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"A Perspective on
the Dangers of
Plutonium"

Toxicological versus Radiological Hazards of ^{239}Pu

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Introduction:

Plutonium is frequently referred to as "the most toxic substance known to man". While there are other chemicals that cause more immediately serious health consequences, plutonium does have the lowest permissible levels for any of the radioactive elements. Concentration limits for plutonium and its compounds are based on its radiotoxicity, specifically carcinogenicity, not on its chemical toxicity. The specific activity of ^{239}Pu is 61.3 Ci/mg, the inverse of which is 16.3 g/Ci¹, its half-life being 24,400 years. The derived air concentration (DAC) for ^{239}Pu is 2×10^{-12} Ci/cc = 2×10^{-6} Ci/m³, which is based on a committed effective dose equivalent of 50 mSv (5 rem)².

Chemical Toxicity of Plutonium:

In terms of mass per unit volume, the DAC for ^{239}Pu of 2×10^{-6} Ci/m³ is equal to **3.26×10^{-5} g/m³**. Shorter-lived plutonium isotopes have even smaller mass concentration limits. The most restrictive time-weighted average (TWA) threshold limit values (TLVs) listed³ are 0.001 mg/m³ for calcium chromate, and 0.0005 mg/m³ (i.e., **5×10^{-1} g/m³**) for strontium chromate. Both of these limits are based on the potent carcinogenic potential of these chemicals, so they form a good basis for comparison with the alpha-emitting plutonium isotopes. The TLV-TWA is 0.002 mg/m³ for both the soluble salts of platinum, and hexachlorobenzene, and 0.001 mg/m³ for calcium chromate (as Cr). The TLV booklet gives "**Notice of intended changes (for 2001)**" for "Beryllium [7440-41-7] and compounds, as Be" from 0.002 to 0.0002 mg/m³ (i.e., **2×10^{-1} g/m³**) for the inhalable fraction, also based on its carcinogenic potential. No other chemical substances have lower workplace limits than this new value for Be.

The two relevant plutonium entries in SAX⁵ are duplicated in the appendix.

Discussion and Conclusions:

Clearly, the radiation-based limit for ^{239}Pu is several (four) orders of magnitude less than that of the chemical with **the most restrictive** workplace concentration limit. A four order-of-magnitude increase in the DAC for ^{239}Pu would result in a committed effective dose equivalent of 50,000 rem (i.e., an average dose of 1000 rem per annum), enough to cause acute radiation death in at least some people. Radiation dose rates of this magnitude make it impossible to test the non-radiation biological effects: animals die from the radiation effects long before toxic effects can manifest themselves.

Any overt toxicity of plutonium and its compounds would be overwhelmed by their radiological effects.

References:

1. Radiological Health Handbook, U.S. Department of Health, Education, and Welfare Public Health Service. Revised Edition, January 1970.
2. U.S. DOE; 10 CFR 835, Appendix A, Derived Air Concentrations (DAC) for Controlling Radiation to Workers at DOE Facilities, January 1, 2001.
3. 2001 TLVs™ and BEIs™: Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices; American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH (2001).
4. Documentation of TLVs and BEIs. Sixth Edition. ACGIH, Cincinnati, OH. (1991).
5. SAX's Dangerous Properties of Industrial Materials, Tenth Edition. Richard J. Lewis, Sr. (Ed.). John Wiley & Sons, Inc. (New York, 2000)

Appendix

PLUTONIUM

DPIM: PJH750 Hazard Rating: 3
A Formula: Pu A Weight: 242

Properties:

A silvery, radioactive metal; chemically reactive. Melting point: 641°, boiling point: 3232°, density: 19.816 @ 20°/4°.

SAFETY PROFILE:

An extremely poisonous radioactive material. The permissible levels for plutonium are the lowest for any of the radioactive elements. This is occasioned by the concentration of plutonium directly on bone surfaces, rather than the more uniform bone distribution shown by other heavy elements. This increases the possibility of damage from equivalent activities of plutonium and has led to the adoption of the extremely low permissible levels given. Radiation Hazard: Artificial isotope ^{238}Pu , $T_{0.5} = 86 \text{ Y}$, decays to radioactive ^{234}U by alphas of 5.5 MeV. Artificial isotope ^{239}Pu , $T_{0.5} = 24,000 \text{ Y}$ decays to radioactive ^{235}U by alphas of 5.1 MeV. Artificial isotope ^{240}Pu , $T_{0.5} = 6600 \text{ Y}$ decays to radioactive ^{236}Pu (Neptunium Series), $T_{0.5} = 13 \text{ Y}$ decays to radioactive ^{241}Am by betas of 0.02 MeV. Artificial isotope ^{242}Pu , $T_{0.5} = 3.8 \times 10^5 \text{ Y}$ decays to radioactive

^{238}U by alphas of 4.9 MeV. Ignites in air as low as 135°C. Explosive reaction with carbon tetrachloride. Particles exposed to air and moisture may ignite spontaneously. Corrosion products are usually pyrophoric. When heated to decomposition it emits toxic and radioactive fumes of Pu. See also PLUTONIUM COMPOUNDS.

PLUTONIUM COMPOUNDS

DPIM: PJI000 Hazard Rating: 3

SAFETY PROFILE:

The toxicity of plutonium compounds is based first upon the very high radiotoxicity of the plutonium atom and secondly upon whatever atoms or combinations of atoms they might contain. Very dangerous! Any disaster which causes quantities of plutonium or plutonium compounds to be scattered about the environment will cause great ecological stress and render areas of the land unfit for public occupancy. Long-term storage in plastic containers is not recommended, as the alpha particles can cause stress cracks and there is a potential for leakage. See also PLUTONIUM.

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"Deterministic
Health Effects
from Plutonium
Inhalation"

Deterministic Health Effects from Plutonium Inhalation

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Abstract

Department of Energy (DOE) standards require evaluation of consequences to the immediate worker from health effects other than cancer in order to know the intake level that corresponds to “serious injury” or “prompt death”. Historically, only criticality prompt doses have been calculated and evaluated as “high”, “moderate”, or “low”, depending upon the dose. Inhalation doses have not been calculated, but only given a “high”, “moderate”, or “low” based on engineering judgement, with little quantitative basis to verify the judgement. The work reported here is an attempt to correct this deficiency by providing a means to quantify deterministic health effects to the immediate worker whom may inhale a significant quantity of plutonium in a postulated accident. The results show that an inhalation intake of ≥ 4 -mg of Weapons Grade Plutonium (WG Pu) (depending upon solubility class) will lead to a non-cancer fatality in most immediate workers (“high consequence”). On the other hand, inhalation of about 2-mg of WG Pu would lead to serious lung injury (“moderate consequence”) but not a non-cancer fatality in these workers. These individuals, however, would almost certainly contract a fatal lung cancer later in life if they didn’t die from some other disease or mishap first. It is recommended that “serious injury” to the immediate worker be identified with an inhalation intake of ≥ 2 -mg of Weapons Grade (WG) Pu. The deterministic “prompt death” limit would be double this.

Introduction

DOE standards¹ require evaluation of consequences to the immediate worker from health effects other than cancer. These include both fatalities (a “high consequence”) and serious injuries (a “moderate consequence”). The terms “acute” and “prompt” are often used when describing these effects. These terms imply effects that happen quickly, within hours or days. However, many serious non-cancer health effects occur weeks, months, or even years beyond the time of intake. In this calculation, all such non-cancer health effects are considered, as there is no clear limit to the delay for such effects. The delay between intake and manifestation of the effect is a function of the size of the intake. (In this sense, “prompt” can be extended to mean any non-cancer health effect that occurs following intake. In this study, the delay is extended to five years, as that what has been observed in some experiments with dogs.) Non-cancerous health effects from inhalation

of plutonium are deterministic, having a threshold below which these health effects are not noted. They differ from stochastic health effects, such as cancer, which do not have a threshold. Large intakes of ^{239}Pu and ^{241}Am have occurred in Russia for workers involved in the production of Pu for nuclear weapons. Many workers developed lung, bone, and liver cancer as well as other health effects^{2,3,4}. The large intakes led to radiation induced deterministic effects including death from what was called pneumosclerosis⁵, a term that appears to involve both radiation pneumonitis and pulmonary fibrosis.

The Deterministic Health Model

A model for deterministic health effects has been developed at the Lovelace Respiratory Research Institute (LRRRI) in Albuquerque, NM^{6,7}. The LRRRI model was developed in two stages, first for low Linear Energy Transfer (LET) β - and γ -radiation, and later for high-LET α -radiation. The low-LET and high-LET versions differ mainly in the way of accounting for radiation damage, the alpha radiation being the more damaging. This difference is in the application of a relative biological effectiveness (RBE) factor^a for the high-LET radiation. The thresholds for α -radiation and the so-called shape factor (explained below) are also different for α -radiation.

The LRRRI model for acute health effects is based on a two-parameter Weibull function called the hazard function, H , defined as

$$H = \ln(2) (D/D_{50})^V \quad (1)$$

where D is the dose, D_{50} is called the median tolerance dose, and V is called the shape factor as it represents the steepness of the dose-response curve. The value of the median tolerance dose, D_{50} , depends upon whether fatality or morbidity is being considered. It is LD_{50} (lethal dose to 50% of the people) for fatality considerations or ED_{50} (effective dose for 50% of the people) for morbidity considerations. The corresponding risk, R , is

$$R = 1 - e^{-H} \quad (2)$$

R represents the fraction of people in a population that would be expected to experience the specified health effect. If the dose, D , is below a threshold, the corresponding hazard function is set to zero. If the hazard function is zero, the risk is also zero.

Two types of dose are considered here. The first is absorbed dose. This is the energy deposited per unit mass of tissue. Its measurement units are Gray (Gy) or rad. The second is adjusted dose, which accounts for biological damage. It equals the absorbed dose times the RBE. (For stochastic effects, such as cancer, the RBE would be replaced by the radiation-weighting factor, W_R , and the measurement unit would be Sievert (Sv) or rem. However, for deterministic effects, the unit for adjusted dose is Gy or rad, the same as with absorbed dose.) For β - and γ -radiation, the RBE is one, so that the absorbed and adjusted doses are equal. For high-LET radiation, however, the

a The RBE is similar to the radiation-weighting factor, W_R , used in estimating cancer risk. The radiation-weighting factor is a single value for a given type of radiation (such as $W_R = 20$ for α -radiation) whereas the RBE is organ specific. The term "radiation-weighting factor" used to be called the "quality factor", Q .

RBE is larger than one, its value being organ specific. In the calculation of the hazard function, H , the D and D_{50} must both be either absorbed dose or adjusted dose, not a mix of the two.

The median tolerance dose, D_{50} , depends on the dose rate history. If the rate of delivery of the dose is constant, as for β - and γ -radiation, it is given by

$$D_{50} = \theta_1 / d + \theta_\infty \quad (3)$$

where d is the dose rate (Gy/hr), θ_∞ represents the asymptotic value of D_{50} for high dose rates (such as 100 Gy/hr), and θ_1 represents the increase in D_{50} for a dose rate of 1 Gy/hr. (For α -radiation, the situation is more complex, as discussed below.) The values of θ_1 ($\beta\gamma$), θ_∞ ($\beta\gamma$), and RBE (α) for lungs and the shape factors for α -radiation, are given in Table 1. These parameters have a degree of uncertainty, also shown in the table. The table entries are the minimum, central, and maximum values of triangular distributions.

Table 1. Triangular Distributions of Input Parameters^{6,7}.

Parameter	Lung Value
RBE (α)	5, 12, 20
V (α)	4, 5, 6
θ_1 ($\beta\gamma$), fatality, Gy ² /hr	15, 30, 45
θ_1 ($\beta\gamma$), morbidity, Gy ² /hr	7.5, 15, 22.5
θ_∞ ($\beta\gamma$), fatality, Gy	8, 10, 12
θ_∞ ($\beta\gamma$), morbidity, Gy	4, 5, 6

For this study, only α -radiation damage to the lungs is of importance. The dose conversion factor (DCF) for the lungs is several orders of magnitude larger than that of other organs. The lungs will therefore be at much higher risk for deterministic effects than are the other organs. For this study, only the minimum inhalation intake to cause deterministic health effects is desired.

In the calculation of deterministic health effects, the uncertainties shown in the above table are taken into account by using Monte Carlo simulations. Crystal Ball[®], add-in software to Microsoft Excel[®], was used to do this. The appropriate equations were set up in an Excel spreadsheet and the above triangular distributions were assigned. The simulations consisted of 40,000 random combinations of values within the triangular distributions. This was more than enough to ensure convergence in the final results. The Monte Carlo simulations are discussed in more detail below.

The popular atmospheric dispersion and consequence code, MACCS⁸ (and its successor, MACCS2), has partially incorporated the LRR model. However, this code also relies on an older model, in which "effective acute DCFs" are provided. The method developed for MACCS / MACCS2 "acute" doses has been tested for the current application but it is not used here as it was found to be much too conservative and its scientific basis is considered weak. The median tolerance doses (D_{50}) and their thresholds are also presented in MACCS / MACCS2 but they are found inappropriate for high-LET radiation. These thresholds are also derived below.

The determinations of LD_{50} , ED_{50} , and their thresholds are based on the calculation of the normalized dose, X , the D/D_{50} ratio in the hazard function. Although equation (3) is appropriate for β - and γ -radiation, it must be modified for α -radiation, because of its higher RBE. The higher RBE is accounted for through use of the adjusted dose rate (ADR) and adjusted dose. The dose rate, d , in equation (3) is replaced with the ADR , and the modified form of equation (3) for α -radiation becomes

$$\theta_{ADR} = \theta_l / ADR + \theta_\infty \quad (4)$$

where the ADR is the absorbed dose rate times the RBE. Because the ADR varies with radiation exposure time and because θ_{ADR} depends on ADR , the normalized dose is calculated as

$$X = \int (ADR / \theta_{ADR}) dt \quad (5)$$

where the integral is over a sufficiently long period to encompass the deterministic health effect of interest. This period is taken as five years, based on the recommendation of Bobby Scott of the LRRRI because in experiments with dogs it has sometimes taken that long for the deterministic health effect (lung injury) to manifest. The radiation dose continues to accumulate in the lung although the period of inhalation exposure to Pu is brief. The values of θ_l and θ_∞ are the same as for β - and γ -radiation. The values of LD_{50} and ED_{50} correspond to $X = 1$, by definition. (This yields $H = \ln 2$ and $R = 0.5$, which means that 50% of the affected population suffer this effect, hence the "50" in LD_{50} and ED_{50} .) Thus, the inhalation intakes that yield $X = 1$ are the intakes that yield LD_{50} and ED_{50} . (The LD_{50} and ED_{50} differ because the corresponding θ_l and θ_∞ values differ. Note that the θ values for morbidity are half those for fatality.) The corresponding thresholds are taken to correspond to $X = 0.5$, by convention, as corresponds approximately to observations. Thus, the inhalation intakes that yield $X = 0.5$ are the intakes that yield the thresholds.

The Calculational Method

In order to calculate ADR and θ_{ADR} as a function of time, the variation of DCF with time is needed. These DCFs have been determined from the dose factor file DOSD87, which was produced at Oak Ridge (Keith Eckerman). DOSD87 was distributed with the MACCS2 code and was used to derive the DCFs for cancer used in MACCS / MACCS2. It is likely that this is also the data file used to produce the DCFs published in Federal Guidance Report 11 (FGR11). The DCFs derived below for plutonium are identical with those given FGR11, once the difference between RBE and W_R is taken into account, as well as the difference in integration time (5 vs. 50 years).

DOSD87 contains dose factors increments for periods of 0 – 1 days, 2 – 7 days, 7 – 14 days, etc. out to 50 years. Dose factor increments are given for 60 isotopes and 21 organs for three respiratory compartments – NP (nasal passage and pharynx), TB (trachea and bronchial passages), and P (pulmonary). The ultimate value of DCF depends on particle size, for which Regional Deposition Fractions (RDFs) are assigned to each respiratory compartment. For one-micrometer particles, the RDFs are 0.30 for NP, 0.08 for TB, and 0.25 for P; these are the factors

used in this calculation, as well as in FGR11 and the MACCS DCF database.^b For particulates, these dose factor increments are given for three solubility classes – D, W, and Y. In addition, separate dose factors are given for both low-LET and high-LET radiation, as both types of radiation are emitted for many isotopes. For example, for ²³⁹Pu the dominant α -radiation is accompanied by γ -radiation. In this case, the γ -radiation is a very minor contributor to dose. In the case of ²⁴¹Pu, a β -emitter, the low-LET dose factor increments dominate but there is also a high-LET component because ²⁴¹Pu decays to ²⁴¹Am, which is an α -emitter. These dose factor increments thus take into account daughter products. The dose factor increments for plutonium isotopes and ²⁴¹Am have been extracted from DOSD87 and copied into the Excel spreadsheet.

The method to determine LD_{50} , ED_{50} , and their thresholds is comprised of the following steps:

1. For each isotope, the adjusted dose factor increments (Gy/Bq) are calculated by multiplying the dose factor increments for each respiratory compartment by their RDFs and summing the results. This is done for both the low-LET and high-LET components. The high-LET result is multiplied by the RBE and added to the low-LET result to derive the final adjusted dose factor increment. Note that the NP region is included in this calculation although it can be argued that this region is not part of the lungs. It is included here to be consistent with the approach taken in FGR11 and MACCS/MACCS2. This point is moot however, as the dose factors for the NP region are orders of magnitude smaller than those of the other regions and therefore contribute an insignificant amount to the resulting adjusted dose factor increments.
2. For a given isotopic mix, the adjusted dose increments (Gy) are calculated by multiplying each isotope's activity (Bq/g-mix) by the inhalation intake (g-mix) and its dose factor increment from step 1 (Gy/Bq), and summing over all isotopes.
3. The adjusted dose (Gy) is calculated by integrating the adjusted dose increments out to five years. This integration is simply the sum of the increments over the selected period. (For purposes of comparison with FGR11, this sum was also made for 50 years. This was not used in this calculation except to note that the results are identical to FGR11 when the RBE is set to 20.)
4. The ADR (Gy/hr) is calculated by dividing the adjusted dose increment (from step 2) by the corresponding period (in hours).
5. The θ_{ADR} is calculated by using equation (4) for both fatality and morbidity.
6. The normalized dose increments, ΔX , for both fatality and morbidity, are calculated by dividing the adjusted dose increment (step 3) by the respective values of θ_{ADR} for each increment, then summing these increments out to five years to determine X .
7. The LD_{50} , ED_{50} , and their thresholds were determined by adjusting the inhalation intake until $X = 1$ or $X = 0.5$. The "Goal Seek" function of Excel allows this to be done easily and quickly.

^b Note that the term "inhalation intake" used in this report refers to the amount of WG Pu in the air inhaled. The amount deposited in a given respiratory region is less, as given by its RDF. The pulmonary burden, for example, is 25% of the inhalation intake for one-micrometer particles. The difference between one and the sum of the RDFs (0.37 for one-micrometer particles) is the fraction of the inhalation intake that is exhaled.

Once the LD_{50} , ED_{50} , and their thresholds have been determined, the Hazard Function and Risk can be calculated for any inhalation intake, using equations (1) and (2). However, for the Monte Carlo simulations, the input parameters (RBE, V , and the θ 's for fatality and morbidity) are selected randomly within their triangular distributions in order to determine distributions of hazard and risk for any given inhalation intake. The LD_{50} , ED_{50} , and their thresholds are different for each combination of these input parameters. Equations giving the dependence of LD_{50} , ED_{50} , and their thresholds on the input parameters were therefore required before the Monte Carlo simulations could be run. Therefore, LD_{50} , ED_{50} , and their thresholds have been determined (see step 7, above) for many combinations of the input parameters. The Excel curve-fitting capability has been used to derive these parameterizations. It is found that the dependence of the adjusted dose values of LD_{50} , ED_{50} , and their thresholds on both RBE and θ_{∞} is so weak that it can be ignored. This results from the fact that the θ_i / ADR term in equation (4) is much larger than the θ_{∞} term for most intervals. The resulting dependence on θ_i is nearly linear but a quadratic equation was used to maintain accuracy. The weak dependence on RBE is a result of the constraint of $X = 1$ or $X = 0.5$ and the weak dependence on θ_{∞} .

Although deterministic health effects have been calculated for three isotopic mixes commonly used at RFETS, only that of Weapons Grade Plutonium (WG Pu) is reported here. The calculations were done for solubility classes W and Y. Plutonium oxides and hydroxides are of class Y; the other Pu compounds are of class W. (There are no class D compounds.) The specific activities of WG Pu are shown in Table 2. Note that Pu-242 is not included in this table because it is not included in the DOSD87 file. This omission leads to a trivial error because Pu-242 is a minor constituent (less than 0.0003% of overall activity) and contributes little to the overall health effects.

Table 2. Isotopic Activities for WG Pu.

Isotope	Activity (Bq/g-mix)
Pu-238	1.85E+08
Pu-239	2.13E+09
Pu-240	4.77E+08
Pu-241	1.24E+10
Am-241	2.22E+07

Calculations

LD_{50} , ED_{50} , and their thresholds were first derived for various combinations of θ_i and θ_{∞} for RBE = 5, 12, and 20. The variation of LD_{50} , ED_{50} , and their thresholds are found to have a very weak dependence on RBE and the corresponding gram amounts vary inversely as RBE. For example, for $\theta_i = 30 \text{ Gy}^2/\text{hr}$ and $\theta_{\infty} = 10 \text{ Gy}$, the LD_{50} (adjusted dose) varies from 341 Gy for RBE = 5 to 342 Gy for RBE = 20, which shows the very weak dependence on RBE. In contrast, the corresponding inhalation intakes vary from 0.0280 g for RBE = 5 to 0.00700 g for RBE = 20, a factor of four variation, the same as the RBE variation. Thus, the LD_{50} , ED_{50} , and their

thresholds are almost independent of RBE when expressed as adjusted doses but the corresponding inhaled amounts to reach these limits vary inversely to the RBE. Recall that the absorbed dose is the adjusted dose divided by the RBE. Thus, as expected, the absorbed dose values of LD_{50} , ED_{50} , and their thresholds are proportional to the corresponding inhalation intakes; the corresponding adjusted dose values, however, are not.

The Monte Carlo simulations were made for eight levels in inhalation input (1E-3, 2E-3, 3.3E-3, 5E-3, 7.5E-3, 1E-1, 2E-1, and 3.3E-2 grams) and both solubility classes (W and Y). Two types of probabilities are determined in the Crystal Ball calculations. The first is “risk”, which is a measure of the fraction of persons that would suffer a given health effect for the specified intake. For example, a prompt fatality risk of 0.5 means that half the people that receive the specified intake are expected to die from deterministic effects (as opposed to cancer). The second probability is expressed as a percentile. This is referred to here as a “calculational distribution statistic” because it refers to a point on the horizontal axis of the calculated risk distribution. The distribution accounts for uncertainties of the input parameters. For example, a risk value of 0.5 at the 95th percentile level means that 95% of the Monte Carlo trials gave risks that are 0.5 or less; only 5% of the trials gave a risk that exceeds 0.5. The median, or 50th percentile, can be considered the “best estimate” of the risk for a given intake because it corresponds to the risk for which half of Monte Carlo simulations give larger risks and half give smaller.

Results

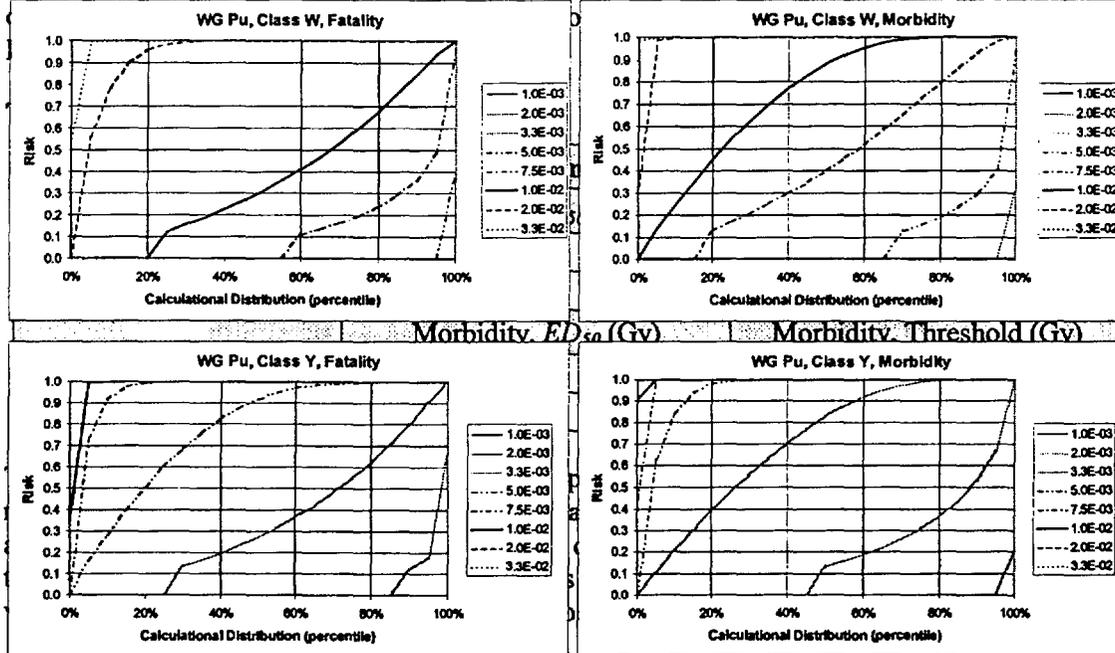
The distributions of LD_{50} , ED_{50} , and their thresholds were determined from the Monte Carlo simulations. When these limits are expressed as adjusted doses, the resulting distributions are nearly triangular. The probabilities are slightly depressed from linear for values below the median (left side of triangle) and slightly inflated above linear for values above the median (right side of triangle). The nearly triangular distributions of adjusted dose measures from the Monte Carlo simulations are shown in Table 3. Note that the thresholds are about 70% of the corresponding LD_{50} or ED_{50} values, not 50% as might have been anticipated from the fact that LD_{50} and ED_{50} correspond to $X = 1$ whereas the thresholds correspond to $X = 0.5$. The 50% rule doesn't apply because the expression for X is not linearly proportional to inhalation intake. On the other hand, the ED_{50} values (morbidity) are the same as the threshold values for fatality, which is a direct result of the θ values for morbidity being half those of fatality. Note that the morbidity thresholds are about half of the LD_{50} values. This is because the thresholds are about 70% of the LD_{50} or ED_{50} and the fatality threshold is the same as ED_{50} ; thus the morbidity threshold is about $0.7 \times 0.7 \approx 0.5$ of the LD_{50} .

