

CHAPTER 1. BACKGROUND AND PURPOSE AND NEED FOR ACTION

1.1 Background

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

To assist the reader in understanding key terms used in this document, those terms have been **bolded** the first time they are used and are discussed in Table 1-1, Primer of Technical Terms, located at the end of this chapter.

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

Radionuclides

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 21.3 million years, and Cs-134 has a half-life of 2 years.

Plutonium (Pu)

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

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.

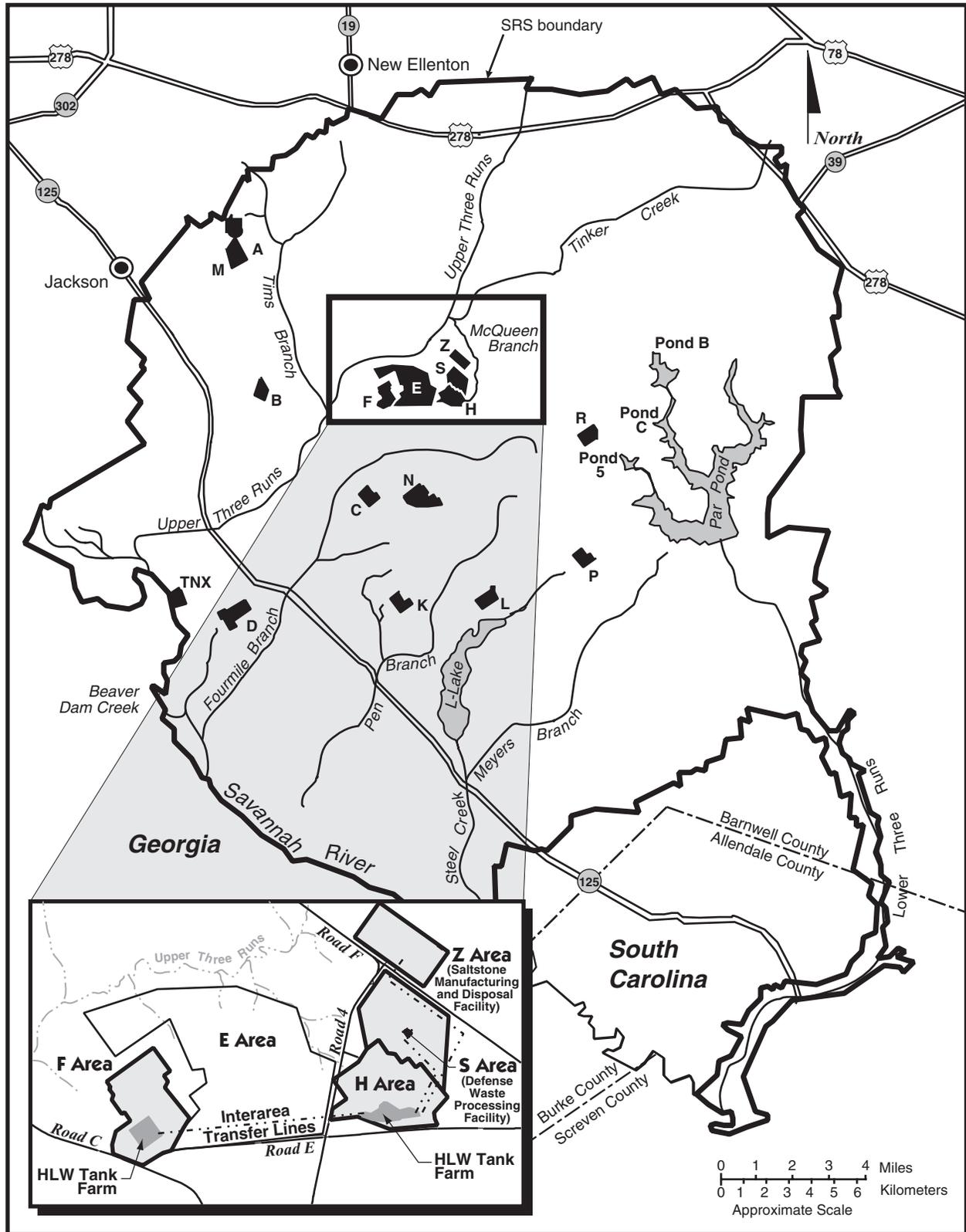


Figure 1-1. Savannah River Site map with F, H, S, and Z Areas highlighted.

plutonium). Radionuclides found in the salt component include **isotopes** of cesium and technetium, as well as some strontium and actinides.

