements that are applicable if the owner/operator finds Appendix IX constituents in the groundwater that are not already identified in the permit as monitoring constituents.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.100 (Subpart F) R.61-79.264.100 (Subpart F)	Corrective Action Program - An owner/operator required to establish a corrective action program must: (a) Take corrective action to ensure that regulated units are in compliance with the groundwater protection standard under Section 264.92. (b) Implement a corrective action program that prevents hazardous constituents from exceeding their respective concentration limits at the compliance point by removing hazardous waste constituents or treating them in place. (c) Begin corrective action within a reasonable period after the groundwater protection standard is exceeded. (d) In conjunction with a corrective action program, establish and implement a groundwater monitoring program based on the requirements for compliance monitoring under Section 264.99 and as effective in determining compliance with the groundwater protection standards and in determining the success of a corrective action program. (e) Conduct corrective action to remove or treat in place any hazardous constituents under Section 264.93 that exceed concentration limits under Section 264.94 in groundwater. (f) Continue corrective action measures during the compliance period to the extent necessary to ensure that the groundwater protection standard is not exceeded. If the owner/operator is conducting corrective action at the end of the compliance period, he must continue that corrective action as long as necessary to achieve compliance with the groundwater protection standard.	Potentially relevant and appropriate only with respect to establishing a performance objective for groundwater protection. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.100 (Subpart F) R.61-79.264.100 (Subpart F) (cont.)	This section also sets forth reporting requirements and procedures for seeking modifications to the approved corrective action program.		
RCRA 40 CFR 264.101 (Subpart F) R.61-79.264.101 (Subpart F)	Corrective Action for Solid Waste Management Units - An owner/operator seeking a permit for the treatment, storage, or disposal of hazardous waste must institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any Solid Waste Management Unit at the facility, regardless of the time at which the waste was placed in such unit. Corrective action will be specified in the permit application in accordance with this section and subpart S. The owner/operator must implement corrective action beyond the facility property boundary, where necessary to protect human health and the environment, unless he demonstrates that he was unable to obtain the necessary permission to undertake such actions. This section also sets forth standards for monitoring well installation.	Applicable to the HLW tanks because the F- and H-Area Tank Farms are identified on the site evaluation list (Appendix G) of the FFA. Compliance with the requirements of the FFA, including the schedules and commitments therein, will constitute compliance with the corrective action requirements at SWMUs and Areas of Concern (AOCs) set forth in Module IV, "Corrective Action," of the SRS RCRA permit. Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA requirements for corrective action for SWMUs with respect to the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.	A
RCRA 40 CFR 268 R.61-79.268	Land Disposal Restrictions - Specifies standards to which hazardous waste must be treated prior to land disposal and prohibits storage of untreated hazardous waste except under specified conditions. Subpart D sets forth the treatment standards and Subpart E identifies prohibitions on storage applicable to restricted wastes.	LDR applicable to land disposal of hazardous wastes: • Removed from HLW tanks as part of tank closure activities • Generated as a result of tank closure activities	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 268.40 (Subpart D) R.61-79.268.40 (Subpart D)	Applicability of Treatment Standards - A waste identified in the table "Treatment Standards for Hazardous Wastes" in this section may be land disposed only if it meets the requirements found in the table. For each waste, the table identifies one of three types of treatment requirements: (1) All hazardous constituents in the waste or in the treatment residues must be at or below the levels found in the table ("total waste standards") (2) The hazardous constituents in the extract of the wastes or the treatment residue must be at or below the levels found in the table ("waste extract standards") (3) The waste must be treated using the technology specified in the table ("technology standard") These standards are established for two types of waste: "wastewaters" which are generally wastes containing less than 1 percent by weight TOC and less than 1 percent by weight TSS and "nonwastewaters" [Sections 268.2(d) and (f)]. The table includes entries specific to certain mixed wastes: "Radioactive high level wastes generated during the reprocessing of fuel rods" (nonwastewaters only) that are D002 or D004-D011 hazardous wastes are subject to the HLVIT standard. "Radioactive lead solids" (nonwastewaters only) that are D008 hazardous wastes are subject to the MACRO standard. "Elemental mercury contaminated with radioactive materials" (nonwastewaters only) that are D009 hazardous wastes are subject to the AMLGM standard.	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 268.40 (Subpart D) R.61-79.268.40 (Subpart D) (cont.)	In the Third Third rule, EPA indicated that the HLVIT standard would apply to the "high-level fraction of the mixed waste generated during the reprocessing of fuel rods" exhibiting the characteristics of corrosivity and toxicity for metals (see 55 FR 22627). Incidental wastes associated with HLW tank closure that are also mixed wastes would not require treatment by vitrification, but could nevertheless require treatment in accordance with the applicable LDR treatment standards for any hazardous characteristics, including standards for any underlying hazardous constituents. In addition to a specified technology or waste-specific concentration standard, wastes may also be subject to LDR treatment standards for underlying hazardous constituents set forth in Section 268.48. For example, a corrosive characteristic waste (D002) would have to be deactivated (i.e., rendered no longer corrosive) and treated to achieve the UTS concentration limits for any underlying hazardous constituents.		
RCRA 40 CFR 268.45 R.61-79.268.45	<u>Treatment Standards for Hazardous Debris</u> - Hazardous debris may be treated in accordance with the waste-specific standards or, alternatively, the debris may be treated in accordance with the standards set forth in Table 1 of this section. The alternative standards for hazardous debris include extraction, destruction, and immobilization technologies. Debris that is treated using one of the specified extraction or destruction technologies, and which does not exhibit a hazardous waste characteristic, is no longer subject to regulation as hazardous waste. Debris that is treated using one of the specified immobilization technologies may be excluded (e.g., debris that, after immobilization, no longer exhibits the characteristic for which the debris was hazardous waste).	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 268.48 R.61-79.268.48	Universal Treatment Standards - Table UTS in this section identifies the hazardous constituents and their nonwastewater and wastewater treatment standard levels. For determining compliance with the treatment standards for underlying hazardous constituents as defined in Section 268.2(i), these constituent-specific treatment standards may not be exceeded.	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A
RCRA 40 CFR 268.50 (Subpart E) R.61-79.268.50 (Subpart E)	Prohibitions on storage of restricted wastes - Storage of hazardous wastes restricted from land disposal is prohibited unless such storage is in tanks, containers, or containment buildings solely for the purpose of accumulating such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal.	Applicable to management of hazardous wastes generated as a result of SRS HLW tank closure activities.	A
RCRA Section 3004(c)	Liquids in Landfills - The placement of bulk or noncontainerized liquid hazardous waste or free liquids contained in hazardous waste (whether or not absorbents have been added) in any landfill is prohibited. Disposal in landfills of liquids that have been absorbed in materials that biodegrade or that release liquids when compressed as might occur during routine landfill operations is also prohibited.	Relevant and appropriate to determining stabilization requirements for any free liquids that are disposed of in the course of HLW tank closure activities. [Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.i(5)(b).]	RA
RCRA Section 3004(o)	Minimum Technology Requirements - The design of any new or replacement landfill or surface impoundment unit, or lateral expansion to a landfill or surface impoundment unit, shall include two or more liners and a leachate collection system (for landfills) between such liners.	Might be relevant and appropriate to hazardous waste disposal that occurs outside the boundaries of an existing unit. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA Regulation 61-63, RHA 7.14	Postclosure Observation and Maintenance - The licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the site closure is complete and the license is transferred by the Department in accordance with 7.15. Responsibility for the disposal site must be maintained by the licensee for 5 years. A shorter or longer time period for postclosure observation and maintenance may be established and approved as part of the site closure plan, based on site-specific conditions.	SC state regulation that, while not directly applicable to HLW tank closure, is relevant and appropriate because it is well suited for use as an indicator of protection of human health and the environment. [No direct comparison for license termination. Substantive requirement met by compliance with DOE Orders 5820.2A and 5400.5.]	RA
AEA Regulation 61-63, RHA 7.18	Protection of the General Population from Releases of Radioactivity - Concentration of radioactive material that might be released to the general environment in groundwater, surface water, air, soil, plant, or animals shall not result in an annual dose exceeding an equivalent of 25 millirem (0.25 mSv) to the whole body, 75 millirem (0.75 mSv) to the thyroid, and 25 millirem (0.25 mSv) to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluent to the general environment as low as reasonably achievable.	SC state regulation that, while not directly applicable to HLW tank closure, is relevant and appropriate because it is well suited for use as an indicator of protection of human health and the environment. [Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.a establishes a public dose limit of 100 mrem/yr. More stringent requirement for public dose limit of 25 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	RA
AEA Regulation 61-63, RHA 7.19	Protection of Individuals from Inadvertent Intrusion - Design, operation, and closure of the land disposal facility shall ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.	SC state regulation that, while not directly applicable to HLW tank closure, is relevant and appropriate because it is well suited for use as an indicator of protection of human health and the environment. [Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.a(3), which stipulates maximum inadvertent intruder exposure limits.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA Regulation 61-63, RHA 7.21	Stability of the Disposal Site After Closure - The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care is required.	SC state regulation that, while not directly applicable to HLW tank closure, is relevant and appropriate because it is well suited for use as an indicator of protection of human health and the environment. [Requirement met by compliance with DOE Order 5820.2A, Chapter III, 2.a.]	RA
AEA 40 CFR 191.3(a)	Dose Limits - Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities regulated by the NRC or by Agreement States shall be conducted in a manner that provides reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage and all operations covered by Part 190 shall not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ.	EPA regulations that would be applicable to any waste associated with HLW tank closure that is HLW. For waste that is not HLW, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.c which stipulates a dose equivalent not to exceed 25 mrem/yr to the whole body or a committed dose equivalent not to exceed 75 mrem/yr to any organ. More stringent requirements for dose equivalent not to exceed 75 mrem/yr to the thyroid and 25 mrem/yr to any other organ will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 191.3(b)	Dose Limits - Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities for the disposal of such fuel or waste that are operated by the DOE and that are not regulated by the NRC or Agreement States shall be conducted in a manner that provides reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 mrem to the whole body and 75 mrem to any critical organ.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.c which stipulates a dose equivalent not to exceed 25 mrem/yr to the whole body or a committed dose equivalent not to exceed 75 mrem/yr to any organ. More stringent requirements for dose equivalent not to exceed 75 mrem/yr to the thyroid and 25 mrem/yr to any other organ will be evaluated to determine the impact, if any, on remedial goals.]	RA
AEA 40 CFR 191.13(a)	Containment Requirements - Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based on performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that might affect the disposal system shall have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A), and have a likelihood of less than one chance in 1,000 of exceeding 10 times the quantities calculated according to Table 1 (Appendix A).	EPA regulations that would be applicable to any waste associated with HLW tank closure that is HLW. For waste that is not HLW, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [More specific requirements regarding quantities of radionuclides that might be released will be evaluated to determine impact, if any, on remedial goals.]	RA
AEA 40 CFR 191.15	Dose Limits - (a) Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that, for 10,000 years after disposal, undisturbed performance of the disposal system shall not cause the annual committed effective dose, received through all potential pathways from the disposal system, to any member of the public in the accessible environment, to exceed 15 mrem. (b) Annual committed effective dose shall be calculated in accordance with Appendix B of this part.	[Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.c stipulates that releases to the environment should result in a dose equivalent that does not exceed 25 mrem/yr to the whole body or a committed dose equivalent of 75 mrem/yr to any organ. More specific requirements for a committed effective dose not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 191.24	Disposal Standards - Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that 10,000 years of undisturbed performance after disposal shall not cause the levels of radioactivity in any underground source of drinking water in the accessible environment to exceed the limits specified in 40 CFR Part 141 as they exist on January 19, 1994.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.d.]	RA
AEA 10 CFR 61.40 (Subpart C)	Performance Objectives - Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within limits established in the performance objectives in Sections 61.41 through 61.44.	NRC regulations that, while not directly applicable to HLW tank closure, would be relevant and appropriate because they are well suited for use as indicators of the protection of human health and the environment. [Requirements met by compliance with applicable requirements of DOE Orders 5400.5 and 5820.2A, with specific exceptions noted below.]	RA
AEA 10 CFR 61.41 (Subpart C)	Protection of the general population from releases of radioactivity - Concentrations of radioactive material that might be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual effective dose exceeding an equivalent of : • 25 mrem whole body • 75 mrem thyroid • 25 mrem any other organ Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable.	[Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.a establishes a dose limit of 100 mrem/yr. More stringent requirements for dose equivalent not to exceed 25 mrem/yr whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other organ will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 61.42 (Subpart C)	Protection of individuals from inadvertent intrusion - Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.	[Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.a(3), which stipulates maximum inadvertent intruder exposure limits.]	RA
AEA 10 CFR 61.43 (Subpart C)	Protection of individuals during operations - Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as reasonably achievable.	[Comparable applicable requirement of DOE Order 5820.2A, Chapter III, 3.a establishes performance objectives for low-level waste disposal. More specific requirements in the referenced regulations (10 CFR 20, 10 CFR 61.41) are evaluated to determine impact, if any, on remedial goals.]	RA
AEA 10 CFR 61.44 (Subpart C)	Stability of the disposal site after closure - The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.	[Requirement met by compliance with DOE Order 5820.2A, Chapter III, 2.a and 3.j.]	RA
AEA 10 CFR 61.52(a)(6)	Near surface disposal facility operation and disposal site closure - Wastes must be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with all provisions of Section 20.105 of this chapter at the time the license is transferred pursuant to Section 61.30 of this part.	[No direct comparison for license termination. Specific requirements in the referenced regulation (10 CFR 20.105) are evaluated separately to determine impact, if any, on remedial goals.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use^a	Requirements/ Guidance Category^b
AEA 10 CFR 61.55(a)(2)(iv)	Classification of waste for near surface disposal - Waste that is not generally acceptable for near-surface disposal is waste for which waste form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, proposals for disposal of this waste can be submitted to the Commission for approval, pursuant to Section 61.58 of this part.	[Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.i(4).]	RA
AEA 10 CFR 61.58	Alternative requirements for waste classification and characteristics - The Commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a special basis if after evaluation of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in Subpart C of this part.	[Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.i.]	RA
CERCLA “Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual (HHEM) (Part A),” Interim Final, Dec. 1989, EPA/540/1-89/002		To be considered as guidance for risk assessments conducted at hazardous waste sites. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC
CERCLA “RAGS/HHEM (Part B), Development of Risk-Based Preliminary Remediation Goals,” Interim, Dec. 1991, EPA/540/R-92/003		To be considered as guidance for risk assessments conducted at hazardous waste sites. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA "RAGS/HHEM (Part C), Risk Evaluation of Remedial Alternatives," Interim, Dec. 1991, EPA/540/R-92/004		To be considered as guidance for risk assessments conducted at hazardous waste sites. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC
CERCLA "RAGS: Volume II - Environmental Evaluation Manual," Interim Final, March 1989, EPA/540/1-89/001		To be considered as guidance for risk assessments conducted at hazardous waste sites. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC
CERCLA "Supplemental Guidance to RAGS: Region 4 Bulletins," Human Health Risk Assessment, Bulletins 1-5 November 1995	Region IV clarifications and interpretations supplementing EPA-wide guidance (RAGS) for risk assessments at hazardous waste sites.	EPA Region 4 bulletins intended as guidance to all risk assessors preparing human health assessments for CERCLA NPL sites and Federal sites in the region. To be considered as guidance for risk assessments conducted for non-CERCLA remedial actions, such as the HLW tank closures. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA *Policy on Decommissioning of Department of Energy Facilities under the Comprehensive Environmental Response, Compensation, and Liability Act*	The Policy, dated May 22, 1995, establishes a decommissioning framework that presumes DOE's decommissioning projects will be conducted as non-time-critical removal actions under CERCLA. Non-time-critical removal actions are defined in the NCP as removals with a planning horizon of 6 months or more. The Policy concludes that non-time-critical removals are the appropriate CERCLA action for decommissioning projects for the following reasons: (1) The alternative approaches available to conduct decommissioning projects typically are clear and very limited, a situation that usually will eliminate the need for more detailed analysis of alternatives required for remedial action. (2) The requirements for non-time-critical removal actions provide greater flexibility to develop decommissioning plans that are appropriate for the circumstances presented. (3) Non-time-critical removal actions usually will provide benefits to worker safety, public health, and the environment more rapidly and cost-effectively than remedial action. Under Section 300.415(b)(1), the lead agency (DOE) shall determine if there is a threat to public health or welfare or the environment , and if so take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release. Section 300.415(b)(2) of the NCP sets forth criteria for determining the appropriateness of a removal action, which include: "(iii) Hazardous substances of pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers, that may pose a threat of release."	Appropriate to the extent activities associated with HLW tank closure constitute final decommissioning of the subject facilities. [Requirement substantially met by the general process set forth in this closure plan, which requires compliance with substantive applicable requirements and consideration of relevant and appropriate requirements for HLW tank closure.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
Decommissioning Handbook DOE/EM-0142P U.S. Department of Energy Office of Environmental Restoration, March 1994	Technical guidance for the decommissioning of nuclear facilities, including removal of radioactive and hazardous materials to levels protective of human health and the environment. Chapter 13 identifies standards for air, surface-water, and groundwater quality during decommissioning including the National Ambient Air Water Quality Standards, DOE Order 5400.5, National Emissions Standards for Hazardous Air Pollutants, and Safe Drinking Water Act maximum contaminant levels.	Appropriate to the extent activities associated with HLW tank closure under this plan constitute final decommissioning of the F- and H-Area Tank Farms. [Compliance with this plan ensures consistency with substantive provisions of this handbook. Specific requirements in the regulations and Orders referenced in the handbook (AWQS, NESHAP, SDWA, DOE Order 5400.5) have been evaluated and, where applicable or relevant and appropriate, addressed in this plan.]	TBC
Ambient Water Quality Criteria (AWQC)	EPA's AWQC for protection of freshwater organisms will be preferentially used to judge ecological impacts to aquatic resources. Other resources will be used for chemicals without AWQC.	AWQC provides the most appropriate criteria for judging ecological impacts. [Requirement met by compliance with R.61-68.E(7).]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 193.13(a) (Proposed)	Standards for Disposal - Disposal systems for low-level radioactive waste shall be designed to provide a reasonable expectation that [*OPTION 1. "within 1,000 years of disposal, no member of the public shall receive,"*] or [*OPTION 2. "the highest projected dose following disposal and received through all pathways from the disposal system will not exceed,"*] or [*OPTION 3. "no member of the public shall receive, through all pathways from the disposal system, during a period following disposal as determined by the implementing agency,"*] an annual committed effective dose of more than 150 microsieverts (15 mrem).	Proposed EPA Federal regulation that, when promulgated, will be applicable to activities involving disposal of low-level radioactive waste. While not directly applicable to HLW tank closure, these requirements would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Comparable applicable requirement of DOE Order 5820.2A, Chapter III, 3.a(2) stipulates releases to the environment should result in an effective dose equivalent that does not exceed 25 mrem/yr. More specific requirement for a committed effective dose not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals. The 15 mrem/yr committed effective dose standard is also imposed by 40 CFR 191.15 for a 10,000-year performance period.]	TBC
AEA 40 CFR 193.24(a) (Proposed)	Standards for Protection of Underground Sources of Drinking Water - Disposal systems for low-level radioactive waste shall be designed to provide a reasonable expectation that the levels of radioactivity from the disposal system in any underground source of drinking water will not exceed [*OPTION 1. "the MCLs, as they exist on the effective date of this subpart, regardless of pre-existing contamination*] or [*OPTION 2. "up to the MCLs, as they exist on the effective date of this subpart, if the pre-existing contamination is below the MCLs and permit up to one additional MCL if the pre-existing contamination is above the MCLs.*]	[Requirement met by compliance with DOE Order 5400.5 Chapter II, 1.d. The MCL standards are also invoked by 40 CFR 191.24 for a 10,000-year performance period.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.101(a) (Proposed)	Dose Limits - A DOE activity shall be conducted in a manner such that the exposure of members of the public to ionizing radiation will: (1) comply with the ALARA program requirements in Section 834.104; and (2) not cause a TEDE greater than 100 mrem (1 mSv) in a year from all sources of ionizing radiation and exposure pathways, excepting: (i) dose from radon and its decay products (which is regulated separately); (ii) dose received by patients from medical sources of radiation used for diagnostic or therapeutic purposes, and by volunteers in medical research programs; (iii) dose from background radiation; and (iv) dose to workers that arises from DOE activities during the performance of work duties and that is regulated under 10 CFR 835.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a and substantially equivalent ALARA requirements in Chapter II, 2.]	TBC
AEA 10 CFR 834.101(b) (Proposed)	Dose Limits - On request, the Department may authorize temporary dose limits for members of the public in excess of 100 mrem (1 mSv) in a year, but not in excess of 500 mrem (5 mSv). A request for an authorization for a temporary operation that could result in a higher dose level shall: (1) be submitted as soon as practicable when the need is recognized and, where possible, before the 100-mrem dose limit is exceeded; (2) contain: (i) a justification for the higher dose limit; (ii) a discussion of the alternatives considered; (iii) an ALARA evaluation; (iv) an estimate of how long the higher limit will be necessary; and (v) a description of what is being done to return to normal operations and to minimize doses to members of the public; and (3) be made promptly a matter of public record delineating the nature of the unusual operating condition, and the basis for the variance as documented under Section 834.101(b)(2).	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Substantive requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a(4)(a).]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.201(a) (Proposed)	Dose Limits - A DOE activity shall be conducted in a manner such that the release of radioactive material to the atmosphere shall: (1) be evaluated using the ALARA process; (2) not cause any member of the public to receive a TEDE in excess of 10 mrem (0.1 mSv) in a year, excluding doses from radon-220 and radon-222 and their decay products and from background sources; (3) not cause annual radon-222 flux rates to exceed 20 pCi (0.7 Bq)/(m^2sec) averaged over the surface area overlaying the waste, including the covering or other confinement structures, wherever radium-226 residues are accepted for storage or disposal; (4) not cause outdoor annual concentrations of radon-220 or radon-222 resulting from a facility where sources of radon are handled or processed to exceed 3 pCi (0.1 Bq)/L above background at the facility or at any location beyond the facility boundary that is accessible to the public; and (5) not cause an annual radon-220 or radon-222 average concentration to exceed 0.5 pCi (0.02 Bq)/L above background at any offsite location where people reside or work.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.b and Chapter IV, 6.d(1).]	TBC
AEA 10 CFR 834.214(a) (Proposed)	Dose Limits - The drinking water system for a DOE activity shall be managed in a manner that complies with the provisions of 40 CFR 141 -- National Primary Drinking Water Regulations Pursuant to Section 1412 of the Safe Drinking Water Act.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with R.61-68 and DOE 5400.5, Chapter II, 1.d(1).]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.214(b) (Proposed)	Dose Limits - Discharges from DOE activities shall be managed in a manner that will not cause private or public drinking water systems downstream or downgradient of the facility discharge to exceed the drinking water maximum contamination levels in 40 CFR 141.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with R.61-68 and DOE Order 5400.5, Chapter II, 1.d(3).]	TBC
AEA 10 CFR 834.221(a) (Proposed)	Dose Limits - A DOE activity shall be conducted in a manner such that exposure of members of the public to radiation from radioactive waste: (1) complies with ALARA process requirements; and (2) does not exceed a TEDE of 25 mrem (0.25 mSv) in a year from all exposure pathways and radiation sources, except radon and its daughters.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [More stringent requirement for TEDE not to exceed 25 mrem/yr will be evaluated to determine impact, if any, on remedial goals. Applicable requirement (DOE Order 5400.5, Chapter II, 1.a) limit is 100 mrem/yr.]	TBC
AEA 10 CFR 834.231 (Proposed)	Dose Limits for aquatic organisms - A DOE activity shall be conducted in a manner such that the absorbed dose to aquatic animal organisms (e.g., fish, crustaceans, mollusks, and benthic invertebrates) will not exceed 1 rad (0.01 gray) per day from exposure to radiation or radioactive material discharged in liquid waste to natural waterways.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter II, 3.a(5).]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.301(a) (Proposed)	Release of Property Containing Residual Radioactive Material - DOE property or personal property containing residual radioactive material shall not be released from DOE control unless: (1) the release of property is in compliance with Authorized Limits (Section 834.301(b)) and Supplemental Limits (Section 834.301(d)) for concentrations of residual radioactive material on property surfaces or interior; (2) the property is evaluated and appropriately surveyed to identify and characterize contamination within the property and removable radioactive material and total radioactive material on property surfaces (including contamination present on and under any coating); and (3) documentation, in a Department-approved format, is completed that: (i) describes the property, (ii) describes the radiological history of the property, (iii) states the criteria for release of the property and the bases for the criteria which have been approved by the Department and coordinated with appropriate state and Federal organizations, (iv) describes any restrictions on use or disposition of the property and how the implementation of the restrictions will be ensured, (v) describes the survey of the property, including the date, the identity of the surveyor, the types and identification numbers of the instruments used, and the results of the survey, (vi) indicates the quantity and disposition of the waste resulting from any decontamination effort, and (vii) identifies the recipient of the property, its destination, or its disposition; and (4) appropriately notifies the recipient or owner of the property of the results of the survey of the property, including the availability of documentation required by Section 834.301(a)(3).	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter II, 5.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.301(b) (Proposed)	Release of Property Containing Residual Radioactive Material - The Authorized Limits shall be derived in accordance with the ALARA process requirements, documented, approved by the Department, and made part of the public record.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter II.5.]	TBC
AEA 10 CFR 834.302(a) (Proposed)	Soil - Authorized Limits and Supplemental Limits for all radionuclides in soil shall be derived using approved models in accordance with the requirements of this subpart and selected on the basis of the ALARA process.	Proposed DOE regulation, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.a.]	TBC
AEA 10 CFR 834.302(b) (Proposed)	Soil - Authorized Limits for radon-226 and radon-228 shall be selected consistent with Section 834.302(a) and shall not exceed 5 pCi/gram (0.2 Bq/gram) in excess of background levels, averaged over 100 m^2, in the first 15-cm depth of the surface layer of soil; and 15 pCi/gram (0.56 Bq/gram) in excess of background levels, averaged over any subsequent 15-cm subsurface layer of soil.	Proposed DOE regulation, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.a(2).]	TBC
AEA 10 CFR 834.303(a) (Proposed)	Radon - Remedial actions shall be conducted on habitable and occupied structures with the objective of reducing residual radioactive material levels such that the annual average radon-222 decay product concentration will not exceed 0.02 WL (or 4 pCi/L radon, when 0.02 WL is approximately equivalent to 4 pCi/L assuming that the radon decay products are at 50 percent of equilibrium), including background, in the structure. [A working level (WL) is any combination of short-lived radon decay products in 1 L of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.]	Proposed DOE regulation, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.b.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.303(b) (Proposed)	Radon - If residual radioactive material cannot be reduced, practicably, to levels that reduce radon decay product concentration in a habitable structure to 0.02 WL, remedial measures, including active controls, shall be employed to reduce concentrations to 0.03 WL, or less. In any case, the radon decay product concentration shall not exceed 0.03 WL, including background, in such structures as a result of residual radioactive material.	Proposed DOE regulation, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.b.]	TBC
AEA 10 CFR 834.304 (Proposed)	Structures - Authorized Limits and Supplemental Limits for residual radionuclides in or on structures at specific DOE properties shall be (a) established in accordance with the requirements of this subpart, (b) consistent with Department guidelines or derived using DOE-approved models, and (c) selected on the basis of the ALARA process.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.d.]	TBC
AEA 10 CFR 834.306(c) (Proposed)	Control and Disposition of Residual Radioactive Material - A property may be maintained under an interim management arrangement when the residual radioactive material exceeds authorized limits developed for unrestricted release if: (1) the residual radioactive material is in locations that are not readily accessible to members of the public; (2) the residual contamination would be unreasonably costly to remove; and (3) when needed, administrative controls are instituted by the operating organization to protect members of the public.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6.c.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.306(d) (Proposed)	Control and Disposition of Residual Radioactive Material - (1) Appropriate administrative and physical controls for the management of storage or disposal activities shall be developed, documented, and implemented to limit access, use, and removal of material contaminated with residual radioactive material. (2) Controls shall be designed such that concentrations of radionuclides in the groundwater and residual radioactive material will not cause the requirements of this part to be exceeded. (3) Control and stabilization features for the interim management and storage of residual radioactive material shall be designed to meet the applicable dose limits and dose constraints selected through application of the ALARA process for 25 years at a minimum, and 50 years if practicable to do so. (4) The controls shall be designed to limit radon concentrations in the atmosphere above facilities to levels that will not exceed: (i) an annual average radon-220 and radon-222 concentration of 0.5 pCi (0.02 Bq)/L, above background, at any offsite location where persons are likely to reside or work; (ii) flux rates from the storage of radon-producing wastes of 20 pCi (0.7 Bq)/(m^2 sec), averaged over the area containing the radon-generating material.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.306(e) (Proposed)	Control and Disposition of Residual Radioactive Material - (1) Long-term management of residual radioactive material in residue and waste from a DOE activity shall be in accordance with this section and DOE approved plans. (2) Long-term management of the residue and waste shall be conducted in a manner that will: (i) comply with dose limits (Sections 834.201, 834.214, and 834.221); (ii) comply with the ALARA requirements of this part (Section 834.104); (iii) comply with the Ground-Water Protection Management Plan (Section 834.215); (iv) limit radon-222 emanation to the atmosphere from radon-222 generating waste to less than an annual average release rate of 20 pCi (0.7 Bq)/(m^2 sec) averaged over the surface area overlying the waste, including the covering or other confinement structures; (v) limit radon-220 emanation to the atmosphere from waste to an annual average release rate of 20 pCi (0.7 Bq)/(m^2 sec), and (vi) limit increases in the annual average radon-222 or radon-220 concentration at or above any location outside the boundary of the controlled area to 0.5 pCi (0.02 Bq)/L. (3) Control and stabilization features shall be designed to: (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years; (ii) minimize unauthorized public access or use that might breach containment of waste; and (iii) provide for proper conditioning or barriers to control the generation and escape of biogenic gases from potentially biodegradable contaminated waste or residue to ensure that this material will not cause the emission limits or dose limits to be exceeded and biodegradation within the facility will not result in premature structural failure. (4) In the development of controls and waste management plans, where appropriate, the impacts of alternative disposal modes shall be evaluated beyond the 1,000-year design requirement, to 10,000 years. (5) For wastes containing a high specific activity (e.g., $\geq$1 nCi/g) of radium or thorium, alternative disposal methods, such as deep land disposal, protective covers (e.g., riprap), concrete vaults, or geologic repositories that provide additional protection from possible inadvertent intrusion shall be evaluated and employed if justified by potential risk considerations.	Proposed DOE Federal regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirements met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 10 CFR 834.306(e)(4) constitutes a more stringent requirement for evaluation of alternative disposal modes to 10,000 years.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 20.1301	Dose Limits for Individual Members of the Public - Each licensee shall conduct operations such that: (1) The total effective dose equivalent (TEDE) to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with §20.2003; and (2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any 1 hour. If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals. A licensee may apply for prior NRC authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). In addition to the requirements of this part, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190 shall comply with those standards. The Commission may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.	NRC regulation that, while not directly applicable to HLW tank closure, would be relevant and appropriate because it is well suited for use as an indicator of protection of human health and the environment. [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a, except for TEDE not to exceed 2 mrem in any one hour. This more stringent requirement will be evaluated to determine impact, if any, on remedial goals]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 20.1404(a) (Proposed)	Radiological Criteria for Unrestricted Release: A site will be considered acceptable for unrestricted use if: (a) the residual radioactivity that is distinguishable from background radiation results in a TEDE to the average member of the critical group that does not exceed 15 mrem (0.15 mSv) per year; and (b) the residual radioactivity has been reduced to levels that are ALARA.	Proposed NRC regulation, when promulgated, will provide requirements for NRC licensee activities resulting in residual radioactive material, similar to SRS HLW tank closure. [Applicable requirement (DOE Order 5400.5, Chapter IV, 3.a) establishes a dose limit of 100 mrem/yr. More stringent requirement of TEDE not to exceed 15 mrem/year will be evaluated to determine impact, if any, on remedial goals.]	TBC
AEA 10 CFR 20.1404(b) (Proposed)	Radiological Criteria for Unrestricted Release: A site will be considered acceptable for unrestricted use if the residual radioactivity has been reduced to levels that are as low as reasonable achievable.	[Requirement met by compliance with DOE Order 5400.5, Chapter IV, 7.]	TBC
AEA 10 CFR 20.1405(a) (Proposed)	Criteria for License Termination Under Restricted Conditions: A site will be considered acceptable for license termination under restricted conditions if: The licensee can demonstrate that further reduction in residual radioactivity necessary to comply with the provisions of Section 20.1404 are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm.	[Requirement met by compliance with DOE Order 5400.5, Chapter IV, 7.]	TBC
AEA 10 CFR 20.1405(b) (Proposed)	Criteria for License Termination Under Restricted Conditions: A site will be considered acceptable for license termination under restricted conditions if the licensee has made provisions for institutional controls that provide reasonable assurances that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 15 mrem (0.15 mSv) TEDE per year. Institutional controls must be enforceable by a responsible government entity or in a court of law in response to suits by affected parties.	[Applicable requirement (DOE Order 5400.5, Chapter IV, 7) establishes a dose limit of 100 mrem/yr. More stringent requirement of TEDE not to exceed 15 mrem/year will be evaluated to determine impact, if any, on remedial goals.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 20.1405(d) (Proposed)	Criteria for License Termination Under Restricted Conditions: A site will be considered acceptable for license termination under restricted conditions if residual radioactivity at the site has been reduced so that, if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group would not exceed 100 mrem (1 mSv) per year, and is as low as reasonably achievable. Calculations used to show compliance with this provision may not assume any benefit from earthen cover or other earthen barriers unless specifically authorized by the NRC.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a.]	TBC
AEA 40 CFR 196.04(a) (Proposed)	Environmental Standards for Site Remediation - Remediation of sites shall be conducted to provide a reasonable expectation that, for 10,000 years after completion of the remedial action, radionuclide concentrations in excess of natural background levels shall not exceed those amounts that could cause any member of the public to receive, through all potential pathways under a residential land use scenario, an annual committed effective dose of 15 mrem/yr (0.15 mSv/yr).	Proposed EPA regulation that, when promulgated, will be applicable to activities resulting in residual radioactive material, including SRS HLW tank closure. [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 40 CFR 196.04(a) constitutes a more stringent requirement of 15 mrem/yr dose limit for 10,000 years.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 196.04(c) (Proposed)	Environmental Standards for Site Remediation - In the event that remediation of a site will not meet the conditions of Section 196.04(a), the implementing agency shall: (1) remediate the site to provide a reasonable expectation that, for 10,000 years after completion of the remedial action, radionuclide concentrations in excess of natural background levels shall not exceed those concentrations that could cause any member of the public to receive, through all potential pathways under the conditions of the selected active control measures, an annual committed effective dose of 15 mrem/yr (0.015 mSv/yr); and (2) remediate the site to provide a reasonable expectation that, for 10,000 years after completion of the remedial action in the absence of active control measures, radionuclide concentrations in excess of natural background levels on the site shall not exceed those amounts that could cause any member of the public to receive, through all potential pathways under the conditions of residential land use, an annual committed effective dose that is less than 75 mrem/yr (0.075 mSv/yr).	[Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 40 CFR 196.04(a) constitutes a more stringent requirement of 15 mrem/yr dose limit for 10,000 years.]	TBC
AEA 40 CFR 196.04(d) (Proposed)	Environmental Standards for Site Remediation - All existing and future structures on sites shall meet the guidelines of the EPA Radon Program.	[Requirement met by compliance with DOE Order 5400.5, Chapter IV, 4.b.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 196.04(e) (Proposed)	<u>Environmental Standards for Site Remediation</u> - The implementing agency shall perform compliance assessments. Compliance assessments need not provide complete assurance that the requirements of Section 196.04 of this subpart will be met. Because of the long period involved and the nature of the processes and events of interest, there may be substantial uncertainties in projective remedial action performance. Proof of the future annual committed effective dose from radioactive concentrations is not to be had in the ordinary sense of the word in situations that deal with much shorter timeframes. Rather, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with Section 196.04 will be achieved.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 5.]	TBC
AEA 40 CFR 196.23(a) (Proposed)	<u>Environmental Standards for Groundwater Protection</u> - Remediation of sites shall be conducted to provide a reasonable expectation that 10,000 years after completion of the remedial action, onsite radioactive material shall not cause the levels of radioactivity in any groundwater that is a current or potential source of drinking water, in the accessible environment, to exceed the limits specified in 40 CFR 141.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.d.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 196.23(b) (Proposed)	Environmental Standards for Groundwater Protection - Compliance assessments need not provide complete assurance that the requirements of Section 196.23 of this subpart will be met. Because of the long time period involved and the nature of the processes and events of interest, there will inevitably be substantial uncertainties in projecting remedial action performance. Proof of the future levels of radioactivity in any groundwater that is a current or potential source of drinking water, in the accessible environment, is not to be had in the ordinary sense of the word in situations that deal with much shorter timeframes. Rather, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with Section 196.23 will be achieved.	[Requirement met by compliance with DOE Order 5820.2A, Chapter III, 3.b.]	TBC
AEA 40 CFR 196.23(c) (Proposed)	Environmental Standards for Groundwater Protection - Compliance with Section 196.23(a) of this subpart will not be required, if the implementing agency determines compliance to be technically impracticable from an engineering perspective. In this situation, the implementing agencies shall: (1) select active control measures that ensure members of the public will not be exposed to groundwater that is drinking water, in which the levels of radioactivity exceed the limits specified in 40 CFR 141; (2) select and perform remedial actions that limit, to the greatest extent, contamination of groundwater that is not already contaminated, as is reasonable under the circumstances; (3) select and perform remedial actions that restore, to the greatest extent, groundwater that is already contaminated, as is reasonable under the circumstances; (4) comply with the public notice and comment requirements of Section 196.03(a) of subpart A; and (5) comply with the periodic verification requirements of Section 196.24 of this subpart.	[More specific requirement for active control measures over groundwater which exceeds levels of radioactivity specified in 40 CFR 141 will be evaluated to determine impact, if any, on remedial goals.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA EPA Proposed Federal Guidance for Protection of the Public from Radiation, December 23, 1994	Recommendation 1 - There should be no exposure of the general public to ionizing radiation unless it is justified by the expectation of an overall benefit from the activity causing the exposure. Justified activities may be allowed, provided exposure of the general public is limited in accordance with these recommendations.	Proposed EPA Federal guidance that, when finalized, will apply to activities involving potential radiation exposure of members of the public, including SRS HLW tank closure. [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.]	TBC
	Recommendation 2 - A sustained effort should be made to ensure that doses to individuals and to populations are maintained as low as reasonably achievable.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 2.]	TBC
	Recommendation 3 - The combined radiation doses incurred in any single year from all sources of exposure covered by these recommendations should not normally exceed a Radiation Protection Guide of 1 mSv (100 mrem) effective dose equivalent to an individual. The Radiation Protection Guide applies to the sum of the effective dose equivalent resulting from exposure to external sources of radiation during a year and the committed effective dose equivalent incurred from the intake of radionuclides during that year. The Radiation Protection Guide might not be reasonably achievable in some unusual situations. It may be exceeded temporarily in situations that are not anticipated to recur chronically and when Recommendations 1 and 2 are satisfied, provided that the radiation dose incurred in any year does not exceed 5 mSv (500 mrem) effective dose equivalent. Continued exposure of an individual over substantial portions of a lifetime at or near the level of the Radiation Protection Guide should be avoided.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a.]	TBC