Table 3. Adjusted Dose Measures (Gray).

Isotopic Mix, Class	Min	Median	Max	Min	Median	Max
	Fatality, LD_{50} (Gy)			Fatality, Threshold (Gy)		
WG Pu, Class W	244	342	416	171	240	293
WG Pu, Class Y	673	947	1,156	476	671	820
	Morbidity, ED_{50} (Gy)			Morbidity, Threshold (Gy)		

WG Pu, Class W	172	240	293	121	169	206
WG Pu, Class Y	478	670	820	337	473	579

The absorbed dose measures show distributions that more resemble lognormal than triangular. The distribution values are shown in Table 4. Note that again, the threshold values are about 70%



The risk distributions for WG Pu and both solubility classes as calculated in the Monte Carlo

Figure 1. Variation of risk with calculational distribution for various inhalation intakes (g). The pulmonary intakes are 25% of the inhalation intakes.

Curves on the left half mean that more than half of the Monte Carlo trials yielded risks as large as those shown. The 50th percentile risks may be considered "best estimates" in the sense that they correspond to the central values of the uncertainties in the parameters that enter the calculation. As an example, the "best estimate" risk for fatality for WG Pu, Class W for an intake of 10 mg is 0.31 (31% of the people with this intake would be expected to die within five years). Likewise, the "best estimate" for 20 mg is 1.0 (everybody dies) and for 7.5 mg, it is 0.0 (nobody dies). For serious injury (morbidity), the "best estimate" risk for an intake of 10 mg is 0.89 (89% of the people would be expected to suffer from lung injury). The "best estimate" for 20 mg it is 1.0 and for 7.5 mg it is 0.4.

For purposes of risk comparisons, the inhalation intakes that yield a 50th percentile risks of 0.5 are shown in Table 5. These have been estimated from the above figures. These are the same as the gram amounts that correspond to LD_{50} and ED_{50} for $RBE = 12$, $\theta_1 = 30 \text{ Gy}^2/\text{hr}$, and $\theta_\infty = 10 \text{ Gy}$. These values can be thought of as the limits appropriate for healthy adults. Inhalation intakes smaller than those shown would be less serious for a healthy adult. If a worker who inhales Pu were to be promptly treated by Occupational Medicine (lavage/chelation therapy), the dose would be decreased. Reference 6 recommends a dose reduction of a factor of two for such treatment. This would correspond to doubling the values in this table.

Table 5. Inhalation Intakes (grams) Corresponding to 50th Percentile Risks of 0.5.

Isotopic Mix/ Class	Fatality	Morbidity
WG Pu, Class W	1.2E-2	8.2E-3
WG Pu, Class Y	4.0E-3	2.8E-3

Conclusions

The results in Table 5 can be used as the basis for recommendations concerning the inhalation intake that would produce a serious injury for a worker. For example, an inhalation of 12-mg of WG Pu, Class W would be expected to lead to a "prompt" fatality (i.e., death within the next five years) for 50% of healthy adults. On the other hand, inhalation of 8-mg of WG Pu, Class W would be expected to lead to a "prompt" fatality (non-cancer) for relatively few individuals although it would lead to serious lung injury (morbidity) for 50% of these adults. These individuals, however, would almost certainly contract a fatal lung cancer later in life, as is shown below. To be conservative, the morbidity values in Table 5 can be used to define "serious injury" for healthy workers at sites having WG Pu. Note that these workers would also receive prompt treatment from Occupational Medicine following an intake, which would reduce their effective intake.

What value of risk should be used as the basis of recommendations for inhalation intake for “serious injury” or “prompt fatality”? To be conservative, one could use, say, a 1% risk, that is, only 1% of the persons with this intake would suffer the health effect. However, the immediate worker would receive prompt medical attention, which would be expected to reduce the lung burden by a factor of about two⁶. Because of the steepness of the curve of risk vs. intake, a factor of two gives a large change in risk. For example, the intake corresponding to a risk of 0.5 if cut in half would give a risk of less than 1%. It is therefore recommended that for the immediate worker, a risk of 0.5 be used, along with the 50th percentile calculation distribution. Based on these calculations, it is recommended that “prompt fatality” and “serious injury” from inhalation of WG Pu be identified with ≥ 11 -mg and ≥ 7 -mg, respectively, for Class W, or ≥ 4 -mg and ≥ 2 -mg for Class Y. If the solubility class is unknown, the smaller of these values (i.e., Class Y) should be used. Although an intake of 2-mg of WG Pu may seem like a very small intake, it is, in fact, much larger than almost every intake calculated in most accident analyses. Consider, for example, a dose of 30-rem Committed Effective Dose Equivalent (CEDE)^c, a dose greater than the evaluation guidelines for workers for stochastic effects. Because the dose conversion factor (DCF) for CEDE for WG Pu is about $3E7$ rem/g (class Y), a 30-rem dose would correspond to an intake of about $(30 \text{ rem}) / (3E7 \text{ rem/g}) = 1E-6$ grams (or $1E-3$ mg). This is only 0.05% of the recommended intake for serious injury. Note, however, that an intake of 2-mg of WG Pu would almost certainly lead to lung cancer later in life. The stochastic risk factor for lung cancer is about $8E-5$ latent cancer fatalities (LCF) per rem of lung dose⁶. The probability of contracting cancer can be estimated from product of the stochastic risk factor, the DCF, and 2-mg. This gives a result greater than one^d. This means that this person would almost certainly die of lung cancer within the next 50 years, provided death didn’t first come by other means. An inhalation intake of double this, or about 4-mg, can be used as the limit for “prompt fatality”^e. As noted earlier, the pulmonary burdens would be 25% of these values, that is, a lung burden of 0.5 mg would correspond to “serious injury” and 1 mg to “prompt fatality”.

The Nuclear Safety Analyst can use this recommendation to estimate the likelihood of a given accident scenario producing a serious injury. For the given accident conditions, the analyst can estimate the maximum inhalation intake of a worker. This would be based on the Material at Risk (MAR), the Airborne Release Fraction (ARF), Respirable Fraction (RF), and so forth. If the intake cannot exceed 2-mg of WG Pu, the probability of serious injury can be considered incredible (or “beyond extremely unlikely”). This will be the case for most accident scenarios to be analyzed. As an example, suppose the breathing rate is $3.6E-4 \text{ m}^3/\text{s}$ and the worker is exposed to a cloud of Pu powder (oxide, for example) for 10 seconds. The concentration required to produce an intake of 2 mg would be $(2E-3 \text{ g}) / [(3.6E-4 \text{ m}^3/\text{s}) (10 \text{ s})] = 0.56 \text{ g/m}^3$. If the cloud of plutonium particles were contained within a volume of 100 m^3 (say, a room measuring $2.5 \text{ m} \times 5 \text{ m} \times 8 \text{ m}$), the amount of material released (the respirable source term) would have to be 56

^c CEDE is used for stochastic effects, not deterministic.

^d A probability greater than one is impossible, of course. This result simply implies the certainty of contracting cancer. The stochastic risk factor used is intended for use with low levels of intake, so isn’t appropriate for the large intakes considered here.

^e This implies the Russian workers at the Mayak plutonium production facility who died from deterministic effects must have inhaled mg quantities of plutonium/ameridium over their many years of employment.

grams. For a fire, an ARF of $5E-4$ and a RF of 1.0 would be appropriate so that the MAR would have to be $56 / 5E-4 \approx 100,000 \text{ g} = 100 \text{ kg}$. Such a large release is very improbable. Alternatively, for an explosion within the container, an ARF of 0.7 and a RF of 0.1 may be appropriate, for which the MAR would be $56 / 0.07 \approx 800 \text{ g}$. This, too, would be very improbable, given the probability of explosions. There are, of course, an infinite number of scenarios that can be imagined that could produce an inhalation of 2-mg, but all (or almost all) of them would be highly unlikely to occur.

The DCFs used in this analysis are from the ICRP-30 database. The more recent ICRP-68 data shows a significant decrease in DCFs for plutonium and americium for the whole body. The organ DCFs are not provided in ICRP-68, so an analysis as done here is not possible at this time. Had that data been available, the dose and gram limits found here presumably would have been higher by a factor between three and ten. Furthermore, for the ICRP-30 database used here, the RDFs used were for one-micron particles. If the RDFs for five-micron particles been used instead, the DCFs would have been smaller by about a factor of three. ICRP-68 recommends using DCFs for five-micron particles for occupational exposure, unless there are data showing that another particle size is more appropriate. It is safe to conclude, then, that the recommended intake limits for serious injury are very conservative.

Finally, since plutonium is a heavy metal it is likely that it is chemically toxic. No Emergency Response Planning Guidelines (ERPGs) are available for plutonium, so its chemical toxicity is unknown. However, its toxicity may be similar to that of uranium. For example, UF_6 has ERPG-2 and ERPG-3 values of 15 and 30 mg/m^3 , respectively. Both of these values are less than the concentration found in the example above (560 mg/m^3). However, the ERPG values assume a person is exposed to that concentration for up to one hour, or 360 times longer than in the example. On this basis, the radiological effects of plutonium would be greater than the chemical toxicity effects. It seems reasonable, then, to base the recommendations for serious injury and prompt fatality on radiological considerations instead of chemical toxicity.

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Preconstruction and Preoperational
Environmental Monitoring Plan

P.D. Fledderman
Environmental Monitoring Section



Plutonium Disposition Program (PDP) Preconstruction and Preoperational Environmental Monitoring Plan

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1. Introduction

This report provides an overview of plans to conduct surveys and monitoring of existing environmental and ecological conditions at areas identified as potential locations of the Savannah River Site's (SRS) Plutonium Disposition Project (PDP) facilities. This information is required to document existing environmental and baseline conditions from which PDP construction and operation impacts can be defined. In general, the report is divided on the basis of contaminant type and exposure pathway. It has two sections, as follows:

- *General Information*, which provides information on the PDP project and monitoring philosophy
- *Physical and Chemical Parameters*, which defines points of emission and the sampling plans that will generate appropriate baseline conditions from which PDP construction and operation impacts can be defined

This document is intended to satisfy the requirements of U.S. Department of Energy (DOE) Order 5400.1 (DOE, 1988) and draft 10 CFR, part 834, which may be promulgated before construction or operation of the PDP. The primary purpose of preoperational monitoring is to define current baseline conditions. However, the monitoring also will provide data expected to be required for other purposes, namely, identifying any contaminants that could be a safety concern for construction personnel and applying for environmental permits.

In summary, the PDP Preconstruction and Preoperational Monitoring Plan calls for several surveys which will perform selected measurements and analyses that will define environmental conditions at the PDP site before construction. These surveys are intended to supplement routine monitoring actions—both in and around the project area and across SRS—in order to provide the required information. Water quality, possible soil contaminants, the concentration of radionuclides in vegetation, and types and abundance of biota will be assessed.

Monitoring and informational needs shift as time passes. Before PDP construction begins, the soil, vegetation, and sediment will be examined for previous contaminants to ensure the safety of land clearing and excavation personnel and to ensure that no critical habitat disruption occurs. Late in the construction cycle and preoperation test stages, the focus of monitoring will shift to (1) gathering up-to-date information on water quality at proposed discharge locations and (2) habitat and biota impacts.

The PDP Preconstruction and Preoperational Monitoring Plan is intended to be adjusted as construction or operating plans change, and as called for by reviews of newly generated data.

2.0 General Information

2.1 Project Description

As a result of the end of the cold war in 1991, significant quantities of excess plutonium exist in both domestic and foreign stockpiles. As part of its stockpile stewardship responsibility, one mission of the DOE is to reduce the threat of nuclear weapons proliferation by disposing of surplus plutonium in the United States. This disposition must be completed in a timely and environmentally safe manner to ensure that surplus plutonium is converted into proliferation-resistant forms. DOE's disposition strategy allows for the immobilization of surplus plutonium and for its use as a mixed oxide fuel in existing domestic commercial power reactors.

The PDP project consists of the following types of facilities:

- A facility for disassembling pits (weapons components) and converting the recovered plutonium, as well as plutonium from other sources, into plutonium dioxide suitable for disposition. It is referred to as the Pit Disassembly and Conversion Facility (PDCF).
- A facility for immobilizing surplus plutonium for eventual disposal in a geologic repository, pursuant to the Nuclear Waste Policy Act. This facility will be able to convert nonpit plutonium materials into plutonium dioxide suitable for immobilization. It is referred to as the Plutonium Immobilization Plant (PIP).
- A facility for fabricating plutonium dioxide into a mixed oxide (MOX) fuel. This facility will be privately operated and licensed by the Nuclear Regulatory Commission. It is referred to as the MOX facility.

2.2 Purpose

The purpose of monitoring and sampling of the potentially affected ecosystems at the proposed PDP site before construction (preconstruction monitoring) or facility operation (preoperational monitoring) begins is to establish a baseline of existing radiological, chemical, physical, and biological conditions in the area. These baseline conditions will serve as a reference point to distinguish preexisting environmental conditions or contamination from any contamination or impacts resulting from PDP construction activities and operations. The monitoring also can identify environmental conditions that would be of concern to workers at the PDP site.

Another goal of the preconstruction and preoperational environmental study is to develop an understanding of the critical pathways that would transport contaminants to human and other receptors. This is important in determining the appropriate types of media to be sampled. Preconstruction and preoperational environmental monitoring for the PDP will be performed according to DOE Order 5400.1. This monitoring, along with a review of existing historical data, will be used to establish environmental baseline conditions for the PDP site.

2.3 Area Description

The proposed sites for the PDP facilities are located along the existing F-Area perimeter, on the northeast and northwest sides. Six potential areas (including two supplemental areas) have been identified for facility construction (figure 1, table 1). The PDCF will be located in Area X, and the MOX fuel fabrication facility will be located in Area 2 and Area 2A. The location of the PIP has not been determined.

The terrain of the areas under investigation is relatively level near the F-Area boundary. An unnamed tributary of Upper Three Runs originates in the general PDP project area. Surface drainage is into the Upper Three Runs watershed. As the land descends to the unnamed tributary, fairly steep gradient drops are evident. Close to the F-Area boundary, the land is primarily cleared. Several areas include light industrial and administrative activities (office trailers, equipment storage areas, roads, and parking lots). Grass and shrubs are the primary vegetation in

these areas. As the land approaches and drops to the Upper Three Runs tributary, the cover changes to thicker shrubs and forest.

2.3.1 Waste Units

Because of the PDP project's proximity to F-Area, areas of historical contamination may exist and would be of interest. These could include both identified waste units and other areas of local increased contamination from facility operations and releases. In the PDP project area, a small number (10) of waste units and early construction and operation disposal (ECOD) sites have been identified. Table 2 and figure 2 provide details on these features.

2.3.2 Groundwater

Based on the groundwater flow patterns underlying the PDP site, the water table outcrops into Upper Three Runs and its tributaries (figure 3). The regional groundwater flow pattern for the deeper aquifers (Gordon and Dublin-Midville) is toward the Savannah River, and the overall pressure gradient in this area of the site is upward. As detailed elsewhere in this report, historical operations from E-Area and F-Area have resulted in groundwater contamination that impacts portions of the PDP project area.

2.3.3 Existing Monitoring Sites

A number of active and inactive sampling sites are located in the PDP project area. These include wells and sampling sites for liquid, soil, and/or vegetation. Tables 3 and 4 and figures 3 and 4 provide details on these monitoring points.

2.4 Preconstruction and Preoperational Monitoring Plan Outline

The entire preoperational monitoring period can be broken into three stages, each of which requires somewhat different information. These stages are preconstruction, construction, and postconstruction (facility testing and preparation for operation).

During the preconstruction period, monitoring activities generally will consist of surveys that (1) define baseline conditions that will be disrupted by construction activities and (2) provide data needed during construction. As construction nears completion, additional baseline data will be required to assess the PDP's operational impact on the environment.

Each stage of the preoperational monitoring period will be designed as needs arise and will incorporate results from prior stages.

2.5 Expected Environmental Impacts

Ecological factors that could be affected by PDP construction differ from those related to operation of the facility. During construction, all vegetation would be lost in the immediate area, but overall plant diversity at SRS is not expected to decrease. Increased human activity at the PDP site and the removal of vegetation that provides wildlife habitat are expected to impact wildlife. More mobile animals, such as birds and larger mammals, likely would be displaced during construction. The loss of some less mobile animals, such as lizards, snakes and toads, is expected. However, no impacts are anticipated on communities of—or potential habitats for—threatened and endangered species or candidate species.

Construction activities also could change stream habitats because of erosion, deposition, or the transport of existing soil contamination by wind and rain. The tributaries to which the PDP site would drain are expected to receive runoff during and after construction, but no direct process discharges. Mitigation activities are planned to reduce or eliminate adverse impacts. Erosion of the cleared construction site will be controlled, as necessary, by silt fences, spray-on adhesives, and seeding. Consequently, sedimentation in—or transport of—contaminants to the creeks is not expected during construction.

Although site selection, facility design, and mitigation activities are intended to reduce environmental impacts, the monitoring of ecological conditions is required to ensure that such impacts are minimized. Sampling or surveys of various environmental media prior to construction or facility operation can provide a baseline to be used later to demonstrate adequate mitigation or to determine environmental impacts from the construction or operations. Monitoring that continues during construction activities or facility operations can identify adverse impacts at an early stage so that action can be taken to prevent additional impact or loss.

2.6 Historical Data

A review and compilation of historical monitoring data in and around the PDP area has been completed as a precursor to this plan (Fledderman, 2000). The combination of this information with preconstruction environmental monitoring for the PDP site will be used to establish environmental baseline conditions for the PDP site.

2.7 Quality Assurance

To ensure that the sampling and analytical activities are conducted in a defensible manner, all work will be performed according to the Environmental Monitoring Section's (EMS) quality assurance (QA) manual (WSRC, 1996). Laboratory spikes, duplicates, and blanks will be performed according to U.S. Environmental Protection Agency (EPA) protocol. In no case will less than 10 percent of the total number of samples be spikes, duplicates, or blanks analyzed as part of the laboratory QA program.

All laboratory analyses will be conducted according to EPA or other accepted methods. If no standard analysis exists, 10 percent of the samples will be sent to an external laboratory for analysis. This procedure will be used to produce definitive data in cases where no standard procedure exists, or where the laboratory is not certified in a particular method. Any external laboratory must be able to produce at least the same minimum detection limits as the EMS laboratory.

The EMS QA officer will conduct random periodic assessments of the sampling and laboratory programs to ensure that proper procedures and methods are being employed. Any abnormal findings will be brought to the attention of the project manager so that corrective measures can be taken immediately. The QA officer will conduct followup assessments to ensure that any deficiencies have been resolved.

2.8 Data Interpretation and Reporting

As stated in the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991), "Good data analysis and statistical treatment practices are essential for the production of quality results." Field work on the one-year preoperational study is expected to be completed no later than October 31, 2001. The report presenting the study's findings is scheduled to be issued by April 15, 2002.

2.9 Sampling and Analysis Plan

The following sections primarily describe monitoring that will be conducted prior to initiating PDP construction. Activities that will continue through the construction or operation phases generally are not included, but will be developed as required at later dates. The preconstruction sampling program will begin in September 2000 and last for one year. If required, additional specific monitoring requirements will be developed based on construction activities, preconstruction survey results, and other data needs. The preoperational program will begin immediately following construction and will continue until PDP operations begin. The preoperational program will be modified as required and will serve as the basis for the operational surveillance program.

3.0 Physical, Chemical, and Biological Parameters

To obtain baseline environmental information on physical and chemical conditions at the PDP site prior to construction and/or operation, a variety of media—such as groundwater, surface water, sediment, soil, vegetation, air, and biota—must be sampled on and around the proposed construction site. This is because these media have the ability to either transport or concentrate contaminants. This chapter identifies the media and locations to be sampled, along with any existing sampling stations, in an effort to facilitate a better understanding of the proposed PDP site's baseline conditions.

3.1 Historical Information and Inventory

Routine manufacturing operations in F-Area have released quantities of material to the environment since operations began there in late 1954. Releases are documented in a series of technical reports issued by SRTC, in an EMS compilation of release data from 1954 to 1988, and in site environmental and groundwater reports. As previously described, a compilation detailing historical release information and routine monitoring results has been developed as a precursor to the PDP Preconstruction and Preoperational Monitoring Plan.

Potential pathways include the airborne release of material from F-Area, the deposition of airborne material, and the release of material via process discharge and/or rainwater runoff. Samples collected and analyzed through EMS's routine effluent monitoring, National Pollutant Discharge Elimination System (NPDES), and environmental surveillance programs indicate the impact of this material. Generally, air surveillance samples from areas near the PDP project area show gross alpha and gross beta results similar to those from the regional control site at the U.S. Highway 301 bridge. However, soil samples from areas near the PDP project area show Cs-137, Sr-89,90, Pu-238, and Pu-239 concentrations greater than those from the regional control site at the U.S. Highway 301 bridge.

Major radiological contaminants released from F-Area operations include moderate- to long-lived fission products (primarily Cs-137 and Sr-89,90), isotopes of uranium (U-234, U-235, and U-238) and plutonium (Pu-238 and Pu-239), and other actinides (Am-241 and Cm-244). Only those radionuclides with a half-life greater than one year have been considered; likewise, noble gases have been excluded. Except for tritium, airborne releases through 1999 totaled approximately 739 Ci, and direct liquid releases to streams totaled approximately 768 Ci. Table 5 details the quantities of materials released from F-Area.

Chemicals of specific concern that may result in offsite impacts have been identified, although actual amounts released have not been estimated. The following chemicals have been identified as those released in quantities that could pose adverse health effects: ammonia, nitrate, cadmium, chromium, hydrazine, mercury, manganese, nitric acid, and oxides of nitrogen.

3.2 Surface Water Surveillance

3.2.1 Description and Rationale

Surface drainage from the proposed PDP site is into an unnamed tributary of Upper Three Runs Creek (figure 1), which ultimately discharges to the Savannah River. Although largely pristine, Upper Three Runs is impacted by several site facilities. The Effluent Treatment Facility (ETF) discharges directly into the stream; portions of F-Area discharge into tributaries; and McQueen Branch receives process discharges from S-Area. Runoff from portions of E-Area, F-Area, H-Area, S-Area, and Z-Area also enter Upper Three Runs. In addition, both Upper Three Runs and Tinker Creek originate off site and are impacted by offsite activities.

Routine surface water monitoring is conducted on Upper Three Runs and a number of its tributaries as part of the radiological effluent, radiological environmental surveillance, NPDES, and nonradiological environmental surveillance programs (figures 5 and 6). Control locations are located on Upper Three Runs (radiological and

nonradiological surveillance programs) and Tinker Creek (nonradiological surveillance program). However, no historical data is available from the unnamed tributary.

The first phase of the PDP monitoring is limited to preconstruction support activities. The primary objective of this phase is to establish a baseline of physical stream water quality conditions. This provides a reference level of water quality parameters unimpacted by construction activities. This information may be used as a basis for comparison with water quality conditions observed during construction, and from it, any impact caused by construction can be determined.

Construction activities would result in the clearing of a significant land area (up to approximately 100 acres). This would alter the amount and composition of surface water runoff from the PDP site, potentially impacting the chemistry of an unnamed tributary and Upper Three Runs.

3.2.2 Sampling and Analysis

3.2.2.1 Nonradiological Parameters

Because the unnamed tributary is expected to be the most impacted body of water, monitoring will focus on documenting conditions in this stream. For the purpose of the PDP Preconstruction and Preoperational Monitoring Plan, the unnamed tributary will be referred to as the indicator tributary, or Trib-I. Grab samples will be collected quarterly for one year from Trib-I, downstream of surface runoff from the PDP project area. These samples will be analyzed for the following constituents: temperature, pH, dissolved oxygen (DO), conductivity, chemical oxygen demand (COD), nitrogen as nitrate, nitrogen as nitrite, total suspended solids (TSS), total phosphorous, total organic carbon (TOC), aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, pesticides, and herbicides. Also, monthly measurements of the following basic water quality parameters will be conducted at the Trib-I sampling location: pH, DO, temperature, and TSS. These parameters are among those most likely to show an adverse impact from construction activities in the PDP project area. An unimpacted stream similar to Trib-I in flow and drainage characteristics will be established as a control; this site will be referred to as the control tributary, or Trib-C. Trib-C will be sampled for the same analytes and at the same frequency as Trib-I.

Upper Three Runs also may be impacted by activities in the PDP project area, via releases through Trib-I. Two sampling locations on Upper Three Runs will be established; one upstream of the Trib-I mouth (U3R-U), and one downstream of the Trib-I mouth (U3R-D). These sites will be sampled monthly for one year for the following basic water quality parameters: pH, DO, temperature, and TSS.

