Savannah River Site

Salt Processing Alternatives

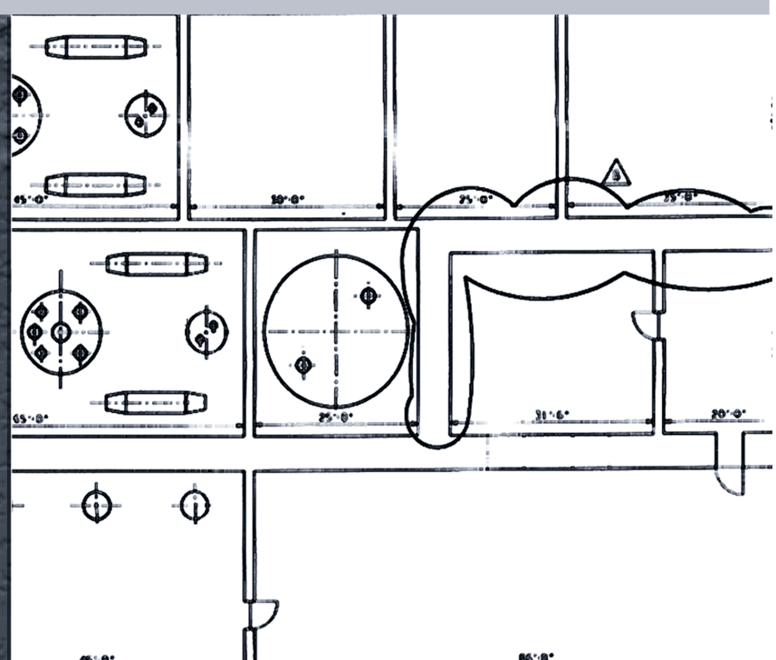
Draft Supplemental Environmental Impact Statement

U.S. Department of Energy
Savannah River Operations Office
Aiken, South Carolina

Summary

March 2001

DOE/EIS-0082-S2D



COVER SHEET

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

TITLE: Savannah River Site Salt Processing Alternatives Draft Supplemental Environmental Impact Statement (DOE/EIS-0082-S2D)

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

ABSTRACT: DOE prepared this Draft SEIS on alternatives for separating the high-activity fraction from the low-activity fraction of the high-level radioactive waste salt solutions now stored in underground tanks at the Savannah River Site (SRS) near Aiken, South Carolina. The high-activity fraction of the high-level waste (HLW) salt solution would then be vitrified in the Defense Waste Processing Facility (DWPF) and stored until it could be disposed of as HLW in a geologic repository. The low-activity fraction would be disposed of as low-level waste (saltstone) in vaults at SRS.

A process to separate the high-activity and low-activity waste fractions of the HLW salt solutions is needed to replace the In-Tank Precipitation (ITP) process which, as presently configured, cannot achieve production goals and safety requirements for processing HLW. This SEIS analyzes the impacts of constructing and operating facilities for four alternative processing technologies – Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout – and the No Action Alternative. DOE has not selected a Preferred Technology Alternative. Preferred sites for locating processing facilities within S and Z Areas at SRS are identified.

Because replacing the ITP process constitutes a substantial change to the HLW salt processing operation of the DWPF, as evaluated in a 1994 SEIS (DOE/SEIS-0082-S) to the 1982 DWPF EIS (DOE/EIS-0082), DOE prepared this second SEIS to evaluate the potential environmental impacts of alternatives to the ITP process.

PUBLIC INVOLVEMENT: In preparing this Draft SEIS, DOE considered comments received by letter and voice mail and comments received at two public scoping workshops held in Columbia and North Augusta, South Carolina, on March 11 and March 18, 1999, respectively.

A 45-day comment period on the Draft Salt Processing Alternatives SEIS 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 SEIS will be held on May 1, 2001, at the North Augusta Community Center in North Augusta, South Carolina, and on May 3, 2001, at the Holiday Inn Coliseum in Columbia, South Carolina. Comments may be submitted at the public meetings and by voice mail, e-mail, or 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 SEIS. Comments received or postmarked after the close of the comment period will be considered to the extent practicable.

Table of Contents

List of Tables

List of Figures

ACRONYMS, MEASUREMENT ABBREVIATIONS, USE OF SCIENTIFIC NOTATION, AND METRIC CONVERSION CHART

Acronyms

CST	Crystalline Silicotitanate
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FR	Federal Register
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste
ITP	In-Tank Precipitation
LCF	latent cancer fatality
MEI	maximally exposed (offsite) individual
MST	monosodium titanate
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OWST	organic waste storage tank
PHA	precipitate hydrolysis aqueous
PSD	prevention of significant deterioration
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SEIS	Supplemental Environmental Impact Statement
SRS	Savannah River Site
TPB	tetraphenylborate
VOCs	Volatile Organic Compounds
WSRC	Westinghouse Savannah River Company

Abbreviations for Measurements

m	meter
m^3	cubic meter
µg	microgram
µm	micrometer
mg	milligram
mg/m^3	milligrams per cubic meter
mrem	millirem
rem	rem
yr	year
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

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

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

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

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

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

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

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

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

SUMMARY

S.1 Introduction

Nuclear materials production operations at the Savannah River Site (SRS) (Figure S-1) resulted in the generation of large quantities of **high-level radioactive waste** (referred to as high-level waste or HLW). This waste has been stored onsite in large underground tanks. The U.S. Department of Energy (DOE) built the Defense Waste Processing Facility (DWPF) to convert this HLW to a stable glass form suitable for disposal in a geologic repository. The DWPF has been operating since 1996 to **vitrify** (i.e., convert to glass) some of the **HLW components**.

> To assist the reader in understanding key terms used in this document, those terms have been **bolded** the first time they are used and are discussed in Table S-8, Primer of Technical Terms, which is located at the end of the Summary.

SRS HLW was generated as an acidic solution, then was chemically converted to an alkaline solution for storage. In its alkaline form it consists of two components: **salt** and insoluble **sludge**. Both components contain highly radioactive residues from nuclear materials production. **Radionuclides** found in the sludge include **fission products** (such as strontium-90) and long-lived **actinides** (such as uranium and plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides.

The salt component consists of **saltcake** and **salt supernatant**. To process the salt component, solid saltcake must first be dissolved and combined with salt supernatant to form a salt solution. An important part of the DWPF system, as designed, was to then separate the highly radioactive constituents from the salt solution. The high-activity fraction removed from the salt solution would be vitrified in DWPF, and the less radioactive constituents, still in the salt solution, would be stabilized with grout (a cement-like mixture), to create a saltstone waste form for onsite disposal as **low-level radioactive waste** (LLW).

The process selected in 1994 to separate the high-activity fraction from the salt solution is known as In-Tank Precipitation (ITP). This process was designed to be carried out primarily in one of the underground HLW storage tanks with a 1.3-million-gallon capacity. An inorganic **sorbent**, **monosodium titanate**, was to be used to remove actinides and radioactive strontium from the salt solution. An organic **reagent**, **sodium tetraphenylborate**, was to precipitate radioactive cesium from the salt solution. The ITP process also included washing and filtration steps to separate the solid phases holding these radioactive materials.

The reagent used to precipitate cesium in the ITP process, sodium tetraphenylborate, is subject to **catalytic** and **radiolytic decomposition**. Its decomposition inhibits its ability to bind with cesium and keep it out of the salt solution, and results in the generation of **benzene**. Benzene is a toxic, flammable, and potentially explosive organic substance that must be safely controlled.

To achieve the objectives of the ITP process, the decomposition of sodium tetraphenylborate must be limited to minimize: (1) the amount of precipitated cesium that is returned to the salt solution, and (2) the amount of benzene generated. The ITP process was designed to accommodate some sodium tetraphenylborate decomposition and to limit benzene accumulation. Startup testing of the ITP facility in 1995 generated benzene in much greater quantities than had been anticipated. As a result, in March 1996, ITP operations were suspended. However, the DWPF facility continues to process and vitrify HLW sludge.

In August 1996, the Defense Nuclear Facilities Safety Board (DNFSB), an independent oversight board chartered by Congress to review operations at DOE nuclear defense facilities and make recommendations necessary to protect

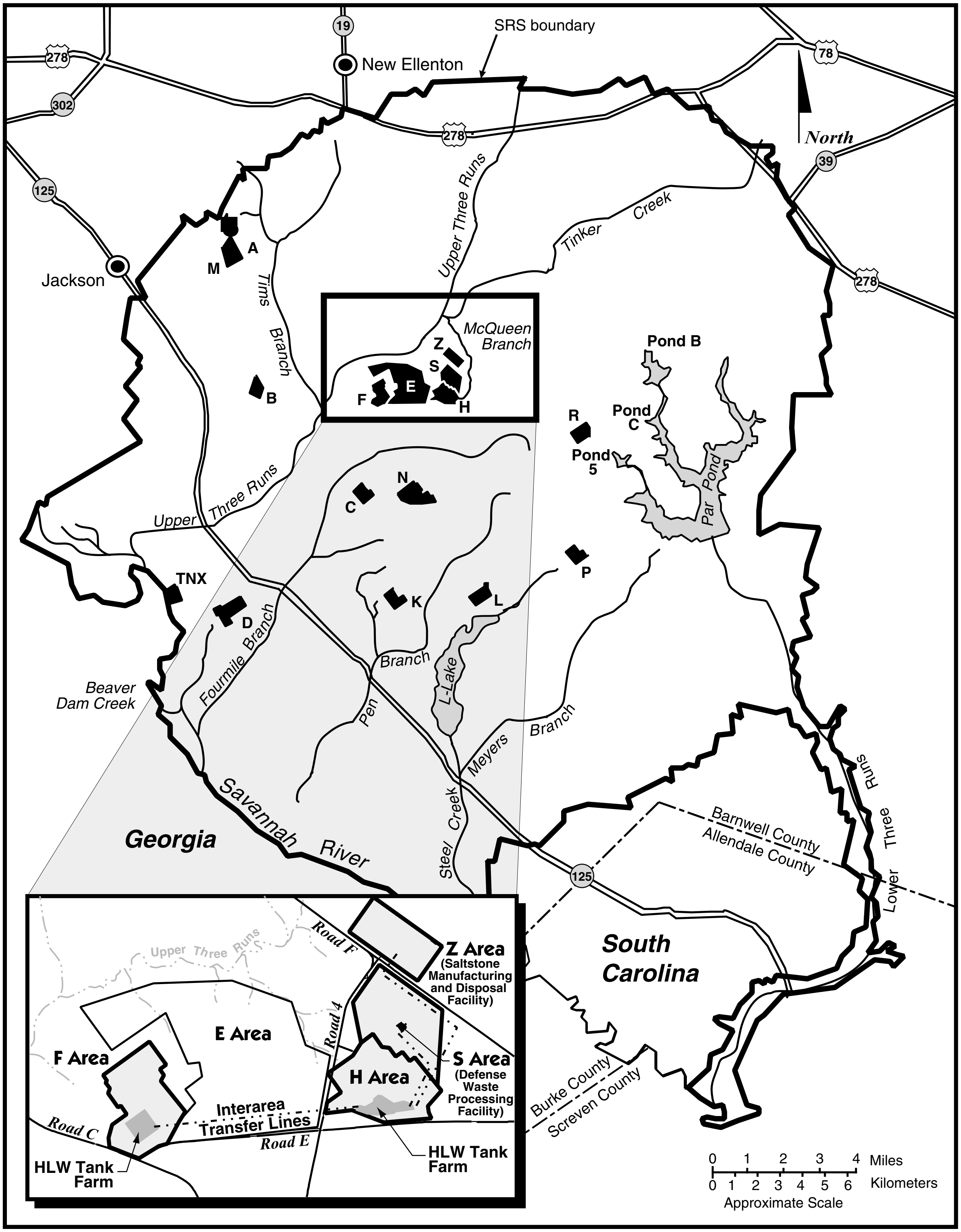

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Figure S-1. Savannah River Site map with F, H, S, and Z Areas highlighted.

Radionuclides

Antimony (Sb)

Antimony is a silver-white, metallic element. Antimony-125 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for antimony is Sb. Sb-125 has a half-life of 2.7 years.