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA "Design and Construction of RCRA/CERCLA Final Covers," EPA/625/4-91/025, May 1991	EPA recommendations to be considered in the design of low hydraulic conductivity cover systems.	Relevant and appropriate to the design of a cover system if capping is performed as part of the HLW tank closure activities. [Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensure that closure activities to be conducted under this plan will be consistent with RCRA closure and postclosure care requirements for the F- and H-Area Tank Farms, which will be implemented under the SRS ER Program in accordance with the FFA.]	TBC
AEA DOE 5820.2A, Chapter I, 2	High-Level Waste Management - All high-level waste generated by DOE operations shall be safely stored, treated, and disposed of according to requirements set forth in this Order. Storage operations shall comply with applicable EPA standards and EPA/State regulations. Geologic disposal shall comply with both NRC regulations and EPA standards.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. This section would be applicable only to those waste residues considered to be high-level waste.	A
AEA DOE 5820.2A, Chapter III, 2.a	Low-Level Waste Management - DOE LLW operations shall be managed to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure that no legacy requiring remedial action remains after operations have been terminated.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 2.b	Low-Level Waste Management - DOE LLW shall be managed on a systematic basis using the most appropriate combination of waste generation reduction, segregation, treatment, and disposal practices so that the radioactive components are contained and the overall system cost effectiveness is maximized.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 2.c	Low-Level Waste Management - DOE LLW shall be disposed of on the site at which it is generated, if practical, or, if onsite disposal capability is not available, at another DOE disposal facility.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.a(1-2)	Low-Level Waste Management - DOE LLW that has not been disposed of prior to issuance of this Order shall be managed on the schedule developed in the Implementation Plan to protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders and to assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, groundwater, soil, plants and animals result in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.a(3-4)	Low-Level Waste Management - DOE LLW that has not been disposed of prior to issuance of this Order shall be managed on the schedule developed in the Implementation Plan to assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure. LLW shall also be managed to protect groundwater resources, consistent with Federal, state and local requirements.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(1)	Low-Level Waste Management - LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in paragraph 3a, consistent with the disposal site radiological performance assessment in paragraph 3b.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.i(2)	Low-Level Waste Management - Engineered modifications (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the performance assessment model. In the course of this process, site-specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(4)	Low-Level Waste Management - Disposition of waste designated as greater-than-class C (GTCC), as defined in 10 CFR 61.55, must be handled as special cases. Disposal systems for such waste must be justified by a specific performance assessment through the NEPA process and with the concurrence of DP-12 for all DP-1 disposal facilities and of NE-20 for those disposal facilities under the cognizance of NE-1.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.i(5)(a-c)	Low-Level Waste Management - The following disposal requirements are intended either to improve stability of the disposal site or to facilitate handling and provide protection of the health and safety of personnel at the disposal site. Waste must not be packaged for disposal in cardboard or fiberboard boxes, unless such boxes meet U.S. Department of Transportation (DOT) requirements and contain stabilized waste with a minimum of void space. For all types of containers, void spaces within the waste and between the waste and its packaging shall be reduced as much as practical. Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container, or 0.5 percent of the volume of the waste processed to a stable form. In addition, waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(5)(d-e)	Low-Level Waste Management - Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged at a pressure that does not exceed 1.5 atmospheres at 20 degrees centigrade.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(5)(f)	Low-Level Waste Management - Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(8)(b)	Low-Level Waste Management - Disposal units shall be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with the NEPA process.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.i(9)(b)	Low-Level Waste Management - Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(9)(d)	Low-Level Waste Management - Waste placement into disposal units should minimize voids between containers.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.j(2)	Low-Level Waste Management - During closure and postclosure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.j(4)	Low-Level Waste Management - Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with RCRA, CERCLA, and SARA, or, if mixed waste is involved, may be included in permit applications for operation of contiguous disposal facilities.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter V, 3.c(2)	Decommissioning of Radioactively Contaminated Facilities - All HLW and stored hazardous materials should be removed by the operator as part of the last operational activities prior to entering the decommissioning phase.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. [Substantive requirement met by compliance with provisions of this closure plan.]	RA
AEA DOE Order 5820.2A, Chapter V, 3.d(1)(d)	Decommissioning of Radioactively Contaminated Facilities - Baseline data for project activities shall include information on factors that could influence the selection of decommissioning alternatives (safe storage, entombment, dismantlement) such as potential future use, long-range site plans required by DOE Order 4300.1B, facility condition, and potential health, safety, and environmental hazards.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. [Substantive requirements met by compliance with provisions of this closure plan.]	RA

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter V, 3.d(2)	Decommissioning of Radioactively Contaminated Facilities - The CERCLA, SARA, and/or RCRA status of each project shall be identified and an RI/FS performed, if required. Based on the results of the RI/FS and any additional data deemed necessary, an appropriate environmental review shall be performed according to the requirements of NEPA, CERCLA, RCRA, and SARA. Candidate decommissioning alternatives shall be identified, assessed, and evaluated, and a preferred alternative selected based on the results of the environmental review.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. [Substantive requirements met by compliance with provisions of this plan, which ensure compliance and consistency with RCRA corrective action and CERCLA remedial action requirements implemented under the FFA.]	RA
AEA DOE 5400.5, Chapter II, 1.a	Dose Limits - Except as provided by II.1a(4), the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem (1 mSv).	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.a(3)(a)	Dose Limits - DOE operators shall make a reasonable effort to be aware of the existence of other than DOE manmade sources of radiation that, combined with the DOE sources, might present a potential for exceeding contributions of 10 mrem (0.1 mSv) effective dose equivalent in a year. Reasonable efforts shall be made to limit dose to members of the public, from multiple sources of radiation, to 100 mrem (1 mSv) EDE, or less, in a year.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.a(4)(a)	Dose Limits - Operations Office may request from EH-1 specific authorization for a temporary public dose limit higher than 100 mrem (1 mSv), but not to exceed 500 mrem (5 mSv), for the year.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.b	Dose Limits - The exposure of members of the public to radioactive materials released to the atmosphere as a consequence of routine DOE activities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem (0.1 mSv).	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter II, 1.c	Dose Limits - The exposure of members of the public to direct radiation or radioactive materials released from DOE management and storage activities at a disposal facility for spent nuclear material or for high-level or transuranic radioactive wastes that are not regulated by the NRC shall not cause members of the public to receive, in a year, a dose equivalent greater than 25 mrem (0.25 mSv) to the whole body or a committed dose equivalent greater than 75 mrem (0.75 mSv) to any organ.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. Requirements would be applicable to any waste associated with HLW tank closure that is considered high-level waste. For waste that is not considered high-level waste, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Applicable if residual waste is determined to be HLW.]	RA
AEA DOE 5400.5, Chapter II, 1.d	Dose Limits - The level of protection provided to the public for drinking water must be equivalent to the drinking water standards of 40 CFR 141. These systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) in a year. Combined radium-226 and radium-228 shall not exceed 5 x 10^{-9} µCi/ml and gross alpha activity (including radium-226 but excluding radon and uranium) shall not exceed 1.5 x 10^{-8} µCi/ml.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.d(3)	Dose Limits - The liquid effluents from DOE activities shall not cause private or public drinking water systems downstream of the facility discharge to exceed the drinking water radiological limits in 40 CFR 141.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 3.a(5)	Dose Limits for Aquatic Organisms - To protect native animal aquatic organisms, the absorbed dose to these organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter II, 5.a	Residual Radioactivity - Release of real property (land and structures) shall be in accordance with the guidelines and requirements for residual radioactive material presented in Chapter IV. These guidelines and requirements apply to both DOE-owned facilities and to private properties that are being prepared by DOE for release. Real properties owned by DOE that are being sold to the public are subject to the requirements of Section 120(h) of CERCLA, as amended, concerning hazardous substances, and to any other applicable Federal, state, and local requirements. The requirements of 40 CFR 192 are applicable to properties remediated by DOE under Title I of the UMTRA.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.a	Residual Radionuclides in Soil - Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2. (1) If the average concentration in any surface or below-surface area less than or equal to 25 m^2 exceeds the limit or guideline by a factor of $(100/A)^{0.5}$, [where A is the area (in square meters) of the region in which the concentrations are elevated] limits for "hot spots" shall also be developed and applied. Procedures for calculating these hot-spot limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclides that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil. (2) The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230 and thorium-232 are: (a) 5 pCi/g, averaged over the first 15 cm of soil below the surface (b) 15 pCi/g, averaged over 15-cm thick layers of soil more than 15 cm below the surface	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.b	Airborne Radon Decay Products - Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. [A working level (WL) is any combination of short-lived radon decay products in 1 L of air that will result in the ultimate emission of 1.3 x 10^5 MeV of potential alpha energy.] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required to comply with this guideline when there is reasonable assurance that residual radioactive material is not the source of the radon concentration.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 4.c	Residual Radioactivity - The average level of gamma radiation inside a building or habitable structure on a site to be released without restrictions shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an "appropriate-use" scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic limit and the ALARA process, considering appropriate-use scenarios for the area.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.d	Residual Radioactivity - The generic surface contamination guidelines provided in Figure IV-1 are applicable to existing structures and equipment. These limits apply to both interior equipment and building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in paragraph IV.6a are applicable to the resulting contamination in the ground.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 5.a	Residual Radioactivity - The authorized limits for each property shall be set equal to the generic or derived guidelines unless it can be established, on the basis of specific property data (including health, safety, practical, programmatic, and socioeconomic considerations), that the guidelines are not appropriate for use at the specific property. The authorized limits shall be established to (1) provide that, at a minimum, the basic dose limits in paragraph IV.3 will not be exceeded under the "worst-case" or "plausible-use" scenarios, consistent with the procedures and guidance provided in DOE/CH-8901, or (2) be consistent with applicable generic guidelines. The authorized limits shall be consistent with limits and guidelines established by other applicable Federal and state laws. The authorized limits are developed through the project offices in the field and are approved by the Headquarters Program Office.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 5.b	Residual Radioactivity - Remedial action shall not be considered complete until the residual radioactive material levels comply with the authorized limits, except as authorized pursuant to paragraph IV.7 for special situations where the supplemental limits and exceptions should be considered and it is demonstrated that it is not appropriate to decontaminate the area to the authorized limit or guideline value.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.b(1)	Residual Radioactivity - Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(2)	Residual Radioactivity - Controls shall be designed such that Rn-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels, will not exceed: (a) 100 pCi/L at any given point; (b) an annual average concentration of 30 pCi/L over the facility site; (c) an annual average concentration of 3 pCi/L at or above any location outside the facility site; and (d) flux rates from the storage of radon producing wastes shall not exceed 20 pCi/(m^2sec), as required by 40 CFR 61.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(3)	Residual Radioactivity - Controls shall be designed such that concentrations of radionuclides in the groundwater and quantities of residual radioactive material will not exceed applicable Federal or state standards.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(4)	Residual Radioactivity - Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR 192. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.c	Interim Management - A property may be maintained under an interim management arrangement when the residual radioactive material exceeds the guideline values if the residual radioactive material is in accessible locations and would be unreasonably costly to remove; provided that administrative controls are established by the responsible authority (Federal, state, or local) to protect members of the public and that such controls are approved by the appropriate Program Assistant Secretary or Director. The administrative controls include but are not limited to: periodic monitoring as appropriate; appropriate shielding; physical barriers to prevent access; and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate. The owner of the property should be responsible for implementing the administrative controls and cognizant Federal, state, and local authorities should be responsible for enforcing them.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.d(1)	Residual Radioactivity - For uranium, thorium, and their decay products: (a) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years. (b) Control and stabilization features shall be designed to limit Rn-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 pCi/(m^2sec) and prevent increases in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates shall be in accordance with the requirements of 40 CFR Part 61. (c) Before any potentially biodegradable contaminated wastes are placed in a long-term management facility, such wastes shall be properly conditioned so that the generation and escape of biogenic gases will not cause the requirement in paragraph IV.6d(1)(b) to be exceeded and that biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph IV.6d(1)(a). (d) Groundwater shall be protected in accordance with legally applicable Federal and state standards. (e) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These controls should be designed to be effective to the extent reasonable for at least 200 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-2. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 7	Residual Radioactivity - If specific property circumstances indicate that the guideline or authorized limits established for a given property are not appropriate for any portion of that property, supplemental limits or an exception may be requested. Any supplemental limits shall achieve the basic dose limits set forth in Chapter II of this Order for both current and potential unrestricted uses of a property. Exceptions to the authorized limits defined for a property may be applied to any portion of the property when it is established that the authorized limits cannot reasonably be achieved and that restrictions on use of the property are necessary. It shall be demonstrated that the exception is justified and that the restrictions will protect members of the public within the basic dose limits of this Order.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

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a. Entry shown in brackets provides rationale for including/excluding guidance in the Relevant and Appropriate and To-be-Considered Materials categories from the consolidated table. In general, such guidance is included in the consolidated table (Table C-3) in cases where it is more stringent than a requirement in the Applicable category, and excluded from the consolidated table in cases where it is less stringent than a requirement in the Applicable category or where compliance is met by adherence to general provisions of the Closure Plan.

b. Categories are defined as follows:
- A = Applicable (substantive Federal and state environmental protection requirements, criteria, or limits that directly apply to SRS high-level waste tank system closure operations.)
- RA = Relevant and Appropriate (substantive Federal and state environmental protection requirements, criteria, or limits that, while not directly applicable, are judged to be well suited for use for SRS high-level waste tank system closure operations based on their applicability to similar operations.)
- TBC = To-be-Considered Materials (advisories, guidance, proposed rules and the like issued by Federal or State government that are not legally binding, but that are judged to be useful in establishing environmental protection protocols and performance objectives or in evaluating closure options with respect to protectiveness of human health and the environment.)

Table C-3. Consolidated potential requirements and guidance detail for SRS high-level waste tank system closure.

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SCPCA R.61-82, Section IV	Proper Closeout of Waste Treatment Facilities Not Defined As Lagoons or Package Plants - Waste treatment units shall be closed out in accordance with guidelines issued by SCDHEC on an individual basis. These guidelines shall be designed to prevent health hazards and to promote safety in and around the abandoned sites.	Applicable to SRS HLW tanks that are permitted by SCDHEC as industrial wastewater treatment facilities (FFA, Section IX.E.4). Made applicable to all SRS HLW tanks except Tank 16 by DOE's commitment in its November 9, 1993, Waste Removal Plan and Schedule (FFA, Section IX.E.1,2). Applicability extended to all SRS HLW tank systems pursuant to discussions with SCDHEC and EPA.	A
CWA R.61-68.E(7)	Water Quality Criteria to Protect Aquatic Life - Numeric criteria for all class surface waters are adopted for toxic pollutants for which the EPA has published national criteria to protect aquatic life pursuant to Section 304(a) for the Federal CWA and for ammonia and chlorine. No numeric criteria are listed in this regulation; however, the national numeric criteria developed and published by EPA are hereby adopted by reference. Compounds with national criteria to protect aquatic life listed in this regulation include: Arsenic Cadmium Chromium (+3 and +6) Copper Lead Mercury Nickel Selenium (+4) Silver Zinc [Additional standards are included for pesticides and PCBs.]	Generally applicable standards for maintaining quality of surface water.	A
CWA NPDES Permit Limitations and Rationale Guidance	Water Quality Criteria - SCDHEC guidance (spreadsheet) that identifies ambient water quality criteria (concentration limits for individual constituents) for purposes of deriving NPDES permit limits.	SCDHEC guidance to be considered in the identification of appropriate ambient water quality criteria for protection of aquatic life and human health.	TBC

Table C-3. (Continued).

Citation	Requirement/Guidance Summary		Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA R.61-68.E(8)(b)	Water Quality Standards to Protect Human Health - State ambient water quality standards to protect human health are listed in Appendix 2 of this regulation. These standards will be applicable to surface waters at average annual flow conditions or at average tidal dilution conditions, whichever is appropriate. The substances and their standards (µg/l) are:		Generally applicable standards for maintaining quality of surface water.	A
	Antimony	4,308		
	Arsenic	1.4		
	Beryllium	1.17		
	Cadmium	5		
	Chromium (+3)	673,077		
	Chromium (+6)	50		
	Lead	50		
	Mercury	0.153		
	Nickel	4,584		
	Selenium	10		
	Silver	50		
	Thallium	48		
	[Addition standards are included for cyanide, asbestos, and organics.]			

