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7. Abstract


The purpose of this document is to present an outline of the Hanford Site Low-Level Waste (LLW) disposal program, what it has accomplished, what is being done, and where the program is headed. This document may be used to provide background information to personnel new to the LLW management/disposal field and to those individuals needing more information or background on an area in LLW for which they are not familiar. This document should be appropriate for outside groups that may want to learn about the program without immediately becoming immersed in the details.

The scope of this document is to provide a technical overview of the LLW disposal program with emphasis on the LLW disposal history, technology, process and final disposal of the waste. The document gives references which can provide more in-depth information. Retrieval and pretreatment functions are briefly addressed as they relate to LLW. The status of the LLW program reported in this document is as of April 30, 1995.

This document is not a program or systems engineering baseline report, and personnel should refer to more current baseline documentation for critical information.


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# DRAFT LOW LEVEL WASTE TECHNICAL SUMMARY

September 1995

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## Preface

This document was initiated with the expectation that it would be updated through the years as the LLW disposal program progressed. It is very possible that the document will now be a "snapshot" in time frozen at April 30, 1995. In April of 1995 very little was known of privatization strategies that would come to be the expectation for the Hanford site in late 1995, and particularly waste disposal.

The purpose of this document is to provide an outline of the LLW program, what it has done, what is being done, and where it is headed. This document may be used to provide background information to personnel new to the LLW management field and to those individuals needing more information or background in an area in which they are not familiar. The document provides references about the general LLW disposal subject and specific parts of the program, allowing personnel to find information on specific subjects. It also allows outside groups to get a broad view of the technical program and program direction as it existed in April 1995.

## EXECUTIVE SUMMARY

The purpose of this document is to present an outline of the Hanford Site Low-Level Waste (LLW) disposal program, what it has accomplished, what is being done, and where the program is headed. This document may be used to provide background information to personnel new to the LLW management/disposal field and to those individuals needing more information or background on an area in LLW for which they are not familiar. This document should be appropriate for outside groups that may want to learn about the program without immediately becoming immersed in the details.

The scope of this document is to provide a technical overview of the LLW disposal program with emphasis on the LLW disposal history, technology, process and final disposal of the waste. The document gives references which can provide more in-depth information. Retrieval and pretreatment functions are briefly addressed as they relate to LLW. The status of the LLW program reported in this document is as of April 30, 1995.

This document is not a program or systems engineering baseline report, and personnel should refer to more current baseline documentation for critical information. The initial Tank Waste Remediation System (TWRS) technical baseline has been established through four levels of functional decomposition and is documented in DOE/RL-92-60, *Tank Waste Remediation System Functions and*

*Requirements* (RL 1994).* Technical baseline documents are defined in WHC-SD-WM-WP-285, *Tank Waste Remediation System Systems Engineering Working Plan* (WHC 1994).[2] The technical baseline documents include the updated functions and requirements document, DOE/RL-92-60. The next level, more detailed baseline documentation is WHC-SD-W378-DRD-001, *Preliminary Design Requirements Document for the Low-Level Waste Vitrification Plant, Project W-378* (Swanson 1995),[3] which serves as the project interface document between the U.S. Department of Energy (DOE) and the operating contractor. The next level down is the flowsheet (Orme 1994).[4] These documents provide input to the Architect-Engineer interface.

The mission of the LLW disposal program is to manage the receipt, immobilization, packaging, storage/disposal, and *Resource Conservation and Recovery Act of 1976*[5] closure of the Hanford Site low-level tank waste in an environmentally sound, safe, and cost-effective manner. According to the Tri-Party agreement the LLW vitrification facility will initiate hot operations on 6/30/05. The Preliminary Design Requirements Document for the LLWVP gives the operating life of the facility as 14 years.

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*RL, 1994, *Tank Waste Remediation System Functions and Requirements*, DOE/RL-92-60, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[2]WHC, 1994, *Tank Waste Remediation System Systems Engineering Working Plan*, WHC-SD-WM-WP-285, Rev.0, Westinghouse Hanford Company, Richland, Washington.

[3]Swanson, L. M., 1995, *Preliminary Design Requirements Document for the Low-Level Waste Vitrification Plant, Project W-378*, WHC-SD-W378-DRD-001, Westinghouse Hanford Company, Richland, Washington.

[4]Orme, R. M., 1994, *TWRS Process Flowsheet*, WHC-SD-WM-TI-613, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

[5]*Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.

The TWRS flowsheet provides an overview of the process and the assumptions in the development of the process. Flowsheets are subject to change as the program and individual projects develop. This summary represents the flowsheet as of the status date.

The retrieval process is the first step in disposal of the waste. Retrieval starts with removal of waste from single-shell tanks, transfer to double-shell tanks, and storage until required. Pretreatment of waste in-tank is expected to be via enhanced sludge washing with sodium hydroxide to leach problem components such as aluminum hydroxide [$Al(OH)_3$] and chromium hydroxide [$Cr(OH)_3$] from the solids. The process also takes advantage of the relative solubility of certain compounds to metathesize phosphate ($PO_4^{-3}$) from the solids. The enhanced sludge-washing process reduces 17,200 MT of solids to 12,000 MT of washed solids. The solids are stored for vitrification as HLW. Liquids are stored for LLW disposal. Cesium removal by ion exchange occurs next. Flowrates of pretreated supernatant from cesium ion exchange at 4*M* sodium solution are expected to average 206 L/min for 14 years at a 60% operating efficiency. Solid-liquid separation completes pretreatment and is expected to be performed by settling and decantation.

The LLW disposal portion of the TWRS flowsheet (Orme 1994) starts when the ion exchange effluent and several other dilute process waste streams are combined for concentration by evaporation. The waste is mixed with product formers (silica and others) to provide feed to the melter for vitrification of the waste. The design vitrification product flow rates are expected to average 140 tons/day of glass product from the melter for 14 years. The glass may be water quenched to form a cullet and/or further encapsulated in matrix materials. The *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement (Ecology et al. 1994),* direction is that LLW be disposed of onsite, in glass form, and be retrievable.

The major process items in the flowsheet and associated technical evaluations are described in more detail in the document, with emphasis on the LLW portion of the evaluations and process.

The systems engineering process is described as it relates to LLW. The strategy of TWRS and LLW are briefly reviewed to ensure that the mission and goals of each are understood.

Site selection criteria for operations is reviewed and the site recommended in the 200 East Area of the Hanford Site is illustrated. The site evaluation is briefly reviewed as it relates to storage of the final product, and the investigation needed to assure that the site has been evaluated adequately. The effect of retrieval sequence on the LLW product is evaluated. Retrieval of LLW appears to be manageable without a lot of special mixing of the tank waste supernate. The major limiting chemical component in the low level waste will be the sodium content. The product glass is anticipated to contain from about 15% to 30% sodium oxides. Major components of interest which may be limiting besides sodium are sulfite $(SO_3)^{-2}$, fluorine $(F_2)$,

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*Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

phosphate $(P_2O_4)^{-2}$, and chromium (Cr), in that order, at 25 wt% sodium oxide loading in the glass.

The LLW portion of the TWRS activities starts with a review of the existing 242-A evaporator in comparison with what is needed for LLW processing. Upgrades would be required to use the existing evaporator as the LLW evaporator.

LLW glass feed guidelines are given for receipt of waste from the retrieval and pretreatment functions. The major limiting component of the waste will normally be the sodium oxide loading limit of 25 wt%. The larger the sodium oxide limit in the glass the more waste can be concentrated in the glass; other waste composition components may be limiting in isolated cases.

Glass formulation product specifications are being developed. Glass compositions developed for LLW vitrification will be primarily high sodium glasses to limit total waste glass volume. A reference glass formulation is to be developed by June 1996 to meet a Tri-Party Agreement milestone and proceed with disposal.

The melter selection effort is progressing through two phases of melter evaluation and selection, which involve private vendors. Phase I melter testing is a "proof of principle" test to demonstrate that an available melter system technology can process a highly alkaline LLW simulant to a glass waste product of consistent quality, and is essentially complete. In Phase II testing, the equipment and procedures will be optimized based on lessons learned during Phase I. This will allow remaining vendors to provide data needed for Westinghouse Hanford Company selection of a reference melter system and an alternate. The outlined process should meet the Tri-Party Agreement milestone "select reference melter concept" due in June 1996.

Other main areas of the process, such as melter offgas and feed, are so melter-specific that they will be delayed until the next revision of this document in order to reduce the options to a manageable size.

Product acceptance requirements have not yet been developed for the LLW product but should include at least three types of specifications. One will be glass properties related to product homogeneity and processability. The second and third specifications should focus on short-term and long-term glass durability.

In the disposal system area, investigations on a variety of disposal systems are being evaluated based on vitrified product geometry, packaging configurations, and chemical barriers. A preferred mitigating disposal system should be selected by October 1995 at which time a disposal decision document is expected to be issued to document the decision process.

A Performance Assessment (PA) is developed when radioactive waste is to be disposed on DOE sites. The PA needs to provide reasonable assurance that public health and environmental resources will be protected consistent with local, state, and federal environmental regulations. Time frames considered by the PA stretch from 500 to 10,000 years or more. Results of preliminary scoping studies show technetium-99 and iodine-129 as key radioactive components of interest within the 10,000-year time frame.

The Hanford Site low-level tank waste disposal facility PA will be conducted in three phases. The first phase is the interim PA, which is not part of the DOE PA process as outlined in draft DOE Order 5820.2B, *Waste Management* (DOE 1994).* The purpose of the interim PA is to show before any LLW facility construction that there will be a high likelihood that the final PA will be approved. The second phase is the preliminary PA that is required by the draft DOE Order 5820.2B. The draft revision of the DOE Order requires that RL approves the preliminary PA before construction starts on the disposal facility. The third phase is the final PA, which must be approved by DOE-Headquarters before the disposal facility operates. Performance assessment analysis and personnel provide advice and results to designers of the final disposal system, product specifications, and/or all parts of the design effort for disposal.

As a contingency, technical investigations were initiated to generate the information required for the bases for stabilization, treatment, and disposal of hard-to-vitrify melter off-gas waste streams. Results show that simulated products from the melter offgas system can be stabilized in a low-melting vitreous material or in durable cementitious solids.

The regulatory requirements applicable to the LLW immobilization facility are outlined as well as the progress made in meeting them. A LLW vitrification facility will be subject to extensive environmental regulatory limitations that apply to the glass product, airborne emissions, as well as solid and liquid waste by-products resulting from vitrification. Major safety

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*DOE, 1994, *Waste Management*, DOE Order 5820.2B, DRAFT, U.S. Department of Energy-Headquarters, Washington, D.C.

documentation required for the LLW vitrification plant are outlined herein including facility hazards category, site evaluation report, preliminary and final safety analysis reports, fire hazards analysis, single failure evaluation, and technical safety requirements.

Major alternatives and uncertainties that could change the thrust of the LLW disposal are discussed. Alternatives include the reference contracting strategy of competitive bid, government financed, design and construction with operations provided by the site operating contractor. Alternatives being evaluated include a commercialization strategy where a single contract is awarded for design and construction management. The site operating contractor would operate the facilities. Another contracting option is a privatization strategy in which the capital needed for design and construction originates in the private sector. The private investors are paid by the quantity of material processed by their facilities.

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# LOW-LEVEL WASTE TECHNICAL SUMMARY

## 1.0 INTRODUCTION

In 1989, the U.S. Department of Energy (DOE), Washington State Department of Ecology (Ecology), and U.S. Environmental Protection Agency (EPA) co-signed the *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement (Ecology et al. 1994). The Tri-Party Agreement establishes a strategy, schedule, and milestones for disposal of the waste in Hanford Site single-shell tanks (SST) and double-shell tanks (DST).

The DOE, through its contractors, is applying the systems engineering approach to comply with the commitments of the Tri-Party Agreement and to establish the technical strategy for remediation of Hanford Site underground storage tank (UST) waste. Systems analysis by Westinghouse Hanford Company (WHC) has identified the functions of the tank waste disposal mission (DOE 1993a). Previously, WHC had spent several years evaluating the available technology options and operational scenarios for carrying out those functions (Boomer et al. 1993). A series of reports has been produced to document the results of these systems engineering efforts:

- DOE/RL-92-60, *Tank Waste Remediation System Functions and Requirements* (RL 1994a)

- DOE/RL-92-61, Draft, *Tank Waste Remediation System Integrated Technology Plan* (RL 1994b)

- WHC-EP-0616, *Tank Waste Technical Options Report* (Boomer et al. 1993)

- WHC-EP-0617, Draft, *Tank Waste Decision Analysis Report* (Johnson et al. 1993).

The Tri-Party Agreement signatories proposed modifications to the Tri-Party Agreement on September 30, 1993. Final approval of the revised Tri-Party Agreement was reached on January 25, 1994, providing a new planning basis for the Tank Waste Remediation System (TWRS). Systems engineering planning documents produced prior to January 1994 may not include the current baseline. For example, WHC-EP-0617 does not contain the revised Tri-Party Agreement baseline.

The Tri-Party Agreement revision shifts the emphasis from early high-level waste (HLW) vitrification to early low-level waste (LLW) vitrification. Certain chemical separations must also be deployed earlier to support LLW vitrification. Separations for the new basis are focused on cesium (and strontium, if required) removal from LLW. Aggressive measures to develop a process for dissolving and processing high-level and transuranic (TRU) sludge envisioned by the old Tri-Party Agreement and old technical strategy were discontinued. An enhanced sludge-washing process emerged as the reference strategy.

The remaining Tri-Party agreement milestones for LLW are listed below.

| Number | Milestone | Due Date |
|---|---|---|
| M-60-03 | Submit conceptual design and initiate definitive design of the LLW vitrification Facility. | 11/96 |
| M-60-04 | Initiate construction of the LLW Vitrification facility | 12/97 |
| M-60-05 | Initiate hot operations of the LLW vitrification facility | 6/05 |
| M-60-05-T01 | Complete construction of the LLW vitrification facility | 12/03 |
| M-70-00 | The ERDF will be operational (available to receive remediation waste) | 9/96 |
| M-60-00 | Complete vitrification of Hanford low level tank waste | 12/28 |

It was felt that a overview document was needed that would outline the history of the LLW disposal effort, the current status, and the direction in which the program is moving. This document serves as that overview.

## 1.1 PURPOSE

The purpose of this document is to provide an outline of the LLW program, what it has done, what is being done, and where it is headed. This document may be used to provide background information to personnel new to the LLW management field and to those individuals needing more information or background in an area in which they are not familiar. This is especially appropriate for oversight groups that may want to learn more about the program without immediately becoming immersed in the details.

This document may serve as a general input to design, assist the Safety Analysis group, and provide training and background information to contractors or the public. The purpose of this document is to help unify the LLW disposal program by describing the technical pieces and their interrelationships. The document provides the connective tissue needed to present the program in a coherent form.

Critical assumptions and approved critical values will either be referenced or included in this document, which is not a substitute for project design requirements documents such as WHC-SD-W378-DRD-001, *Preliminary Design Requirements Document for the Low-Level Waste Vitrification Plant, Project W-378* (Swanson 1995), or WHC-SP-1101, *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994). This Low-Level Waste Technical Summary document can be used to record important working values outside the scope of developed projects if required and noted in the document. In general, referenced baseline documentation should be consulted for baseline information.

Some of the information presented herein is to document past work in the LLW area that may not be readily apparent, and to provide a working reference and index for the technical work. Future plans are outlined for information only, to show the direction of the effort, including major alternatives and changes that may significantly impact the LLW disposal effort.

This document is intended to give an overview of the TWRS LLW history, strategy description, baseline and planning assumptions, flowsheet summary, technology development needs and status, as well as existing technical issues and their status, with appropriate references. The document provides completed and ongoing work that will assist in the design of an LLW vitrification facility and familiarization with the LLW disposal program.