Carbon (C)

Carbon is a black, nonmetallic element. Carbon-14 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Carbon is C. C-14 has a half-life of 5,700 years.

Cesium (Cs)

Cesium is a silver-white, highly reactive, metallic element. Cesium-137, -135, and -134 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for cesium is Cs. Cs-137 has a half-life of 30 years, Cs-135 has a half-life of 2.3 million years, and Cs-134 has a half-life of 2 years.

Iodine (I)

Iodine is a nonmetallic, halogen element. Iodine-129 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Iodine is I. I-129 has a half-life of 16 million years.

Plutonium (Pu)

Plutonium is a man-made, silver-gray, metallic element in the actinide series. All isotopes of plutonium are radioactive. Plutonium is a fission fuel for reactors and atomic weapons. Plutonium-239 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for plutonium is Pu. The half-life of Pu-239 is 24,000 years.

Ruthenium (Ru)

Ruthenium is a grayish, metallic element. Ruthenium-106 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Ruthenium is Ru. Ru-106 has a half-life of 372 days.

Selenium (Se)

Selenium is a lustrous gray, nonmetallic element. Selenium-79 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Selenium is Se. Se-79 has a half-life of 65,000 years.

Strontium (Sr)

Strontium is a silver-yellow, metallic element. Strontium-90 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for strontium is Sr. Sr-90 has a half-life of 29 years.

Technetium (Tc)

Technetium is a man-made, silver-gray, metallic element. All isotopes of technetium are radioactive. Technetium-99 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for technetium is Tc. Tc-99 has a half-life of 200,000 years.

Tin (Sn)

Tin is a bluish-white, metallic element. Tin-126 is the principal radioactive isotope of this element present in the HLW tanks at SRS. The symbol for Tin is Sn. Sn-126 has a half-life of 100,000 years.

Tritium (H-3)

Tritium is a radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons. In the HLW tanks at SRS, tritium is usually bound in water molecules, where it replaces one of the normal hydrogen atoms. The symbol for Tritium is H-3. Tritium has a half-life of 12.5 years.

Uranium (U)

Uranium is a silver-white, highly reactive, metallic element in the actinide series. All isotopes of uranium are radioactive. Uranium is used as a fission fuel for reactors and atomic weapons. Uranium-235 and -238 are the principal radioactive isotopes of this element present in the HLW tanks at SRS. The symbol for uranium is U. U-235 has a half-life of 700 million years and U-238 has a half-life of 4 billion years.

public health and safety, recommended that testing and operation of ITP not proceed further until DOE had a better understanding of how benzene was generated and released during the **precipitation** process. In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements.

DOE must develop a technology to safely process the salt component of the HLW stored at SRS. Such a technology is a crucial prerequisite for placing the SRS HLW salt component in a configuration acceptable for safe disposal. DOE has prepared this Supplemental Environmental Impact Statement (SEIS) to ensure that the public and DOE's decisionmakers have a thorough understanding of the potential environmental impacts of the design, construction, and operation of alternative technologies for salt processing before one technology is chosen. This Summary provides a brief description of the HLW processing technology at SRS, describes the National Environmental Policy Act (NEPA) process that DOE is using to aid in decision-making, summarizes the salt processing alternatives, and outlines the major conclusions, areas of controversy, and issues that remain to be resolved as DOE proceeds with selection of a salt processing technology.

High-Level Waste Management System

The underground storage tanks are one of seven interconnected parts of the HLW management system at SRS, as follows:

- HLW storage and evaporation in the F- and H-Area Tank Farms
- Sludge processing in the Extended Sludge Processing Facility
- Salt processing through the ITP process, including the Late Wash Facilities (inactive, as described below)
- HLW vitrification in DWPF
- Solidification of low-activity salt solution in the Saltstone Manufacturing and Disposal Facility
- Wastewater treatment in the Effluent Treatment Facility
- Organic destruction in the Consolidated Incineration Facility (CIF) (inactive, as described below).

This system is currently operating, except for salt processing through ITP, CIF, and the Late Wash Facility. ITP operations are now limited to facility surveillance and maintenance. The Late Wash Facility has been tested, using nonradioactive materials, and is in standby status.

CIF operations were suspended in October 2000. The CIF was constructed primarily to incinerate benzene generated in the ITP process and solvent wastes from F- and H-Canyon operations. If an effective alternative to solvent disposal by incineration can be identified, DOE will no longer operate CIF.

S.2 Technology Review and Selection of Alternatives to be Evaluated

DOE evaluated the potential impacts of constructing and operating DWPF in a 1982 environmental impact statement (EIS). In 1994, DOE published an SEIS to evaluate changes in the process proposed after the 1982 EIS was issued. The Record of Decision (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of DWPF and would use the ITP technology for salt processing after satisfactory completion of startup testing.

After evaluating the ITP process in the large waste tank, DOE determined that ITP, as designed, could not meet both safety requirements and production goals. In 1998, DOE determined that it must therefore select an alternative technology for HLW salt processing.

In early 1998, Westinghouse Savannah River Company (WSRC), the SRS operating contractor, recommended to DOE that a systematic evaluation be conducted to identify viable salt treatment technologies to replace the ITP process. This evaluation was done and, in October 1998, WSRC presented its recommendation of alternatives to DOE. WSRC recommended four technologies for further consideration: Small

Tank **Tetraphenylborate Precipitation**, **Crystalline Silicotitanate Ion Exchange**, **Caustic Side Solvent Extraction**, and Direct Disposal (of cesium) in Grout. In early 1999, following review of the recommendation by DOE and independent reviewers, DOE decided to pursue three of the four candidate alternatives for replacement of the ITP process. Solvent Extraction was dropped from consideration at that time because it was considered technically immature. DOE restored Solvent Extraction to the list of potential alternatives in February 2000, based on recommendations from the National Academy of Sciences and new research and development results.

In response to a June 1999 request from the Under Secretary of Energy, the National Academy of Sciences - National Research Council provided an independent technical review of alternatives for processing the HLW salt solutions at the SRS. The review was conducted by a committee composed of expert consultants in the fields of nuclear reactor and fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. The final Council Report endorsed in general the selection of the four candidate processes considered as alternatives for salt disposal, concluding that each of the processes was potentially appropriate and no obvious major processing options were overlooked. Recommendations for addressing the technical uncertainties associated with each of the alternative were identified, with schedule constraints and potential regulatory restrictions noted.

S.3 Purpose and Need for Action

The ability to safely process the salt component of the HLW stored in underground storage tanks at SRS is a crucial prerequisite for completing HLW disposal. Without a suitable method for salt management, DOE would not be able to place the HLW in a configuration acceptable for safe disposal. Thus, DOE must identify and implement one or more technologies to prepare the SRS HLW salt component for disposal. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal as LLW at SRS.

If salt processing is delayed beyond 2010, DOE recognizes that the salt waste must be vitrified separately from the sludge component of the HLW, and the total number of HLW canisters would be greatly increased over that projected for concurrent sludge and salt waste vitrification.

HLW Tank Closure

DOE, EPA, and the South Carolina Department of Health and Environmental Control (SCDHEC) have agreed to a schedule for closure of the HLW tanks. DOE must close the tanks in accordance with applicable laws, regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems*. Bulk waste must be removed from the tanks before closure can begin. Without a salt processing alternative and with continued sludge-only vitrification in the DWPF, HLW storage requirements will be such that DOE may not be able to empty tanks and, therefore, after about 2010, tank closure commitments may not be met. DOE has prepared the *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, to evaluate the impacts of the tank closure program.

S.4 NEPA Process

In parallel with development of the WSRC recommendations on alternative technologies, DOE prepared a supplement analysis in accordance with the Department's NEPA regulations (10 CFR 1021) and made it available to the public. Based on the supplement analysis, DOE decided to prepare this second SEIS on DWPF and its supporting processes because necessary additional changes will significantly alter how the HLW salt is processed from that described in the original EIS and the 1994 SEIS. This second SEIS evaluates the potential environmental impacts of designing, constructing, and operating a salt processing technology to replace the ITP process. The SEIS also considers the impacts of a No Action alternative.

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.

On February 22, 1999, DOE announced in the *Federal Register* its intent to prepare a *Supplemental Environmental Impact Statement for Alternatives to the In-Tank Precipitation Process* (64 FR 8558). To more accurately describe the process, DOE has since retitled this document as the Salt Processing Alternatives SEIS.

DOE encouraged SRS stakeholders and other interested parties to submit comments and suggestions for the scope of the SEIS. DOE held scoping meetings on the SEIS in Columbia, South Carolina, on March 11, 1999, and in North Augusta, South Carolina, on March 18, 1999. Each meeting included a presentation on the NEPA process as it related to the proposed action, a presentation on the process used to identify reasonable alternatives for salt processing for further evaluation, public comment opportunities, and question-and-answer opportunities. DOE considered comments received during the scoping period in preparing this Draft SEIS. The comments, along with DOE's responses, are given in Appendix C of this SEIS and briefly summarized here.

DOE received four comment letters, one comment e-mail, one recommendation from the SRS Citizens Advisory Board, and 59 oral comments at the public scoping meetings. DOE identified about 90 separate comments in these submittals and presentations.

Several comments related to the alternative salt processing technologies. Commentors questioned how the Small Tank Precipitation alternative could be successful when the ITP, which used the same chemical process, was not. Commentors were specifically concerned about how generation of benzene from this process could be controlled. DOE believes the Small Tank Precipitation alternative may be a viable process, because differences in design between the Small Tank Precipitation process and the ITP process are intended to control benzene generation.

Commentors questioned the vault design for the Direct Disposal in Grout alternative, and asked that it be justified on technical and health and safety grounds. DOE has described the vault design and the potential impacts on human health and safety in the Draft SEIS, and has compared the Direct Disposal in Grout alternative to the other technologies in this regard.

Commentors stated that DOE should pursue one of the technologies rather than take no action, and questioned the description of the No Action alternative. DOE proposes to pursue one of the processing technologies rather than take no action. However, No Action is analyzed under NEPA to provide a basis for comparison of the action alternatives. DOE has revised the No Action alternative to represent a continuation of DOE's ongoing tank management activities as long as tank space is available. Under No Action, DOE estimates that additional tank space would be required around 2010, and assumes for purposes of analysis that DOE would build new tanks. For analysis of long-term impacts, DOE assumes loss of institutional control 100 years after the short-term action period ends (2023).

Because the Direct Disposal in Grout alternative would result in millions of curies of cesium being disposed of at SRS, commentors were interested in the quantities of radioactive materials disposed of in other locations, and wanted to be sure that DOE evaluated the long-term impacts of disposal. DOE has disposed of almost 10 million curies at SRS, and about 7 million curies of LLW have been disposed of at nearby Barnwell, South Carolina. In the SEIS, DOE evaluates the long-term impacts of disposal of about 120 million curies in saltstone vaults, which would be the result of the Direct Disposal in Grout alternative.

Commentors had questions about waste tank utilization, particularly about reuse of old tanks if a salt processing technology were not available. DOE discusses waste tank utilization in Chapter 2 and Appendix A of the SEIS. DOE intends to manage the selection, construction, and operation of a salt processing facility and current facilities such that tank waste removal and tank closure commitments can be met.

Commentors had several specific questions about the technology research and development activities that DOE is conducting, and how these activities were coordinated with the SEIS. The SEIS describes the technology research. The Final SEIS will be available to the public and the decisionmakers before DOE selects a technology for salt processing. In addition, the results of several studies are available now for public review on the SRS web site at www.srs.gov/general/srtech/spp/randd.htm.

Commentors asked if cost would be included in the SEIS to differentiate between alternatives. Commentors also asked if cost was the sole attraction of the Direct Disposal in Grout alternative. The preliminary cost estimates that are available do not provide any differentiation between alternatives and, at this preliminary stage, are all in the same range. The greatest attraction of the Direct Disposal in Grout alternative is not cost, but the fact that there is no technical uncertainty involved in its implementation.