To document changes in physical stream conditions (sedimentation, erosion, etc.), photographs will be made by EMS at each site during each sampling event.

3.2.2.2 Radiological Parameters

As described in the historical data review document, a number of radiological effluent and environmental surveillance sampling points are located in the SPD project area. In support of the PDP project, two monitoring sites are of particular interest—the Upper Three Runs-F3 (U3R-F3) and F-05 stations. Upper Three Runs-F3 is an environmental surveillance monitoring site located in PDP Area 2 on the northwest side of F-Area. It receives stormwater runoff from the vicinity of the Naval Fuels Facility. The F-05 site is an environmental surveillance point on the northeast side of F-Area and is located in PDP Area X. It receives nonprocess water and stormwater runoff from the northeast portion of F-Area.

Together, these points monitor all process discharges and surface runoff from F-Area that may impact the SPD project area. However, to monitor and document the radiological conditions in the stream itself, EMS will collect grab samples quarterly for one year from Trib-I and Trib-C. These samples will be analyzed for the following constituents: gross alpha/beta activity, gamma-emitting radionuclides, tritium, total strontium, and actinides.

3.3 Sediment Surveillance

3.3.1 Description and Rationale

Sediment provides an integrating medium that can account for contaminants released to streams; sediment monitoring can be used to evaluate long-term accumulation trends.

As detailed in section 3.2, surface drainage from the proposed PDP site is into Trib-I, an unnamed tributary of Upper Three Runs. In addition to surface drainage, three discharge points that are located in the PDP project area feed this tributary. Also, both Upper Three Runs and Tinker Creek originate off site and are impacted by offsite activities.

Routine sediment monitoring is conducted on Upper Three Runs Creek and Tinker Creek as part of EMS's radiological and nonradiological environmental surveillance programs (figures 7 and 8). Control locations are located on Upper Three Runs Creek and Tinker Creek, with an indicator station below all site discharges. However, no historical data is available from the PDP project area.

The first phase of the PDP monitoring plan is limited to preconstruction support activities. The primary objective of this phase is to establish a baseline of physical radiological and nonradiological conditions in the sediment. This provides a reference level of analytical parameters unimpacted by construction activities. This information may be used as a basis for comparison with conditions observed during construction, and from it, any impact caused by construction can be determined.

Construction activities would result in the clearing of a significant land area (up to approximately 100 acres). This would alter the amount and composition of sediment in the tributary by scouring (removal), transport, and/or deposition. These actions could impact the quality of the unnamed tributary and Upper Three Runs.

3.3.2 Sampling and Analysis

3.3.2.1 Nonradiological Parameters

Because the unnamed tributary is expected to be the most impacted body of water, monitoring will focus on documenting conditions in this stream. To accomplish this, grab samples will be collected quarterly for one year from Trib-I and Trib-C. To document conditions at the outfalls that impact the PDP project area, quarterly grab samples will be collected downstream of each of the three NPDES outfalls. Upper Three Runs also may be impacted by activities in the PDP project area, via releases through Trib-I. Quarterly grab samples will be collected from U3R-U and U3R-D to document conditions in Upper Three Runs. All samples will be analyzed for the following constituents: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, zinc, pesticides, and herbicides. All samples will be gathered from areas covered with water, rather than from sediment that might have been exposed as a result of low-flow conditions. To document changes in physical stream conditions (sedimentation, erosion, etc.), photographs will be made by EMS at each site during each sampling event.

3.3.2.2 Radiological Parameters

Sediment sampling for radiological analyses will be conducted as described above from the Trib-I, Trib-C, U3R-U, and U3R-D sites. As described in section 3.2.2.2, two radiological effluent and environmental surveillance sampling points are located in the SPD project area: U3R-F3 and F-05. Together, these points monitor all process discharges and surface runoff from F-Area that may impact the SPD project area. Historical releases from these sites have released radionuclides that may be present in the sediment. To monitor and document the radiological conditions in the sediment, EMS will collect grab samples quarterly for one year downstream of these release points. All samples will be analyzed for the following constituents: gross alpha/beta activity, gamma-emitting radionuclides, total strontium, and actinides.

3.4 Air Surveillance

3.4.1 Description and Rationale

Contaminants can be transported from the source term to the receptor via the air pathway. For human receptors, the exposure can be by immersion or inhalation. Exposure also can be by ingestion of foodstuffs on which contaminants have been deposited by either wet or dry deposition processes.

3.4.2 Sampling and Analysis

WSRC maintains a complex atmospheric transport and radiological assessment model. Atmospheric contaminants are quantified at the point of discharge. This model will be used to predict contaminant concentrations in both air and rain from projected PDP releases. Because of this, air surveillance is not required during the preconstruction phase.

In addition to this model, WSRC maintains a comprehensive airborne radiological surveillance system, as described in the SRS Environmental Monitoring Program (WSRC, 1999). The airborne surveillance system has been used to verify model predictions. As part of this system, one existing air monitoring station (Burial Ground North) is located near the proposed PDP site. Years of historical results are available from this site, as well as from three recently discontinued sites. Results from the Burial Ground North station will be used to provide the required regional monitoring results.

Because of these factors, additional air surveillance is not required.

3.5 Soil Surveillance

3.5.1 Description and Rationale

Soil provides an integrating medium that can account for contaminants released to the atmosphere. Soil sampling can be used to evaluate potential hazards during construction and to provide long-term accumulation trends. The purpose of this sampling program is to determine baseline concentrations in the soil that may be impacted by PDP construction and/or operations.

As detailed the historical data summary document, significant amounts of material have been released from F-Area operations. Results from the EMS routine soil surveillance program indicate slightly elevated levels of a number of radioisotopes in the soil surrounding F-Area.

Soil sampling is designed to determine location, types, and amounts of radioactive materials in the PDP project area. The goal of this sampling is twofold. First, results may used to protect the health of workers by minimizing potential exposure to contamination and establishing any protective equipment requirements. Second, the results will establish a baseline of radiological conditions in the soil, and will provide a reference level of radiological parameters unimpacted by construction activities. This information may be used as a basis of comparison with conditions observed during or after construction, and from it, any impact caused by construction can be determined.

3.5.2 Sampling and Analysis

To obtain soil samples for the preconstruction phase, EMS will develop and utilize a statistical-based sampling grid. Development of this grid will be based on the protocols established in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)(NRC, 1997). A regular triangular grid with a random origin will be established, and samples will be collected from each point to a depth of one-foot. To obtain a depth distribution profile, each sample will be divided into 3-inch segments. If necessary, these samples will be supplemented with samples from selected areas of possible contamination. The selection of these areas will be subjective and will be based on information sources such as aerial overflight data or field observations.

Samples will be collected as a one-time event, and samples will be analyzed for the following constituents: gross alpha/beta activity, gamma-emitting radionuclides, total strontium, and actinides.

3.6 Vegetation Surveillance

3.6.1 Description and Rationale

Vegetation (trees and plants) can bioaccumulate heavy metals, organic chemicals, and radionuclides; as such, it can be a reliable indicator of low-grade contamination of water or soil. Results of the analysis of this vegetation will establish a baseline of radiological conditions to provide a reference level of radiological parameters unimpacted by construction activities. This information may be used as a basis for comparison with conditions observed during or after construction, and from it, any impact caused by construction can be determined.

3.6.2 Sampling and Analysis

Vegetation will be sampled at the same locations established in section 3.5.2 for the soil sampling program. Ground vegetation will be collected quarterly for one year at each location, if available. Green leaves or pine needles will be collected where ground vegetation is not available, and all samples will be analyzed for the following constituents: gross alpha/beta activity, gamma-emitting radionuclides, total strontium, tritium, and actinides.

3.7 Ambient Gamma Exposure Rate

3.7.1 Description and Rationale

Because radioactive material can be transported in the air and deposited on vegetation and soil, ambient gamma radiation measurements will be performed using thermoluminescent dosimeters (TLDs) at locations on and around the proposed PDP site. The measurement of ambient gamma exposure rates verifies that assumptions regarding the distribution of radioactive materials in the construction area are valid.

The measurement of ambient gamma radiation is designed to characterize exposure rates in the PDP project area. The goal of this exposure rate measurement is twofold. First, results may be used to protect the health of workers by minimizing potential exposure to contamination and by establishing any protective equipment requirements. Second, the results will establish a baseline of area gamma exposure conditions. This provides a reference level of area exposure rates unimpacted by construction activities. This information may be used as a basis for comparison with conditions observed during or after construction, and from it, any impact caused by construction can be determined.

3.7.2 Sampling and Analysis

TLDs will be colocated at the same locations established in section 3.5.2 for the soil sampling program. The TLDs will be collected/replaced and analyzed quarterly for one year.

3.8 Groundwater Surveillance

3.8.1 Description and Rationale

Because of SRS operations, considerable groundwater contamination exists in the vicinity of separation and waste management areas. Sources of this contamination include buried material in E-Area and in seepage basins. Concern, as far as the PDP project, is focused on the old F-Area seepage basin (located in PDP Area 1) and on E-Area contamination that impacts PDP Areas 4 and 5. Figure 9 shows the extent of contaminated groundwater plumes, defined by tritium. As the figure shows, the most significant plume relating to the PDP project originates

from the northwest portion of E-Area and has moved northwest toward Upper Three Runs, impacting PDP Areas 4 and 5.

Figure 9 shows only the tritium-contaminated groundwater plumes, but E-Area releases a variety of other contaminants as well. The extent of groundwater contamination by other materials depends on their mobility; tritium is the most mobile. Volatile organic compounds (VOC) represent the only other contaminant showing a significant plume impacting the PDP project area, although the plume is much smaller. However, other contaminants may be present. In addition to tritium and VOCs, a number of other contaminants are found in one or more wells at concentrations above their respective limits, as established by the EPA in the Safe Drinking Water Act's primary drinking water standards.

The primary objective of the preconstruction monitoring is to establish a baseline of groundwater quality conditions. Construction activities may impact the chemistry of the underlying groundwater because a significant land area will be cleared during this time, which will alter the amount and composition of surface water runoff from the PDP site. This provides a reference level of water quality parameters unimpacted by construction activities. This information may be used as a basis for comparison with water quality conditions observed during and after construction, and from it, any construction-caused impact on water quality can be determined.

3.8.2 Sampling and Analysis

Where possible, existing wells will be sampled to determine the quality of the groundwater underlying the PDP site. As described in the historical data summary, there are 80 wells in the PDP project area, 44 of which are active (table 4). The use of existing wells eliminates the cost of installation and allows the use of existing program management, data, and data analysis and interpretation.

An extensive and comprehensive program is in place to characterize and monitor groundwater contamination and to track plume movement. Included in this program are the plumes in and around E-Area and F-Area that may impact the PDP project area. Because of the comprehensive nature of the existing groundwater monitoring program, no additional project-specific groundwater monitoring is required.

3.9 Macroinvertebrate Surveillance

3.9.1 Description and Rationale

Macroinvertebrates are integral components of the food webs of freshwater stream systems, and they provide a vital link between primary food sources and organisms higher on the food chain. Studies of the distribution and abundance of these organisms can be used to discern important patterns of variation in water quality. The lifespans of some species extend for a year or more, which is long enough to evaluate the effects of continuous or intermittent pollutants but short enough to respond relatively quickly to water quality changes. The different species vary in their responses to pollution or disturbance, with some able to tolerate high levels of pollution or disturbance, and others unable to withstand even mild effects. The abundance, species, and diversity of aquatic macroinvertebrates are indicative of the ecological conditions of a stream. Therefore macroinvertebrates represent a key component for environmental impact assessment.

If erosion control efforts at the PDP site fail, soil exposed during and after site clearing may be transported to the streams in the surrounding areas. Siltation generated by erosion at the construction site could affect macroinvertebrates by causing loss of habitat, embedment with sediments, or physical displacement resulting from increased flows and/or from scouring of the stream beds. Over time, species sensitive to stream quality could be displaced by pollution-tolerant species.

3.9.2 Sampling and Analysis

Sampling locations generally will coincide with the surface water sampling stations established in section 3.2.2. Because of natural variations in the macroinvertebrate population, sampling will be performed quarterly for one year. A minimum of five replicates will be used per location.

At each of the sampling stations, Hester-Dendy multiplate samplers will be used to determine the macroinvertebrate population and species present. These samplers provide a consistent substrate for colonizing macroinvertebrates. The consistent substrate allows for comparisons over time and location. Qualitative sampling of the natural substrates also will be performed; this provides for collection of species that do not colonize the Hester-Dendy substrate.

4.0 References

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TABLE 1
PDP Project Potential Construction Sites

Location	Area (acres)	Area (m²)
X	25.36	1.026e+5
1M	21.61	8.745e+4
2	24.81	1.004e+5
2A	39.52	1.599e+5
3	25.09	1.015e+5
4	45.85	1.855e+5
5	25.09	1.015e+5
5A	17.50	7.085e+4

**Table 2
Waste Units and ECODs within the PDP Project Area**

Waste Unit ID	Waste Unit Name	Index Number	PDP Construction Area
474-3	General Area, Other: Process and Sewer Lines as Abandoned, NBN ¹	474	All
372	Spill on 01/01/87 of Unknown of Potassium Permanganate, NBN	372	1M
426	Spill on 05/22/86 of 2 Gal of 50% Sodium Hydroxide, NBN	426	1M
523-1 523-2 523-4 523-5	ECODS F-1 (Southeast of F-Ash Basin, 276-0F) ²	523	4
276	F-Area Ash Basin, 288-0F	276	4, 5
16-2	Mixed Waste Management Facility (including the RCRA Regulated Portions of LLRWF 643-7E), 643-28E ³	16	5
2	F-Area Acid Caustic Basin, 904-47G	2	5A
284	F-Area Acid/Caustic Basin (Groundwater)	284	5A
277	F-Area Ash Basin, 288-1F	277	5A
71	F-Area Coal Pile Runoff Basin, 289-F ³	71	5A

Notes :

¹NBN = No Building Number

²ECODS F-01 is composed of five subunits, four are located

³An slight overlap exists between this waste unit and the PDP project area

TABLE 3
Monitoring Locations within the PDP Project Area

Sampling Point Name	Monitoring Program	Status	PDP Construction Area
F-002	NPDES	Inactive	1M
F-03	NPDES	Active	2
F-Area North	RAD Soil Surveillance	Inactive	2
Upper Three Runs-F3	RAD Liquid Surveillance	Active	2
F-007	NPDES	Inactive	4
F-Area East	RAD Soil Surveillance	Inactive	5
OBG-2	RAD Vegetation Surveillance	Inactive	5
F-05	NPDES	Active	X
F-05	RAD ALARA	Active	X

**Table 4
Monitoring Wells within the PDP Project Area**

Well Name	Type	Date Installed	Date Abandoned	Catalog ID	PDP Construction Area
FNB 8	Mw	10/11/96		FNB8	1M
ZW 20				ZW20	2
FC 1A		7/23/76		FC1A	2A
FC 1B		8/4/76		FC1B	2A
FC 1C		8/18/76		FC1C	2A
FC 1D		9/21/76		FC1D	2A
FNB 4	Mw	7/24/84		FNB4	2A
BG 93	Ab,Mw	10/12/81	1/22/97	BG93	3
DRB 1WW	Sp	2/1/61		DRB1WW	3
F 51	Ab	5/18/67	1978	F51	3
HMD 2D	Mw	2/1/91		HMD2D	3
BG 122	Ab,Mw		1/21/97	BG122	4
BG 125	Ab,Mw		1/23/97	BG125	4
BG 38	Ab,Mw	5/24/76	4/25/88	BG38	4
BG 39	Ab,Mw	5/25/76	4/22/88	BG39	4
BG 91	Ab,Mw	10/6/81	1/21/97	BG91	4
BG 92	Ab,Mw	10/8/81	1/22/97	BG92	4
BGO 11D	Ab,Mw	8/24/87	11/1/95	BGO11D	4
BGO 11DR	Mw	9/7/95		BGO11DR	4
BGO 12A	Ab,Mw	10/2/87	11/1/95	BGO12A	4
BGO 12AR	Ab,Mw	2/21/91	1/26/96	BGO12AR	4
BGO 12AX	Mw	10/3/95		BGO12AX	4
BGO 12C	Ab,Mw	10/1/87	2/25/92	BGO12C	4
BGO 12CR	Ab,Mw	3/18/91	1/26/96	BGO12CR	4
BGO 12CX	Mw	9/29/95		BGO12CX	4
BGO 12D	Ab,Mw	9/29/87	11/1/95	BGO12D	4
BGO 12DR	Mw	9/12/95		BGO12DR	4
BGO 43A	Mw	4/26/91		BGO43A	4
BGO 43AA	Mw	4/1/91		BGO43AA	4
BGO 43CR	Mw	6/6/91		BGO43CR	4
BGO 43D	Mw	4/29/91		BGO43D	4
F 43	Ab	2/13/67	1978	F43	4
F 55		9/19/67		F55	4
F 56		10/25/67		F56	4
F 57A	Ab	10/30/67	1978	F57A	4
F 57B	Ab	11/8/67	1978	F57B	4
F 57C	Ab	11/8/67	1978	F57C	4
F 58	Ab	11/16/67	1978	F58	4
F 59		12/4/67		F59	4
ZW 4	Ab,Mw	9/7/51	1/27/97	ZW4	4
BG 40	Ab,Mw	5/26/76	4/21/88	BG40	5
BGO 13D	Mw	10/12/87		BGO13D	5
BGO 13DR	Mw	2/27/91		BGO13DR	5
FAC 6P	Pz	2/3/92		FAC6P	5

**Table 4 (continued)
Monitoring Wells within the PDP Project Area**

Well Name	Type	Date Installed	Date Abandoned	Catalog ID	PDP Construction Area
FAC 7	Ab,Mw	9/15/88	4/4/96	FAC7	5
FAC 8	Ab,Mw	9/9/88	4/4/96	FAC8	5
FAC 9C	Mw	6/21/94		FAC9C	5
MZ 6	Ab		1/27/97	MZ6	5
BG 13		6/1/61		BG13	5A
BG 14		5/26/61		BG14	5A
FAB 1	Mw	5/13/94		FAB1	5A
FAB 2	Mw	5/9/94		FAB2	5A
FAB 3	Mw	5/12/94		FAB3	5A
FAB 4	Mw	5/10/94		FAB4	5A
FAC 1P	Ab,Pz	1/28/92	4/11/96	FAC1P	5A
FAC 2	Ab,Mw	8/24/83	3/10/89	FAC2	5A
FAC 3	Ab,Mw	8/26/83	4/4/96	FAC3	5A
FAC 3P	Ab,Pz	1/21/92	4/4/96	FAC3P	5A
FAC 4P	Ab,Pz	1/21/92	4/4/96	FAC4P	5A
FAC 5	Ab,Mw	9/2/88	4/4/96	FAC5	5A
FAC 6	Ab,Mw	9/15/88	4/4/96	FAC6	5A
FAC 10C	Mw	6/21/94		FAC10C	5A
FAC 11C	Ab,Mw	6/24/94	4/4/96	FAC11C	5A
FAC 12C	Ab,Mw	6/24/94	4/4/96	FAC12C	5A
FCB 1	Ab,Mw	10/16/81	7/13/88	FCB1	5A
FCB 7	Mw	7/7/88		FCB7	5A
FAC 2P	Ab,Pz	1/28/92	4/3/96	FAC2P	X
FAC 4	Ab,Mw	7/20/84	4/3/96	FAC4	X
FC 2A		4/1/77		FC2A	X
FC 2B		4/7/77		FC2B	X
FC 2C		4/14/77		FC2C	X
FC 2D		4/18/77		FC2D	X
FC 2E		4/21/77		FC2E	X
FC 2F		4/22/77		FC2F	X
P 28A	Mw	9/27/86		P28A	X
P 28TA	Mw	7/8/86		P28TA	X
P 28TB	Mw	10/2/86		P28TB	X
P 28TC	Mw	10/7/86		P28TC	X
P 28TD	Mw	10/9/86		P28TD	X
P 28TE	Mw	10/14/86		P28TE	X

Mw: monitoring well
 Ab: abandoned
 Pz: piezometer
 Sp: special

Table 5
Inventory of Radionuclides Released from F-Area

Radionuclide	Liquid Release (Ci) ¹	Airborne Release (Ci) ¹
Am-241	1.85e-5	4.68e-3
C-14		6.48e+2
Cm-244	7.28e-6	5.35e-3
Co-60		1.91e-2
Cs-134		8.56e-4
Cs-137	1.00e+0	5.97e-1
Eu-154		5.21e-7
H-3	7.50e+2	See note ²
I-129		1.92e-2 ³
Pm-147	6.13e-2	
Pu-238	3.80e-5	1.46e-2
Pu-239	9.28e-4	2.44e+0
Ru-103,106		3.85e+1
Ru-106		3.29e+1
Sb-125		2.93e-3
Sr-89,90	3.69e-2	6.76e-1
Sr-90	2.95e-1	
U (nat)	5.95e-5	5.80e-1
U-234	2.13e-4	4.02e-4
U-235	1.65e-5	2.07e-3
U-238	4.17e-4	2.03e-3
Unidentified Alpha ⁴	2.90e-1	7.41e-2
Unidentified Beta ⁵	1.63e+1	1.53e+1

Notes

¹Blanks indicate either no quantifiable activity or monitoring for the radionuclide is not conducted.

²Airborne releases of tritium from F-Area and H-Area are combined

³Releases from F-Area and H-Area combined until 1991.

⁴Assumed to be Pu-239

⁵Assumed to be Sr-89,90

**Table 6
Summary of PDP Preconstruction and Preoperational Monitoring Activities**

Program	Location	Frequency	Analytes
Surface Water Nonradiological	Trib-I	M	temperature, pH, dissolved oxygen (DO), total suspended solids (TSS)
Surface Water Nonradiological	Trib-I	Q	temperature, pH, dissolved oxygen (DO), conductivity, chemical oxygen demand (COD), nitrogen as nitrate, nitrogen as nitrite, total suspended solids (TSS), total phosphorous, total organic carbon (TOC), aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, pesticides, herbicides
Surface Water Nonradiological	Trib-C	M	temperature, pH, dissolved oxygen (DO), total suspended solids (TSS)
Surface Water Nonradiological	Trib-C	Q	temperature, pH, dissolved oxygen (DO), conductivity, chemical oxygen demand (COD), nitrogen as nitrate, nitrogen as nitrite, total suspended solids (TSS), total phosphorous, total organic carbon (TOC), aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, pesticides, herbicides
Surface Water Nonradiological	U3R-U	M	temperature, pH, dissolved oxygen (DO), total suspended solids (TSS)
Surface Water Nonradiological	U3R-D	M	temperature, pH, dissolved oxygen (DO), total suspended solids (TSS)
Surface Water Radiological	Trib-I	Q	gross alpha/beta, gamma-emitting radionuclides, tritium, total Sr, and actinides
Surface Water Radiological	Trib-U	Q	gross alpha/beta, gamma-emitting radionuclides, tritium, total Sr, and actinides

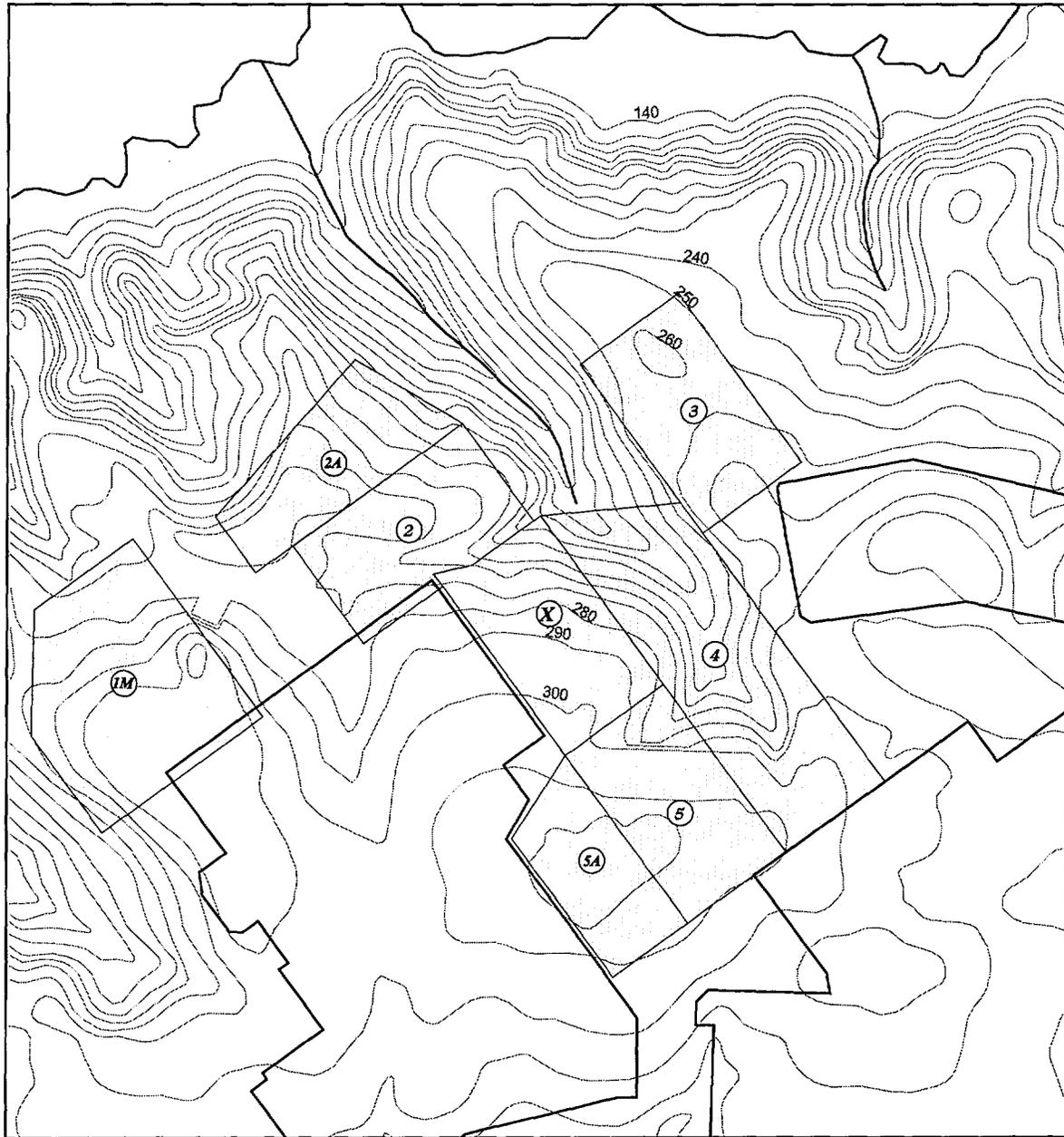
Table 6 (continued)
Summary of PDP Preconstruction and Preoperational Monitoring Activities