## 1.2 SCOPE

The scope of this document is to provide a technical overview of the LLW disposal program. The emphasis of the document is on the LLW process, technology, history, and final disposal of the waste. Pretreatment and retrieval are briefly addressed where they relate to LLW. The HLW process is not covered except where it is expected to interface with LLW.

This Low-Level Waste Technical Summary is a central document for general summaries of technical status, needs, and work flow, but is not a part of the LLW technical baseline. The document may serve as input to design; assist the Safety Analysis group; and provide training, references, and background information. The document provides interactive logic diagrams of the LLW technical baseline work flow and may be useful in planning new work and ensuring that required, planned work was completed.

From inspection of this document, one should be informed of the history, current efforts, and future intentions of the LLW disposal program technical efforts. The reader also would be provided with the appropriate references to delve more deeply into specifics of the LLW program. The document references--not repeats--the detailed analysis provided in other program documentation.

The work progress status of the LLW program is included as of April 30, 1995. Work occurring after that time is not reported in this document.

## 1.3 LLW BACKGROUND

### 1.3.1 History of LLW

In 1943, the U.S. Army Corps of Engineers selected an area of about 600 $mi^2$ in semiarid southeastern Washington State for producing plutonium and other nuclear materials supporting weapons production for World War II. The area is called the Hanford Site, and it was divided into three major operation areas supporting plutonium production: the 100 Areas for reactor operations; the 200 Areas for fuel reprocessing, plutonium recovery, and waste management; and the 300 Area for fuel fabrication. Reactor operation began in 1944, and the last production reactor was put in cold standby in 1987. In the 1940's and 1950's, support facilities were constructed in the 200 and 300 Areas (Ballinger and Hall 1991).

Hanford Site wastes were primarily produced from the reprocessing of irradiated fuel from the plutonium production reactors in the bismuth phosphate process, which operated from 1944 to 1956. The reduction and oxidation (REDOX) process was operated from 1952 to 1966, and the plutonium uranium reduction and extraction (PUREX) solvent extraction process was operated from 1956 to 1972 and 1983-88. Certain tank wastes, such as the metal waste stream from the bismuth phosphate process, were subsequently reworked to recover uranium (1952-57). During this same period, other supernate wastes were reworked to induce the precipitation of cesium-137 ($^{137}$Cs) and strontium-90 ($^{90}$Sr) before discharging the wastes to cribs or trenches (nickel ferrocyanide scavenging operations). Later (1965 to 1976), high-heat PUREX waste sludge and general supernate wastes were reworked in B Plant to recover $^{137}$Cs and $^{90}$Sr by ion exchange and solvent extraction (cesium/strontium encapsulation operation). This operation served to remove most of the high heat-producing radionuclides, permitting further waste concentration and more economical storage.

Process condensates from the separations building canyons and other slightly contaminated streams were discharged to a crib, a buried structure filled with aggregate. The solution seeped into the sand bottom of the crib, which acted as a sorbent for many of the fission products.

Liquid waste from the separations processes in the 200 Areas was neutralized and piped to large tanks, several of which comprise a tank farm. Other operations which influenced tank waste were:

- In-tank scavenging of strontium and cesium by the precipitation of strontium phosphate and cesium ferrocyanide to reduce the concentration in the supernatant. Supernatant was later stored as LLW.

- Concentration of tank contents by evaporation of water to crystallize the waste as a salt cake.

The bismuth phosphate separations process used in B and T Plants generated large amounts of dilute waste in comparison to the REDOX and PUREX processes. Waste tanks were equipped to contain boiling waste and used air-lift circulators to keep the tank contents mixed.

Currently, there are 149 SSTs and 28 DSTs in the 200 Area of the Hanford Site.

### 1.3.2 History of Grout

The Grout Project at the Hanford Site is the only project that has permanently disposed of liquid LLW. All other projects have stored the waste in "interim" facilities or otherwise temporarily processed (i.e., waiting on final disposal actions) the waste. According to McDaniel (1995), the grout concept was conceived of by Joe Wetch in about 1981 for disposal of REDOX waste. Work began at Oak Ridge in October 1981 with trade studies. It was proposed that a transportable grout facility for processing LLW be constructed to move from tank farm to tank farm.

In 1983, a decision was made to build a grout operating facility that was to be the first of three. Reactor cleanout waste, designated phosphate/sulfate waste (PSW), was the first waste planned for the facility. It was expected that 45.5 to 91 million liters (12 to 24 million gal) would be available from N Reactor cleanup (McDaniel 1995).

In fiscal year (FY) 1985, a contract was awarded to design and build the transportable grout facility. The job was defaulted due to problems with the remote operation aspects of the equipment. The company that had been awarded the contract had severely underestimated the cost and complexity of remote operations and defaulted on the contract upon realization of the budget problem.

In FY 1986, ATI was awarded the contract to design and build the transportable grout facility. The first waste to be processed was PSW; but because of N Reactor shutdown, double-shell slurry feed (DSSF) waste would soon follow as the second type of feed to the facility. The transportable grout facility was constructed in the next several years as well as pipelines and a new grout disposal system, designated vault 101.

The first grout campaign of PSW was initiated in August 1988 and completed in July 1989. Two significant interruptions occurred before more than 3.79 million liters (1 million gal) of waste, or 5.3 million liters (1.4 million gal) of low-level grout was successfully poured into vault 101 at the Hanford Site. Results from sampling of the grout in the vault showed that the grout exceeded all requirements by a significant margin. For example, the mean compressive strength criterion of $\geq$0.35 MPa (50 psi) was tested as 4.17 MPa (605 psi). The leachability indexes for $^{137}$Cs, cobalt-60 ($^{60}$Co), sodium, and $SO_4$ for PSW grout cores exceeded the ANS 16.1 leachability criterion of $\geq$7 by at least one index point. This means that the ability of the grout to resist leaching of waste species is at least ten times greater than the limiting criterion (Huang et al. 1993).

Four more 6.44 liter (1.7 million gal) vaults were completed in 1992 to provide permanent storage facilities for LLW. These vaults were of a different design than vault 101 in that they did not use a landfill-type separate liner to provide primary containment. The primary containment was provided by a spray-on liner, which easily passed leak-testing requirements. Also, the confinement around the concrete vault was increased to 102 cm (40 in.) of asphalt and gravel in addition to the standard confinement and containment features of vault 101.

Pilot-scale tests were completed with the new grout formulation to determine if there would be concerns with quality or operability. No significant problems were encountered, and the grout pilot plant met all requirements (Bagaasen and Powell 1993). Laboratory tests with radioactive grout also determined that the new formulation for DSSF waste was effective in meeting all criteria requirements for the LLW form (Welsh 1993).

In late 1992, the grout program was put on standby due to renegotiation of the Tri-Party Agreement. The concerns expressed regarding grout were the apparent non-retrievability of the waste, the adequacy of the waste form, and the amount of land that would be required for disposal of the grouted waste form.

In 1995, the grout facility continues in standby mode for use if required due to lack of tank space or other identified needs. It would take approximately 2 years to get the facility running again, primarily due to equipment, staffing, and readiness review needs. The facility could process about 11.4 million liters (3 million gal) of waste before shutting down to allow grout formulation efforts to catch up to the production rate (Lee 1994).

### 1.3.3 History of Glass

In 1993 and early 1994, the Tri-Party Agreement was renegotiated. It was indicated by the parties involved that glass would be a more appropriate final waste form than grout. Some of the bases of the decision included available life-cycle cost estimates of glass versus grout plants, which appeared to be similar at that time (Boomer 1994). To that end, the Tri-Party Agreement set new milestones that eliminated the series of milestones for grout operation, and established a new series for LLW vitrification. The major milestone driving the program became M-60-00, "Complete vitrification of Hanford low-level tank waste" December 2028.

The first TWRS vitrification flowsheet outlining the process of retrieval, pretreatment, LLW, and HLW disposal was issued (Orme 1994). During 1994, phase I of LLW melter testing was initiated with seven melter vendors whose work scope was described in a statement of work (Wilson 1994). The first preliminary design requirements document (PDRD) was released for conceptual design of the LLW vitrification facility (Swanson 1995). This PDRD was developed in accordance with the systems engineering (DOE 1994) breakdown of the top four levels of functions, requirements, and architectural concepts necessary to accomplish the TWRS mission.

From late 1994-95, a series of seminars on glass technology was held at the Hanford Site by prominent melter experts and LLW experts. Seminar notes as well as videotapes of the presenters are available. This series of speakers helped to raise the level of understanding of glass chemistry, glass-making equipment, glass processes, and the problems that could be expected in dealing with the process.

# 2.0 TWRS & LLW PURPOSE, OBJECTIVES, AND STRATEGY

## 2.1 TWRS PURPOSE, OBJECTIVE, AND STRATEGY

As stated in DOE/RL-92-61, *Tank Waste Remediation System Integrated Technology Plan* (RL 1994b), the **purpose** of the TWRS is to safely manage and dispose of tank wastes. To execute this purpose, the TWRS program is broken down into 6 specific program elements, as follows:

- Waste Tank Safety
- Characterization
- Retrieval
- Pretreatment
- LLW Immobilization
- HLW Immobilization.

This document concentrates on the LLW immobilization function. The **purpose** of the LLW immobilization function is to convert the low-level portion of the wastes currently stored in the Hanford Site tanks into a vitrified waste form suitable for disposal at an onsite disposal facility. The vitrified waste will be disposed of in a retrievable form.

The **objective** of LLW immobilization technology is to assist in developing the scientific and engineering bases needed for a vitrification capability that fulfills the TWRS program mission. This includes ensuring--through technology development, data collection, and analysis--the production of an acceptable vitrified waste form for storage and disposal, and the design and construction of a suitable facility for the storage and disposal of the vitrified waste form.

The **strategy** for vitrifying LLW employs industrial melter technology to the maximum extent possible. Verification of this strategy requires evaluation and performance testing of various commercial melters and subsystems. Performance assessment results are used to allocate system performance requirements and to develop performance-based product specifications for the disposal system components during the design and development phase of the project. This approach ensures protection of the public health and the environment.

The initial emphasis of the LLW immobilization program will be on the following functional development needs as established by the Tri-Party Agreement.

- Establish waste simulant formulation for testing candidate commercial melter systems that match the range of expected pretreatment discharge compositions.

- Evaluate the performance of commercial melter types using simulants consistent with the LLW expected from pretreatment processes.

- Evaluate melter performance, product quality, offgas systems, and feed systems as part of the melter selection process.

- Identify the preferred melter type(s) for further testing and development to support vitrification facility design.

- Develop preliminary performance requirements for the disposal facility and the waste form using the performance assessment methodology to establish the amount of pretreatment required, the needed glass properties (durability, type, and waste loading), and storage/disposal facility performance requirements.

- Match the capacity of the LLW vitrification facility with waste retrieval rates to minimize the amount of DST storage needed.

Additional TWRS strategy details are available in Section 2.3 and can be found in Alumkal (1994). Implementation of the program strategy may be found in WHC-SP-1101, *Tank Waste Remediation System Multi-Year Program Plan* (WHC 1994).

## 2.2 SYSTEMS ENGINEERING

In November 1992, the TWRS Program Leadership Council directed that systems engineering be adopted as the paradigm for development and management of the TWRS program.

As defined in DOE Order 4700.1, *Project Management System* (DOE 1987), the systems engineering process is a sequence of activities that transforms an identified mission need into a description of system performance parameters and a preferred system configuration. A sound requirements baseline must be established to provide the foundation on which the systems engineering process can be carried out. Functional analysis, which is just one step within the implementation of the overall systems engineering process, establishes this foundation.

Functional analysis is based on the premise that, when describing a system, it is better to think in terms of the functions that must be performed than a collection of parts that compose the system. A comprehensive functional analysis begins with a statement of the mission, from which all essential functions that the system must perform are derived. The functional analysis process is sequential and iterative. There are three distinct steps, each leading to three important pieces of information: functions (F), requirements (R), and architecture (A). Iterations to this sequential process lead to progressively increasing levels of detail.

Functions are statements of purpose, defining what the system must do; requirements indicate how well the function must be accomplished; and architectures represent strategies, processes, or pieces of the actual physical system that satisfy a corresponding requirement. This triad of functions, requirements, and architectures is needed to completely describe and understand the physical system at each level and to establish a basis for the next level of decomposition.

The systems engineering process is being applied to the Hanford Site and implemented within TWRS to establish the functions and requirements necessary for accomplishing the TWRS mission. The program requirements to implement *Fiscal Year 1995 Hanford Mission Plan* (DOE-RL 1993a). The policy and guidance for application of systems engineering throughout the TWRS program is described in DOE/RL-93-0106, *Tank Waste Remediation Systems (TWRS) Systems Engineering Management Plan* (DOE-RL 1993b). The initial TWRS technical baseline has been established through four levels of functional decomposition and is documented in DOE/RL-92-60, *Tank Waste Remediation System Functions and Requirements* (RL 1994a).

The development of the functions that form the basis for the LLW disposal program have been provided through continuation of the systems engineering process from the top-level system requirements. The results of the TWRS systems engineering functional hierarchy to the fourth level are shown in Figure 2-1. The fifth-level functions defined for the Low-Level Waste Vitrification Plant (LLWVP) are also shown in Figure 2-1. Approval of the fifth-level functions will be obtained by issuance and approval of a technical requirements specification (TRS).

Function levels 0 and 1 address the entire Hanford Site while the level 2 function, 4.2, is specific to the TWRS program. The TWRS Functions and Requirements document (RL 1994a) contains TWRS program-unique functions from levels 2-4. From the TWRS functions and requirements, the TRS document begins at level 4 and continues decomposing functions to levels that are sufficient for defining projects. The LLW disposal program is contained in the fourth-level function, 4.2.2.4 - Immobilize Low-Level Waste; and the fifth-level functions, 4.2.2.4.1 - Treat LLW, 4.2.2.4.2 - Analyze LLW Immobilization Samples, 4.2.2.4.3 - Control ILLW Process, 4.2.2.4.4 - Support ILLW Process, and 4.2.2.4.5 - Dispose of ILLW Product. The level 5 function tables will be contained in the TRS. (The TRS may contain lower levels for other projects.)