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

DOE evaluated the potential impacts of constructing and operating DWPF in a 1982 environmental impact statement (EIS) (DOE 1982). In 1994, DOE published a Supplemental EIS (SEIS) (DOE 1994) evaluating changes in the process proposed after the 1982 EIS was issued. The Record of Decision (60 FR 18589; April 12, 1995) announced that DOE would complete the construction and startup testing of the DWPF.

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

The reagent used to precipitate cesium in the ITP process, sodium tetrphenylborate, is subject to **catalytic** and **radiolytic decomposition**. Its decomposition inhibits its ability to bind with cesium and keep it out of the salt solution, and results in the generation of **benzene**. Benzene is

a toxic, flammable, and potentially explosive organic substance that must be safely controlled.

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

In August 1996, the Defense Nuclear Facilities Safety Board (DNFSB), an independent oversight board chartered by Congress to review operations at DOE nuclear defense facilities and make recommendations necessary to protect public health and safety, recommended that testing and operation of ITP not proceed further until DOE had a better understanding of how benzene was generated and released during the **precipitation** process (DNFSB 1996). In January 1998, DOE determined that ITP, as designed, could not meet production goals and safety requirements, and that it must therefore select an alternative technology for HLW salt processing.

In early 1998, Westinghouse Savannah River Company (WSRC), the SRS operating contractor, recommended to DOE that a systematic evaluation be conducted to identify viable salt treatment technologies to replace the ITP process (DOE 1998a). This evaluation was done and, in October 1998, WSRC presented its recommendation of alternatives to DOE (WSRC 1998). WSRC recommended four technologies for further consideration: Small Tank **Tetrphenylborate Precipitation, Crystalline Silicotitanate Ion Exchange, Caustic Side Solvent Extraction**, and Direct Disposal in Grout. In early 1999, following review of the recommendation by DOE and independent reviewers, DOE decided to pursue three of the four candidate alternatives for replacement of the ITP process.

The High-Level Waste Management System

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

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

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

CIF operations were suspended in October 2000. The CIF was constructed primarily to incinerate benzene generated in the ITP process and plutonium/uranium extraction (PUREX) solvent wastes from F- and H-Canyon operations. It was also scheduled to destroy some solid LLW from ongoing operations and decontamination and decommissioning (D&D) projects. As originally planned, the benzene would be used to dilute the PUREX solvent and be co-disposed during incineration. However, the benzene waste was not produced due to the suspension of ITP operations, and the D&D projects were deferred. In the absence of these wastes, DOE found that it would not be cost-effective to operate the CIF only for solid LLW and PUREX solvent. Solid LLW could be more cost-effectively managed by compaction, and operation of the CIF for disposal of the PUREX waste stream without a benzene stream for dilution would be cost-prohibitive. DOE is investigating alternatives for PUREX solvent disposal and will not operate the CIF if an effective alternative to solvent disposal by incineration can be identified. DOE expects to make a decision on CIF by April 2002.

Solvent Extraction was dropped from consideration at that time because it was considered technically immature. DOE restored Solvent Extraction to the list of potential alternatives in February 2000 (DOE 2000a), based on recommendations from the National Academy of Sciences (NAS 1999) and new research and development results. A description of DOE's salt processing program, including results of research and development, may be found on the Internet at <http://www.srs.gov/general/srtech/spp/randd.htm>.