Surface Water Radiological	U3R-U	Q	gross alpha/beta, gamma-emitting radionuclides, tritium, total Sr, and actinides
Surface Water Radiological	U3R-D	Q	gross alpha/beta, gamma-emitting radionuclides, tritium, total Sr, and actinides
Sediment Nonradiological	Trib-I	Q	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, zinc, pesticides, herbicides
Sediment Nonradiological	Trib-U	Q	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, zinc, pesticides, herbicides
Sediment Nonradiological	U3R-U	Q	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, zinc, pesticides, herbicides
Sediment Nonradiological	U3R-D	Q	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, uranium, zinc, pesticides, herbicides
Sediment Radiological	F-02	Q	gamma, total Sr, actinides
Sediment Radiological	F-03	Q	gamma, total Sr, actinides
Sediment Radiological	F-05	Q	gamma, total Sr, actinides
Sediment Radiological	Trib-I	Q	gamma, total Sr, actinides

Table 6 (continued)
Summary of PDP Preconstruction and Preoperational Monitoring Activities

Sediment Radiological	Trib-U	Q	gamma, total Sr, actinides
Sediment Radiological	U3R-U	Q	gamma, total Sr, actinides
Sediment Radiological	U3R-D	Q	gamma, total Sr, actinides
Soil	Statistical	1-Time	gamma, total Sr, actinides
Vegetation	Statistical, same as soil	Q	gamma, total Sr, actinides, tritium
Ambient Gamma	Statistical, same as soil	Q	exposure rate
Macroinvertebrate	Trib-I	Q	macroinvertebrate population and species
Macroinvertebrate	Trib-U	Q	macroinvertebrate population and species
Macroinvertebrate	U3R-U	Q	macroinvertebrate population and species
Macroinvertebrate	U3R-D	Q	macroinvertebrate population and species

Figure 1
PDP Project Areas with Topography (20' Contours)



-  Elevation (Ft MSL)
-  Streams
-  Fence Line
-  SPD Footprints

500 0 500 1000 Feet



Figure 4
Routine EMS Monitoring Locations

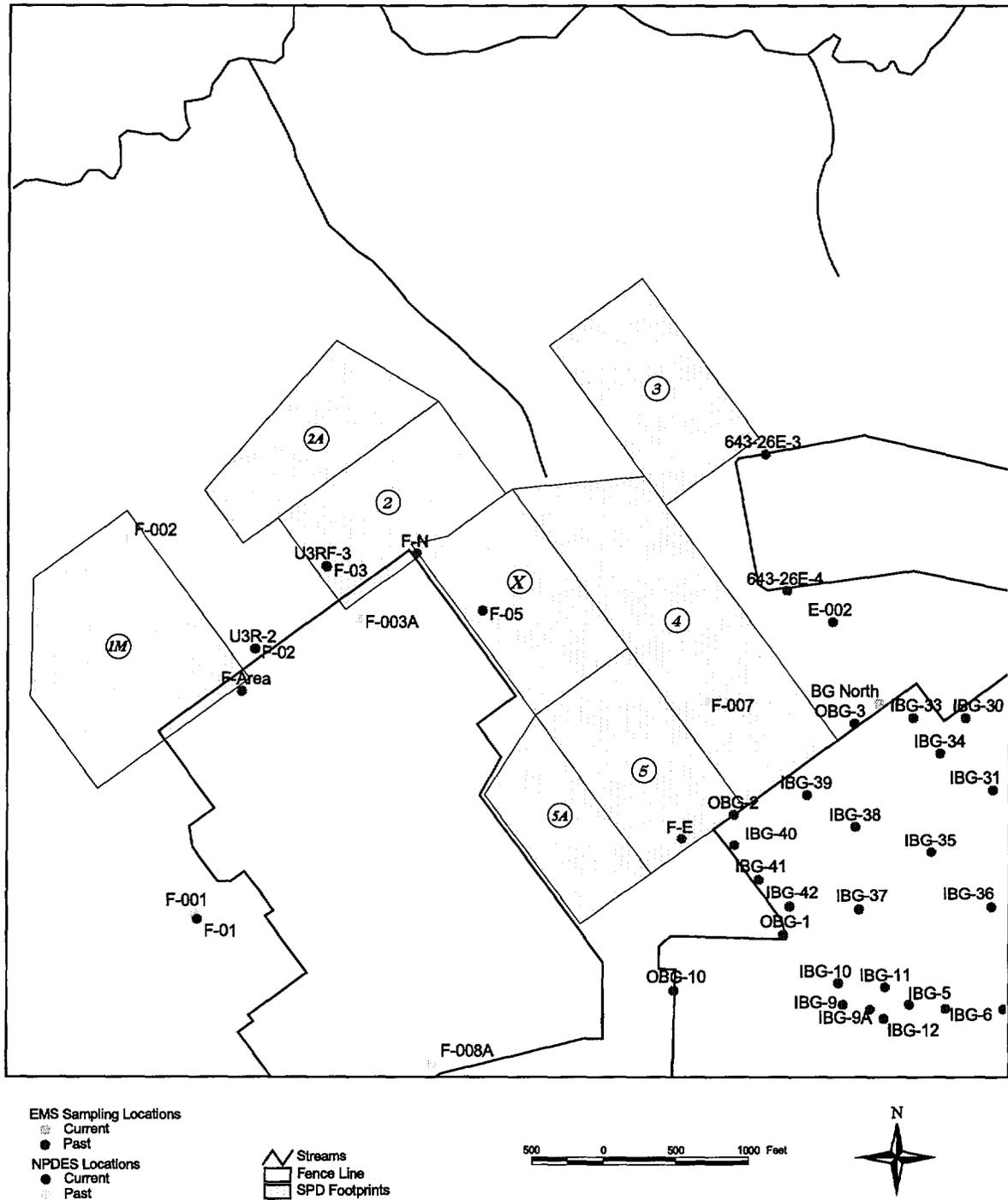


Figure 5
Radiological Surface Water Monitoring

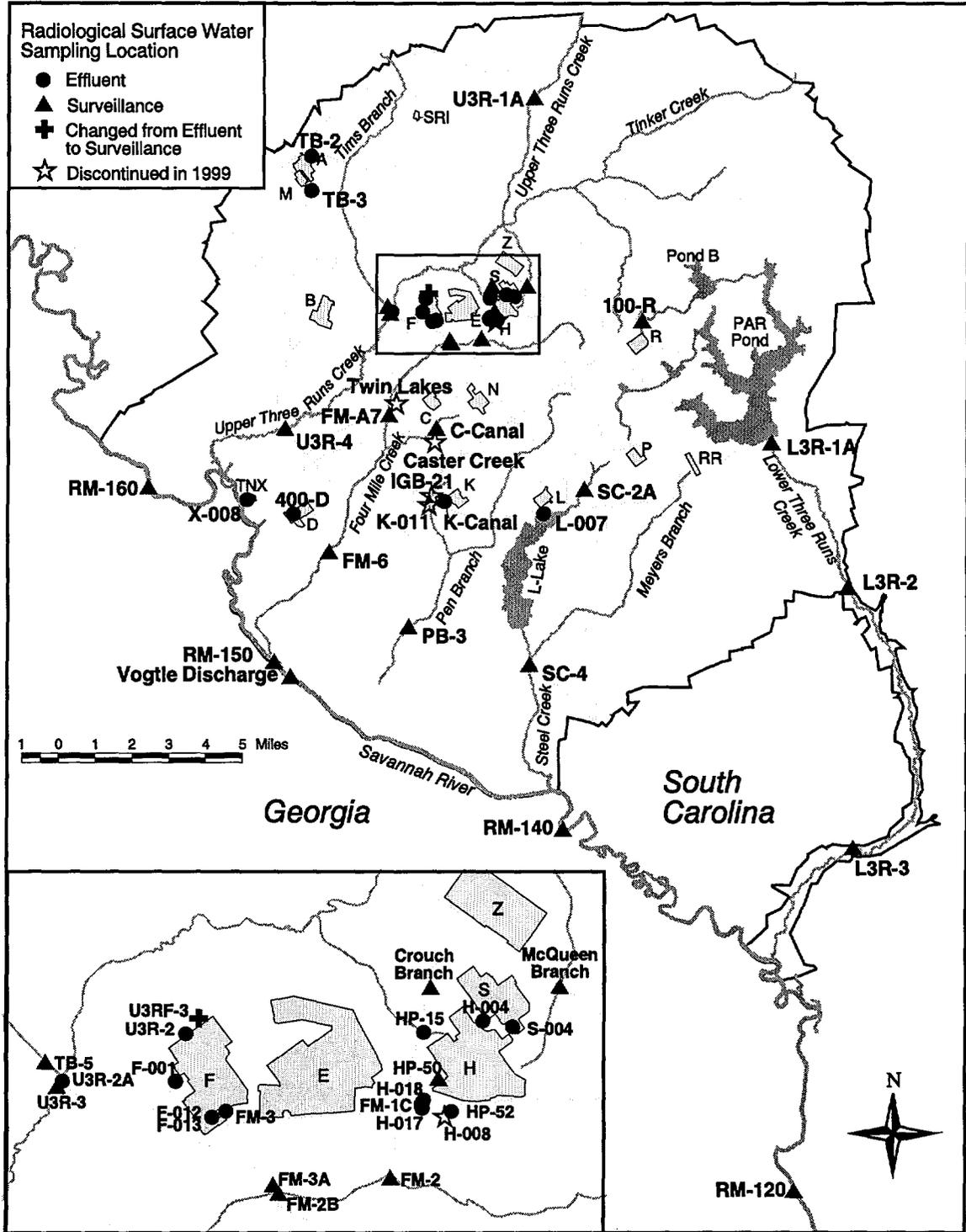


Figure 6
Nonradiological Surface Water Monitoring

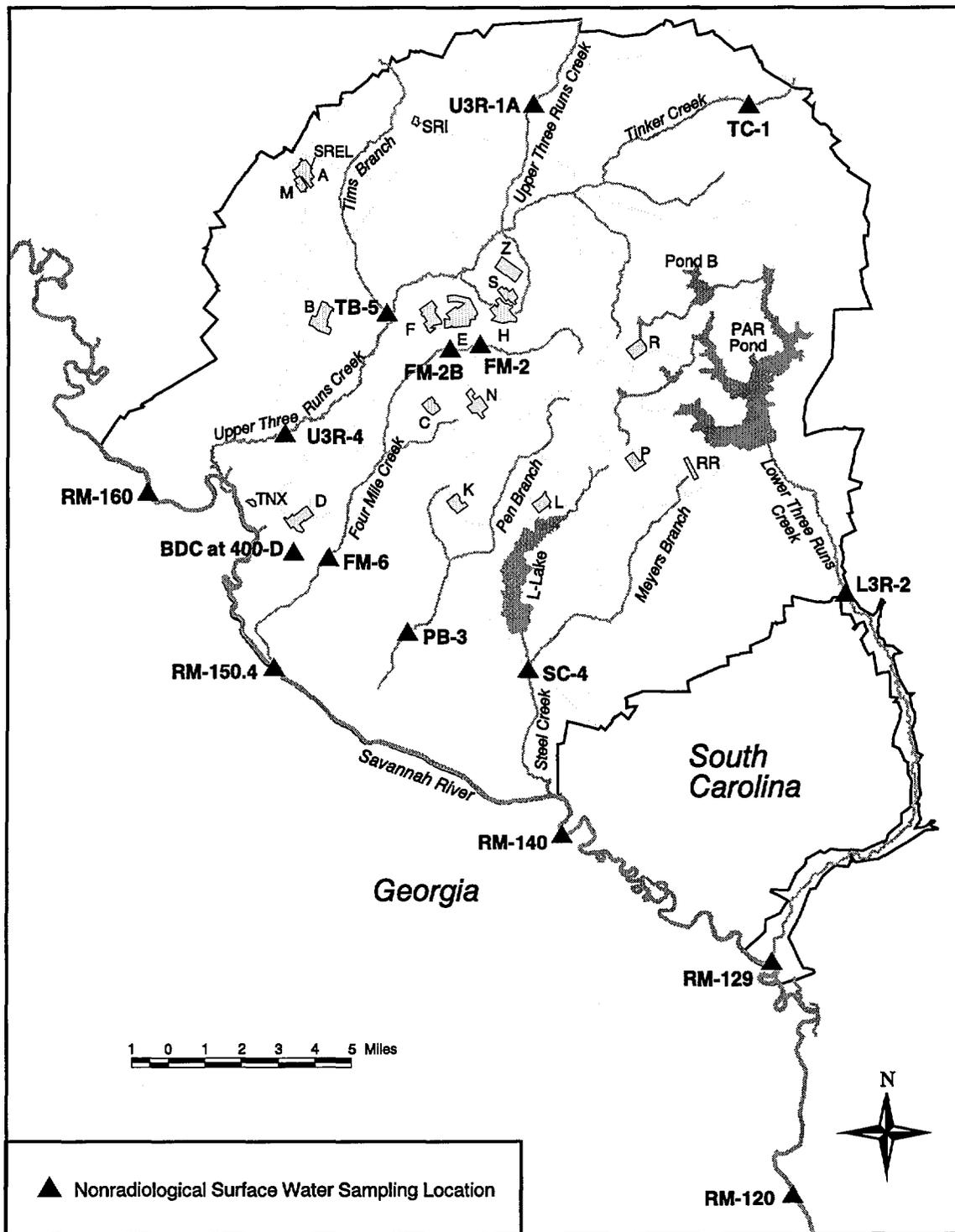


Figure 7
Radiological Sediment Monitoring

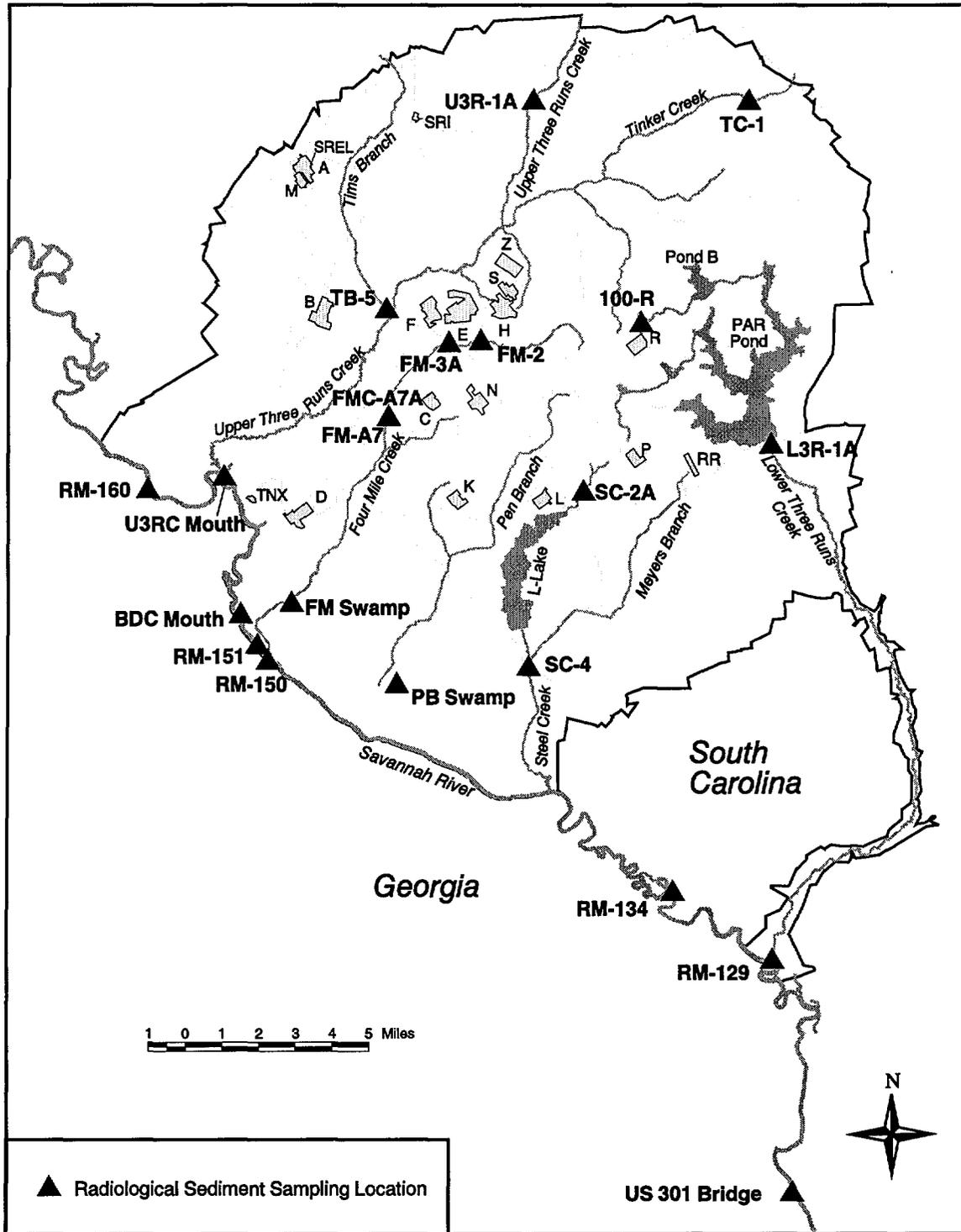
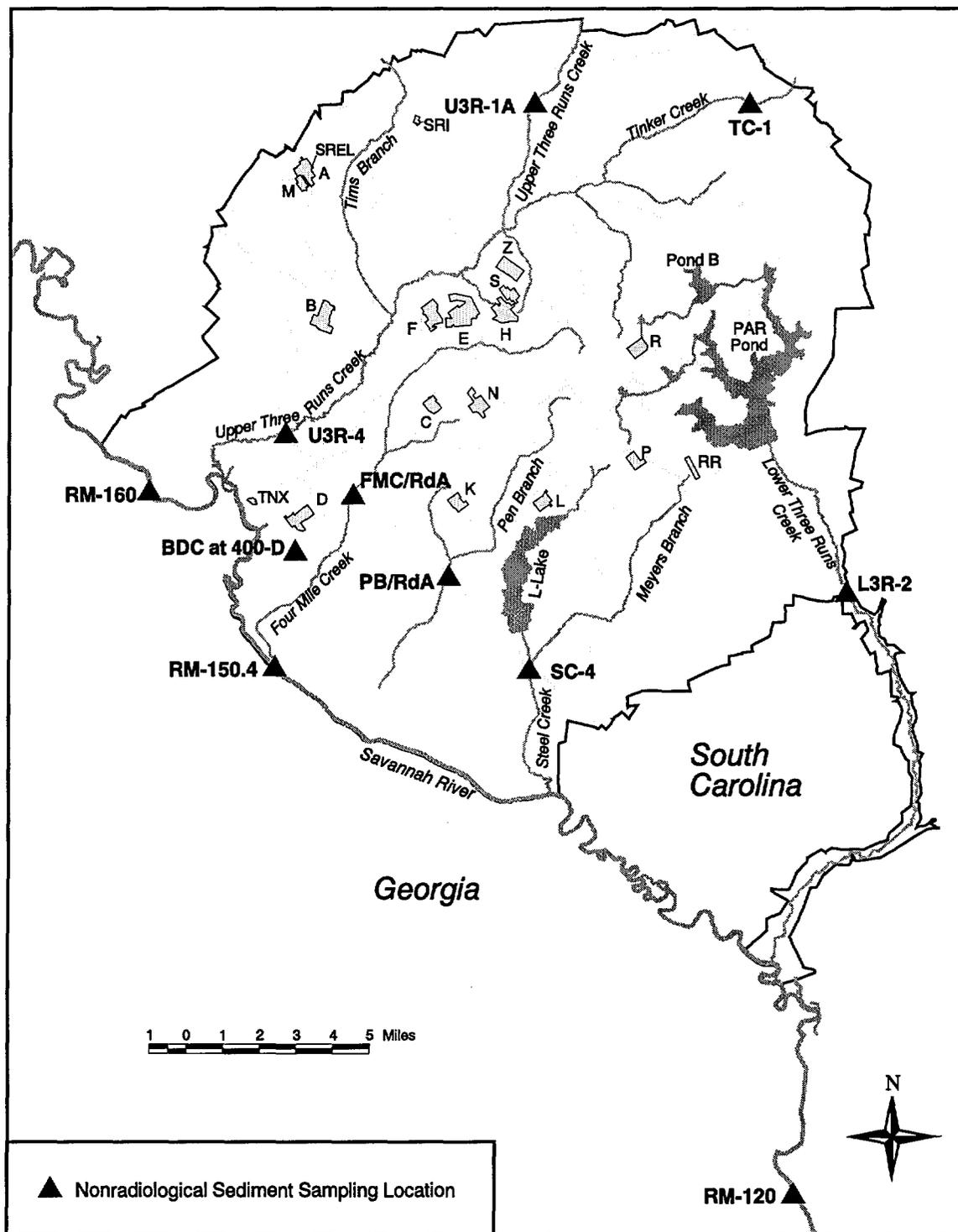
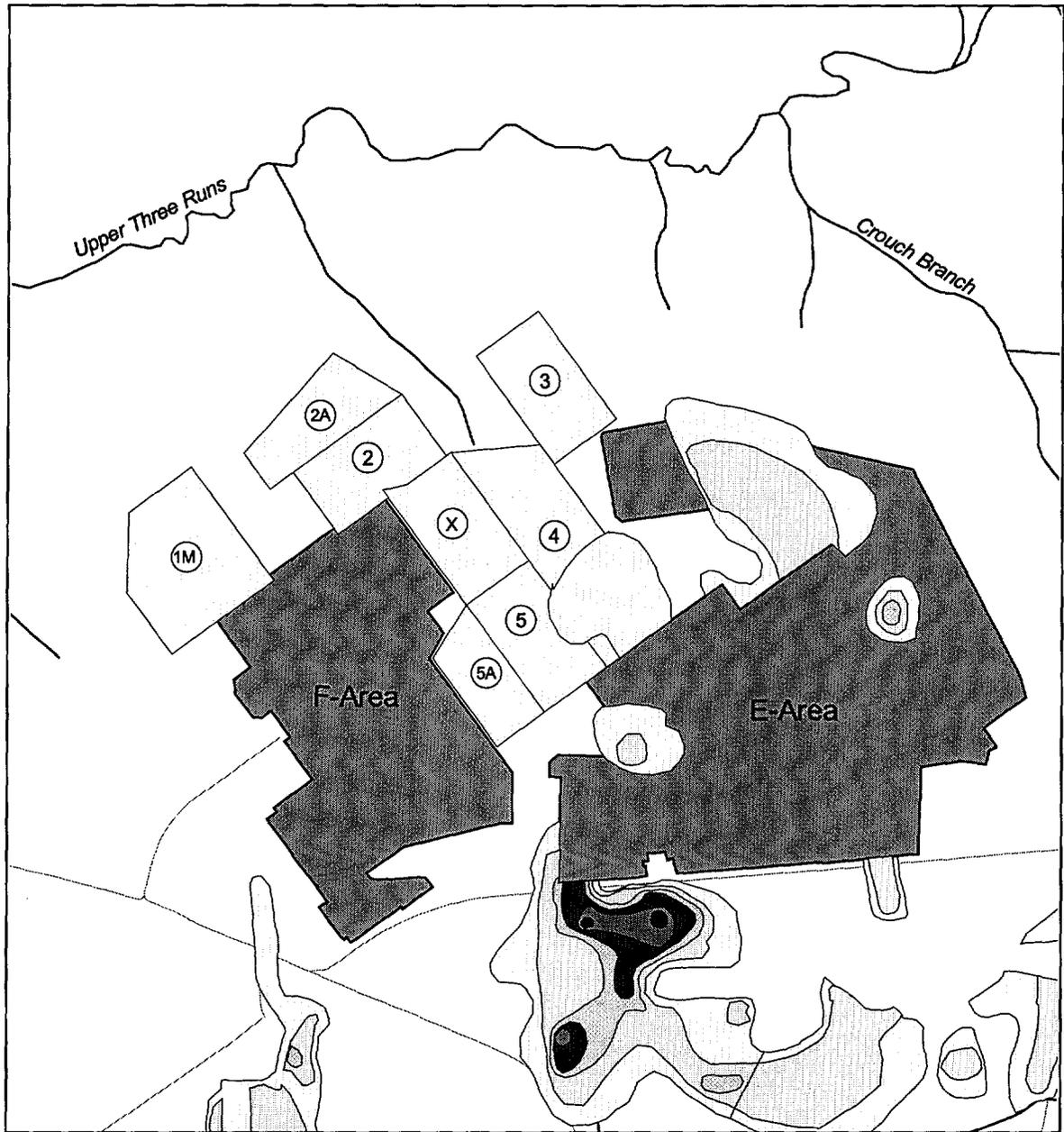