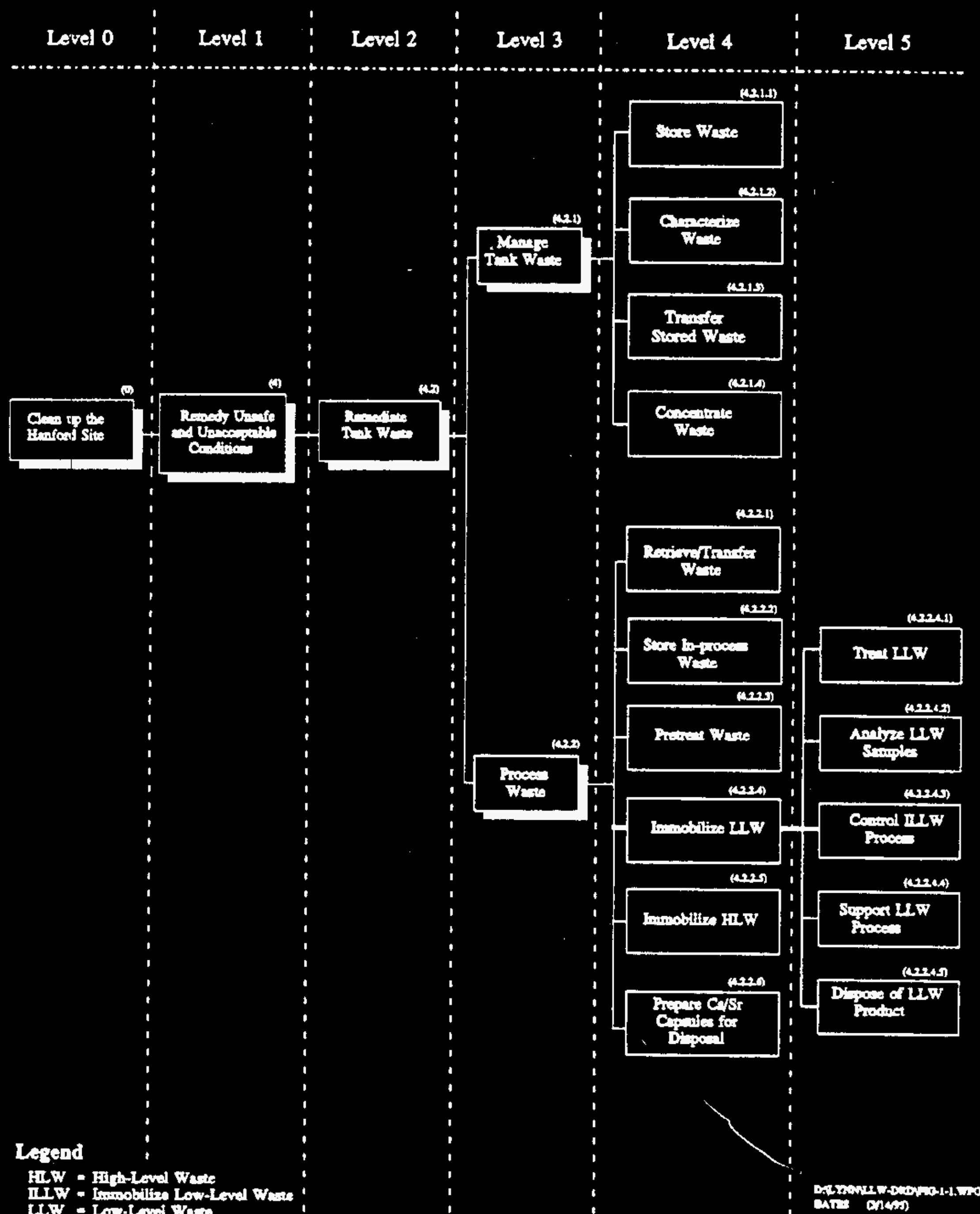
Following the allocation of specific TRS functions to a project, a design requirements document (DRD) will be produced. A preliminary DRD has been prepared for the LLWVP Project (WHC-SD-W378-DRD-001, *Preliminary Design Requirements Document for the Low-Level Waste Vitrification Plant, Project W-378* [Swanson 1995]). Design requirements documents accomplish several purposes. First, they contain the functions and requirements for a single project in a single document, for convenience. Second, TRS project data are organized into an easily readable specification format. Third, TRS project data are expanded and explained to a degree suitable for providing direction to a project Architect-Engineer.

## 2.3 TWRS LLW STRATEGY

The overall strategy for the LLW disposal program is to use mature, commercially available technologies or systems whenever possible; modify or enhance existing technologies; develop technologies when none exist; and provide a technically defensible basis for the immobilization and disposal of low-level tank wastes (Bledsoe and Kruger 1995).

Throughout the system's life cycle, teams using the systems engineering process work together to develop the technical baseline. The teams include specialists from specialty and engineering disciplines. Examples of specialty

Figure 2-1 Tank Waste Remediation System Systems Engineering Functional Hierarchy.



disciplines are regulatory compliance, safety, value engineering, operations, decontamination and decommissioning, and training.

The TWRS Functions and Requirements document (RL 1994a) defines the TWRS mission parameters.

Alternative technologies will be investigated on a case-by-case basis for their viability to the program. This strategy supports the tight schedule and intent of the Tri-Party Agreement. Outside consultants will be used to aid in glass formulation, melter selection, performance assessment, and disposal systems. The consultants will lend the experience of commercial glass making and equipment design to the process. In the case of the performance assessment and evaluation of disposal systems, they will provide a constant vigilance to technically defensible work and adherence to rigid standards. It is envisioned that this involvement will aid in external peer review and with the general public.

Creative and innovative methods will be evaluated during the design and construction of the LLWVP. This may include 'commercialization' (design, build, and operate with government funds); 'privatization' (use of private capital to build and operate a vitrification facility, and deliver a specified waste form for negotiated fee); and/or the traditional method of DOE contracting techniques.

The use of private capital to build and operate a facility is becoming increasingly attractive to the DOE. The concept is based on the existence of corporate entities willing to accept waste from the Hanford Site operations and return a waste form that meets predetermined performance criteria. Many points of the strategy remain the same, but they become the responsibility of the contracted private operator. The basic premise is that a mature technology exists for this process and that a private entity would be willing to undertake the operation within the schedule constraints of the existing Tri-Party Agreement. For more information on privatization, see section 19.3.

The principles which guide the development of the performance assessment will also be used to guide the development of the design work. As the melter design, glass formulation, waste glass package design, and disposal site design proceed, the information will be transmitted to the performance assessment developers. The design information may then be processed to detect any deficiencies, with respect to environmental protection, which will require design modification.

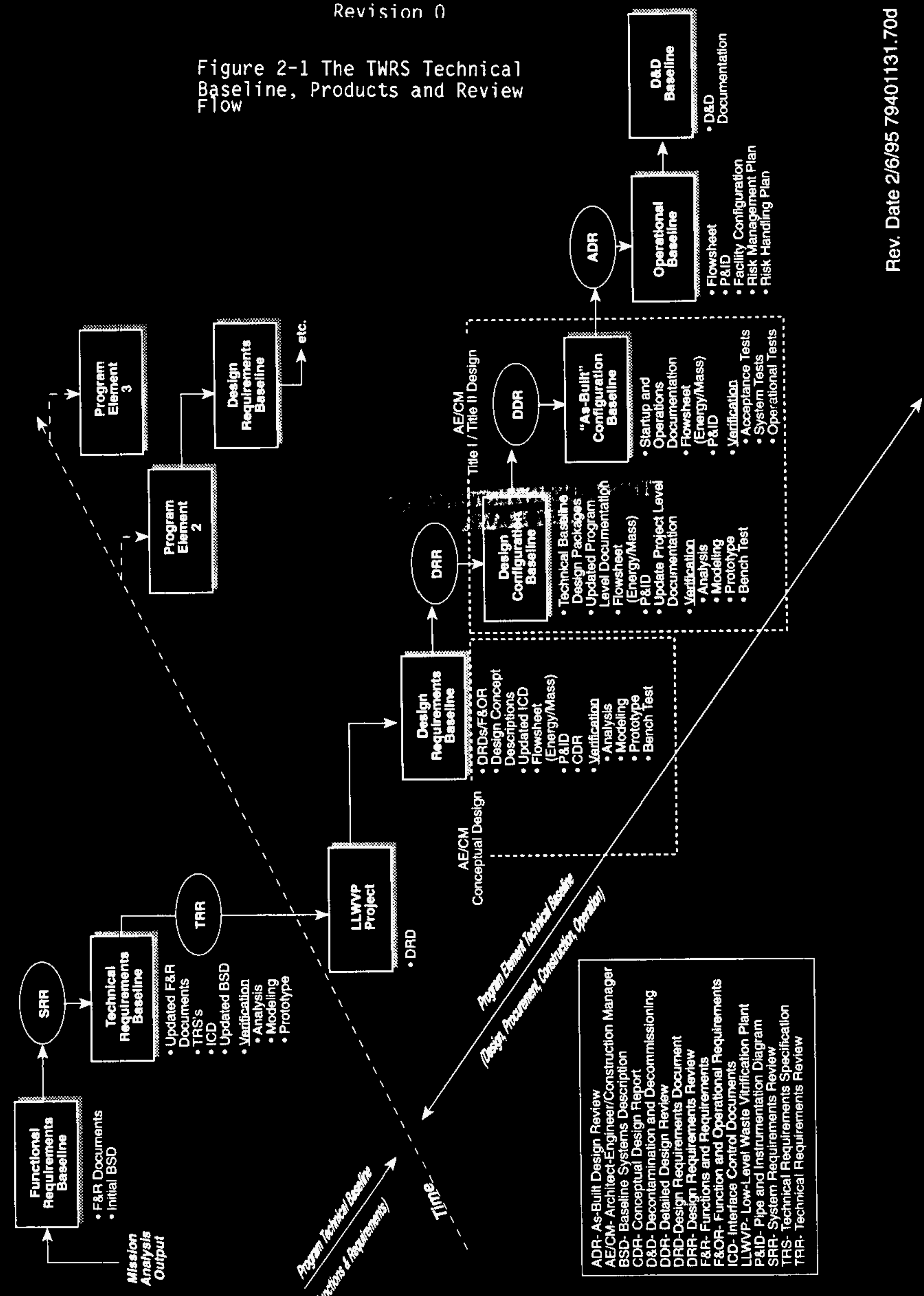
This program is a part of the overall TWRS mission to comply with the Tri-Party Agreement and, specifically, to allow for the timely treatment of the low-level fraction of tank wastes.

## 2.4 LLW LOGIC DIAGRAMS

One segment of the LLW program development planning is shown in logic diagrams in the Appendix. This planning outlines the current (1995) program strategy in diagram form as derived from systems engineering. It is intended that the planners, program personnel, and cost account managers (CAM) get a better idea of the logic ties of the program by reviewing these diagrams, which are designed to help the CAMs plan their work for the next year and serve as a cross check that the work was done logically during the present year.

The intent of the LLW logic diagrams is to illustrate the effects of one part of the LLW program on the other parts of the program. As the program changes, it will be easier to track and compensate for the modification through the use of the logic diagrams.

Figure 2-1 The TWRS Technical Baseline, Products and Review Flow



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# 3.0 FLOWSHEET SUMMARY

This section provides a summary of the process for the Hanford Site TWRS with emphasis on LLW vitrification. The process entails characterizing, retrieving, treating, and disposing of 234,000 MT (not including water) of chemicals contained in 149 SSTs and 28 DSTs. A very small mass fraction of the waste is actually radioactive. To the extent possible, with simple separations technology, the waste is segregated into a low-activity fraction containing the bulk of the nonradioactive constituents, and a high-activity fraction containing a relatively small percentage of the nonradioactive constituents. The high-activity/TRU fraction is stored in underground tanks until the HLW treatment facility is operational. The HLW is vitrified and stored onsite pending removal to a national geologic repository. The low-activity fraction is vitrified and disposed of on the Hanford Site.

The process uses large amounts of water for retrieving and transferring waste to processing facilities. Water is recycled extensively within the process. Water that cannot be recycled or reused is treated and released to the environment. Offgas generated during vitrification are scrubbed, filtered, treated for appropriate pollutants, and released to the environment.

A summary process flow diagram (PFD) and mass balance are shown in Figure 3-1. A detailed PFD and mass balance may be found in Orme (1994).

This flowsheet will be revised as development work and technology selection in support of the TWRS mission progress. The flowsheet reflects pretreatment requirements as defined on this documents reference definition date; other requirements may be added later. The LLW and HLW treatment, and the LLW disposal depicted in the flowsheet, are tentative.

## 3.1 GENERAL FLOWSHEET SUMMARY

### 3.1.1 Retrieve Waste

Waste can be retrieved from the tanks by hydraulic, mechanical, or pneumatic methods. Hydraulic methods (sluicing and mixer pumps) are selected as the primary systems for retrieving tank wastes because they have been demonstrated and are compatible with the underground pipe transfer system available at the Hanford Site. The waste will be slurried to retrieval annexes, conditioned as necessary to prepare slurries for long-distance transfers, and pumped to storage/treatment facilities. The retrieved volume of waste is 595 x $10^6$ L of nominal 5*M* Na solution carrying 17,200 MT of undissolved solids.

Waste will be retrieved from DSTs and SSTs to the extent required for final closure of the waste tanks. The closure requirements have not been fully specified; the initial retrieval goal is 99% removal.

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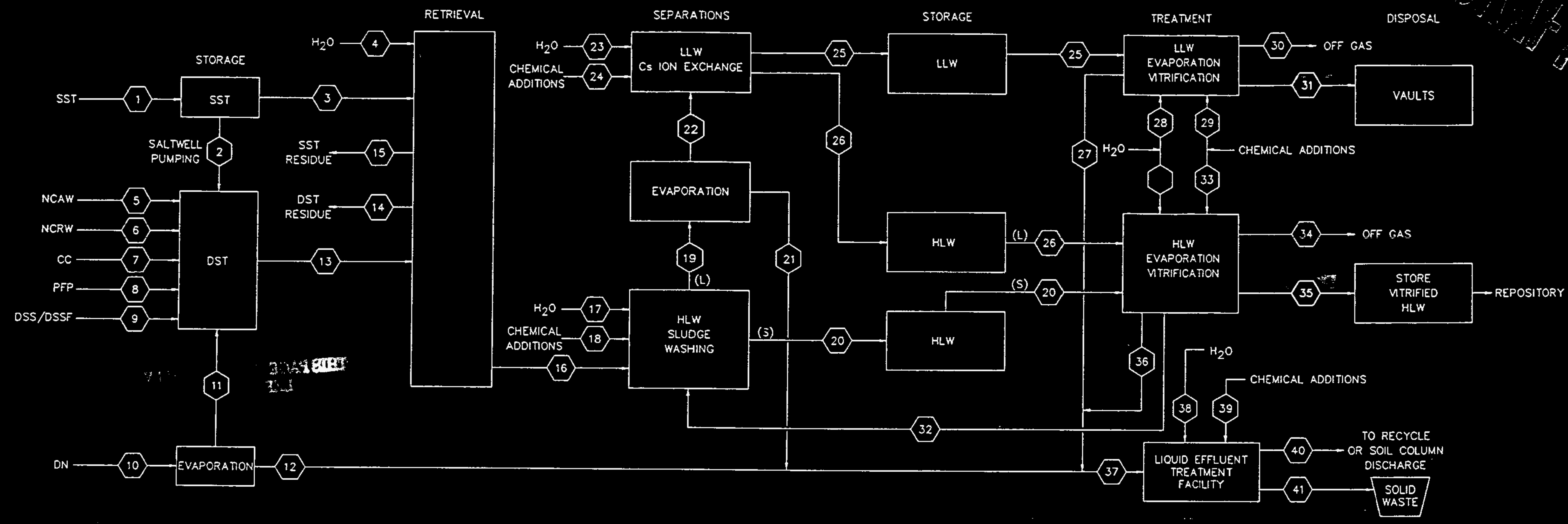
Figure 3-2 TWRS COMBINED FACILITY TOP-LEVEL FLOW DIAGRAM (JOULE HEATED HLW MELTER)