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA R.61-68.E(8)(e)	Water Quality Standards to Protect Human Health - A list of water quality standards based organoleptic data (prevention of undesirable taste and odor) are adopted herein. For those substances that have both human health standards and organoleptic standards, the more stringent of the two will be used for the purpose of derivation of effluent limits. The substances and their standards (μg/l) are: Copper 1000 Zinc 5000 Chlorobenzene 20 2-chlorophenol 0.1 2,4-dichlorophenol 0.3 2,4-dimethylphenol 400 3-methyl-4-chlorophenol 3000 Pentachlorophenol 30 Phenol 300 Acenaphthene 20 Hexachlorocyclopentadiene 1	Generally applicable standards for maintaining quality of surface water.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CWA R.61-68.G(3)(c)	Class Descriptions and Specific Standards for Surface Waters - Freshwaters shall meet standards for toxic pollutants listed in Section 307 of the Federal CWA and for which EPA has developed national criteria for ammonia and chlorine. Standards for these substances are prescribed in Sections E(7) and E(8) of this regulation. [The surface waters potentially affected by HLW tank closure activities, Fourmile Branch and Upper Three Runs, are classified as "freshwaters" under R.61-68.G.]	Generally applicable standards for maintaining quality of surface water.	A
CWA R.61-68.H	Class Descriptions and Specific Standards for Ground Waters - All South Carolina groundwater is classified GB effective June 28, 1995. Quality standards for Class GB groundwaters are: • Inorganic chemicals shall meet standards set forth in the State Primary Drinking Water Regulations, R.61-58.5.B(2). • Organic chemicals shall meet standards set forth in the State Primary Drinking Water Regulations, R.61-58.5.D(2). • Man-made radionuclides shall not exceed concentrations or amounts such as to interfere with use, actual or intended, as determined by the Department. [This standard also includes primary pollutant VOCs, pesticides, herbicides, PCBs, synthetic organic compounds, and various wastes.]	Generally applicable standards for maintaining quality of groundwater.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.15 (Subpart B) R.61-58.5(J)(2)	Maximum Contaminant Levels - The following are the maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity: (a) Combined radium-226 and radium-228 - 5 pCi/L. (b) Gross alpha particle activity (including radium-226 but excluding radon and uranium) - 15 pCi/L.	EPA regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A
SDWA 40 CFR 141.16(a) (Subpart B) R.61-58.5(L)(2)(a)	Maximum Contaminant Levels - The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr.	EPA regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.16(b) (Subpart B) R.61.58.5(L)(2)(b)	Maximum Contaminant Levels - Except for the radionuclides listed in Table A, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalents shall be calculated on the basis of a 2 liter per day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," NBS Handbook 69 as amended August 1963, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or any organ shall not exceed 4 mrem/yr. Table A - Average Annual Concentrations Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr Radionuclide — Critical Organ — pCi per liter Tritium — Total body — 20,000 Strontium-90 — Bone marrow — 8	EPA regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Invoked by DOE Order 5400.5, Chapter II, 1.d as applicable.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.51 (Subpart F)	Maximum Contaminant Levels Goals - The MCLGs for inorganic constituents are: Contaminant — Milligrams per liter Antimony — 0.006 Barium — 2 Beryllium — 0.004 Cadmium — 0.005 Chromium — 0.1 Copper — 1.3 Fluoride — 4 Lead — zero[1] Mercury — 0.002 Nitrate — 10 (as N) Nitrite — 1 (as N) Total nitrate & nitrite — 10 (as N) Selenium — 0.05 Thallium — 0.0005 [1] action level for lead is 0.015 mg/l	EPA regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. [Provides relevant and appropriate groundwater quality standards for copper and lead.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary		Rationale for Use[a]	Requirements/ Guidance Category[b]
SDWA 40 CFR 141.62(b) (Subpart G) R.61-58.5(B)(2)	Maximum Contaminant Levels - The MCLs for inorganic constituents are:		EPA regulation and corresponding SC regulation that is applicable to operators of public drinking water systems. These limits have been applied to groundwater beneath and adjacent to projects similar to the HLW tank closure and are well suited for use as indicators of groundwater protection. Made applicable by R.61-68.H.	A
	Contaminant	Milligrams per liter		
	Fluoride	4.0		
	Arsenic	0.05		
	Barium	2.0		
	Cadmium	0.005		
	Chromium	0.1		
	Mercury	0.002		
	Nitrate	10 (as N)		
	Nitrite	1 (as N)		
	Total nitrate & nitrite	10 (as N)		
	Selenium	0.05		
	Antimony	0.006		
	Beryllium	0.004		
	Cyanide (as free cyanide)	0.2		
	Nickel	0.1[1]		
	Thallium	0.002		
	[1] nickel standard is in R.61-58.5(B)(2) only			
	[Standard also includes asbestos fiber limit.]			

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA SRS FFA WSRC-05-94-42 - DOE, EPA & SCDHEC, 8/16/93	The agreement directs the comprehensive remediation of SRS and also delineates the relationship between its requirements and the requirements for corrective measures being conducted under RCRA Section 3004 (u) and (v) according to the conditions of the Federal and state RCRA permit. Section IX - High-Level Radioactive Waste Tank System(s) Section IX.E.1 - DOE has submitted a waste removal plan and schedule for the waste tank system. DOE shall remove the tanks from service according to the approved plan(s) and schedule(s). Waste tanks deemed unsuitable by SCDHEC shall not receive additional waste prior to schedule approval for such receipt and only if waste receipt is approved as part of the plan associated with such schedule. Section IX.E.2 - The DOE waste tank system(s) removal plan(s) shall provide for the removal or decontamination of all residues, contaminated containment systems components (liners, etc.), contaminated soils and structures and equipment contaminated with hazardous and/or radioactive substances. If DOE demonstrates that it cannot practicably remove or decontaminate soils or structures and equipment, then DOE shall conduct all necessary response actions under Section XI through XVI of this agreement for those waste tank system(s). Section IX.E.3 - DOE will submit to EPA and DHEC an annual report on the status of the tanks being removed form service under Subsection E.1. Section IX.E.4 - For waste tank system(s) that DOE decides to remove from service that have been issued an industrial wastewater permit under the SC Pollution Control Act (SCPCA), DOE shall remove such waste tank system(s) from service in accordance with the SCPCA and all applicable regulations promulgated pursuant to the SCPCA. For any waste tank systems(s) for which closure or removal from service is or has been conducted under the SCPCA, DOE shall conduct a site evaluation in accordance with Section X of the FFA.	Standards for SRS HLW tank systems set forth in Section IX and Appendix B of the FFA apply to tank operations, including closure activities. Section XXIII "Permits" and Section XXIV "Creation of Danger" are applicable to activities undertaken pursuant to the FFA, including HLW tank closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA Waste Removal Plan and Schedule for the HLW Tank Farms, WSRC-RP-93-1477, Rev. 0, 11/9/93	Waste removal plan and schedule for the HLW tank system(s) and/or component(s) that do not meet secondary containment standards or that leak or have leaked as required by Section IX.E of the SRS FFA. III. HLW Facility Descriptions and Operating Plans - Tank Farm Waste Tanks & Waste Removal Operations: (1) Type III tanks will be reused while the Type I, II, and IV tanks will be removed from service. (2) The tanks to be removed will undergo a water washing operation in the primary vessel and an annulus cleaning if waste is present in the annulus. (3) Salt will be removed from the new style tanks first, and these tanks will be reused to support Tank Farm evaporator operations and processing of DWPF recycle. (4) The first sludge tanks to be emptied will be old-style tanks, which will be removed from service. Operating Plans: Each waste tank will be fitted with special waste removal equipment. (1) Tanks containing sludge will have four slurry pumps and one transfer pump installed to suspend the settled sludge into a pumpable slurry for transfer to ESP. (2) Tanks containing salt will have three slurry pumps and one transfer jet installed to dissolve the salt and transfer it to ITP. IV. Assumptions - Waste Removal: (1) Each tank's waste removal schedule is based upon a typical construction-through-startup authorization task duration of 22-30 months. (2) As waste removal and water washing/annulus cleaning operations are completed for each old-style tank, that tank will be transitioned to SRS's Environmental Restoration Division for decommissioning and closure in accordance with applicable permits and other regulatory requirements.	Applicable to the removal of SRS HLW tanks from service in accordance with Section IX.E.1 of the FFA. To the extent that the proposed closure activities differ from those described in the Waste Removal Plan and Schedule, modifications to the plan may be required.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CERCLA Waste Removal Plan and Schedule for the HLW Tank Farms, WSRC-RP-93-1477, Rev. 0, 11/9/93 (cont.)	VI. Waste Removal Description/Definition: For the purposes of this plan, "removal from service" is defined as: (1) As much high level waste (salt, sludge and/or supernate) as practical is removed from the tank primaries and any annulus that had received waste via mechanical agitation (slurry pumps and eductor jets). (2) All tanks primaries and any annulus that received waste will be washed with inhibited water and as much waste as practical removed via installed systems (eductor jets and pumps). (1) Upon further evaluation, it may be decided that an additional chemical cleaning step may occur on some tanks as necessary. (2) A closure plan will be developed per SC Regulation R.61-82, Proper Closeout of Wastewater Treatment Facilities and submitted to DHEC for review and approval. (3) Upon approval, it is anticipated that the tank system/component will be turned over to the RCRA/CERCLA Program for decommissioning. (4) It may also be necessary to maintain a heel of inhibited water in some of the tanks to prevent structural damage to the tank bottom caused by upward groundwater pressure.		
CAA 40 CFR 61.92 (NESHAP)	Standard - Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	EPA regulation that is applicable to all SRS operations, including HLW tank closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
CAA SC R.61-62.5 Air Pollution Control Standard No. 2	Ambient Air Quality Standard - The following table constitutes the ambient air quality standards for the State of South Carolina. The analytical methods to be used will be those applicable Federal Reference Methods published in 40 CFR 50, Appendices A-H as revised July 1, 1986. In the case of fluorides either the double paper tape sampler methods (ASTM D-3266-79) or the sodium bicarbonate-coated glass tube and particulate filter method (ASTM D3268-78) may be used.	SC standards that implement national primary and secondary ambient air quality standards. Standards are applicable to all SRS operations, including HLW tank closure, and provide standards for evaluation of criteria pollutant emissions and impacts.	A

Pollutant	Measuring Interval	Standard (µg/m^3 unless noted otherwise) (1)(2)
Sulfur dioxide	3 hour	1,300(4)
	24 hours	365(4)
	annual	80
Total suspended Particulates	Annual geometric mean	75
PM_{10}	24 hours	150(3)
	annual	50(3)
Carbon monoxide	1 hour	40 mg/m^3
	8 hour	10 mg/m^3
Ozone	1 hour	0.12 ppm (3)
Gaseous fluorides (as HF)	12 hr. avg.	3.7
	24 hr. avg.	2.9
	1 wk. avg.	1.6
	1 mo. avg.	0.8
Nitrogen dioxide	annual	100

Table C-3. (Continued).

Citation	Requirement/Guidance Summary			Rationale for Use[a]	Requirements/ Guidance Category[b]
CAA SC R.61-62.5 Air Pollution Control Standard No. 2 (cont.)	Lead	Calendar quarterly mean	1.5		

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(1) Arithmetic average except in case of total suspended particulate matter.

(2) At 25°C and 760 mm Hg.

(3) Attainment determinations will be made based on the criteria contained in Appendixes H and K, 40 CFR 50, July 1, 1987.

(4) Not to be exceeded more than once a year.

Table C-3. (Continued).

<table>
<tr><th>Citation</th><th>Requirement/Guidance Summary</th><th>Rationale for Use[a]</th><th>Requirements/ Guidance Category[b]</th></tr>
<tr><td>CAA
SC R.61-62.5
Air Pollution Control Standard No. 8, Toxic Air Pollutants</td><td>II. Toxic Air Emissions - B. The allowable ambient air concentrations of a toxic air pollutant at the plant property line as determined by modeling under Part A shall be limited to the value listed in the following table in this section, which include:
<table>
<tr><th>Chemical Name</th><th>CAS No.</th><th>Maximum Allowable Concentration (μg/m³)[a]</th></tr>
<tr><td>Category I: Low Toxicity</td><td></td><td></td></tr>
<tr><td>None</td><td></td><td></td></tr>
<tr><td>Category II: Moderate Toxicity</td><td></td><td></td></tr>
<tr><td>Oxalic acid</td><td>144627</td><td>10.00</td></tr>
<tr><td>Category III: High Toxicity</td><td></td><td></td></tr>
<tr><td>Benzene</td><td>71423</td><td>150.00</td></tr>
<tr><td>Chromium(+6) compounds</td><td>None</td><td>2.50</td></tr>
<tr><td>Manganese compounds</td><td>None</td><td>25.00</td></tr>
<tr><td>Mercury</td><td>7439976</td><td>0.25</td></tr>
<tr><td>Nickel</td><td>7440020</td><td>0.50</td></tr>
<tr><td>Selenium compounds</td><td>None</td><td>1.00</td></tr>
</table>
a. For the purpose of this standard, these values shall be rounded to the nearest hundredth of a μg/m³. For example, a test or modeled value of 0.005 through 0.01 would be rounded to 0.01 but values less than 0.005 would be rounded to 0.00.
[Note: See SC R.61-62.5 for complete list of pollutants and corresponding standards.]</td><td>SC standards that implement Federal air toxic control program requirements. Standards are applicable to all SRS operations, including HLW tank closure and provide standards for evaluation of toxic pollutant emissions and impact.</td><td>A</td></tr>
</table>

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
National Environmental Policy Act 42 U.S.C. 4321 et seq.), 10 CFR 1021	Requirements of NEPA to evaluate SRS HLW tank closure options would be fulfilled in accordance with DOE implementing regulations (10 CFR 1021). NEPA evaluation will address impacts, including occupational exposure to site personnel, associated with various closure alternatives.	Environmental assessment requirements of NEPA are applicable to all SRS operations, including HLW tank closure.	A
Endangered Species Act of 1973 (16 U.S.C. 1531 et seq); 50 CFR 402 and related statutes (Anadromous Fish Conservation Act, Bald Eagle Protection Act, South Carolina Nongame and Endangered Species Conservation Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act)	Prohibits Federally authorized actions that probably would jeopardize the existence of any threatened or endangered or otherwise protected species or result in the destruction or adverse modification of critical habitat.	Applicable if threatened or endangered or otherwise protected species or habitats exist on or near the site, or could be affected by the proposed action.	A
National Historic Preservation Act, 16 U.S.C. 470 et seq. and related legislation (e.g., Antiquities Act, Historic Sites Act, Archeological and Historic Preservation Act, Archaeological Resources Protection Act, American Indian Religious Freedom Act).	Impact potential on cultural resources for HLW tank closure options, if any, would be formally evaluated in the context of NEPA.	Requirements to evaluate potential impact to cultural resources is applicable to all SRS projects.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 262 R.61-79.262	Standards Applicable to Generators of Hazardous Waste - Generators of hazardous waste are required to do the following: • Determine if the waste is hazardous waste and; identify requirements for management of hazardous waste as set forth in Parts 264, 265, and 268; and obtain an EPA identification number (Subpart A) • Comply with manifest requirements for transport of hazardous waste offsite (Subpart B) • Comply with pre-transport requirements for hazardous waste packaging, labeling, marking, placarding, and accumulation; comply with storage facility requirements of Parts 264, 265, and 270 if hazardous waste is stored for more than 90 days (Subpart C) • Comply with recordkeeping and reporting requirements for hazardous waste generation, offsite transport, treatment, storage, and disposal (Subpart D)	Applicable to any hazardous waste generated as a result of SRS HLW tank closure activities. Hazardous wastes that are managed in wastewater treatment units (e.g., wastes transferred to other HLW tank systems) may be excluded from RCRA permitting and operating standards.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 264.101 (Subpart F) R.61-79.264.101 (Subpart F)	Corrective Action for Solid Waste Management Units - An owner/operator seeking a permit for the treatment, storage, or disposal of hazardous waste must institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit at the facility, regardless of the time at which the waste was placed in such unit. Corrective action will be specified in the permit application in accordance with this section and subpart S. The owner/operator must implement corrective action beyond the facility property boundary, where necessary to protect human health and the environment, unless he demonstrates that he was unable to obtain the necessary permission to undertake such actions. This section also sets forth standards for monitoring well installation.	Applicable to the HLW tanks since the F- and H-Area Tanks Farms are identified on the site evaluation list (Appendix G) of the FFA. Compliance with the requirements of the FFA, including the schedules and commitments therein, will constitute compliance with the corrective action requirements at solid waste management units (SWMUs) and areas of concern (AOCs) set forth in Module IV "Corrective Action" of the SRS RCRA permit. Compliance with provisions of this closure plan and regulatory approval of individual HLW tank system closure plan modules ensures that closure activities to be conducted under this plan will be consistent with RCRA requirements for corrective action for SWMUs with respect to the F and H-Area tank farms, which will be implemented under the SRS ER Program in accordance with the FFA.	A
RCRA 40 CFR 268 R.61-79.268	Land Disposal Restrictions - Specifies standards to which hazardous waste must be treated prior to land disposal and prohibits storage of untreated hazardous waste except under specified conditions. Subpart D sets forth the treatment standards and Subpart E identifies prohibitions on storage applicable to restricted wastes.	LDR applicable to land disposal of hazardous wastes: • Removed from HLW tanks as part of tank closure activities • Generated as a result of tank closure activities	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 268.40 (Subpart D) R.61-79.268.40 (Subpart D)	Applicability of Treatment Standards - A waste identified in the table "Treatment Standards for Hazardous Wastes" in this section may be land disposed only if it meets the requirements found in the table. For each waste, the table identifies one of three types of treatment requirements: (1) all hazardous constituents in the waste or in the treatment residues must be at or below the levels found in the table ("total waste standards"); (2) the hazardous constituents in the extract of the wastes or the treatment residue must be at or below the levels found in the table ("waste extract standards"); or (3) the waste must be treated using the technology specified in the table ("technology standard"). These standards are established for two types of waste: "wastewaters," which are generally wastes containing less than 1percent by weight TOC and less than 1percent by weight TSS and "nonwastewaters" (Sections 268.2(d) and (f)). The table includes entries specific to certain mixed wastes: "Radioactive high level wastes generated during the reprocessing of fuel rods" (nonwastewaters only) that are D002 or D004-D011 hazardous wastes are subject to the HLVIT standard. "Radioactive lead solids" (nonwastewaters only) that are D008 hazardous wastes are subject to the MACRO standard. "Elemental mercury contaminated with radioactive materials" (nonwastewaters only) that are D009 hazardous wastes are subject to the AMLGM standard.	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
	In the Third Third rule, EPA indicated that the HLVIT standard would apply to the "high-level fraction of the mixed waste generated during the reprocessing of fuel rods" exhibiting the characteristics of corrosivity and toxicity for metals (see 55 FR 22627). Incidental wastes associated with HLW tank closure that are also mixed wastes would not require treatment by vitrification, but might nevertheless require treatment in accordance with the applicable LDR treatment standards for any hazardous characteristics, including standards for any underlying hazardous constituents. In addition to a specified technology or waste-specific concentration standard, wastes might also be subject to LDR treatment standards for underlying hazardous constituents set forth in Section 268.48. For example, a corrosive characteristic waste (D002) would need to be deactivated (i.e., rendered no longer corrosive) and treated to achieve the UTS concentration limits for any underlying hazardous constituents.		
RCRA 40 CFR 268.45 R.61-79.268.45	Treatment Standards for Hazardous Debris - Hazardous debris may be treated in accordance with the waste-specific standards or, alternatively, in accordance with the standards set forth in Table 1 of this section. The alternative standards for hazardous debris include extraction, destruction, and immobilization technologies. Debris that is treated using one of the specified extraction or destruction technologies, and that does not exhibit a hazardous waste characteristic, is no longer subject to regulation as hazardous waste. Debris that is treated using one of the specified immobilization technologies may be excluded (e.g., debris that, after immobilization, no longer exhibits the characteristic for which the debris was hazardous waste).	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
RCRA 40 CFR 268.48 R.61-79.268.48	Universal Treatment Standards - Table UTS in this section identifies the hazardous constituents and their nonwastewater and wastewater treatment standard levels. For determining compliance with the treatment standards for underlying hazardous constituents as defined in Section 268.2(i), these constituent-specific treatment standards may not be exceeded.	Applicable to land disposal of hazardous wastes that occurs as a result of HLW tank closure activities.	A
RCRA 40 CFR 268.50 (Subpart E) R.61-79.268.50 (Subpart E)	Prohibitions on storage of restricted wastes - Storage of hazardous wastes restricted from land disposal is prohibited unless such storage is in tanks, containers, or containment buildings solely for the purpose of accumulating such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal.	Applicable to management of hazardous wastes generated as a result of SRS HLW tank closure activities.	A
AEA Regulation 61-63, RHA 7.18	Protection of the General Population from Releases of Radioactivity - Concentration of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plant, or animals shall not result in an annual dose exceeding an equivalent of 25 millirem (0.25 mSv) to the whole body, 75 millirem (0.75 mSv) to the thyroid, and 25 millirem (0.25 mSv) to any other organ or any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluent to the general environment as low as is reasonably achievable.	SC state regulations that, while not directly applicable to HLW tank closure, are relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.a establishes a public dose limit of 100 mrem/yr. More stringent requirement for public dose limit of 25 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 191.3(b)	Dose Limits - Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities for the disposal of such fuel or waste that are operated by the Department of Energy and that are not regulated by the Nuclear Regulatory Commission or Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 mrem to the whole body and 75 mrem to any critical organ.	[Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.c, which stipulates a dose equivalent not to exceed 25 mrem/yr to the whole body or a committed dose equivalent not to exceed 75 mrem/yr to any organ. More stringent requirements for dose equivalent not to exceed 75 mrem/yr to the thyroid and 25 mrem/yr to any other organ will be evaluated to determine impact, if any, on remedial goals.]	RA
AEA 40 CFR 191.13(a)	Containment Requirements - Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).	EPA regulations that would be applicable to any waste associated with HLW tank closure that is considered high-level waste. For waste that is not considered high-level waste, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [More specific requirements regarding quantities of radionuclides that may be released will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 191.15	Dose Limits - (a) Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that, for 10,000 years after disposal, undisturbed performance of the disposal system shall not cause the annual committed effective dose, received through all potential pathways from the disposal system, to any member of the public in the accessible environment, to exceed 15 mrem. (b) Annual committed effective dose shall be calculated in accordance with Appendix B of this part.	[Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.c stipulates releases to the environment should result in a dose equivalent that does not exceed 25 mrem/yr to the whole body or a committed dose equivalent of 75 mrem/yr to any organ. More specific requirements for a committed effective dose not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	RA
AEA 10 CFR 61.40 (Subpart C)	Performance Objectives - Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within limits established in the performance objectives in §§61.41 through 61.44.	NRC regulations that, while not directly applicable to HLW tank closure, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Requirements met by compliance with applicable requirements of DOE Orders 5400.5 and 5820.2A with specific exceptions as noted below.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 61.41 (Subpart C)	Protection of the general population from releases of radioactivity - Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual effective dose exceeding an equivalent of : 25 mrem whole body 75 mrem thyroid 25 mrem any other organ Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.	[Comparable applicable requirement of DOE Order 5400.5, Chapter II, 1.a establishes a dose limit of 100 mrem/yr. More stringent requirements for dose equivalent not to exceed 25 mrem/yr whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other organ will be evaluated to determine impact, if any, on remedial goals.]	RA
AEA 10 CFR 61.43 (Subpart C)	Protection of individuals during operations - Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as reasonably achievable.	[Comparable applicable requirement of DOE Order 5820.2A, Chapter III, 3.a establishes performance objectives for low-level waste disposal. More specific requirements in the referenced regulations (10 CFR 20, 10 CFR 61.41) are evaluated to determine impact, if any, on remedial goals.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 193.13(a) (Proposed)	Standards for Disposal - Disposal systems for low-level radioactive waste shall be designed to provide a reasonable expectation that [*OPTION 1. "within 1,000 years of disposal, no member of the public shall receive,"*] or [*OPTION 2. "the highest projected dose following disposal and received through all pathways from the disposal system will not exceed,"*] or [*OPTION 3. "no member of the public shall receive, through all pathways from the disposal system, during a period following disposal as determined by the implementing agency,"*:] an annual committed effective dose of more than 150 microsieverts (15 mrem).	Proposed EPA regulation that, when promulgated, will be applicable to activities involving disposal of low-level radioactive waste. While not directly applicable to HLW tank closure, these requirements would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Comparable applicable requirement of DOE Order 5820.2A, Chapter III, 3.a(2) stipulates releases to the environment should result in an effective dose equivalent that does not exceed 25 mrem/yr. More specific requirement for a committed effective dose not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals. The 15 mrem/yr committed effective dose standard is also imposed by 40 CFR 191.15 for a 10,000-year performance period.]	TBC
AEA 10 CFR 834.221(a) (Proposed)	Dose Limits - A DOE activity shall be conducted in a manner such that exposure of members of the public to radiation from radioactive waste: (1) complies with ALARA process requirements; and (2) does not exceed a TEDE of 25 mrem (0.25 mSv) in a year from all exposure pathways and radiation sources, except radon and its daughters.	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [More stringent requirement for TEDE not to exceed 25 mrem/yr will be evaluated to determine impact, if any, on remedial goals. Applicable requirement (DOE Order 5400.5, Chapter II, 1.a) limit is 100 mrem/yr.]	TBC

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.306(e) (Proposed)	Control and Disposition of Residual Radioactive Material - (1) Long-term management of residual radioactive material in residue and waste from a DOE activity shall be in accordance with this section and DOE-approved plans. (2) Long-term management of the residue and waste shall be conducted in a manner that will: (i) comply with dose limits (Sections 834.201, 834.214, and 834.221); (ii) comply with the ALARA requirements of this part (Section 834.104); (iii) comply with the Ground-Water Protection Management Plan (Section 834.215); (iv) limit radon-222 emanation to the atmosphere from radon-222 generating waste to less than an annual average release rate of 20 pCi (0.7 Bq)/(m^2 sec) averaged over the surface area overlying the waste, including the covering or other confinement structures; (v) limit radon-220 emanation to the atmosphere from waste to an annual average release rate of 20 pCi (0.7 Bq)/(m^2 sec), and (vi) limit increases in the annual average radon-222 or radon-220 concentration at or above any location outside the boundary of the controlled area to 0.5 pCi (0.02 Bq)/L. (3) Control and stabilization features shall be designed to: (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years; (ii) minimize unauthorized public access or use that might breach containment of waste; and (iii) provide for proper conditioning or barriers to control the generation and escape of biogenic gases from potentially biodegradable contaminated waste or residue to ensure that this material will not cause the emission limits or dose limits to be exceeded and biodegradation within the facility will not result in premature structural failure. (4) In the development of controls and waste management plans, where appropriate, the impacts of alternative disposal modes shall be evaluated beyond the 1,000-year design requirement, to 10,000 years. (5) For wastes containing a high specific activity (e.g., $\geq$1 nCi/g) of radium or thorium,	Proposed DOE regulation that, when promulgated, will be applicable to SRS HLW tank operations, including closure. (When promulgated, this rule will replace DOE Order 5400.5.) [Requirements met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 10 CFR 834.306(e)(4) constitutes a more stringent requirement for evaluation of alternative disposal modes to 10,000 years.]	TBC

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 834.306(e) (Proposed) (cont.)	Alternative disposal methods, such as deep land disposal, protective covers (e.g., riprap), concrete vaults, or geologic repositories that provide additional protection from possible inadvertent intrusion shall be evaluated and employed if justified by potential risk considerations.		
AEA 10 CFR 20.1301	Dose Limits for Individual Members of the Public - Each licensee shall conduct operations such that: (1) The total effective dose equivalent (TEDE) to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with Section 20.2003; and (2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any 1 hour. If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals. A licensee may apply for prior NRC authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). In addition to the requirements of this part, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR 190 shall comply with those standards. The Commission may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.	NRC regulation that, while not directly applicable to HLW tank closure, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Requirement met by compliance with DOE Order 5400.5, Chapter II, 1.a, except for TEDE not to exceed 2 mrem in any 1 hour. This more stringent requirement will be evaluated to determine impact, if any, on remedial goals.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 10 CFR 20.1404(a) (Proposed)	Radiological Criteria for Unrestricted Release: A site will be considered acceptable for unrestricted use if: (a) the residual radioactivity that is distinguishable from background radiation results in a TEDE to the average member of the critical group that does not exceed 15 mrem (0.15 mSv) per year; and (b) the residual radioactivity has been reduced to levels that are ALARA.	Proposed NRC regulation that, when promulgated, will provide requirements for NRC licensee activities resulting in residual radioactive material, similar to SRS HLW tank closure. [Applicable requirement (DOE Order 5400.5, Chapter IV, 3.a) establishes a dose limit of 100 mrem/yr. More stringent requirements of TEDE not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	TBC
AEA 10 CFR 20.1405(b) (Proposed)	Criteria for License Termination Under Restricted Conditions: A site will be considered acceptable for license termination under restricted conditions if the licensee has made provisions for institutional controls that provide reasonable assurances that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 15 mrem (0.15 mSv) TEDE per year. Institutional controls must be enforceable by a responsible government entity or in a court of law in response to suits by affected parties.	[Applicable requirement (DOE Order 5400.5, Chapter IV, 7) establishes a dose limit of 100 mrem/yr. More stringent requirements of TEDE not to exceed 15 mrem/yr will be evaluated to determine impact, if any, on remedial goals.]	TBC
AEA 40 CFR 196.04(a) (Proposed)	Environmental Standards for Site Remediation - Remediation of sites shall be conducted to provide a reasonable expectation that, for 10,000 years after completion of the remedial action, radionuclide concentrations in excess of natural background levels shall not exceed those amounts that could cause any member of the public to receive, through all potential pathways under a residential land use scenario, an annual committed effective dose of 15 mrem/yr (0.15 mSv/yr).	Proposed EPA regulation that, when promulgated, will be applicable to activities resulting in residual radioactive material, including SRS HLW tank closure. [Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 40 CFR 196.04(a) constitutes a more stringent requirement of 15 mrem/yr dose limit for 10,000 years.]	TBC

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 196.04(c) (Proposed)	Environmental Standards for Site Remediation - In the event that remediation of a site will not meet the conditions of §196.04(a), the implementing agency shall: (1) remediate the site to provide a reasonable expectation that, for 10,000 years after completion of the remedial action, radionuclide concentrations in excess of natural background levels shall not exceed those concentrations that could cause any member of the public to receive, through all potential pathways under the conditions of the selected active control measures, an annual committed effective dose of 15 mrem/yr (0.015 mSv/yr); and (2) remediate the site to provide a reasonable expectation that, for 10,000 years after completion of the remedial action in the absence of active control measures, radionuclide concentrations in excess of natural background levels on the site shall not exceed those amounts that could cause any member of the public to receive, through all potential pathways under the conditions of residential land use, an annual committed effective dose that is less than 75 mrem/yr (0.075 mSv/yr).	[Requirement met by compliance with DOE Order 5400.5, Chapter IV, 6 except that (proposed) 40 CFR 196.04(a) constitutes a more stringent requirement of 15 mrem/yr dose limit for 10,000 years.]	TBC