Figure 8
Nonradiological Sediment Monitoring



**Figure 9
Groundwater Tritium Plumes**



Groundwater Plumes

- MDL - 100 pCi/ml Tritium
- 100 - 1,000 pCi/ml Tritium
- 1,000 - 5,000 pCi/ml Tritium
- 5,000 - 10,000 pCi/ml Tritium
- 10,000 - 50,000 pCi/ml Tritium
- 50,000 - 100,000 pCi/ml Tritium

- ▬ Major Roads
- ▬ Streams
- ▬ Fence Line
- SPD Footprints

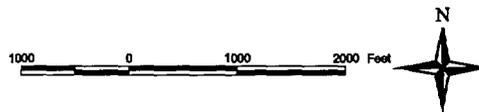
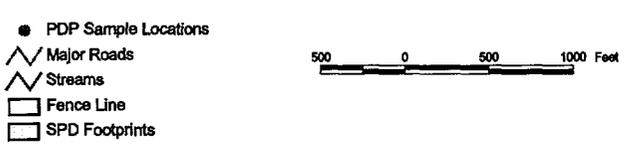
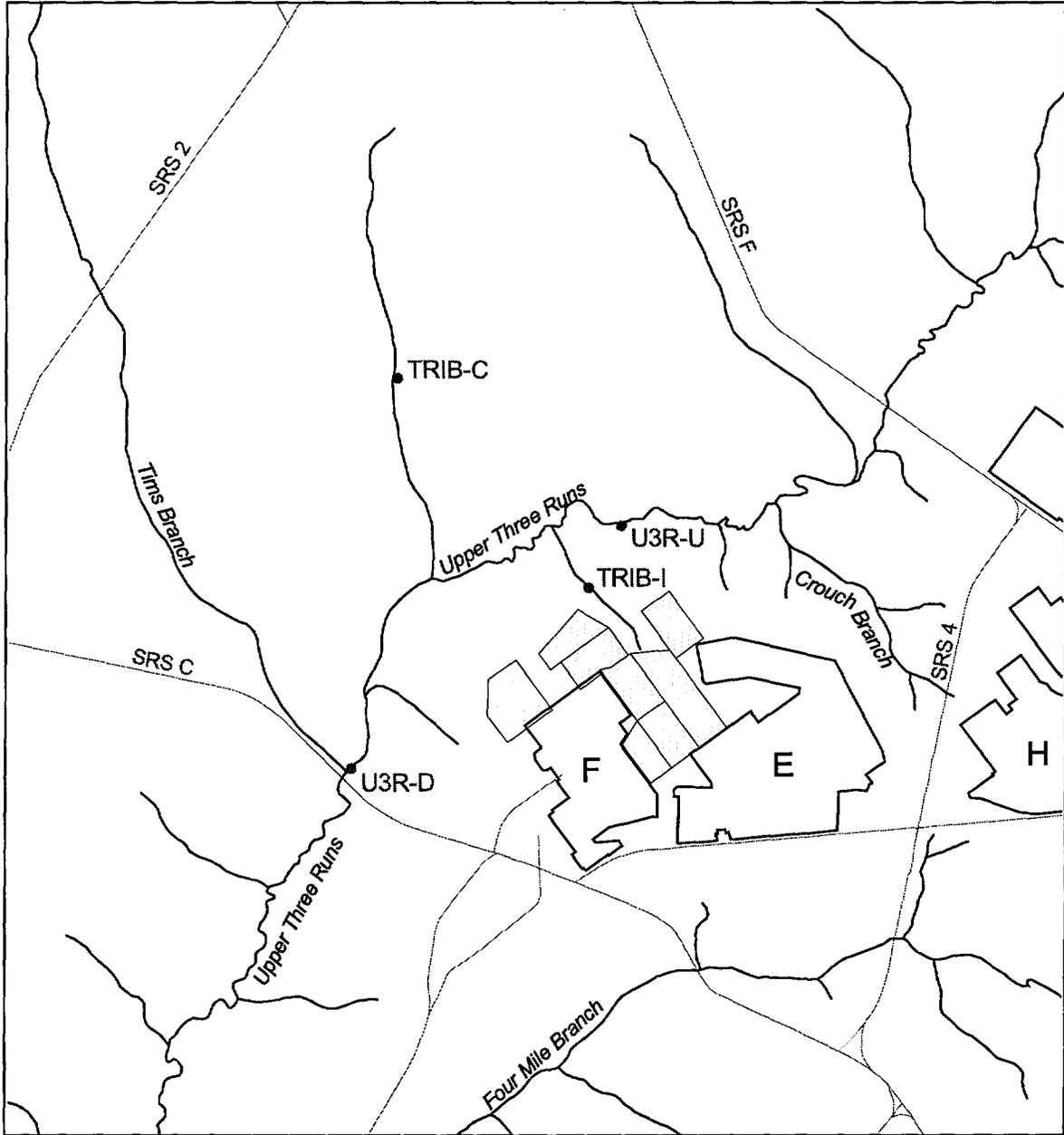


Figure 10
Preconstruction and Preoperational Surface Water Monitoring

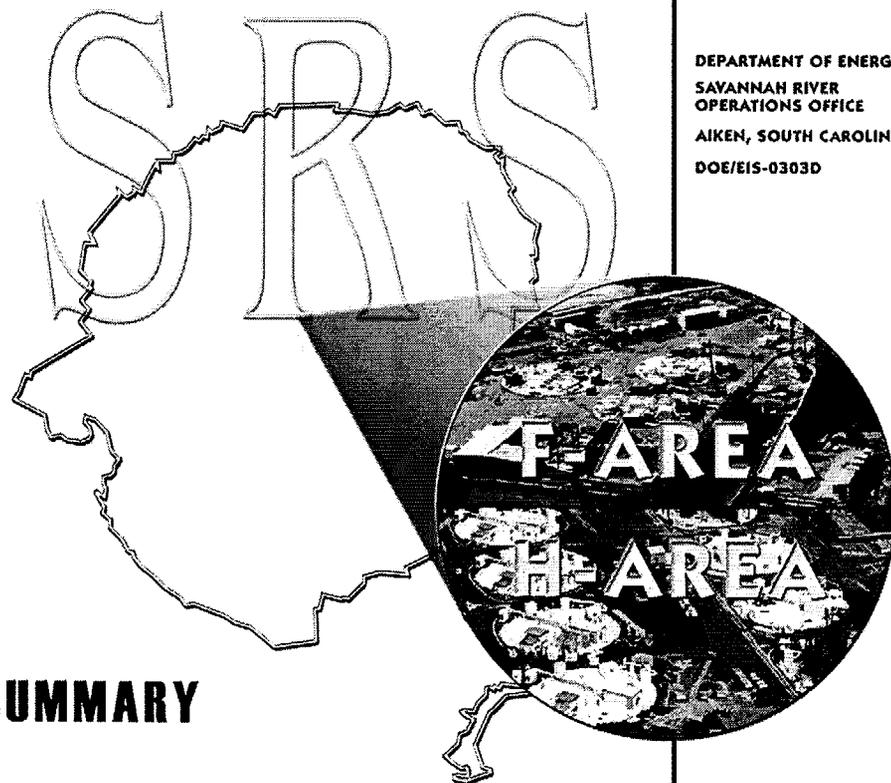


Savannah River Site

HIGH-LEVEL WASTE **TANK CLOSURE**

Draft Environmental Impact Statement

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



SUMMARY

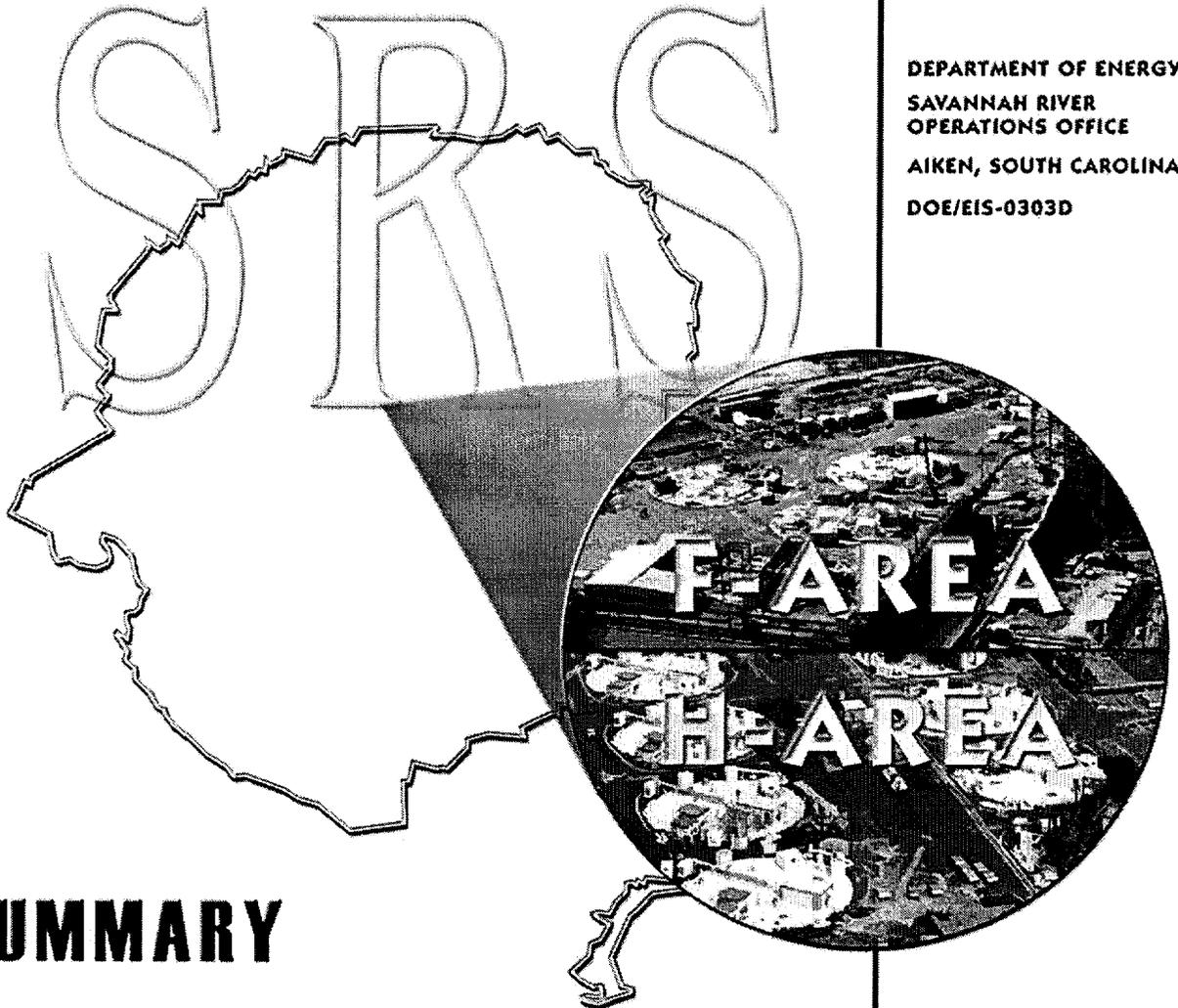
November 2000

Savannah River Site

HIGH-LEVEL WASTE **TANK CLOSURE**

Draft Environmental Impact Statement

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



SUMMARY

November 2000

COVER SHEET

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

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

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

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

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

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

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

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

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

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

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ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

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

MCL	maximum contaminant level
MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO _x	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O ₃	ozone
OSHA	Occupational Safety and Health Administration
PM ₁₀	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO ₂	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

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

Use of Scientific Notation

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

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

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

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

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1,000 = 4,900$

0.049 is written 4.9×10^{-2}

1,490,000 or 1.49 million is written 1.49×10^6

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

In some cases, a slightly different notation (“E-notation”) is used, where “ $\times 10$ ” is replaced by “E” and the exponent is not superscripted. Using the above examples

$$4,900 = 4.9 \times 10^3 = 4.9E+03$$

$$0.049 = 4.9 \times 10^{-2} = 4.9E-02$$

$$1,490,000 = 1.49 \times 10^6 = 1.49E+06$$

Metric Conversion Chart

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

Metric Prefixes

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

S.1 Introduction

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

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

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

have been removed from service. Closure of the HLW tanks will comply with DOE's responsibilities under the AEA and the South Carolina closure requirements, and be carried out under a schedule agreed to by DOE, EPA, and SCDHEC.

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

S.2 High-Level Waste Storage and Tank Closure

S.2.1 HIGH-LEVEL WASTE

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation."

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

Currently, about 34 million gallons of HLW are stored in 49 underground tanks in two tank farms, the F-Area Tank Farm and the H-Area Tank Farm. Two additional tanks have been

closed. The tank farms are in the central part of the SRS, about 5.5 miles from the SRS boundaries. Figure S-1 shows the locations of F- and H-Areas and the tank farms.

The HLW in the tanks is in three forms: sludge, salt, and liquid. The sludge is solid material that has precipitated and settled to the bottom of the tank. The salt is comprised of salt compounds¹ that have crystallized as a result of concentrating the liquid by evaporation. The liquid is a highly concentrated solution of salt compounds in water. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks, while others are considered salt tanks, containing both salt and liquid.

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

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before treatment. As described in the *Defense Waste Processing Facility Supplemental Environmental Impact Statement* (DOE/EIS-0082S), any In-Tank Precipitation Process would separate the salt and liquid portions of the HLW into high- and low-radioactivity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification along with the sludge portion. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed of in vaults at SRS. Since issuance of that EIS, DOE

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

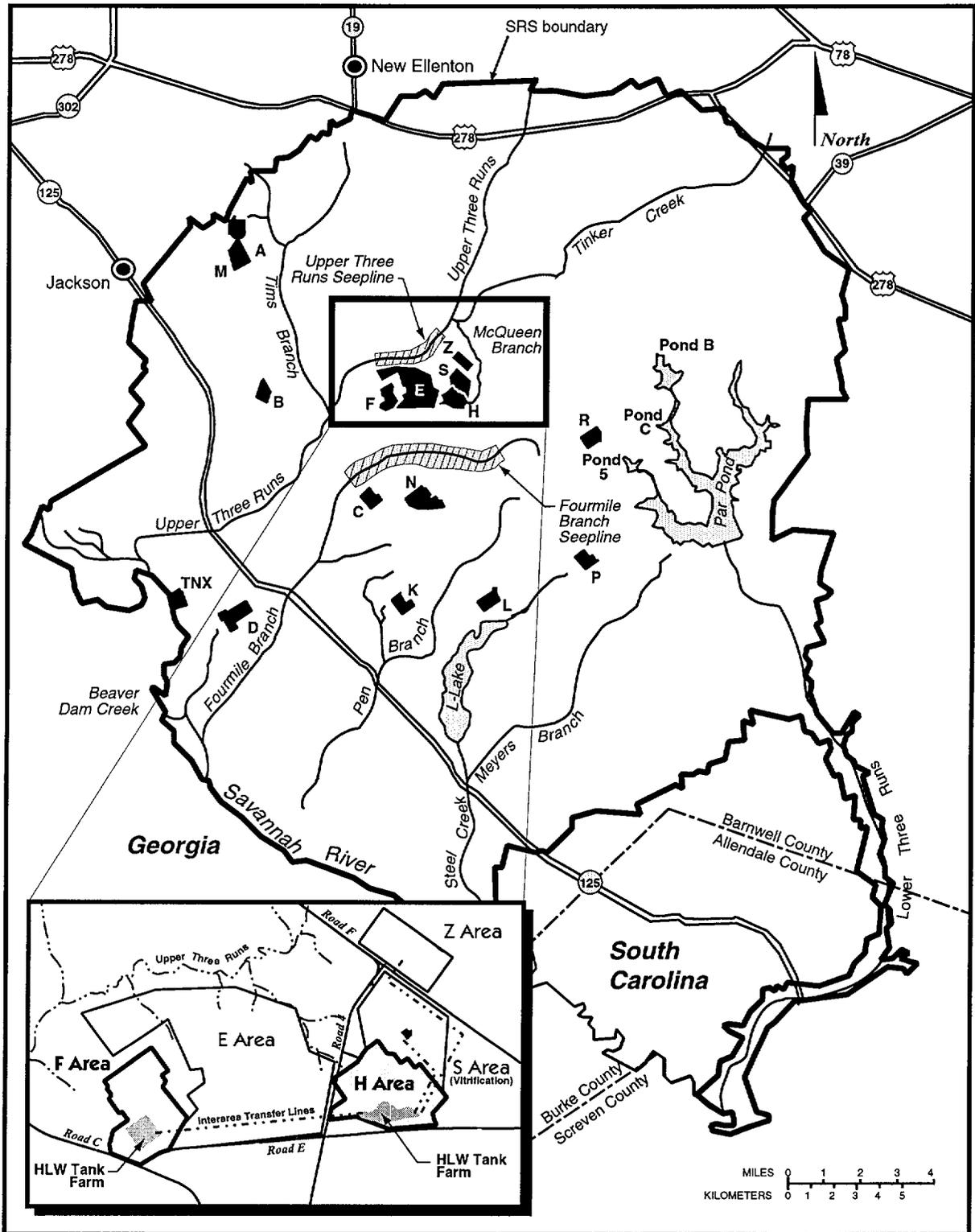
has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559, February 22, 1999). DOE is conducting research and development for a new technology for separating the salt and liquid portions of the HLW and is preparing an EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*, to evaluate the impacts of alternative technologies. Figure S-2 shows the current configuration of the SRS HLW management system.

S.2.3 HIGH-LEVEL WASTE TANKS AND TANK FARMS

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

The HLW tanks are of four different designs, all constructed of carbon-steel inside reinforced concrete containment vaults. The major design features and dimensions of each tank design are shown in Figure S-5.

There are 12 Type I tanks (4 in H-Area and 8 in F-Area) that were built in 1952 and 1953. These tanks have partial height secondary containment and active cooling. The tank tops are 9.5 feet below grade, and the bottoms of Tanks 1 through 8 in F-Area are above the seasonal high water table. The bottoms of Tanks 9 through 12 in H-Area are in the water table. Tanks 1 and 9 through 12 are known to have leak sites where waste has leaked from the primary to the secondary containment. There is no evidence that the waste has leaked from the secondary containment.



NW TANK/Grtx/Sum/S-1 SRS F&H.ai

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

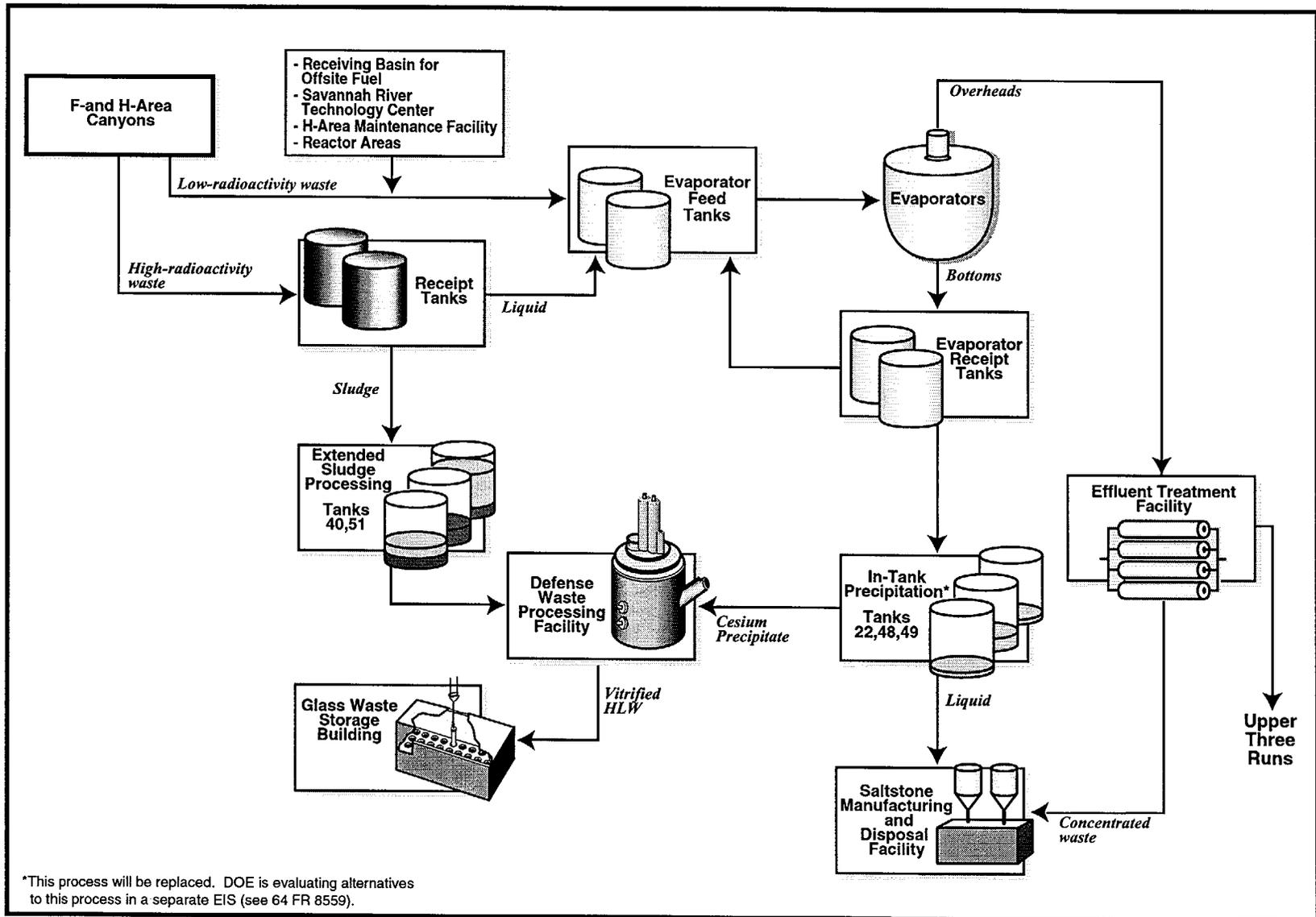
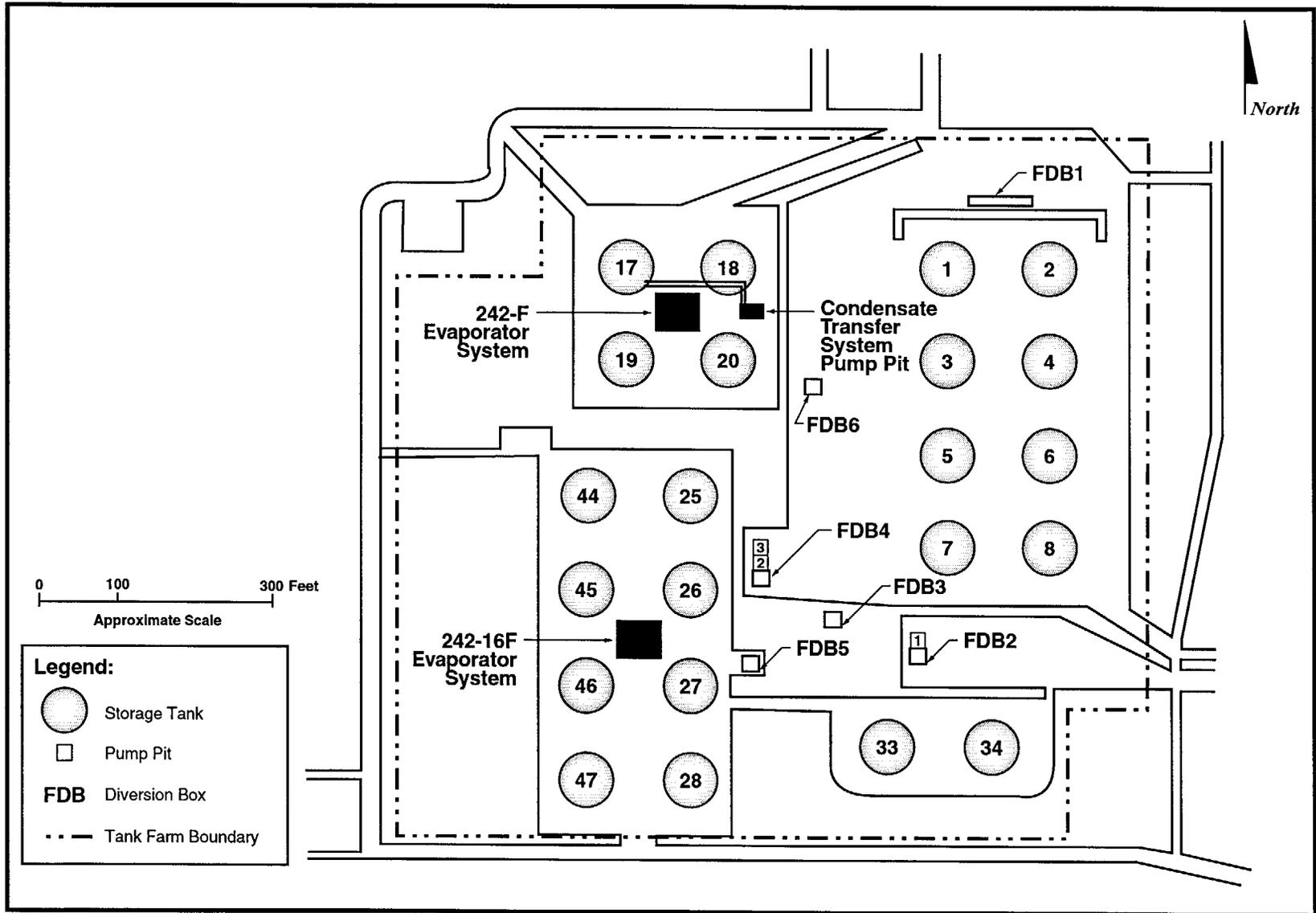


Figure S-2. Process flows for Savannah River Site High-Level Waste Management System.