Joule-Heated Melter, Combined Separations, Parallel HLW & LLW Vitrification, 20-8% Solids Wash, Enhanced Sludge Wash, >45 wt% WOL in HLW, 25 wt% $Na_2O$ in LLW (3 H2O washes)

| STREAM NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Mass Flow (MT) | 1.85E+5 | | 1.83E+5 | 4.42E+5 | 8.52E+3 | 3.73E+3 | 2.69E+4 | 7.93E+1 | 8.06E+4 | 3.64E+4 | 6.36E+3 | 2.74E+4 | 1.26E+5 | 1.00E+1 |
| Component Flow (MT) | | | | | | | | | | | | | | |
| Al, (MT) | 2.60E+3 | | 2.57E+3 | | 6.74E+1 | 1.59E+1 | 5.56E+2 | 1.71E+1 | 1.54E+3 | 6.96E+1 | 6.96E+1 | | 2.27E+3 | 2.00E-1 |
| Fe, (MT) | 7.20E+2 | | 7.13E+2 | | 5.94E+1 | 2.89E+0 | 2.88E+1 | 9.30E+0 | 1.13E+0 | 4.68E+0 | 4.68E+0 | | 1.06E+2 | 1.00E-2 |
| Cr, (MT) | 9.70E+1 | | 9.60E+1 | | 6.25E+0 | 4.11E+0 | 2.56E+1 | 9.31E+0 | 2.30E+1 | 7.00E-1 | 7.00E-1 | | 6.90E+1 | 6.50E-3 |
| Na, (MT) | 5.10E+4 | | 5.05E+4 | | 5.89E+2 | 4.55E+2 | 4.51E+3 | 5.98E+1 | 1.13E+4 | 8.66E+2 | 8.66E+2 | | 1.78E+4 | 1.60E+0 |
| Si, (MT) | 4.60E+2 | | 4.56E+2 | | 5.33E+0 | 1.47E+1 | 3.09E+1 | 9.50E-1 | 8.12E+0 | | | | 6.00E+1 | 5.80E-3 |
| P, (MT) | 1.50E+3 | | 1.49E+3 | | 1.63E+1 | | 3.52E+1 | 7.73E+0 | 1.16E+1 | | | | 7.08E+1 | 7.00E-3 |
| NO2- and NO3-, (MT) | 1.00E+5 | | 9.90E+4 | | 5.37E+2 | 1.76E+2 | 4.97E+3 | 8.62E+1 | 1.40E+4 | 1.82E+3 | 1.82E+3 | | 2.16E+4 | 1.70E+0 |
| H2O, (MT) | 4.80E+3 | | 4.75E+3 | 4.42E+5 | 6.54E+3 | 2.00E+3 | 1.34E+4 | 4.84E+2 | 4.41E+4 | 3.10E+4 | 3.60E+3 | 2.74E+4 | 7.01E+4 | 5.30E+0 |
| Radionuclides | | | | | | | | | | | | | | |
| Cs and Ba, (MCi) | 3.47E+1 | | 3.43E+1 | | 2.52E+1 | 7.71E-1 | 1.42E+1 | 3.72E-1 | 2.58E+1 | Trace | Trace | Trace | 6.63E+1 | 6.60E-3 |
| Sr and Y, (MCi) | 1.13E+2 | | 1.12E+2 | | 2.16E+1 | 1.40E-1 | 3.78E+0 | 1.76E-1 | 6.12E-2 | Trace | Trace | Trace | 2.58E+1 | 2.60E-3 |
| Tc, (kCi) | 8.02E+0 | | 1.60E+1 | | 4.40E+0 | | 1.00E+1 | 2.85E-1 | 9.30E+0 | Trace | Trace | Trace | 2.40E+1 | 2.40E-3 |
| TRU, (kCi) | 6.12E+1 | | 6.06E+1 | | 6.09E+1 | 2.98E+0 | 1.69E+1 | 3.90E+1 | 2.00E+0 | Trace | Trace | Trace | 1.22E+2 | 1.20E-3 |
| Total MCi | 1.48E+2 | | 1.46E+2 | | 4.69E+1 | 9.11E-1 | 1.80E+1 | 5.87E-1 | 2.59E+1 | Trace | Trace | Trace | 9.23E+1 | 9.20E-3 |
| HLW Casks (10 m^3) | | | | | | | | | | | | | | |
| HLW Canisters (1.1 m^3) | | | | | | | | | | | | | | |
| LLW Vaults (5300 m^3) | | | | | | | | | | | | | | |

| STREAM NUMBER | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Mass Flow (MT) | 6.27E+3 | 7.51E+5 | 3.92E+5 | 3.34E+4 | 1.11E+6 | 1.49E+5 | 4.71E+5 | 6.29E+5 | 4.32E+5 | 1.39E+4 | 1.07E+6 | 4.88E+3 | 1.12E+6 | 1.16E+5 |
| Component Flow (MT) | | | | | | | | | | | | | | |
| Al, (MT) | 2.60E+1 | 4.84E+3 | | | 4.13E+3 | 7.16E+2 | .48 | 4.13E+3 | | | 4.11E+3 | 7.95E+0 | .41 | |
| Fe, (MT) | 7.20E+0 | 8.19E+2 | | | 1.67E-1 | 8.04E+2 | | 1.67E+1 | | | 9.92E+0 | 6.77E+0 | | |
| Cr, (MT) | 9.70E-1 | 1.65E+2 | | | 1.32E+2 | 3.23E+1 | | 1.32E+2 | | | 1.32E+2 | 3.30E-1 | | |
| Na, (MT) | 5.10E+2 | 6.83E+4 | | 9.56E+3 | 7.61E-4 | 1.72E+3 | 1.753 | 7.61E+4 | | 2.55E+3 | 7.84E+4 | 2.58E+2 | 9.53 | |
| Si, (MT) | 4.60E+0 | 5.06E+2 | | | 2.57E-1 | 4.89E+2 | | 2.57E+1 | | 2.04E+1 | 1.35E+1 | 3.26E+1 | | |
| P, (MT) | 1.50E+1 | 1.89E+3 | | | 1.67E-3 | 2.14E+2 | | 1.67E+3 | | | 1.67E+3 | 2.59E+0 | | |
| NO2- and NO3-, (MT) | 1.00E+3 | 1.21E+5 | | 1.65E+2 | 1.20E+5 | 1.30E+3 | .46 | 1.20E+5 | | 2.86E+3 | 1.21E+5 | 1.60E+3 | 14.7 | |
| H2O, (MT) | 4.47E+3 | 5.17E+5 | 3.92E+5 | 1.65E+4 | 8.66E+5 | 1.36E+5 | 4.71E+5 | 3.90E+5 | 4.32E+5 | 6.45E+3 | 8.23E+5 | 2.79E+3 | 1.12E+6 | 1.16E+5 |
| Radionuclides | | | | | | | | | | | | | | |
| Cs and Ba, (MCi) | 3.47E-1 | 1.00E+2 | | | 9.57E-1 | 1.11E+1 | Trace | 9.57E+1 | | | 7.69E-1 | 9.49E+1 | Trace | |
| Sr and Y, (MCi) | 1.13E+0 | 1.40E+2 | | | 6.35E+0 | 1.34E+2 | Trace | 6.35E+0 | | | 5.05E+0 | 1.30E+0 | Trace | |
| Tc, (kCi) | 8.02E-2 | 3.99E+1 | | | 3.54E+1 | 9.15E+0 | Trace | 3.54E+1 | | | 3.50E+1 | 4.07E-1 | Trace | |
| TRU, (kCi) | 6.12E-1 | 1.85E+2 | | | 9.46E+0 | 1.76E+2 | Trace | 9.46E+0 | | | 7.97E+0 | 1.48E+0 | Trace | |
| Total MCi | 1.48E+0 | 2.41E+2 | | | 1.02E+2 | 1.46E+2 | Trace | 1.02E+2 | | | 5.86E+0 | 9.62E+1 | Trace | |
| HLW Casks (10 m^3) | | | | | | | | | | | | | | |
| HLW Canisters (1.1 m^3) | | | | | | | | | | | | | | |
| LLW Vaults (5300 m^3) | | | | | | | | | | | | | | |

| STREAM NUMBER | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Mass Flow (MT) | 7.37E+5 | 2.61E+5 | 5.69E+5 | 7.73E+4 | 1.78E+4 | 6.49E+3 | 2.26E+4 | 6.68E+4 | 1.68E+6 | 1.68E+4 | 1.90E+4 | 1.69E+6 | 1.00E+4 |
| Component Flow (MT) | | | | | | | | | | | | | |
| Al, (MT) | 7.07E+3 | 4.48E-6 | 1.12E+4 | 1.34E+0 | | | 7.23E+2 | | | | | | |
| Fe, (MT) | | | 8.44E+0 | 1.50E+0 | | | 8.09E+2 | | | | | | |
| Cr, (MT) | | 5.30E-8 | 1.32E+2 | 6.04E-2 | | | 3.26E+1 | | | | | | |
| Na, (MT) | | 3.14E-5 | 7.84E+4 | 6.02E+0 | | | 1.99E+3 | | | | | | |
| Si, (MT) | 1.16E+5 | 4.64E-5 | 1.16E+5 | 9.07E+0 | 4.38E+3 | | 4.90E+3 | | | | 1.10E+1 | | |
| P, (MT) | | 6.67E-7 | 1.67E+3 | 4.01E-1 | | | 2.17E+2 | | | | | | |
| NO2- and NO3-, (MT) | | | | 5.18E+2 | | | | | | | | | |
| H2O, (MT) | | 1.41E+4 | | 7.67E+4 | 1.51E+3 | 4.92E+1 | | 6.68E+4 | 1.68E+6 | 1.68E+4 | 1.90E+4 | 1.69E+6 | 1.00E+4 |
| Radionuclides | | | | | | | | | | | | | |
| Cs and Ba, (MCi) | | Trace | 7.68E-1 | 6.82E+0 | | Trace | 9.91E+1 | Trace | 2.40E-3 | | | Trace | 2.40E-3 |
| Sr and Y, (MCi) | | Trace | 5.04E+0 | 2.55E-1 | | Trace | 1.34E+2 | Trace | 3.10E-5 | | | Trace | 3.10E-5 |
| Tc, (kCi) | | Trace | 3.48E+1 | 4.70E+0 | | Trace | 4.83E+0 | Trace | 4.00E-2 | | | Trace | 4.00E-2 |
| TRU, (kCi) | | Trace | 7.98E+0 | 3.28E-1 | | Trace | 1.77E+2 | Trace | 1.30E-5 | | | Trace | 1.30E-5 |
| Total MCi | | Trace | 5.85E+0 | 7.08E+0 | | Trace | 2.34E+2 | Trace | 2.40E-3 | | | Trace | 2.40E-3 |
| HLW Casks (10 m^3) | | | | | | | 1,100 | | | | | | |
| HLW Canisters (1.1 m^3) | | | | | | | 7,800 | | | | | | |
| LLW Vaults (5300 m^3) | | | 43 | | | | | | | | | | |

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### 3.1.2 Transfer Waste

The slurried SST waste will be transported by pipeline. In the 200 West Area, a Waste Staging and Sampling Facility (WSSF) will be required to accumulate batches of retrieved waste sufficiently large for cross-site transfer. The SY Tank Farm is tentatively identified for this purpose.

### 3.1.3 Store Waste

The SST waste will be retrieved into DSTs. The DST system provides lag storage for feed to pretreatment operations. In the 200 West Area, this storage is provided in the SY Tank Farm.

A major assumption of this flowsheet is that it will be possible to operate a close-coupled LLW pretreatment and LLW vitrification process by "on-the-fly" process control with the capability to rework out-of-spec glass.

### 3.1.4 Pretreat Wastes

Enhanced sludge washing is assumed to be adequate to achieve an acceptable volume of HLW. This process involves settling and decanting retrieved waste, leaching the settled solids with concentrated NaOH, and washing the solids with a dilute caustic solution. Enhanced sludge washing takes advantage of the amphoteric property of certain waste components [$Al(OH)_3$ and $Cr(OH)_3$] to leach them from the solids. It also exploits the relative solubility of certain compounds to metathesize $PO_4^{-3}$ from the solids. The enhanced sludge-washing process reduces 17,200 MT of solids to 12,000 MT of washed solids. Solid-liquid separations are by solids settling and decanting of the supernate liquid.

Processes for removing other constituents from the waste (e.g., technetium) are being investigated and developed but they are not included in this general flowsheet. An option to the in-tank sludge washing is pretreatment out of tank, which includes filtration to ensure solids separation. In-tank sludge washing is the baseline process.

Waste supernates and wash liquors are treated by ion exchange to remove radioactive Cesium ($Cs^{137}$). The Cesium depleted product is to be fed to LLW immobilization. Washed sludge are fed to HLW immobilization.

### 3.1.5 Immobilize LLW

The ion exchange effluent and several other dilute process waste streams are combined and concentrated by evaporation. LLW immobilization is by vitrification. The vitrified waste is tentatively assumed to be a cullet for the purpose of the first flowsheet. The cullet is accumulated in bins and air dried in a cullet storage facility. The dried cullet is mixed with a binder and pumped to a near surface facility (disposal vault) for onsite disposal. Offgas treatment includes quenching, removal of particulates and $SO_2$, and reduction of $NO_x$.

### 3.1.6 Dispose of LLW

Specific Tri-Party Agreement and internal technical direction is currently limited to requiring that the LLW be disposed of in glass and in a retrievable form. For flowsheet evaluations (Orme 1994), LLW glass cullet is mixed with a re-meltable sulfur polymer cement (SPC) binder and disposed of in monolithic form in vaults. Evaluation of disposal alternatives is in progress therefore the flowsheet is tentative. Further study may identify alternatives that are more attractive. For example, an alternate disposal concept might be retrievable packages of cullet without a binder, or as glass logs, placed in retrievable storage/disposal. See Section 14.0 for more information.

## 3.2 TECHNICAL ASSUMPTIONS AND BASIS

Assumptions for development of the TWRS flowsheet are listed in WHC-SD-WM-TI-613, *TWRS Process Flowsheet* (Orme 1994). General LLW vitrification input was derived from the following:

- Systems engineering (see Section 2.1)
- Alumkal (1994) (also see Section 2.1)
- Federal, state, and DOE regulation or orders (see Section 7.0).

## 3.3 CRITICAL ASSUMPTIONS

Immobilize LLW

- Glass as LLW form will be developed and implemented.

- Radionuclides will be removed from the LLW stream to permit construction of a low-shielding LLW vitrification facility if practical. The cost of radionuclide removal versus the cost of shielding for LLW vitrification must be evaluated.

- Grout will not be used for disposal of LLW unless a situation arises requiring that tank space be freed before new tanks are available in the 200 West Area.

Dispose LLW

- LLW will be disposed of as a retrievable glass waste form in onsite, near-surface disposal.

### 3.3.1 Status

The flowsheet continues to evolve as engineering and development continue.

### 3.3.2 Options which Affect LLW

Some major process areas that are being evaluated are in-tank versus out-of-tank pretreatment, the type of melter to be used for LLW, the waste form, and packaging of the waste form.

### 3.3.3 Future Plans

A revision of the Orme (1994) flowsheet is expected in September 1995. It is anticipated that more information will be available at that time. For example, several more varied inventory evaluations that will assist in the analysis of flexibility of the system will be available in 1995.

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# 4.0 SITE SELECTION AND CHARACTERIZATION

## 4.1 TWRS COMPLEX

A schematic of the Hanford Site and TWRS interest areas is shown in Figure 4-1, which functionally depicts the "TWRS Complex" required to carry out the single- and double-shell tank remediation effort. The complex will require the construction and operation of major pretreatment and vitrification plants along with supporting facilities and infrastructure. The need for a complex was identified so that all elements of the remediation mission could be considered from a systematic and centralized perspective rather than an individual project standpoint to ensure (1) separate TWRS projects are properly integrated physically and sequenced to meet the overall TWRS mission, and (2) common systems are used to the extent needed to facilitate design, construction, and operations. This approach has the following advantages:

- Ensures conflicting space needs and construction support areas are properly considered
- Eliminates duplication of support facilities
- Addresses common needs for area and consolidates infrastructure service functions to save money and construction time, and to minimize site size
- Establishes project and site interfaces within TWRS and with the remainder of the Hanford Site
- Provides the bases for an infrastructure project to supply all utilities, services, and centralized process control and monitoring for TWRS waste remediation activities.