In parallel with development of the WSRC recommendations on alternative technologies, DOE

prepared a supplement analysis (DOE 1998b) in accordance with the Department's National Environmental Policy Act (NEPA) regulations (10 CFR 1021). Based on the supplement analysis, DOE decided to prepare this second SEIS on DWPF and its supporting processes because necessary additional technical changes will significantly alter the way in which HLW salt is processed from that described in the original EIS and the 1994 SEIS. This second Draft SEIS evaluates the potential environmental impacts of replacing the ITP process for salt processing with an alternative technology. The Draft SEIS also considers the impacts of a No Action alternative.

1.2 Purpose and Need for Action

The ability to safely process the salt component of the HLW stored in underground storage tanks at SRS is a crucial prerequisite for completing HLW disposal. Without a suitable method for salt management, DOE would not be able to place the HLW in a configuration acceptable for safe disposal. Thus, DOE must identify and implement one or more technologies to prepare the SRS HLW salt component for disposal. The new technology must be compatible with existing facilities and processes for HLW storage and vitrification and for disposal of LLW at SRS. If salt processing is delayed beyond 2010, DOE recognizes that the salt waste must be vitrified separately from the sludge component of the HLW, and the total number of HLW canisters would be greatly increased over that projected for concurrent sludge and salt waste vitrification.

HLW Tank Closure Activities

DOE, the U.S. Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control have agreed to a schedule for closure of the Savannah River Site HLW tanks. DOE must close the tanks in accordance with applicable laws, regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996). Bulk waste must be removed from the tanks before closure can begin. Without a salt processing alternative, and with continued sludge-only vitrification in the DWPF, HLW storage requirements will be such that DOE may not be able to empty all tanks and, therefore, after about 2010, tank closure commitments may not be met. DOE has prepared the *Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement*, DOE/EIS-0303D, to evaluate the impacts of the tank closure program (DOE 2000b).

1.3 SEIS Overview

1.3.1 SCOPE

In accordance with Council on Environmental Quality (CEQ) requirements, DOE is integrating the NEPA analysis early in the planning process to ensure that environmental values are consid-

ered in decision making (40 CFR 1501.2). This SEIS describes the technology alternatives that DOE is considering to replace the ITP technology for salt processing. Processes and facilities that would be needed for each alternative are presented. The SEIS also estimates the environmental impacts that could result from the construction and operations associated with each of the alternatives, based on information from **preconceptual facility designs** for the action alternatives and other information developed specifically for the SEIS. For each alternative, the impacts to the environment and human health from normal facility operation and from accidents that might occur during operation are estimated and presented in the SEIS.

In addition, the SEIS describes the potential impacts of a No Action alternative, as required by NEPA. The impacts of the No Action alternative provide a basis for comparison with the impacts of the action alternatives. The No Action alternative is defined as the continuation of actions DOE has already taken or is currently taking. As such, No Action could be defined as operation of the ITP Facility for salt processing, as projected in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility Record of Decision* (60 FR 18589 – 18594; April 12, 1995). However, because DOE has determined that the ITP process cannot simultaneously achieve both safety and production requirements, it will not be operated. A comparison of the impacts of the alternatives to the operation of the ITP Facility would not, therefore, prove meaningful. Consequently, DOE has defined No Action as a continuation of current HLW management activities, including tank space management, and vitrification of the sludge component of HLW, without operation of the ITP Facility. See Chapter 2 for a full explanation of the No Action alternative.

Decisions to be Made

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

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

1.3.2 ORGANIZATION

DOE has prepared this SEIS in accordance with the NEPA regulations of the CEQ (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021). This SEIS identifies the methods used for analyses and the scientific and other sources of information consulted. In addition, results available from ongoing studies are incorporated directly or are summarized and referenced. The organization of the SEIS is as follows:

- Chapter 1 describes the background and purpose and need for DOE action regarding salt processing at SRS.
- Chapter 2 describes the proposed action and the alternatives that DOE is evaluating.
- Chapter 3 describes the SRS environment as it relates to the alternatives described in Chapter 2.
- Chapter 4 assesses the potential environmental impacts of the alternatives.
- Chapter 5 discusses the cumulative impacts of salt processing in relation to other past, present, and reasonably foreseeable future activities at SRS, and in the surrounding region.
- Chapter 6 identifies irreversible and irretrievable resource commitments.