Commentors asked about the schedule for salt processing technology selection and implementation. DOE expects to complete preliminary research and development and identify a preferred technology by June 2001. DOE will identify the preferred technology in the Final SEIS and announce its decision in a Record of Decision no sooner than 30 days after EPA publishes a Notice of Availability of the Final SEIS. Selection by the Summer of 2001 is critical to selecting a design contractor, initiating Pilot Plant studies of the selected technology and, ultimately, bringing a salt processing alternative on line in time to meet SRS commitments for HLW vitrification and HLW tank closure. Startup of the salt processing facility is planned for about 2010.

S.5 Decisions to be Made

Following completion of this SEIS and related technical studies, DOE will select a technology to process the salt components of the HLW stored at SRS.

DOE will complete laboratory research and development in April 2001. Following evaluation of the studies, DOE will identify a preferred alternative in the Final SEIS, planned for June 2001. No sooner than 30 days after EPA publishes a Notice of Availability of the Final SEIS, DOE will select a salt processing technology and issue a Record of Decision. DOE will construct and operate a Pilot Plant of the selected technology and then produce a final design of the facility to implement full-scale operation of the selected technology.

S.6 Site Selection

WSRC prepared a site selection study to identify a suitable location at the SRS for the construction and operation of a salt processing facility in S or H Areas. The study sought to optimize siting for facility-specific engineering requirements, sensitive environmental resources, and applicable regulatory requirements. The goal of the study was to evaluate alternative sites for building and support facilities for the Small Tank Precipitation technology, the Ion Exchange technology, or the Solvent Extraction technology.

Siting of the salt processing facility would be constrained by an operational requirement that it be located near the HLW processing facilities (in F, H, and S Areas; see Figure S-1). In order to transfer materials from the proposed salt processing facility to the DWPF, the salt processing facility must be located within 2,000 feet of the DWPF or a low point pump pit. This constraint identified general areas suitable for construction and operation. Thirteen areas with sufficient acreage for the buildings, construction laydown, and support facilities were identified. Subsequent evaluation of these areas resulted in the identification of four candidate sites (A [subsequently excluded], B, C, and D) in S Area (Figure S-2). A comparative analysis of the sites provided a suitability ranking based on geological, ecological, human health, and engineering considerations. Overall, Site B ranked higher than Sites C or D, although no distinct differences were identified between the four sites for geological, ecological, or human health considerations.

Because there were no distinct differences and Site B is representative of all sites, DOE assumes for purposes of analysis and comparison,

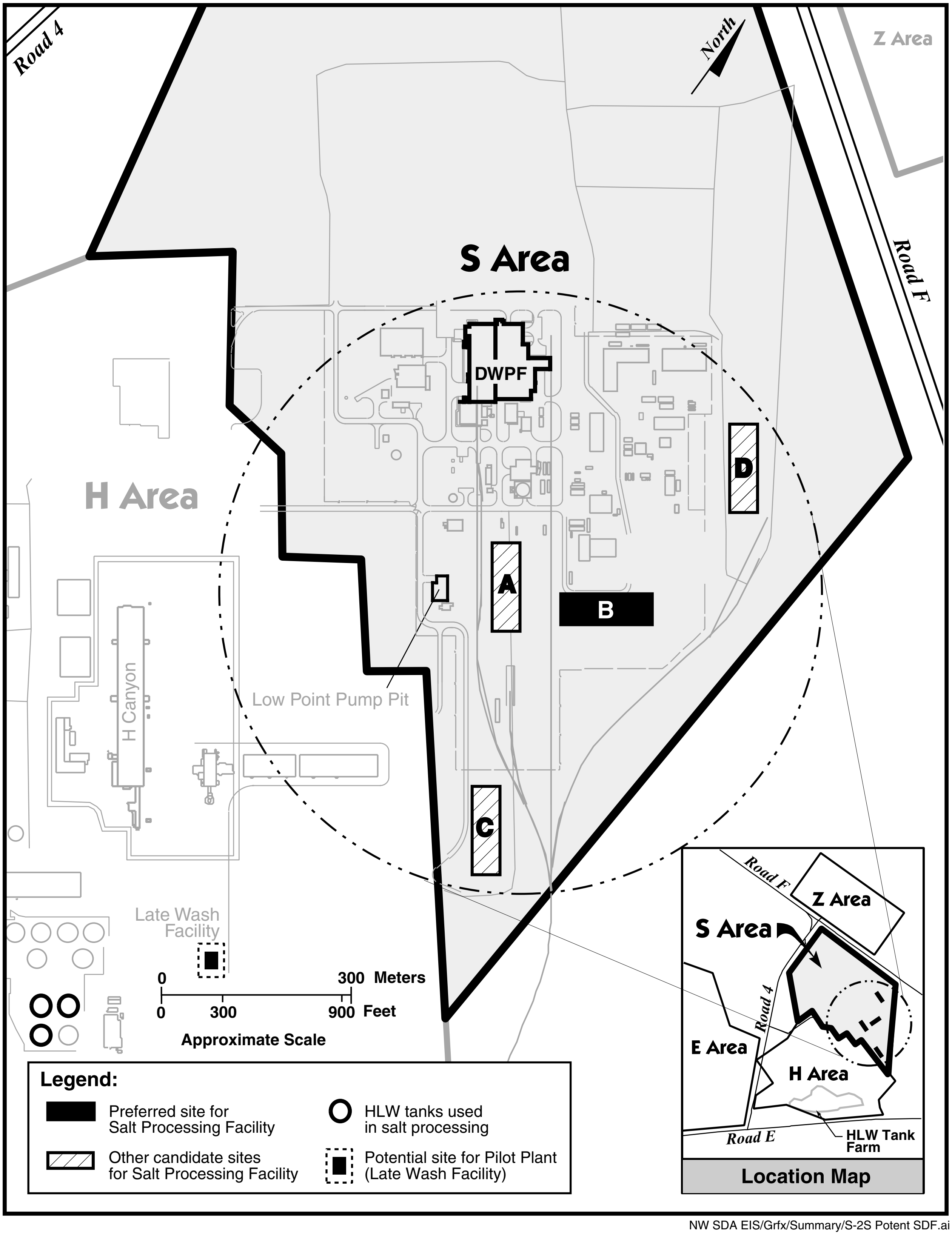

Figure S-2. Potential salt processing facility sites.

DOE assumes in this SEIS that all facilities for the Small Tank Precipitation, the Ion Exchange, or the Solvent Extraction technologies would be located at Site B.

The Direct Disposal in Grout technology was not considered in the siting study because the grout manufacturing facility would need to be located in Z Area, near the saltstone vaults and existing infrastructure that could support the grout production. Figure S-3 shows the preferred location of the Direct Disposal in Grout processing facility and the saltstone disposal vaults that would be constructed and operated under any of the action alternatives.

S.7 DOE's Proposed Action and the Alternatives

DOE proposes to select a salt processing technology and to design, construct, and operate the facilities required to process HLW salt. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of LLW at SRS.

This Draft SEIS describes and assesses the potential environmental impacts of the construction and operation of facilities to implement each of four process alternatives for HLW salt processing to replace the ITP process. Each of these action alternatives could accomplish the purpose and need for action, in contrast to the No Action alternative, which does not include a method for salt processing.

DOE, with the help of independent experts, has performed research on each of the four process alternatives to establish the technological risk(s) involved in implementing each one. Independent scientists reviewed the results of the research. This Draft SEIS assesses the potential environmental impacts of each alternative.

DOE has not yet selected a preferred alternative for processing HLW salt. The identification of a preferred alternative will be based on research, evaluation, and independent review of the technology alternatives to be completed in April 2001, with the preferred alternative to be identified in the Final SEIS.

No Action Alternative

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management, without a process for separating the high-activity and low-activity salt fractions. DWPF would vitrify only sludge from the HLW tanks. Saltcake and salt supernatant would be stored in the HLW tanks and monitoring activities would continue. Tank space would continue to be managed to ensure adequate space to meet safety requirements and closure commitments. Current tank space management projections indicate that, after 2010, additional tank space would be needed to support continued operations under the No Action alternative.

DOE recognizes, however, that without a salt processing technology in place, current HLW storage operations cannot continue indefinitely. DWPF operations result in large volumes of waste, mostly water, that is returned to the HLW tanks. DOE uses evaporators to substantially reduce this volume but, until a salt processing alternative is on-line, DWPF operation will increase rather than decrease the volume of HLW that must be stored in the tanks.

To maintain tank space until about 2010, tank space management under the No Action alternative would include the following activities intended to enhance storage capacity in the HLW tanks:

- Continue to evaporate water from liquid waste
- Use tanks for HLW storage instead of In-Tank Precipitation (ITP) processing (Tanks 49 and 50)
- Reduce the DWPF low-level liquid waste stream sent to the Tank Farms
- Implement several activities that gain small incremental storage volumes (e.g., optimize washwater use at Extended Sludge Processing)

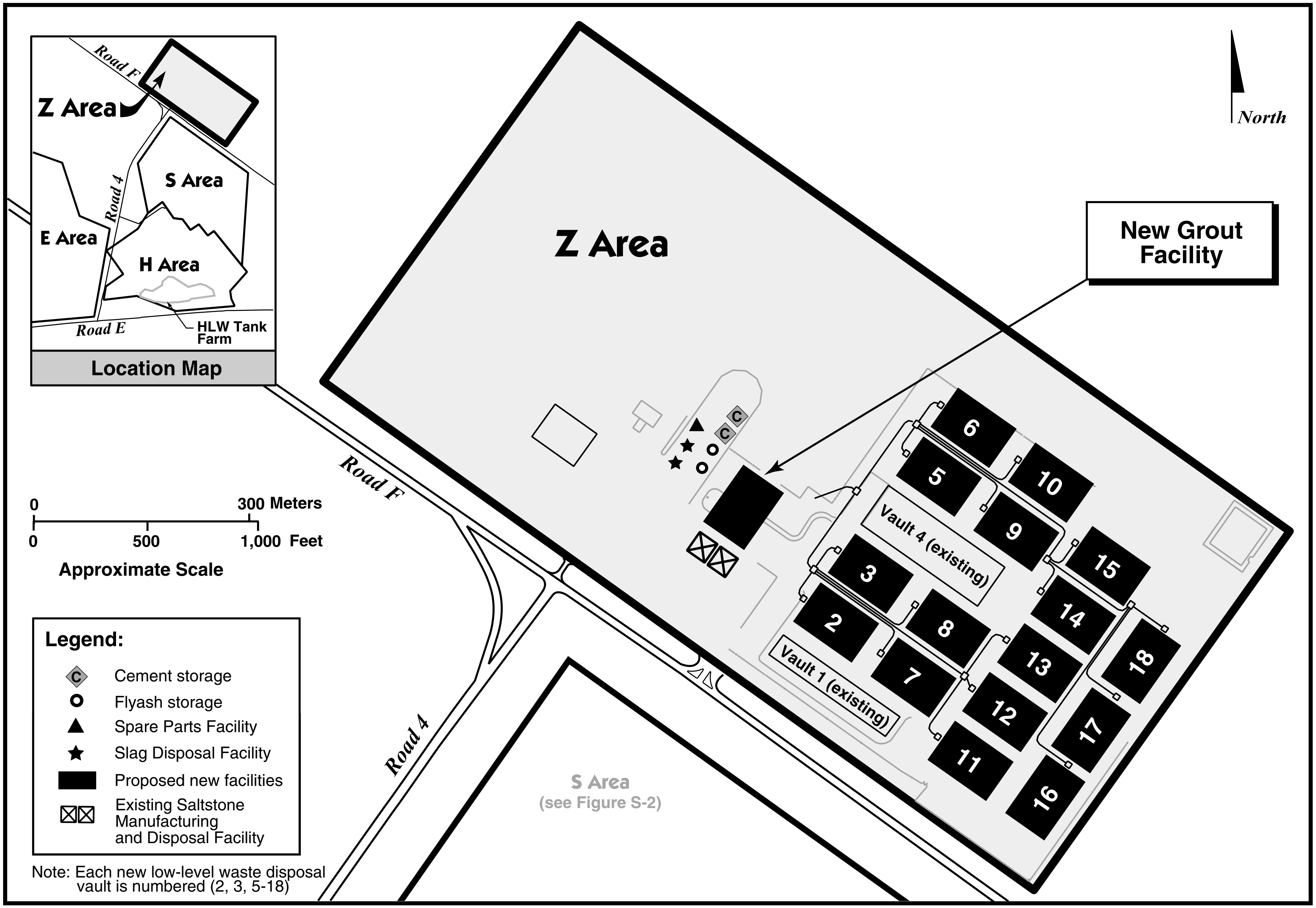

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Figure S-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

- As 2010 approaches, reduce the available emergency space in the Tank Farms (presently 2,600,000 gallons) to the minimum required by the Authorization Basis determined by a safety assessment (1,300,000 gallons), as necessary.