## 4.2 200 AREAS

As described in RL-W94-044, *Hanford Site Development Plan* (RL 1994c) and DOE/RL-92-29, *Hanford 200 Areas Development Plan* (RL 1993), and shown in Figure 4-2, the Hanford Site 200 Areas (Central Plateau) reflects land that has been heavily used for fuel reprocessing and waste management and disposal activities. As such, the 200 Areas (specifically the 200 East and 200 West Areas) will be dedicated for future site-wide waste disposal and tank waste remediation activities. *The Future for Hanford: Uses and Cleanup--The Final Report of the Hanford Site Uses Working Group* (Drummond 1992) included the following recommendations relative to the waste management function of the Central Plateau.

- Waste management, storage, and disposal activities should be concentrated within the 200 Areas whenever feasible to minimize the amount of land devoted to, or contaminated by, waste management activities. When bringing wastes to the area, adverse effects should be minimized, especially to currently uncontaminated areas of the Central Plateau.

Figure 4-1

# Hanford Tank Waste Remediation System Strategy

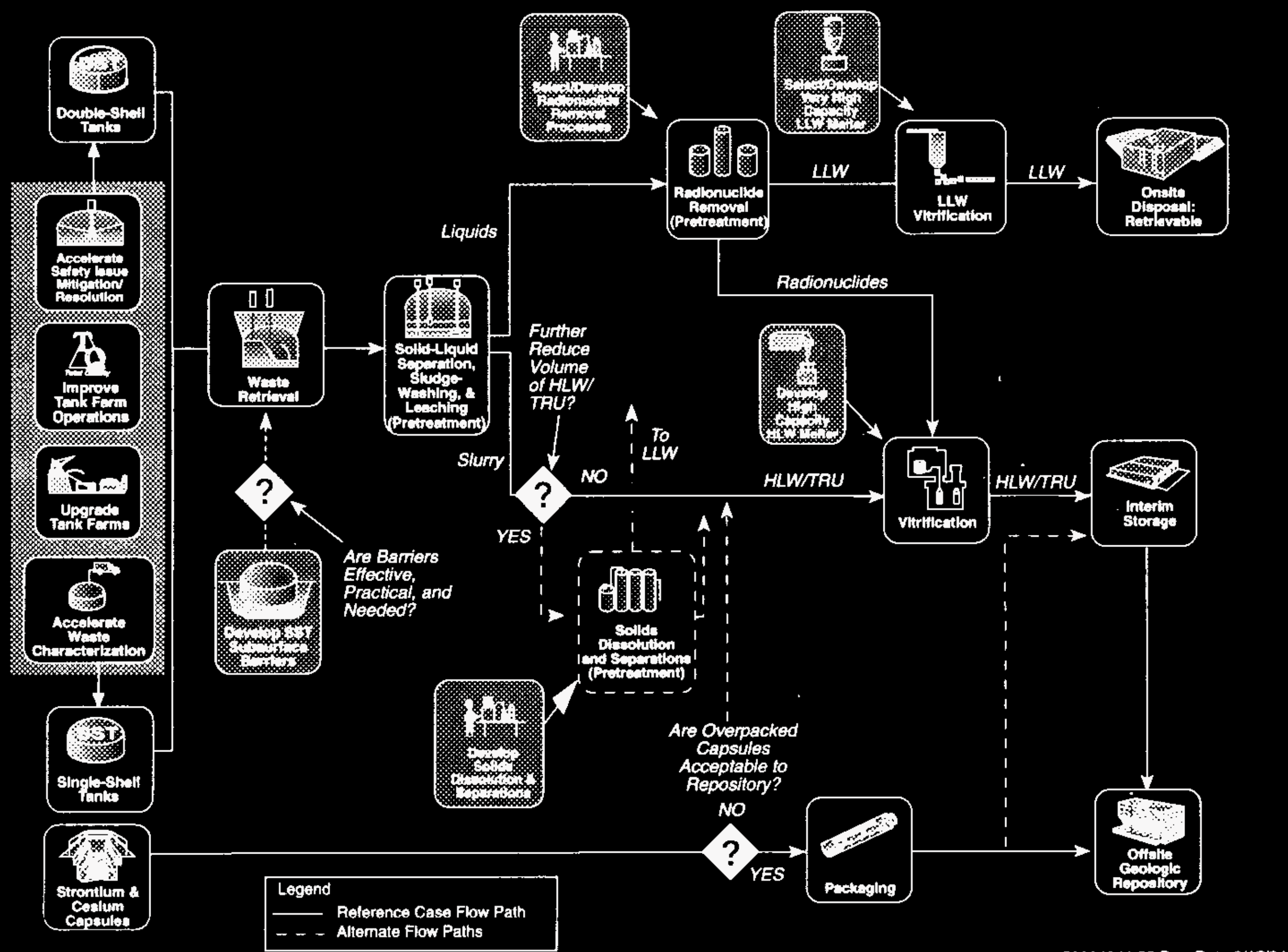
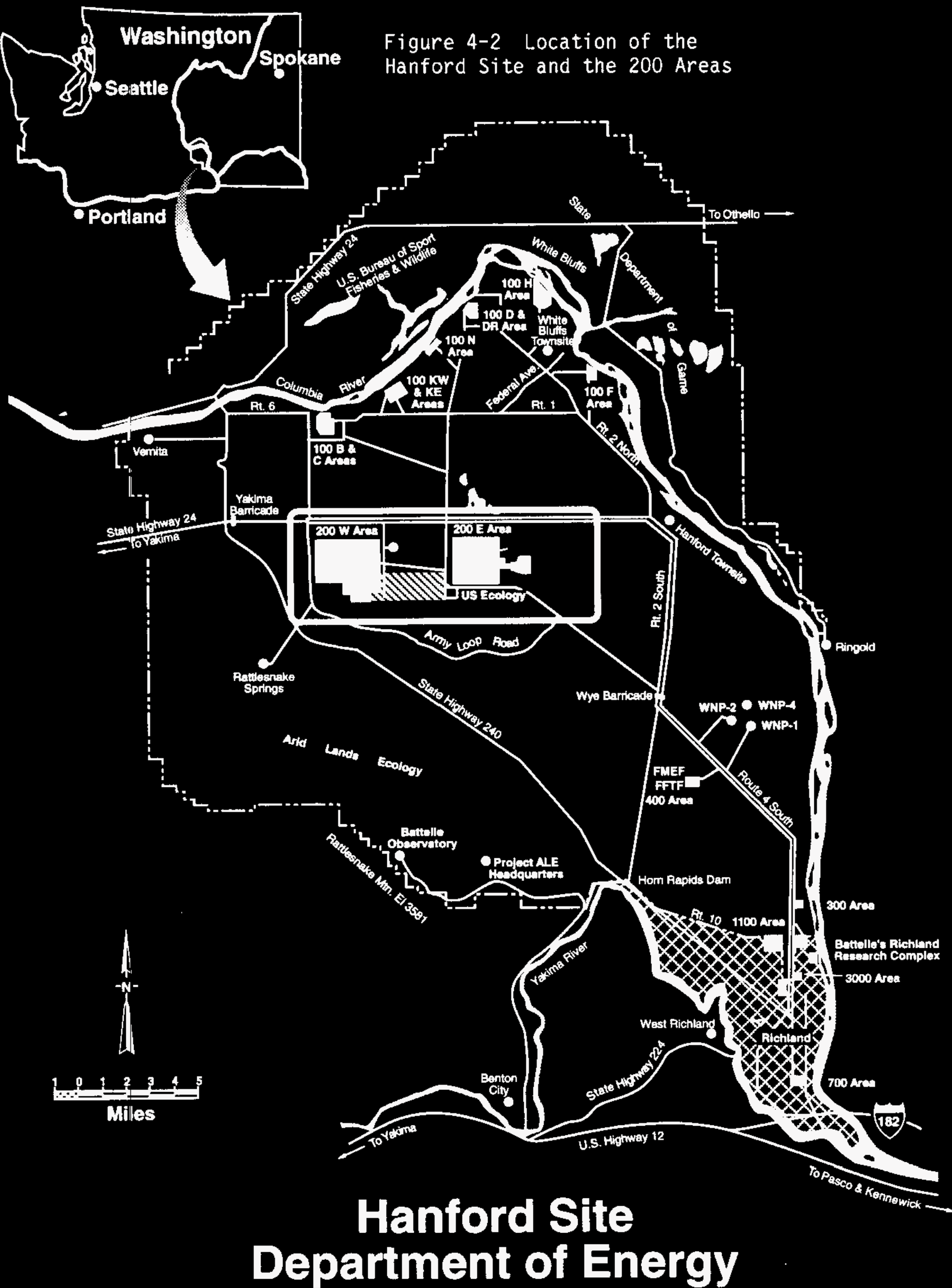


Figure 4-2 Location of the Hanford Site and the 200 Areas



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- The waste management area would encompass the "squared off" boundaries of the current 200 East and West Areas (expanded to include the area to the east of the 200 East Area where grout vaults were planned to be located).

- The remainder of the Central Plateau, including the 200 North Area, that encircles the waste management area would be designated a "buffer" area to reduce the risks that are expected to continue to emanate from the waste management area. In this case "risks" are interpreted to be slow migration of radionuclides through the soil and ground water to the off-site environment.

## 4.3 200 EAST AREA LOCATION

Based on the information presented in Section 4.2, the TWRS Complex would be located within/adjacent to the 200 East or 200 West Areas. The 200 East Area location was selected for the following reasons.

- Based on WHC-SD-WM-ES-295, *Tank Waste Remediation System Facility Configuration Study* (Boomer 1994) and WHC-SD-WM-TI-613, *TWRS Process Flowsheet* (Orme 1994), pretreatment of tank waste would be done by the in-tank sludge-washing process in the 200 East A Farm Tank Complex. Tank waste from the 200 West Area would be retrieved to the SY Tank Farm and transferred cross-site to the 200 East AW Tank Farm where in-tank sludge washing would be performed. Waste in the 200 East Area would be retrieved to the AN Tank Farm where it would be washed and separated into HLW and LLW streams. The LLW streams would be pumped to the AP Tank Farm and then to the pretreatment and LLW vitrification facilities. The HLW streams would be pumped directly from the AN and AW Tank Farms to the HLW vitrification facility, or to interim storage.

- Throughout the past 20 years, the Hanford Site has consolidated activities in the 200 East Area (as opposed to the 200 West Area), which has placed much of the necessary facilities and infrastructure in and around the 200 East Area.

- There is more available/useable land in the 200 East Area than the 200 West Area, i.e., land that is unused or is reserved for other use.

## 4.4 TWRS COMPLEX SITE LOCATION

An evaluation of the available area for the TWRS Complex within/adjacent to the 200 East Area, based on TWRS area and expansion needs and planned development, was conducted. The evaluation was conducted in accordance with applicable DOE and WHC procedures. A systems engineering process was used and a site evaluation team formed that reflected organizations/personnel either responsible for, or knowledgeable of, assigned site criteria.

Based on site location factors (available/useable land and infrastructure), operational considerations, and the size of known/anticipated projects that would comprise the TWRS Complex, six alternative sites were selected for evaluation within, and adjacent to, the 200 East Area. The sites were evaluated by the site evaluation team using stakeholder value-based selection criteria and associated performance measurements. A site selection comparison matrix was constructed to summarize the evaluations and compare the ranking of the alternative sites. The three highest ranked sites were further evaluated to arrive at a recommendation.

The recommended location for the TWRS Complex is shown in Figure 4-3. It was ranked the highest and had the most desirable features of the candidate sites. In general, the process facilities for pretreatment and vitrification of tank wastes and closely related support facilities would be located central to the 200 East Area on essentially vacant land between the 200 East Area power plant and Plutonium-Uranium Extraction (Facility) (PUREX) plant. The remaining, distant, shared, support facilities would be located to maximize use of infrastructure recently constructed by the Hanford Waste Vitrification Plant.

## 4.5 LLW LOCATION

Subsequent to recommending an area for the TWRS Complex, several work efforts were undertaken to locate specific sites within the complex for the treatment-related facilities. One of the efforts to identify specific treatment facility sites (upon which the characterization plan to collect the data necessary to support the final performance assessment of the LLW disposal facility is based) is documented in WHC-SD-W378-ES-002, *Facility Design Philosophy: TWRS Process Support and Infrastructure Definition*, Draft (Leach 1995). Figure 4-4 (taken from WHC-SD-W378-ES-002 [Draft]) identifies a preliminary site plan for the TWRS treatment facilities including the LLW facilities.

## 4.6 SITE CHARACTERIZATION

Site characterization of a new disposal site is required by DOE Order 5400.1, *General Environmental Protection Program* (DOE 1988a), and is necessary to fully implement DOE/RL 89-12, *Hanford Site Groundwater Protection Management Program* (DOE-RL 1989). In addition, the DOE guidance on the management of LLW (DOE 1990a) indicates that a complete environmental monitoring program for a disposal site should consist of four phases, which correspond to the four phases in the life cycle of the disposal site: (1) site characterization, (2) preoperational monitoring, (3) operational, and (4) post-operational.

The site characterization phase is the first step designed to ensure that the site can be designed, operated, closed, and controlled after closure so "that a reasonable assurance exists that exposure to humans is within limits established by performance objectives" (DOE 1990b). This goal is accomplished through the performance assessment with in situ characterization data.

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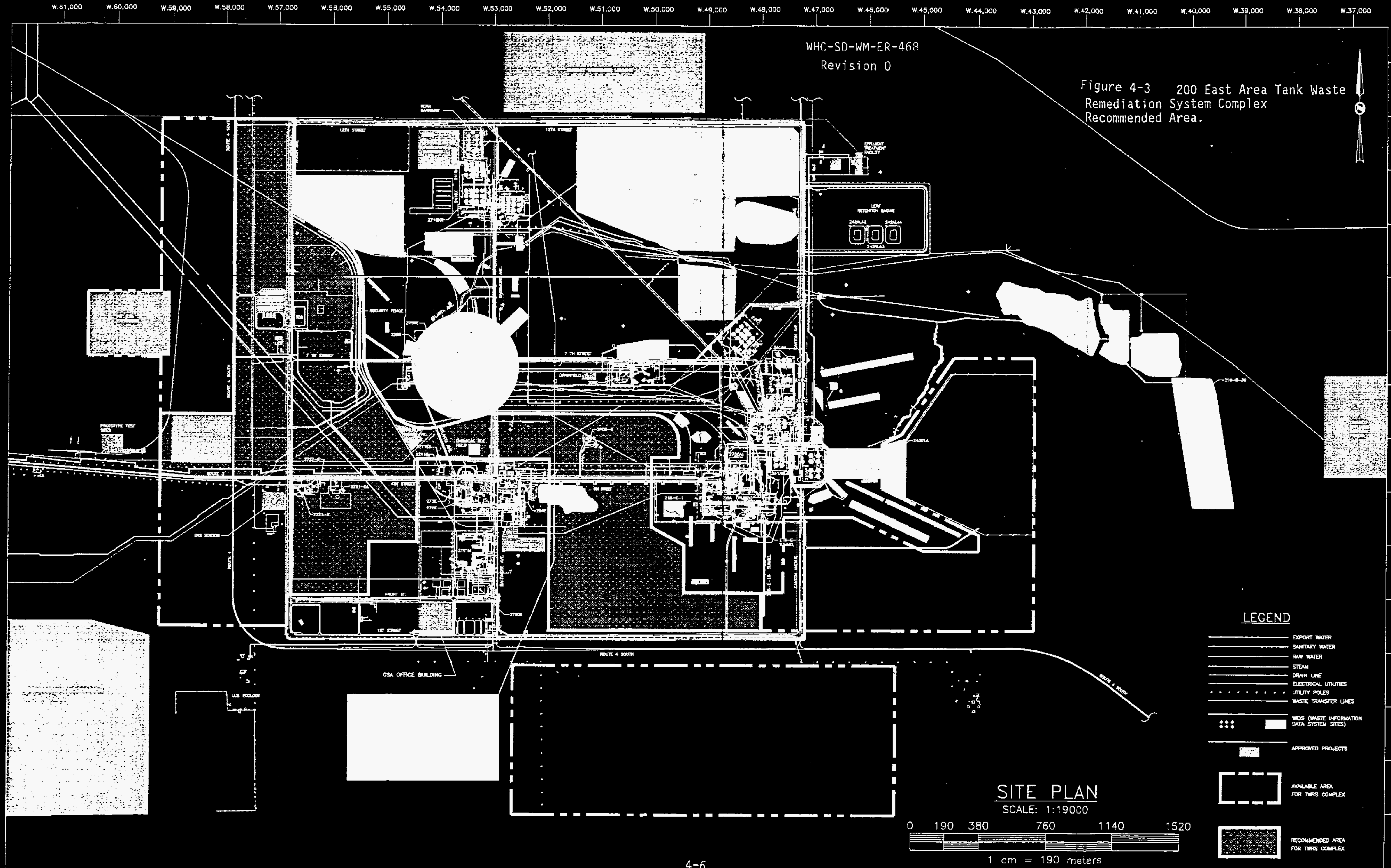
Figure 4-3 200 East Area Tank Waste Remediation System Complex Recommended Area.