- Chapter 7 discusses applicable statutes, state and Federal regulations, DOE Orders, and agreements.

The appendices provide more detailed discussions of certain topics. Appendix A describes the facilities that would be used for each of the alternatives. Appendix B describes the methods used for accident analysis and results of the analysis. Appendix C describes the SEIS scoping process, stakeholder and public comments received, and the way in which DOE addressed those comments. Appendix D gives the methods, concentrations, doses, and results of long-term performance modeling used to evaluate the long-term impacts of salt processing alternatives. Corresponding health effects are given in Section 4.3 of Chapter 4.

1.3.3 STAKEHOLDER PARTICIPATION

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

DOE encouraged SRS stakeholders and other interested parties to submit comments and suggestions for the scope of the SEIS. DOE held scoping meetings in Columbia, South Carolina, on March 11, 1999, and in North Augusta, South Carolina, on March 18, 1999. Each meeting included a presentation on the NEPA process as it related to the proposed action, a presentation on the process used to identify reasonable alternatives for salt processing for further evaluation, public comment opportunities, and question-and-answer opportunities.

From the scoping process, DOE identified about 90 separate comments. The comments addressed six broad issues: alternatives, the ITP process, impact evaluations and analyses, criteria and regulations, schedule and process, and miscellaneous topics. A summary of the comments received during the scoping period and the way(s) in which they influenced the scope of this Draft SEIS, are included in Appendix C.

1.4 Related Information

This SEIS makes use of information contained in other DOE NEPA documents related to HLW management. It is consistent with DOE's parallel EIS process on HLW tank closure at SRS, which is related to activities in the F- and H-Area Tank Farms. The NEPA documents pertaining to this Salt Processing Alternatives SEIS are briefly described below.

1.4.1 NEPA DOCUMENTS

Final Environmental Impact Statement, Defense Waste Processing Facility (DOE 1982)

DOE prepared this EIS to address the potential impacts of constructing and operating the DWPF to vitrify HLW in preparation for final disposal in a monitored geologic repository. DOE announced its decision to construct and operate the DWPF in a ROD published in the *Federal Register* (47 FR 23801) on June 1, 1982.

Final Environmental Impact Statement, Waste Management Activities for Groundwater Protection (DOE 1987)

DOE prepared this EIS to address the potential environmental impacts of **hazardous waste**, LLW, and **mixed waste** management activities that could affect the groundwater resources under and near SRS. On March 9, 1988, DOE decided (53 FR 7557) that LLW generated by each alternative will be disposed of in vaults on the SRS. Disposal will have to meet SRS waste disposal performance assessment criteria that are imposed to protect groundwater.

Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility (DOE 1994)

DOE prepared an SEIS to examine the impacts of completing construction and operating the DWPF at SRS. This document assisted the Department in deciding whether and how to proceed with the DWPF project, given the changes to processes and facilities that had occurred since 1982, when DOE issued the original DWPF EIS. The evaluation in the EIS included

short- and long-term impacts associated with the construction and operation of the Saltstone Manufacturing and Disposal Facility and disposal vaults.

On April 12, 1995, the ROD (60 FR 18589) announced that DOE would complete the construction and startup testing of the DWPF, and would operate the facility using ITP for salt processing, after satisfactory completion of startup testing. The ROD also announced that the low-activity salt solution resulting from salt and sludge pretreatment would be immobilized in the Saltstone Manufacturing and Disposal Facility and permanently disposed of in the Z-Area vaults. DOE has now determined that the ITP process cannot simultaneously meet safety requirements and production goals and is therefore pursuing alternative technologies for HLW salt processing.

