

CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

The U.S. Department of Energy (DOE) proposes to select a salt processing technology and to design, construct, and operate the facilities required to process high-level waste (HLW) salt. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of low-level waste at the Savannah River Site (SRS).

2.2 Inventory and Schedule for Processing of High-Level Waste Salt

DOE stores HLW in 49 tanks in the F-Area (20 tanks) and H-Area (29 tanks) Tank Farms. These tanks contain a total of approximately 34 million gallons of liquid waste with a radioactivity content of approximately 480 million curies. The HLW consists of a sludge component (2.8 million gallons) containing approximately 320 million curies and a salt component (31.2 million gallons) containing approximately 160 million curies. The salt component includes a solid phase known as saltcake (15.2 million gallons) and the salt supernatant (16 million gallons). Waste volumes and curie content are subject to change because the supernatant is evaporated to reduce its volume, and sludge is being removed for processing and vitrification.

DOE has developed a program for disposal of the wastes currently stored in the waste tanks. In this program, HLW sludge is being converted to a glass waste form by vitrification in the Defense Waste Processing Facility (DWPF). DWPF has already processed approximately 30 million curies of the original 320 million curies of the sludge component. The glass waste, in stainless steel canisters, is being stored onsite, pending shipment to a geologic repository for

disposal. Processing the salt components of the wastes (saltcake and salt supernatant) for vitrification and disposal requires (1) dissolution of the saltcake and combining with the supernatant to form a salt solution and (2) separation of the low-volume high-radioactivity fraction of the salt solution for incorporation, along with the sludge, into the glass waste form, leaving a high-volume low-radioactivity waste stream suitable for onsite disposal (see Figure 2-1).

Planning bases for the HLW disposal operations are presented in the periodically updated *High-Level Waste System Plan* (WSRC 2000). The latest version of the System Plan, Rev. 11, (WSRC 2000) projects as a programmatic target case an average annual output of 200 HLW canisters for Fiscal Years (FY) 2001-2010 and 225 canisters annually for FY 2011 to program completion (FY 2023). This schedule for vitrifying HLW is critical to fulfilling planned HLW operations. Maintaining the waste removal schedule as described in the System Plan is necessary to meet mandates for removing the tanks from service.

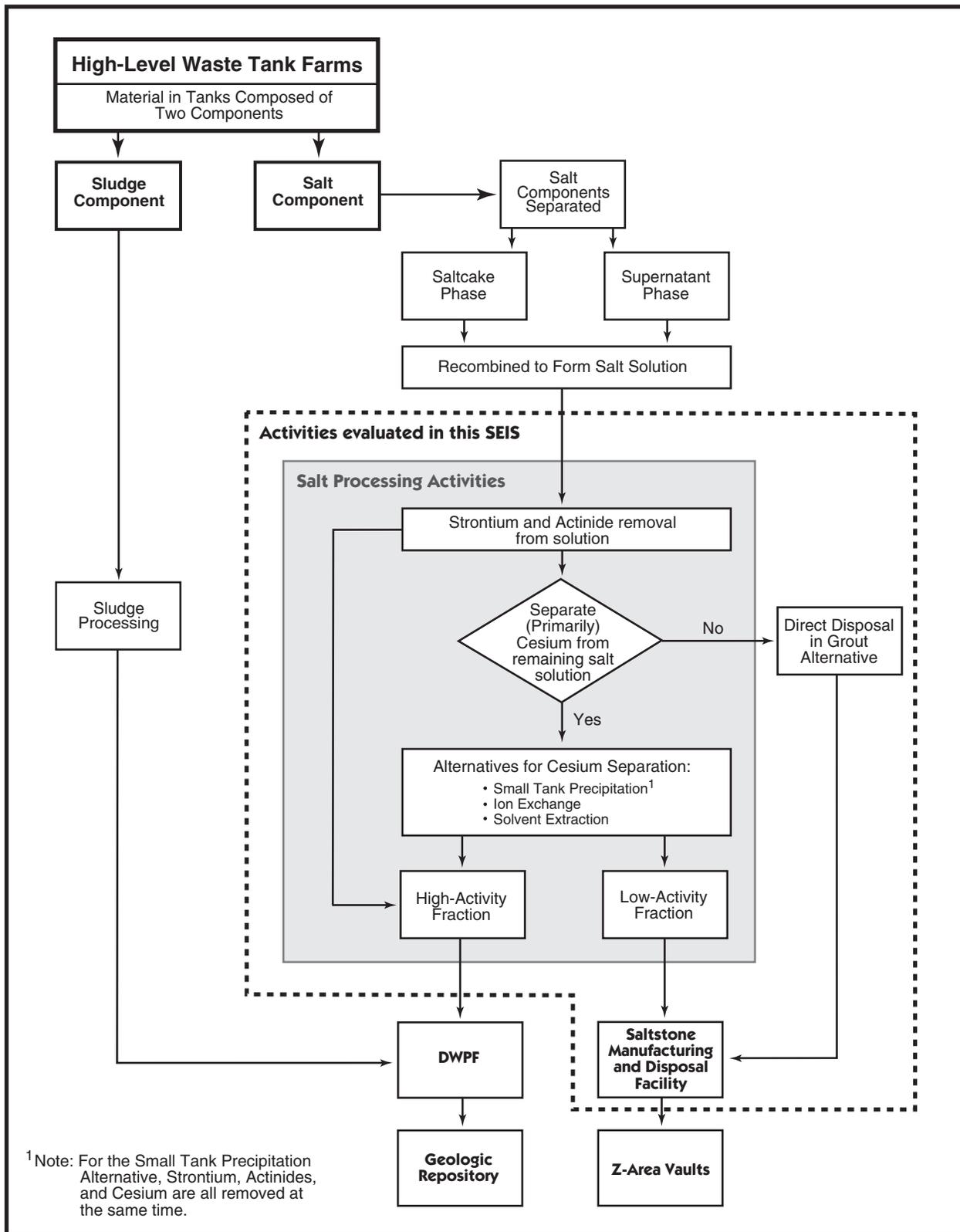
Milestones for Salt Processing Alternatives

These milestones serve as the target basis for preconceptual design of the alternatives, and are subject to change.

Salt processing facility operations initiated	FY 2010
Waste removed from non-compliant tanks (1-24) ^a	FY 2016
Salt and sludge processing operations completed	FY 2023

Source: (WSRC 2000).

- a. Non-compliant tanks have inadequate secondary containment and leak detection capabilities as defined by the Federal Facilities Agreement (FFA). Closure of these tanks is mandated by the year 2022.



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Figure 2-1. Process Flow for High-Level Waste at the Savannah River Site.

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 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 contained 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.

2.3 No Action Alternative

Under the No Action alternative, DOE would continue current HLW management activities, including tank space management and tank closure, 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 (WSRC 1999a) and meet tank closure commitments 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 (WSRC 2000):

- 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)

- 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.

The following sections qualitatively describe the actions that DOE could take, either individually or in combination, under the No Action alternative. Attempts at quantification are very preliminary and offered only for purposes of comparison among these potential options. Should DOE need to implement the No Action alternative, the specific actions, costs, and quantities (e.g., number of tanks required) would then be determined.

2.3.1 IDENTIFY ADDITIONAL WAYS TO OPTIMIZE TANK FARM OPERATIONS

On February 26, 1999, the HLW Salt Processing Program Manager chartered the HLW Tank

Space Management Team (SM Team). The SM Team identified approximately 300 potential ways to maximize available tank space. This detailed study by experienced engineers and scientists led to an “Intermediate List” of 24 ideas, each of which was capable of increasing available tank space by more than 900,000 gallons. These ideas were grouped into strategies, and the SM Team recommended a strategy to ensure sufficient storage capacity through 2009 (WSRC 1999a). Optimizing tank farm operations would be a reasonable first step, should the No Action alternative be implemented. Additional ideas include: bypassing the tank farms by pretreating DWPF wastewater to meet the waste acceptance criteria for the Effluent Treatment Facility or Z-Area Saltstone Manufacturing and Disposal Facility; changing the operation of DWPF to reduce the wastewater stream by reducing DWPF production; installing evaporators at the DWPF or reducing sludge washing; and using tanks outside the Tank Farms, such as in the reactor areas and offsite.

To optimize tank farm operations, DOE would need to divert limited funds that otherwise could support the development of a salt processing alternative. Managing any leaks from the aging tanks and cleaning up resulting contamination would require additional funds. Although SRS would find it more difficult to meet its regulatory commitments, DWPF operation could continue for some time beyond 2010.

2.3.2 REUSE TANKS SCHEDULED TO BE CLOSED BY 2019

This potential action would continue to use Tanks 4 through 8, which were built in 1953 and are to be closed by 2019. Utilization of these tanks would only provide an interim solution for management of newly generated HLW (and wastewater from DWPF) and, because of the age of the tanks, would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks. Although using these tanks would provide 3.75 million gallons of HLW storage (more than 4 years of inflow), it requires the use of the older tanks and delays closure of these tanks.

Implementing this option would compromise major mission goals of safety and regulatory commitment.

2.3.3 BUILD TANKS PERMITTED UNDER WASTEWATER TREATMENT REGULATIONS

About 340,000 of the 800,000-gallons-per-year tank space requirement is due to sludge-only processing in DWPF. DWPF wastewater could be safely stored in new tanks with designs similar to those of the older (Type I) HLW tanks. These tanks have 5-foot-high secondary annulus “pans” and active cooling, but do not have the full-height secondary containment tank design used in the newest tanks (Type III). Such tanks would not be used for storage of newly generated HLW. The net capacity of each wastewater storage tank would be about 800,000 gallons. Therefore, based on scheduled completion of sludge-only processing in 2023, it would take about six tanks to hold the DWPF wastewater. The tanks would be built in a brownfield (previously disturbed) area near existing waste transfer lines. Nearly all of the resources evaluated in Section 4.1 of this SEIS would be impacted by this option. Implementing this option also would delay the regulatory commitments for tank closure and stabilization of HLW. It would require large financial commitments to provide interim storage capacity and would increase Site restoration requirements. Further, this option would not be appropriate for more than half (460,000) of the 800,000-gallons-per-year requirement.

2.3.4 BUILD TANKS PERMITTED UNDER RCRA REGULATIONS

Resource Conservation and Recovery Act (RCRA)-permitted tanks require double liners, leachate collection systems, and other characteristics designed to ensure tank integrity. The Type III tanks in the F- and H-Area Tank Farms are RCRA-compliant. They were constructed from 1969 through 1978. They have a full-height secondary tank, active cooling systems, and are above the water table. Each of these tanks has a net usable storage capacity of about 800,000 gallons. To accommodate newly gen-

erated HLW and the waste that would be generated at DWPF, 18 new tanks would be required. They could be located in a brownfield area in or near the F- and H-Area Tank Farms (associated land use impacts are presented in Chapter 4, Section 4.1).

DOE has estimated that it would take approximately five years to design, permit, and construct the first four tanks. Thus, to avoid suspending critical operations, the effort would have to be initiated in 2005.

As with the wastewater-permitted tanks, nearly all of the resources evaluated in Section 4.1 would be impacted by implementation of this option. This option would compromise regulatory commitments for stabilization of HLW. The cost to construct and operate these tanks would be extremely high and this option would not provide a permanent solution for management of newly generated HLW and wastewater from DWPF.