As soon as DOE were to determine that a salt processing facility would not be available by 2010, decisions about additional tank space would have to be made immediately. The course of action that DOE would follow cannot be predicted at this time, but available options may include the following, either individually or in combination.

1. Identify additional ways to optimize tank farm operations
2. Reuse tanks scheduled to be closed by 2019
3. Build tanks permitted under wastewater treatment regulations
4. Build tanks permitted under RCRA regulations
5. Suspend operations at DWPF.

Because of the speculative nature concerning DOE's future course of action, DOE provides a mostly qualitative assessment of the No Action alternative in Chapter 4.

Salt Processing Alternatives

Common features of all processes include initial separation of low-concentration soluble radioactive strontium and actinides (including plutonium) by **sorption** (Table S-1) on granular solid monosodium titanate (MST), followed by filtration. Essential differences in the alternatives are the technologies for removal of the relatively high concentrations of radioactive cesium, except for the Direct Disposal in Grout alternative, in which cesium is not removed. The final waste forms are similar for each alternative, except Direct Disposal in Grout, with the high-activity salt fraction extracted from the salt and incorporated into the DWPF glass waste form for eventual repository disposal, and the low-activity salt fraction immobilized as saltstone for onsite disposal. A diagram and an overview comparing the process phases for the salt processing alternatives are presented in Figure S-4 and Table S-1, respectively. Greater detail is provided in Appendix A, Technology Descriptions.

DOE believes that it would be able to demonstrate that the low-activity salt fraction processed under any action alternative could appropriately be managed as LLW under the waste incidental to reprocessing criteria in DOE Manual 435.1-1 (which provides procedures for implementing DOE Order 435.1, Radioactive

Table S-1. Comparison of salt processing alternatives.

Salt processing alternatives	Process phases: Strontium and actinide (Pu) removal from salt solution	Process phases: Cesium removal from salt solution	Final waste form: DWPF glass	Final waste form: Saltstone
Small Tank Precipitation	MST sorption	TPB Precipitation	MST/TPB solids	Low-activity salt solution
Ion Exchange	MST sorption	CST Ion Exchange	MST solids, CST resins	Low-activity salt solution
Solvent Extraction	MST sorption	Organic extractant	MST solids, aqueous cesium solution	Low-activity salt solution
Direct Disposal in Grout	MST sorption	None	MST solids only	Cesium-bearing salt solution

MST = Monosodium Titanate, CST = Crystalline Silicotitanate, TPB = Tetraphenylborate.

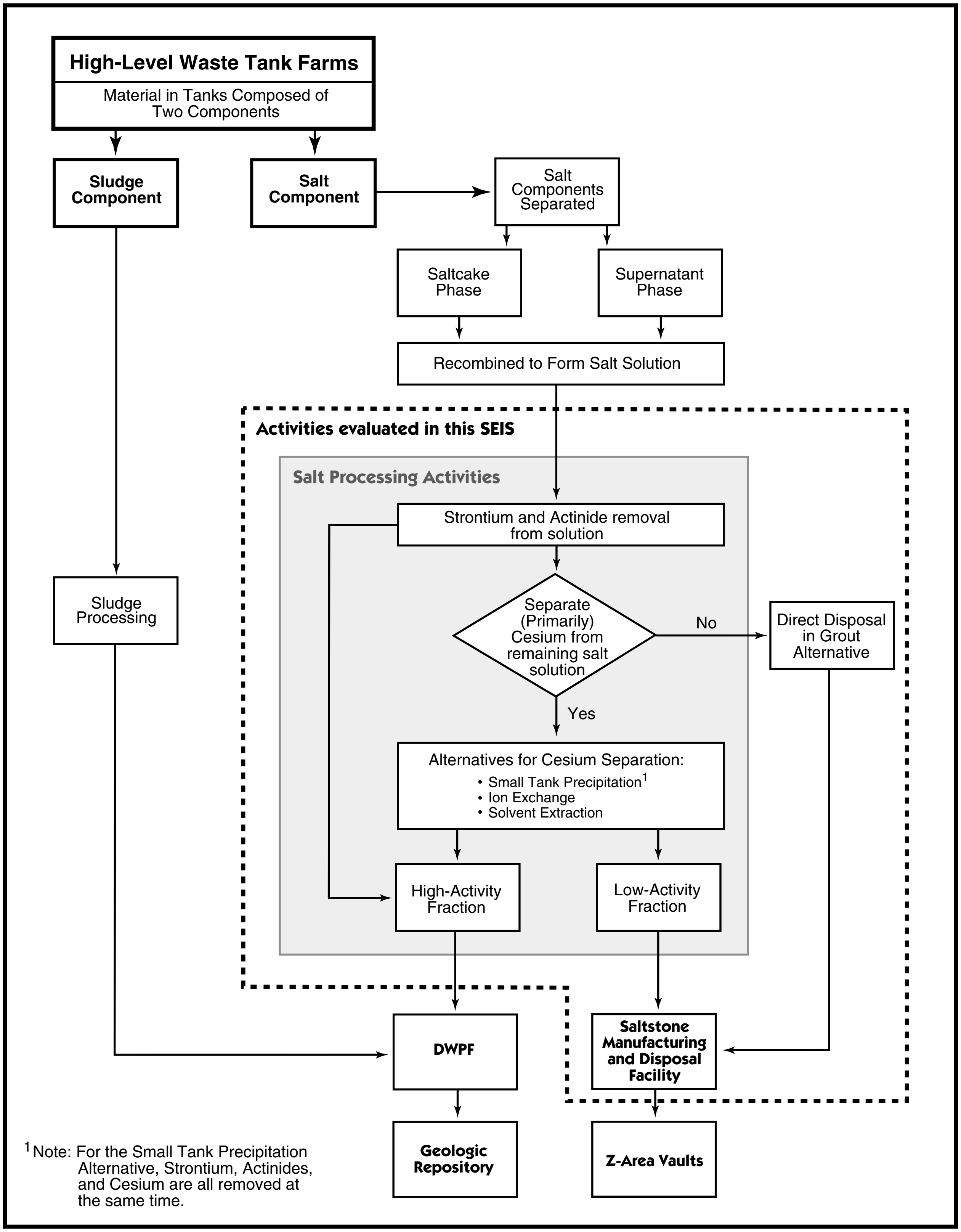


Figure S-4. Process Flow for High-Level Waste at the Savannah River Site.

Waste Management). The waste incidental to reprocessing determination process is described in detail in Chapter 7.

S.7.1 SMALL TANK PRECIPITATION

The Small Tank Precipitation alternative would use the same chemical reaction as ITP (i.e., tetraphenylborate **precipitation**) to remove the radioactive cesium from the HLW salt solution. However, the process would be conducted as a continuous operation using a small, temperature-controlled reaction vessel to inhibit tetraphenylborate decomposition and benzene generation. The vessel and operating conditions would be designed to minimize benzene emissions and flammability hazards by maintaining an inert gas (nitrogen) atmosphere within the reaction vessel.

Radioactive cesium would be separated from the salt solution by precipitation as an insoluble tetraphenylborate solid. Radioactive strontium and actinides would be removed concurrently by sorption onto a granular solid, monosodium titanate. These solids would be separated from solution and concentrated by filtration, then treated chemically by a precipitation hydrolysis process to decompose the tetraphenylborate precipitate and remove the benzene formed. The solids slurry containing the separated radioactive constituents is called **Precipitate Hydrolysis Aqueous** (PHA). This slurry would be transferred to DWPF for vitrification. The low-activity salt fraction would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

Benzene Control for Small Tank Precipitation

Several important features have been incorporated into the design of the Small Tank Precipitation alternative to avoid the benzene production problems encountered in the original ITP process.

Small Tank Precipitation	ITP
Continuous, small volume process	Batch process; very large volume
Temperature-controlled process vessels	Limited temperature control
Continuous agitation	Intermittent agitation
Short processing time (hours)	Longer processing time (months)
Pressure-tight process vessels for effective nitrogen gas inerting	Incomplete nitrogen gas inerting

S.7.2 ION EXCHANGE

The Ion Exchange alternative would use **crystalline silicotitanate** resin in ion exchange columns to separate cesium from the salt solution. The salt solution would pass through large stainless steel ion exchange columns filled with the ion exchange resin to react the cesium with the resin. Treatment of the solution with monosodium titanate to separate strontium and actinides, and filtration to remove those solids and residual sludge, would be necessary prior to separating the cesium to prevent plugging the ion exchange columns.

Both the monosodium titanate solids and the cesium-loaded crystalline silicotitanate resin would be transferred to DWPF for vitrification. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

The Ion Exchange process would result in the accumulation of as much as 15 million curies of radioactive cesium on the resin inventory within the process cell. This radioactive loading would necessitate stringent shielding requirements and operational controls because of high radioactivity, high heat generation, and the generation of hydrogen and other gases.

S.7.3 SOLVENT EXTRACTION

The Solvent Extraction alternative would use a highly specific organic extractant to separate cesium from the HLW salt solution. The cesium would be transferred from the aqueous salt solution into an insoluble organic phase, using a centrifugal contactor to provide high surface area contact, followed by centrifugal separation of the two phases. Recovery of the cesium by back extraction from the organic phase into a secondary aqueous phase would generate a concentrated cesium solution (strip effluent) for vitrification in DWPF. Prior treatment of the HLW salt solution, using monosodium titanate to separate soluble strontium and actinides and filtration to remove those solids and residual sludge, would be required to meet salt solution decontamination requirements and avoid interference in the solvent extraction process. The monosodium titanate solids would be transferred to DWPF for vitrification along with the strip effluent solution. The low-activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as grout in onsite vaults.

S.7.4 DIRECT DISPOSAL IN GROUT

Under the other three technologies considered in this SEIS, cesium would be removed from the salt solution and eventually disposed of, along with the high-activity fraction, as HLW. Under the Direct Disposal in Grout alternative, the HLW salt solution would be disposed onsite as saltstone without prior separation of radioactive cesium. Prior to solidifying the salt solution as grout, monosodium titanate would be used to remove the strontium and actinides to meet saltstone waste acceptance criteria as LLW. The monosodium titanate slurry would be transferred to DWPF for incorporation into HLW glass.

The clarified salt solution resulting from monosodium titanate treatment would be combined with flyash, cement, and slag in a grout mixer for disposal in the saltstone vaults. The resulting waste form would meet 10 CFR 61.55 Class C LLW limits for near-surface disposal, but would exceed Class A limits. Current regulations require SCDHEC notification if wastes in saltstone vaults exceed the Class A limits.

S.7.5 PROCESS INPUTS AND PROCESSING REQUIREMENTS

Design of salt processing facilities depends on specifications of processing requirements, including product input and output. Volumes of input streams and requirements for their processing to final forms are summarized in Table S-2. The specified capacities of the process facilities would maintain an average processing of about 6 million gallons of waste salt solution per year. This processing rate would allow complete processing of about 80 million gallons total (approximate volume of salt solution when the saltcake is dissolved) within about 13 years after facility startup. It is important to finish processing the salt waste within this time so that the HLW sludge and the high-activity fraction of the HLW salt can be vitrified together in the DWPF. If salt processing is delayed so that salt waste must be vitrified separately, the total number of HLW canisters would be greatly increased over that projected for concurrent sludge-salt waste vitrification. Vitrification of the combined HLW sludge and salt would produce about 5,700 glass waste canisters.