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA 40 CFR 196.23(c) (Proposed)	Environmental Standards for Groundwater Protection - Compliance with Section 196.23(a) of this subpart will not be required if the implementing agency determines compliance to be technically impracticable from an engineering perspective. In this situation, the implementing agencies shall: (1) select active control measures that ensure members of the public will not be exposed to groundwater that is drinking water, in which the levels of radioactivity exceed the limits specified in 40 CFR 141; (2) select and perform remedial actions that limit to the greatest extent, contamination of groundwater that is not already contaminated, as is reasonable under the circumstances; (3) select and perform remedial actions that restore to the greatest extent, groundwater that is already contaminated, as is reasonable under the circumstances; (4) comply with the public notice and comment requirements of Section 196.03(a) of subpart A; and (5) comply with the periodic verification requirements of Section 196.24 of this subpart.	[More specific requirement for active control measures over groundwater which exceeds levels of radioactivity specified in 40 CFR 141 will be evaluated to determine impact, if any, on remedial goals.]	TBC
AEA DOE 5820.2A, Chapter I, 2	High-Level Waste Management - All high-level waste generated by DOE operations shall be safely stored, treated, and disposed of according to requirements set forth in this Order. Storage operations shall comply with applicable EPA standards and EPA/State regulations. Geologic disposal shall comply with both Nuclear Regulatory Commission regulations and EPA standards.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. This section would only be applicable to those waste residues considered to be high-level waste.	A
AEA DOE 5820.2A, Chapter III, 2.a	Low-Level Waste Management - DOE LLW operations shall be managed to protect the health and safety of the public, preserve the environment of the waste management facilities, and ensure that no legacy requiring remedial action remains after operations have been terminated.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 2.b	Low-Level Waste Management - DOE LLW shall be managed on a systematic basis using the most appropriate combination of waste generation reduction, segregation, treatment, and disposal practices so that the radioactive components are contained and the overall system cost effectiveness is maximized.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 2.c	Low-Level Waste Management - DOE LLW shall be disposed of on the site at which it is generated, if practical, or, if onsite disposal capability is not available, at another DOE disposal facility.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.a(1-2)	Low-Level Waste Management - DOE LLW that has not been disposed of prior to issuance of this Order shall be managed on the schedule developed in the Implementation Plan to protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders, and to assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, groundwater, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable (ALARA).	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.a(3-4)	Low-Level Waste Management - DOE LLW that has not been disposed of prior to issuance of this Order shall be managed on the schedule developed in the Implementation Plan to assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure. LLW shall also be managed to protect groundwater resources, consistent with Federal, state and local requirements.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(1)	Low-Level Waste Management - LLW shall be disposed of by methods appropriate to achieve the performance objectives stated in paragraph 3a, consistent with the disposal site radiological performance assessment in paragraph 3b.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(2)	Low-Level Waste Management - Engineered modifications (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions (fission products, induced radioactivity, uranium, thorium, radium) for each disposal site shall be developed through the performance assessment model. In the course of this process, site specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.i(4)	Low-Level Waste Management - Disposition of waste designated as greater-than-class C (GTCC), as defined in 10 CFR 61.55, must be handled as special cases. Disposal systems for such waste must be justified by a specific performance assessment through the NEPA process and with the concurrence of DP-12 for all DP-1 disposal facilities and of NE-20 for those disposal facilities under the cognizance of NE-1.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(5)(a-c)	Low-Level Waste Management - The following disposal requirements are intended either to improve stability of the disposal site or to facilitate handling and provide protection of the health and safety of personnel at the disposal site. Waste must not be packaged for disposal in cardboard or fiberboard boxes, unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space. For all types of containers, void spaces within the waste and between the waste and its packaging shall be reduced as much as practical. Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container, or 0.5 percent of the volume of the waste processed to a stable form. In addition, waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures or of explosive reaction with water.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(5)(d-e)	Low-Level Waste Management - Waste must not contain, or be capable of generating quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged at a pressure that does not exceed 1.5 atmospheres at 20 degrees centigrade.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5820.2A, Chapter III, 3.i(5)(f)	Low-Level Waste Management - Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(8)(b)	Low-Level Waste Management - Disposal units shall be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with the NEPA process.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(9)(b)	Low-Level Waste Management - Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.i(9)(d)	Low-Level Waste Management - Waste placement into disposal units should minimize voids between containers.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.j(2)	Low-Level Waste Management - During closure and postclosure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5820.2A, Chapter III, 3.j(4)	Low-Level Waste Management - Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with RCRA, CERCLA, and SARA, or, if mixed waste is involved, may be included in permit applications for operation of contiguous disposal facilities.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.a	Dose Limits - Except as provided by II.1a(4), the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem (1 mSv).	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter II, 1.a(3)(a)	Dose Limits - DOE operators shall make a reasonable effort to be aware of the existence of other than DOE manmade sources of radiation which, combined with the DOE sources, might present a potential for exceeding contributions of 10 mrem (0.1 mSv) effective dose equivalent in a year. Reasonable efforts shall be made to limit dose to members of the public, from multiple sources of radiation, to 100 mrem (1 mSv) EDE, or less, in a year.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.a(4)(a)	Dose Limits - Operations Office may request from EH-1 specific authorization for a temporary public dose limit higher than 100 mrem (1 mSv), but not to exceed 500 mrem (5 mSv), for the year.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.b	Dose Limits - The exposure of members of the public to radioactive materials released to the atmosphere as a consequence of routine DOE activities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem (0.1 mSv).	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5 Chapter II, 1.c	Dose Limits - The exposure of members of the public to direct radiation or radioactive materials released from DOE management and storage activities at a disposal facility for spent nuclear material or for high-level or transuranic radioactive wastes that are not regulated by the NRC shall not cause members of the public to receive, in a year, a dose equivalent greater than 25 mrem (0.25 mSv) to the whole body or a committed dose equivalent greater than 75 mrem (0.75 mSv) to any organ.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure. Requirements would be applicable to any waste associated with HLW tank closure that is considered high-level waste. For waste that is not considered high-level waste, these requirements, while not directly applicable, would be relevant and appropriate because they are well suited for use as indicators of protection of human health and the environment. [Applicable if residual waste is determined to be HLW.]	RA

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter II, 1.d	Dose Limits - The level of protection provided to the public for drinking water must be equivalent to the drinking water standards of 40 CFR 141. These systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) in a year. Combined radium-226 and radium-228 shall not exceed 5 x 10^{-9} µCi/ml and gross alpha activity (including radium-226 but excluding radon and uranium) shall not exceed 1.5 x 10^{-8} µCi/ml.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 1.d(3)	Dose Limits - The liquid effluents from DOE activities shall not cause private or public drinking water systems downstream of the facility discharge to exceed the drinking water radiological limits in 40 CFR 141.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 3.a(5)	Dose Limits for Aquatic Organisms - To protect native animal aquatic organisms, the absorbed dose to these organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter II, 5.a	Residual Radioactivity - Release of real property (land and structures) shall be in accordance with the guidelines and requirements for residual radioactive material presented in Chapter IV. These guidelines and requirements apply to both DOE-owned facilities and to private properties that are being prepared by DOE for release. Real properties owned by DOE that are being sold to the public are subject to the requirements of Section 120(h) of CERCLA, as amended, concerning hazardous substances, and to any other applicable Federal, state, and local requirements. The requirements of 40 CFR 192 are applicable to properties remediated by DOE under Title I of the UMTRA.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.a	Residual Radionuclides in Soil - Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2. (1) If the average concentration in any surface or below-surface area less than or equal to 25 m^2 exceeds the limit or guideline by a factor of $(100/A)^{0.5}$ [where A is the area (in square meters) of the region in which the concentrations are elevated], limits for "hot spots" shall also be developed and applied. Procedures for calculating these hot-spot limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclides that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil. (2) The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230 and thorium-232 are: (a) 5 pCi/g, averaged over the first 15 cm of soil below the surface (b) 15 pCi/g, averaged over 15-cm thick layers of soil more than 15 cm below the surface	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.b	Airborne Radon Decay Products - Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. [A working level (WL) is any combination of short-lived radon decay products in 1 L of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required to comply with this guideline when there is reasonable assurance that residual radioactive material is not the source of the radon concentration.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 4.c	Residual Radioactivity - The average level of gamma radiation inside a building or habitable structure on a site to be released without restrictions shall not exceed the background level by more than 20 µR/h and shall comply with the basic dose limit when an "appropriate-use" scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic limit and the ALARA process, considering appropriate-use scenarios for the area.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 4.d	Residual Radioactivity - The generic surface contamination guidelines provided in Figure IV-1 are applicable to existing structures and equipment. These limits apply to both interior equipment and building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in paragraph IV.6a are applicable to the resulting contamination in the ground.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 5.a	Residual Radioactivity - The authorized limits for each property shall be set equal to the generic or derived guidelines unless it can be established, on the basis of specific property data (including health, safety, practical, programmatic and socioeconomic considerations), that the guidelines are not appropriate for use at the specific property. The authorized limits shall be established to (1) provide that, at a minimum, the basic dose limits in paragraph IV.3, will not be exceeded under the "worst-case" or "plausible-use" scenarios, consistent with the procedures and guidance provided in DOE/CH-8901, or (2) be consistent with applicable generic guidelines. The authorized limits shall be consistent with limits and guidelines established by other applicable Federal and state laws. The authorized limits are developed through the project offices in the field and are approved by the Headquarters Program Office.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 5.b	Residual Radioactivity - Remedial action shall not be considered complete until the residual radioactive material levels comply with the authorized limits, except as authorized pursuant to paragraph IV.7 for special situations where the supplemental limits and exceptions should be considered and it is demonstrated that it is not appropriate to decontaminate the area to the authorized limit or guideline value.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.b(1)	Residual Radioactivity - Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(2)	Residual Radioactivity - Controls shall be designed such that Rn-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels, will not exceed: (a) 100 pCi/L at any given point; (b) an annual average concentration of 30 pCi/L over the facility site; and (c) an annual average concentration of 3 pCi/L at or above any location outside the facility site; (d) flux rates from the storage of radon producing wastes shall not exceed 20 pCi/(m^2sec), as required by 40 CFR 61.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(3)	Residual Radioactivity - Controls shall be designed such that concentrations of radionuclides in the groundwater and quantities of residual radioactive material will not exceed applicable Federal or state standards.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A
AEA DOE 5400.5, Chapter IV, 6.b(4)	Residual Radioactivity - Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR 192. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.c	Interim Management - A property may be maintained under an interim management arrangement when the residual radioactive material exceeds the guideline values if the residual radioactive material is in accessible locations and would be unreasonably costly to remove provided that administrative controls are established by the responsible authority (Federal, state, or local) to protect members of the public and that such controls are approved by the appropriate Program Assistant Secretary or Director. The administrative controls include but are not limited to periodic monitoring as appropriate; appropriate shielding; physical barriers to prevent access; and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate. The owner of the property should be responsible for implementing the administrative controls, and cognizant Federal, state, and local authorities should be responsible for enforcing them.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 6.d(1)	Residual Radioactivity - For uranium, thorium, and their decay products: (a) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years. (b) Control and stabilization features shall be designed to limit Rn-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 pCi/(m^2sec) and prevent increases in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates shall be in accordance with the requirements of 40 CFR 61. (c) Before any potentially biodegradable contaminated wastes are placed in a long-term management facility, such wastes shall be properly conditioned so that the generation and escape of biogenic gases will not cause the requirement in paragraph IV.6d(1)(b) to be exceeded and that biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph IV.6d(1)(a). (d) Groundwater shall be protected in accordance with legally applicable Federal and State standards. (e) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR, Part 192. These controls should be designed to be effective to the extent reasonable for at least 200 years.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

Table C-3. (Continued).

Citation	Requirement/Guidance Summary	Rationale for Use[a]	Requirements/ Guidance Category[b]
AEA DOE 5400.5, Chapter IV, 7	Residual Radioactivity - If specific property circumstances indicate that the guideline or authorized limits established for a given property are not appropriate for any portion of that property, supplemental limits or an exception may be requested. Any supplemental limits shall achieve the basic dose limits set forth in Chapter II of this Order for both current and potential unrestricted uses of a property. Exceptions to the authorized limits defined for a property may be applied to any portion of the property when it is established that the authorized limits cannot reasonably be achieved and that restrictions on use of the property are necessary. It shall be demonstrated that the exception is justified and that the restrictions will protect members of the public within the basic dose limits of this Order.	DOE Orders implement AEA requirements pertinent to SRS HLW tank operations, including closure.	A

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a. Entry shown in brackets provides rationale for including/excluding guidance in the Relevant and Appropriate and To-be-Considered Materials categories from this consolidated requirements and guidance table. In general, such guidance is included in the consolidated table in cases where it is more stringent than a requirement in the Applicable category, and excluded from the consolidated table in cases where it is less stringent than a requirement in the Applicable category or where compliance is met by adherence to general provisions of the Closure Plan.

b. Categories are defined as follows:

- A = Applicable (substantive Federal and State environmental protection requirements, criteria, or limits that directly apply to SRS high-level waste tank system closure operations.)
- RA = Relevant and Appropriate (substantive Federal and State environmental protection requirements, criteria, or limits that, while not directly applicable, are judged to be well suited for use for SRS high-level waste tank system closure operations based on their applicability to similar operations.)
- TBC = To-be-Considered Materials (advisories, guidance, proposed rules and the like issued by Federal or State government that are not legally binding, but that are judged to be useful in establishing environmental protection protocols and performance objectives or in evaluating closure options with respect to protectiveness of human health and the environment.)

Table C-4. Nonradiological air quality performance standards applicable to high-level waste tank system closure.

AMBIENT AIR QUALITY STANDARD NO. 2.[a]

Pollutant	Measuring Interval	Standard ($\mu g/m^3$ unless noted otherwise)[b,c]
Sulfur dioxide	3 hours	1300[d]
	24 hours	365[d]
	Annual	80
Total suspended particulates	Annual geometric mean	75
PM_{10}	24 hours	150[e]
	Annual	50[e]
Carbon monoxide	1 hour	40 mg/m^3
	8 hours	10 mg/m^3
Ozone	1 hour	0.12 ppm
Gaseous fluorides (as HF)	12 hour average	3.7
	24 hour average	2.9
	1 week average	1.6
	1 month average	0.8
Nitrogen dioxide	Annual	100
Lead	Calendar quarterly mean	1.5

AMBIENT AIR QUALITY STANDARD NO. 8

Chemical Name[f]	Maximum Allowable Concentration ($\mu g/m^3$)[g]
Category I: Low Toxicity	
Antimony compounds	2.50
Category II: Moderate Toxicity	
Oxalic acid	10.00
Category III: High Toxicity	
Benzene	150.00
Chromium(+6) compounds	2.50
Manganese compounds	25.00
Mercury	0.25
Nickel	0.50
Selenium compounds	1.00

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a. See SC R.61-62.5 for detailed compliance requirements.
b. Arithmetic average except in case of total suspended particulate matter.
c. At 25°C and 760 mm Hg.
d. Not to be exceeded more than once per year.
e. Attainment determinations will be based on the criteria contained in Appendixes H and K, 40 CFR 50, July 1, 1987.
f. See SC R.61-62.5 for complete list of constituents and corresponding standards.
g. For the purpose of this standard, these values are rounded to the nearest hundredth of a $\mu g/m^3$.

Table C-5. Nonradiological groundwater and surface-water performance standards applicable to high-level waste tank system closure.

Constituents of Concerns	Maximum Contaminant Level (40 CFR §141.62) (mg/l)[a]	Maximum Contaminant Level Goal (40 CFR §141.51) (mg/l)[b]	Maximum Contaminant Levels (SC R.61-58.5.B(2)) (mg/l)[c]	Water Quality Criteria for Protection of Human Health (SC R.61-68, Appendix 2) (mg/l)[d,e]	Criteria to Protect Aquatic Life (SC R.61-68, Appendix 1) (mg/l)[d,f]	
					Average	Maximum
Aluminate						
Aluminum					0.087	0.750
Boron						
Calcium						
Carbonate						
Chloride						
Chromium III				637.077	0.120[g]	0.980[g]
Chromium VI				0.050	0.011[g]	0.016[g]
Total chromium	0.1	0.1	0.1		0.011	0.016
Copper		1.3			0.0065[g]	0.0092[g]
Hydroxide						
Fluoride	4.0	4.0	4.0			
Iron					1.000	2.000
Lead		zero[h]		0.050	0.0013	0.034
Lithium						
Magnesium						
Manganese						
Mercury	0.002	0.002	0.002	1.53 x 10^{-4}	1.2 x 10^{-5}[g]	0.0024[g]
Molybdenum						
Nickel			0.1	4.584	0.088[g]	0.790[g]
Nitrate	10 (as N)	10 (as N)	10 (as N)			
Nitrite	1 (as N)	1 (as N)	1 (as N)			
Total nitrate & nitrite	10 (as N)	10 (as N)	10 (as N)			
Oxalate						
Phosphate						
Potassium						
Selenium	0.05	0.05	0.05	0.010	0.0050[g]	0.020[g]
Silicon						
Silver				0.050		0.0012[g]
Sodium						
Sulfate						
Titanium						
Tributylphosphate						
Zirconium						

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a. Safe Drinking Water Act (SDWA) - The MCLs (§141.62) for inorganic contaminants apply to community water systems, nontransient noncommunity water systems, and transient noncommunity water systems.

b. Safe Drinking Water Act (SDWA) - The MCLGs (§141.50) are nonenforceable health goals corresponding to the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and that allows an adequate margin of safety.

c. SC Safe Drinking Water Act (SC SDWA) - The MCLs for inorganic contaminants specified in R.61-58.5.B(2) apply to all public water systems.

Table C-5. (continued).

d. SC Water Classifications and Standards - The water quality standards are applicable to both surface waters and groundwaters unless indicated otherwise (R.61-68.C).
   - With the exception of human health criteria listed in Section E(8), the numeric standards of this regulation are applicable to any flowing waters when the flow rate is equal to or greater than the minimum 7-day average flow rate that occurs with an average frequency of once in 10 years (7Q10). State water quality standards for human health protection will be applicable to surface waters at average annual flow conditions or a average tidal dilution conditions, whichever is appropriate (R.61-68.E(8)).
   - Numeric criteria for all class surface waters are adopted for toxic pollutants for which EPA has published national criteria to protect aquatic life pursuant to Section 304(a) for the Federal CWA and for ammonia and chlorine. No numeric criteria are listed in this regulation; however, the national numeric criteria developed and published by EPA are incorporated by reference. If the State develops site-specific criteria for any substances for which EPA has developed national criteria, the site-specific criteria will supersede the national criteria. If metal concentrations for national criteria are hardness-dependent, the chronic and acute concentrations shall be based on 50 mg/l hardness if the ambient hardness is less than 50 mg/l and based on the actual mixed stream hardness if it is greater than 50 mg/l (R.61-68.E(7)(a)(3)).
   - Freshwater standards for toxic pollutants listed in Section 307 of the Federal CWA and for which EPA has developed national criteria are subject to the standards prescribed in Sections E(7) and E(8) of this regulation (R.61-68.G(3)).
   - It is policy of the Department to maintain the quality of groundwater consistent with its highest potential uses. For this reason, all South Carolina groundwater is classified GB effective on June 28, 1995. Quality standards for inorganic chemicals in Class GB Groundwaters are those set forth in the State Primary Drinking Water Regulations R.61-58.5.B(2) (R.61-68.H(2)).

e. SC Water Classifications and Standards - State water quality standards for human health protection specified in Section 8(a) will be applicable to surface waters at average annual flow conditions or at average tidal dilution conditions, whichever is appropriate (R.61-68.E(8)(b)).

f. Average and maximum values for water quality to protect aquatic life identified in spreadsheet obtained from M. Vickers of SCDHEC.

g. Denotes compounds with national criteria to protect aquatic life identified in R.61-68.E(7).

h. Action level for lead is 0.015 mg/l.

Table C-6. Radiological performance standards applicable to high-level waste tank closure[a].

Agency/Type of Standard	DOE[b]	EPA[c]	NRC[d]	SCDHEC[e]
Standards that Apply to Radiation Site Cleanups	Multiple Pathways			
	100 mrem/yr	15 mrem/yr (residential exposure) or	15 mrem/yr or	
		15 mrem/yr (all pathways under selected active controls) and 75 mrem/yr (residential exposure)	15 mrem/yr (under institutional controls) and 100 mrem/yr (in the absence of those controls)	
	Single Media - Soil			
	"Hot spot" limits developed and applied if the average concentration in any surface or below surface area ≤ 25 m^2 exceeds the limit by a factor of $(100/A)^{0.5}$ where A is area (m^2)			
	5 pCi/g; averaged over the first 15 cm of soil below the surface; and 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface			
	Annual average radon decay product concentration not to exceed 0.02 WL[f] and radon decay product concentration (including background) not to exceed 0.03 WL			
	Single Media - Air			
	10 mrem/yr			
	20 pCi/(m^2-sec) Rn-222 emanation to the atmosphere from wastes; and 0.5 pCi/l increase in annual average concentration at or above any location outside the boundary of the contaminated area			

Table C-6. (Continued).

Agency/Type of Standard	DOE[b]	EPA[c]	NRC[d]	SCDHEC[e]
Standards that Apply to Radiation Site Cleanups (cont.)	Single Media - Groundwater	4 mrem/yr beta particle and photon radioactivity 5 pCi/l combined radium-226 and radium-228 15 pCi/l gross alpha (including radium-226 but excluding radon and uranium) 20,000 pCi/l tritium 8 pCi/l strontium If compliance with the above is impracticable: • Select active controls that preclude exposure to groundwater that exceeds MCLs • Limit contamination of groundwater that is not already contaminated • Restore groundwater to the greatest extent, as reasonable under the circumstances		
	Single Media - Buildings or Habitable Structures			
	20 μR/hour gamma radiation Surface contamination guidelines (DOE 5400.5, Figure IV-1) for equipment or building components; if the building is demolished, the guidelines are applicable to the resulting contamination in the ground Rn-122 concentrations in the atmosphere above facility surfaces or openings: • 100 pCi/l at any point • 30 pCi/l annual average over the facility site • 3 pCi/l annual average at or above any location outside the facility site • 20 pCi/(m^2-sec) flux rate from storage of radon producing wastes			

Table C-6. (Continued).

Agency/Type of Standard	DOE[b]	EPA[c]	NRC[d]	SCDHEC[e]
Standards that Apply to Radiation Exposure During Facility Operations	Multiple Pathways			
	100 mrem/yr		100 mrem/yr	
			200 mrem in any 1 hour	
			500 mrem/yr with prior authorization	
	25 mrem/yr whole body	25 mrem/yr whole body	25 mrem/yr whole body	25 mrem/yr whole body
	75 mrem/yr critical organ	75 mrem/yr any critical organ	75 mrem/yr thyroid	75 mrem/yr thyroid
			25 mrem/yr any other organ	25 mrem/yr any other organ
	25 mrem/yr [proposed 10 CFR 834.221(a)]			
	Single Media - Air			
	10 mrem/yr	10 mrem/yr		
	Single Media - Groundwater			
	4 mrem/yr beta particle and photon radioactivity	4 mrem/yr beta particle and photon radioactivity		4 mrem/yr beta particle and photon radioactivity
	5 x 10^{-9} µCi/ml combined radium-226 and radium-228	5 pCi/l combined radium-226 and radium-228		5 pCi/l combined radium-226 and radium-228
	1.5 x 10^{-8} µCi/ml gross alpha (including radium-226 but excluding radon and uranium)	15 pCi/l gross alpha (including radium-226 but excluding radon and uranium)		15 pCi/l gross alpha (including radium-226 but excluding radon and uranium)
	20,000 pCi/l tritium	20,000 pCi/l tritium		20,000 pCi/l tritium
	8 pCi/l strontium	8 pCi/l strontium		8 pCi/l strontium
	Single Media - Surface Water (Aquatic Organisms)			
	1 rad/day from liquid discharges to natural waterways			

Table C-6. (Continued).

Agency/Type of Standard	DOE[b]	EPA[c]	NRC[d]	SCDHEC[e]
Standards that Apply to Radioactive Waste Management	Multiple Pathways			
• Low-Level Waste	25 mrem/yr	15 mrem/yr	25 mrem/yr whole body	
			75 mrem/yr thyroid	
			25 mrem/yr any other organ	
	100 mrem/yr - intruder (chronic)			
	500 mrem/yr - intruder (acute)			
• High-Level Waste		15 mrem/yr		
		less than 1 chance in 10 of exceeding the quantities calculated according to Table 1 of 40 CFR 191.13 (Appendix A); and less than 1 chance in 1,000 of exceeding 10 times the quantities calculated according to Table 1		
	Single Media - Air			
	10 mrem/yr			
	Single Media - Groundwater			
		4 mrem/yr beta particle and photon radioactivity		
		5pCi/l combined radium-226 and radium-228		
		15 pCi/l gross alpha (including radium-226 but excluding radon and uranium)		
		20,000 pCi/l tritium		
		8 pCi/l strontium		

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a. Dose limit for member of the public unless otherwise specified.
b. Includes DOE Orders 5400.5 and 5820.2A, proposed regulation 10 CFR 834.
c. Includes EPA Regulations 40 CFR 61, 40 CFR 141, and 40 CFR 191; draft proposed 40 CFR 193; and preliminary draft 40 CFR 196.
d. Includes NRC Regulations 10 CFR 20 and 10 CFR 61; and proposed 10 CFR 20 (Subpart E).
e. Includes SCDHEC Regulations R.61-58.5 and R.61-68.
f. A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.3 REFERENCES

EPA (U.S. Environmental Protection Agency), 1988, CERCLA Compliance With Other Laws Manual *(Interim Final)*, EPA 540/G-89/006, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., August.

EPA (U.S. Environmental Protection Agency), 1989a, *CERCLA Compliance With Other Laws Manual - RCRA ARARs: Focus on Closure Requirements*, Directive 9234.2-04/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., October.

EPA (U.S. Environmental Protection Agency), 1989b, *CERCLA Compliance With Other Laws Manual - CERCLA Compliance With State Requirements*, Publication 9234.2-05/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., December.

EPA (U.S. Environmental Protection Agency), 1990a, *CERCLA Compliance With Other Laws Manual - CERCLA Compliance with the CWA and SDWA*, Publication 9234.2-06/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., February.

EPA (U.S. Environmental Protection Agency), 1990b, *CERCLA Compliance With Other Laws Manual - Summary of Part II, CAA, TSCA, and Other Statutes*, Publication 9234.2-07/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., April.

EPA (U.S. Environmental Protection Agency), 1990c, *ARARs Q's & A's: State Ground-Water Antidegradation Issues*, Publication 9234.2-11/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., July.

EPA (U.S. Environmental Protection Agency), 1991, *ARARs Q's & A's: Compliance with New SDWA National Primary Drinking Water Regulations for Organic and Inorganic Chemicals*, Publication 9234.2-15/FS, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., August.

EPA, DOE, and SCDHEC, 1993, Federal Facility Agreement for the Savannah River Site, Administrative Docket No. 89-05-FF, signed January 15, 1993, effective August 16, 1993, U.S. Environmental Protection Agency, U.S. Department of Energy, and South Carolina Department of Health and Environmental Control.

APPENDIX D.

EXAMPLE OF FATE AND TRANSPORT MODELING

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APPENDIX D. EXAMPLE OF FATE AND TRANSPORT MODELING

This appendix provides an example of the fate and transport modeling that will be performed to support closure of the SRS High-Level Waste (HLW) tanks. This modeling estimates the potential human health and ecological impacts of residual contamination remaining in closed HLW tanks. The modeling also estimates the concentration and dose levels at the groundwater seepline, which is the established point of compliance.

For this example, Tanks 17 through 20 in the F-Area Tank Farm were modeled assuming conditions that will exist after tank closure for four tank closure scenarios. The specific closure scenarios modeled were (1) not filling the tanks, (2) filling the tanks with grout, (3) filling the tanks with grout and placing an engineered cap over the filled tanks, and (4) filling the tanks with sand and placing an engineered cap over the filled tanks. The engineered cap used in closure scenarios 3 and 4 will have a design similar to the F- and H-seepage basin caps.

This modeling assumed institutional control for 100 years and subsequent industrial land use. The area immediately around the F-Area Tank Farm will remain in commercial/industrial use for the entire 10,000-year period of analysis. The area of commercial/industrial land use will extend to Fourmile Branch in the direction of groundwater flow in the unconfined aquifer.

Potential impacts to the following receptors were analyzed:

- *Worker*: an adult who has authorized access to, and works at, the tank farm and surrounding areas but is considered to be a member of the public for compliance purposes. This analysis assumes that the worker remains on the shore of Fourmile Branch during working hours.