2.3.5 SUSPEND OPERATIONS AT DWPF

In the event that a salt processing technology is not available by the year 2010, DOE could suspend operations at DWPF. This would not jeopardize the environment or human health. However, if the suspension of operations at this facility is not temporary, it could result in a workforce reduction, which could have a substantial negative impact on the communities surrounding SRS. This option would also seriously delay DOE's mission of processing HLW in the DWPF to produce approximately 200 canisters of vitrified HLW per year for eventual disposal in a geologic repository. In addition, DOE would eventually have to commit a large sum of money to restart these facilities to resume operations necessary to stabilize HLW. Finally, suspending operations could result in loss of technical expertise (core competency) and, depending on the length of time the facilities are shutdown, the ability to recapture these core competencies would diminish.

2.4 Selection of Salt Processing Technologies for Evaluation as Alternatives

A comprehensive program conducted by Westinghouse Savannah River Company (WSRC) to identify, evaluate, and recommend alternative technologies for conversion of HLW salt to acceptable final waste forms selected the following four options for additional development.

- Small Tank Tetraphenylborate Precipitation (Small Tank Precipitation)
- Crystalline Silicotitanate (non-elutable) Ion Exchange (Ion Exchange)
- Caustic Side Solvent Extraction (Solvent Extraction)
- Direct Disposal (of cesium) in Grout (Direct Disposal in Grout).

Following review by a WSRC Review Panel Team, WSRC recommended to DOE the Small Tank Precipitation process as the most reasonable replacement salt processing technology and the Ion Exchange technology as a backup (WSRC 1998a).

A DOE Savannah River (SR) Review Team evaluated the WSRC recommendation and concluded that the remaining technical uncertainties for both alternatives were too significant to justify selection of a preferred technology. The DOE-SR Review Team recommended that additional research and development be conducted to address the key technical uncertainties associated with the two technologies, so that one could be identified as the most reasonable. A DOE-Headquarters Independent Review Team concluded that both the Small Tank Precipitation and the Ion Exchange technologies were feasible, and recommended that further research and technology development be pursued. Advances in the technology for Solvent Extraction were

also noted by DOE and, coupled with recommendations from the National Academy of Sciences (NAS 1999), led to DOE's reconsideration of the potential for developing and implementing this technology in time to support waste processing needs.

DOE also considered the Direct Disposal in Grout technology, based on demonstrated technology, safety, operational feasibility, and potential to reduce construction and operating costs. DOE recognized, however, that this alternative, which retained a highly radioactive constituent (cesium) in the saltstone waste form for onsite disposal, could not be implemented within regulatory constraints if other alternatives that separated the radioactive cesium for incorporation into the glass waste form proved to be technically and economically practical.

2.5 Salt Processing Facility Site Identification

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 (WSRC 1999b). The study sought to optimize siting for engineering requirements, sensitive environmental resources, and applicable regulatory requirements. The goal of the study was to evaluate alternative siting options for site building and support facilities for either 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 2-2). In order to transfer the solids slurry at the proper solids concentration from the 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 2-2). A comparative analysis of the sites provided a total score, based on geological, ecological, human health, and engineering considerations. No distinct differences were identified among the four sites for geological, ecological, or human health considerations. Therefore, because Site B was superior to Sites C and D on the basis of engineering and total score, it was selected as the preferred site.

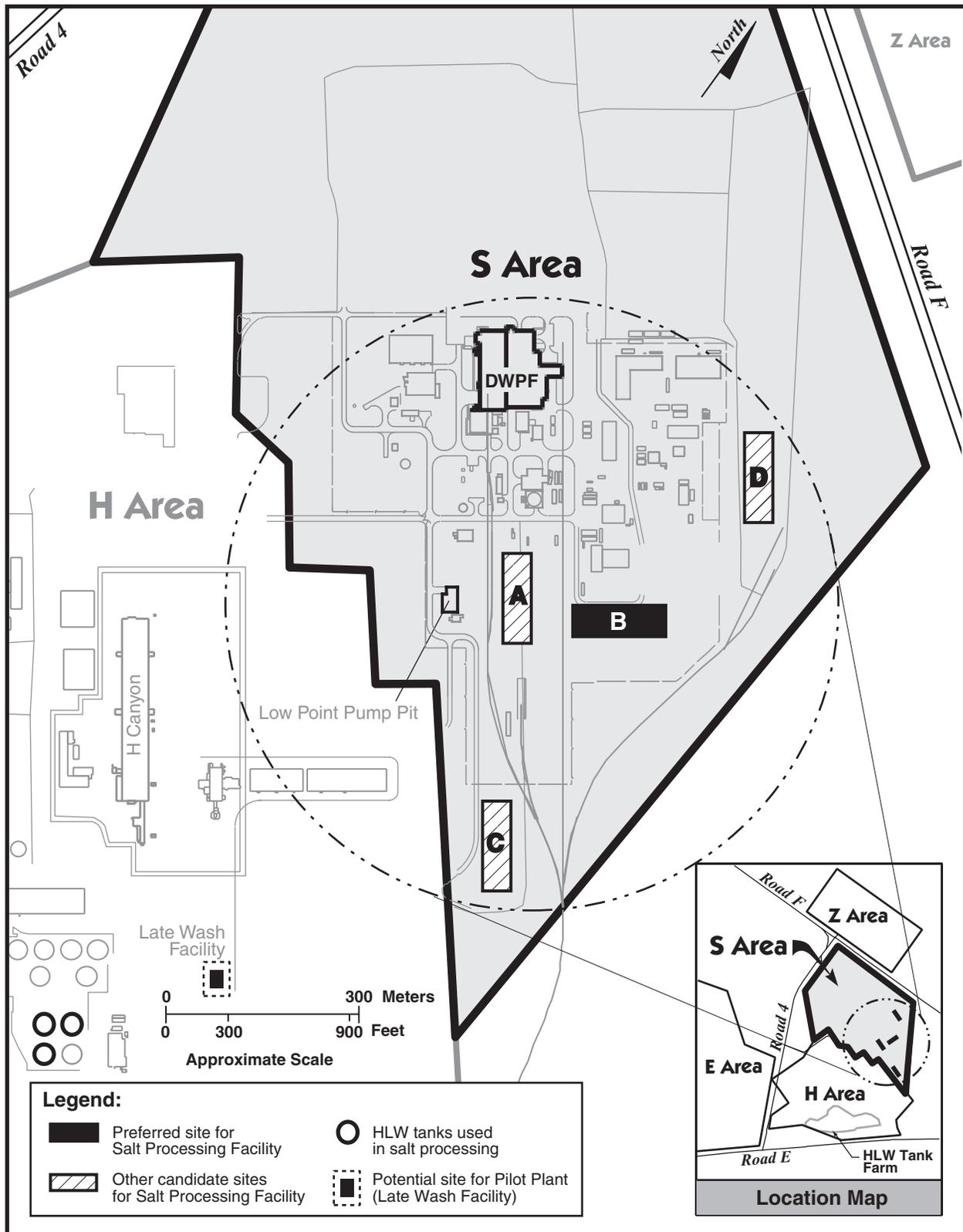
For purposes of analysis and comparison, DOE assumes in this SEIS that all facilities for the Small Tank Precipitation, the Ion Exchange, and the Solvent Extraction technologies would be located at Site B.

The Direct Disposal in Grout technology was not considered in the siting study because the grout manufacturing facility would be located in Z Area, near the saltstone vaults and existing infrastructure that could support the grout production operation (Figure 2-3).

2.6 Salt Processing Alternatives

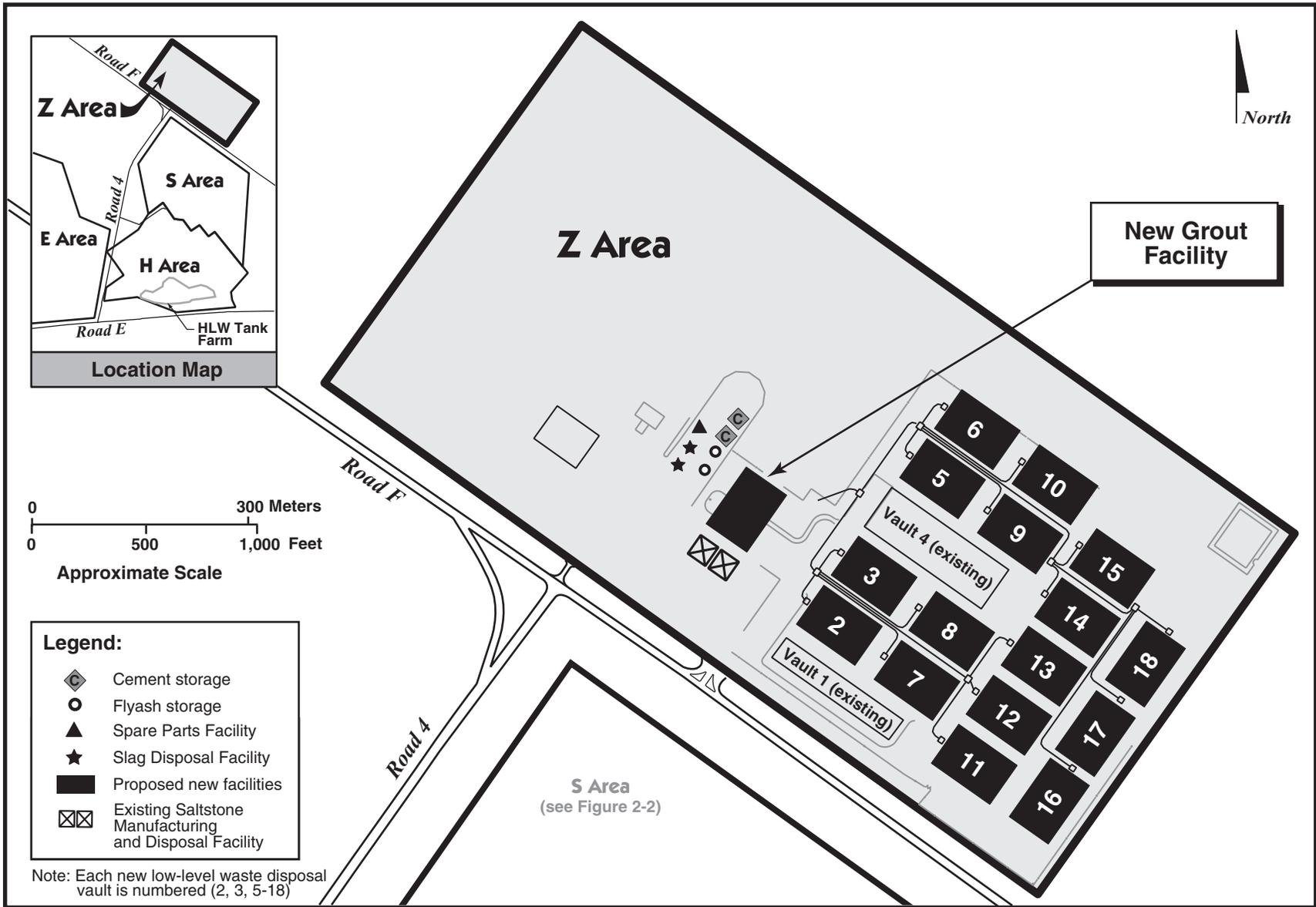
This SEIS describes and assesses the potential environmental impacts of the construction and operation of four alternatives for HLW salt processing to replace the ITP process. Each of the alternatives could accomplish the purpose and need for action described in Section 1.2, in contrast to the No Action alternative (Section 2.3), which does not include a method for salt processing.