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| CADFILE: | ZRBT0343 |
| DATE: | 1-3-95 |
| CUSTOMER: | AL SHORD |
| DRAWN BY: | RAFAEL TORRES |
| TITLE: | 200 EAST TWRS COMPLEX RECOMMENDED AREA |

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The Site Characterization Plan presents a program to characterize the area designated for the TWRS Treatment Complex (see Figure 4-4) that is located in the south central portion of the 200 East Area. The major focus of the Site Characterization Plan is on characterization of the vadose zone at and near the Low-Level Tank Waste Disposal Site (LLTWDS) portion of the TWRS Treatment Complex. However, it also includes data collection supporting the near-surface *preoperational baseline* or characterization program for the entire TWRS Treatment Complex and the uppermost aquifer at the LLTWDS. Groundwater and vadose zone monitoring plans for the LLTWDS are included as part of the overall characterization plan. An extensive database exists for the Hanford Site from past site characterization activities. All, except site-specific data needs, are deemed adequate for characterization of the TWRS Treatment Complex.

The purpose of site characterization is to (1) determine the physical and chemical properties of the vadose zone and upper part of the saturated zone at, and in, the immediate vicinity of the proposed LLTWDS in support of the Hanford Low-Level Tank Waste performance assessment (HLLTWPA), and (2) to screen the TWRS Treatment Complex for shallow, buried material or near-surface contamination from past activities.

The objective of the vadose and saturated zone characterization is to develop a conceptual geohydrologic model of the LLTWDS for use in the HLLTWPA. The geohydrologic model will include geologic, hydrologic, and hydrochemical parameters determined as part of the data quality objectives (DQO) process (EPA 1992). The conceptual model will be used in the final performance assessment to model the movement of moisture and contaminants through the vadose zone. The characteristics of the saturated zones, as well as results of in situ testing, will be used in groundwater modeling.

## 4.6.1 DQO Process

The DQO process as applied to the Site Characterization Plan is used to specify the type, quantity, and quality of subsurface data (for example: physical and hydrological properties, numbers and types of drilling samples) needed to support decisions related to the suitability of the site for long-term disposal of LLW. The primary purpose or function of DQOs is to ensure that the type, quantity, and quality of environmental data used in the decision-making process are appropriate for their intended applications and that there is no unnecessary duplication of effort.

The principal DQO factors governing the proposed site characterization sampling strategy are (1) to provide the site data needs for the performance assessment modeling, (2) to acquire information on the nature and presence of synthetic objects and materials on or near the surface, and (3) to conduct site characterization activities in a cost-effective manner through careful planning and integration of sampling efforts where possible.

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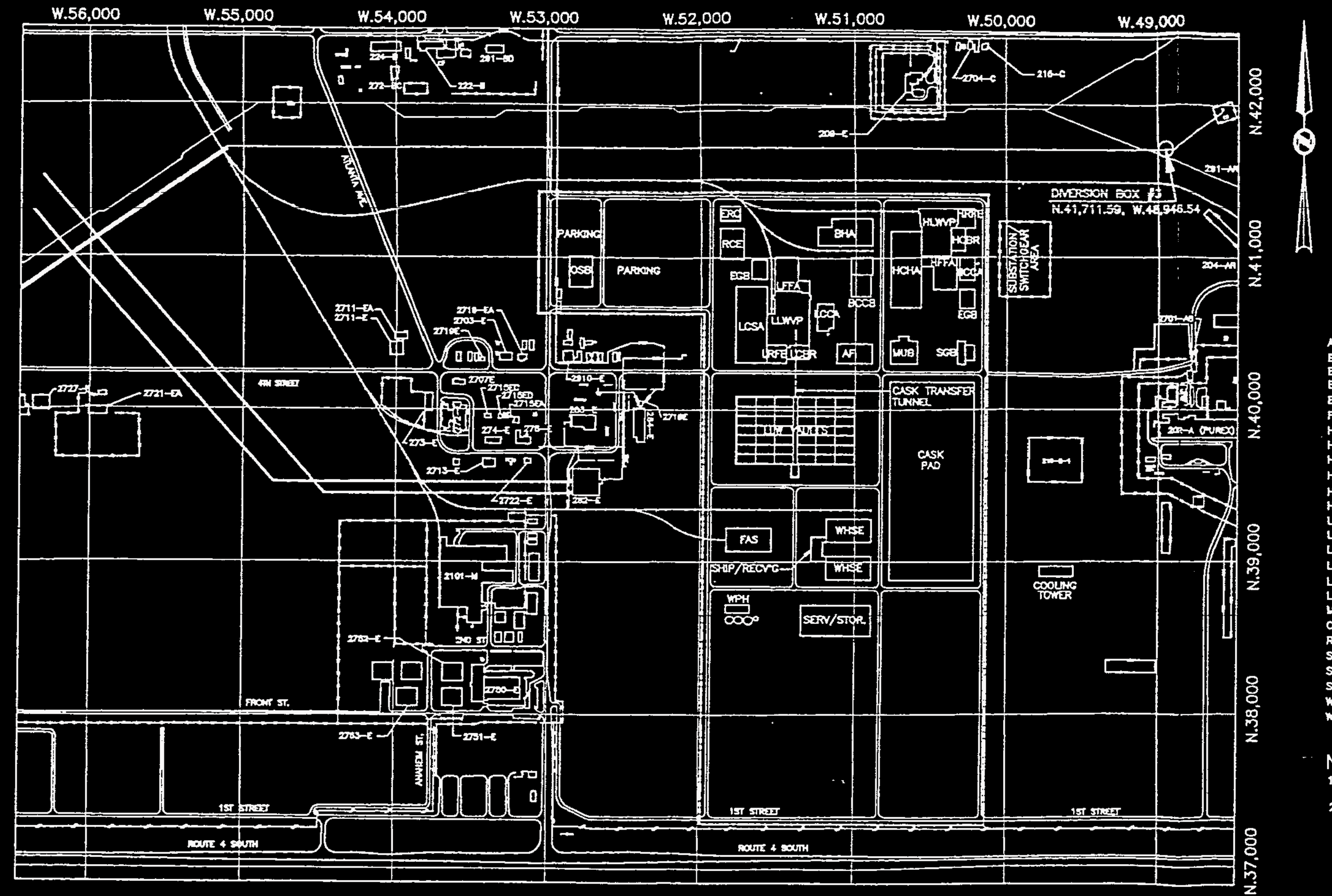


## LEGEND

| | |
|---|---|
| AF | ANALYTICAL FACILITY |
| BCCB | BULK COLD CHEMICAL BUILDING |
| BHA | BULK HANDLING AREA |
| EGB | EMERGENCY GENERATOR |
| ERC | EMERGENCY RESPONSE CENTER |
| FAS | FABRICATION & ASSEMBLY SHOP |
| HLWVP | HLW VITRIFICATION BUILDING |
| HCBR | CONTACT FILTER/BLOWER ROOM (HL) |
| HCCA | CONDENSATE COLLECTION ANNEX (HL) |
| HCHA | CANISTER/CASK HANDLING ANNEX (HL) |
| HFFA | FAN/FILTER ANNEX (HL) |
| HRFE | REGULATED FACILITY ENTRY ANNEX (HL) |
| LLWVP | LLW VITRIFICATION BUILDING (NOTE 2) |
| LCBR | CONTACT FILTER/BLOWER ROOM (LL) |
| LCCA | CONDENSATE COLLECTION ANNEX (LL) |
| LCSA | CONTAINER STAGING ANNEX (LL) |
| LFFA | FAN/FILTER ANNEX (LL) |
| LRFE | REGULATED FACILITY ENTRY ANNEX (LL) |
| MUB | MECHANICAL UTILITY BUILDING |
| OSB | OPERATIONS SUPPORT BUILDING |
| RCE | REGULATED TWRS COMPLEX ENTRY |
| SERV/STOR | SERVICE/STORAGE YARD |
| SGB | SWITCHGEAR BUILDING |
| SHIP/RECV'G | SHIPPING AND RECEIVING BUILDING |
| WHSE | WAREHOUSE |
| WPH | WATER PUMPHOUSE |

NOTE:
1. OVERALL AREA OF THE TWRS TREAMENT COMPLEX IS 200 ACRES.
2. LLWVP INCLUDES SEPARATIONS PLANT.

200 EAST AREA

0 100 200 300 400 500
GRAPHIC SCALE IN METERS

0 100 400 700 1000 1300 1600
GRAPHIC SCALE IN FEET

REFERENCE DRAWINGS
NEXT USED ON

00 | 1/14/95 | ISSUED FOR 2001 REPORT
SITEF02
28:18M:AC02:10.C2:SS
ENGINEERING RELEASE
U.S.DEPARTMENT OF ENERGY
FLUOR DANIEL, INC.
ADVANCED TECHNOLOGY DIVISION
TWRS TREATMENT COMPLEX SITE PLAN
436303
2001/2011
C.AHIGAN | 12-18-94 | 1:3000
NONE | NOT REQD | ES-SITEF-2 | 1 | 1 | 00

Figure 4-4 - TWRS Treatment Complex Site Plan

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### 4.6.2 Characterization Tasks

The tasks that will provide the subsurface characterization data for the site suitability and performance assessments, as identified through the DQO process, are grouped into two major studies:

- Geohydrologic model development
- Site monitoring.

## 4.7 GEOHYDROLOGIC MODEL DEVELOPMENT

The geohydrologic model development study provides an integrated resource effective plan for the collection and interpretation of the geologic and hydrologic properties necessary for characterizing the site and assessing its performance. The study consists of three parts based on location in the geologic column: surface and near-surface characterization, vadose zone geohydrologic characterization, and unconfined aquifer characterization. Site monitoring includes near surface (preoperational) baseline, vadose zone monitoring, and groundwater monitoring.

The surface and near-surface portion of the geohydrologic model includes surface geology and physiography as well as the preliminary screening for radiological/chemical soil contamination and the location and description of buried structures and waste disposal sites.

The geohydrologic properties of the vadose zone control the flow of water and the transport of contaminants through the vadose sediments to the unconfined aquifer. The purpose of the vadose zone study is to determine and characterize the physical and geochemical properties of the vadose zone underlying the proposed LLTWDS for the HLLTWPA. The other equally important purpose is to determine the presence of radiological and chemical contaminants throughout the borehole section that will provide a preliminary baseline of conditions prior to operations.

The aquifer characterization task describes geohydrologic and geochemical characterization of the unconfined aquifer at the site. Geohydrologic characterization describes the conditions and properties that control groundwater flow directions and rates within the aquifer.

## 4.8 SITE MONITORING

The site monitoring consists of three separate monitoring plans: environmental monitoring, vadose zone monitoring, and groundwater monitoring.

### 4.8.1 Environmental Monitoring

The environmental monitoring program for the LLTWDS and the TWRS Treatment Complex consists of four coordinated phases, corresponding to the four stages in the life cycle of a disposal site. These phases are as follows:

1. Site Characterization Phase--Provides assurance that the proposed site is capable of meeting siting criteria. Much of this level of characterization has been completed

2. Preoperational Monitoring Phase--Establishes baseline parameters for determining performance

3. Operational Monitoring Phase--Data are compared to baseline data to verify performance or identify design or construction flaws

4. Post-closure Monitoring Phase--To be carried out for some as yet to be determined time after closure to verify performance.

Environmental monitoring is required by DOE Order 5820.2A (DOE 1988b) and 10 CFR 61. The following objectives are the same for each U.S. Nuclear Regulatory Commission (NRC) agency:

- To provide and record data used to evaluate potential health and environmental impact (performance objectives)
- To alert management and regulators of any need for mitigative actions, and to record the utility of any mitigative actions
- To ascertain and record the regulatory compliance status of the facility.

### 4.8.2 Vadose Zone Monitoring

Vadose zone monitoring is to be completed for a hazardous waste treatment, storage, and disposal (TSD) facility as a measure to prevent contamination. Vadose zone monitoring is intended to provide early detection of the contaminant migration prior to groundwater degradation. By installing and using early warning leak detection systems in the vadose zone, migrating contamination can be detected before groundwater quality is compromised. The situation can be evaluated and remediated before serious groundwater damage occurs.

A second consideration involves the expensive and time-consuming groundwater monitoring regulations required by the *Resource Conservation and Recovery Act of 1976* (RCRA). By installing an early warning vadose zone leak detection system, the groundwater monitoring network may be reduced thus saving money in installation and incurring less maintenance costs.

### 4.8.3 Groundwater Monitoring Plan

The groundwater monitoring program is designed to: (1) provide baseline conditions concerning groundwater quality in the uppermost aquifer beneath the site; and (2) conduct groundwater investigation in a technically sound and cost-effective manner. Information gathered from this program can be used in developing future groundwater monitoring plans to address operational and post-operational phases, if deemed necessary.

As currently interpreted, a groundwater monitoring program may be required for compliance with the intent of final status requirements of WAC 173-303-645 and 40 CFR 264, Subpart F. However, WAC 173-303-645 (1)(b) indicates that the owner/operator of a regulated unit is exempted if the department finds that seven criteria are met. For example, if the regulated unit is an engineered structure designed to exclude water and contain waste constituents to at least the end of the post-closure care period, the waste is doubly contained and has a built-in leak detection system. It is believed that these design criteria will be met and that, together with a vadose zone monitoring system, the LLTWDS will be exempted from the groundwater operational or post-operational monitoring requirement. However, this determination cannot be made until some point in the future.

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# 5.0 RETRIEVAL AND BLENDING WASTES

## 5.1 OVERVIEW

Waste retrieval is the process of removing sludge, salt cake, and supernate (liquid) from a tank and transferring the waste to another tank or to a final disposal facility. The purpose of retrieval is to provide space in the tank farms, or to proceed a step closer to disposal, or to proceed to final disposal itself.

Many waste streams to the high-level and low-level vitrification facilities have components that limit waste loading in the respective waste glasses. Blending of waste feed streams is one simple, but effective, method of increasing the waste oxide loading in glass. The basic concept is that a feed high in one component, relative to its waste oxide loading limits, would be mixed with another feed that contains a low level of the same component. The blended wastes could be immobilized with greater overall waste oxide loading and a lower volume of waste glass produced. Another benefit of blending waste is the reduction in the number of unique waste form types requiring repository qualification.

### 5.1.1 Recent Work Summary

The effect of blend size (number of tanks per blend) on blending performance (i.e., waste oxide loading per unit volume of glass) was examined; two methods of solving the discrete blending problem were examined; and several blend formulation strategies were evaluated (Hoza 1994). An approach for using the results of this work to develop and evaluate retrieval sequences was proposed. The emphasis of these studies was HLW blending due to the large cost savings possible.