Differences in the total number of combined sludge and salt waste canisters produced following the different salt processing alternatives would be small because of the relatively minor contribution of HLW salt compared to HLW sludge in the glass waste form. As many as 16 saltstone vaults in addition to the two existing vaults would be required for final disposal of the low-activity salt solution.

S.7.6 PRODUCT OUTPUTS

The product outputs from the process facilities, including high-radioactivity solids slurry or solution to DWPF, low-activity salt solution to grout, and saltstone generated by the salt processing alternatives are compared in Table S-3. The Solvent Extraction facility would deliver a greater volume of product to DWPF than the other facilities because of the relatively high volume of cesium solution (strip effluent) in its product output. However, the amount of sludge processed at DWPF is the primary determinant for canister production. Therefore, the high volume of cesium solution from the solvent extraction facility would not affect the number of canisters produced. Salt solutions to grout and the product grout produced would be about the same for each alternative.

Table S-2. Inputs and processing requirements for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Capacity throughput of salt solution (million gallons per year)	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution (million gallons per year)	6.0	6.0	6.0	6.0
Throughput limitation	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks	Salt removal rate from waste tanks
Number of years for construction of process facilities	4.0	4.2	4.0	3.9
Number of years for startup testing	1.3	1.3	1.3	1.3
Number of years of facility operations	13	13	13	13
Planned canister production per year[a]	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced[a]	≈5,700	≈5,700	≈5,700	≈5,700
Additional vaults for Class A waste	16	13	15[c]	0
Additional vaults for Class C waste[b]	0	0	0	13

a. DWPF planned glass waste canister production includes both sludge and salt wastes.
b. Additional saltstone vaults for onsite disposal of processed salt solution.
c. This alternative would require between 14 and 15 vaults; for purposes of impact analysis, 15 vaults were assumed.

Table S-3. Product outputs for the salt processing alternatives.

	Alternative			
Product Output	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Solids Slurry (and solution) to DWPF				
Annual (million gallons)	0.22	0.20	0.68[a]	0.15
Life cycle (million gallons)	2.9	2.6[b]	8.8[a]	2.0
Salt solution to grout				
Annual (million gallons)	8	6.6	7.5	5.9
Life cycle (million gallons)	104	86	97	77
Grout produced				
Annual (million gallons)	15	12	14	11
Life cycle (million gallons)	190	160	180	140

a. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr strip effluent solution, assuming no evaporation; analogous life cycle outputs shown.
b. Includes 2 million gallons monosodium titanate slurry and 0.6 million gallons crystalline silicotitanate slurry.
Note: Material balance estimates are ± 25 percent.

In addition to the principal product outputs specified in Table S-3, the Small Tank Precipitation process would generate by-product benzene. About 60,000 gallons per year (20 metric tons per year) of liquid benzene would be produced by decomposition of the tetraphenylborate salt in the precipitation hydrolysis process, to be stored for final disposition.

The Solvent Extraction process would generate a liquid organic solvent also requiring final processing. The total solvent inventory for the process is projected to be 1,000 gallons. DOE conservatively assumes that this inventory would be replaced once per year. For a facility operation time of 13 years, the accumulated total volume of solvent requiring processing would be 13,000 gallons.

S.7.7 PROCESS FACILITIES

DOE would construct a new shielded facility to house chemical processing equipment (tanks, pumps, filter systems) to implement any alternative. The facility would be sized to contain large feed storage and product hold tanks to ensure an average daily processing rate of 25,000 gallons of salt solution. The process facilities are more fully described in Chapter 2 and Appendix A. The large tanks would also buffer the continuous salt processes from the batch processes of the Tank Farm operations. Transfer facilities required to direct the flow of process streams among the various facilities are described in Appendix A.

Because the facilities required for any of the action alternatives are very similar, this discussion is relevant to all four alternatives.

New shielded process buildings would be constructed, regardless of the salt disposal alternative selected. The preferred site for the process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives is Site B in S Area. The process building for the Direct Disposal in Grout alternative would be in Z Area. In each case, the process buildings would be constructed of reinforced concrete and contain shielded cells designed to handle highly radioactive materials.

The building specifications would be similar for each of the four salt processing alternatives, albeit somewhat less for Direct Disposal in Grout. Preliminary design dimensions are provided in Table S-4.

Table S-4. Building specifications for each action alternative.[a]

	Process Alternative			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Length, ft.	310	280	300	220
Width, ft.	140	140	120	120
Height, ft.	60 (100 ft. bay)	60 (100 ft. bay)	70 (110 ft. bay)	60 (90 ft. bay)
Depth below grade, ft.	40	40	40	20
Floor Area, $ft.^2$				
including processing cells	66,000	60,000	62,000	54,000
excluding processing cells	50,000	48,000	48,000	43,000
Volume, $ft.^3$				
including processing cells	4,500,000	4,200,000	4,500,000	1,800,000
excluding processing cells	3,900,000	3,600,000	3,900,000	1,200,000
Processing cell floor area, $ft.^2$	16,000	12,000	13,000	11,000
Processing cell volume, $ft.^3$	640,000	550,000	600,000	570,000

a. Building specifications rounded to two significant figures.

The floor plans and elevations for the salt processing facilities are shown in Chapter 2 of the Draft SEIS, and Appendix A provides more detail. Each alternative would also require support facilities, including a service and office building and an electrical substation. Support facilities are described in detail in Appendix A.

S.7.8 Z-AREA VAULTS

As many as 16 new saltstone disposal vaults would be constructed in addition to the two existing vaults in Z Area to support the salt disposal for each of the alternatives (Figure S-4). The concrete vaults would be 300 feet long by 200 feet wide by 25 feet high. Each vault would consist of six cells, 100 feet long by 100 feet wide. Due to the heat generated during grout solidification, the cells in each vault would be filled in a rotation that would meet grout cooling requirements. All vaults would be equipped with cameras and lights to monitor filling and thermocouple assemblies to monitor heat generation during the curing process. As with the original Z-Area vaults, the new vaults would be constructed at or somewhat below grade and covered over with soil after vault closure for additional shielding. Figure S-5 illustrates how Z Area would look after vault closure.

For the Direct Disposal in Grout alternative, 13 new vaults would be constructed in Z Area. Because the grout would contain radioactive cesium, the disposal procedure for this alternative would differ from that of the other three alternatives. Each vault would have a 500-cubic-foot-per-minute ventilation system, equipped with high-efficiency particulate air filters that would operate during the cell-filling process for temperature control while the saltstone cures. Radiation monitors and dampers would be included. Because the other three alternatives would remove more radionuclides (including radioactive cesium) from the low-activity salt solution, forced air ventilation would not be required under those alternatives. After each batch of grout was transferred to a vault under each alternative, the grout transfer lines, Saltstone Hold Tank, and Grout Feed Pumps would be flushed to the vault to remove any residual grout material.

S.7.9 FACILITY DECONTAMINATION AND DECOMMISSIONING

Any new facility would be designed and constructed to limit the generation and dispersion of radioactive and hazardous materials and to facilitate ultimate decontamination and decommissioning or reuse. Areas of the facility that might become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions would incorporate design features to simplify their decontamination. Items such as service piping, conduits, and ductwork would be minimized in these areas and arranged to facilitate decontamination. Facility design would include a dedicated area for decontamination of tools and some equipment.

Design features that would be incorporated into the facility include the following:

- Modular confinement would be used for radioactive and hazardous materials to preclude contamination of fixed portions of the structure

- Long runs of buried piping that would carry radioactive or hazardous materials would be minimized to the extent possible, and provisions would be included in the design that would allow testing of the integrity of joints in buried pipelines

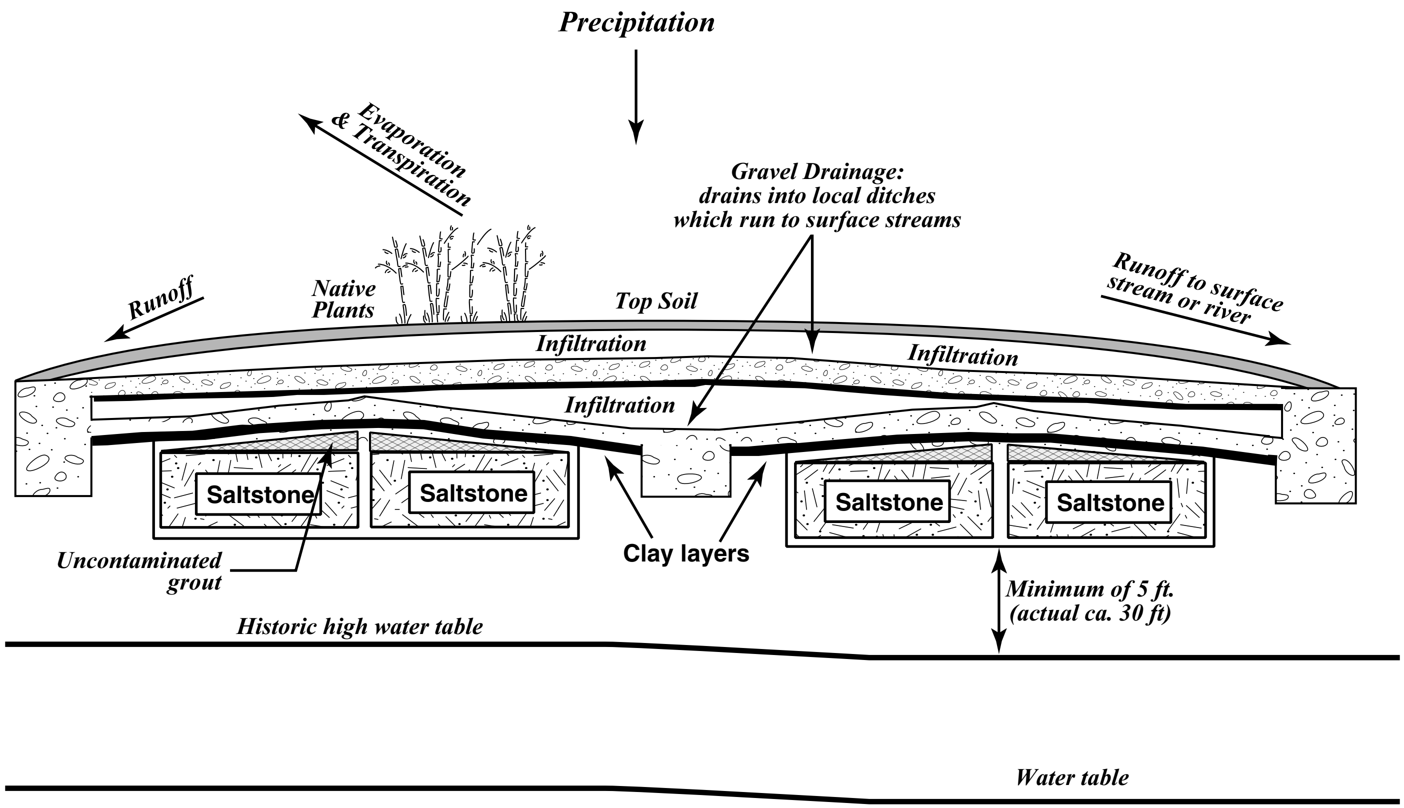
- The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment

- Lifting lugs would be used on equipment to facilitate remote removal from the process cell

- The piping systems that would carry hazardous products would be fully drainable.

S.8 Pilot Plant

If DOE selects a salt processing alternative, a Pilot Plant would be designed and constructed to provide pilot-scale testing of process technology before operation of the full-scale facility. The



Source: Martin Marietta, 1992.

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Figure S-5. Cross-section diagram of vault closure concept.

Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address the remaining key technical uncertainties will be completed in April 2001, but the uncertainties cannot be fully addressed without the performance of pilot-scale tests using actual waste from the SRS HLW system. The Pilot Plant components would be sized to operate on a scale ranging from 1/100 to 1/10 of a full-sized facility.