Final Environmental Impact Statement, Waste Management (DOE 1995)

DOE issued the SRS Waste Management EIS (DOE 1995) to provide a basis for the selection of a Sitewide approach to managing present and future (through 2024) wastes generated at SRS. These wastes would come from ongoing operations and potential actions, new missions, environmental restoration, and decontamination and decommissioning programs. The SRS Waste Management EIS included the treatment of wastewater discharges in the Effluent Treatment Facility, F- and H-Area Tank Farm operations and waste removal, and construction and operation of a replacement HLW evaporator in the H-Area Tank Farm. In addition, it evaluated the CIF for the treatment of mixed waste, including incineration of benzene waste from the then-planned ITP process. The first ROD (60 FR 55249) on October 30, 1995, stated that DOE would configure its waste management system according to the moderate treatment alternative described in the EIS. The SRS Waste Management EIS is relevant to this Salt Processing Alternatives SEIS because it evaluates management alternatives for various types of waste that actions proposed in this SEIS could generate. The Waste Management EIS is also relevant to the assessment of cumulative impacts that could

occur at SRS. The second ROD (62 FR 27241) was published on May 19, 1997, to ensure consistency with the *Approved Site Treatment Plan* (WSRC 1996) and also announced DOE's decision to construct and operate additional facilities at SRS for characterization and treatment of mixed waste.

Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options (DOE 1998b)

DOE prepared a supplement analysis that led to a determination to prepare this SEIS. The supplement analysis provides a description and comparison of the impacts of the ITP facility with the proposed salt processing alternatives that DOE was considering in 1998.

Savannah River Site High-Level Waste Tank Closure Draft Environmental Impact Statement (DOE 2000b)

On December 29, 1998, DOE published a Notice of Intent to prepare an EIS on closure of HLW tanks at SRS (63 FR 71628). The Draft EIS, issued in November 2000, examines the impacts of closing the SRS HLW tanks in accordance with applicable laws and regulations, DOE Orders, and the *Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems* (DOE 1996) approved by the South Carolina Department of Health and Environmental Control. The proposed action would begin on a tank-by-tank basis after bulk waste removal has been completed. Alternatives considered include the preferred alternative that would consist of cleaning the tanks with water and filling them with grout. If necessary to meet performance requirements, additional cleaning (e.g., with oxalic acid) could be performed. The use of sand or saltstone as fill material is also considered. The EIS considers a No Action alternative that would consist of leaving the tank system in place after bulk waste removal. Under each alternative, except No Action, DOE would close 49 HLW tanks and associated waste handling equipment, including evaporators, pumps, diversion boxes, and transfer lines. The comment period for the Draft EIS ended on Janu-

ary 23, 2001. Publication of the Final EIS is tentatively planned for Summer 2001.

1.4.2 OTHER RELEVANT DOCUMENTS

High-Level Waste Salt Disposition Systems Engineering Team Final Report (WSRC 1998)

This report describes the technology selection process that WSRC used to evaluate the final four technologies recommended to DOE for replacement of the ITP process.

Nuclear Waste – Process to Remove Radioactive Waste From Savannah River Tanks Fails to Work (GAO 1999)

At the request of Congress, the General Accounting Office reviewed the reasons the ITP process did not work. This report describes the history of developing the ITP process and of selecting a replacement salt processing technology. The General Accounting Office concluded that the “Department and Westinghouse have taken steps that, if fully implemented, should better ensure a successful alternative.”

Savannah River Site High-Level Waste Tank Space Management Team Final Report (WSRC 1999a)

This report identifies a strategy (including the potential operation of a new HLW evaporator in DWPF) for managing liquid HLW to ensure that existing SRS HLW tanks provide sufficient storage and processing capacity pending startup of a replacement process for ITP.

High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report (WSRC 1999b)

This report describes the process used to recommend a path forward for salt processing at the SRS. The report identifies programmatic risks, estimated costs, and project implementation schedules developed for the candidate technologies. The document recommended best-suited and backup technologies.