- *Intruder*: a teenager who gains unauthorized access to the F-Area Tank Farm and is potentially exposed to contaminants.

- *Nearby adult resident*: an adult who lives in a dwelling across Fourmile Branch downgradient of the F-Area Tank Farm, near the location of the groundwater outcropping (seepline).

- *Nearby child resident*: a child who lives in a dwelling across Fourmile Branch downgradient of the F-Area Tank Farm, near the location of the groundwater outcropping (seepline).

In addition to the receptors identified above, concentration and dose levels were calculated at the groundwater seepline point of exposure. For informational purposes, concentration and dose levels were also calculated at 1-meter and 100-meters downgradient from the edge of F-Area Tank Farm.

The identity and level of residual contaminants in Tanks 17 through 20 were derived from data provided in d'Entremont (1996a,b). The calculated impacts from the residual contamination can then be used in conjunction with results from modeling of other sources in the Groundwater Transport Segment to develop the tank-specific performance objectives discussed in Chapter 6. This comparison provides the data needed in developing closure strategies for specific tanks.

D.1 Analyzed Scenario

Tanks 17 through 20 were modeled as a single area source by combining the areas of all four tank bottoms. The area was considered as one contiguous region due to the proximity of the four tanks and the fact that the majority of the estimated releases from the tanks would flow toward Fourmile Branch. Therefore, the inventories were totaled for the four tanks to determine a cumulative waste volume and aggregate concentration. In the analyzed scenario, the mobile contaminants in the tanks will gradually migrate downward through soil to the groundwater aquifer. The contaminants will be transported by the groundwater to the seepline and subsequently to Fourmile Branch. Upon reaching the surface water, some contaminants will contaminate the seepline, sediments at the bottom of Fourmile Branch, and the shoreline. Aquatic organisms in the stream and plants along the shoreline will become exposed to the contaminants. Terrestrial organisms might then ingest the contaminated vegetation and also obtain their drinking water from the contaminated stream. Human receptors will potentially be exposed to contaminants through various pathways associated with the surface water.

Example calculations were performed for four tank closure scenarios shown in Figure D-1:

- Scenario 1 No Action
- Scenario 2 Grout Filled - No Cover
- Scenario 3 Grout Filled - With Cover
- Scenario 4 Sand Filled - With Cover

The example closure actions and major modeling assumptions associated with each of these scenarios is discussed below.

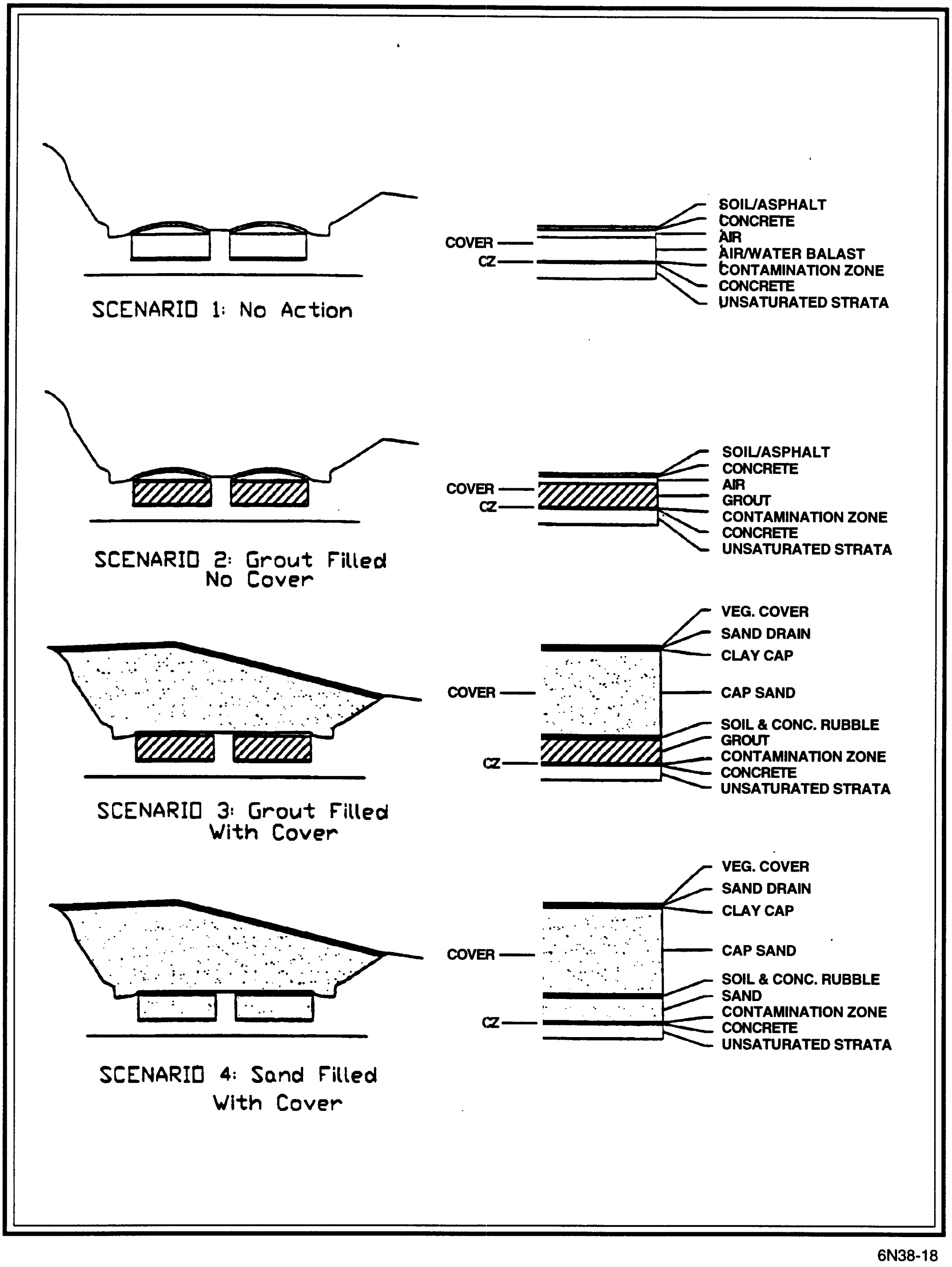

Figure D-1. Tank closure scenarios.

D.1.1 SCENARIO 1 - NO ACTION

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

At some point in the future, the hydraulic forces associated with the rising and falling of the water table will destroy the top and bottom of the tanks. The contaminants are then assumed to reside at the bottom of a hole 34 feet deep (approximately 60 feet below grade). Although debris will exist in the hole, it plays no role in inhibiting infiltration or preventing flow into the soil. For simplicity and conservatism, the tanks and concrete basemat are assumed to catastrophically fail at 100 years, exposing the contaminated media to rainfall with subsequent infiltration to groundwater.

The No-Action scenario is the only closure option that could conceivably expose receptors by the atmospheric pathway from the tank area, because each of the other closure alternatives entails either the placement of an engineered cap or filling the tanks with grout. The only foreseeable occurrence of an atmospheric release under No Action would be if the tank structures collapsed, causing the suspension of particulates containing contaminants. However, the likelihood of an atmospheric release is considered to be minimal, at best, for the following reasons. Due to the high infiltration rate associated with the No-Action scenario, the residual at the bottom of the tanks will remain wet, preventing any suspension of contaminated matter. In addition, the collapse of the tank structure will result in tank pieces and surface material falling into the tank interior, covering and containing the contaminated layer. Finally, the depth to the tank bottom will prevent any appreciable "cloud" of contaminants from reaching open space where prevailing winds could transport the contaminants. Based on these reasons, no analyses were performed for the atmospheric pathway.

D.1.2 SCENARIO 2 - GROUT FILLED - NO COVER

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

D.1.3 SCENARIO 3 - GROUT FILLED - WITH COVER

Scenario 3 assumes that the tanks will be filled with grout and the area surrounding the tanks is backfilled and covered with an engineered cap. The combination of the engineered cap, tank top, and grout fill provide an extremely effective barrier to water infiltration. Given a conservative erosion rate of 0.06 cm/yr (Hamby 1993), it will take about 1,000 years for the 2-foot thick vegetation layer to erode to expose the clay layer. Although the 2-foot clay layer will take about another 1,000 years to erode away, once exposed to sunlight and air, the clay layer could begin to crack, thus impacting the infiltration rate.

For this scenario, the conservative assumption is made that the cap, tank top, grout, and basemat fail at 1,500 years. Although the engineered cap may fail prior to 1,500 years, the decreased infiltration rate achieved during the period in which the cap is intact is assumed to cause the longevity of the grout, tank top, and basemat to increase by 500 years. This low rate of infiltration is justified based on the combined effect of the engineered cap and the low hydraulic conductivity of the intact grout.

D.1.4 SCENARIO 4 - SAND FILLED - WITH COVER

Scenario 4 assumes that the tanks are filled with sand and the area surrounding the tanks is backfilled and covered with an engineered cap. This scenario conservatively assumes that although the local erosion rate predicts that the cover vegetation will remain intact for 1,000 years, the cap fails at 500 years because settling of the sand in the tanks might lead to earlier collapse of the tank roof and subsequent degradation of the cap.

D.2 Methodology

D.2.1 HUMAN HEALTH ASSESSMENT

D.2.1.1 General Methodology

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

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

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

Calculated pollutant concentrations, dose levels, and peak time of occurrence are provided at 1 meter and 100 meters downgradient from the edge of the F-Tank Farm, at the seepline, and at Fourmile Branch for the receptors discussed in Section 3.

D.2.1.2 Receptors

The potential receptors and exposure pathways are identified in the following sections and illustrated in Figure D-2.

Worker

The worker is assumed to be located in the area including and surrounding the F-Area Tank Farm. Because institutional controls are in place, the potential for exposure of the worker to the primary source (residual at the bottom of the tanks) is minimal, owing to the barrier provided by the cover over the tank, the structural integrity of the tank, the lack of any industrial work that will be performed over the tanks, and safety measures that will be taken to further reduce potential exposure. Therefore, this analysis will assume that the worker is located constantly at the nearest place where contaminants will be accessible (i.e., on the bank of Fourmile Branch, as part of his work duties). The assumption is conservative because the worker has a greater potential for exposure to contaminants at the seepline. For compliance purposes, the worker is assumed to be a member of the public at all points in time. However, the fact

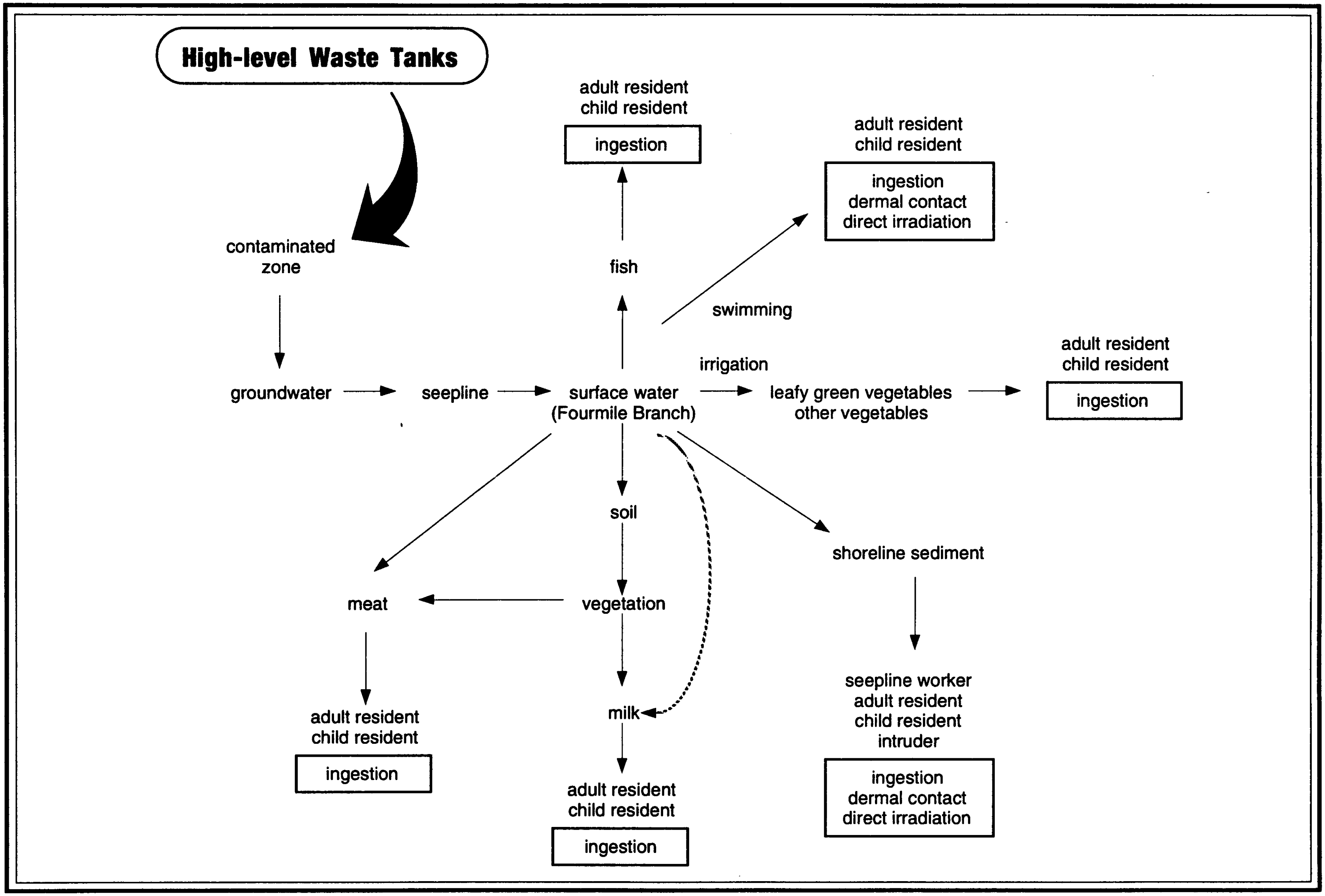

Figure D-2. Potential exposure pathways for human receptors.

that he is a worker limits, and, hence, eliminates pathways that might be considered if he were considered a resident. The potential exposure pathways for the seepline worker are:

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

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

Intruder

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

Nearby Adult Resident/Nearby Child Resident

Nearby residents could also potentially be exposed to contaminants from the F-Area Tank Farm. Members of the public are assumed to construct a dwelling near the tank farm on the Savannah River Site (but outside the Tank Farm site) because the entirety of the Savannah River Site will not be off limits to the public for the next 10,000 years. The location of the residential dwelling is assumed to be downgradient near Fourmile Branch on the side opposite the F-Area Tank Farm at a point 100 meters downstream of the groundwater outcropping in Fourmile Branch. The residents of this dwelling include both adults and children. The adult resident will be modeled separately from the child resident because of different body weights and consumption rates.

The resident is assumed to use Fourmile Branch for recreational purposes; to grow and consume produce irrigated with water from Fourmile Branch; to obtain milk from cows raised on the residential property;

and to consume meat that was fed contaminated vegetation from the area. Therefore, potential exposure pathways for both the nearby adult and nearby child resident are the following:

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

Atmospheric Pathway Receptors

Based on the reasoning presented in Sections D.2.1.1 and D.3.1.2, no analyses were performed for the atmospheric pathway.

D.2.1.3 Computational Code

Groundwater and surface water concentrations and human health impacts were calculated using the MEPAS computer code. MEPAS integrates source-term, transport, and exposure models for contaminants. In the MEPAS code, contaminants are transported from a contaminated area to potential human receptors through various transport pathways (groundwater, surface water, soils, food, etc.). Human receptors then receive doses, both chemical and radiation, through exposure or intake routes (ingestion, dermal contact, inhalation, etc.) and numerous exposure pathways (drinking water, leafy vegetables, meat, etc.).

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

The MEPAS code is widely used and accepted throughout the DOE complex and has been presented to and accepted by other regulatory agencies such as EPA. Examples of its use by DOE include the

EH-Environmental Survey Risk Assessment and the Complex-Wide Programmatic Waste Management EIS Impact Analysis. This code has been used to demonstrate environmental impacts in RCRA-Subpart X permit applications to various EPA regions; these analyses were accepted and permits based on them were issued.

D.2.1.4 Calculational Methodology

The modeling results presented in this appendix are based on the amount of contaminants remaining in the tanks after bulk waste removal and spray washing. The results can generally be scaled to differing amounts of residual contaminants left in a tank. Although the waste is present as supernate (salt solution), damp saltcake, sludge, and zeolite, the total waste volume was assumed, conservatively, to be sludge, based on the assumption that all the residual contaminants reside in the sludge (d'Entremont 1996a).

Since MEPAS was not specifically designed to model rainwater runoff efficiencies afforded by engineered caps or thick covers, analyses were performed specifying infiltration rates that relate to the four closure scenarios. For example, an infiltration rate of 4 centimeters per year relates to an intact engineered cap such as the ones previously designed and evaluated at SRS (WSRC 1993). Similarly, an infiltration rate of 40 centimeters per year (average infiltration rate for SRS soils) was used to model scenarios that did not include engineered caps or for time periods after cap failure (WSRC 1994). An infiltration rate of 122 centimeters per year was used for the No-Action case to simulate infiltration of 100 percent of the average annual precipitation. The latter assumption is considered to be reasonable given the fact that the tanks are located in a depression that could fill with rainwater if the storm drain system fails.

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

In the groundwater transport pathway, infiltration causes leaching of pollutants from the tanks through distinct media found below the waste unit down to the groundwater aquifer (saturated zone). To model the movement of the pollutants from the waste unit to the aquifer, MEPAS requires that the distinct strata that the pollutants encounter be identified. For modeling Tanks 17 to 20, the residual at the bottom of the tanks was considered to be the contaminated zone.

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

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

As contaminants are transported from the contaminated zone to the seepline, they are longitudinally (along the streamline of fluid flow), vertically, and transversely (out sideways) dispersed by the transporting medium. MEPAS incorporates longitudinal dispersivity of pollutants moving downward through the partially saturated zone layers (i.e., concrete basemat and vadose zone) in concentration calculations. In the saturated zone, MEPAS incorporates into concentration calculations the three-dimensional dispersion along the length of travel. Dispersion distances were calculated through the concrete basemat, the vadose zone, and the groundwater aquifer. As expected, dispersion increases with longer travel distances.

A previous study by Geo Trans Inc. [as cited in Butcher (1996)] indicates that a fraction of contaminants released into groundwater from F-Area Tank Farm would migrate into the lower aquifer and be transported to Upper Three Runs Creek. However, the data indicate that contaminant levels in Upper Three Runs Creek due to releases from F-Area Tank Farm would be no more than 3 percent of those calculated for Fourmile Branch. Therefore, this modeling conservatively assumed that all contaminants remain in the upper aquifer and are transported to Fourmile Branch.

Groundwater concentrations and doses due to ingestion of water are calculated at hypothetical wells at 1 meter and 100 meters downgradient from the edge of the F-Tank Farm, at the seepline and in Fourmile Branch. No human receptors are actually exposed to the groundwater pathway at these locations, but the calculations are performed for information purposes.

Impacts to adult and child residential receptors are evaluated at a point 100 meters downstream of the groundwater outcropping in Fourmile Branch. The concentration of contaminants in Fourmile Branch was also calculated. Based on the dimensions, flow rate, and stream velocity of Fourmile Branch, MEPAS accounts for mixing of the contaminant-containing water from the aquifer with stream water and other groundwater contributions. For both adult and child residents, ingestion rates were based on site-specific parameters. Parameters and associated assumptions used in calculating human impacts are presented in Section D.4.2.5.

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

D.2.2 ECOLOGICAL RISK ASSESSMENT

D.2.2.1 General Methodology

Several potential scenarios were considered for assessing ecological risks associated with tank closure. These included contamination of runoff water during rainstorms, soil contamination from air emissions following tank collapse, and contamination of groundwater. On inspection, it was realized that because the tank tops are considerably (4 to 7 meters) below the surrounding, original land surface. Therefore, runoff or soil contamination was not a reasonable assumption. Groundwater contamination was selected as the basis of the analyzed scenario, which includes seepage of the groundwater at a downgradient outcrop (seepline) and subsequent mixing in Fourmile Branch. The groundwater pathway, together with potential routes of entry into ecological receptors, is shown in the conceptual site model (Figure D-3).

The habitat in the vicinity of the seepline is bottomland hardwood forest, which grades into marsh around the channels of Fourmile Branch and its tributaries. On the upslope side of the bottomland, the forest becomes a mixture of pine and hardwood.

The analyzed scenario includes potential impacts to terrestrial receptors at the seepline and aquatic receptors in Fourmile Branch. For the assessment of risk due to toxicants, the aquatic receptors are treated as a group because water quality criteria have been derived for protection of aquatic life in general.

These criteria, or equivalent values, are used as threshold concentrations. For the radiological risk assessment, the redbreast sunfish was selected as an indicator species due to its abundance in Fourmile Branch.

There are no criteria established for the protection of terrestrial organisms from toxicants. Receptor indicator species are usually selected for risk analysis and the results extrapolated to the populations, communities or feeding guilds (e.g., herbivores, predators) that they represent. Two terrestrial animal receptors, the southern short-tailed shrew and the mink, were selected according to EPA Region IV guidance, which calls for investigation of small animals with small home ranges. The guidance also calls for investigation of predators when biomagnifying contaminants are being studied, such as mercury. The southern short-tailed shrew is small and one of the most common mammals on the SRS; the mink is a small-bodied predator, associated with waterways, which inhabits the SRS. These indicator species are also used in the radiological assessment.

The seepage area is estimated to be small, about 0.5 hectare, so risk to plant populations is considered negligible even if individual plants might be 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 inhabitants. Because no protected species were seen or are known to live in this area, risks to terrestrial plants are not treated further in the risk assessment.

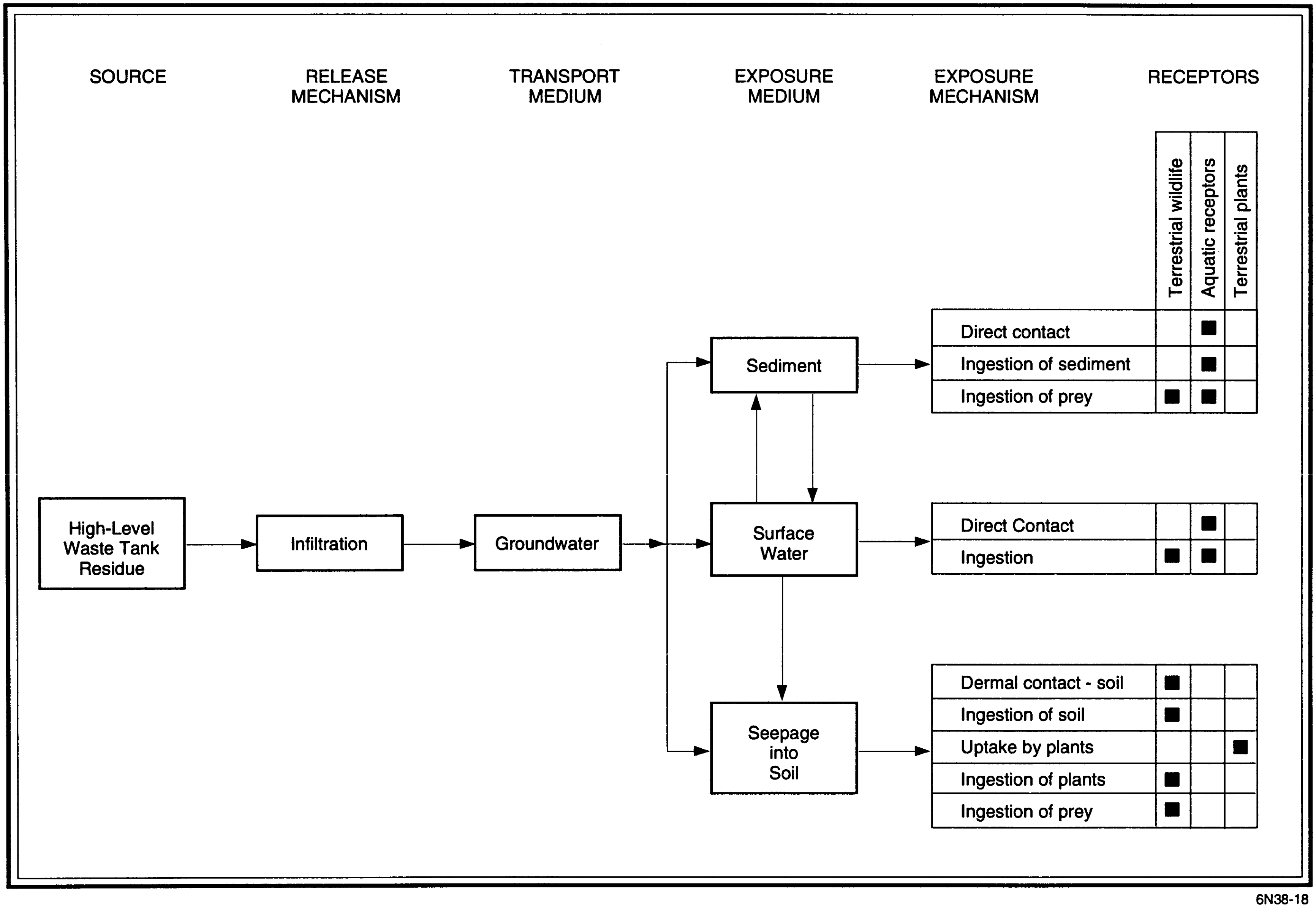

Figure D-3. Conceptual site model for high-level waste tank ecological risk assessment.

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: 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.

D.2.2.2 Exposure and Toxicity Assessment

D.2.2.2.1 Exposure to Chemical Toxicants

Exposure for aquatic receptors is simply expressed as the concentration of contaminant in the water surrounding them. This is the surface water exposure medium shown in the conceptual site model (Figure D-3). The conceptual model also includes sediment as an exposure medium; sediment might become contaminated from the influence of the surface water, or from seepage that enters sediment directly. However, this exposure medium was not evaluated for the following reasons: estimating sediment contamination from surface water inputs would be highly speculative and seepage into sediment is not considered in the groundwater model - all of the transported material is assumed to come out at the seepline.

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

D.2.2.2.2 Chemical Toxicity Assessment

The goal of the toxicity assessment is to derive threshold exposure levels that are protective of the receptors (Table D-1). For aquatic receptors, most of the threshold values are ambient water quality criteria for chronic exposures. Other values include the concentration for silver, which is an acute value (no chronic level was available), and zirconium, which is based on entries in the AQUIRE database with a highest no-observed-adverse-effect-level (NOAEL) of 15,000 mg/L in an acute mortality study.

Table D-1. Threshold toxicity values.

Contaminant	Aquatic Receptors (mg/L)	Terrestrial Receptors (mg/kg-d) Shrew	Mink
Aluminum	0.087	27.7	6.4
Chromium	0.011	11.6	2.7
Copper	0.0014[a]	52.2	12
Fluoride	NA	8.3	2.5
Iron	1.0	NA	NA
Lead	0.00013[a]	0.012	0.003
Manganese	NA	52.9	12.1
Mercury	0.000012	0.082	0.019
Nickel	0.019[a]	29.7	6.8
Nitrate	NA	b	-
Phosphate	NA	NA	NA
Silver	0.000055[a]	0.33	0.077
Zirconium	1500	5.6	1.3

NA: Not applicable (not normally a toxin for this type of receptor).

a. Based on a hardness of 8.2 mg $CaCO_3$/L.

b. Screening for MCL level (10 mg/L) in seep water considered protective for nitrate.

For terrestrial receptors, toxicity thresholds are based on the lowest oral doses found in the literature that are NOAELs or lowest-observed-adverse-effect-levels (LOAELs) for chronic endpoints that could affect population viability or fitness (Table D-2). Usually the endpoints are adverse effects on reproduction or development. Uncertainty factors are applied to these doses to extrapolate from LOAELs to NOAELs and from subchronic or acute to chronic study durations. The derivation of these values is presented in Table D-3. Differences in metabolic rates between experimental animals, usually rats or mice, and indicator species are accounted for by applying a factor based on relative differences in estimated body surface areas.

D.2.2.3 Calculational Design

D.2.2.3.1 Chemical Contaminants

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

Table D-2. Toxicological basis of NOAELs for indicator species.