The Pilot Plant would be located in an existing process area well within the SRS boundary. Candidate sites include the Late Wash Facility in H Area (see Figure S-1), near DWPF in S Area, or in another area similar to the location of the full-scale facility.

Detailed design and construction of the Pilot Plant would be initiated upon selection of the preferred salt processing alternative and operation would extend through completion of final design and potentially through startup of the full-scale facility. Principal process operations would be conducted inside shielded cells. Scaled-down hardware, instrumentation, and controls appropriate to the selected process would be installed. The unit would use modular design to facilitate remote installation and modification of the process equipment. Services that would be provided to support operations include utilities, process chemicals, ventilation systems, and personnel. An appropriate chemical storage area would be developed, with isolation of acids, caustics, oxidizing and reducing agents, and other incompatible reactants. Ventilation systems would be operated so that airflow was from areas of low contamination to those of higher contamination potential.

Operations would be conducted in accordance with appropriate safety documentation requirements, including provisions for safe and orderly emergency shutdown. Emergency equipment and procedures would ensure that operations were maintained within constraints analogous to those of the full-size facility.

The generation and dispersion of radioactive and hazardous materials would be minimized. Process waste would be disposed of at appropriate site locations, such as the HLW Tank Farms, DWPF, Saltstone Manufacturing and Disposal Facility, Effluent Treatment Facility, or LLW vaults. Limited radioactive material inventories and appropriate operating parameters would ensure that the overall environmental impacts would be substantially less than those of the full-scale facility.

Detailed examples of proposed test objectives are given in Appendix A.

S.9 Comparison of Environmental Impacts among Alternatives

Design, construction, and operation of a salt processing facility would affect the environment and human health and safety during the time of facility construction and operation, as well as after operations ceased. For purposes of analysis in this Draft SEIS, DOE has defined the facility life cycle to be from the year 2001 through about 2023, when salt processing would be complete. This is the period used to estimate short-term impacts. For the No Action alternative, short-term impacts are considered for the two periods, Continuing Tank Space Management (until 2010) and Post Tank Space Management. DOE expects the long-term impacts to be those that could result after 2023 from the eventual release of residual waste from the Z-Area vaults (or from tanks containing salt solution under the No Action alternative) to the environment. In this Draft SEIS, DOE has used modeling to predict these long-term impacts.

This section compares the impacts of the No Action alternative and the four action alternatives: Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout. The action alternatives would involve very similar construction and operations activities that enable a sharply-focused comparison of impacts to each environmental resource. The purpose of this section is to present impacts of the alternatives in comparative form to provide the decisionmaker(s) and the public a clear basis for choosing among the alternatives.

In general, the impacts of construction and operation of the action alternatives may be described as similar and not significant. Where differences appear, many are due to the presence of benzene in the Small Tank Precipitation alternative. In the long term, the environmental concern would be contamination of groundwater from the saltstone vaults under the action alternatives. The presence of 120 million curies in the vaults from the Direct Disposal in Grout alternative would be evident in the long-term impacts, but the impacts of all the alternatives may still be described as small.

S.9.1 SHORT-TERM IMPACTS

DOE has evaluated the short-term impacts of the alternatives in Section 4.1 of the Draft SEIS. These impacts would occur between the approximate years 2001 and 2023 for each of the action alternatives. Notable differences between the alternatives are shown in Table S-6. The analysis of impacts summarized here shows that, in general, the differences in impacts between the alternatives is attributable to the presence of benzene in the Small Tank Precipitation alternative and its absence from the other alternatives. There are some processes that are unique to a particular alternative. These are shown in Table S-5 to point out the differences, but the impacts are small.

There are no notable differences between alternatives and the impacts are small, in the following areas:

- Geologic resources
- Water resources
- Occupational Health and Safety
- Environmental Justice
- Ecological Resources
- Land Use
- Cultural resources
- Transportation

These resources areas are not discussed further here, but a complete assessment may be found in Section 4.1 of the Draft SEIS.

Nonradiological air quality –For any of the four action alternatives, the increases in pollutant concentrations resulting from construction activities would be small, would not exceed regulatory limits, and are not expected to result in any adverse health effects.

Nonradiological emissions from routine operations (with the exception of VOCs) would be below regulatory limits. The Small Tank Precipitation alternative would require additional permit review, whereas emissions from the other alternatives are either covered by the existing permit(s) or below the threshold values.

Radiological air quality – Radiation dose to the MEI from air emissions associated with the salt processing alternatives would be highest (0.31 millirem per year) for the Solvent Extraction alternative, due to the higher emissions of radioactive cesium, which would account for 90 percent of the total dose to the MEI. Dose to the MEI from other alternatives would be lower: 0.20 millirem per year for the Small Tank Precipitation alternative, 0.049 millirem per year for the Ion Exchange alternative, and 0.086 millirem per year for the Direct Disposal in Grout alternative. Estimated dose to the offsite population would also be highest for the Solvent Extraction alternative (18.1 person-rem per year). For the Small Tank Precipitation alternative, the offsite population dose would be 12.0 person-rem per year; for the Ion Exchange alternative, the offsite population dose would be 2.9 person-rem per year; and for the Direct Disposal in Grout alternative, the offsite population dose would be 4.0 person-rem per year. None of these emissions are expected to result in adverse health effects (i.e., latent cancer fatalities; see text box).

Radiological doses to the noninvolved onsite worker, the involved worker, and the collective onsite population from life-cycle operation of any of the alternatives are not expected to result in adverse health effects.

Table S-5. Summary comparison of short-term impacts.

Parameter	No Action[a] Continue Tank Space Management	No Action[a] Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Air Resources						
Nonradiological air emissions (tons/yr.):						
Volatile organic compounds (PSD Standard - 40)	No Change	Minimal[b]	70	1.6	40	1.5
Nitrogen dioxide (PSD Standard - 40)	No Change	Minimal[b]	21	21	21	19
Formic Acid (PSD Standard - NA)	No Change	Minimal[b]	1.6[c]	None	None	None
Benzene (PSD Standard - NA)	No Change	Minimal[b]	53	0.0085	0.0085	0.0085
Biphenyl (PSD Standard - NA)	No Change	Minimal[b]	1.1	None	None	None
Isopar®L (PSD Standard - NA)	None	None	None	None	38	None
Air pollutants at the SRS boundary (maximum concentrations-μg/m³):						
Benzene - 24 hr. (Standard - 150)	5[d]	Minimal[b]	4.0	0.0010	0.0010	0.0010
Biphenyl - 24 hr. (Standard - 6)	0.02[d]	Minimal[b]	0.45	None	None	None
Annual radionuclide emissions (curies/year): (Doses are reported in Worker and Public Health Section.)	No Change[e]	Minimal[b]	5.3	18.2	25.4	9.3[f]
Worker and Public Health - Radiological						
Radiological dose and health impacts to the public:						
Maximally-exposed individual (MEI) (mrem/yr.)	No Change[g]	Minimal[h]	0.20	0.049	0.31	0.086
MEI project-phase latent cancer fatality	No Change[g]	Minimal[h]	1.3×10^{-6}	3.2×10^{-7}	2.0×10^{-6}	5.6×10^{-7}
Offsite population dose (person-rem/yr.)	No Change[g]	Minimal[h]	12.0	2.9	18.1	4.0
Offsite population project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.078	0.019	0.12	0.026

Table S-5. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Radiological dose and health impacts to involved workers:						
Involved worker dose (mrem/yr)	No Change[g]	Minimal[h]	16	3.9	23	10
Project-phase dose to population of involved workers (total person-rem)	No Change[g]	Minimal[h]	29	5.0	47	14
Project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	0.012	0.0020	0.019	0.0056
Radiological dose and health impacts to noninvolved workers:						
Noninvolved worker dose (mrem/yr.)	No Change[g]	Minimal[h]	3.3	0.8	4.8	1.7
Project-phase latent cancer fatality increase	No Change[g]	Minimal[h]	1.7×10^{-5}	4.2×10^{-6}	2.5×10^{-5}	8.6×10^{-6}
Worker and Public Health - Nonradiological						
Nonradiological health impacts to the public:						
Maximally exposed offsite individual						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	1.7×10^{-5}	(i)	(i)	(i)
Nonradiological health impacts to noninvolved workers:						
Latent cancer fatality from benzene	No Change[g]	Minimal[h]	0.0066	(i)	(i)	(i)
OSHA-regulated nonradiological air pollutants at noninvolved worker location (max conc. in mg/m^3)						
Oxides of nitrogen (as NO_x) - ceiling (OSHA Standard - 9)	No Change[g]	Minimal[h]	7.0	7.0	7.0	7.0
Benzene - 8 hr. (OSHA Standard - 3.1)	No Change[g]	Minimal[h]	0.1	3.0×10^{-4}	3.0×10^{-4}	3.0×10^{-4}
Benzene - ceiling (OSHA Standard - 15.5 m^3)	No Change[g]	Minimal[h]	0.8	0.004	0.004	0.004

Table S-5. (Continued).

Parameter	No Action[a]		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Formic Acid - 8 hr. (OSHA Standard - 9 m^3)	No Change[g]	Minimal[h]	2.2×10^{-4}[c]	None	None	None
Socioeconomics (employment - full time equivalents)						
Annual construction employment	None	500	500	500	500	500
Annual operational employment	No Change	65[j]	180	135	220	145
Waste Generation						
Maximum annual waste generation:						
Radioactive liquid waste (gallons)	No Change	No Change	300,000	250,000	900,000	150,000
Nonradioactive liquid waste (million gallons)	No Change	No Change	Minimal	34,000	Minimal	Minimal
Mixed low-level liquid waste (gallons)	No Change	No Change	60,000	None	1,000	None
Total waste generation:						
Radioactive liquid waste (million gallons)	No Change	No Change	3.9	3.3	12.0	2.0
Nonradioactive liquid waste (million gallons)	No Change	No Change	Minimal	0.49	Minimal	Minimal
Utilities (total life cycle)						
Water (million gallons)			435	403	380	289
Construction	None	(k)	35	37	35	33
Operations	No Change	No Change	400	366	345	256
Electricity (gigawatt-hours)			319	365	391	245
Construction	None	(k)	76	79	76	73
Operations	No Change	No Change	243	286	315	172
Steam (million pounds)			2,548	2,300	1,915	1,536
Construction	None	(k)	0	0	0	0
Operations	No Change	No Change	2,548	2,300	1,915	1,536

Table S-5. (Continued).

Parameter	No Action[a] Continue Tank Space Management	No Action[a] Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Fuel (million gallons)			8.7	9.3	8.7	8.2
Construction	None	(k)	8.4	9	8.4	8
Operations	No Change	No Change	0.3	0.3	0.3	0.2

a. Under the No Action alternative DOE would continue tank space management activities until approximately 2010, when the existing HLW tanks would reach capacity. Because the course of action that DOE would pursue after the initial period of tank space management has not been determined. For each resource evaluated, only those post tank space management scenarios that would be expected to have an impact are included.
b. Air emissions under the No Action alternative would be similar to those from the existing HLW Tank Farm operations for all scenarios. Therefore, the No Action alternative is represented by slight increases above the baseline.
c. Formic acid emissions would shift from DWPF to the Small Tank TPB facility, resulting in no net increase in emissions.
d. SRS baseline concentration at the site boundary. Emissions from ongoing tank space management activities are included in this value.
e. Radionuclide emissions from ongoing tank space management activities are included in the site baseline. SRS baseline emissions are shown in Table 3-12.
f. Includes building stack and ground level vault emissions. Vaults for the other three action alternatives would have no measurable emissions because the saltstone produced by these action alternatives would have a much lower activity level and the vaults would not be ventilated.
g. Under No Action, air emissions during tank space management activities would remain at current levels, therefore no change in worker and public health impacts would be expected.
h. For all scenarios under No Action impacts to worker and pubic health would be expected to increase slightly above the current baseline.
i. Latent cancer fatalities from benzene from the other alternatives would be substantially less than that from Small Tank TPB Precipitation.
j. Up to 65 new employees would be required for operation of any new HLW tanks constructed under No Action. Alternatively, DOE could suspend operations at the DWPF and F and H Canyons, which, if prolonged, could result in a sizeable workforce reduction.
k. DOE could build as many as 18 new HLW storage tanks under the No Action alternative. Utility and energy use during the construction period would be similar to usage rates under the action alternatives.