The motivation for blending efforts (see Geeting and Kurath 1993; Hoza and Geeting 1993; Hoza 1993; Hoza 1994; Lambert and Kim 1994) is primarily to reduce HLW glass volume and the number of HLW waste types. LLW volume is not as costly or sensitive to blending as HLW. Most (but not all) LLW batches are limited by sodium content.

## 5.2 CRITICAL ASSUMPTIONS

The following are some of the major critical assumptions used to determine blending options:

- In-tank pretreatment (see section 5.3)
- Agnew's Inventory, normalized to adjusted environmental impact statement (EIS) (see Orme 1994 and section 5.3)
- Water and caustic wash factors (see section 5.3)
- No retention of chlorine, fluorine, and sulfur in LLW glass

- HLW glass - borosilicate
- LLW glass - borosilicate
- HLW glass composition limits
- Retrieval annexes--4 (see section 5.3)
- HLW staging tank--18 month delay
- Close-coupled LLW pretreatment and vitrification.

## 5.3 RETRIEVEL AND BLENDING CONSIDERATIONS AFFECTING Low-level Waste (LLW)

In-tank sludge washing and caustic leaching is the baseline case for pretreatment. If out-of-tank pretreatment is chosen, it will be required to reallocate use of DSTs. As a result, it is possible that there may be some loss of HLW incidental blending that occurred in the settle/decant tanks, but the action will have freed many DSTs for intentional blending. The level of LLW blending, due to high volumes and low residence time, will probably be similar to in-tank pretreatment.

The tank inventory databases used for much of FY 1995 work was based upon variations of the LANL Tank Layer Model (Agnew 1994) normalized to the HDW-EIS totals. As Agnew's totals are reviewed and accepted by TWRS, the preferred inventory database is migrating toward direct use of Agnew's inventory (with adjustment for charge balance, etc). If this is done, chromium will be increased by a factor of about 2.8, iron by 3.6 and aluminum by 1.8; sodium will decrease by a factor of about 2. A decrease in sodium may change the sizing basis for LLW pretreatment and vitrification. An increase in chromium should mainly affect HLW, but could also increase soluble chromium in the LLW feed. It is not known if sodium will remain the main limiting component in the LLW glass after these changes.

The water and caustic wash factors used in the TWRS Process Flowsheet are periodically updated to reflect new laboratory data. One possible outcome may be that certain tanks contain greater amounts of soluble chromium than previously thought. Increases in the removal of chromium from HLW will increase the amount of chromium in LLW. There will be similar concerns for $P_2O_4$.

The need for two of the four retrieval annexes (areas to accumulate and help process waste recovered from SSTs) is being examined as a means of reducing early capital expenditures. It has been proposed that waste retrieved from tanks supported by the SE and SW annexes be transferred directly to DSTs. If simultaneous retrieval from two tanks per annex (eight total) is not possible under this new configuration, a certain amount of incidental blending of LLW waste will be lost. This issue will need to be evaluated.

## 5.4 STATUS

### 5.4.1 Retrieval Status

Retrieval is proceeding with several projects designated for consolidating waste, alleviating safety concerns, performing process tests to demonstrate sluicing and solids washing, and providing tank space. The consolidations include the following:

- Project W320--Retrieval of solid waste from tank 241-C-106 to tank 241-AY-102, as defined in Bailey (1994). This test is part of the technical baseline given in Umek (1995). Construction is underway, and the transfer needs to be complete by December 1998.

- Project W151--Installation of two mixers and one transfer pump into tank AZ-101 for retrieval of solids from tank AZ-101 to tank AZ-102. Construction is underway. This process test needs to be completed by December 1998 (Umek 1995; Waters and Kohlman 1992).

- Project W058--A cross-site transfer line for solids transport is provided. It has been proposed to use this transfer line to move TRU solids from tank 102-SY to tank AW-103. The transfer is to be completed by March 1998, as proposed in Umek (1995).

- Project W211--Initial Tank Retrieval Systems, provides equipment and analysis for waste mixing and transport in 10 DSTs.

- Proposed consolidation of TRU solids in tank AW-103 from tank AW-105--No project is associated with this transfer, which would complete the consolidation of all current DST TRU waste into one tank (AW-103). Proposed to be completed by December 1999 (Umek 1995).

Currently, several systems engineering studies are ongoing to ensure that the above transfers can be made safely and that the transfers are the best compromise for consolidating waste, testing in-tank sludge washing, and consolidating HLW for ultimate disposal.

### 5.4.2 Blending Status

A simple investigation of the waste composition variability in the LLW stream was performed using the TWRS flowsheet inventory (Conner 1995). The normalized TWRS inventory was provided by L. W. Shelton on January 13, 1995.

This waste inventory, described in WHC-SD-WM-RD-052, *Preliminary Low-Level Waste Feed Definition Guidance Low-Level Waste Pretreatment Interface* (Shade et al. 1995), includes an estimate of the water-soluble portion of each tank. The inventory included the water-soluble waste components dissolved and decanted to the LLW stream during retrieval and water washing of the waste.

Using these water-soluble data, glass compositions were projected on a tank-by-tank basis. Data from tanks that contain very little waste (<189,300 L [<50,000 gal]) were not included because they add little to the LLW inventory. The glass composition limits are taken from WHC-SD-WM-RD-052 (Shade et al. 1995, Section 7.0).

Table 5-1 lists the maximum concentrations of key components predicted from the water-soluble tank data. The data are derived from mass ratios in the tank (e.g., chlorine/sodium). These ratios are converted to loading in glass, assuming an $Na_2O$ loading of 25 wt%.

The aluminum and chlorine concentrations vary across tanks but do not exceed limiting values. Chlorine is concentrated in the DSTs. Fluorine is highly concentrated in neutralized cladding removal waste (NCRW) and is found in $LaF_3$ waste and in DSTs. A number of high fluorine tanks

Table 5-1. Potential Maximum Predicted Low-Level Waste Glass Concentrations.

| Component (wt%) | $Al_2O_3$ | Cl | $Cr_2O_3$ | F | $Na_2O$ | $P_2O_5$ | $SO_3$ |
|---|---|---|---|---|---|---|---|
| Maximum (one tank) | 8.0 | 0.75 | 1.05 | 15 | 25 | 5.4 | 4.1 |
| Average of top 10 tanks | 6.1 | 0.56 | 0.63 | 7 | 25 | 5.2 | 2.8 |
| Overall average | 1.3 | 0.09 | 0.07 | 0.3 | 25 | 0.7 | 0.5 |
| Limit in glass | 12 | 1.0 | 0.5 | 1.7 | 25 | 3.0 | 1.0 |

exceed the limit of 1.7 wt%. Both chlorine and fluorine are semi-volatile and therefore may be concentrated in recycle streams, causing potential operating concerns with condensate recycle. High concentrations of chromium are found mostly in the SX Tank Farm; a few of the tanks in S and SY Tank Farms exceed the 0.5 wt% $Cr_2O_3$ limit as well. Many tanks exceed the $P_2O_5$ limit of 3.0 wt%. The $SO_4$ is distributed across the tank farms, with generally higher concentrations in DSTs. Many tanks exceed the $SO_3$ limit of 1.0 wt% in the glass.

To examine the magnitude of the blending problem in another way, Table 5-2 shows the LLW glass volume penalty if the tank contents are not mixed. This is a type of worst case analysis because some mixing of the tank contents is inevitable.

From Table 5-2, it is apparent that dilution of the glass with nonwaste will significantly reduce the amount of glass that is affected by critical waste components.

From Table 5-3, it is concluded that fluoride, $P_2O_5$, and $SO_3$ are the most important limiting components in the glass product at high sodium loadings. At lower sodium loadings, only fluorine and $SO_3$ will be limiting.

Table 5-2. Glass Volume Penalty to Low-Level Waste if Tanks are Not Mixed.

| Sodium oxide loading ($Na_2O$) | 15 wt% | 20 wt% | 25 wt% |
|---|---|---|---|
| Additional glass volume produced (% of total) | 4.1 | 9.3 | 16 |

Table 5-3. Waste Constituents which Cause Increase in Glass Volume.

| Sodium oxide loading ($Na_2O$) | 15 wt% | 20 wt% | 25 wt% |
|---|---|---|---|
| Components that cause increases in glass volume | Relative contribution (%) | | |
| Cr | 1 | 2 | 2 |
| F | 57 | 39 | 32 |
| $P_2O_5$ | 2 | 21 | 26 |
| $SO_3$ | 40 | 39 | 40 |

The critical tanks in this effort are given in Conner (1995). For fluoride, they are tanks AW-105, AW-103, and tank C-104. For sulfate, they include tanks 102-AZ, BX-109, 101-AZ, and BY-104. If the supernate from these tanks could be well blended with other tanks, it would benefit the LLW glass volume projections by reducing the concentration of their critical components.

Preliminary results indicate that the additional glass produced by the LLW melter, due to exceeding waste loading limits, drops from an estimated 16% (if no blending is conducted) to around 5% with the benefit of incidental blending during retrieval and processing. Approximately 250 batches (circa 750 kgal) of LLW are to be provided to LLW Pretreatment and Vitrification. Feed variability may remain a concern in regard to the capability of the melter to handle varying concentrations of key components in the melter feed, and especially any step changes in feed composition. These concerns and solutions are further discussed in WHC-SD-WM-RD-052 (Shade et al. 1995).

In addition to the above results, the following efforts are in progress.

- Computer blending models are up and running. Certain measures (relative cost and relative risk) are being redefined.

- Related decisions: first major SST retrieval project appears to be certain tanks from A/AX Tank Farms; second SST project appears to be most remaining tanks from A/AX and some from S Tank Farms. Primarily, incidental blending is being studied. Intentional blending at the input to HLW glass staging tanks is being coded. Blending of "as-retrieved" waste in the SY Tank Farm did not significantly affect HLW glass volumes.

- Some sequences show a lack of LLW pretreatment feed circa 2010-2011. Work is continuing to better understand causes and work-arounds.

## 5.5 FUTURE PLANS

### 5.5.1 Future Retrieval Plans

Future long-range plans involve meeting Tri-Party Agreement milestones (see Ecology et al. 1994).

### 5.5.2 Future Blending Investigations

One of the ongoing blending efforts at WHC is funded by the pretreatment program and is titled, "Select Retrieval Sequence and Blending Strategy." This work has two objectives for FY 1995: to establish a preliminary retrieval sequence and blending strategy that will be incorporated into the TWRS baseline and to provide an indication of the time-varying composition of feed to the HLW and LLW vitrification facilities. The intention is to select the preliminary retrieval sequence and blending strategy in May 1995 and to document its basis in September 1995. It is expected that early results from testing of a few sequences will be available in January 1995. The work is divided into three main tasks.

- The first is a decision analysis task that ensures the retrieval/blending problem is properly framed (identify values, establish metrics that relate to the values, assist with interpretation of results, and document the selected retrieval sequence and blending strategy). This has been completed (see Certa 1995).

- The second task involves formulation of candidate retrieval sequences and blending strategies using simple (manual or semi-automatic heuristic) approaches, testing these candidates by modeling with the "TWRS Baseline/Simulation Model" (ARENA/SIMON) and an abbreviated version of the "TWRS Process Flowsheet" (ASPEN), and evaluation of the results in terms of the metrics. The blending architecture considered will probably be limited to (1) the unavoidable blending that occurs during retrieval, enhanced sludge washing, and lag storage, and (2) unavoidable blending with a stage of rule-based intentional blending for waste entering the HLW vitrification feed storage tanks.

- The third task is to review alternative approaches to solving the fully constrained (logistics, etc.) retrieval sequence and blending strategy problem. This review will consider approaches used at the Hanford Site and other sites in addition to more advanced methods (artificial intelligence, fuzzy logic, neural nets, etc.).

The objective of this work for FY 1996 is to update the TWRS baseline retrieval sequence and blending strategy for inclusion in SST retrieval sequence Tri-Party Agreement milestone M-45-02A, "Submit initial SST retrieval sequence document for Ecology Approval" (9/30/96). The retrieval program is responsible for this milestone, which will also document the planned retrieval methods for each tank. Milestone M-45-02A is the first of a series of milestones that requires submittal of an annual update of the SST retrieval sequence.

A summary of work to be performed in FY 1996 is as follows:

- Switch tank inventory database.
- Revise model to reflect current (or emerging) baseline with respect to retrieval, pretreatment, LLW, HLW, safety, and to upgrade program thinking.
- Refine the measures, measures of success, and other metrics.
- Formulate and test new blending strategies and retrieval sequences.

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# 6.0 WASTE PRETREATMENT

The objective of waste pretreatment is to separate the waste in the tanks at the Hanford Site into high- and low-level components. Pretreatment should produce an LLW stream, which will allow the final waste disposal system to meet NRC Class C requirements for near-surface disposal of LLW (10 CFR 61.55) and NRC Incidental Waste requirements, see section 7.

Several unit operations must be performed on the waste before it is ready for processing into the final LLW waste form. Those processes, why they are needed, their development status, and how the processes affect LLW will be discussed briefly.

## 6.1 SOLIDS/LIQUID SEPARATION

Solids/liquid separation is needed because most of the HLW and TRU components are contained in the tank solids. Separation also preventscarryover of solids into the ion exchange process, thereby preventing ion exchange column plugging. Solids/liquid separation will also be performed after the ion exchange system to prevent carryover of ion exchange material to the LLW form, thereby minimizing the radionuclides in the LLW.

The types of solids/liquid separation technologies being evaluated for use are listed in Table 6-1. The original evaluations were for in-tank separation. However, one of the concepts being evaluated is removal of most solids in an out-of-tank process.

The purpose of the solids/liquid separation development program is to determine the method and type of equipment that will be used for the solids/liquid separation. The planned development tests include bench- and pilot-scale tests with simulants. In addition, laboratory- and bench-scale tests will be performed with actual waste to verify the results of simulant tests.

Table 6-1. Evaluation of Solids/Liquid Separation Technologies.

| | | |
|---|---|---|
| 1. | Settling | This separation method will be used in conjunction with other solids/liquid separation methods. If sufficient time for settling is allowed, excellent separation can be achieved, minimizing the quantity of solids that must be removed by other methods. |
| 2. | Centrifugation | Plate/disc centrifugation is being considered. |
| 3. | Cross-flow filters | Sintered metal filters operated in a recycled flow, flow-through mode are being considered. |
| 4. | Etched disc filters | Vacco* stacked discs operated in cross-flow mode are being considered. |
| 5. | Precoat filter (PHP) | Pneumatic hydropulse filtration consisting of sintered metal filters operated in a dead-end mode with a diatonaceous earth precoat. |

*Vacco is a trademark of Vacco Industries, a division of ESCO Electronics Corp.

## 6.2 CAUSTIC LEACHING AND SLUDGE WASHING

Caustic leaching and sludge washing will be used to separate soluble solids in the tanks from the insoluble solids. These solids may be soluble either in water or in alkaline liquids. Part of this process will be to settle the solids to remove them from the supernatant after mixing.

Caustic leaching and sludge washing decrease the amount of HLW by minimizing the amount of nonradioactive soluble salts remaining with the sludge (insoluble solids). These processes increase the amount of LLW because soluble aluminum and some chromium compounds will be directed to the LLW rather than remaining with the solids in HLW. Approximately 10% of the total sodium in LLW is added as process chemicals during caustic leaching.

The current baseline process for caustic leaching and sludge washing is an in-tank process (Orme 1994). However, a recently completed trade study (Peiffer 1995) recommends removing all possible solids from the tanks and performing the caustic leaching and sludge washing as an out-of-tank process. Therefore, in the future, the baseline process may change to an out-of-tank process.