The alternatives, as described below and detailed in Appendix A, are based on preconceptual designs (WSRC 1998b). As conceptual designs are developed, the components of the process could be modified to optimize the efficiency, safety, environmental protection, and economics of the process. For example, DOE may need to increase the capacity of process or storage vessels to ensure continuous operation of the salt processing facility, which would receive batch input from the Tank Farms and transfer its clarified waste stream and HLW products, respectively, to batch operations in the Saltstone Manufacturing and Disposal Facility and



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Figure 2-2. Potential salt processing facility sites in S Area.



NW SDA EIS/Grfx/ch_2/2-3 Grout Z.ai

Figure 2-3. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

DWPF. DOE will consider whether any modification that develops during conceptual or final design requires further environmental review under the National Environmental Policy Act (NEPA).

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. The results of the research were reviewed by impartial scientists (DOE 1998). DOE has also evaluated the life-cycle cost and schedule for construction and operation for each alternative (WSRC 1998c). This Draft SEIS assesses the potential environmental impacts of each alternative, which are evaluated in Chapter 4 and compared in Section 2.9.

DOE has not yet selected a preferred alternative for processing HLW salt. This selection will be based on continuing research, evaluation, and independent review of the technology alternatives, with the preferred alternative to be identified in the final SEIS.

DOE would conduct pilot scale testing of the alternative (selected in a Record of Decision [ROD]) before implementing the selected alternative. The Pilot Plant facility proposed for use in the testing is described in Section 2.7.6 and in

Appendix A. Environmental impacts of the Pilot Plant are discussed in Chapter 4.

The following sections briefly describe each salt processing alternative, its products and waste streams, and the facilities in which the process would operate. A comparison of the process stages for the salt processing alternatives is presented in Table 2-1.

Common features of all processes include initial separation of low-concentration soluble radioactive strontium and actinides (including plutonium) by **sorption** (bolded terms are found in Table 2-2 and Table 1-1) on granular solid monosodium titanate (MST), followed by filtration. Essential differences in the alternatives are represented by 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. Greater detail is provided in Appendix A, Technology Descriptions.

Table 2-1. Comparison of salt processing alternatives.

Salt processing alternatives	Process phases			
	Strontium and actinide (Pu) removal from salt solution	Cesium removal from salt solution	Final waste form	
			DWPF glass (HLW)	Saltstone (LLW)
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

LLW = Low-level waste, MST = Monosodium Titanate, TPB = Tetraphenylborate, CST = Crystalline Silicotitanate.

Table 2-2. Primer of technical terms (other scientific terms are defined in the glossary).

Back extraction

Process for transfer of constituent from organic phase to secondary aqueous phase; used to recover radioactive cesium from organic phase in solvent extraction process.

Cement

A building material made by grinding calcined limestone and clay (silica, lime, and other mineral oxides), to a fine powder, which can be mixed with water and poured to set as a solid mass or used as an ingredient in making mortar or concrete; used as an ingredient in saltstone.

Centrifugal contactor

A device used in Solvent Extraction salt processing alternative to separate cesium from HLW salt solution. Aqueous waste enters the contactor and is mixed with an organic solvent, which extracts the cesium. The two liquids are then separated by centrifugal force in a rapidly rotating inner chamber of the device.

Extractant

A component of the solvent used in the Solvent Extraction process to facilitate the removal of a constituent from aqueous solution, as in the separation of radioactive cesium from HLW salt solution.

Flyash

Fine particulate ash produced by the combustion of a solid fuel, such as coal, and discharged as an airborne emission or recovered as a byproduct for various commercial uses; used as an ingredient in saltstone to limit water infiltration by decreasing porosity.

Hydrolysis

Decomposition of a chemical compound by reaction with water, as in the treatment of a tetraphenylborate precipitate to eliminate benzene.

Nitrate

Any member of a class of compounds derived from nitric acid. Nitrate salts are ionic compounds containing the negative nitrate ion, NO_3 , and a positive ion, such as sodium (Na) in sodium nitrate (NaNO_3). Sodium nitrate is a major constituent of the salt component in the HLW tanks.

Nitrite

Any member of a class of compounds derived from nitrous acid. Salts of nitrous acid are ionic compounds containing the negative nitrite ion, NO_2 , and a positive ion such as sodium (Na) in sodium nitrite (NaNO_2).

Slag

The vitreous material left as a residue by the smelting of metallic ore; used as an ingredient in saltstone.

Solvent Extraction

Process for separation of constituent from aqueous solution by transfer to an immiscible organic phase; used to separate radioactive cesium from HLW salt solution.

Sorption

Assimilation of one substance by a material of a different phase. Adsorption (sorption on a surface) and absorption (sorption into bulk material) are two types of sorption phenomena.

Strip effluent

Aqueous cesium solution resulting from the back extraction of cesium from the organic phase in the Solvent Extraction salt processing alternative.

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 low-level waste (LLW) under the waste incidental to reprocessing criteria of DOE Manual 435.1-1. The Manual identifies procedures for implementing DOE Order 435.1, Radioactive Waste Management, which provides two processes for determining if a waste stream is waste incidental to reprocessing. The waste incidental to reprocessing determination process is described in detail in Chapter 7.

2.6.1 SMALL TANK PRECIPITATION

The Small Tank Precipitation alternative would use **tetraphenylborate precipitation**, the same chemical reaction as ITP, to remove the radioactive cesium from the HLW salt solution. 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. In contrast, the ITP process used a very large batch waste tank as a reaction vessel with limited temperature control and incomplete nitrogen gas inerting.

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 **precipitate 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 solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal as LLW grout in onsite vaults.

Small Tank Precipitation Features

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.

<u>Small Tank Precipitation</u>	<u>ITP</u>
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

Process flows for the Small Tank Precipitation alternative are shown in Figure 2-4.

2.6.2 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 be passed 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

Process flows for the Ion Exchange alternative are shown in Figure 2-5.

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.

2.6.3 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.

Process flows for the Solvent Extraction alternative are shown in Figure 2-6.

2.6.4 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 of 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 a low-level waste. 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 low-level waste 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.

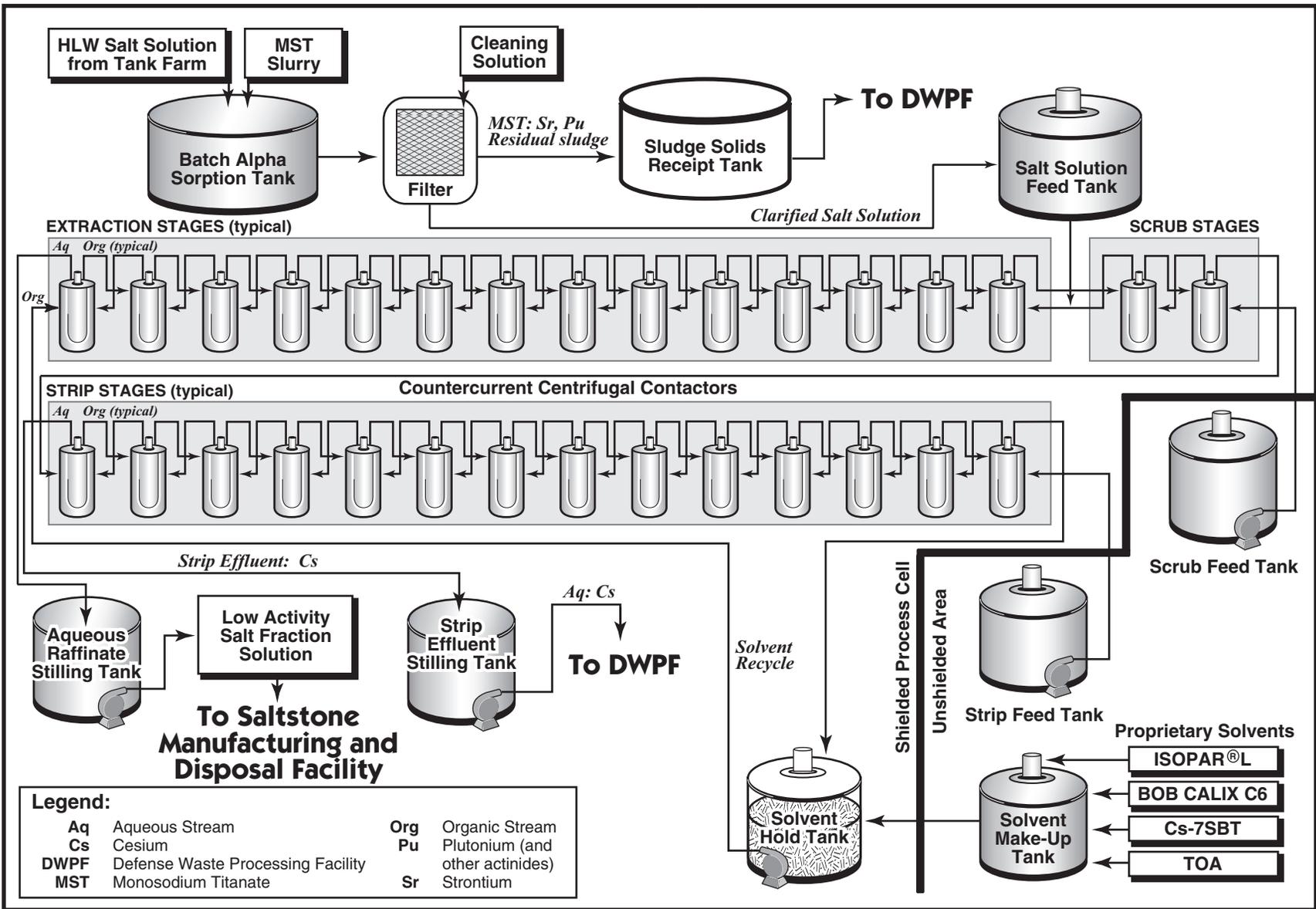
Process flows for the Direct Disposal in Grout alternative are shown in Figure 2-7.