ND = Not Determined.

Radiation Dose and Cancer Fatalities

Worker and public health impacts are expressed in terms of latent cancer fatalities. The primary health effect of radiation is an increased rate of cancer. A radiation dose to a population is believed to result in cancer fatalities at a certain rate, expressed as a dose-to-risk conversion factor. The National Council on Radiation Protection and Measurement 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 result in no additional cancer risks to the exposed population.

Socioeconomics – Each of the salt processing alternatives, including No-Action, would require approximately 500 construction workers annually. During operations, the number of workers for the action alternatives would range from 135 for the Ion Exchange alternative to 220 for the Solvent Extraction alternative. None of the action alternatives is expected to have a measurable effect on regional employment or population trends.

Waste generation – Salt processing activities under the action alternatives would generate 150,000 (Direct Disposal in Grout) to 900,000 (Solvent Extraction) gallons of radioactive liquid waste annually. This radioactive liquid waste consists of wastewater recycled from the treatment of the high-activity portion of the salt solutions at DWPF. The solvent extraction alternative would thus have the greatest requirement for evaporator operation and tank space.

Utilities and energy consumption – In general, the Direct Disposal in Grout alternative would consume the least water, electricity, and steam compared to the other alternatives, which would consume a similar amount of these utilities.

Accidents – DOE evaluated the impacts of potential accidents related to each of the action alternatives (Table S-6). For each action alternative, the accidents considered were: loss of confinement; earthquakes; loss of cooling; external events, such as aircraft and helicopter crashes; and explosions from benzene and radiation-generated hydrogen. In general, accident consequences would be highest for the Small Tank Precipitation alternative and lowest for the Direct Disposal in Grout alternative.

Because the No Action alternative includes primarily current operations that have been evaluated in approved safety analysis reports, only the radiological and nonradiological hazards associated with accidents under the four action alternatives were evaluated.

In general, accidents involving nonradiological hazardous materials would result in minimal impacts to onsite and offsite receptors. However, noninvolved workers exposed to atmospheric releases of benzene from two of the accidents evaluated under the Small Tank Precipitation alternative could experience serious or life-threatening health effects. Workers exposed to airborne benzene concentrations (950 mg/m^3) resulting from an Organic Waste Storage Tank (OWST) loss of confinement accident could develop irreversible or other serious health effects that may impair their ability to take protective action. Workers exposed to airborne benzene concentrations (8,840 mg/m^3) resulting from an explosion in the OWST could experience life-threatening health effects. Both of these accidents would occur less than once in 100,000 years and are considered extremely unlikely.

Pilot Plant – Under the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives, DOE would design and construct a 1/100 to 1/10 scale Pilot Plant to demonstrate the salt processing technology. No Pilot Plant is needed for the Direct Disposal in Grout alternative because the technology has already been demonstrated in the existing Saltstone Manufacturing and Disposal Facility. Because the Pilot Plant would be a scaled-down version of the salt processing facility, impacts would typically be no more than 10 percent of the full-sized facility.

Table S-6. Comparison of accident impacts among alternatives.[a]

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Accidents Involving Radioactive Materials					
Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual					
Dose (rem)		0.0016	8.3×10^{-4}	8.3×10^{-4}	2.4×10^{-4}
LCF per accident[b]		8.2×10^{-7}	4.2×10^{-7}	4.2×10^{-7}	1.2×10^{-7}
LCF per year		2.8×10^{-8}	1.4×10^{-8}	1.4×10^{-8}	4.1×10^{-9}
Offsite population					
Dose (person-rem)		88	45	45	14
LCF per accident		0.044	0.022	0.022	0.0072
LCF per year		0.0015	7.6×10^{-4}	7.6×10^{-4}	2.4×10^{-4}
Involved Worker (100 m)					
Dose (rem)		3.2×10^{-6}	6.4×10^{-8}	6.4×10^{-8}	7.3×10^{-8}
LCF per accident[b]		1.3×10^{-9}	2.6×10^{-11}	2.6×10^{-11}	2.9×10^{-11}
LCF per year[b]		4.3×10^{-11}	8.7×10^{-13}	8.7×10^{-13}	9.8×10^{-13}
Noninvolved Worker (640 m)					
Dose (rem)		0.024	0.012	0.012	0.0036
LCF per accident[b]		9.5×10^{-6}	4.9×10^{-6}	4.9×10^{-6}	1.5×10^{-6}
LCF per year[b]		3.2×10^{-7}	1.6×10^{-7}	1.6×10^{-7}	4.9×10^{-8}
Onsite population					
Dose (person-rem)		39	20	20	4.2
LCF per accident		0.016	0.0080	0.0080	0.0017
LCF per year		5.3×10^{-4}	2.7×10^{-4}	2.7×10^{-4}	5.7×10^{-5}
Beyond Design Basis Earthquake	Less than once in 2,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		0.31	0.12	0.12	0.042
LCF per accident[b]		1.5×10^{-4}	5.9×10^{-5}	5.8×10^{-5}	2.1×10^{-5}
LCF per year[b]		7.6×10^{-8}	2.9×10^{-8}	2.9×10^{-8}	1.0×10^{-8}
Offsite population					
Dose (person-rem)		16,000	6,200	6,100	2,300
LCF per accident		8.0	3.1	3.0	1.1
LCF per year		0.0040	0.0016	0.0015	5.7×10^{-4}
Involved Worker (100 m)					
Dose (rem)		310[c]	120	120	42
LCF per accident[b]		0.12	0.047	0.046	0.017
LCF per year		6.1×10^{-5}	2.4×10^{-5}	2.3×10^{-5}	8.4×10^{-6}
Noninvolved Worker (640 m)					
Dose (rem)		9.6	3.7	3.6	1.3
LCF per accident[b]		0.0038	0.0015	0.0015	5.3×10^{-4}
LCF per year[b]		1.9×10^{-6}	7.4×10^{-7}	7.3×10^{-7}	2.6×10^{-7}
Onsite population					
Dose (person-rem)		9,000	3,500	3,400	1,000
LCF per accident		3.6	1.4	1.4	0.41
LCF per year		0.0018	6.9×10^{-4}	6.8×10^{-4}	2.1×10^{-4}

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Loss of Cooling to Loaded Resin Hold Tanks	Once in 5,300 years				
Maximally Exposed Offsite Individual					
Dose (rem)		NA	9.4×10^{-7}	NA	NA
LCF per accident[b]		NA	4.7×10^{-10}	NA	NA
LCF per year[b]		NA	8.9×10^{-14}	NA	NA
Offsite population					
Dose (person-rem)		NA	0.052	NA	NA
LCF per accident		NA	2.6×10^{-5}	NA	NA
LCF per year		NA	5.0×10^{-9}	NA	NA
Involved Worker (100 m)					
Dose (rem)		NA	8.8×10^{-8}	NA	NA
LCF per accident[b]		NA	3.5×10^{-11}	NA	NA
LCF per year[b]		NA	6.7×10^{-15}	NA	NA
Noninvolved Worker (640 m)					
Dose (rem)		NA	1.4×10^{-5}	NA	NA
LCF per accident[b]		NA	5.7×10^{-9}	NA	NA
LCF per year[b]		NA	1.1×10^{-12}	NA	NA
Onsite population					
Dose (person-rem)		NA	0.023	NA	NA
LCF per accident		NA	9.0×10^{-6}	NA	NA
LCF per year		NA	1.7×10^{-9}	NA	NA
Benzene Explosion in PHC[d]	Once in 99,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		0.70	NA	NA	NA
LCF per accident[b]		3.5×10^{-4}	NA	NA	NA
LCF per year[b]		3.5×10^{-9}	NA	NA	NA
Offsite population					
Dose (person-rem)		38,000	NA	NA	NA
LCF per accident		19	NA	NA	NA
LCF per year		1.9×10^{-4}	NA	NA	NA
Involved Worker (100 m)					
Dose (rem)		0.0014	NA	NA	NA
LCF per accident[b]		5.5×10^{-7}	NA	NA	NA
LCF per year[b]		5.6×10^{-12}	NA	NA	NA
Noninvolved Worker (640 m)					
Dose (rem)		10	NA	NA	NA
LCF per accident[b]		0.0041	NA	NA	NA
LCF per year[b]		4.1×10^{-8}	NA	NA	NA
Onsite population					
Dose (person-rem)		17,000	NA	NA	NA
LCF per accident		6.7	NA	NA	NA
LCF per year		6.8×10^{-5}	NA	NA	NA

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Hydrogen Explosion in Extraction Cell	Once in 1,300,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		NA	NA	0.0029	NA
LCF per accident[b]		NA	NA	1.4×10^{-6}	NA
LCF per year[b]		NA	NA	1.1×10^{-12}	NA
Offsite population					
Dose (person-rem)		NA	NA	160	NA
LCF per accident		NA	NA	0.081	NA
LCF per year		NA	NA	6.1×10^{-8}	NA
Involved Worker (100 m)					
Dose (rem)		NA	NA	2.7×10^{-4}	NA
LCF per accident[b]		NA	NA	1.1×10^{-7}	NA
LCF per year[b]		NA	NA	8.1×10^{-14}	NA
Noninvolved Worker (640 m)					
Dose (rem)		NA	NA	0.044	NA
LCF per accident[b]		NA	NA	1.8×10^{-5}	NA
LCF per year[b]		NA	NA	1.3×10^{-11}	NA
Onsite population					
Dose (person-rem)		NA	NA	70	NA
LCF per accident		NA	NA	0.028	NA
LCF per year		NA	NA	2.1×10^{-8}	NA
Accidents Involving Nonradioactive Hazardous Materials					
Accidents Involving Sodium Hydroxide Releases					
Caustic Dilution Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	NA	0.0031
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	NA	0.93[e]
Accidents Involving Nitric Acid Releases					
Nitric Acid Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		NA	NA	8.8×10^{-5}	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		NA	NA	0.026	NA
Accidents Involving Benzene Releases					
Organic Evaporator Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		0.45	NA	NA	NA

Table S-6. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Noninvolved Worker (640 m) Dose (mg/m^3)		130	NA	NA	NA
OWST Loss of Confinement	Once in 140,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		3.2	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		950[f]	NA	NA	NA
Benzene Explosion in the OWST	Once in 770,000 years				
Maximally Exposed Offsite Individual Dose (mg/m^3)		30	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m^3)		8,840[g]	NA	NA	NA

NA = not applicable.
a. Accident impacts based on bounding case.
b. Probability of latent cancer fatality (LCF) to the exposed individual.
c. An acute dose of over 300 rem to an individual would likely result in death.
d. PHC = precipitate hydrolysis cell.
e. Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m^3 could experience mild transient health effects (headache, nausea, rash) or perception of a clearly defined objectionable odor.
f. Individuals exposed to benzene concentrations above 480 mg/m^3 could experience or develop irreversible (kidney damage) or other serious health effects (dizziness, confusion, impaired vision).
g. Individuals exposed to benzene concentrations above 3,190 mg/m^3 could experience or develop life-threatening health effects, such as loss of consciousness, cardiac disrhythmia, respiratory arrest.

S.9.2 LONG-TERM IMPACTS

Section 4.2 of the Draft SEIS discusses fractions of the long-term impacts associated with disposing of the salt solutions as a saltstone grout in Z-Area vaults. DOE estimated long-term impacts by doing a performance assessment that included fate and transport modeling to determine when certain impacts (e.g., radiation dose) could reach a maximum value. DOE used the *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility* as the basis for analysis of the long-term water resource and human health impacts. This performance assessment was based on the original saltstone that would have resulted from the ITP process.

Analytical results, particularly those attempting to predict impacts over a long period of time, always have some uncertainties. Uncertainties could be associated with assumptions used, the complexity and variability of the process being analyzed, or incomplete or unavailable information. The uncertainties involved in estimating the long-term impacts analyzed in this Draft SEIS are described in Appendix D.