Analyte	Surrogate Species	LOAEL mg/kg/d	Duration	Effect	NOAEL mg/kg/d	Reference	Notes
Inorganics							
Aluminum	mouse	-	13 mo	repro; syst	19	Ondreicka et al. 1966 in ATSDR 1990	
Chromium VI	rat	-	1 y	systemic	3.5	Mackenzie et al. 1958 in ATSDR 1991	
Copper	mink	15	50 w	reproductive	12	Aulerich et al. 1982 in Opresko et al. 1994	
Fluoride	rat	5	60 d	reproductive	-	Araibi et al. 1989 in ATSDR 1993	
	mink	5	382 d	systemic	-	Aulerich et al. 1987 in ATSDR 1993	Systemic LOAEL < reproductive
Iron							Data inadequate; essential nutrient
Lead	rat	0.28	30 d	reproductive	0.014	Hilderbrand et al. 1973	
Manganese	rat	-	100-224 d	reproductive	16	Laskey et al. 1982	
Mercury	mink	0.25	3 mo	death; devel.	0.15	Wobeser et al. 1976 in Opresko et al. 1994	
Nickel	rat	18	3 gens	reproductive	-	Ambrose et al. 1976	Based on first generation effects
Nitrate							MCL of 10 mg/L at seepline protective
Phosphate							Essential nutrient
Silver	mouse	23	125 d	behavioral	-	Rungby & Danscher 1984	
Zirconium	rat	-	> 1 y	longevity	1.7	Schroeder et al. 1968b in Opresko et al. 1994	

Table D-3. Derivation of NOAELs for indicator species.

Contaminant of Concern	Surrogate Species	NOAEL or LOAEL in Surrogate Species mg/kg/d	UF[a]	Body Surface Area Conversion Factor	Indicator Species	Indicator Species NOAEL in mg/kg/d	Notes
Inorganics							
Aluminum	mouse	19	1	0.33	mink	6.4	
	mouse	19	1	1.46	shrew	27.7	
Chromium VI	rat	3.5	1	0.76	mink	2.7	
	rat	3.5	1	3.30	shrew	11.6	
Copper	mink	12	1	1.00	mink	12.0	
	mink	12	1	4.35	shrew	52.2	
Fluoride	mink	5	2	1.00	mink	2.5	UF for less serious LOAEL
	rat	5	2	3.30	shrew	8.3	UF for less serious LOAEL
Iron							Data inadequate; essential nutrient
Lead	rat	0.014	4	0.76	mink	0.003	UF for study duration
	rat	0.014	4	3.30	shrew	0.012	UF for study duration
Manganese	rat	16	1	0.76	mink	12.1	
	rat	16	1	3.30	shrew	52.9	
Mercury	mink	0.15	8	1.00	mink	0.019	UF for study duration
	mink	0.15	8	4.35	shrew	0.082	UF for study duration
Nickel	rat	18	2	0.76	mink	6.8	UF for LOAEL: NOAEL in 2nd and 3rd generations
	rat	18	2	3.30	shrew	29.7	UF for LOAEL: NOAEL in 2nd and 3rd generations
Nitrate							MCL of 10 mg/L at seepline protective
Phosphate							Essential nutrient
Silver	mouse	23	100	0.33	mink	0.077	UF for LOAEL and nature of study
	mouse	23	100	1.46	shrew	0.33	UF for LOAEL and nature of study
Zirconium	rat	1.7	1	0.76	mink	1.29	
	rat	1.7	1	3.30	shrew	5.62	

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a. UF = Uncertainty Factors.

Although this ratio is not considered a hazard quotient, it is used to help identify concentrations indicating potential risk.

D.2.2.3.2 Radioactive Contaminants

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

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

The amount of radioactivity that the terrestrial organisms were estimated to ingest, through all postulated ingestion pathways, was then multiplied by the dose conversion factors to calculate an annual radiation dose to the organism. For the aquatic organism, the concentration of radioactivity in the surface water was multiplied by the submersion and uptake dose conversion factors to calculate an annual radiation dose to the sunfish. These radiation doses are then compared to the limit of 1.0 rad per day (365 rad per year).

D.3 Assumptions and Inputs

D.3.1 SOURCE TERM

D.3.1.1 Radionuclides

Radioactive material source terms for the tank and ancillary piping residuum used for the modeling are listed in Table D-4. These source terms relate to quantities remaining after bulk waste removal and spray washing. The ancillary piping and evaporator residuum was conservatively estimated to be equal to 20 percent of the tank inventories.

Table D-4. Tanks 17-20 residual after bulk waste removal and spray washing, curies.[a]

Radionuclide	Tank 17	Tank 18	Tank 19	Tank 20	Total
Se-79 (Ci)	6.23E-02	1.35E-01	3.95E+00	3.50E-02	4.18E+00
Sr-90 (Ci)	7.45E+03	1.57E+04	8.77E+03	4.39E+03	3.63E+04
Tc-99 (Ci)	1.08E+00	2.45E+00	2.16E+01	6.06E-01	2.57E+01
Sn-126 (Ci)	8.40E-08	2.55E-04	1.86E-04	0.00E+00	4.41E-04
Cs-135 (Ci)	3.99E-07	1.21E-03	8.84E-04	0.00E+00	2.09E-03
Cs-137 (Ci)	5.01E+02	1.62E+03	3.19E+04	2.94E+02	3.43E+04
Sm-151 (Ci)	1.37E-06	4.14E-03	3.03E-03	0.00E+00	7.17E-03
Eu-154 (Ci)	4.55E+01	9.40E+01	4.69E+01	2.78E+01	2.14E+02
Np-237 (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238 (Ci)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239 (Ci)	1.21E+01	2.77E+01	3.14E+01	4.15E+00	7.54E+01

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a. Derived from d'Entremont (1996a).

D.3.1.2 Chemicals

Chemical material source terms used in this modeling are listed in Table D-5. As with the radioactive source term, the ancillary piping and evaporator residuum was conservatively estimated to be equal to 20 percent of the tank inventories. In addition, the 12,000 pounds of lead in the tank top risers (500 pounds per riser, 6 risers per tank) was modeled.

Table D-5. Tanks 17-20 residual inventory of chemical constituents after bulk waste removal and spray washing, kilograms.[a]

Constituent	Tank 17	Tank 18	Tank 19	Tank 20	Total
Iron (kg)	4.30E+02	8.60E+02	1.68E+03	2.15E+02	3.19E+03
Manganese (kg)	4.56E+01	9.13E+01	1.82E+02	2.28E+01	3.42E+02
Nickel (kg)	3.74E+01	7.48E+01	1.48E+02	1.87E+01	2.78E+02
Aluminum (kg)	8.38E+01	1.65E+02	1.17E+03	4.69E+01	1.46E+03
Chromium VI (kg)	3.75E+00	7.50E+00	1.48E+01	1.88E+00	2.79E+01
Mercury (kg)	1.10E+00	2.40E+00	4.41E+00	5.48E-01	8.46E+00
Silver (kg)	5.33E+00	1.07E+01	2.07E+01	2.67E+00	3.93E+01
Copper (kg)	2.67E+00	5.33E+00	1.04E+01	1.33E+00	1.97E+01
Zirconium (kg)	8.89E+00	1.78E+01	3.47E+01	4.44E+00	6.58E+01
Nitrate (kg)	5.71E+02	6.00E+02	2.36E+04	2.59E+01	2.48E+04
Phosphate (kg)	2.33E+00	4.05E+00	1.13E+01	5.04E+00	2.27E+01
Chloride (kg)	2.17E+01	4.33E+01	9.06E+01	1.38E+01	1.69E+02
Fluoride (kg)	3.01E+00	5.63E+00	4.66E+01	5.43E+00	6.06E+01

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a. Derived from d'Entremont (1996b).

D.3.2 CALCULATIONAL PARAMETERS

The modeling example is designed to be specific to Tanks 17 to 20, which are located in F-Area at SRS. This is accomplished by utilizing site-specific data where available. For the hundreds of MEPAS input parameters, default values were used only for the distribution coefficients for chemical constituents (except selenium).

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

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

D.3.2.1 Distribution Coefficients

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

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

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

Distribution coefficients for each strata under various conditions are listed in Table D-6. A detailed discussion of the selection process is provided for each closure scenario.

D.3.2.1.1 Scenario 1 - No Action

For this scenario, K_d s for the contaminated zone (CZ) were assumed to behave similarly to that of clay found in the vicinity of the SRS tank farms. For the radionuclides and chemicals of interest, these K_d s are listed in Column V of Table D-6.

Table D-6. Radionuclide and chemical groundwater distribution coefficients, cm^3/gram.

	I		II		III		IV		V	
Constituent	SRS Soil	Ref.	Non-Reducing Concrete[l]	Ref.	Reducing[j] Concrete	Ref.	Reducing[j] CZ	Ref.	Non-Reducing CZ	Ref.
Se-79[a]	5	b	0	b	0.1	i	0.1	i	740[m]	b
Sr-90	10	b	10	b	1	i	1	i	110[m]	b
Tc-99	0.36	b	700	b	1,000	i	1,000	i	1[m]	b
Sn-126	130	b	200	b	1,000	i	1,000	i	670[m]	b
Cs-135, 137	100	b	20	b	2	i	2	i	1,900[m]	b
Sm-151	800[d]	c	1,300	e	5,000[q]	i	5,000[q]	i	1,300	e
Eu-154[p]	800[d]	c	1,300	e	5,000[q]	i	5,000[q]	i	1,300	e
Pu-239	100	c	5,000	b	5,000	b	NA	f	5,100[m]	b
Iron	15	g	15	n	1.5	o	1.5	o	15	n
Manganese	16.5	g	36.9	n	100	i	100	i	36.9	n
Nickel	300	b	650	n	100	i	100	i	650	n
Aluminum	35,300	g	35,300	n	353	o	353	o	35,300	n
Chromium VI[h]	16.8	g	360	n	7.9	o	7.9	o	360	n
Mercury	322	g	5,280	n	5,280	o	5,280	o	5,280	n
Silver	0.4	g	40	n	1	i	1	i	40	n
Copper	41.9	g	336	n	33.6	o	33.6	o	336	n
Zirconium	50	g	1,000	n	5,000	i	5,000	i	1,000	n
Nitrate	0	g	0	n	0	o	0	o	0	n
Phosphate	50	g	50	n	5	o	5	o	50	n
Chloride[r]	0	g	0	n	20	i	20	i	0	n
Fluoride	0	g	0	n	0	o	0	o	0	n
Lead	234	g	NA	s	NA	s	NA	s	NA	s

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a. Values also used for chemical contaminant.
b. E-Area RPA (WSRC 1994), Table 3.3-2, page 3-69.
c. Yu et al. 1993, Table 32.1, page 105.
d. Value used for loam from c.
e. Value used for clay from c.
f. Solubility limit of 4.4E-13 M/liter used, WSRC 1994, page D-32.
g. MEPAS default for soil <10% clay and pH from 5-9.
h. For conservatism, all chromium modeled as VI valence.
i. Bradbury and Sarott 1995, Table 4, Region 1, page 42.
j. Reducing environment assumed for grout cases..
k. Non-reducing environments assumed for No Action and Sand cases.
l. Values used for basemat concrete for No Action and Sand cases.
m. Value used for clay from b.
n. MEPAS default used for soil >30% clay and pH from 5-9.
o. MEPAS default used for soil >30% clay and pH >9.
p. Characteristics similar to Sm per i, Table 3, page 16.
q. Characteristics similar to Am per i, Table 3, page 16.
r. Modeled as chlorate.
s. Lead is outside of reducing environments for all cases.

For the first partially saturated zone (concrete basemat), K_d s were selected for concrete in a non-reducing environment and are listed in Column II of Table D-6.

K_d s for the second partially saturated zone (vadose zone) and the saturated zone are the same and were selected to reflect characteristics of SRS soil. These values are listed in Column I of Table D-6.

For the ancillary equipment and piping, K_d s for the CZ are presented in Column V, partially saturated and saturated zones are listed in Column I of Table D-6.

D.3.2.1.2 Scenario 2 - Grout Filled - No Cover

This scenario assumes that the tanks and ancillary piping will be filled with a strongly reducing grout. Therefore, for the tank model, K_d s for the CZ, first and second partially saturated zones, and the saturated zone are listed in Columns IV, III, I, and I of Table D-6, respectively.

Similarly, for the piping model, K_d s for the CZ, partially saturated zone, and the saturated zone are listed in Columns IV, I, and I of Table D-6, respectively.

D.3.2.1.3 Scenario 3 - Grout Filled With Cover

This scenario uses the same K_d s as for scenario 2.

D.3.2.1.4 Scenario 4 - Sand Filled With Cover

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

D.3.2.2 MEPAS Groundwater Input Parameters

Table D-7 lists input parameters used for the partially saturated zones for the various closure scenarios.

Table D-8 lists input parameters for the saturated zone. These values are constant for all closure scenarios.

D.3.2.3 Hydraulic Conductivities

Because leach rate is ultimately limited by the lowest hydraulic conductivity of the strata and structures above and below the contaminated zone, this parameter is highly sensitivity in its effect on breakthrough

Table D-7. Partially saturated zone MEPAS input parameters.

	Concrete Basemat		
	Intact	Failed	Vadose Zone Partially Saturated Zone
Strata Thickness (ft)	0.58[a]	0.58[a]	2.85[b]
Bulk Density (g/cm^3)	2.21[c]	1.64[d]	1.59[c]
Total Porosity	15%[c]	38%[d]	40%[c]
Field Capacity	15%[c]	9%[d]	30%[c]
Longitudinal Dispersion (ft)	0.0058[e]	0.0058[e]	0.03[e]
Hydraulic Conductivity (cm/s)	9.6E-09[c]	6.6E-03[d]	3.17E-04[c]

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a. WSRC, Drawing #W202091, 1991.
b. Calculated based on field notebooks, gauging data, 1973-1986; WSRC WATRELEV Database, 1996; and WSRC Drawing #W202091, 1991.
c. WSRC (1994).
d. Droppo (1995), Table 2.1.
e. Calculated using MEPAS formula for longitudinal dispersivity.

Table D-8. MEPAS input parameters for the saturated zone.

Thickness (ft)	32.8[a]
Bulk Density (g/cm^3)	1.59[b]
Total Porosity	40%[b]
Effective Porosity	30%[b]
Pore Velocity (ft/day)	0.019[c]

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a. Based on autocad drawing of third quarter 1993 water level data.
b. WSRC (1994).
c. Calculated based on autocad drawing, F-Area, for third quarter 1993, and WSRC (1994).

times and peak concentrations at the receptor locations. Table D-9 shows the changes in hydraulic conductivities due to failure as a function of time and closure scenario for the concrete basemat. For modeling purposes, it was assumed that excess water has a place to run off (over the sides of the basemat or cover) and that ponding above the contaminated zone does not occur.

Table D-9. Scenario-specific concrete basemat hydraulic conductivities, cm/sec.

Time (yrs)	Scenario 1 No Action	Scenario 2 Grout/No Cover	Scenario 3 Grout with Cover	Scenario 4 Sand with Cover
0	9.6E-09	9.6E-09	9.6E-09	9.6E-09
100	6.6E-03	9.6E-09	9.6E-09	9.6E-09
500	6.6E-03	9.6E-09	9.6E-09	6.6E-03
1000	6.6E-03	6.6E-03	9.6E-09	6.6E-03
1500	6.6E-03	6.6E-03	6.6E-03	6.6E-03

D.3.2.4 Infiltration Rates

As discussed in Section 2.1, infiltration rates are a function of closure scenario and time to failures of cap, tank top, grout, and concrete basemat. Scenario-specific infiltration rates as a function of time are listed in Table D-10.

Table D-10. Scenario-specific infiltration rates.

Time (yrs)	Scenario 1 No Action	Scenario 2 Grout/No Cover	Scenario 3 Grout with Cover	Scenario 4 Sand with Cover
0	122 cm/yr	4 cm/yr	2 cm/yr	4 cm/yr
100	122 cm/yr			
	(failure)	4 cm/yr	2 cm/yr	4 cm/yr
500				40 cm/yr
	122 cm/yr	4 cm/yr	2 cm/yr	(failure)
1000		40 cm/yr		
	122 cm/yr	(failure)	2 cm/yr	40 cm/yr
1500			40 cm/yr	
	122 cm/yr	40 cm/yr	(failure)	40 cm/yr

D.3.2.5 Human Health Exposure Parameters and Assumed Values

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

For this modeling effort, site-specific values were used as much as possible: that is, values that had been used in other modeling efforts for the SRS were incorporated when available and appropriate. Table D-11 lists the major parameters that were used in assigning characteristics to the receptors used in the calculations.

D.3.3 ECOLOGICAL RISK ASSESSMENT

The exposure factors used in calculating doses to the shrew and mink are listed in Table D-12. An important assumption of the exposure calculation is that no feeding or drinking takes place outside of the influence of the seepage, even though the home range of the shrew is about twice as large as the seep area and the mink's home range is more than ten times larger than the seep area. The bioaccumulation factor for soil and soil invertebrates is one for all metals, as is the factor for soil invertebrates and

Table D-11. Assumed human health exposure parameters.

Parameter	Applicable Receptor	Value	Comments
Body Mass	Adult	70 kg	This value is taken directly from ICRP (1975). In radiological dose calculations, this is the standard value in the industry.
	Child	30 kg	This value was obtained from ICRP (1975). Both a male and female child of age 9 have an average mass of 30 kg.
Exposure Period	All	1 year	This value is necessary so that MEPAS will calculate an annual radiation dose. Lifetime doses can be calculated by multiplying the annual dose by the assumed life of the individual.
Leafy Vegetable Ingestion Rate	Adult	21 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	8.53 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Other Vegetables Ingestion Rate	Adult	163 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	163 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Meat Ingestion Rate	Adult	43 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	16 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Milk Ingestion Rate	Adult	120 L/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	128 L/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Water Ingestion Rate	All	2 L/day	This value is standard in MEPAS and is consistent with maximum drinking water rates in NRC (1977).
Finfish Ingestion Rate	Adult	9 kg/yr	This value was taken from Hamby (1993), which was used previously in other modeling work at SRS.
	Child	2.96 kg/yr	This value was calculated based on the adult ingestion rate from Hamby (1993) and the ratio of child to adult ingestion rates for maximum individuals in NRC (1977).
Time Spent at Shoreline	Adult Resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child Resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).

Table D-11. (continued).

Parameter	Applicable Receptor	Value	Comments
Time Spent at Shoreline(cont.)	Seepline Worker	2080 hrs/yr	This value is based on the assumption of continuous exposure of the seepline worker during each working day.
	Intruder	1040 hrs/yr	This value is based on the conservative assumption of half-time exposure during each working day.
Time Spent Swimming	Adult Resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).
	Child Resident	12 hrs/yr	This is a default value from MEPAS and is consistent with NRC (1977).

shrews. K_d values for estimating contaminant concentrations in soil due to the influence of seepage are from Baes et al. (1984). Bioconcentration factors for estimating contaminant concentrations in aquatic prey items are from the EPA Region IV water quality criteria table. The mink was modeled as obtaining half its diet from shrews at the seep area and the other half from aquatic prey downstream of the seepline.

D.4 Results

D.4.1 HUMAN HEALTH ASSESSMENT

For each scenario, the maximum concentration or dose was identified for each receptor and for each contaminant along with the time period during which the maximum occurred within a 10,000-year performance period. In addition, for radiological constituents, the total dose was calculated to allow evaluation of the impact of all radiological constituents. Because the maximum doses for each radionuclide do not necessarily occur simultaneously, it is not appropriate to add the maximum doses for each radionuclide. Rather, it is more appropriate to assess the doses as a function of time, sum the doses from all radionuclides for each time increment, and then select the maximum total dose from this compilation; an example of this is shown in Figure D-4. Therefore, the total dose reported in the following tables for radiological constituents may not necessarily correlate to the maximum dose or time period for any individual radionuclide because of the contributions from all radionuclides at a given time. In addition to total dose, the gross alpha concentration (due to Pu-239), the beta-gamma dose, and the lifetime risk of incidence of excess cancer were calculated to allow comparison to the appropriate performance objectives.

Nonradiological constituent concentrations in the various water bodies were calculated to allow direct comparison to performance objectives. For each constituent, the maximum concentration was calculated along with the time period during which the maximum concentration occurred. None of the

Table D-12. Parameters for foodchain model ecological receptors.

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

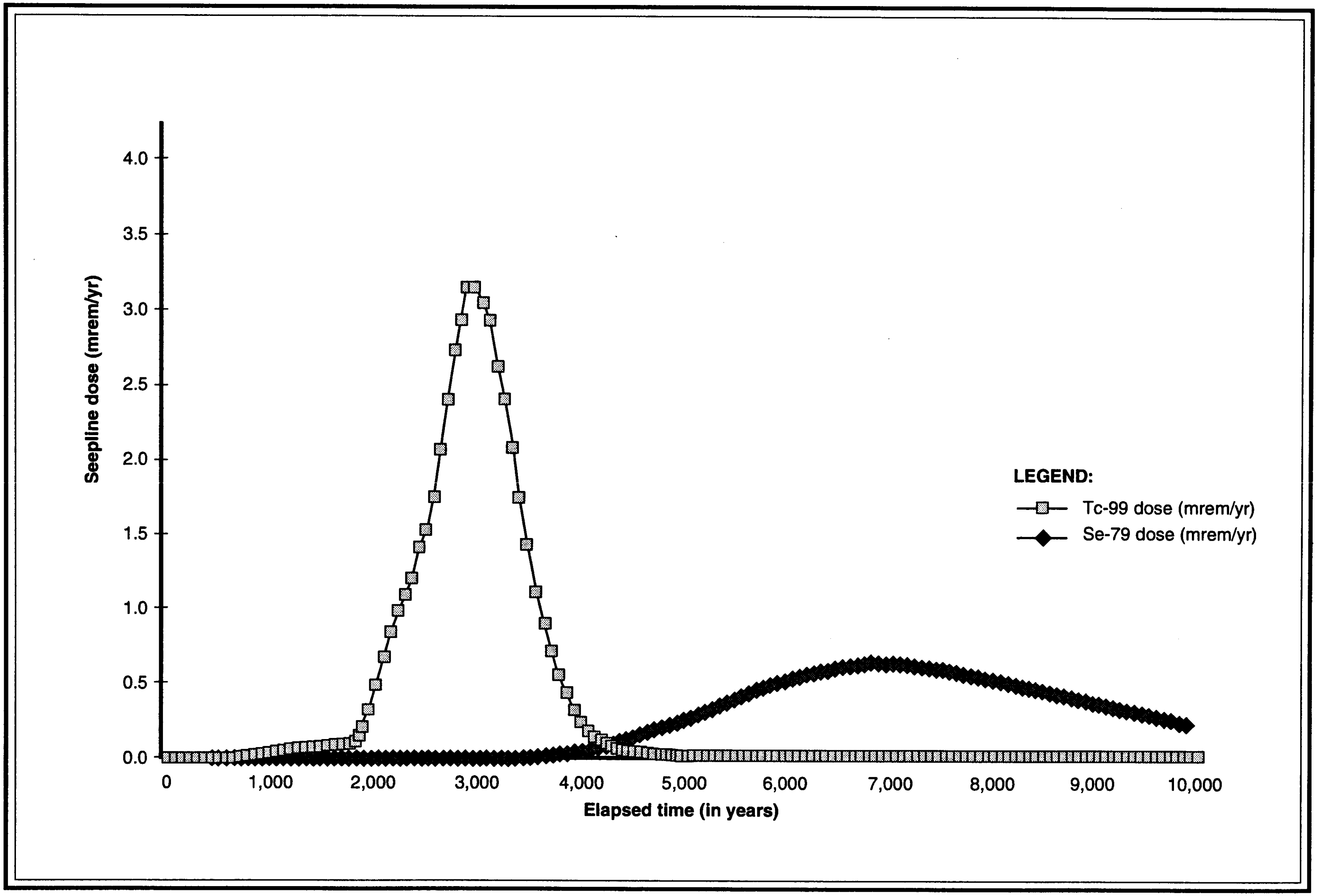

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Figure D-4. Seepline dose profile over time for closure scenario 3, grout filled with cover.

nonradiological constituents are known ingestion carcinogens; therefore cancer risk was not calculated for these contaminants.

Tables D-13 through D-24 list impact estimates for the four scenarios described in Section D.2.0. For those tables describing radiological impacts, doses are presented for postulated receptors (i.e., Adult Resident, Child Resident, Seepline Worker, and Intruder) and at the seepline. Additional calculations were performed at groundwater locations close to the tank farm for informational purposes. For nonradiological constituents, the maximum concentration of each contaminant is reported for each water location.

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

- The amount of rainfall in the area will tend to keep the tank contents damp through the time of failure. After failure, a substantial amount of debris on top of the contaminated material would prevent release even if the contents were to dry during a period of drought.

- The considerable depth of the tanks below grade will tend to discourage resuspension of any of the tanks' contents.

D.4.2 ECOLOGICAL ASSESSMENT

D.4.2.1 Nonradiological Analysis

None of the contaminants indicated potential risk to the shrew or mink. Table D-25 indicates that, under the no action scenario, hazard quotients (HQs) for silver range up to 0.51 for the shrew and 0.28 for the mink, while for fluoride the maxima are 0.25 for the shrew and 0.11 for the mink. All other HQs were lower. Closure scenarios differed in their predicted risks, with more effective scenarios lowering potential risks and causing them to occur at later times. The two extreme scenarios are listed in Table D-25, with "no action" least effective and "grout with cap" most effective. The ecological results indicate that effectiveness of the scenarios is ranked as follows: grout-filled with cap > grout-filled without cap > sand-filled with cap > no action.

Table D-13. Estimates of radiological impacts (radiation dose) from radionuclides in Scenario 1, No Action.

Location		Se-79 dose (mrem/yr)	Sr-90 dose (mrem/yr)	Tc-99 dose (mrem/yr)	Sn-126 dose (mrem/yr)	Cs-135 dose (mrem/yr)	Cs-137 dose (mrem/yr)	Sm-151 dose (mrem/yr)	Eu-154 dose (mrem/yr)	Pu-239 dose (mrem/yr)
Adult resident	Maximum value	2.0E-03	(a)	1.5E-02	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	5495	(a)	805	(a)	(a)	(a)	(a)	(a)	(a)
Child resident	Maximum value	1.0E-03	(a)	1.4E-02	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	5495	(a)	805	(a)	(a)	(a)	(a)	(a)	(a)
Seepline worker	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Intruder	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1-meter well	Maximum value	5.3E+01	4.6E-02	1.5E+02	(a)	(a)	(a)	(a)	(a)	1.0E+04
	Time of maximum (yr)	735	525	315	(a)	(a)	(a)	(a)	(a)	9975
100-meter well	Maximum value	1.9E+01	(a)	7.3E+01	(a)	(a)	(a)	(a)	(a)	2.8E+02
	Time of maximum (yr)	1015	(a)	315	(a)	(a)	(a)	(a)	(a)	9905
Seepline	Maximum value	5.1E-01	(a)	4.7E+00	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	5425	(a)	805	(a)	(a)	(a)	(a)	(a)	(a)
Surface water	Maximum value	(a)	(a)	5.4E-03	(a)	(a)	(a)	(a)	(a)	(a)
(drinking)	Time of maximum (yr)	(a)	(a)	805	(a)	(a)	(a)	(a)	(a)	(a)

a. Radiation dose is less than 0.001 mrem/yr.

Table D-14. Estimates of radiological impacts from Scenario 1, No Action, for comparison against performance objectives.

Location		Beta-gamma dose dose (mrem/yr)	Total dose (mrem/yr)	Pu-239 concentration (pCi/L)	Lifetime risk
Adult resident	Maximum value	N/A	1.5E-02	N/A	3.2E-07
	Time of maximum (yr)	N/A	805	N/A	
Child resident	Maximum value	N/A	1.4E-02	N/A	9.9E-08
	Time of maximum (yr)	N/A	805	N/A	
Seepline worker	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
Intruder	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
1-meter well	Maximum value	1.5E+02	1.0E+04	4.0E+03	2.3E-01
	Time of maximum (yr)	315	9975	9975	
100-meter well	Maximum value	7.3E+01	2.8E+02	1.1E+02	6.2E-03
	Time of maximum (yr)	315	9975	9905	
Seepline	Maximum Value	4.7E+00	4.7E+00	4.5E-23	1.0E-04
	Time of maximum (yr)	805	805	9975	
Surface water (drinking)	Maximum value	5.4E-03	5.4E-03	0.0E+00	1.2E-07
	Time of maximum (yr)	805	805	35	

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a. Radiation dose is less than 0.001 mrem/yr.

b. Lifetime risk is less than 1×10^{-10}.

Table D-15. Estimates of concentrations of nonradiological constituents from Scenario 1, No Action, for comparison against performance objectives.