2.7 Salt Processing Facilities

2.7.1 PROCESS INPUTS AND PROCESSING REQUIREMENTS

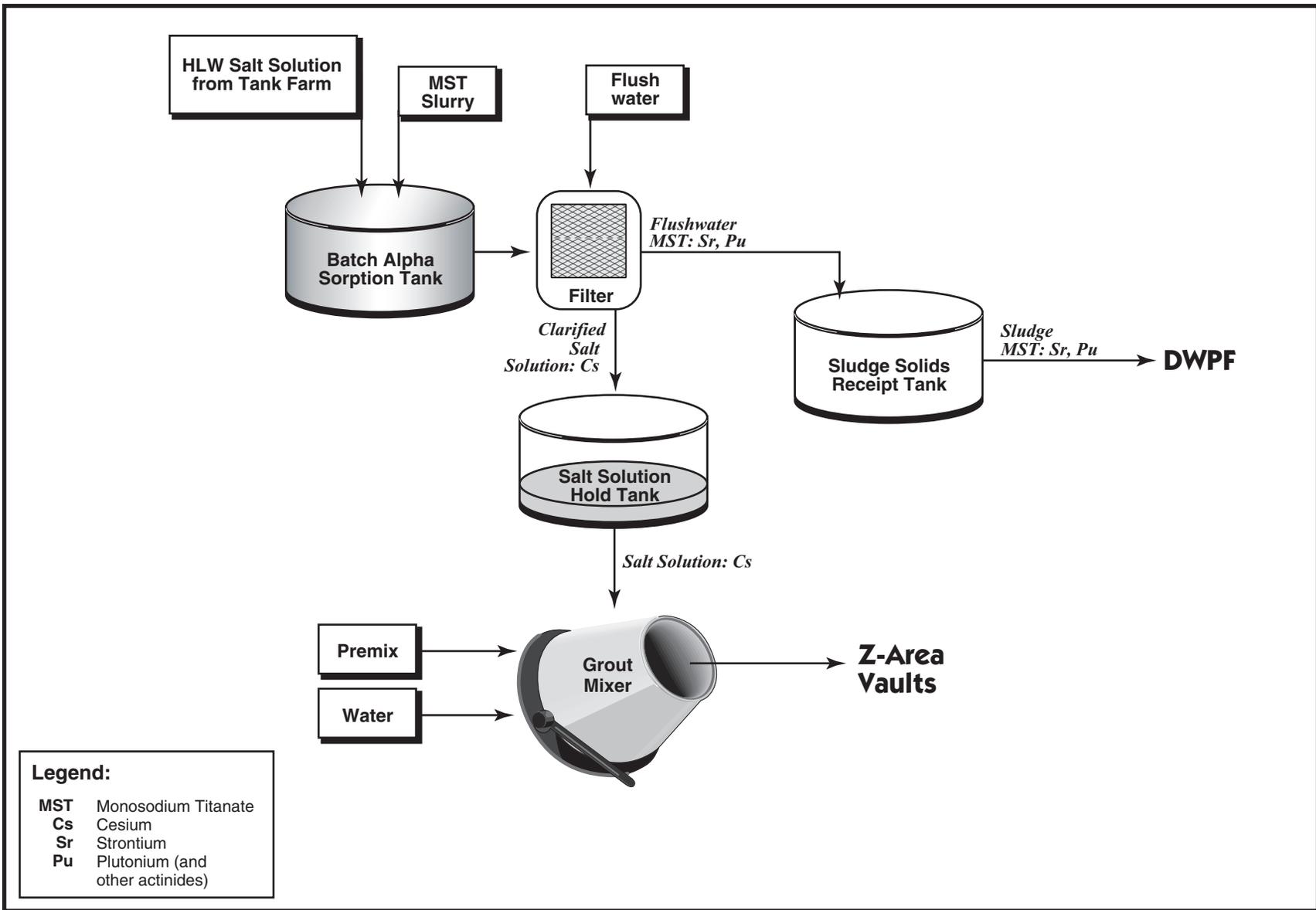
Design of salt processing facilities depends on specifications of processing requirements, including process input and product output. Volumes of input streams and requirements for their processing to final forms are summarized in Table 2-3. The specified capacities of the process facilities would maintain an average processing of about 6 million gallons of waste salt solution per year, allowing 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 (WSRC 1999c). 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 beyond 2010 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



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Figure 2-6. Solvent Extraction process flow diagram.



NW SDA EIS/Grfx/Ch 2/2-7 Dir Disp flow.ai

Figure 2-7. Direct Disposal in Grout process flow diagram.

Table 2-3. 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) ^a	6.9	6.9	6.9	6.0
Long-term average throughput of salt solution (million gallons per year) ^a	6.0	6.0	6.0	6.0
Throughput limitation ^a	Salt removal rate from waste tanks			
Number of years for construction of process facilities ^b	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 ^c	13 ^d	13 ^e	13 ^f
Planned canister production per year ^{g,h}	225 (average)	225 (average)	225 (average)	225 (average)
Canisters produced ^{g,h}	≈5,700	≈5,700	≈5,700	≈5,700
New Class A vaults ⁱ	16 ^c	13 ^d	15 ^j	0 ^f
New Class C vaults ⁱ	0 ^c	0 ^d	0	13 ^f

a. WSRC (1998b).

b. WSRC (1998c).

c. WSRC (1998d, 2000).

d. WSRC (1998e).

e. WSRC (1998f).

f. WSRC (1998g).

g. WSRC (2000) target case.

h. DWPF planned glass waste canister production includes both sludge and salt wastes.

i. New saltstone vaults for onsite disposal of processed salt solution.

j. This alternative would require between 14 and 15 vaults (WSRC 1998f) for purposes of impact analysis, 15 vaults were assumed.

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.

2.7.2 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 2-4. 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 glass waste canisters produced. Differences between alternatives in salt solutions to grout and the product grout produced are not considered significant because there is a 25 percent uncertainty in the materials balance estimate.

In addition to the principal product outputs specified in Table 2-4, the Small Tank Precipitation process would generate by-product ben-

Table 2-4. Product outputs for the salt processing alternatives.

	Alternative			
	Small Tank Precipitation ^a	Ion Exchange ^b	Solvent Extraction ^c	Direct Disposal in Grout ^d
Solids Slurry (and solution) to DWPF				
Annual (million gallons)	0.22	0.20	0.68 ^c	0.15
Life cycle (million gallons)	2.9	2.6 ^f	8.8 ^c	2.0
Salt solution to grout				
Annual (million gallons)	8	6.6	7.5	5.9
Life cycle (million gallons)	100	86	97	77
Grout produced				
Annual (million gallons)	15	12	14	11
Life cycle (million gallons)	190	160	180	140

a. WSRC (1998d, 2000).

b. WSRC (1998e).

c. WSRC (1998f).

d. WSRC (1998g).

e. Includes 0.154 million gallons/yr solids slurry and 0.523 million gallons/yr strip effluent solution, assuming no evaporation (WSRC 1998b); analogous life-cycle outputs shown.

f. Includes 2 million gallons monosodium titanate slurry and 0.6 million gallons crystalline silicotitanate slurry (WSRC 1998b, 1998e).

Note: Material balance estimates are ± 25 percent.

zene. 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 would be a projected 1,000 gallons. This inventory is conservatively assumed to be replaced once per year. For a tentatively assigned operational time of 13 years, the accumulated total volume of solvent requiring processing would be 13,000 gallons.

2.7.3 PROCESS FACILITIES

DOE would construct a new shielded facility to house chemical processing equipment (tanks, pumps, filter systems) to implement any alternative. Preconceptual designs are included in this section. The facilities 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 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 processing alternative selected. The preferred site for the process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives is at 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, requiring a somewhat smaller building with Direct Disposal in Grout. Preliminary design dimen-

sions are provided in Table 2-5. A more detailed description of the process facilities for each alternative, including preliminary floor plans, is provided in Appendix A.

2.7.4 SUPPORT FACILITIES

Each alternative would require support facilities including a service and office building and an electrical substation. Support facilities are described in Appendix A.

2.7.5 Z-AREA VAULTS

As shown in Table 2-3, 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 2-2). 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 proc-

ess. As with the original saltstone vaults, the new vaults would be constructed at or somewhat below grade and covered over with soil after vault closure for additional shielding. Figure 2-8 illustrates how Z Area would look after vault closure.

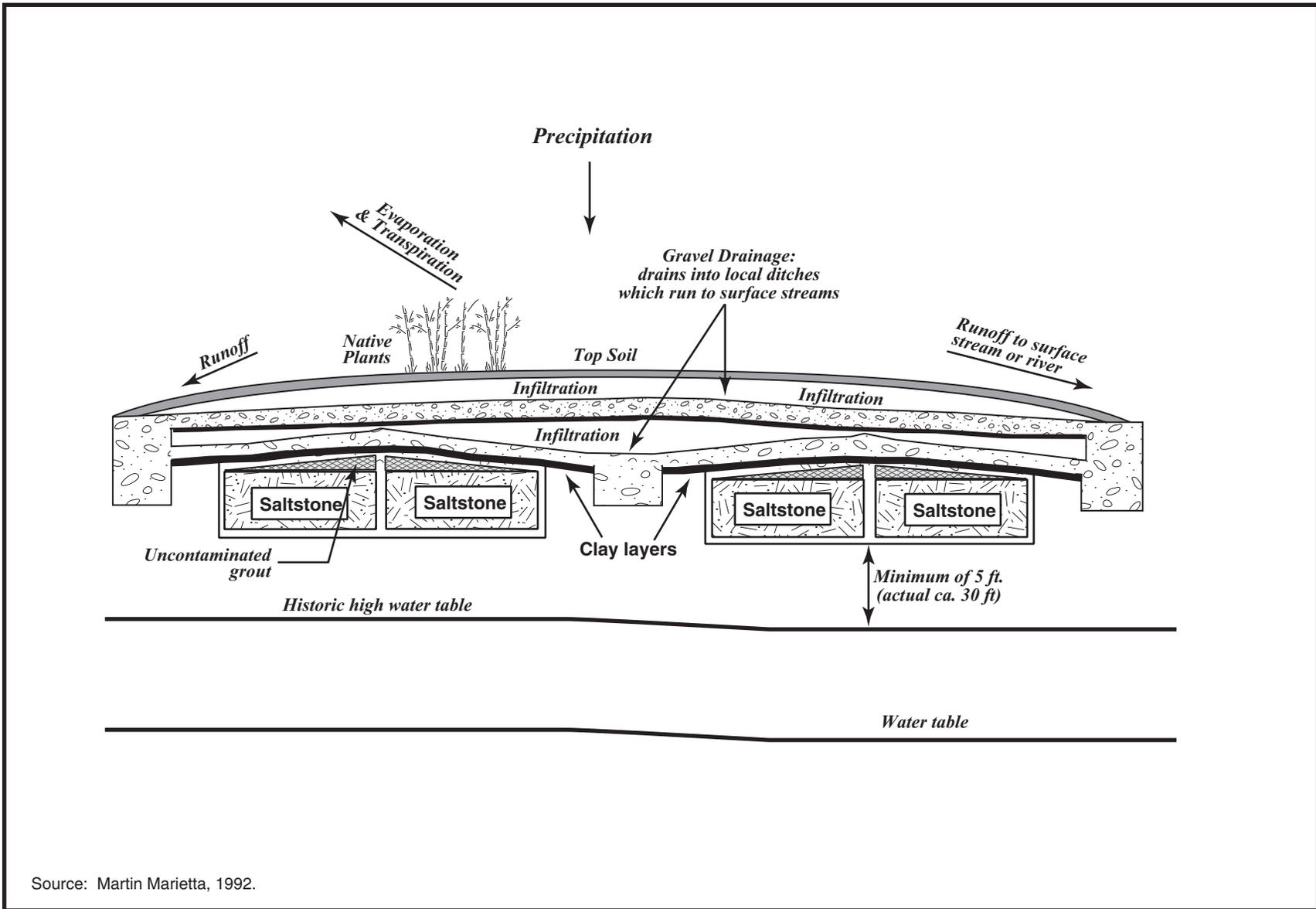
For the Direct Disposal in Grout alternative, 13 new vaults would be constructed in Z Area. Because the grout would contain large amounts of radioactive cesium, the disposal procedure for this alternative would differ from that of the other three alternatives. Each vault would have a 500-cubic-foot-per-minute 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.