In order to estimate the impacts of no action in the long term, DOE must assume that the HLW remains in the HLW storage tanks and no action is ever taken to ensure safe management. In this scenario, following loss of institutional control after 100 years, the HLW tanks would eventually fail and the contents would be released to the groundwater and eventually to surface water. DOE has not attempted to model this scenario because of the numerous uncertainties involved. Some indication of the potential for impacts may be gained, however, from a comparison with modeling results DOE prepared for the *High-Level Waste Tank Closure Draft Environmental Impact Statement* as described in the following paragraph.

Under the No Action alternative in the Tank Closure Draft EIS, DOE would remove most of the waste from the tanks and spray water wash the tanks, but would take no further action to stabilize the waste remaining in the tanks or to stabilize the tank systems themselves. Under this scenario, the tanks would eventually fail (after a period of perhaps several hundred years), creating physical hazards to humans and wildlife in the area and releasing the residual HLW to the groundwater at SRS. DOE estimated that residual waste in the F- and H-Area Tank Farms would contain about 200 curies of long half-life isotopes, technetium-99 and plutonium-239, and 9,900 curies of cesium-137, which has a relatively short half-life of 30 years. DOE modeled the eventual release of these contaminants to the groundwater at SRS. The modeling showed that an adult resident in the F-Area Tank Farm could receive a lifetime radiation dose of 430 millirem (primarily from groundwater), and incur an incremental risk of 2.2×10^{-4} of a fatal cancer. The greatest risk would occur within about 500 years of tank abandonment, but doses for residents would be greater than 100 millirem for over 1,000 years.

In contrast, if DOE were to take no action and leave the HLW in the tanks at SRS, approximately 450,000,000 curies (160,000,000 in salt component, and 290,000,000 in the sludge component assuming that about 10 percent of the curies in the sludge component have been vitrified in DWPF) would be available for release to the groundwater. While modeling would be required to calculate exposures and health effects over time, it is clear that the impacts to human health resulting from a No Action alternative would be catastrophic.

Certain resources would not experience long-term impacts: socioeconomics, worker health, environmental justice, traffic and transportation, waste generation, utilities and energy, and accidents. Similarly, all impacts in areas other than public health are very similar between alternatives over the long term.

Public health – DOE evaluated the long-term impacts to public health, using the methods developed in the original radiological performance assessment prepared for the Z-Area Saltstone Manufacturing and Disposal Facility. This included determining concentrations in groundwater and radiological doses from those concentrations, radiological doses from crops grown on the vaults, doses from living in a home constructed on the vaults 100 years after closure, and doses from living in a home on the vault site 1,000 years after closure.

The differences in calculated concentrations and doses among the alternatives are a function primarily of the differences in composition of the saltstone by alternative. The Small Tank Precipitation alternative would produce a saltstone that is very similar to that originally planned. The Ion Exchange alternative would result in a saltstone with slightly more concentrated contaminants, thus causing greater impacts. The Solvent Extraction alternative would produce a saltstone with slightly lower contaminant concentrations, resulting in smaller impacts. The Direct Disposal in Grout alternative would produce saltstone with radioactive cesium concentrations many times higher than the other alternatives, but with only slightly higher concentrations of other contaminants.

As shown in Table S-7, the Direct Disposal in Grout alternative results in higher doses and greater health effects over the long term than the other alternatives. However, in all cases the projected number of latent cancer fatalities is very much less than one and DOE does not, therefore, expect any alternative to result in adverse health effects over the long term.

Table S-7. Summary comparison of long-term impacts by salt processing alternative.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Public Health				
Radiation dose from Agricultural Scenario (mrem/yr)	52-110	61-130	49-110	64-140
Latent Cancer Fatalities[a] from Agricultural Scenario	1.8×10^{-3} to 3.9×10^{-3}	2.1×10^{-3} to 4.6×10^{-3}	1.7×10^{-3} to 3.9×10^{-3}	2.2×10^{-3} to 4.9×10^{-3}
Radiation dose from Residential Scenario at 100 years post-closure (mrem/yr)	0.015-0.11	0.017-0.13	0.014-0.1	150-1200
Latent Cancer Fatalities[a] from Residential Scenario at 100 years post-closure	5.3×10^{-7} to 3.9×10^{-6}	6.0×10^{-7} to 4.6×10^{-6}	4.9×10^{-7} to 3.5×10^{-6}	5.3×10^{-3} to 4.2×10^{-2}
Radiation dose from Residential Scenario at 1,000 years post closure (mrem/yr)	9.2-69	11-80	8.6-65	11-85
Latent Cancer Fatalities[a] from Residential Scenario at 100 years post-closure	3.2×10^{-4} to 2.4×10^{-3}	3.9×10^{-4} to 2.8×10^{-3}	3.0×10^{-4} to 2.3×10^{-3}	3.9×10^{-4} to 3.0×10^{-3}

a. Lifetime (70 year) to an individual.

Table S-8. Primer of Technical Terms (other scientific terms are defined in the glossary).[a]

Actinide
Any member of the group of elements with atomic numbers from 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive.

Benzene
Benzene, the simplest aromatic hydrocarbon, is widely used in industry. The chemical formula for benzene is C_6H_6. Benzene is a toxic, flammable, and potentially explosive substance that must be safely controlled. It is generated by the catalytic and radiolytic decomposition of the reagent sodium tetraphenylborate, formerly used in the In-Tank Precipitation process and currently projected for use in the Small Tank Precipitation Tetraphenylborate salt processing alternative.

Catalyst
A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process.

Catalytic decomposition
A chemical reaction in which a compound is broken down into simpler compounds or elements in the presence of a catalyst.

Caustic
A substance capable of burning, corroding, dissolving, or eating away by chemical action.

Caustic Side Solvent Extraction
A process for separating radioactive cesium from alkaline (caustic) HLW solutions, by transfer to an immiscible organic phase, followed by recovery into a secondary aqueous stream.

Conceptual design
The conceptual design phase includes the fundamental decisions that are made regarding the desired chemistry or processing operations to be used, the sequencing of unit operations, the relationship of the process with other operations, and whether batch or continuous processing will be employed. Often, these decisions must be made preliminary to the collection of any engineering data regarding actual process yields, generation of reaction by-products, or the efficacy of any needed separation steps.

Crystalline
Being, relating to, or composed of crystal or crystals.

Crystalline silicotitanate
Insoluble granular inorganic solid ($Na_4SiO_4 \bullet TiO_2$) ion exchange material developed through a Cooperative Research and Development Agreement between DOE and private industry. Provides capability for removal of cesium from acid or alkaline salt solution containing high-potassium cancer concentrations.

Decomposition
The process by which a compound is broken down into simpler compounds or elements by chemical or physical reactions.

Final design
In the final design phase, the emphasis has shifted almost completely from the qualitative aspects of the process to the quantitative. Major process vessels are sized, and initial valve counts are often completed. By the end of this phase, a preliminary piping and instrumentation diagram will typically be complete, and broad considerations of facility site design will have been concluded. Opportunities for major process changes are few at this stage, but preliminary cost estimates (on the order of +/- 30%) and economic analyses can be produced.

Fission Product
Nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

Table S-8. (Continued).

Hazardous waste
A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency (EPA) in 40 CFR 261.31 through 40 CFR 261.33. Source, special nuclear, or by-product materials as defined by the Atomic Energy Act are not hazardous waste because they are not solid waste under RCRA.

High-level radioactive waste (HLW)
Defined by statute (the Nuclear Waste Policy Act) to mean the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products nuclides in sufficient concentrations; and other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule to require permanent isolation. The NRC has not defined "sufficient concentration" of fission products or identified "other highly radioactive material that requires permanent isolation." The NRC defines HLW to mean irradiated (spent) reactor fuel, as well as liquid waste resulting from the operation of the first cycle solvent extraction system, the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuel, and solids into which such liquid wastes have been converted.

HLW components
The HLW from the SRS chemical separations process consists of water soluble salts and insoluble sludges. The sludges settle to the bottom of the HLW tanks. The salt solutions are concentrated by evaporation to reduce their volume, forming a solid saltcake and a concentrated supernatant salt solution in the tanks.

Ion exchange/Ion exchange medium (resin)
The process by which salts present as charged ions in water are attached to active groups on and in an ion exchange resin and other ions are discharged into water, allowing separation of the two types of ions. Ion exchange resins can be formulated to remove specific chemicals and radionuclides from the salt solutions in the HLW tanks.

Low-level radioactive waste (LLW)
LLW is radioactive waste that does not meet the definition of high-level, transuranic waste, spent nuclear fuel, or by-product tailings from processing of uranium or thorium. LLW contains typically small amounts of radioactivity dispersed in large amounts of material. Some LLW requires shielding during handling and transportation to minimize personal exposure. The SRS generates LLW in both solid and liquid forms.

Mixed waste
Waste that contains both hazardous waste, as defined under RCRA, and source, special nuclear, or by-product material subject to the Atomic Energy Act.

Monosodium titanate
Water-insoluble inorganic substance ($NaTiO_5H$) used to remove residual actinides (uranium, plutonium) by adsorption and fission product strontium by ion exchange from waste salt solutions.

Precipitation (chemical)
Conversion of a dissolved substance into insoluble form by chemical or physical means.

Preconceptual design
The preconceptual design phase includes the early articulation of process objectives, selection of process steps, and determination of constraints.

Radiolytic decomposition
A physical process in which a compound is broken down into simpler compounds or elements from the absorption of sufficient radiation energy to break the molecular bonds.

Table S-8. (Continued).

Radionuclide/Isotope
A radionuclide is an unstable isotope that undergoes spontaneous transformation, emitting radiation. An isotope is any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number), but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable, carbon-14 is radioactive).

Reagent
A substance used in a chemical reaction to detect, measure, examine, or produce other substances.

Salt
Salt components of the HLW consist of water-soluble constituents that do not separate from the solutions in the HLW tanks. The salt components consist principally of sodium nitrate, with radionuclide contents being mainly isotopes of cesium and technetium.

Saltcake
Solid, crystalline phase of the salt component in HLW tanks that forms as a result of evaporation and concentration of the supernatant.

Salt supernatant
Highly concentrated solution of the salt component in HLW tanks.

Sludge
Sludge components of HLW consist of the insoluble solids that have settled at the bottom of the HLW storage tanks. Radionuclides present in the sludge include fission products and long-lived actinides.

Sodium tetraphenylborate
An organic reagent used to remove cesium, potassium, and ammonium ions from a salt solution by precipitation of an insoluble solid. The chemical formula for sodium tetraphenylborate is $Na(C_6H_5)_4B$. This reagent was used in the ITP process to separate radioactive cesium from HLW salt solution, forming insoluble cesium tetraphenylborate. It would be used for the same purpose in the Small Tank Precipitation salt processing alternative.

Solvent
A substance in which another substance is dissolved, forming a solution. It may also refer to the substance, usually a liquid, capable of dissolving another substance.

Solvent extraction
Solvent extraction is a method for separating mixtures by exploiting differences in the solubilities of the components. For example, a coffee machine extracts the soluble components of ground coffee with water, and leaves the insoluble components behind. The sample is shaken or mixed with solvent (or with two immiscible solvents) to effect the separation. The “like dissolves like” is a useful guide for selecting solvents to use in the extraction. Nonpolar substances are usually successfully extracted into nonpolar solvents like hexane or methylene chloride. Polar and ionic substances are often extracted with water.

Sorbent
A material that sorbs another substance; (i.e., that has the capacity or tendency to take it up by either absorption or adsorption).

Tetraphenylborate Precipitation
Process used to separate cesium, potassium, and ammonium constituents from HLW salt solution by formation of insoluble solids. The process is projected for use in the Small Tank Tetraphenylborate Precipitation salt processing alternative.

Vitrify or Vitrification
The process of converting the high-level liquid nuclear waste currently stored at the SRS into a solid glass form suitable for long-term storage and disposal. Scientists have long considered this glassification process, called "vitrification," as the preferred option for immobilizing high-level radioactive liquids into a more stable, manageable form until a Federal repository is ready.

a. See also *Glossary of Terms used in DOE NEPA Documents*.