Receptor		Iron	Manganese	Nickel	Aluminum	Chromium	Mercury	Silver	Copper	Zirconium	Nitrate	Phosphate	Chloride	Fluoride	Lead
1-meter well	Maximum concentration (mg/L)	2.3E+00	2.2E-01	(a)	(a)	1.8E-02	(a)	3.0E-01	5.2E-03	1.5E-02	2.1E+02	5.0E-03	1.4E+00	5.1E-01	(a)
	Time of maximum (yr)	1785	1925	(a)	(a)	2065	(a)	175	4935	5915	105	5775	105	105	(a)
100-meter well	Maximum concentration (mg/L)	8.3E-01	8.1E-02	(a)	(a)	6.5E-03	(a)	1.7E-01	1.9E-03	5.3E-03	1.2E+02	1.8E-03	8.3E-01	3.0E-01	(a)
	Time of maximum (yr)	2765	2975	(a)	(a)	3115	(a)	175	7385	9135	105	8435	105	105	(a)
Seepline	Maximum concentration (mg/L)	6.7E-03	3.8E-04	(a)	(a)	2.7E-05	(a)	6.9E-03	(a)	(a)	1.1E+01	(a)	7.3E-02	2.6E-02	(a)
	Time of maximum (yr)	9975	9975	(a)	(a)	9975	(a)	665	(a)	(a)	245	(a)	245	245	(a)
Surface water	Maximum concentration (mg/L)	7.1E-06	(a)	(a)	(a)	(a)	(a)	7.8E-06	(a)	(a)	1.1E-02	(a)	7.7E-05	2.8E-05	(a)
	Time of maximum (yr)	9975	(a)	(a)	(a)	(a)	(a)	735	(a)	(a)	245	(a)	245	245	(a)

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

Table D-16. Estimates of radiological impacts (radiation dose) from radionuclides in Scenario 2, Grout filled without cover.

Location		Se-79 dose (mrem/yr)	Sr-90 dose (mrem/yr)	Tc-99 dose (mrem/yr)	Sn-126 dose (mrem/yr)	Cs-135 dose (mrem/yr)	Cs-137 dose (mrem/yr)	Sm-151 dose (mrem/yr)	Eu-154 dose (mrem/yr)	Pu-239 dose (mrem/yr)
Adult resident	Maximum value	1.8E-03	(a)	7.5E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6545	(a)	2485	(a)	(a)	(a)	(a)	(a)	(a)
Child resident	Maximum value	(a)	(a)	6.9E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	2485	(a)	(a)	(a)	(a)	(a)	(a)
Seepline worker	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Intruder	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1-meter well	Maximum value	7.0E+01	(a)	5.3E+01	(a)	1.2E-03	(a)	(a)	(a)	1.2E-01
	Time of maximum (yr)	1645	(a)	1995	(a)	9975	(a)	(a)	(a)	9975
100-meter well	Maximum value	2.6E+01	(a)	2.8E+01	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	1995	(a)	1995	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Maximum value	6.0E-01	(a)	3.1E+00	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6335	(a)	2485	(a)	(a)	(a)	(a)	(a)	(a)
Surface water (drinking)	Maximum value	(a)	(a)	2.8E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	2485	(a)	(a)	(a)	(a)	(a)	(a)

a. Radiation dose is less than 0.001 mrem/yr.

Table D-17. Estimates of radiological impacts from Scenario 2, Grout filled without cover for comparison against performance objectives.

Location		Beta-Gamma dose dose (mrem/yr)	Total dose (mrem/yr)	Pu-239 concentration (pCi/L)	Lifetime risk
Adult resident	Maximum value	N/A	7.5E-03	N/A	1.6E-07
	Time of maximum (yr)	N/A	2625	N/A	
Child resident	Maximum value	N/A	6.9E-03	N/A	5.0E-08
	Time of maximum (yr)	N/A	2625	N/A	
Seepline worker	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
Intruder	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
1-meter well	Maximum value	1.0E+02	1.0E+02	4.5E-02	2.3E-03
	Time of maximum (yr)	1785	1785	9975	
100-meter well	Maximum value	5.4E+01	5.4E+01	8.0E-05	1.2E-03
	Time of maximum (yr)	1995	1995	9975	
Seepline	Maximum value	3.1E+00	3.1E+00	0.0E+00	6.8E-05
	Time of maximum (yr)	2555	2555	35	
Surface water (drinking)	Maximum value	2.8E-03	2.8E-03	0.0E+00	6.1E-08
	Time of maximum (yr)	2625	2625	35	

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a. Radiation dose is less than 0.001 mrem/yr.

b. Lifetime risk is less than 1 x 10^{-10}.

Table D-18. Estimates of concentrations of nonradiological constituents from Scenario 2, Grout filled without cover for comparison against performance objectives.

Receptor		Iron	Manganese	Nickel	Aluminum	Chromium	Mercury	Silver	Copper	Zirconium	Nitrate	Phosphate	Chloride	Fluoride	Lead
1-meter well	Maximum concentration (mg/L)	3.2E+00	3.4E-01	(a)	(a)	2.5E-02	(a)	2.6E-01	7.5E-03	1.7E-02	2.2E+02	7.2E-03	2.4E+00	5.4E-01	(a)
	Time of maximum (yr)	2835	3185	(a)	(a)	2975	(a)	1085	6055	9975	1015	6965	1015	1015	(a)
100-meter well	Maximum concentration (mg/L)	1.2E+00	1.2E-01	(a)	(a)	9.6E-03	(a)	1.7E-01	2.8E-03	1.3E-03	1.2E+02	2.7E-03	1.1E+00	2.8E-01	(a)
	Time of maximum (yr)	3675	3885	(a)	(a)	4165	(a)	1085	8505	9905	1015	9905	1015	1015	(a)
Seepline	Maximum concentration (mg/L)	4.4E-03	2.3E-04	(a)	(a)	1.6E-05	(a)	4.8E-03	(a)	(a)	5.8E+00	(a)	6.8E-02	1.4E-02	(a)
	Time of maximum (yr)	9975	9975	(a)	(a)	9975	(a)	1575	(a)	(a)	1155	(a)	1225	1155	(a)
Surface water	Maximum concentration (mg/L)	3.7E-06	(a)	(a)	(a)	(a)	(a)	4.2E-06	(a)	(a)	5.0E-03	(a)	6.1E-05	1.2E-05	(a)
	Time of maximum (yr)	9975	(a)	(a)	(a)	(a)	(a)	1575	(a)	(a)	1155	(a)	1225	1155	(a)

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

Table D-19. Estimates of radiological impacts (radiation dose) from radionuclides in Scenario 3, Grout filled with cover.

Location		Se-79 dose (mrem/yr)	Sr-90 dose (mrem/yr)	Tc-99 dose (mrem/yr)	Sn-126 dose (mrem/yr)	Cs-135 dose (mrem/yr)	Cs-137 dose (mrem/yr)	Sm-151 dose (mrem/yr)	Eu-154 dose (mrem/yr)	Pu-239 dose (mrem/yr)
Adult resident	Maximum value	1.7E-03	(a)	7.5E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6895	(a)	2975	(a)	(a)	(a)	(a)	(a)	(a)
Child resident	Maximum value	(a)	(a)	6.9E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	2975	(a)	(a)	(a)	(a)	(a)	(a)
Seepline worker	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Intruder	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1-meter well	Maximum value	6.4E+01	(a)	5.3E+01	(a)	1.0E-03	(a)	(a)	(a)	5.9E-02
	Time of maximum (yr)	2135	(a)	2485	(a)	9905	(a)	(a)	(a)	9975
100-meter well	Maximum value	2.5E+01	(a)	2.8E+01	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	2485	(a)	2485	(a)	(a)	(a)	(a)	(a)	(a)
Seepline	Maximum value	5.8E-01	(a)	3.1E+00	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6755	(a)	2975	(a)	(a)	(a)	(a)	(a)	(a)
Surface water	Maximum value	(a)	(a)	2.8E-03	(a)	(a)	(a)	(a)	(a)	(a)
(drinking)	Time of maximum (yr)	(a)	(a)	2975	(a)	(a)	(a)	(a)	(a)	(a)

a. Radiation dose is less than 0.001 mrem/yr.

Table D-20. Estimates of radiological impacts from Scenario 3, Grout filled with cover for comparison against performance objectives.

Location		Beta-Gamma dose dose (mrem/yr)	Total dose (mrem/yr)	Pu-239 concentration (pCi/L)	Lifetime risk
Adult resident	Maximum value	N/A	7.5E-03	N/A	1.6E-07
	Time of maximum (yr)	N/A	3115	N/A	
Child resident	Maximum value	N/A	6.9E-03	N/A	5.0E-08
	Time of maximum (yr)	N/A	3115	N/A	
Seepline worker	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
Intruder	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
1-meter well	Maximum value	1.0E+02	1.0E+02	2.3E-02	2.2E-03
	Time of maximum (yr)	2275	2275	9975	
100-meter well	Maximum value	5.3E+01	5.3E+01	2.4E-05	1.2E-03
	Time of maximum (yr)	2485	2485	9975	
Seepline	Maximum value	3.1E+00	3.1E+00	0.0E+00	6.8E-05
	Time of maximum (yr)	3045	3045	35	
Surface water (drinking)	Maximum value	2.8E-03	2.8E-03	0.0E+00	6.1E-08
	Time of maximum (yr)	3115	3115	35	

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a. Radiation dose is less than 0.001 mrem/yr.

b. Lifetime risk is less than 1×10^{-10}.

Table D-21. Estimates of concentrations of nonradiological constituents from Scenario 3, Grout filled with cover for comparison against performance objectives.

Location		Iron	Manganese	Nickel	Aluminum	Chromium	Mercury	Silver	Copper	Zirconium	Nitrate	Phosphate	Chloride	Fluoride	Lead
1-meter well	Maximum concentration (mg/L)	3.1E+00	3.3E-01	(a)	(a)	2.5E-02	(a)	2.5E-01	7.5E-03	1.4E-02	2.0E+02	7.2E-03	2.3E+00	5.0E-01	(a)
	Time of maximum (yr)	3325	3535	(a)	(a)	3535	(a)	1575	6615	9975	1505	7665	1505	1505	(a)
100-meter well	Maximum concentration (mg/L)	1.2E+00	1.2E-01	(a)	(a)	9.4E-03	(a)	1.6E-01	2.8E-03	8.1E-04	1.1E+02	2.5E-03	1.0E+00	2.6E-01	(a)
	Time of maximum (yr)	4235	4375	(a)	(a)	4725	(a)	1575	8995	9975	1505	9765	1505	1505	(a)
Seepline	Maximum concentration (mg/L)	3.0E-03	1.5E-04	(a)	(a)	9.7E-06	(a)	4.3E-03	(a)	(a)	5.2E+00	(a)	6.4E-02	1.3E-02	(a)
	Time of maximum (yr)	9975	9975	(a)	(a)	9975	(a)	2065	(a)	(a)	1645	(a)	1715	1645	(a)
Surface water	Maximum concentration (mg/L)	2.4E-06	(a)	(a)	(a)	(a)	(a)	3.8E-06	(a)	(a)	4.6E-03	(a)	5.8E-05	1.1E-05	(a)
	Time of maximum (yr)	9975	(a)	(a)	(a)	(a)	(a)	2065	(a)	(a)	1645	(a)	1715	1645	(a)

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

Table D-22. Estimates of radiological impacts (radiation dose) from radionuclides in Scenario 4, Sand filled with cover.

Location		Se-79 dose (mrem/yr)	SR-90 dose (mrem/yr)	Tc-99 dose (mrem/yr)	Sn-126 dose (mrem/yr)	Cs-135 dose (mrem/yr)	Cs-137 dose (mrem/yr)	Sm-151 dose (mrem/yr)	EU-154 dose (mrem/yr)	Pu-239 dose (mrem/yr)
Adult resident	Maximum value	1.9E-03	(a)	9.8E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6055	(a)	1575	(a)	(a)	(a)	(a)	(a)	(a)
Child resident	Maximum value	1.0E-03	(a)	9.0E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	6055	(a)	1575	(a)	(a)	(a)	(a)	(a)	(a)
Seepline worker	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Intruder	Maximum value	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
1-meter well	Maximum value	7.0E+01	(a)	8.5E+02	(a)	1.2E-03	(a)	(a)	(a)	1.2E+03
	Time of maximum (yr)	1225	(a)	315	(a)	9975	(a)	(a)	(a)	9975
100-meter well	Maximum value	2.8E+01	(a)	4.6E+01	(a)	(a)	(a)	(a)	(a)	3.4E+00
	Time of maximum (yr)	1645	(a)	1085	(a)	(a)	(a)	(a)	(a)	9975
Seepline	Maximum value	6.4E-01	(a)	4.1E+00	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	5775	(a)	1575	(a)	(a)	(a)	(a)	(a)	(a)
Surface water (drinking)	Maximum value	(a)	(a)	3.6E-03	(a)	(a)	(a)	(a)	(a)	(a)
	Time of maximum (yr)	(a)	(a)	1575	(a)	(a)	(a)	(a)	(a)	(a)

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a. Radiation dose is less than 0.001 mrem/yr.

Table D-23. Estimates of radiological impacts from Scenario 4, Sand filled with cover for comparison against performance objectives.

Location		Beta-Gamma dose dose (mrem/yr)	Total dose (mrem/yr)	Pu-239 concentration (pCi/L)	Lifetime risk
Adult resident	Maximumvalue	N/A	9.8E-03	N/A	2.1E-07
	Time of maximum (yr)	N/A	1645	N/A	
Child resident	Maximum value	N/A	9.0E-03	N/A	6.6E-08
	Time of maximum (yr)	N/A	1645	N/A	
Seepline worker	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
Intruder	Maximum value	N/A	(a)	N/A	(b)
	Time of maximum (yr)	N/A	(a)	N/A	
1-meter well	Maximum value	8.5E+02	1.2E+03	4.6E+02	2.6E-02
	Time of maximum (yr)	315	9975	9975	
100-meter well	Maximum value	4.9E+01	4.9E+01	1.3E+00	1.1E-03
	Time of maximum (yr)	1085	1085	9975	
Seepline	Maximum value	4.1E+00	4.1E+00	5.7E-29	8.9E-05
	Time of maximum (yr)	1645	1645	9975	
Surface water (drinking)	Maximum value	3.6E-03	3.6E-03	0.0E+00	7.9E-08
	Time of maximum (yr)	1645	1645	35	

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a. Radiation dose is less than 0.001 mrem/yr.

b. Lifetime risk is less than 1 x 10^{-10}.

Table D-24. Estimates of concentrations of nonradiological constituents from Scenario 4, Sand filled with cover for comparison against performance objectives.

Location		Iron	Manganese	Nickel	Aluminum	Chromium	Mercury	Silver	Copper	Zirconium	Nitrate	Phosphate	Chloride	Fluoride	Lead
1-meter well	Maximum concentration (mg/L)	3.4E+00	3.3E-01	(a)	(a)	2.9E-02	(a)	6.5E-01	7.8E-03	2.3E-02	2.6E+02	7.3E-03	1.8E+00	6.3E-01	(a)
	Time of maximum (yr)	2485	2485	(a)	(a)	2905	(a)	595	5915	7315	525	6685	525	525	(a)
100-meter well	Maximum concentration (mg/L)	1.3E+00	1.2E-01	(a)	(a)	1.0E-02	(a)	2.4E-01	2.9E-03	7.8E-03	1.3E+02	2.7E-03	9.2E-01	3.3E-01	(a)
	Time of maximum (yr)	3325	3395	(a)	(a)	3815	(a)	665	8575	9975	525	9415	525	525	(a)
Seepline	Maximum concentration (mg/L)	6.5E-03	3.5E-04	(a)	(a)	1.8E-05	(a)	8.6E-03	(a)	(a)	6.7E+00	(a)	4.6E-02	1.6E-02	(a)
	Time of maximum (yr)	9975	9975	(a)	(a)	9975	(a)	1155	(a)	(a)	665	(a)	665	665	(a)
Surface water	Maximum concentration (mg/L)	5.4E-06	(a)	(a)	(a)	(a)	(a)	7.4E-06	(a)	(a)	5.9E-03	(a)	4.0E-05	1.4E-05	(a)
	Time of maximum (yr)	9975	(a)	(a)	(a)	(a)	(a)	1155	(a)	(a)	665	(a)	665	665	(a)

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

Table D-25. Results of terrestrial risk assessment.

	No Action			Grout with Cover		
Analyte	Maximum mink	HQ shrew	Time[a] of maximum HQ	Maximum mink	HQ shrew	Time of maximum HQ
Manganese	1.4E-04	2.5E-04	9,975	5.5E-05	9.9E-05	9,975
Nickel	(b)	(b)	NA	(b)	(b)	NA
Aluminum	(b)	(b)	NA	(b)	(b)	NA
Chromium	5.9E-04	1.1E-03	9,975	2.1E-04	3.8E-04	9,975
Lead	(b)	(b)	NA	(b)	(b)	NA
Mercury	(b)	(b)	NA	(b)	(b)	NA
Silver	2.8E-01	5.1E-01	665-735	1.7E-01	3.2E-01	2,065
Copper	5.8E-12	1.1E-11	9,975	1.7E-13	3.2E-13	9,975
Zirconium	1.5E-10	2.8E-10	9,975	1.6E-18	2.9E-18	9,975
Fluoride	1.1E-01	2.5E-01	245	5.4E-02	1.3E-01	1,645

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a. Years after closure.
b. HQ is less than ~ 1 x 10^{-35}.
NA = Not Applicable.

D.4.2.2 Radiological Analysis

Calculated absorbed doses to the referenced organisms are provided below. All calculated doses are below the regulatory limit of 365,000 mrad per year (365 rad per year).

Scenario	Sunfish dose (mrad/yr)	Shrew dose (mrad/yr)	Mink dose (mrad/yr)
Grout fill with cap	0.015	418	45
Grout fill without cap	0.015	417	44
Sand fill with cap	0.019	547	57
No action	0.028	633	66

D.4.3 SUMMARY OF RESULTS

Radiological doses at the seepline (the point of compliance) were calculated to be as high as 4.7 mrem/year (for No Action) and as low as 3.1 mrem/year (for Scenario 3, Grout filled with Cover). Essentially all of this dose is due to selenium-79 and technetium-99 because the other radionuclides either decay en route or do not migrate at a sufficient rate to reach the seepline within the 10,000-year period of analysis. The calculated gross alpha concentration at the seepline demonstrates that appreciable amounts of plutonium-239 do not arrive at the seepline within the 10,000-year period of analysis, regardless of the analyzed scenario. For nonradiological constituents, nitrate is the only contaminant to reach the seepline in quantities that could exceed the maximum contaminant level.

These results apply to Tanks 17 through 20 in the F-Area Tank Farm. In accordance with the methodology presented in Chapter 6 and illustrated in Appendix E of this closure plan, these results will be used in conjunction with results from modeling of other sources in the groundwater transport segment to determine if overall performance objectives would be satisfied.

D.5 Uncertainty/Sensitivity Analysis

D.5.1 HUMAN HEALTH ANALYSIS

The estimates of impacts for the various closure scenarios depend upon several factors. However, on inspection of the results in Section D.5.1, the maximum doses and concentrations do not vary dramatically and usually vary by less than an order of magnitude. (The major exception to this observation is the case of Pu-239, which is limited by solubility in Scenarios 2 and 3.) This is primarily because most of the radionuclides are long-lived; that is, the amount of "hold-up" provided by the lower infiltration rates and/or greater K_d values has little effect on the amount of material if the half-life of the material is long compared to the transport time. The shorter-lived nuclides (e.g., Sr-90, Cs-137) do show some differences based on the initial infiltration rate and the failure time. For longer-lived radionuclides, though, the primary effect of different infiltration rates and failure times is the shifting of the time of maximum dose/concentration.

Other parameters affect the estimate of impacts:

- **Source term:** The amount of material in the tanks directly affects the concentrations at any given location, unless the amount of material is so great that the solubility limit is exceeded. Once the solubility limit is exceeded, greater amounts of source material do not necessarily result in increased concentrations at receptor locations. In this modeling effort, only Pu-239 was assumed to be limited by solubility for the scenarios where grout is used to fill the tanks.

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

- **Strata thickness:** The thickness of the strata between the contaminated region and the aquifer does not necessarily reduce the concentration so much as it slows the progress toward the aquifer. For shorter-lived radionuclides, extra time granted by thicker strata can decrease the activity before they reach the aquifer. For longer-lived radionuclides, however, the maximum concentration would not necessarily be significantly changed, but the time at which the maximum occurs would be moved out farther in time.

- **Dispersion coefficient:** The dispersion coefficient affects the degree to which the plume "spreads" as it moves toward receptor locations. Less dispersion would understandably cause greater concentrations to be calculated for a given point, while greater dispersion would result in lower concentration estimates.

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

As described in Sections D.1 and D.2, a number of conservative assumptions were included as part of this modeling effort. This has the effect of providing dose/concentration estimates that may be greater than values that might actually be measured. The relative lack of sensitivity of the magnitude of the results to many of the parameters listed above, however, suggests that the estimates depend on a limited few key parameters, such as source term, assumed strata layering, and the amount of dispersion. Therefore, the impact estimates in this appendix could be high by an order of magnitude (or more). That is, it is expected that the "true" value is less than the estimates presented in this document because of the conservative assumptions. The uncertainties associated with this modeling are comparable to those typically performed elsewhere to estimate potential environmental impacts. This modeling underwent an independent sensitivity and uncertainty analysis by Sandia National Laboratory. An evaluation of the Sandia analysis (Cook 1996) concluded that the results were "... similar enough to conclude that the problem has been addressed properly."

D.5.2 ECOLOGICAL RISK ASSESSMENT

D.5.2.1 Uncertainty in the Toxicological Analysis

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

The relationship between seep area and home range has already been mentioned; the lack of correction for home range is likely to overestimate risk to an individual shrew by a factor of 2 and to an individual mink by a factor greater than 10.

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

Because toxicity data is mostly limited to individual responses, a risk assessment is usually limited to the probability of risk to an individual. This makes the evaluation of risk to populations, communities, and ecosystems a speculative and uncertain undertaking, even though characterization of risks to populations is the typical goal of an ecological risk assessment. In the case of the seep, it is reasonable to assume that terrestrial effects will be limited to this area, because the contaminants have not been shown to bioaccumulate in terrestrial systems. Surface water is the only likely pathway for contaminants to exit the seep area. (Mercury is known to accumulate in aquatic food chains, but no mercury or lead is transported to the seepline during the 10,000-year modeled time period.)

D.6 References

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

ATSDR (Agency for Toxic Substances and Disease Registry), 1990, *Draft Toxicological Profile for Aluminum*, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, Atlanta, GA, October.

ATSDR (Agency for Toxic Substances and Disease Registry), 1991, *Draft Toxicological Profile for Chromium*, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, Atlanta, GA, October.

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

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

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

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

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

Butcher, B. T., 1996, "Consideration of Leakance into Congaree Aquifer on Tank Closure Options Analysis (U)," Interoffice Memorandum to J. Newman, Westinghouse Savannah River Company, Aiken, South Carolina, May 13.

Cook, J., 1996, "Evaluation of Computer Modeling for High Level Waste Tank Closure," Interoffice Memorandum to B. T. Butcher, Westinghouse Savannah River Company, Aiken, South Carolina, May 17.

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, SC.

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

d'Entremont, P., 1996b, "Chemical Source Terms for Tanks 17-20," Interoffice Memorandum to D. Bignell and J. Newman, Westinghouse Savannah River Company, Aiken, South Carolina, May 23.

Droppo, J. G., et al., 1995, *Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance: Guidance for Evaluating MEPAS Parameters for Version 3.1,* PNL-10523, Pacific Northwest Laboratory, Richland, Washington.

EPA (Environmental Protection Agency), 1993, *Wildlife Exposure Factors Handbook*, EPA/600/R-93/187, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

Hamby, D. M.,1993, *Soil Concentration Guidelines for the Savannah River Site Using the DOE/RESRAD Methodology (U),* WSRC-TC-93-304, Savannah River Technology Center, Westinghouse Savannah River Company, Aiken, South Carolina.

Hilderbrand, D. C., et al., 1973, "Effect of Lead Acetate on Reproduction," *American Journal of Obstetrics and Gynecology*, Volume 115, pp. 1058-1065. (cos)

ICRP (International Commission on Radiological Protection), 1959, *Recommendation of the International Commission on Radiological Protection,* International Commission on Radiological Protection, Publication No. 2, Pergamon Press, New York.

ICRP (International Commission on Radiological Protection), 1975, *Report of the Task Group on Reference Man,* International Commission on Radiological Protection, Publication No. 23, Pergamon Press, New York.

Jorgensen, S. E., S. N. Nielsen, and L. A. Jorgensen, 1991, *Handbook of Ecological Parameters and Ecotoxicology*, Elsevier Science Publishers D.V., New York, NY.

Laskey, J. W., G. L. Rehnberg, and J. F. Hein, 1982, "Effects of Chronic Manganese (Mn_3O_4) Exposure on Selected Reproductive Parameters in Rats," *Journal of Toxicology Environmental Health*, 9: pp. 677-687.

NRC (U.S. Nuclear Regulatory Commission), 1977, *Calculation of Annual Dose to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Regulatory Guide 1.109*, Nuclear Regulatory Commission, Washington, D.C.

Opresko, D. M., B. E. Sample, and G. W. Suter II, 1994, *Toxicological Benchmarks for Wildlife*: 1994 Revision, ES/ER/TM-86/R1, Oak Ridge National Laboratory, Oak Ridge, TN.

Rungby, J. and G. Danscher, 1984, "Hypoactivity in Silver Exposed Mice," *Acta Pharmacol et Toxicol.*, 55: pp. 398-401.

WSRC (Westinghouse Savannah River Company), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility (U),* WSRC-RP-92-1360, Savannah River Site, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1993, *1992 Renewal Application for a RCRA Part B Permit, Volume IV, F-Area HWMF Postclosure*, WSRC-IM-91-53, Savannah River Site, Westinghouse Savannah River Company, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1994, *Radiological Performance Assessment for the E-Area Vaults Disposal Facility (U),* WSRC-RP-94-218, Savannah River Site, Westinghouse Savannah River Company, Aiken, South Carolina.

Yu, C., et al., 1993, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil,* ANL/EAIS-8, Environmental Assessment and Information Sciences Division, Argonne National Laboratory, Argonne, Illinois.

APPENDIX E.

EXAMPLE OF METHODOLOGY FOR ESTABLISHING TANK-SPECIFIC PERFORMANCE OBJECTIVES

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APPENDIX E. EXAMPLE OF METHODOLOGY FOR ESTABLISHING TANK-SPECIFIC PERFORMANCE OBJECTIVES

DOE has developed a method to apportion performance objectives applicable to groundwater in the F- and H-Area Tank Farms at SRS. This appendix is an example of the methodology described in Chapter 6. A preliminary evaluation of environmental pathways and receptors determined that groundwater was the limiting pathway for radionuclides and chemicals of concern to impact receptors. Therefore, this method was developed to apportion performance objectives for the groundwater pathway only. DOE will use this apportionment method to establish tank-specific performance objectives based on post-closure residual contamination after waste removal is completed and design of the closure configuration is identified. The method involves definition of a groundwater transport segment (GTS), identification of HLW tank systems and other nontank sources in the GTS, apportionment of each source based on its contribution to total impacts, and development of adjusted and tank-specific performance objectives.

This example includes the definition of a GTS for Tanks 17 through 20 in the F-Area Tank Farm, identified as GTS-1F. Example tank-specific performance objectives will also be determined for Tank 20.

E.1 Definition of Groundwater Transport Segment

Based on gauging data from the first quarter of 1993, DOE constructed a potentiometric map for the water table aquifer (i.e., Upper Aquifer Zone of Upper Three Runs Aquifer). Flow lines were then constructed with each line normal to potentiometric lines to form a flownet. Based on this construct, the groundwater divide was determined. However, due to the seasonal fluctuation of the divide, all groundwater was assumed to migrate toward Fourmile Branch. This is a conservative assumption because Fourmile Branch has a lower flow rate that results in less dilution for downstream receptors.

HLW Tanks 17 through 20, that were targeted for closure were identified and flow lines were constructed approximately parallel to the groundwater flow beneath the tanks, each flow line being tangent to the two sides of the tank area. These lines were extended upgradient and downgradient to the groundwater divide and the seepline adjacent to Fourmile Branch, respectively. Figure E-1 shows GTS-1F, which also includes Tank 44. Contributions from this tank will be discussed in Section E.5.