Table 2-5. 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

Source: WSRC (1998c).

a. Building specifications rounded to two significant figures.



Source: Martin Marietta, 1992.

NW SDA EIS/Gr/x/ch_2/2-8 Vault.ai

Figure 2-8. Cross-section diagram of vault closure concept.

2.7.6 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 construction and operation of the full-scale facility. The Pilot Plant would serve primarily to demonstrate overall process objectives. Laboratory-scale testing to address 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. Initial pilot-scale demonstrations would provide data required to perform preliminary and final design of the full-scale facility. Extended operation cycles, by varying operating parameters and feed blends, would provide the needed assurance and understanding of how the process works to complete full-scale design and start construction. Data on unit operations and their integration into a coordinated process would be collected, process extremes and upset conditions would be investigated, equipment operation would be evaluated, and process streams would be qualified for full-scale operations. The Pilot Plant would also provide a facility for training engineers and operators.

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 2-1), 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 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 the low-level waste vaults.

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

2.7.7 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.

2.8 Other Decision-Making Factors

2.8.1 NATIONAL ACADEMY OF SCIENCES REVIEW COMMITTEE FINAL REPORT

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 fields of nuclear reactor and fuel cycle technology, nuclear chemistry and separations, environmental sciences, and nuclear waste disposal. The Under Secretary requested that the Council provide a preliminary report by the end of September 1999 to identify any significant issues or problems with the alternatives that could be factored into the Draft SEIS. The Council issued an interim report in October 1999. Since issuance of the Draft SEIS was delayed for over a year, the Council actually issued a final report in October 2000, prior to the issuance of this

SEIS. The final Council Report (NRC 2000) 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.

The following describes the tasks requested by DOE, the conclusions reached by the Council in the final report, and the subsequent actions taken by DOE:

Task 1: Assess identification of a comprehensive set of processes for separation of cesium from HLW salt solution.

- *Council Conclusions:* A comprehensive set of cesium separation processes was identified and no additional effort on process identification was recommended.
- *DOE Actions:* The Council had no recommendations; therefore, DOE took no subsequent action.

Task 2: Evaluate the technical soundness of the screening procedure and resultant selection of appropriate alternatives.

- *Council Conclusions:* Although deemed complex and based mainly on expert judgment employing qualitative factors, the screening procedure did result in four potentially appropriate processing alternatives.
- *DOE Actions:* Since the Council determined that the screening procedure resulted in four potentially appropriate processing alternatives, DOE took no subsequent action.

Task 3: Identify significant barriers to implementation of any alternative, taking into account state of development and potential for integration into the existing SRS HLW system.

- *Council Conclusions:* A carefully planned and managed research and development (R&D) program would be required for the three cesium separation alternatives (Small Tank Precipitation, Ion Exchange, and Solvent Extraction, each including monosodium titanate treatment for strontium and actinide removal), until enough information is available to make a defensible down-select decision. Good-faith discussions with regulators should be conducted to determine if the fourth alternative, Direct Disposal of cesium in Grout, would be feasible, should all other processing options prove technically or economically impractical. A more fully integrated approach involving tailoring of HLW salt processing in accord with the composition of wastes in individual tanks could prove beneficial. And lastly, the DOE should charter external expert review and oversight groups to provide needed R&D direction and support for management decisions.
- *DOE Actions:* A program plan for technology research and development (TFA 2000) was issued in May 2000 to address the technical uncertainties associated with each of the salt processing alternatives and provide adequate information for making a down-select decision. DOE evaluated the R&D activities identified in the program plan and determined that each R&D recommendation from the Council was adequately addressed in the program plan. DOE has evaluated these R&D activities and identified those activities that need to be completed to support a technology down-selection decision. The activities have been prioritized and are currently on schedule to be completed in April 2001.

Preliminary discussions with the regulators (Nuclear Regulatory Commission, SCDHEC, and EPA, Region IV) indicate general acceptance of the Direct Disposal in Grout concept, provided DOE could establish that the final waste form is not HLW. Current DOE policy includes a requirement that “key radionuclides” must be removed from HLW to the maximum extent techni-

cally and economically practical, before permitting disposal as “waste incidental to reprocessing” in a low-level waste shallow-land disposal facility. DOE considers cesium to be a “key radionuclide” in HLW. It appears that there are at least three alternatives that can technically and/or economically remove cesium from HLW. Therefore, DOE has decided not to pursue further regulator involvement in pursuit of the Direct Disposal in Grout alternative until it is determined that cesium removal by the other alternatives is not technically or economically practical.

DOE agrees with the concept of applying an integrated systems engineering approach to salt processing. The HLW System at SRS is fully integrated and managed in consideration of the broad range of operational and regulatory constraints and requirements to achieve acceptable end states and meet the acceptance criteria for the Defense Waste Processing and Saltstone facilities. This approach is reflected in the *High-Level Waste System Plan* (WSRC 2000) and used in all HLW system planning and production activities, including the evaluation of salt processing options. In order to conserve tank space and optimize processing for disposal in saltstone, studies have been performed to possibly take advantage of the HLW salt solution variability by tailoring waste processing. While there is variability in salt waste, a review of waste characterization data for all receipt and storage tanks indicates that saltstone grout produced from the lowest-activity tank would challenge the basis for the current saltstone operating permit. Additionally, strategies based on multiple process facilities tailored to individual tanks or groups of tanks are not considered to be viable from a cost perspective or environmentally sound when decontamination and decommissioning impacts are considered. Further evaluations of waste processing options will continue through the HLW system planning process in parallel with technology development and down-selection activities.

DOE established in March 2000 a Technical Working Group (TWG) to manage technology development of treatment alternatives. The TWG is composed of staff from DOE's Office of Project Completion, Office of Science and Technology, Office of Technical Program Integration, and the Savannah River Operations Office. The TWG is responsible for managing and overseeing the development of a Research & Development Program Plan, creating technology road maps, establishing separations technology down-selection criteria, project integration, ensuring execution, and technical oversight of technology development efforts. The TWG is supported by DOE's Tanks Focus Area for execution of R&D activities, and a Technical Advisory Team for independent review of technology implementation.

Task 4: Assess the adequacy of planned R&D activities to support implementation of a single preferred alternative.

- *Council Conclusions:* Several recommendations are made for additional R&D to address remaining scientific and technical uncertainties for each of the four salt processing options. These recommendations generally include:
 - Resolution of technical questions concerning reaction kinetics of the monosodium titanate process for removal of strontium and actinides, as advanced for all alternatives
 - Improved understanding of the tetraphenylborate decomposition process, especially catalytic reactions responsible for benzene generation
 - Evaluation of cesium desorption and resin deactivation in alkaline solutions as encountered in the Ion Exchange process
 - Continued development of the Solvent Extraction process to resolve potential solvent instability, recycle, and contaminant problems, and to establish

availability of the extraction agents in quantities required for large-scale processing

- Establishing regulatory acceptance for the Direct Disposal (of cesium) in Grout alternative.
- *DOE Actions:* R&D activities to address each of the Council's recommendations for additional R&D work on remaining scientific and technical uncertainties were included in, and implemented in accordance with, the R&D Program Plan (TFA 2000), issued by DOE's Tanks Focus Area in May 2000. R&D activities necessary to support a technology down-selection decision are scheduled to be completed in April 2001. As discussed above, DOE will not pursue regulatory acceptance of the Direct Disposal in Grout alternative any further, unless it is determined that the cesium-removal technologies are not economically or technically practical.

2.8.2 SELF-PROTECTING HLW CANISTERS

Direct Disposal in Grout would not be consistent with DOE's recent Record of Decision (65 FR 1608; January 11, 2000) for disposing of surplus weapons-grade plutonium, which states that some of the plutonium will be immobilized in HLW canisters for eventual geologic disposal. Implementation of this approach requires the availability of sufficient quantities of cesium-containing HLW to vitrify around the canisters of plutonium. The Direct Disposal in Grout alternative would not produce vitrified HLW that would support this option, because the cesium would not be in the vitrified waste stream.

The U.S. Nuclear Regulatory Commission and the International Atomic Energy Agency consider material emitting more than 100 rads per hour at 1 meter to be sufficiently self-protecting to require a lower level of safeguarding. Canisters containing cesium would emit hundreds of rads per hour, and thus be self-protecting. Canisters without radioactive cesium would emit 1 to 2 rads per hour at 1 meter, which is well be-

low the self-protecting standard. Such canisters produced using the Direct Disposal in Grout alternative would not meet the Spent Fuel Standard without the addition of another radiation source. DOE would have to evaluate alternatives to resolve this issue before selecting the Direct Disposal in Grout alternative.

2.8.3 COST

Based on the preconceptual designs prepared and used by the Salt Processing Systems Engineering Team, the cost through construction of the alternatives would range from \$900 million to \$1.2 billion (WSRC 1998a). Based on this very preliminary information, the Direct Disposal in Grout alternative is the least costly. However, as designs are refined, the cost estimates will change and estimates for each of the alternatives could be higher or lower. Because the designs are preliminary, DOE does not consider the cost estimates to be reliable enough to use as a discriminating factor. Cost estimates will, however, continue to be refined and evaluated in the ultimate selection of an alternative for implementation.

2.9 Comparison of Alternatives

This comparison is based on the information in Chapter 3 (Affected Environment), and analyses in Chapter 4 (Environmental Impacts). Its purpose is to present impacts of the alternatives in comparative form to provide a clear basis for choosing among the alternatives for the decisionmaker(s) and the public.

This section compares the impacts of the four action alternatives: Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout. These action alternatives would involve very similar construction and operations activities that enable a sharply focused comparison of impacts on each environmental resource.

Because the No Action alternative is a continuation of current HLW management activities, very few changes to that baseline would occur if DOE decided to not select and implement a salt-processing alternative. However, should DOE

determine that a salt processing facility would not be available by 2010, decisions about future tank space management 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:

- Identify additional ways to optimize of Tank Farm operations
- Reuse tanks scheduled to be closed by 2019
- Build tanks permitted under wastewater treatment regulations
- Build tanks permitted under RCRA regulations
- Suspend operations at DWPF.

HLW salt processing would affect the environment and human health and safety during the period of time when facilities are being constructed and are operating. For purposes of analysis in this SEIS, DOE has defined this life cycle to be from the year 2001 through about 2023, when salt processing would be complete. 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 from the eventual release of residual waste from the Z-Area vaults to the environment. In this SEIS, DOE has used modeling to predict these long-term impacts.

Chapter 4 of this SEIS presents the potential short-term and long-term environmental impacts associated with each salt processing alternative and the No Action alternative.

2.9.1 SHORT-TERM IMPACTS

Section 4.1 presents the potential short-term impacts (those that would occur between the approximate years 2001 and 2023) for each of the action alternatives and No Action. These potential impacts are compared among the four action alternatives in Table 2-6 for normal operations. Because the specific activities that would be pursued under the No Action alternative have

Table 2-6. Summary comparison of incremental life-cycle impacts to the SRS baseline by salt processing alternative.