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

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

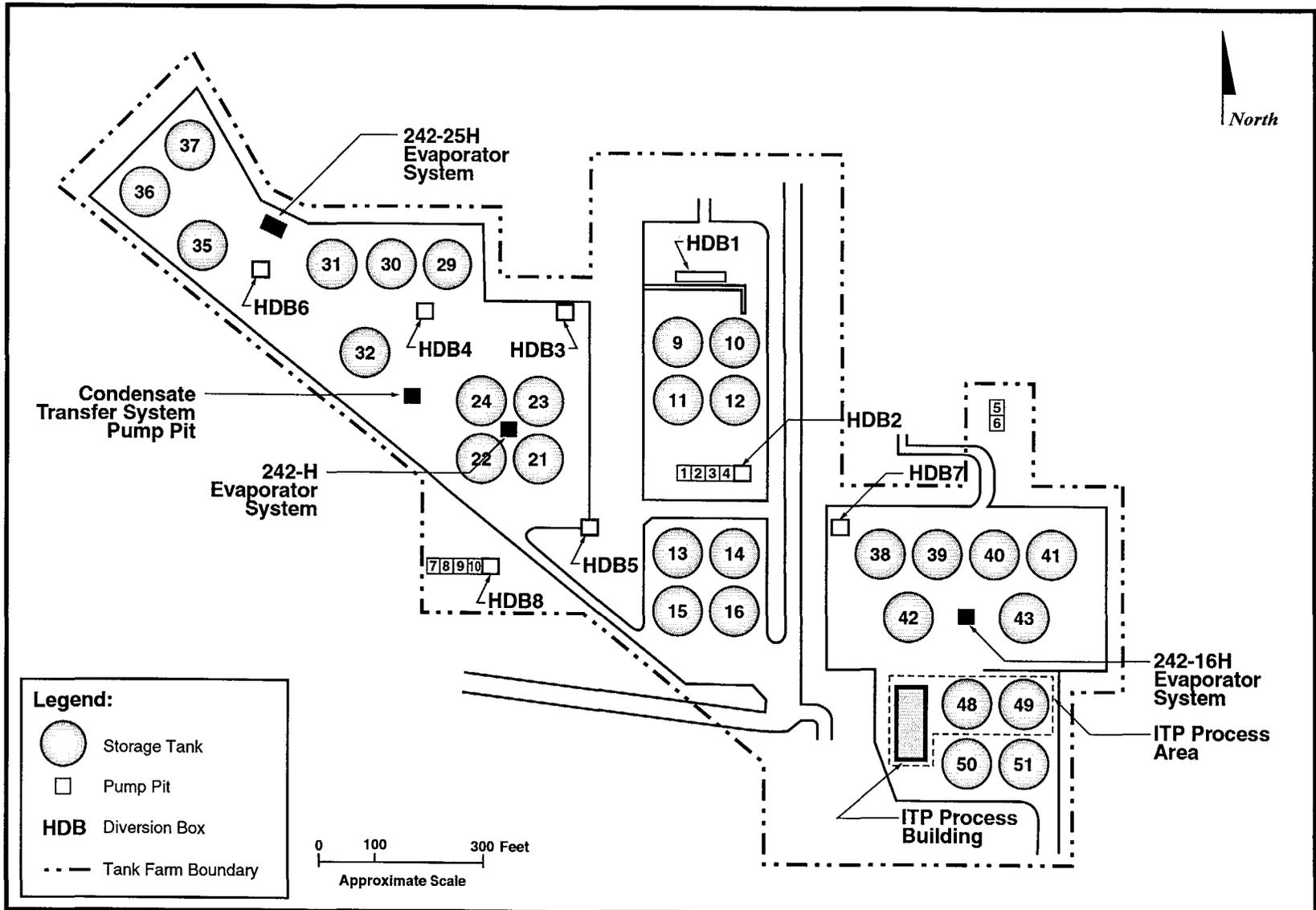


Figure S-4. General layout of H-Area Tank Farm.

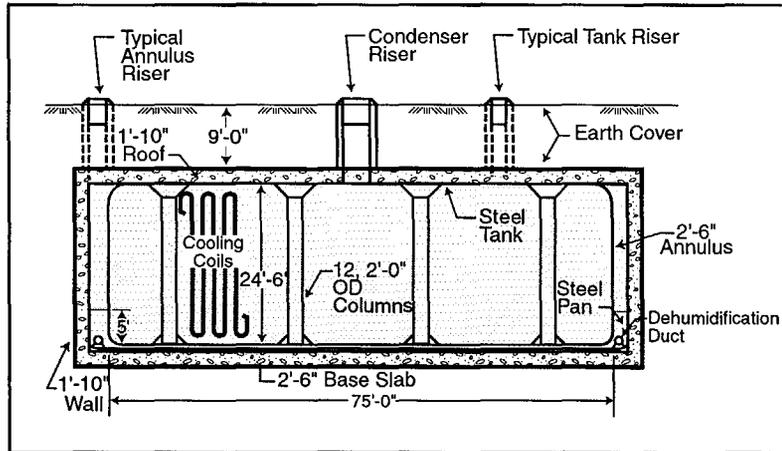


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

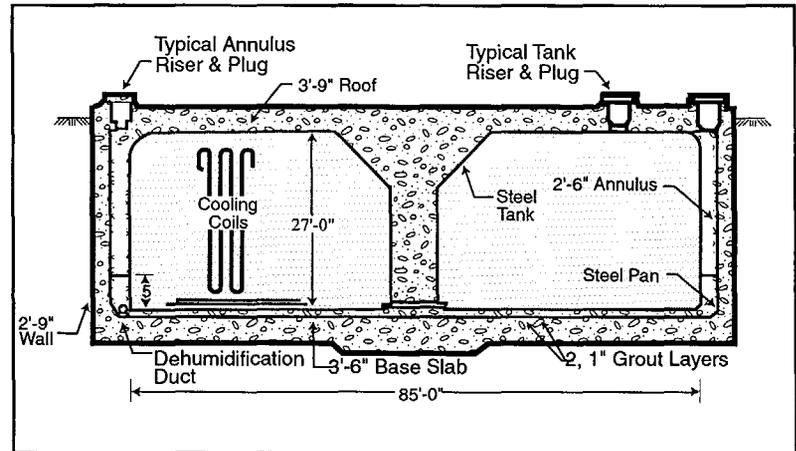


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

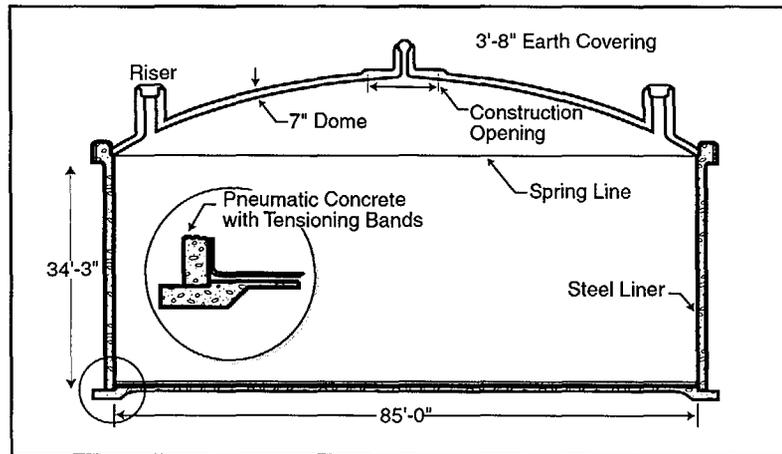


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

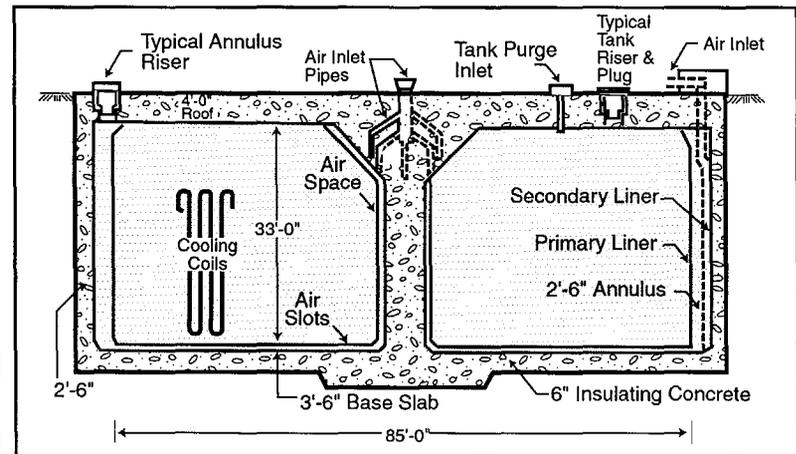


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

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

Figure S-5. Tank configuration.

Four Type II tanks, Tanks 13 through 16, were built in 1956 in H-Area. These tanks have partial-height secondary containment and active cooling. These tanks are above the seasonal water table. All four tanks have known leak sites where waste has leaked from the primary to the secondary containment. In Tank 16, waste overflowed the annulus pan (secondary containment) and migrated into the surrounding soil. Waste removal from the Tank 16 primary vessel was completed in 1980, but waste that leaked into the annulus has not been removed.

Eight Type IV tanks, Tanks 17 through 24, were built between 1958 and 1962. These tanks have single steel walls and do not have active cooling. Tanks 17 through 20 in the F-Area Tank Farm are slightly above the water table. Tanks 19 and 20 have known cracks that are believed to have been caused by groundwater corrosion of the tank walls in the past. Small amounts of groundwater have leaked into these tanks, but there is no evidence that waste ever leaked out. Tanks 17 and 20 have been closed in the manner described in the Clean and Fill with Grout Option of the Clean and Stabilize Tanks Alternative evaluated in this EIS. Tanks 21 through 24 in the H-Area Tank Farm are above the groundwater table, but are in a perched water table, caused by the original construction of the tank area.

The newest design, Type III tanks, have a full-height secondary tank and active cooling. These 27 tanks were placed in service between 1969 and 1986, with 10 in the F-Area and 17 in the H-Area Tank Farms. All Type III tanks are above the water table.

S.2.4 HIGH-LEVEL WASTE TANK CLOSURE

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

DOE has reviewed bulk waste removal of waste from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management

for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks.

In accordance with the SRS Federal Facility Agreement between DOE, EPA, and SCDHEC, DOE intends to remove the tanks from service as their storage missions are completed. DOE is obligated to close 24 tanks that do not meet the EPA's secondary containment standards under the Resource Conservation and Recovery Act (RCRA) by 2022. The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for them, which DOE currently anticipates would occur before the year 2030.

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

The General Closure Plan identifies the resources (e.g., groundwater, air) potentially af-

ected by contaminants remaining in the tanks after waste removal and closure, describes how the tanks would be cleaned and how the tank systems and residual wastes would be stabilized, and identifies Federal and state regulations and guidance that apply to the closures. It describes the use of fate and transport models to calculate potential environmental exposure concentrations or radiological dose rates from the residual waste left in the tank systems. The General Closure Plan describes the method DOE will use to make sure the impacts of closure of individual tank systems do not exceed the environmental standards that apply to the entire F - and H-Area Tank Farms. Chapter 7 of this EIS gives more detail on the development of the General Closure Plan and the environmental standards that apply to closure of the HLW tanks.

Performance Objective

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

Waste Incidental to Reprocessing

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

the tanks is to remove as much waste as can reasonably be removed.

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

Waste Incidental to Reprocessing Determination

The two processes for determining that waste can be considered incidental to reprocessing are "citation" and "evaluation." Waste incidental to reprocessing by "citation" includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission's Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as "waste incidental to reprocessing." These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

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

According to Order 435.1, waste resulting from reprocessing spent nuclear fuel that is determined to be incidental to reprocessing is not HLW, and shall be managed under DOE's

regulatory authority in accordance with requirements for transuranic waste or low-level waste, as appropriate.² Section 7.1.3 of this EIS discusses the waste incidental to reprocessing process in more detail.

HLW Tank Cleaning

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

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

Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity (See Table S-1). Use of oxalic acid in an HLW tank would require successfully demonstrating that dissolution of HLW

sludge solids by the acid would not create a potential for a nuclear criticality.

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

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

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

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

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

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

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

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

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

S.3 NEPA Process

NEPA provides Federal decisionmakers with a process to use when considering the potential environmental impacts of proposed actions and alternatives. This process also provides several

ways the public can be informed about and influence the selection of an alternative.

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

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

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

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

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

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

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

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

Commentors were concerned about the EIS schedule and process as it relates to closure of the HLW tanks. DOE will complete the EIS process before closing any additional waste tanks at SRS. In addition, preparation of the EIS

will not interfere with the established schedule for closure of the HLW tanks.

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

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

One commentor observed that new missions would add to the amount of HLW and prolong the closure process. DOE has recently selected SRS as the site for several new missions. The Pit Disassembly and Conversion Facility, Mixed Oxide Fuel Facility, Immobilization Facility, and the Tritium Extraction Facility will not add HLW to the current SRS inventory. Stabilizing plutonium residues from the Rocky Flats Environmental Technology Site at SRS is expected to result in the equivalent of five DWPF canisters. The melt and dilute facility for management of spent nuclear fuel would add the equivalent of 17 DWPF canisters. These canisters are in addition to the approximately 6,000 canisters DOE expects to produce absent the new missions.

S.4 Purpose and Need

DOE needs to reduce human health and safety risks at and near the HLW tanks, and to reduce the eventual introduction of contaminants into the environment. If DOE does not take action after bulk waste removal, the tanks would fail and contaminants would be released to the environment. Failed tanks would present the risk of

accidents to individuals. Release of contaminants to the environment would present human health risks, particularly to individuals who might use contaminated water, in addition to adverse impacts to the environment.

S.5 Decisions to be Based on This EIS

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

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

additional NEPA review prior to implementing closure of the tank.

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

S.6 Proposed Action and Alternatives

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

DOE is evaluating three alternatives in this EIS.

Tank Closure Alternatives

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

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

S.6.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

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

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

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

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

Tank Stabilization

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

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

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

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

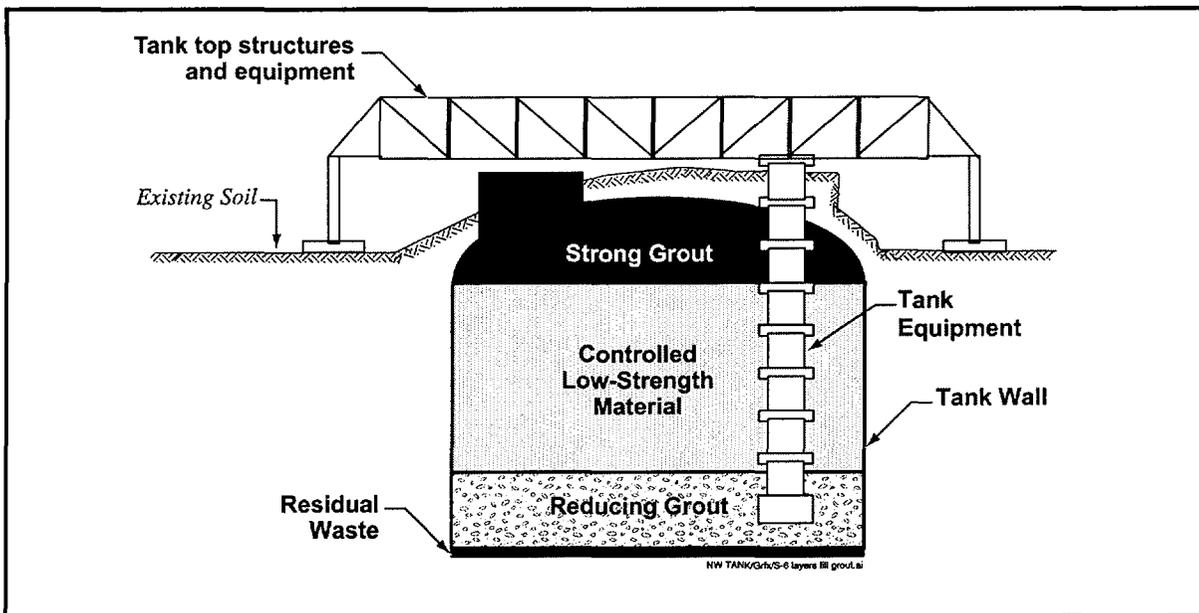


Figure S-6. Typical layers of the fill with grout option.

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

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

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

Following the use of any of the stabilization options described above, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting in the surface depressions. This action would prevent ponding conditions over the tanks that could facilitate degradation of the tank structure.

S.6.2 CLEAN AND REMOVE TANKS ALTERNATIVE

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

For the Clean and Remove Tanks Alternative, DOE would have to perform enhanced cleaning

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

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

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

S.6.3 NO ACTION ALTERNATIVE

For HLW tanks, the No Action Alternative would involve leaving the tank systems in place after bulk waste removal has taken place. Even after bulk waste removal, each tank would contain residual waste and, in those tanks that reside

in the water table, ballast water. The tanks would not be backfilled.

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

S.7 Alternatives Considered, But Not Analyzed

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

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

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

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

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

If DOE determines through the waste incidental to reprocessing process that the tank residues cannot be managed as LLW, as expected, or alternatives as TRU waste, the residues would be

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

S.7.2 OTHER ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

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

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

S.8 Comparison of Environmental Impacts among Alternatives

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

from the stabilized tanks to the environment. In this EIS, DOE has estimated these impacts over a period of 10,000 years.

S.8.1 SHORT-TERM IMPACTS

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

DOE compared impacts in the following areas:

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

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

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

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

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

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

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

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

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Geologic Resources	None	170,000	170,000	170,000	356,000
Soil backfill (m³)					
Air Resources					
Nonradiological air emissions (tons/yr.):					
Particulate matter	None	4.5	3.1	3.6	None
Carbon monoxide	None	5.6	5.6	16.0	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations- $\mu\text{g}/\text{m}^3$) ^a :					
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Annual radionuclide emissions (curies/year):					
Saltstone mixing facility	Not used	Not used	Not used	0.46	Not used
Socioeconomics (employment – full time equivalents)					
Annual employment	40	85	85	131	284
Life of project employment	980	2,078	2,078	3,210	6,963
Radiological dose and health impacts to involved workers:					
Closure collective dose (total person-rem)	29.4 ^b	1,600	1,600	1,800	12,000
Closure latent cancer fatalities	0.012	0.65	0.65	0.72	4.9
Occupational Health and Safety:					
Recordable injuries-closure	110 ^c	120	120	190	400
Lost workday cases-closure	60 ^c	62	62	96	210

Table S-2. (Continued).

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

- a. No exceedances of air quality standards are expected.
- b. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.
- c. For the No Action Alternative, recordable injuries and lost workday cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.

NA = Not available.

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

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

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

S.8.2 LONG-TERM IMPACTS

In the long term, the important impact to consider is the effect on the environment and human health of residual waste contaminants that will eventually find their way to the accessible environment. DOE estimated long-term impacts by completing a performance evaluation that includes fate and transport modeling over a period of 10,000 years to determine when certain impacts (e.g., radiation dose and the associated

health effects) would reach their peak value. Table S-3 shows those areas in which there are notable differences in impacts among the alternatives.

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

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

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

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

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

Table S-3. (Continued).

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

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

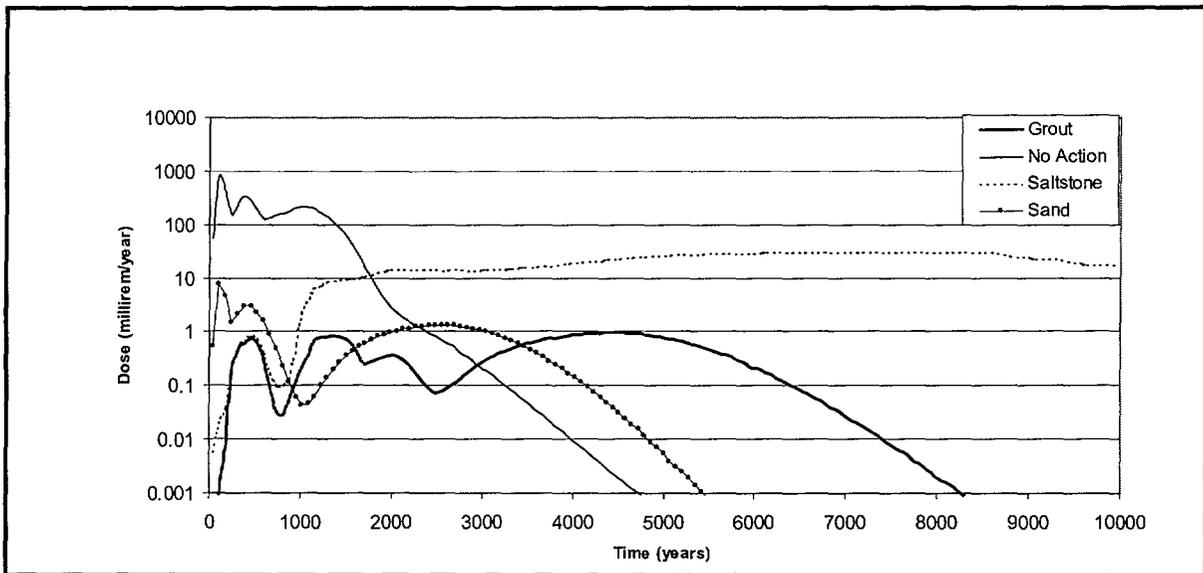


Figure S-7. Predicted Drinking Water Dose Over Time at the H-Area Seepline North of the Groundwater Divide in the Barnwell-McBean and Water Table Aquifers.

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

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

Conservative modeling which exaggerates concentrations at wells close to the tank farms estimates that doses from groundwater at wells 1

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

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

and Fill with Grout or Clean and Fill with Sand Options

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

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

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

SRS personnel have prepared a report, referred to as the *Composite Analysis*, that calculated the potential cumulative impact to a hypothetical member of the public over a period of 1,000 years from releases to the environment

from all sources of residual radioactive material expected to remain in the SRS General Separations Area which contains all of the SRS waste disposal facilities, chemical separations facilities, HLW tank farms, and numerous other sources of radioactive material. The impact of primary concern was the increased probability of fatal cancers. The *Composite Analysis* also included contamination in the soil in and around the HLW tank farms resulting from previous surface spills, pipeline leaks, and Tank 16 leaks as sources of residual radioactive material. The *Composite Analysis* considered 114 potential sources of radioactive material containing 115 radionuclides.