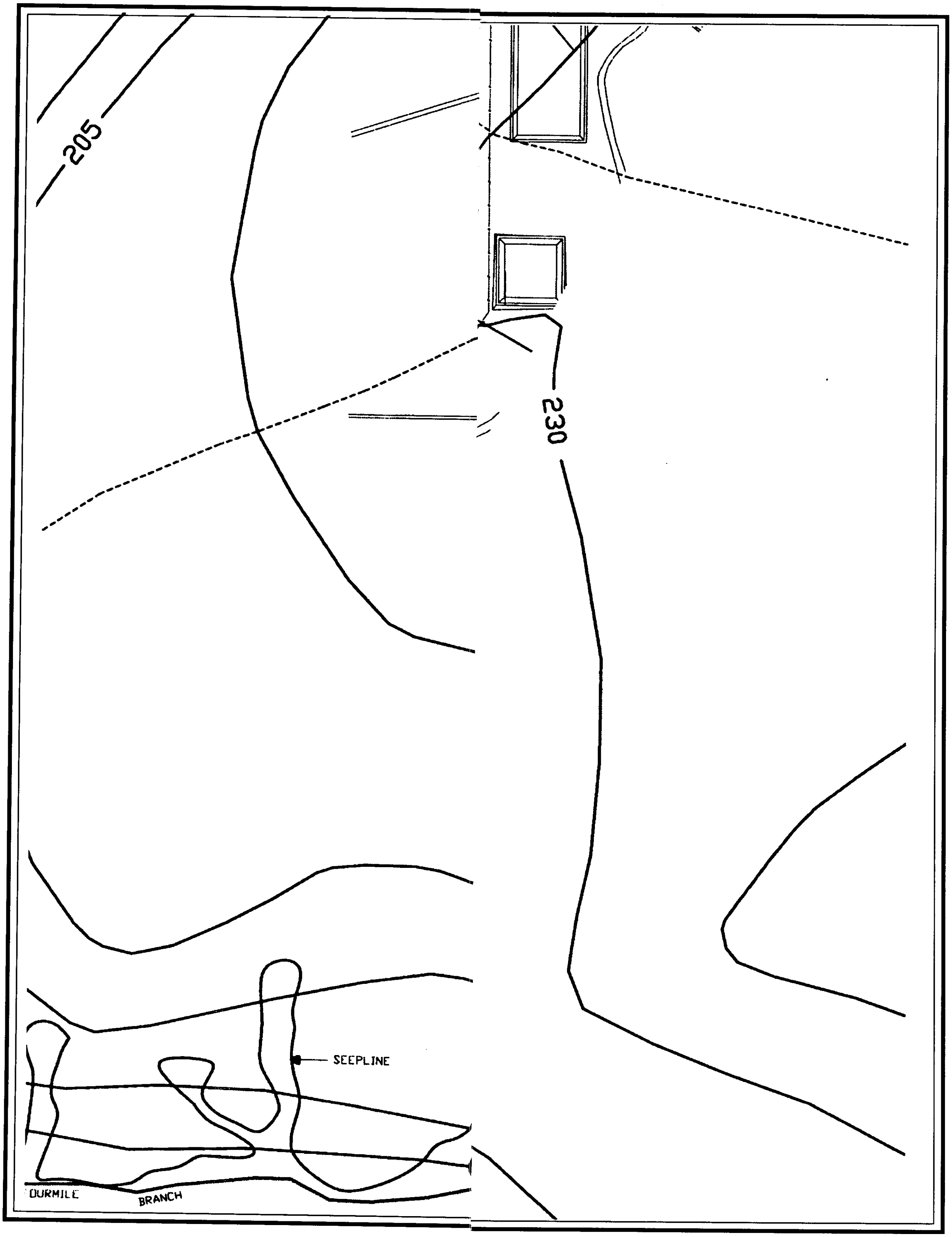

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Figure E-1. Definition of Groundwater Transport Segment.

E.2 Source Identification

DOE identified all tank systems and other sources within GTS-1F. The evaluation identified the following sites with potential to impact GTS-1F:

- Eighty percent of F-Area Seepage Basins
- One hundred percent of HLW Tanks 17 through 20
- One hundred percent of HLW Tank 44

Only a small portion of the F-Area Seepage Basins coincided with GTS-1F; however, for conservatism, 80 percent was considered to lie within GTS-1F.

E.3 Contribution Evaluation

E.3.1 HLW TANK SYSTEMS

Potential environmental impacts from tank systems were evaluated using MEPAS, a fate and transport model described in Appendix D. The following closure scenarios were evaluated to facilitate a decision based on protectiveness to human health and the environment:

- No action
- Reducing grout filled
- Sand filled with infiltration limiting cap
- Reducing grout filled with infiltration limiting cap

These closure scenarios and modeling efforts are discussed in Appendix D. Appendix A of this plan determined that the preferred closure alternative was to fill the tank systems with pumpable self-leveling fill material (grout). Based on this determination, performance objectives were only evaluated for the two grout-filled scenarios.

Tank 44, which is located within GTS-1F, was not modeled with Tanks 17 through 20. This was due to the operational status of the tank, the construction of the tank system, and the extended distance from the water table. A separate MEPAS modeling evaluation was conducted on Tank 44 to assess groundwater impacts at the proposed point of compliance during time periods corresponding to Tanks 17 through 20 concentrations/doses. Because Tank 44 is an active tank, the model was completed with estimated source terms (d'Entremont 1996). The results from the Tank 44 model were then added to the Tanks 17 through 20 results to determine the peak impact time periods for each point of exposure or compliance.

Concentrations and doses were evaluated over time to determine the GTS-1F peaks. These peaks were evaluated for each point of compliance. The results of this evaluation are presented in Section E.5.

E.3.2 F-AREA SEEPAGE BASINS

The time over which contaminants would be released from the F-Area seepage basins was estimated using leach rates calculated in *Environmental Information Document - Estimation of Geochemical Parameters for Assessing Subsurface Transport at the Savannah River Plant* (DPST-85-904 by Looney, Grant, and King 1987). Table 7 of the report gives annual leach rates used for the Waste Management Activities for Groundwater Protection EIS (DOE/EIS-0120). The inverse of the annual leach rate (taken from column entitled "1m Thick," Looney 1987) represents the number of years required for all of a constituent to migrate from the waste zone. For the constituents under investigation for HLW tank closure, values are listed in Table E-1.

Table E-1. Source life determination.

Constituent	Leach Rate (yr^{-1})	Inventory Depletion Time (yr)
Se	9.01×10^{-2}	1.11×10^{1}
Sr	2.94×10^{-2}	3.40×10^{1}
Tc	1.00×10^{0}	1.00×10^{0}
Sn	2.37×10^{-3}	4.22×10^{2}
Cs	4.74×10^{-4}	2.11×10^{3}
Sm	Not in Table 7	---
Eu	Not in Table 7	---
Pu	2.37×10^{-3}	4.22×10^{2}
Pb	2.37×10^{-3}	4.22×10^{2}
Hg	2.37×10^{-5}	4.22×10^{4}
NO_3	1.00×10^{-0} (same as ^3H)	1.00×10^{0}
Cr	5.95×10^{-3}	1.68×10^{2}

Table E-1 shows that all constituents, except for mercury, will leach from the seepage basins within approximately 2,000 years.

DOE also evaluated a fate and transport model (Killian et al. 1987) of the F-Area seepage basins. This model utilized the PATH RAE computer code and determined concentrations of various constituents of concern at points of compliance for 1,000 years. Based on this model and the closure actions completed at F-Area seepage basins, SRS has determined that none of the constituents of concern will be detected at the seepline after 400 years. Because the GTS-1F constituents of concern all peak at times greater than 400 years, no contribution from the seepage basins will be attributed at the seepline within the evaluation of the peaks for Tanks 17 through 20 and Tank 44.

E.4 Adjusted Performance Objectives

DOE evaluated performance standards to determine the overall performance objectives. Table E-2 lists performance objectives at the seepline and stream which are the points of exposure.

Table E-2. Seepline and stream performance objectives for GTS-1F.

	Units	Seepline	Stream
Radiological			
Beta-Gamma Dose	mrem/y	4	4
Alpha Conc.	pCi/l	15	15
Total Dose[a]	mrem/y	4	4
Non-Radiological			
Manganese	mg/l	-	-
Nickel	mg/l	0.1	0.088
Aluminum	mg/l	-	0.087
Chromium (III)	mg/l	0.1	0.120
Chromium (VI)	mg/l	0.1	0.011
Mercury	mg/l	0.002	1.20E-05
Silver	mg/l	0.05	0.0012
Copper	mg/l	1.3	0.0065
Zirconium	mg/l	-	-
Nitrate (as N)	mg/l	10	-
Nitrite (as N)	mg/l	1	-
Phosphate	mg/l	-	-
Chlorate	mg/l	-	-
Fluoride	mg/l	4.0	-
Lead	mg/l	0.015	0.0013
Boron	mg/l	20	-
Uranium	mg/l	-	-

---

a. Total dose (combined alpha and beta-gamma radioactivity) limit used for comparison with performance standards in Appendix C.

DOE calculated adjusted performance objectives based on the contributions of sources within the GTS upgradient from the seepline. Based on the source identification, the sources used to calculate adjusted performance objectives are the HLW tank systems and F-Area seepage basins.

As discussed above, due to differences in arrival and peak times, the seepage basins are assumed not to contribute constituents during the GTS-1F peaks at the seepline. Therefore, the adjusted performance objectives for all points of compliance are equal to the overall performance objectives identified in Table E-2. The following equation expresses this determination:

$$PO_a = PO - C_{OS}$$

where: PO_a = Adjusted Performance Objective

PO = Overall Performance Objective

C_{OS} = Contribution of Other Sources at Peak Contribution from the HLW Tank System

Since $C_{OS} = 0$ (zero):

$$PO_a = PO - 0 \text{ (zero)}$$

$$PO_a = PO$$

The adjusted performance objective is analogous with the performance objective for all tank systems within the GTS-1F.

E.5 Development of Tank-Specific Performance Objectives

Tanks 17 through 20 (Type IV) and Tank 44 (Type III) have different construction attributes (see Chapter 2) and are different distances (2.85 feet and 20 feet, respectively) from the water-bearing (saturated) zone and compliance points. Based on these factors, apportionment of the performance objectives based strictly on source terms is not valid. This is due to the different source to dose relationships between Tanks 17 through 20 and Tank 44 established by the fate and transport model, which considers the tank construction and the geologic setting. Therefore, the adjusted performance objective was subdivided into performance objectives for Tanks 17 through 20 and Tank 44.

The performance objectives for Tanks 17 through 20 are derived by deducting the contributions of the peak doses or concentrations from the adjusted performance objectives (which for this example are equal to the overall performance objectives). Each constituent peak is examined individually so that the most limiting peak is selected. This peak information is extracted from the MEPAS modeling results.

E.5.1 RADIOLOGICAL CONSTITUENTS

The performance objectives (based on absorbed dose limits) for radiological constituents are additive for different radionuclides. Therefore, the dose PO apportionment must consider the contribution of each radionuclide at the time when the total peak from all radionuclides reaches each point of exposure. This is done by examining the MEPAS output results for each radionuclide and determining the fraction of the total peak attributable to each radionuclide. These results are listed for 1 meter, 100 meters, and seepline locations in Tables E-3, E-4, and E-5, respectively.

To determine the Tanks 17 through 20 PO, the PO for Tank 44 (because it is contained within GTS-1F) is subtracted from Tanks 17 through 20 adjusted PO. For example, as listed in Table E-3, approximately 85 percent of the peak dose (at 1,365 years postclosure for Scenario 2) will result from contaminants leaching from Tank 44. Therefore, the PO for Tanks 17 through 20 will be reduced by 85 percent to assure the overall PO at the seepline is not exceeded. However, as listed in Table E-5, only 0.004 percent of the seepline peak dose at 2,555 years for Scenario 2 is due to Tank 44 contaminants and, therefore, the PO for Tanks 17 through 20 will only be reduced by 0.004 percent (a factor of 3.9×10^{-5}). Table E-5 shows that the effects of Tank 44 are negligible at the seepline and, therefore, the Tanks 17 through 20 PO is effectively equal to the overall seepline PO. This evaluation will be performed for each radionuclide distribution and will be reevaluated each time the radionuclide distributions change due to waste removal activities or improved characterization data. This calculation is expressed simply by the following equation:

$$PO_{17\text{-}20} = PO_a - PO_{44}$$

at the seepline, where PO_{44} is approximately equal to 0, therefore,

$$PO_{17\text{-}20} = PO_a$$

To determine the PO for Tank 20, a similar evaluation is performed to determine the fraction of the total Tanks 17 through 20 impact attributable to Tank 20. This evaluation is performed on a radionuclide-specific basis and is dependent on the ultimate distribution of radionuclides remaining after closure.

Table E-3. 1 meter location radiological peak analysis for Scenarios 2 and 3.[b]

	1 Meter Beta-Gamma Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Filled With Cap		
Peak time (yr)	1365			1855		
PO_a	4 mrem/yr			4 mrem/y		
	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)
Se-79	2.73E+01	3.05E+02	3.32E+02	2.54E+01	2.99E+02	3.24E+02
Sr-90	1.45E-09	1.01E-08	1.16E-08	0	(a)	(a)
Tc-99	2.56E+01	(a)	2.56E+01	2.67E+01	(a)	2.67E+01
Sn-126	0	0	0	0	0	0
Cs-135	(a)	0	(a)	(a)	(a)	(a)
Cs-137	0	0	0	0	0	0
Sm-151	0	0	0	0	0	0
Eu-154	0	0	0	0	0	0
Np-237	0	0	0	0	0	0
Pu-238	0	0	0	0	0	0
Pu-239	0	0	0	0	0	0
Total	52.92	305.00	357.92	52.10	299.00	351.10
Fraction of Total Dose	0.15	0.85		0.15	0.85	

	1 Meter Alpha Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Filled With Cap		
Peak time (yr)	9975			9975		
PO_a	15 pCi/l			15 pCi/l		
	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)
Pu-239	1.40E-01	1.40E-07	1.40E-01	8.20E-02	(a)	8.20E-02
Fraction of Total Concentration	1.00E+00	1.00E-06		1.00E+00	(a)	

(a) Value is < 10^{-13}.

(b) Sums of the listed values may not equal totals due to rounding.

Table E-4. 100 meter location radiological peak analysis for Scenarios 2 and 3.[b]

	100 Meter Beta-Gamma Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Filled With Cap		
Peak time (yr)	1785			2205		
PO_a	4 mrem/y			4 mrem/y		
	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)
Se-79	2.10E+01	5.21E+01	7.31E+01	1.59E+01	5.85E+01	7.44E+01
Sr-90	(a)	6.85E-13	7.05E-13	(a)	(a)	(a)
Tc-99	1.92E+01	2.13E-06	1.92E+01	1.49E+01	1.17E-07	1.49E+01
Sn-126	0	0	0	0	0	0
Cs-135	(a)	(a)	(a)	(a)	0	(a)
Cs-137	0	0	0	0	0	0
Sm-151	0	0	0	0	0	0
Eu-154	0	0	0	0	0	0
Np-237	0	0	0	0	0	0
Pu-238	0	0	0	0	0	0
Pu-239	0	0	0	0	0	0
Total	40.20	52.10	92.30	30.80	58.50	89.30
Fraction of Total Dose	0.44	0.56		0.34	0.66	
	100 Meter Alpha Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Fillled With Cap		
Peak time (yr)	9975			9975		
PO_a	15 pCi/l			15 pCi/l		
	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)
Pu-239	6.00E-04	3.90E-13	6.00E-04	2.20E-04	(a)	2.20E-04
Fraction of Total Concentration	1.00E+00	6.50E-10		1.00E+00	(a)	

(a) Value is $< 10^{-13}$.

(b) Sums of the listed values may not equal totals due to rounding.

Table E-5. Seepline location radiological peak analysis for Scenarios 2 and 3.[b]

	Seepline Beta-Gamma Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Filled With Cap		
Peak time (yr)	2555			3045		
PO_a	4 mrem/y			4 mrem/y		
	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)	Tanks 17-20 Dose (mrem/yr)	Tank 44 Dose (mrem/yr)	Total Dose (mrem/yr)
Se-79	3.75E-04	7.63E-05	4.51E-04	1.97E-03	7.63E-05	2.05E-03
Sr-90	(a)	0	(a)	0	0	0
Tc-99	3.09	4.37E-05	3.09E+00	3.09	4.37E-05	3.09E+00
Sn-126	0	0	0	0	0	0
Cs-135	0	0	0	0	0	0
Cs-137	0	0	0	0	0	0
Sm-151	0	0	0	0	0	0
Eu-154	0	0	0	0	0	0
Np-237	0	0	0	0	0	0
Pu-238	0	0	0	0	0	0
Pu-239	0	0	0	0	0	0
Total	3.09	1.20E-04	3.09	3.09	1.20E-04	3.09
Fraction of Total Dose	1.00E+00	3.88E-05		1.00E+00	3.88E-05	
	Seepline Alpha Peak					
	Scenario 2 - Grout Filled No Cap			Scenario 3 - Grout Filled With Cap		
Peak time (yr)	9975			9975		
PO_a	15 pCi/l			15 pCi/l		
	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)	Tanks 17-20 Concentration (pCi/l)	Tank 44 Concentration (pCi/l)	Total Concentration (pCi/l)
Pu-239	0	0	0	0	0	0
Fraction of Total Concentration	0	0		0	0	

(a) Value is $< 10^{-13}$.

(b) Sums of the listed values may not equal totals due to rounding.

The first step in this calculation determines the radionuclide weighted PO fraction. This calculation is performed for all residual radionuclides and is expressed by the following equation:

$$RC_1 \text{ PO fraction} = PO_{17\text{-}20} \times RC_1 \text{ fraction of peak dose}$$

where, RC_1 is the first radionuclide. The RC_1 fraction of the peak dose is determined for each radionuclide by examination of the MEPAS output files.

The second step is to determine the fraction of each radionuclide that resides in Tank 20 compared to the total Tanks 17 through 20 residual. This calculation is also performed for each radionuclide and is expressed by the following equation:

$$\frac{RC_1 \text{ Tank 20 Activity}}{RC_1 \text{ Tanks 17 through 20 Activity}} = \text{Fraction of } RC_1 \text{ in Tank 20}$$

The third step determines the radionuclide-specific PO fraction to be apportioned to Tank 20. This calculation is expressed as follows:

$$RC_1PO_{20} = (\text{Fraction of } RC_1 \text{ in Tank 20}) \times (RC_1 \text{ PO Fraction})$$

Once again, the calculation is completed for all radionuclides.

Finally, the cumulative Tank 20 PO is determined by summing the radionuclide-specific PO fractions as given by the following equation:

$$PO_{20} = RC_1PO_{20} + RC_2PO_{20} + RC_3PO_{20} + \ldots\ldots$$

Table E-6 lists the performance objectives for Tank 20 at the seepline and stream.

Table E-6. Seepline performance objectives for Tank 20 (values at other distances provided for comparison purposes).

		Grout Filled - No Cap		Grout Filled - With Cap	
	Units	Seepline	Stream	Seepline	Stream
Radiological					
Beta-gamma dose	mrem/y	0.03 (3.97)	0.03 (3.97)	0.02 (3.98)	0.02 (3.98)
Alpha conc.	pCi/l	0.5 (14.5)	0.5 (14.5)	0.5 (14.5)	0.5 (14.5)
Total dose	mrem/y	0.03 (3.97)	0.03 (3.97)	0.02 (3.98)	0.02 (3.98)
Nonradiological					
Nickel	mg/l	0 (0.1)	0 (0.088)	0 (0.1)	0 (0.088)
Aluminum	mg/l	-	0 (0.087)	-	0 (0.087)
Chromium (VI)	mg/l	0.0035 (0.097)	03.9E-4 (0.011)	0.0034 (0.097)	3.8E-4 (0.011)
Mercury	mg/l	0 (0.002)	0 (1.2E-5)	0 (0.002)	0 (1.2E-5)
Silver	mg/l	1.4E-3 (0.049)	3.5E-5 (0.0012)	1.4E-3 (0.049)	3.3E-5 (0.0012)
Copper	mg/l	0.09 (1.21)	0 (.0065)	0.09 (1.21)	0 (.0065)
Nitrate	mg/l	8.5E-3 (10)	-	8.5E-3 (10)	-
Lead[b]	mg/l	0.0038 (0.011)	3.2E-4 (9.8E-4)	0.0038 (0.011)	3.2E-4 (9.8E-4)
Fluoride	mg/l	0.33 (3.67)	-	0.33 (3.67)	-

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a. Values in parentheses represent POs for the remainder of the GTS-1F tank sources including Tank 44.
b. Values based on assumption that 25 percent of lead is located in Tank 20, and no lead associated with Tank 44.

E.5.2 CHEMICAL CONSTITUENTS

The contribution of Tank 44 to the peaks of nonradiological (chemical) constituents present in Tanks 17 through 20 was evaluated. The results of this evaluation are presented in Tables E-7, E-8, and E-9 for 1 meter, 100 meters, and seepline locations, respectively.

To determine the Tanks 17 through 20 PO, the PO for Tank 44 (since it is contained within GTS-1F) is subtracted from Tanks 17 through 20 adjusted PO. It should be noted that because no non-tank systems with GTS-1F impact the tank system chemical peaks, the adjusted GTS-1F PO is equal to the overall PO. For the 1 meter location, as shown in Table E-6, Tank 44 contributes 92 percent of the total peak for chromium VI. Therefore, at this location, the Tanks 17 through 20 PO would be reduced by 92 percent to assure that the overall PO would not be exceeded during the peak year of 2275 for Scenario 2. Similar reductions in the Tanks 17 through 20 POs would be performed for each constituent that has a PO for each location. This calculation is expressed by the following equation:

$$PO_{17\text{-}20} = PO_a - PO_{44}$$

where,

$$PO_{44} = PO_a \text{ x } (1\text{-Tank 44 fraction of total peak})$$

To determine a chemical constituent performance objective for Tank 20, the Tanks 17 through 20 performance objective is then multiplied by the fraction of that constituent in Tank 20 relative to the total inventory of the constituent in Tanks 17 through 20.

$$PO_{20} = PO_{17-20} \text{ x} \left({}^{\text{Mass}_{20}} \big/ {}_{\text{Mass}_{17-20}} \right)$$

Once again, this apportionment is only performed for chemical constituents that have groundwater performance objectives. The Tank 20 POs are presented in Table E-6.

E.6 Summary

Establishing tank-specific performance objectives using the methodology described above will provide reasonable assurance that the overall performance objectives will not be exceeded due to future closure activities. The method takes credit for the fact that constituents of concern from various areas impact

Table E-7. 1 meter location non-radiological peak analysis for Scenarios 2 and 3.

	1 Meter-Non-Radiological											
Scenario	Scenario 2 - Grout Filled No Cap						Scenario 3 - Grout Filled With Cap					
	Tanks 17-20	Tank 44		Total		PO_a, mg/l	Tanks 17-20	Tank 44		Total		PO_a, mg/l
COC	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.
Iron	1.1	16	0.94	17.1	2065	-	1	16	0.94	17	2555	-
Nickel	2.90E-08	9.30E-08	0.76	1.22E-07	9975	0.1	7.10E-09	9.10E-09	0.56	1.62E-08	9975	0.1
Aluminum	0	0		0	9975	-	0	0	-	0	9975	-
Chromium (III)	-	-	-	0	-	0.1	-	-	-	0	-	0.1
Chromium (VI)	0.011	0.13	0.92	0.14	2275	0.1	0.01	0.13	0.93	0.14	2765	0.1
Mercury	0	0		0	9975	0.002	0	0		0	9975	0.002
Silver	0.2	1.8	0.90	2	1015	0.05	0.18	1.8	0.91	1.98	1505	0.05
Copper	0.003	0.037	0.93	0.04	4165	1.3	0.003	0.037	0.93	0.04	4655	1.3
Zirconium	0.017	0	0.00	0.017	9975	-	0.014	0	0.00	0.014	9975	-
Nitrate	220	100	0.31	320	1015	10	200	100	0.33	300	1505	10
Nitrite	-	-	-	0	-	1	-	-	-	0	-	1
Phosphate	0.0022	2.30E-02	0.91	0.03	4515	-	0.0022	2.30E-02	0.91	0.03	5005	-
Chlorate	0.046	6.5	0.99	6.55	1085	-	0.042	6.5	0.99	6.54	1575	-
Fluoride	0.54	0.095	0.15	0.64	1015	4.0	0.5	0.095	0.16	0.60	1505	4.0
Lead	0	0	-	0	9975	0.015	0	0	-	0	9975	0.015
Boron	0	0	-	0	1015	20	0	0	-	0	1505	20
Uranium	0	0	-	0	9975	-	0	0	-	0	9975	-

Table E-8. 100 meter location non-radiological peak analysis for Scenarios 2 and 3.

100 Meter-Non-Radiological												
Scenario	Scenario 2 - Grout Filled No Cap						Scenario 3 - Grout Filled With Cap					
	Tanks 17-20	Tank 44		Total		PO_a, mg/l	Tanks 17-20	Tank 44		Total		PO_a, mg/l
COC	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.
Iron	0.72	3.2	0.82	3.92	3045		0.7	3.2	0.82	3.9	3535	-
Nickel	0	0	-	0	9975	0.1	0	0	-	0	9975	0.1
Aluminum	0	0	-	0	9765	-	0	0	-	0	9765	-
Chromium (III)	-	-	-	0	-	0.1	-	-	-	0	-	0.1
Chromium (VI)	0.0059	0.025	0.81	0.031	3325	0.1	0.0063	0.024	0.79	0.0303	3885	0.1
Mercury	0	0	-	0	9975	0.002	0	0		0	9975	0.002
Silver	0.17	0.65	0.79	0.82	1085	0.05	0.16	0.65	0.80	0.81	1575	0.05
Copper	0.0019	0.0071	0.79	0.009	6965	1.3	0.0019	0.0071	0.79	0.009	7455	1.3
Zirconium	0.0013	0	0.00	0.0013	9905	-	0.00081	0	0.00	0.00081	9975	-
Nitrate	120	42	0.26	162	1015	10	110	42	0.28	152	1505	10
Nitrite	-	-	-	0	-	1	-	-	-	0	-	1
Phosphate	0.0017	4.50E-03	0.73	0.0062	7945	-	0.0018	4.50E-03	0.71	0.0063	8505	-
Chlorate	0.25	2	0.89	2.25	1085	-	0.24	0	0.00	0.24	1575	-
Fluoride	0.28	0.04	0.13	0.32	1015	4.0	0.26	0.04	0.13	0.3	1505	4.0
Lead	0	0	-	0	9975	0.015	0	0	-	0	9975	0.015
Boron	0	0	-	0	1015	20	0	0	-	0	1505	20
Uranium	0	0	-	0	9975	-	0	0	-	0	9975	-

Table E-9. Seepline location non-radiological peak analysis for Scenarios 2 and 3.

	Seepline-Non-Radiological													
Scenario	Scenario 2 - Grout Filled No Cap							Scenario 3 - Grout Filled With Cap						
	Tanks 17-20	Tank 44		Total		PO_a, mg/l		Tanks 17-20	Tank 44		Total		PO_a, mg/l	
COC	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.	Stream	mg/l	mg/l	Frac. Total	mg/l	Peak (y)	Gnd.	Stream
Iron	0.0044	0.0047	0.52	0.0091	9975		-	3.00E-03	3.20E-03	0.52	6.20E-03	9975	-	-
Nickel	0	0	-	0	9975	0.1	8.8E-2	0	0	-	0	9975	0.1	8.8E-2
Aluminum	0	0	-	0	9765	-	8.7E-2	0	0	-	0	9765	-	8.7E-2
Chromium (III)	-	-	-	0		0.1	1.2E-1		-	-	0	-	0.1	1.2E-1
Chromium (VI)	1.60E-05	1.60E-05	0.50	3.20E-05	9975	0.1	1.1E-2	9.70E-06	1.00E-05	0.51	1.97E-05	9975	0.1	1.1E-2
Mercury	0	0		0	9975	0.002	1.2E-5	0	0		0	9975	0.002	1.2E-5
Silver	0.0048	0.0067	0.58	0.0115	1575	0.05	1.2E-3	0.0043	0.0067	0.61	0.011	2065	0.05	1.2E-3
Copper	0	0	-	0	9975	1.3	6.5E-3	0	0	-	0	9975	1.3	6.5E-3
Zirconium	0	0	-	0	9975	-	-	0	0	-	0	9975	-	-
Nitrate	5.8	1	0.15	6.8	1155	10	-	5.2	1	0.16	6.2	1645	10	-
Nitrite	-	-	-	0		1	-	-	-	-	0		1	-
Phosphate	0	0	-	0	9975	-	-	0	0	-	0	9975	-	-
Chlorate	0.068	0.05	0.42	0.118	1225	-	-	0.064	0.05	0.44	0.114	1715	-	-
Fluoride	1.40E-02	9.40E-04	0.06	1.49E-02	1155	4.0	-	0.013	0.00094	0.07	0.014	1645	4.0	-
Lead	0	0	-	0	9975	0.015	1.3E-3	0	0	-	0	9975	0.015	1.3E-3
Boron	0	0	-	0	1155	20	-	0	0	-	0	1645	20	-
Uranium	0	0	-	0	9975	-	-	0	0	-	0	9975	-	-

compliance points at different times due to varying closure scenarios and geological conditions. In addition, the method may be used to determine the level of resources required for future site remediation activities.

E.7 References

d'Entremont, P., 1996, WSRC, Aiken, South Carolina, interoffice memorandum to J. Cook, WSRC, "Source Term for Tank 44," May 30.

HNUS, 1996a, Calculations Package for Establishing Performance Objectives for Groundwater Transport Segment (In Preparation).

Killian, T. H., N. L. Kolb, P. Corbo, I. W. Marine, 1987, *Environmental Information Document, F-Area Seepage Basins*, DPST-85-704, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina, March.