Parameter	No Action ^a		Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	Continue Tank Space Management	Post Tank Space Management Scenarios				
Geologic Resources						
	Continuation of tank space management activities would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks.	The reuse of existing HLW tanks would increase the risk of tank failure resulting in the release of HLW to soils. Any new HLW storage tanks would be built in previously disturbed industrial areas. Best management practices would be used to stabilize soils and control erosion during construction. The operation of any new HLW storage tanks would not disturb any landforms or surface soils.	Minimal	Minimal	Minimal	Minimal
Water Resources						
Surface Water	No Change	Construction of any new HLW tanks would be confined to previously disturbed industrial areas with established storm-water controls. Therefore, impacts would be minimal.	Minimal	Minimal	Minimal	Minimal
Groundwater	Continuation of tank space management activities would increase the surveillance necessary to ensure safe and environmentally satisfactory performance of these tanks.	The reuse of existing HLW tanks would increase the risk of tank failure resulting in the release of HLW to groundwater. Any release of HLW to groundwater would have a substantial adverse impact on the quality of the surficial aquifer. Construction of any new HLW tanks would be confined to previously disturbed industrial areas with a deep water table. The operation of any new HLW storage tanks would not involve discharges to groundwater.	Minimal	Minimal	Minimal	Minimal

Table 2-6. (Continued).

Parameter	No Action ^a					
	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Air Resources						
<i>Nonradiological air emissions (tons/yr.):</i>						
Sulfur dioxide (as SO ₂) (PSD Standard - 40)	No Change	Minimal ^b	0.33	0.33	0.33	0.33
Total suspended particulates (PSD Standard - 25)	No Change	Minimal ^b	0.95	0.95	0.95	0.80
Particulate matter (≤10 μm) (PSD Standard - 15)	No Change	Minimal ^b	0.40	0.40	0.40	0.30
Carbon monoxide (PSD Standard - 100)	No Change	Minimal ^b	5.4	5.4	5.4	4.9
Volatile organic compounds (PSD Standard - 40)	No Change	Minimal ^b	70	1.6	40	1.5
Oxides of nitrogen (NO _x) (PSD Standard - 40)	No Change	Minimal ^b	21	21	21	19
Lead (PSD Standard - 0.6)	No Change	Minimal ^b	4.0×10 ⁻⁴	4.0×10 ⁻⁴	4.0×10 ⁻⁴	3.5×10 ⁻⁴
Beryllium (PSD Standard - 4.0×10 ⁻⁴)	No Change	Minimal ^b	1.0×10 ⁻⁴	1.0×10 ⁻⁴	1.0×10 ⁻⁴	5.0×10 ⁻⁵
Mercury (PSD Standard - 0.1)	No Change	Minimal ^b	0.0026	0.0026	0.0026	0.0025
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
Methanol (PSD Standard - NA)	No Change	Minimal ^b	0.42	0.42	0.42	0.42
n-Propanol (PSD Standard - NA)	No Change	Minimal ^b	0.42	0.42	0.42	0.42
Isopar [®] L (PSD Standard - NA)	None	None	None	None	38	None
<i>Air pollutants at the SRS boundary (maximum concentrations-μg/m³):</i>						
Sulfur dioxide (as SO ₂) - 3 hr. (Standard - 1,300)	1240 ^d	Minimal ^b	0.30	0.30	0.30	0.40
Total suspended particulates - annual (Standard - 75)	67 ^d	Minimal ^b	0.0010	0.0010	0.0010	0.0010

Table 2-6. (Continued).

Parameter	No Action ^a					
	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Particulate matter (≤10 μm) - 24 hr. (Standard - 150)	130 ^d	Minimal ^b	0.070	0.070	0.070	0.070
Carbon monoxide - 1 hr. (Standard - 40,000)	10,350 ^d	Minimal ^b	15	15	15	18
Ozone - 1 hr. (Standard - 235)	216 ^d	Minimal ^b	ND	ND	ND	ND
Nitrogen dioxide (NO ₂) - annual (Standard -100)	26 ^d	Minimal ^b	0.030	0.030	0.030	0.030
Lead - max. quarterly (Standard - 1.5)	0.03 ^d	Minimal ^b	4.0×10 ⁻⁷	4.0×10 ⁻⁷	4.0×10 ⁻⁷	4.0×10 ⁻⁷
Beryllium - 24 hr. (Standard - 0.01)	0.0090 ^d	Minimal ^b	1.0×10 ⁻⁵	1.0×10 ⁻⁵	1.0×10 ⁻⁵	1.0×10 ⁻⁵
Mercury - 24 hr. (Standard - 0.25)	0.03 ^d	Minimal ^b	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵
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
Methanol - 24 hr. (Standard - 1,310)	0.9 ^d	Minimal ^b	0.32	0.32	0.32	0.53
<i>Annual radionuclide emissions (curies/year): (Doses are reported in Worker and Public Health Section.)</i>	No Change ^e	Minimal ^b	5.3	18.2	25.4	9.3 ^f
Worker and Public Health						
<i>Radiological dose and health impacts to the public:</i>						
Maximally-exposed individual (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 2-6. (Continued).

Parameter	No Action ^a					
	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
<i>Nonradiological health impacts to the public:</i>						
Maximally exposed offsite individual						
Latent cancer fatality from benzene	No Change ^g	Minimal ^h	1.7×10^{-5}	(c)	(c)	(c)
Latent cancer fatality from beryllium	No Change ^g	Minimal ^h	2.4×10^{-8}	2.4×10^{-8}	2.4×10^{-8}	2.4×10^{-8}
<i>Radiological dose and health impacts to noninvolved workers:</i>						
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}
<i>Nonradiological health impacts to noninvolved workers:</i>						
Latent cancer fatality from benzene	No Change ^g	Minimal ^h	0.0066	(i)	(i)	(i)
Latent cancer fatality from beryllium	No Change ^g	Minimal ^h	7.2×10^{-5}	7.2×10^{-5}	7.2×10^{-5}	7.2×10^{-5}
<i>Radiological dose and health impacts to involved workers:</i>						
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
<i>OSHA-regulated nonradiological air pollutants at noninvolved worker location (max conc. in mg/m³)ⁿ</i>						
Sulfur dioxide (as SO ₂) - 8 hr. (OSHA Standard -13) ^j	No Change ^g	Minimal ^h	0.01	0.01	0.01	0.01
Total suspended particulates - 8 hr (OSHA Standard -15)	No Change ^g	Minimal ^h	0.02	0.02	0.02	0.01

Table 2-6. (Continued).

Parameter	No Action ^a					
	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Particulate matter (≤10 μm) - 8 hr. (OSHA Standard - 5)	No Change ^g	Minimal ^h	0.02	0.02	0.02	0.01
Carbon monoxide - 8 hr. (OSHA Standard - 55)	No Change ^g	Minimal ^h	0.2	0.2	0.2	0.2
Oxides of nitrogen (as NO _x) - ceiling (OSHA Standard - 9)	No Change ^g	Minimal ^h	7.0	7.0	7.0	7.0
Lead - 8 hr. (OSHA Standard - 0.5)	No Change ^g	Minimal ^h	1.0×10 ⁻⁵	1.0×10 ⁻⁵	1.0×10 ⁻⁵	1.0×10 ⁻⁵
Beryllium - 8 hr. (OSHA Standard - 0.002)	No Change ^g	Minimal ^h	3.0×10 ⁻⁶	3.0×10 ⁻⁶	3.0×10 ⁻⁶	3.0×10 ⁻⁶
Beryllium - ceiling (OSHA Standard - 0.005)	No Change ^g	Minimal ^h	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵
Mercury - ceiling (OSHA Standard - 0.1)	No Change ^g	Minimal ^h	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵	3.0×10 ⁻⁵
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
Formic Acid - 8 hr. (OSHA Standard - 9 m ³)	No Change ^g	Minimal ^h	2.2×10 ^{-4c}	None	None	None
Methyl alcohol - 8 hr. (OSHA Standard - 260)	No Change ^g	Minimal ^h	0.08	0.08	0.08	0.08
n-Propyl alcohol - 8 hr. (OSHA Standard - 500)	No Change ^g	Minimal ^h	0.08	0.08	0.08	0.08
Occupational Health and Safety						
Total recordable accidents per year	No Change	0.80 ^k	2.2	1.7	2.7	1.8
Lost workdays per year	No Change	0.35 ^k	1.0	0.72	1.2	0.77
Environmental Justice						
	None	None	None	None	None	None
Ecological Resources						
	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.	Activity and noise could displace small numbers of wildlife.

Table 2-6. (Continued).

Parameter	No Action ^a					
	Continue Tank Space Management	Post Tank Space Management Scenarios	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Land Use						
	Zoned heavy industrial-no change in land use patterns. Land dedicated to HLW tanks could not be used for other purposes.	Zoned heavy industrial-no change in land use patterns. Land dedicated to HLW tanks could not be used for other purposes.	Zoned heavy industrial-no change in SRS land use patterns. Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Zoned heavy industrial-no change in SRS land use patterns. Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Zoned heavy industrial-no change in SRS land use patterns. Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.	Zoned heavy industrial-no change in SRS land use patterns. Land dedicated to vaults for low-activity grout disposal could not be used for other purposes.
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
Cultural Resources						
	None	None	None	None	None	None
Transportation						
<i>Construction:</i>						
Material shipments	None	(k)	3,000	3,000	3,000	3,400
Accidents from material shipments	None	(k)	0.04	0.04	0.04	0.05
Construction worker accidents	None	(k)	95	98	95	91
Construction worker injuries	None	(k)	42	43	42	40
Construction worker fatalities	None	(k)	0.4	0.4	0.4	0.4
<i>Operations:</i>						
Material shipments	No Change	No Change	26,000	21,000	24,000	19,000
Accidents from material shipments	No Change	No Change	0.4	0.3	0.3	0.3
Operations worker accidents	No Change	39 ^l	122	91	148	97
Operations worker injuries	No Change	17 ^l	53	40	65	42
Operations worker fatalities	No Change	0.2 ^l	0.5	0.4	0.6	0.4

Table 2-6. (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				
Waste Generation						
<i>Maximum annual waste generation:</i>						
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
Transuranic waste (m ³)	No Change	No Change	Minimal	Minimal	Minimal	Minimal
Low-level waste (m ³)	No Change	No Change	71	71	71	71
Hazardous waste (m ³)	No Change	No Change	Startup - 23 Operations - 1			
Mixed low-level waste (m ³)	No Change	No Change	1	1	1	1
Mixed low-level liquid waste (gallons)	No Change	No Change	60,000	None	1,000	None
Industrial waste (metric tons)	No Change	No Change	Startup - 30 Operations - 20			
Sanitary waste (metric tons)	No Change	No Change	Startup - 62 Operations - 41			
<i>Total waste generation:</i>						
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
Transuranic waste (m ³)	No Change	No Change	Minimal	Minimal	Minimal	Minimal
Low-level waste (m ³)	No Change	No Change	920	920	920	920
Hazardous waste (m ³)	No Change	No Change	43	43	43	43
Mixed low-level waste (m ³)	No Change	No Change	13	13	13	13
Mixed low-level liquid waste (gallons)	No Change	No Change	780,000	None	13,000	None
Industrial waste (metric tons)	No Change	No Change	299	299	299	299
Sanitary waste (metric tons)	No Change	No Change	611	611	611	611
Utilities (total life cycle)						
<i>Water (million gallons)</i>						
Construction	None	(m)	35	37	35	33
Operations	No Change	No Change	400	366	345	256

Table 2-6. (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				
<i>Electricity (gigawatt-hours)</i>			319	365	391	245
Construction	None	(m)	76	79	76	73
Operations	No Change	No Change	243	286	315	172
<i>Steam (million pounds)</i>			2,548	2,300	1,915	1,536
Construction	None	(m)	0	0	0	0
Operations	No Change	No Change	2,548	2,300	1,915	1,536
<i>Fuel (million gallons)</i>			8.7	9.3	8.7	8.2
Construction	None	(m)	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 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 public 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 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 which, if prolonged, could result in a workforce reduction.
- k. Material shipments and associated accident and injury rates for construction transportation of up to 18 new HLW tanks would be similar to those identified under the action alternatives.
- l. Based on employment of 65 additional workers for operation of any new HLW tanks built under the No Action alternative.
- m. 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.
- n. Under normal operating conditions, involved workers would not be exposed to any OSHA-regulated nonradiological air pollutants; therefore, impacts to involved worker health would be minimal for all alternatives, including No Action.