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

DOE-98
AIKEN, SC
DOE/EIS-0303D

Savannah River Site

Savannah River Site

HIGH-LEVEL WASTE **TANK CLOSURE**

Draft Environmental Impact Statement

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



HIGH-LEVEL WASTE
TANK CLOSURE Draft Environmental
Impact Statement

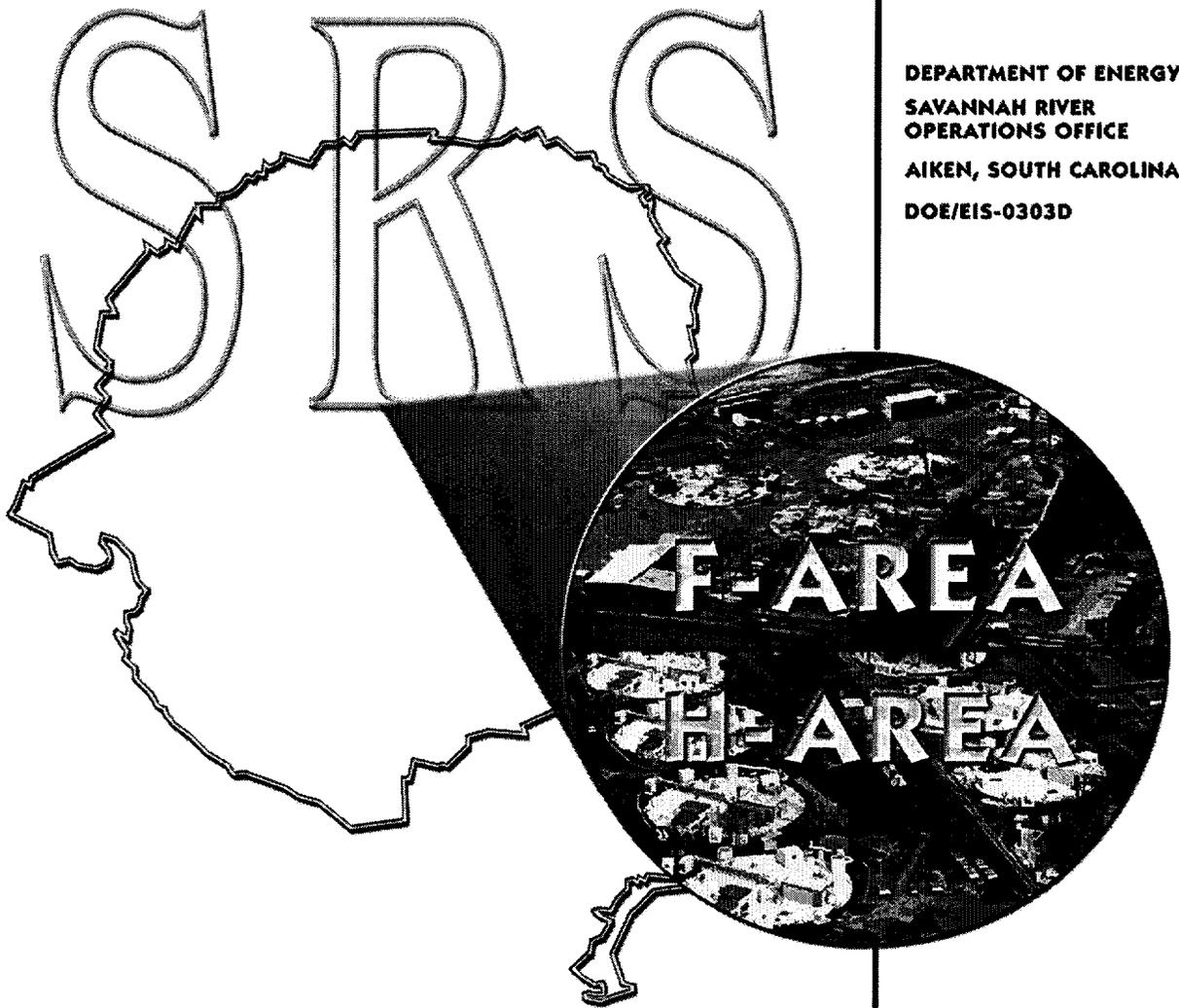
November 2000

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Savannah River Site

HIGH-LEVEL WASTE **TANK CLOSURE** Draft Environmental Impact Statement

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



November 2000

COVER SHEET

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

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

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

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

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

Ms. Carol M. Borgstrom, Director
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U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
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ABSTRACT: DOE proposes to close the high-level waste (HLW) tanks at the Savannah River Site (SRS) in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (approved by the South Carolina Department of Health and Environmental Control), which specifies the management of residuals as waste incidental to reprocessing. The proposed action would begin after bulk waste removal has been completed. This EIS evaluates three alternatives regarding the HLW tanks at the SRS. The three alternatives are the Clean and Stabilize Tanks Alternative, the Clean and Remove Tanks Alternative, and the No Action Alternative. The EIS considers three options for tank stabilization: Fill with Grout (Preferred Alternative); Fill with Sand; and Fill with Saltstone.

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

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

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

FOREWORD

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

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

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

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

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

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

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

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ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

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

MEI	maximally exposed (offsite) individual
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO _x	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
O ₃	ozone
OSHA	Occupational Safety and Health Administration
PM ₁₀	particulate matter less than 10 microns in diameter
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
ROI	Region of Influence
SCDHEC	South Carolina Department of Health and Environmental Control
SO ₂	sulfur dioxide
SRS	Savannah River Site
TRC	total recordable cases
TSP	total suspended particulates
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

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

Use of Scientific Notation

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

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

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

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

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1,000 = 4,900$

0.049 is written 4.9×10^{-2}

1,490,000 or 1.49 million is written 1.49×10^6

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

In some cases, a slightly different notation (“E-notation”) is used, where “ $\times 10$ ” is replaced by “E” and the exponent is not superscripted. Using the above examples

$$4,900 = 4.9 \times 10^3 = 4.9E+03$$

$$0.049 = 4.9 \times 10^{-2} = 4.9E-02$$

$$1,490,000 = 1.49 \times 10^6 = 1.49E+06$$

Metric Conversion Chart

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

Metric Prefixes

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

CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

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

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

1.1.1 HIGH-LEVEL WASTE DESCRIPTION

DOE Manual 435.1-1, which provides direction for implementing DOE Order 435.1, Radioactive Waste Management, defines HLW as "highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation." DOE M 435.1-1 also defines two processes for determining that a specific waste resulting from reprocessing spent nuclear fuel can be considered waste incidental to reprocessing (see Section 7.1.3). Waste resulting from reprocessing spent nuclear fuel that is determined to be inci-

dental to reprocessing does not need to be managed as HLW, and shall be managed under DOE's regulatory authority in accordance with the requirements for transuranic waste or low-level waste, as appropriate.

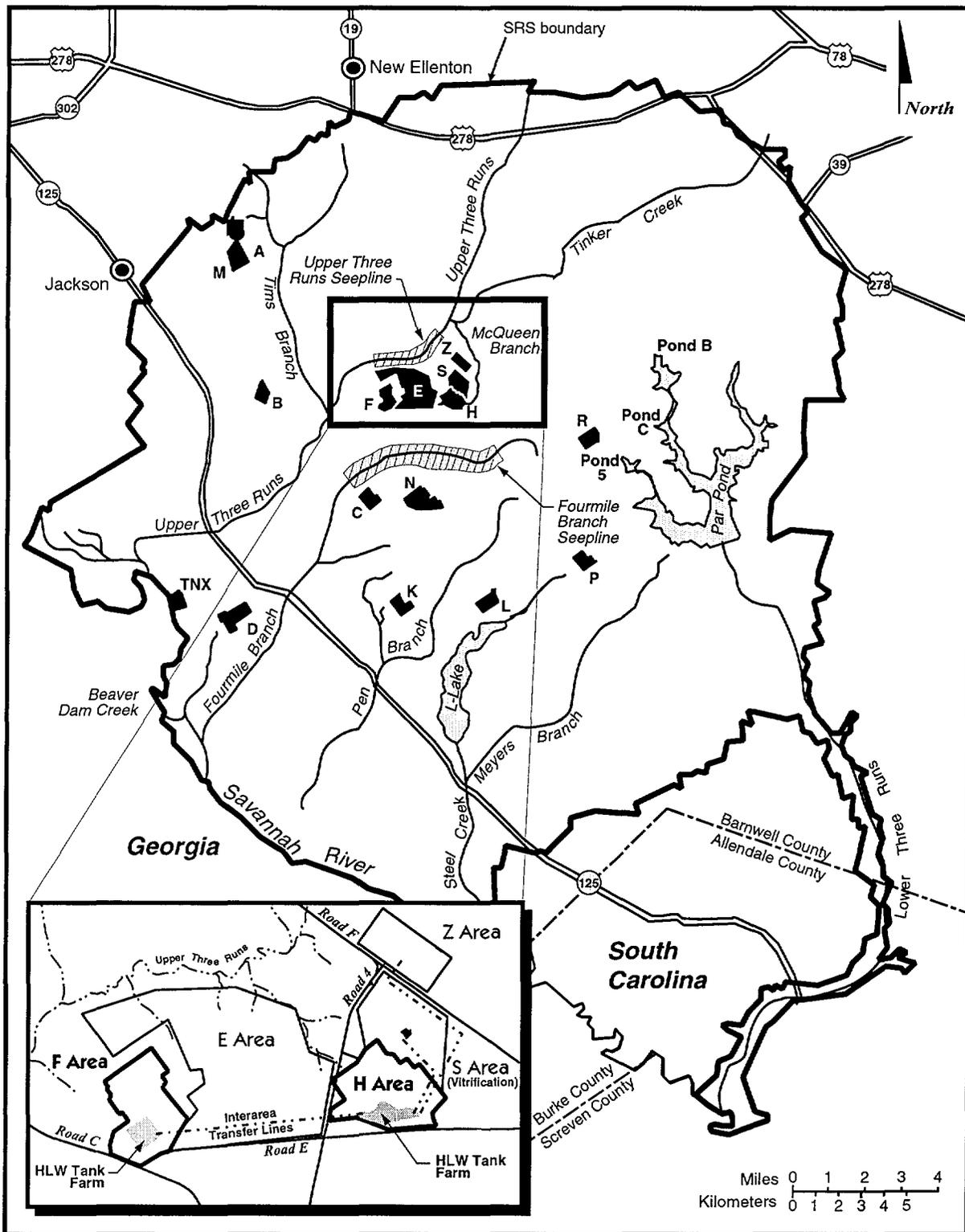
1.1.2 HLW MANAGEMENT AT SRS

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

The HLW in the tanks consists primarily of three physical forms: sludge, salt, and liquid. The sludge is solid material that precipitates and settles to the bottom of a tank. The salt is comprised of salt compounds¹ that have crystallized as a result of concentrating the liquid by evaporation. The liquid is highly concentrated salt solution. Although some tanks contain all three forms, many tanks are considered primarily sludge tanks while others are considered salt tanks (containing both salt and salt solution).

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

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



NW TANK/Grtx/ch_1/1-1 SRS F&H.ai

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

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

The salt and liquid portions of the HLW must be separated into high-radioactivity and low-radioactivity fractions before ultimate treatment. As described in DOE (1994), an In-Tank Precipitation process would separate the HLW into high- and low-activity fractions. The high-radioactivity fraction would be transferred to the DWPF for vitrification. The low-radioactivity fraction would be transferred to the Saltstone Manufacturing and Disposal Facility in Z-Area and mixed with grout to make a concrete-like material to be disposed in vaults at SRS. Since issuance of that EIS, DOE has concluded that the In-Tank Precipitation Process, as currently configured, cannot achieve production goals and meet safety requirements for processing the salt portion of HLW (64 FR 8559; February 22, 1999). The process for separating the HLW is the subject of an on-going EIS, *High-Level Waste Salt Disposition Alternatives at the Savannah River Site*. Figure 1-2 shows the SRS HLW management system as currently configured.

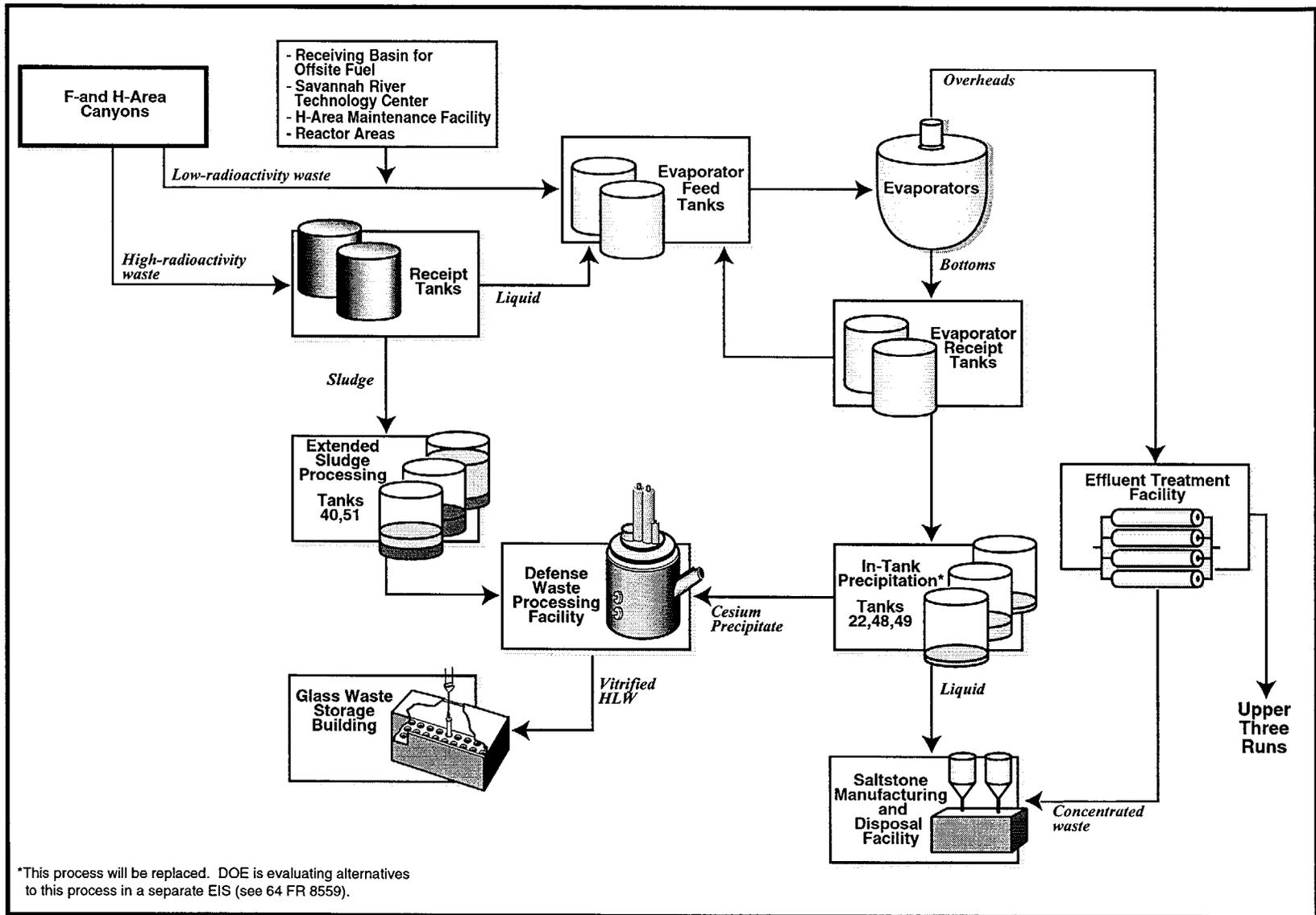
1.1.3 DESCRIPTION OF THE TANK FARMS

The F-Area Tank Farm is a 22-acre site that contains 20 active waste tanks, 2 closed waste tanks (Tanks 17 and 20), 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Figure 1-3 shows the general layout of the F-Area Tank Farm. The H-Area Tank Farm is a 45-acre site that contains 29 waste tanks, 3 evaporator systems (including the new Replacement High-level Waste Evaporator, 242-25H), the In-Tank Precipitation Process, the Extended Sludge Processing facility, transfer pipelines, 8 diversion boxes, and 10 pump pits. Figure 1-4 shows the general layout of the H-Area Tank Farm.

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

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

- Fifty-one large underground waste tanks to receive and age the waste, and allow it to settle
- Five existing evaporator systems to concentrate soluble salts and reduce the waste volume
- Transfer system (i.e., transfer lines, diversion boxes, and pump pits) to transfer supernate, sludge and other waste (e.g., evaporator condensate) between tanks and treatment facilities
- Precipitation/filtration system (i.e., ITP Facility) to separate the salt solution into high- and low-activity fractions for immobilization at the DWPF Vitrification Facility and Z-Area Saltstone Manufacturing and Disposal Facility, respectively [Operation of the ITP Facility was suspended in early 1998. DOE is currently evaluating alternate salt disposition technologies to replace the ITP process.]



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

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

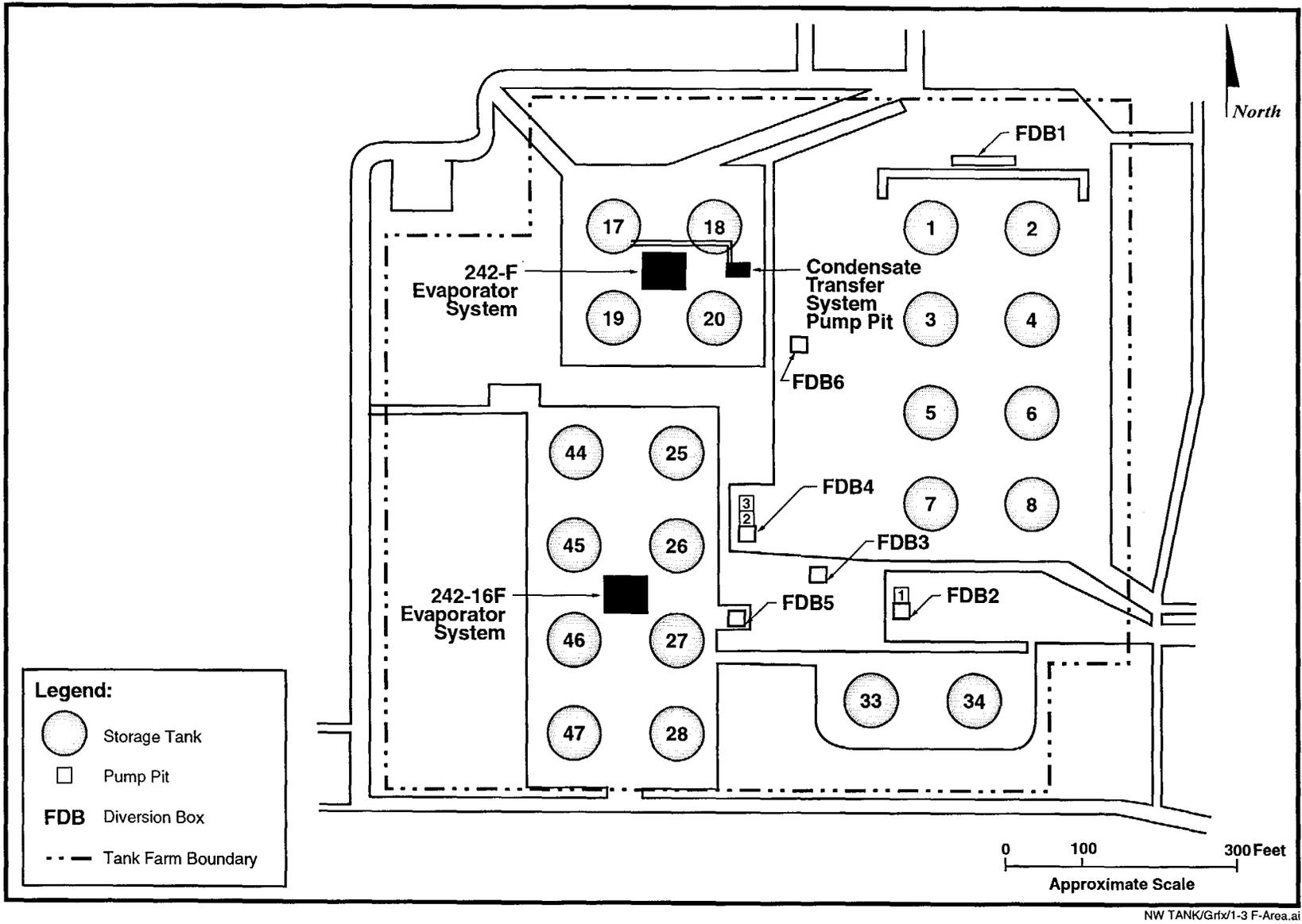
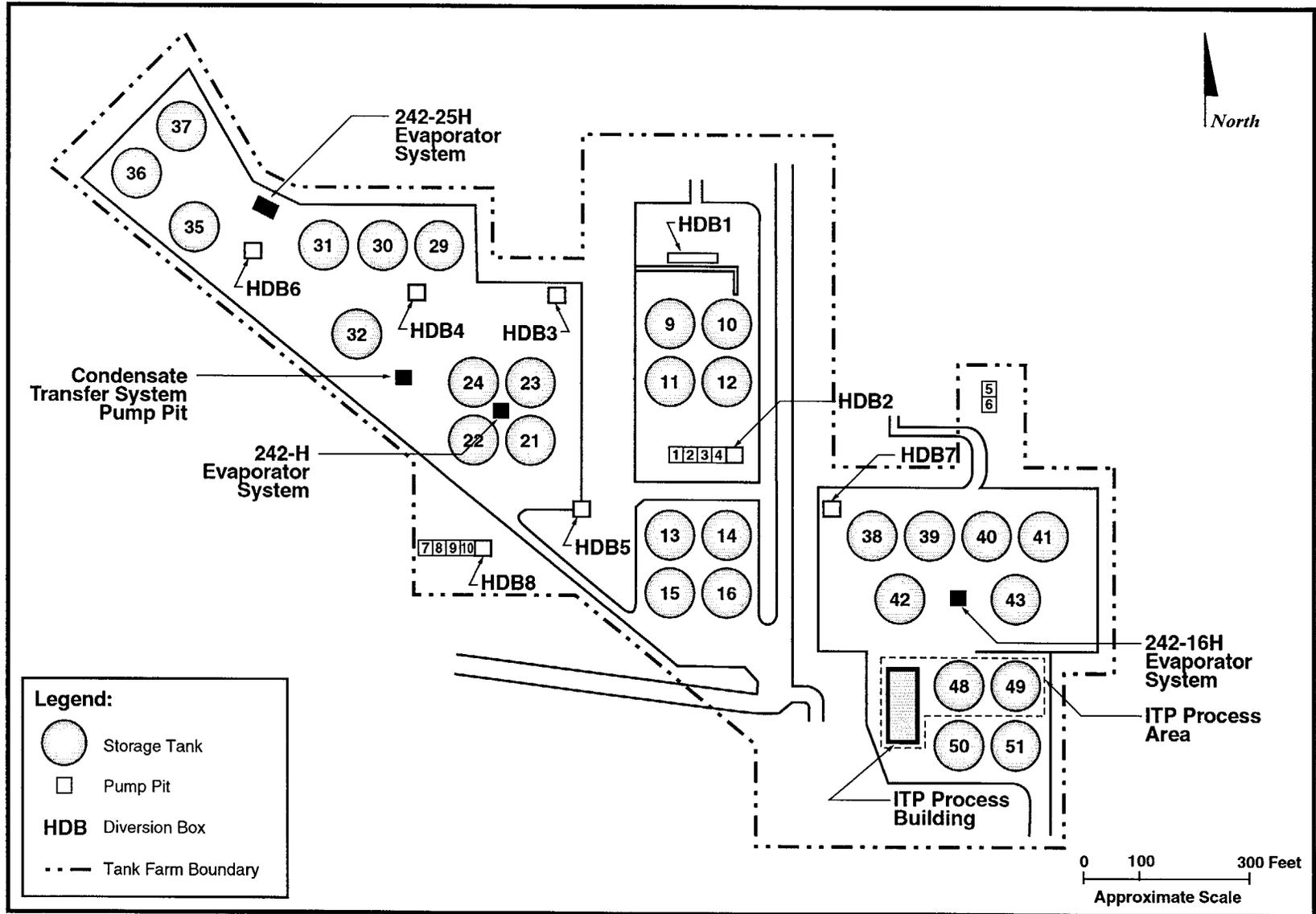


Figure 1-3. General layout of F-Area Tank Farm.



NW TANK/Grfx/1-4 H_Tank.ai

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

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

Tanks

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

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

The four Type II tanks (Tanks 13 through 16) were built in 1956 in the H-Area Tank Farm (Figure 1-5). All four have known leak sites in which waste leaked from primary to secondary containment. In Tank 16, the waste overflowed the annulus pan (secondary containment). The waste was still contained in the concrete encasement that surrounds the tank, but surveys indicated that some waste leaked into the soil, presumably through a construction joint on the side of the encasement that is located near the top of the annulus pan, about 25 feet below grade. Based on soil borings around the tank, it is estimated that some tens of gallons of waste leaked into the soil. Much of the leaked waste was removed from the annulus during the period 1976 to 1978; however, several thousand gallons remain in the annulus. Waste removal from the Tank 16 primary vessel was completed in 1980. Assuming that the waste did leak from the construction joint, the leaked waste is in the vicinity of the seasonal water table and is at times below the water table.

The eight Type IV tanks (Tanks 17 through 24) were built between 1958 and 1962. These tanks have a single steel wall and do not have active cooling (Figure 1-5). Tanks 17 through 20 are in the F-Area Tank Farm and Tanks 21 through 24 are in H-Area. Tanks 19 and 20 have known cracks that are believed to have been caused by corrosion of the tank wall from occasional groundwater inundation from fluctuation in the water table. Small amounts of groundwater have leaked into these tanks; there is no evidence that waste ever leaked out. Tanks 17 through 20 are slightly above the water table. Tanks 21 through 24 are above the groundwater table; however, they are in a perched water table caused by the original construction of the tank area. Tanks 17 and 20 have already been closed in a manner described in the Clean and Fill with Grout option of the Clean and Stabilize Tanks Alternative evaluated in this EIS (see Section 2.1.1).

The newest design (Type III) has a full-height secondary tank and active cooling (Figure 1-5). All of the Type III tanks (25 through 51) are above the water table. These 27 tanks were placed in service between 1969 and 1986 with 10 in the F-Area and 17 in the H-Area Tank Farms. None of them has known leak sites.

By 2022, DOE is required to remove from service and close all the remaining tank systems that have experienced leaks or do not have full-height secondary containment. The 24 Type I, II, and IV tanks have been or will be removed from service before the 27 Type III tanks. Type III tanks will remain in service until there is no further need for the tanks, which DOE currently anticipates would occur before the year 2030.