Defense Nuclear Facility Safety Board Recommendation 96-1 to the Secretary of Energy (DNFSB 1996)

The DNFSB review of planned use of tetraphenylborate (TPB) to remove radioactive cesium from SRS HLW salt solutions conveyed concern over the rate of TPB decomposition and mechanisms for holdup and release of product benzene encountered in large-scale tests using actual HLW. The DNFSB recommended deferral of additional tests involving large quantities of HLW pending: (1) improved understanding of the causes and mechanisms of benzene generation, retention, and release and (2) additional investigation to establish identification and role of catalysts involved in the TPB decomposition, and the factors controlling product benzene retention and release. Such measures were concluded necessary to affirm adequacy of existing safety requirement and to devise new safety and operational constraints.

NAS Review Committee Interim Report (NAS 1999)

This report generally endorsed the selection of the four candidate processes considered as alternatives for salt processing, concluding that, with adequate development time and funding, each of the processes could be made to work. Major technical problems were identified for each alternative, with schedule constraints and potential regulatory restrictions noted. Recommendations included the following: (1) resolve technical questions concerning reaction kinetics of the monosodium titanate process; (2) improve understanding of the TPB decomposition process, especially catalytic reactions responsible for benzene generation; (3) evaluate Ion Exchange process cesium desorption and resin deactivation in alkaline solutions; (4) establish regulatory acceptance for the Direct Disposal in Grout alternative; (5) resume development of the Solvent Extraction process to resolve potential solvent instability, recycle, and contaminant problems.

Table 1-1. Primer of Technical Terms (other scientific terms are defined in the glossary).^a***Actinide***

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

Benzene

Benzene, the simplest aromatic hydrocarbon, is widely used in industry. The chemical formula for benzene is C₆H₆. Benzene is a toxic, flammable, and potentially explosive substance that must be safely controlled. It is generated by the catalytic and radiolytic decomposition of the reagent sodium tetraphenylborate, formerly used in the In-Tank Precipitation process and currently projected for use in the Small Tank Precipitation salt processing alternative.

Catalyst

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

Catalytic decomposition

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

Caustic

Alkaline solution containing sodium hydroxide or other light metal hydroxides. SRS HLW solutions are caustic solutions.

Caustic Side Solvent Extraction

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

Conceptual design

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

Crystalline

Being, relating to, or composed of crystals.

Crystalline silicotitanate

Insoluble granular inorganic solid (Na₄SiO₄ • TiO₂) ion exchange material developed through a cooperative research and development agreement between DOE and private industry. Provides capability for removing cesium from acid or alkaline salt solutions containing high potassium concentrations.

Decomposition

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

Final design

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

Table 1-1. (Continued).

Fission Product

Nuclides (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by radioactive decay of the fission fragments.

Hazardous waste

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

High-level radioactive waste (HLW)

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

HLW components

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

Ion exchange/Ion exchange medium (resin)

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

Low-level radioactive waste (LLW)

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

Mixed waste

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

Monosodium titanate

Water-insoluble inorganic substance (NaTiO_3H) used to remove fission product strontium and residual actinides (uranium, plutonium) by sorption from HLW salt solutions.

Precipitation (chemical)

Conversion of a constituent in solution into insoluble solid form by chemical or physical means.

Preconceptual design

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

Table 1-1. (Continued).***Radiolytic decomposition***

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

Radionuclide/Isotope

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

Reagent

Substance used in a chemical reaction to detect, measure, examine, or produce other substances.

Salt

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

Saltcake

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

Salt supernatant

Highly concentrated solution of the salt component in HLW tanks.

Sorbent

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

Sludge

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

Sodium Tetrphenylborate

Organic reagent used in tetrphenylborate precipitation process for removal of radioactive cesium from HLW salt solution. Chemical formula for sodium tetrphenylborate is $\text{Na}(\text{C}_6\text{H}_5)_4\text{B}$.

Tetrphenylborate Precipitation

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

Vitrify or Vitrification

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

a. See also Glossary of Terms Used in DOE NEPA Documents (DOE 1998c).

References

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