ND = Not Determined.

not been determined, only those potential activities that would be expected to have an impact on a given resource area are discussed in this section.

Geologic and water resources – The sites proposed for salt processing facilities lie within areas of the SRS that are committed to industrial use and have been previously disturbed. Therefore, none of the salt processing action alternatives would have short-term impacts to the geology or groundwater, regardless of which alternative was selected. DOE anticipates small sedimentation impacts to McQueen Branch from construction activities, but these impacts would cease once construction was completed.

Under the No Action alternative reuse of old tanks would increase the risk for the release of radiological and nonradiological hazardous liquids with potential for substantial negative impact on soils and the quality of the surficial aquifer.

Nonradiological air quality – Construction activities and routine operations associated with salt processing activities would result in the release of regulated nonradiological pollutants to the surrounding air. For any of the four action alternatives, the increases in pollutant concentrations resulting from construction activities would be small and would not exceed regulatory limits.

Nonradiological emissions from routine operations (with the exception of volatile organic compounds [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 are below the threshold values.

All options under the No Action alternative would result in emissions similar to those at the existing HLW Tank Farms. Therefore, incremental increases in air emissions as a result of the No Action alternative would be minimal.

For all alternatives, air concentrations at the SRS boundary of the emitted pollutants would be

well below SCDHEC or Clean Air Act regulatory limits. Occupational Safety and Health Administration (OSHA) -regulated pollutant levels would be below regulatory limits at both the noninvolved and the involved worker locations.

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.

For doses to the noninvolved (onsite) worker, the involved worker, and the collective onsite population from the estimated annual radioactive emissions. The highest estimated dose would occur under the Solvent Extraction alternative, with the Small Tank Precipitation having similar results and the Ion Exchange and the Direct Disposal in Grout alternatives having lower doses. The maximum dose to the noninvolved and involved worker would be 4.8 millirem per year and 22.8 millirem per year, respectively, with radioactive cesium emissions contributing about 98 percent of the total dose. The maximum estimated dose to the onsite population would be 6.5 person-rem per year, with 94 percent of this total dose due to radioactive cesium emissions. Under the No Action alternative, air emissions from all potential scenarios would be similar to those from ongoing operations at the HLW Tank Farms.

Impacts on radiological air quality are measured in terms of effects on occupational and public health and are reported in the *Worker and Public Health* section of Table 2-6.

Nonradiological pollutant concentrations at noninvolved worker locations would be well below the regulatory limits, except for oxides of nitrogen. Facility workers would be exposed to minimum levels of nonradiological air pollutants under all four alternatives. Worker exposure to chemicals in the workplace would be monitored in accordance with OSHA regulatory guidance.

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.

Worker and public health impacts – Radiological air doses for the Solvent Extraction alternative translate into 0.12 additional project-phase latent cancer fatalities in the offsite population of approximately 620,000 people. Additional project-phase latent cancer fatalities in the offsite population from Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout radiological doses would be 0.078, 0.019, and 0.026, respectively. For the collective worker population at SRS, additional project phase latent cancer fatalities would be 0.022, 0.0055, 0.034, and 0.012 for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Di-

rect Disposal in Grout alternatives, respectively. Under all action alternatives, the potential for any cancer death as a result of salt processing activities is minimal. Air emissions from all potential scenarios under the No Action alternative are similar to those at the existing HLW Tank Farms and would result in slight increases above the baseline cancer risk.

Occupational Health and Safety – Based on historic SRS injury rates over a four-year period (1995 through 1999), estimated total recordable cases (TRCs) and lost workdays (LWDs) would be greatest for the Solvent Extraction alternative, with 2.7 TRCs and 1.2 LWDs on an annual basis. The Small Tank Precipitation, Ion Exchange, and Direct Disposal in Grout alternatives would generate fewer TRCs (2.2, 1.7, and 1.8, respectively) and LWDs (1.0, 0.72 and 0.77, respectively) because fewer employees are required for these alternatives. Under the No Action alternative, TRCs and LWCs would be expected to remain at current levels during ongoing tank space management activities. In the event that DOE would build new HLW tanks, the number of TRCs and LWCs would increase by approximately 0.80 and 0.35, respectively.

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

Ecological resources – Construction-related disturbances under all alternatives, including No Action, would result in impacts to wildlife that are small, intermittent, and localized. Some individual animals could be displaced by construction noise and activity, but populations would not be affected. Operational impacts would be minimal.

Land use – Each of the four action alternatives would be constructed in areas (S and Z) that are zoned as heavy industrial. Under the No Action alternative, continuation of tank space manage-

ment activities would have no impact on existing land use plans. Any tanks built under the No Action alternative would also be constructed in industrial areas. SRS land use patterns are not expected to change over the short term due to proposed salt processing activities.

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 to 220, depending on the alternative chosen. None of the action alternatives is expected to have a measurable effect on regional employment or population trends.

Under the No Action alternative, DOE could suspend operations at DWPF. If the suspension of operations at these facilities is not temporary, it would result in a sizeable workforce reduction, which would have a substantial negative impact on the communities surrounding SRS. Alternatively, DOE could construct as many as 18 new HLW tanks. Operation of new HLW tanks would require up to 65 new employees. This small increase is not expected to have a measurable effect on regional employment or population trends.

Cultural resources – No impacts to cultural resources would occur under any of the alternatives, including No Action. The sites proposed for salt processing facilities and any tanks built under No Action all lie within areas of SRS that are committed to industrial use and have been previously disturbed by construction activities. There are no known archeological or historic resources on the proposed construction sites. Therefore, there are no expected cultural impacts.

Traffic and Transportation – Transportation by truck of materials to construct and operate the salt processing facilities over the duration of the project would require from 22,000 shipments (400,000 miles) for the Direct Disposal in Grout alternative to 29,000 shipments (525,000 miles) for the Small Tank Precipitation alternative. Construction of any tanks built under the No Action alternative would require a similar num-

ber of material shipments as the action alternatives. No vehicle accidents, occupant injuries, or fatalities would be expected for these miles driven.

Construction worker commutes to the site during the construction phase of the salt processing action alternatives would vary from 24 million miles for the Direct Disposal in Grout alternative to 26 million miles for the Ion Exchange alternative. Up to 98 accidents, 43 occupant injuries, and no fatalities would be expected for these total commuter miles. Commuter miles and impacts would be similar for construction of any tanks under the No Action alternative.

The increased traffic resulting from facility operations for any of the alternatives, including No Action, would be minimal.

Waste generation – Salt processing activities under the action alternatives would generate 150,000 to 900,000 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. Small amounts of waste (low-level radioactive, mixed low-level, hazardous, industrial, and sanitary) would be produced under each of the action alternatives and could be handled within the existing site capacity. The No Action alternative would not generate any waste beyond that which is included in the SRS baseline.

Utilities and energy consumption – Water use over the duration of the project would range from 290 million gallons for the Direct Disposal in Grout alternative to 435 million gallons for the Small Tank Precipitation alternative. Construction and operation phase water usages would be from 33 to 37 million gallons and 260 to 400 million gallons, respectively. At its highest average daily use, the water required would be 1.5 percent of the lowest estimated production capacity of the aquifer.

Electricity use over the duration of the project would range from 245 gigawatt-hours (with a peak power demand of 18 megawatts) for the Direct Disposal in Grout alternative to 391 gi-

gawatt-hours (with a peak power demand of 32 megawatts) for the Solvent Extraction alternative. During the construction and operation phases, electricity use would be from 73 to 79 gigawatt-hours and 172 to 315 gigawatt-hours, respectively. This electricity use and peak power demand could be supported by the current power generation and distribution systems serving SRS.

Steam use over the duration of the project would range from 1.5 billion pounds for the Direct Disposal in Grout alternative to 2.5 billion pounds for the Small Tank Precipitation alternative. No steam would be used during the construction phase of the project.

Liquid fuel use over the duration of the project would range from 8.2 million gallons for the Direct Disposal in Grout alternative to 9.3 million gallons for the Ion Exchange alternative. Fuel use during the operation phase would not exceed 300,000 gallons under any alternative. This fuel use is well within the current regional fuel supply capacity.

Under the No Action alternative, utility and energy use would be similar to consumption rates at the existing tank farm and is therefore included in the SRS baseline.

Accidents – DOE evaluated the impacts of potential accidents related to each of the action alternatives (Table 2-7). Because the No Action alternative includes primarily current operations that have been evaluated in approved safety analysis reports (WSRC 1998h), only the radiological and nonradiological hazards associated with accidents under the four action alternatives were evaluated. For each action alternative, the accidents considered were: loss of confinement; earthquakes; fire in a process cell; loss of cooling; external events, such as aircraft and helicopter crashes; and explosions from benzene and radiation-generated hydrogen. Accidents for which the probability was calculated at less than 1 in 10,000,000 years were not considered credible and were dropped from further consideration.

For each remaining accident scenario involving radioactive materials, the radiation dose to the involved worker, the noninvolved worker, the onsite and offsite MEI, and the collective radiation dose to the onsite and offsite populations were calculated. The impacts of the alternatives, expressed as latent cancer fatalities to these receptors, were also calculated. A beyond-extremely-unlikely aircraft impact at the Ion Exchange facility would result in the highest potential dose to each of the receptor groups and the highest potential increase in latent cancer fatalities. On a latent cancer fatality per year basis (i.e., latent cancer fatality per accident times accident frequency), the beyond design-basis earthquake at the Small Tank Precipitation facility would result in the highest impact on each of the five receptors. In general, severe accident potential was highest for the Small Tank Precipitation alternative and lowest for the Direct Disposal in Grout alternative.

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 (e.g., kidney damage) or other serious health effects that may impair their ability to take protective action (e.g., dizziness, confusion, impaired vision). Workers exposed to airborne benzene concentrations ($8,840 \text{ mg/m}^3$) resulting from an explosion in the OWST could experience life-threatening health effects (e.g., loss of consciousness, cardiac dysrhythmia, respiratory arrest). Both of these accidents would occur less than once in 100,000 years and are in the extremely unlikely category.