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

Evaporator Systems

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

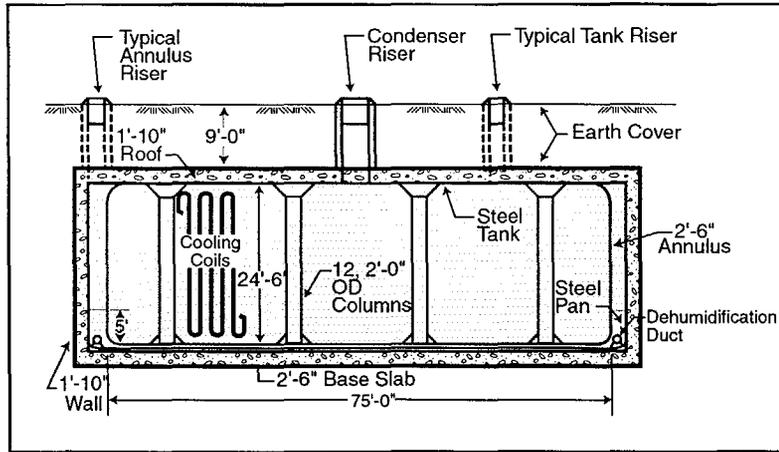


Figure A-4.A. Cooled Waste Storage Tank, Type I (Original 750,000 gallons)

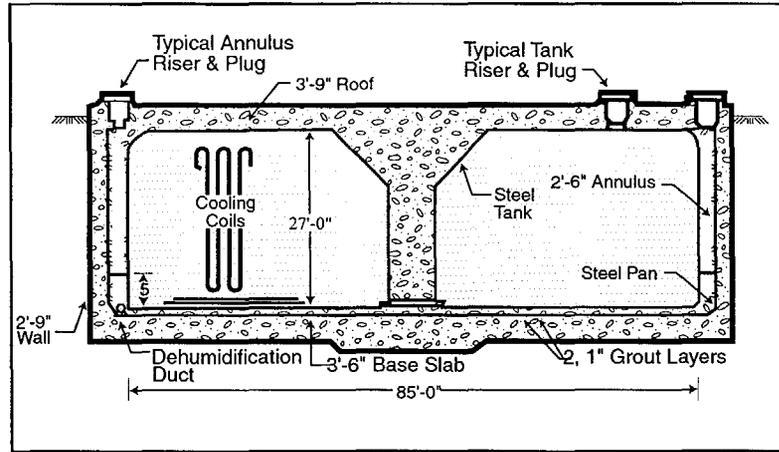


Figure A-4.B. Cooled Waste Storage Tank, Type II (1,030,000 gallons)

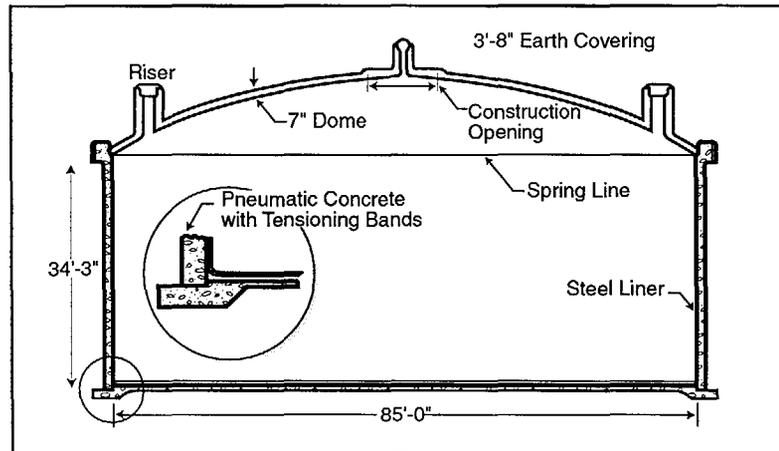


Figure A-4.C. Uncooled Waste Storage Tank, Type IV (Prestressed concrete walls, 1,300,000 gallons)

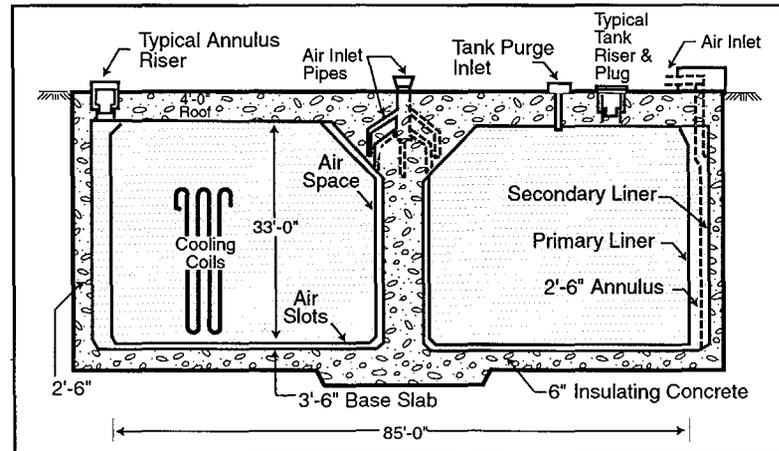


Figure A-4.D. Cooled Waste Storage Tank, Type III (Stress Relieved Primary Liner, 1,300,000 gallons)

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

Figure 1-5. Tank configuration.

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

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

a. Twenty-four Type I, II, and IV HLW tanks will be removed from service by 2022.

b. Two tanks (Tanks 17 and 20) have been closed.

atmospheric pressure under alkaline conditions. The evaporators are 8 feet in diameter and have an operating capacity of approximately 1,800 gallons. An additional evaporator system, the Replacement High-Level Waste Evaporator, has been built in H-Area. The Replacement High-Level Waste Evaporator has almost twice the operating capacity of the existing evaporators. Because of the radioactivity emitted from the waste, the evaporator systems are either shielded (i.e., lead, steel, or concrete vaults) or placed underground. The process equipment is designed to be operated and maintained remotely.

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

Transfer System

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

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

1.1.4 HLW TANK CLOSURE

1.1.4.1 Closure Process

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

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

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

and Tank 20 closure was completed on July 31, 1997. Later in 1997, following preparation and approval of a tank-specific Closure Module, Tank 17 was closed.

DOE has decided to prepare an EIS before any additional HLW tanks are closed at SRS. This decision is based on several factors, including the desire to further explore the environmental impacts from closure and to open a new round of information sharing and dialogue with stakeholders. SRS is committed in the Federal Facility Agreement to close another HLW tank by Fiscal Year 2003. DOE has reviewed bulk waste removal of waste from the HLW tanks in the Waste Management Operations, Savannah River Plant EIS (ERDA-1537) and the Long-term Management for Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization) Savannah River Plant EIS (DOE/EIS-0023). In addition, the SRS Waste Management EIS discusses high-level waste management activities as part of the No Action Alternative (continuing the present course of action), and the Defense Waste Processing Facility Savannah River Plant EIS (DOE/EIS-0082) and the Final Supplemental Environmental Impact Statement Defense Waste Processing Facility (DOE/EIS-0082S) discuss management of high-level waste after it is removed from the tanks.

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

1.1.4.2 Waste Incidental to Reprocessing

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

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

Waste Incidental to Reprocessing Determination

The two processes for determining that waste can be considered incidental to reprocessing are "citation" and "evaluation." Waste incidental to reprocessing by "citation" includes spent nuclear fuel processing plant wastes that meet the description included in the Nuclear Regulatory Commission's Notice of Proposed Rulemaking (34 FR 8712; June 3, 1969) for promulgation of proposed Appendix D, 10 CFR Part 50, Paragraphs 6 and 7 that later came to be referred to as "waste incidental to reprocessing." These radioactive wastes are the result of processing plant operations, such as, but not limited to contaminated job wastes, such as laboratory items (clothing, tools, and equipment).

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

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

1.2 Purpose and Need for Action

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

1.3 Decisions to be Based on this EIS

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

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

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

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

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

1.4 EIS Overview

1.4.1 SCOPE

This EIS analyzes the environmental impacts of cleaning, isolating, and stabilizing the HLW tanks and related systems such as evaporators, transfer piping, sumps, pump pits, diversion boxes, filtration systems, sludge washing equipment, valve boxes, and the condensate

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

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

The HLW organization would be responsible for operational control and the environmental restoration organization would be responsible for en-

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

1.4.2 ORGANIZATION

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

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

1.4.3 STAKEHOLDER PARTICIPATION

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

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

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

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

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

1.4.4 RELATED NEPA DOCUMENTS

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

Environmental Assessment for the Closure of the High-Level Waste Tanks in the F- and H-Areas at the Savannah River Site – DOE prepared an environmental assessment (DOE 1996b) to evaluate the impacts of closing HLW tanks at the SRS after removal of the bulk waste. The proposed action was to remove the residual waste from the tanks and fill them with a material to prevent future collapse and bind up residual waste, to decrease human health risks, and to

increase safety in the area of the tank farms. After closure, the tank system would be turned over to the SRS environmental restoration program for environmental assessment and remedial actions as necessary. A Finding of No Significant Impact was determined based on the analyses in the environmental assessment, and DOE subsequently closed Tanks 17 and 20. DOE has now decided to prepare an EIS for proposal to close the remaining HLW tanks.

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

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

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

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

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

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

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

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

SRS (64 FR 8558). The In-Tank Precipitation process was intended to separate soluble, high-activity radionuclides from HLW before vitrifying the high-activity portion of the waste in the DWPF and disposing of the low-activity fraction as saltstone grout in vaults at SRS. However, the In-Tank Precipitation process as presently configured cannot achieve production goals and safety requirements for processing HLW. The Supplemental EIS will evaluate the

impacts of alternatives to the In-Tank Precipitation process for separating the high- and low-activity fractions of the HLW currently stored in tanks at SRS. Although the *Salt Disposition Alternatives Supplemental EIS* addresses subject matter and some equipment in common with this EIS, the actions proposed in each EIS are independent and are thus appropriately considered in separate EISs.

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CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action and Alternatives

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

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

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

HLW Tank Cleaning

Tank cleaning by spray water washing involves washing each tank using hot water in rotary spray jets. The spray nozzles can remove waste near the edges of the tank that is not readily removed by slurry pumps. After spraying, the contents of the tank would be agitated with slurry pumps and pumped out of the tank. This process has been demonstrated on Tanks 16 (which has not been closed) and 17 (which has

been closed). The amount of waste left after spray washing was estimated at about 3,500 gallons in Tank 16 and about 4,000 gallons in Tank 17 (du Pont 1980; WSRC 1995a). If modeling evaluations showed that performance objectives could not be met after an initial spray water washing, additional spray water washes would be used prior to employing other cleaning techniques.

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

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

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

Oxalic acid has been demonstrated in Tank 16 only and shown to provide cleaning that is about twice as effective as spray water washing for removal of radioactivity (see Table 2-1). Use of oxalic acid in an HLW tank would require a successful demonstration that it would not create a potential for a nuclear criticality. The *Liquid Radioactive Waste Handling Facility Safety Analysis Report* (WSRC 1998) specifically states that oxalic acid cleaning of any waste tank is prohibited. This prohibition was established because of concern that oxalic acid could dissolve a sufficient quantity of fissile materials to create the potential for nuclear criticality.

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

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

Extensive use of oxalic acid cleaning may result in conditions that, if not addressed by checks within the DWPF feed preparation process, could allow carryover of sodium oxalate to the vitrification process. The presence of oxalates in the waste feed to DWPF that would result from oxalic acid cleaning would adversely affect

the quality of the HLW glass produced at DWPF. To prevent that from occurring, special batches of the salt treatment process would be scheduled in which the sodium oxalate concentrations would be controlled to not exceed their solubility limit in the low-radioactivity fraction.

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

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

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

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

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

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

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

containment is small, so the environmental risk of this waste is minimal compared to the amount of residual waste that would be contained inside the tanks after bulk waste removal and cleaning.

2.1.1 CLEAN AND STABILIZE TANKS ALTERNATIVE

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

Tank Closure Alternatives

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

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

In the evaluation and cleaning phase, each tank system or group of tank systems, as appropriate, would be evaluated to determine the inventory of radiological and nonradiological contaminants remaining after bulk waste removal, and spray water washing. This information would be used to conduct a performance evaluation as

part of the Preparation of a Closure Module. In this evaluation, DOE would consider (1) the types of contamination in the tank and the configuration of the tank system and (2) the hydrogeologic conditions at and near the tank location, such as distance from the water table and distance to nearby streams. The performance evaluation would include modeling the projected contamination pathways for selected closure methods and comparing the modeling results with the performance objectives developed in the General Closure Plan (DOE 1996). These performance objectives are described in Section 7.1.2 of this EIS. If the modeling shows that the performance objectives would be met, the Closure Module would be submitted to SCDHEC for approval.

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

Tank Stabilization

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

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

- The grout would be pumpable, self-leveling, designed to prevent future subsidence of the tank, and able to fill voids to the extent

practical, including equipment and secondary containment.

- The grout would be poured in three distinct layers as illustrated in Figure 2.1-1. The bottom-most layer would be a specially formulated reducing grout to retard the migration of important contaminants. The middle layer would be a low-strength material designed to fill most of the volume of the tank interior. The final layer would be a high strength grout to deter inadvertent intrusion from drilling.
- The final closure configuration would meet performance objectives established by SCDHEC and EPA.

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

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

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

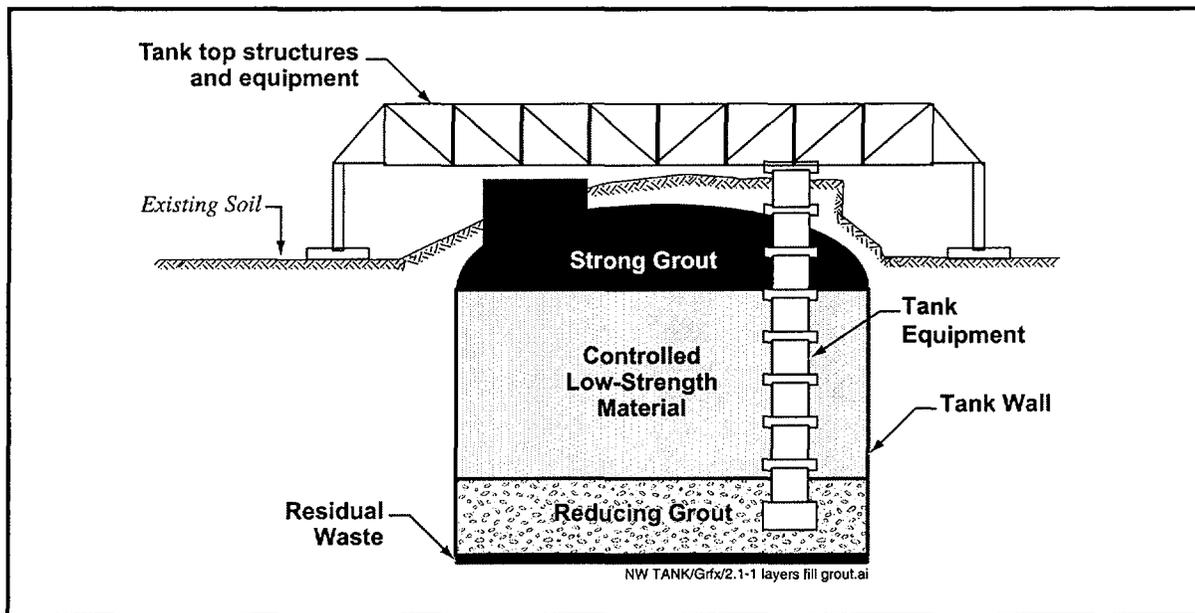


Figure 2.1-1. Typical layers of the fill with grout option.

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

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

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

Filling the tank with saltstone, which is contaminated with radionuclides would considerably complicate the project and increase worker

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

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

For any of the above options, four tanks in F-Area and four tanks in H-Area would require backfill soil to be placed over the top of the tanks. The backfill soil would bring the ground surface at these tanks up to the surrounding surface elevations to prevent water from collecting

in the surface depressions. This action would prevent ponding conditions over these tanks that could facilitate the degradation of the tank structure.

2.1.2 CLEAN AND REMOVE TANKS ALTERNATIVE

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

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

Following bulk waste removal and cleaning, the steel components of the tank would be cut up, removed, placed in radioactive waste transport containers (approximately 3,900 SRS low-level waste disposal boxes per tank), and transported to SRS radioactive waste disposal facilities for disposal (assuming these components are considered waste incidental to reprocessing). During tank removal activities, the top of the tank would have HEPA-filtered enclosures or airlocks. The tank would remain under negative pressure during cutting operations, and the exhaust would be filtered through HEPA filtration. This alternative would require the construction of approximately 16 new low-activity waste vaults at SRS for disposal of the low-level waste disposal boxes containing the tank components from all 49 tanks. This number of new low-activity waste vaults is within the range DOE previously analyzed in the *Savannah River Site*

Waste Management Final Environment Impact Statement (DOE 1995). That EIS analyzed a range of waste treatment alternatives that resulted in the construction of up to 31 new low-activity waste vaults. The long-term impacts presented in that EIS for the low-activity waste vaults are approximately one-one thousandth of the long-term tank closure impacts presented in Section 4.2 of this EIS and are incorporated into this EIS by reference. This alternative has the advantage of allowing disposal of the contaminated tank system in a waste management facility that is already approved for receiving low-level waste.

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

2.1.3 NO ACTION

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

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

No Action would be the least costly of the alternatives (less than \$100,000 per tank), require the fewest worker hours and exposure to radiation

(about two person-rem), and would require fewer workers per tank system than the Clean and Stabilize Tanks Alternative. There would be ongoing maintenance and no interruption of operations in the tank farm.

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

2.1.4 ALTERNATIVES CONSIDERED, BUT NOT ANALYZED

2.1.4.1 Management of Tank Residuals as High-Level Waste

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

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

would apply to managing residuals as HLW, the application of regulatory requirements would be different.

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

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

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

2.1.4.2 Other Alternatives Considered, but not Analyzed

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

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

2.2 Other Cleaning Technologies

The approved General Closure Plan contemplates cleaning the tanks with hot water streams, as described in the Clean and Stabilize Tanks Alternative. Several cleaning technologies have been investigated but are not considered reasonable alternatives to hot water cleaning at this time. However, DOE continues to research cleaning methods and should a particular

method prove practical and be required to meet the performance criteria for a specific tank, its use would be proposed in the Closure Module for that tank. DOE would conduct the appropriate NEPA review for any proposal to use such new technology.

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

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

2.3 Considerations in the Decision Process

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

the EIS, DOE will select and implement a closure method for each tank.

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

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

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

A comment was made that tank removal and grouting should be combined as an alternative. DOE has examined the impacts of both tank removal and grouting. Depending on the ability of

cleaning to meet the performance requirements for a given tank, the decisionmaker may elect to remove a tank if it is not possible to meet the performance requirements by another method. This EIS captures the environmental and health and safety impacts of both options. Additional discussion on these and other comments made during scoping is included in Appendix D.

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

No Action Alternative – <\$100,000

Clean and Stabilize Tanks Alternative

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

2.4 Comparison of Environmental Impacts Among Alternatives

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

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

2.4.1 SHORT-TERM IMPACTS

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

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

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

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

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

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

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

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

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Geologic Resources	None	170,000	170,000	170,000	356,000
Soil backfill (m³)					
Water Resources	None	None	None	None	None
Surface Water					
Groundwater		<0.6% of F-Area well production required			
Air Resources					
Nonradiological air emissions (tons/yr.):					
Sulfur dioxide (as SO _x)	None	2.2	2.2	3.3	None
Total suspended particulates	None	(a)	(a)	3.0	None
Particulate matter	None	4.5	3.1	1.7	None
Carbon monoxide	None	5.6	5.6	8.0	None
Volatile organic compounds	None	2.3	2.3	3.3	None
Nitrogen dioxide (as NO _x)	None	33	33	38	None
Lead	None	9.0×10 ⁻⁴	9.0×10 ⁻⁴	1.5×10 ⁻³	None
Beryllium	None	1.7×10 ⁻⁴	1.7×10 ⁻⁴	2.8×10 ⁻⁴	None
Mercury	None	2.2×10 ⁻⁴	2.2×10 ⁻⁴	4.3×10 ⁻⁴	None
Benzene	None	0.02	0.02	0.43	None
Air pollutants at the SRS boundary (maximum concentrations-μg/m ³): ^b					
Sulfur dioxide (as SO _x) – 3 hr.	None	0.2	0.0	0.6	None
Total suspended particulates – annual	None	(a)	(a)	0.005	None
Particulate matter – 24 hr.	None	0.08	0.06	0.06	None
Carbon monoxide – 1 hr.	None	1.2	1.2	3.4	None
Volatile organic compounds – 1 hr.	None	0.5	0.5	2.0	None
Nitrogen dioxide (as NO _x) - annual	None	0.03	0.03	0.07	None
Lead – max. quarterly	None	1.2×10 ⁻⁶	1.2×10 ⁻⁶	4.1×10 ⁻⁶	None
Beryllium – 24 hr.	None	3.2×10 ⁻⁶	3.2×10 ⁻⁶	1.1×10 ⁻⁵	None

Table 2-2. (Continued).

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

Table 2-2. (Continued).

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

Table 2-2. (Continued).

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

Table 2-2. (Continued).

Parameter	No Action Alternative	Clean and Stabilize Tanks Alternative			Clean and Remove Tanks Alternative
		Clean and Fill with Grout Option	Clean and Fill with Sand Option	Clean and Fill with Saltstone Option	
Total estimated waste generation					
Radioactive liquid waste (gallons)	0	12,840,000	12,840,000	12,840,000	25,680,000
Nonradioactive liquid waste (gallons)	0	428,000	428,000	428,000	0
Transuranic waste (m ³)	0	0	0	0	0
Low-level waste (m ³)	0	1,284	1,284	1,284	19,260
Hazardous waste (m ³)	0	42.8	42.8	42.8	42.8
Mixed low-level waste (m ³)	0	257	257	257	428
Industrial waste (m ³)	0	428	428	428	428
Sanitary waste (m ³)	0	0	0	0	0
Utility and Energy Usage:					
Water (total gallons)	7,120,000	48,930,000	12,840,000	12,840,000	25,680,000
Electricity	NA	NA	NA	NA	NA
Steam (total pounds)	NA	8,560,000	8,560,000	8,560,000	17,120,000
Fossil fuel (total gallons)	NA	214,000	214,000	214,000	428,000
Utility cost (total)	NA	\$4,280,000	\$4,280,000	\$4,280,000	\$12,840,000
<p>a. No data on TSP emissions for these sources is readily available and therefore is not reflected in the analysis.</p> <p>b. No exceedences of air quality standards are expected.</p> <p>c. Collective dose for the No Action Alternative is for the period of closure activities for the other alternatives. This dose would continue indefinitely at a rate of approximately 1.2 person-rem per year.</p> <p>d. For the No Action Alternative, recordable injuries and lost work day cases are for the period of closure activities for the other alternatives. These values would continue indefinitely.</p>					
NA = Not applicable; ND = Below detection limit.					

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

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

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

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

Collective involved worker dose for closure of all 49 tanks would be highest under the Clean and Remove Tanks Alternative (12,000 person-rem), with the three stabilization options under the Clean and Stabilize Tanks Alternative ranging from 1,600 (Clean and Fill with Grout and Clean and Fill with Sand options) to 1,800 person-rem (Clean and Fill with Saltstone Option). Increased latent cancer fatalities attributable to

these collective doses would be 4.9 (Clean and Remove Tanks Alternative), 0.72 (Clean and Fill with Saltstone Option), and 0.65 (Clean and Fill with Grout and Clean and Fill with Sand Options), respectively. The higher dose associated with the Clean and Remove Tanks Alternative relates to larger numbers of personnel required to implement the alternative.

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

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

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

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

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

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

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

last would require less than 0.6 percent (or 0.006) of the annual production from F-Area wells.

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

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

2.4.2 LONG-TERM IMPACTS

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

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

Table 2-3. Estimated accident consequences by alternative.

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

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

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

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

Water resources/surface water – Based on modeling results, any of the three tank stabilization options under the Clean and Stabilize Tanks Alternative would be effective in limiting the long-term movement of residual contaminants in closed tanks to nearby streams via groundwater. Concentrations of non-radiological contaminants moving to Upper Three Runs via the Upper Three Runs seepline would be minuscule, in most cases several times below applicable stan-

dards. Concentrations of non-radiological contaminants reaching Upper Three Runs and Fourmile Branch would be low under the No Action Alternative as well, but somewhat higher than those expected under the Clean and Stabilize Tanks Alternative. In all instances, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

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

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

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

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

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

Table 2-4. (Continued).

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

Table 2-4. (Continued).

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

Table 2-4. (Continued).

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

Table 2-4. (Continued).

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

- a. The Clean and Remove Tanks Alternative is not presented in this table because the residual waste (and tank components) would be removed from the Tank Farm areas and transported to SRS radioactive waste disposal facilities; impacts of this facility are evaluated in the SRS Waste Management EIS (DOE/EIS-0217).
- b. Radiation dose less than 1.0×10^{-6} or non-radiological concentration less than 1.0×10^{-6} mg/L.
- c. Hazard quotient is less than $\sim 1 \times 10^{-2}$.
- d. The radiation dose for this alternative is less than 1×10^{-3} millirem.
- e. The risk for this alternative is less than 4.0×10^{-10} .
- f. Calculated based on an assumed 70-year lifetime.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Ecological resources – Risks to aquatic organisms in Fourmile Branch and Upper Three Runs

for non-radiological contaminants would be negligible under the Clean and Fill with Sand and Clean and Fill with Saltstone Options. For the Clean and Fill with Grout Option and the No Action Alternative, there would be relatively low risk to aquatic organisms.

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

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

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

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

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

Public health – DOE evaluated the impacts over a 10,000-year period. Structural collapse of the tanks would pose a safety hazard under the No Action Alternative, creating unstable ground conditions and forming holes into which workers or other site users could fall. Neither the Clean and Stabilize Tanks Alternative nor the Clean and Remove Tanks Alternative would have this safety hazard, although there could be some moderate ground instability with the Clean and Fill with Sand Option. Airborne releases from the tanks are considered to be possible only under the No Action Alternative, and their likelihood is considered to be minimal for that alternative because the presence of moisture and the considerable depth of the tanks below grade would tend to discourage resuspension of tank contents. Therefore, the principal source of potential impacts to public health is leaching and groundwater transport of contaminants. DOE calculated risks to public health based on postulated release and transport scenarios.

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

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

DOE considered the potential exposures to people who live in a home built over the tanks at some time in the future when they are unaware that the residence was built over closed waste tanks. DOE previously modeled this type of exposure for the saltstone disposal vaults in the Z Area. That analysis found that external radia-

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

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