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

Table 2-7. Comparison of accident impacts among alternatives.^a

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
<i>Accidents Involving Radioactive Materials</i>					
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 2-7. (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
Fire in Process Cell	Once in 10,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		0.014	0.0094	0.0094	0.0027
LCF per accident ^b		7.2×10^{-6}	4.7×10^{-6}	4.7×10^{-6}	1.4×10^{-6}
LCF per year ^b		7.2×10^{-10}	4.7×10^{-10}	4.7×10^{-10}	1.4×10^{-10}
Offsite population					
Dose (person-rem)		780	500	500	160
LCF per accident		0.39	0.25	0.25	0.0081
LCF per year		3.9×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	8.1×10^{-6}
Involved Worker (100 m)					
Dose (rem)		2.8×10^{-5}	9.1×10^{-7}	7.2×10^{-7}	8.2×10^{-7}
LCF per accident ^b		1.1×10^{-8}	3.6×10^{-10}	2.9×10^{-10}	3.3×10^{-10}
LCF per year ^b		1.1×10^{-12}	3.6×10^{-14}	2.9×10^{-14}	3.3×10^{-14}
Noninvolved Worker (640 m)					
Dose (rem)		0.21	0.14	0.14	0.041
LCF per accident ^b		8.5×10^{-5}	5.5×10^{-5}	5.5×10^{-5}	1.6×10^{-5}
LCF per year ^b		8.5×10^{-9}	5.5×10^{-9}	5.5×10^{-9}	1.6×10^{-9}
Onsite population					
Dose (person-rem)		340	220	220	48
LCF per accident		0.14	0.089	0.089	0.019
LCF per year		1.4×10^{-5}	8.9×10^{-6}	8.9×10^{-6}	1.9×10^{-6}

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
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
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

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Helicopter Impact	Once in 2,100,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		3.3	1.7	1.7	0.53
LCF per accident ^b		0.0016	8.5×10 ⁻⁴	8.5×10 ⁻⁴	2.7×10 ⁻⁴
LCF per year		7.9×10 ⁻¹⁰	4.1×10 ⁻¹⁰	4.1×10 ⁻¹⁰	1.3×10 ⁻¹⁰
Offsite population					
Dose (person-rem)		170,000	89,000	89,000	29,000
LCF per accident		87	45	45	14
LCF per year		4.2×10 ⁻⁵	2.1×10 ⁻⁵	2.1×10 ⁻⁵	6.9×10 ⁻⁶
Involved Worker (100 m)					
Dose (rem)		3,300 ^c	1,700 ^c	1,700 ^c	53
LCF per accident ^b		1.3	0.68	0.68	0.21
LCF per year ^b		6.3×10 ⁻⁷	3.2×10 ⁻⁷	3.3×10 ⁻⁷	1.0×10 ⁻⁷
Noninvolved Worker (640 m)					
Dose (rem)		100	53	53	17
LCF per accident ^b		0.041	0.021	0.021	0.0067
LCF per year ^b		2.0×10 ⁻⁸	1.0×10 ⁻⁸	1.0×10 ⁻⁸	3.2×10 ⁻⁹
Onsite population					
Dose (person-rem)		97,000	50,000	50,000	13,000
LCF per accident		39	20	20	5.3
LCF per year		1.9×10 ⁻⁵	9.5×10 ⁻⁶	9.6×10 ⁻⁶	2.5×10 ⁻⁶
Aircraft Impact	Once in 2,700,000 years				
Maximally Exposed Offsite Individual					
Dose (rem)		5.4	2.0	2.0	0.74
LCF per accident ^b		0.0027	0.0010	0.0010	3.7×10 ⁻⁴
LCF per year ^b		1.0×10 ⁻⁹	3.7×10 ⁻¹⁰	3.8×10 ⁻¹⁰	1.4×10 ⁻¹⁰
Offsite population					
Dose (person-rem)		280,000	110,000	110,000	40,000
LCF per accident		140	53	54	20
LCF per year		5.3×10 ⁻⁵	2.0×10 ⁻⁵	2.0×10 ⁻⁵	7.4×10 ⁻⁶
Involved Worker (100 m)					
Dose (rem)		5,400 ^c	2,000 ^c	2,000 ^c	740 ^c
LCF per accident ^b		2.1	0.81	0.81	0.30
LCF per year ^b		8.0×10 ⁻⁷	3.0×10 ⁻⁷	3.0×10 ⁻⁷	1.1×10 ⁻⁷
Noninvolved Worker (640 m)					
Dose (rem)		170	63	64	23
LCF per accident ^b		0.067	0.025	0.026	0.0093
LCF per year ^b		2.5×10 ⁻⁸	9.4×10 ⁻⁹	9.5×10 ⁻⁹	3.4×10 ⁻⁹
Onsite population					
Dose (person-rem)		160,000	59,000	60,000	18,000
LCF per accident		63	24	24	7.3
LCF per year		2.3×10 ⁻⁵	8.8×10 ⁻⁶	8.9×10 ⁻⁶	2.7×10 ⁻⁶

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
<i>Accidents Involving Nonradioactive Hazardous Materials</i>					
Accidents Involving Sodium Hydroxide Releases					
Caustic Feed Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		5.9×10 ⁻⁴	5.9×10 ⁻⁴	5.9×10 ⁻⁴	5.9×10 ⁻⁴
Noninvolved Worker (640 m) Dose (mg/m ³)		0.18	0.18	0.18	0.18
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					
PHA Surge Tank Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		7.4×10 ⁻¹⁰	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m ³)		2.2×10 ⁻⁸	NA	NA	NA
TPB Tank Spill	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		0.060	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m ³)		18.7	NA	NA	NA
Organic Evaporator Loss of Confinement	Once in 30 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		0.45	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m ³)		130	NA	NA	NA
Beyond Design Basis Earthquake	Less than once in 2,000 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		0.0026	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m ³)		0.78	NA	NA	NA
OWST Loss of Confinement	Once in 140,000				

Table 2-7. (Continued).

	Frequency	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
	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
Loss of Cooling	Once in 170,000 years				
Maximally Exposed Offsite Individual Dose (mg/m ³)		0.0015	NA	NA	NA
Noninvolved Worker (640 m) Dose (mg/m ³)		0.44	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.

- Accident impacts based on bounding case.
- Probability of latent cancer fatality (LCF) to the exposed individual.
- An acute dose to an individual over 300 rem would likely result in death.
- PHC = precipitate hydrolysis cell.
- Individuals exposed to sodium hydroxide concentrations above 0.5 mg/m³ could experience mild transient health effects (headache, nausea, rash) or perception of a clearly defined objectionable odor.
- Individuals exposed to benzene concentrations above 480 mg/m³ could experience or develop irreversible (kidney damage) or other serious health effects (dizziness, confusion, impaired vision).
- Individuals exposed to benzene concentrations above 3,190 mg/m³ could experience or develop life-threatening health effects (loss of consciousness, cardiac dysrhythmia, respiratory arrest).

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, impact would typically be no more than 10 percent of that for the full-sized facility.

2.9.2 LONG-TERM IMPACTS

Section 4.2 of the Draft SEIS discusses the long-term impacts associated with disposing of fractions 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 (Martin Marietta 1992) 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 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, 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. 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* (DOE 2000).

Under the No Action alternative in the Tank Closure Draft EIS (DOE 2000), 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 the tank closure 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. 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 a risk of 2.2×10^{-4} of incurring a fatal cancer. The greatest risk occurs within about 500 years of tank abandonment, but doses for residents would be greater than 10 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. Section 4.2 analyzes long-term impacts for geologic resources, water resources (groundwater and surface water), ecological resources, land use, and public health. Table 2-8 summarizes the long-term impacts to these resources.

Geologic resources – No detrimental effect on surface soils, topography, or on the structural or load-bearing properties of the geologic deposits would occur as a result of saltstone manufactured by any of the analyzed alternatives.

Surface water – Based on modeling results, the saltstone manufactured under all alternatives would be effective in limiting the long-term movement of residual contaminants from Z Area to nearby streams via groundwater. Radiological doses at the seepines of Upper Three Runs and McQueen Branch would be orders of magnitude below the drinking water standard of 4 millirem per year. Concentrations of nonradiological contaminants (primarily nitrate) moving to Upper Three Runs via McQueen Branch or the Upper Three Runs seepine would be very low; in most cases, they would be several times below applicable standards. In all instances, predicted long-term concentrations of nonradiological contaminants would be well below applicable water quality standards.

Groundwater – Long-term impacts to the groundwater of the Upper Three Runs Aquifer and the Gordon Aquifer could occur as the saltstone degrades and releases additional contaminants to the aquifers. Based on groundwater modeling, no constituents would occur in concentrations that exceed drinking water standards in wells 100 meters from the vaults. However, for all alternatives, maximum nitrate concentrations in a well 1 meter downgradient from the vaults would exceed the established maximum contaminant level in both aquifers.

Ecological resources – The potential risk is very low to biota in Upper Three Runs or McQueen Branch from long-term effects of saltstone.

Land use – Long-term impacts to land use at Z Area would occur. The placement of 13 to 16 additional vaults that will contain radioactive cementitious grout for up to 10,000 would limit other uses of the land in Z Area.

Public health – Although the vaults would contain radioactive cementitious grout for up to 10,000 years, 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 for the ITP process. 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 2-8, 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 2-8. Summary comparison of long-term impacts by salt processing alternative.

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Geologic Resources				
	After saltstone degradation, soil could become contaminated.			
Surface Water				
	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters but concentrations would be very low.	Contaminants in groundwater could be transported to downgradient surface waters, but concentrations would be very low.
Groundwater				
Maximum radiation dose (mrem/yr) ^a 1 meter downgradient of vaults	0.49	0.58	0.45	0.57
Maximum radiation dose (mrem/yr) 100 meters downgradient of vaults	0.042	0.044	0.038	0.048
Maximum radiation dose (mrem/yr) at seepline	0.0029	0.0028	0.0025	0.0032
Maximum nitrate concentration (mg/L) ^b 1 meter downgradient of vaults	338	395	307	394
Maximum nitrate concentration (mg/L) 100 meters downgradient of vaults	29	31	26	33
Maximum nitrate concentration at seepline (mg/L)	2.2	2.1	1.9	2.4
Ecological Resources				
	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.	Minimal impacts from nitrate and radionuclides for ecological receptors in and near McQueen Branch and Upper Three Runs.
Land Use				
	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.	Z Area zoned heavy industrial; no residential areas allowed on SRS. Vaults would preclude other uses.
Public Health				
Radiation dose from Agricultural Scenario (mrem/yr)	52 to 110	61 to 130	49 to 110	64 to 140
Latent Cancer Fatalities ^c from Agricultural Scenario	0.0018	0.0021 to 0.0046	0.0017 to 0.0039	0.0022 to 0.0049
Radiation dose from Residential Scenario at 100 years post-closure (mrem/yr)	0.015 to 0.11	0.017 to 0.13	0.014 to 0.1	150 to 1200

Table 2-8. (Continued).

Parameter	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Latent Cancer Fatalities ^c 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}	0.0053 to 0.042
Radiation dose from Residential Sce- nario at 1,000 years post-closure (mrem/yr)	9.2 to 69	11 to 80	8.6 to 65	11 to 85
Latent Cancer Fatalities ^c from Residential Scenario at 100 years post- closure	3.2×10^{-4} to 0.0024	3.9×10^{-4} to 0.0028	3.0×10^{-4} to 0.0023	3.9×10^{-4} to 0.0030

- a. mrem/yr = millirem per year.
b. mg/L = milligram per liter.
c. Lifetime (70 year) to an individual.

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