## 6.3 CESIUM REMOVAL BY ION EXCHANGE

Cesium and strontium are the principal radioactive components in the tank waste. Cesium removal from some of the DST waste was agreed to as part of the initial incidental waste decision. Since that time, a decision was made to remove cesium from all of the waste to minimize the amount of radionuclides in the LLW. This relates to part of the incidental waste agreement, section 7.

If cesium is not removed from the waste, the final waste form will have high radioactivity, creating significantly higher heat generation than with the cesium removed. The high radioactivity also makes the waste more difficult to handle, and the larger heat generation affects the stability of the final waste form if it is a sulfur matrix.

The current baseline process for cesium removal is ion exchange using Duolite* CS-100. However, two other ion exchange materials that have greater selectivity for cesium and greater ion exchange capacity (resorcinol-formaldehyde [R-F] resin and crystalline silico-titanate) are also being considered as candidates for cesium removal.

Preliminary ion exchange flowsheets have been written for both CS-100 and R-F resins. The flowsheets serve as a baseline method of converting laboratory data into engineering data and will be updated as more data are obtained. The flowsheets also list many of the cesium ion exchange research documents available for Hanford Site wastes (Eager and Penwell 1994; Penwell and Eager 1994).

## 6.4 PRETREATMENT OPTIONS THAT AFFECT LLW

### 6.4.1 Strontium Removal

Strontium removal is not part of the TWRS baseline process. The LLW from all tanks will meet the NRC Class C requirements for strontium without strontium removal. However, the tanks containing complex concentrate wastes will contain significant amounts of strontium. Therefore, the LLW produced during processing of those tanks will have significant beta radiation fields and heat generation caused by the strontium.

### 6.4.2 Technetium Removal

Technetium removal is not part of the TWRS baseline process. The LLW will meet the requirements for NRC Class C waste without technetium removal. However, technetium is the dominant contributor to the drinking water scenario for the LLW disposal facility performance assessment (see section 15). It is not certain whether technetium needs to be removed from the waste in order for the disposal facility (including the final waste form) to meet the performance criteria.

If technetium removal is required, the amount of additional sodium in the LLW may be significant. This is because the technetium removal ion exchange process, which is currently mature, requires significant amounts of concentrated nitric acid for elution. Even when 70% recycle of nitric acid is assumed, large amounts of sodium will still be required to neutralize the elution acid. However, work is proceeding to develop a process that will not require large amounts of concentrated nitric acid for elution.

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*Duolite is a trademark of Rohn and Haas.

### 6.4.3 TRU Removal

TRU removal is not part of the current baseline flowsheet. However, six tanks contain waste that would probably produce TRU waste if the supernatant were processed "as is" into the LLW form. Blending of waste from some of those tanks to minimize the LLW TRU concentration may be possible. Otherwise, the tanks may be treated to remove TRU from the waste before incorporation into the final waste form (Raytheon/BNFL 1995; Schultz et al. 1995).

No technology has been selected for removal of TRU from the waste supernatant. Several precipitation methods are possible but have not been investigated at this time. Destruction of organics in the waste in the three complexant concentrate (CC) waste tanks containing TRU would remove TRU from the supernatant.

## 6.5 FUTURE PLANS

### 6.5.1 Planned Work that Affects LLW

It is planned to continue solids/liquid separation development work with the goal of determining the solids/liquid separation achievable by different process methods and equipment types. The achievable separation will affect the amount of solid radionuclides remaining in the LLW waste. This in turn affects the performance assessment for the LLW waste disposal system.

Removal of TRU and strontium is desirable and will help the LLW disposal system meet the performance assessment criteria. Therefore, two types of tests are being performed for processes that will remove both TRU and strontium.

It is planned to continue heat and digest work with the CC waste. The tests will destroy organic complexants thereby removing both TRU and strontium.

It is intended to continue displacement/precipitation tests. These tests use chemicals to either destroy the organic complexants in CC waste or displace the TRU and strontium bound to the complexants in the liquid.

It is planned that Argonne National Laboratory (ANL) continue development of a new ion exchange material for technetium removal. This new material appears to be promising for removal of technetium with minimal effect on the LLW. If this new technology proves successful, technetium removal may be practical and economical.

### 6.5.2 Outstanding Pretreatment Issues that Affect LLW

The most significant outstanding pretreatment issues affecting LLW are uncertainties associated with the requirements for removing certain radionuclides, and the type and amount of radionuclides that must be removed to meet the performance requirements associated with the LLW performance assessment.

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# 7.0 FEED REQUIREMENTS/GUIDELINES TO LLW VITRIFICATION

It is necessary to know the waste feed requirements for vitrification of LLW to provide guidance for planning and design activities among various TWRS waste processing operations, and to provide a basis for integrating feed requirements among consecutive LLW operations. These waste processing operations involve waste retrieval and characterization; pretreatment including sludge washing, blending, and ion exchange; and subsequently vitrification and disposal.

## 7.1 LLW COMPOSITION OVERVIEW

Feed requirements and guidelines for LLW feed definition are derived from vitrification process and glass chemistry constraints. The application of these constraints to glass product composition definitions and LLW feed composition definitions includes consideration of appropriate regulatory requirements and recognizes the reality of feed compositional variability associated with flowsheet operations. It is assumed that the product will at least comply with NRC Class C limits and ultimately will reside in a near-surface disposal facility at the Hanford Site. It is expected that as more concise definitions of the glass-based waste form, disposal actions, vitrification processes, and pretreatment options are developed, preliminary specification will be modified as shown in WHC-SD-WM-RD-052, *Preliminary Low-Level Waste Feed Definition Guidance Low-Level Waste Pretreatment Interface* (Shade et al. 1995). Also, performance assessment activities (Kincaid et al. 1994; Rawlins et al. 1995) to evaluate various disposal system options are in progress and expected to provide additional guidance to product durability requirements, which may impact either feed definitions or glass formulation development.

## 7.2 LLW COMPOSITION GUIDELINES

This section includes tables of composition envelopes of major LLW glass-forming constituents based on current LLW glass formulation activities and preliminary composition ranges and limits of minor components known to cause either processing problems or impact glass quality. In addition, tables defining preliminary limits for reducible metals and volatile/semi-volatile constituents are included. Definitions of radionuclide limits based on either NRC Class C or performance assessment considerations are provided (Shade et al. 1995).

### 7.2.1 Major Components

Table 7-1 lists the major component composition ranges in the LLW glass composition envelope in terms of component oxide ranges and as mole ratios with respect to moles of sodium in the glass for glass compositions of 20 wt% and 25 wt% $Na_2O$. These composition ranges include constituents contributed by the LLW feed plus added glass-former constituents. Together, the LLW feed and the glass-formers constitute the melter feed. Not all major glass-forming

Table 7-1. Major Components.

| Element | Oxide | Oxide in glass (wt%) | Element in glass (wt%) | Maximum mole ratio in glass, (x/Na) $Na_2O$ = 20 (wt%) | Maximum mole ratio in glass, (x/Na) $Na_2O$ = 25 (wt%) |
|---|---|---|---|---|---|
| Na | $Na_2O$ | 15-25 | 11-19 | 1.00 | 1.00 |
| Si | $SiO_2$ | 50-70 | 23-33 | 1.82 | 1.46 |
| Al | $Al_2O_3$ | 5-12 | 2.6-6.4 | 0.37 | 0.29 |
| Ca + Mg | CaO + MgO | 0-12 | 8.6 (all Ca) | 0.34 (all Ca) | 0.27 (all Ca) |
| B | $B_2O_3$ | 0-12 | 3.7 | 0.54 | 0.43 |
| Fe | $Fe_2O_3$ | 0-12 | 8.4 | 0.24 | 0.19 |

components are expected to be in the LLW feed in sufficient quantities to meet glass formulation requirements. Also, not all major components are expected to be at maximum concentrations at the same time. Mole ratio values with respect to sodium can be readily calculated for other waste loadings as desired. These ratios can be used as limiting ratios in the LLW feed.

### 7.2.2 Minor Components

The concentration of minor components in the LLW feed, such as phosphorus, sulfur, chlorine, fluorine, and chromium, that can cause either process or product problems will be small compared to sodium and can be limited in the glass by adjusting waste loading. Table 7-2 lists the maximum concentration limits of the these constituents in LLW glass and their mole ratios with respect to sodium in the glass for two $Na_2O$ loadings. These ratios can be used as limiting values in the LLW feed. Appropriate ratios for other sodium loadings can be calculated as desired.

### 7.2.3 Reducible Metals, Volatiles, Semi-Volatiles

Limiting values for selected metals, semi-volatiles, and volatile components are given in WHC-SD-WM-RD-052 (Shade et al. 1995). These components may be reducible, form a secondary phase, or have other concerns. The components may be expected to be of concern if present above the small amounts listed in LLW feed.

## 7.3 STATUS

The most recent enumeration of the feed guidelines from pretreatment to LLW vitrification is contained in WHC-SD-WM-RD-052, *Preliminary Low-Level Waste Feed Definition Guidance Low-Level Waste Pretreatment Interface* (Shade et al. 1995). Efforts to upgrade revision 0 to revision 1 are underway.

Table 7-2. Minor Components (With Combinations).

| Element | Oxide | Oxide in glass (wt%) | Element in glass (wt%) | Maximum mole ratio in glass (x/Na), $Na_2O$ = 20 (wt%) | Maximum mole ratio in glass (x/Na), $Na_2O$ = 25 (wt%) |
|---|---|---|---|---|---|
| P | $P_2O_5$ | 3.0 | 1.31 | 0.066 | 0.052 |
| S | $SO_3$ | 1.0 | 0.40 | 0.019 | 0.015 |
| Cl | -- | 1.0 (0.3 retained | -- | 0.044 | 0.035 |
| F | -- | 1.7 | -- | 0.14 | 0.11 |
| Cr | $Cr_2O_3$ | 0.5 | 0.34 | 0.010 | 0.0081 |
| Cd | CdO | 2.5 | 2.19 | 0.030 | 0.024 |
| Noble metals | -- | -- | 0.25 | -- | -- |
| Rare earths | $La_2O_3$, $Ce_2O_3$, ... | 2.0 | 1.7 (all La) | 0.019 (all La) | 0.015 (all La) |
| P + S | -- | ND | ND | ND | ND |
| Ca + P | -- | ND | ND | ND | ND |
| Cs + Cl | -- | ND | ND | ND | ND |
| F + Cl | -- | ND | ND | ND | ND |

ND = not determined

## 7.4 FUTURE PLANS

A revision to Shade et al. (1995) is scheduled to be released in September 1995. This revision should further outline the variations expected in the LLW feed stream. It also should expand on possible impacts to the LLW vitrification effort and perform a general update of the document. In terms of possible formulation efforts and performance assessment analysis, results will be included in the revision. It is possible that safety analysis sections will be included in this revision, as well.

## 7.5 IMPACTS OF FEEDS WHICH EXCEED GUIDANCE

Analytical verification of waste feed for LLW vitrification may show that some feed components extend beyond ranges known to be acceptable. Feed with component concentrations outside of the preliminary guidance ranges may still be rendered acceptable for vitrification following an engineering evaluation of the relative impacts of the following alternatives:

- Blending with other acceptable pretreated feeds
- Reduction of the waste loading in the glass
- Modification of the glass formers
- Modification of the glass formulation
- Modification of the pretreatment process
- Modification of the melter system design
- Modification of the disposal system design.

# 8.0 EVAPORATION

To reduce the waste volume and concentrate the waste before mixing waste with glass formers prior to the LLW melter, and after pretreatment, it will be necessary to remove as much of the water as possible from the waste. This will allow the melter to run at higher capacities. The benefit will be to reduce the size and cost of the melter and the associated ventilation system. It is noted in WHC-SD-WM-TI-613, *TWRS Process Flowsheet* (Orme 1994) that the capacity of the evaporator will need to be 1.43 billion L with boiloff of 1.1 billion kg of water. The time-averaged rate of boiloff is 8,970 kg/h. With a 60% total operating efficiency (TOE) applied, the instantaneous rate is 14,000 kg/h (233 L/min = 61.6 gal/min).

## 8.1 OVERVIEW

Designing and building a new evaporator is an option that will be investigated. It is anticipated that refurnishing the existing 242-A evaporator/crystallizer located in the 242-A Building in the 200 East Area for this service may be cost effective. The 242-A evaporator process uses a well-demonstrated, conventional, forced-circulation, vacuum evaporation system to concentrate radioactive waste solutions. Main process components of the evaporator-crystallizer system are the reboiler, vapor-liquid separator, recirculation pump and pipe loop, slurry product pump, primary condenser, jet vacuum system, condensate collection tank, and ion exchange system. For more information on the existing evaporator, refer to WHC-SD-WM-SAR-023, *242-A Evaporator/Crystallizer Safety Analysis Report* (WHC 1992).

The 242-A evaporator was constructed in 1977 by Hanford Project B-100. The purpose of the 242-A evaporator is to reduce the volume of dilute waste solutions thereby reducing the number of underground storage tanks needed for waste storage. The evaporator originally had a design life of 10 years. To extend the mission of the facility through the year 2003, the recent Project B-534 used appropriate national consensus codes and standards for upgrade of the facility components. The facility recently underwent an integrity assessment to determine that the system is not leaking and is fit for use (Ohl 1994). Five-year, or 8,000-h operation, reassessments were recommended.

### 8.1.1 Operating Parameters

The 242-A evaporator was designed to maintain a net boiloff rate of 2.65 L/s (42 gal/min) at a feed rate of 4.4 to 7.6 L/s (70 to 120 gal/min), yielding a waste volume reduction factor ranging from 35 to 60% (Muller 1973). Process experience has shown an evaporation capacity of >3.47 L/s (>55 gal/min) at normal dilute waste compositions and input rates (6.32 L/s [100 gal/min]). Recent upgrades, including slurry pump changeout, have given the evaporator the capacity to pump slurry of up to 1.8 specific gravity. In the past, the evaporator routinely concentrated waste to >10*M* Na solutions. The TWRS flowsheet (Orme 1994) calls for concentration of pretreated waste to about 7*M* Na solutions. The slurry will be stored in holding tanks for mixing with dry formers and introduction into the melter.

**8.1.1.1 Evaporator Options.** Orme (1994) assumed that a new LLW evaporator will take the place of the existing 242-A evaporator when the existing evaporator meets its useful life limit. A new evaporator of the same type as 242-A could be necessary because of life considerations, processing requirements, or cost factors.

An option is to use the existing 242-A evaporator as the LLW evaporator is still viable. The equipment life and limited scope of upgrades for the 242-A evaporator were discussed with the equipment cognizant engineer. It is believed that >20 years' lifetime increase may be reasonably possible with relatively minor upgrades.

Another option is to build a new evaporator that could concentrate the waste almost to dryness. These types of evaporators are being investigated at ANL.

**8.1.1.2 Status.** Currently, the next campaign for the 242-A evaporator is planned to process 11,370,000 L (3 million gal) of waste in 1995. No major studies to ascertain if the 242-A evaporator could be the LLW evaporator are planned at this time. Logic diagrams in the Appendix show a decision point to determine if the existing evaporator could perform this function.

**8.1.1.3 Future Plans.** As noted in the LLW logic diagram in Appendix A, an engineering study is needed to determine if the 242-A evaporator can fulfill the needs of an LLW vitrification evaporator. It is anticipated that at least the following items would need to be upgraded to obtain enhanced life past the year 2003:

- Heating, ventilating, and air conditioning system replacement/ upgrade
- Drain lines upgrade
- Condenser replacement
- Demister pads changeout
- Cleanout to remove existing contaminants to acceptable levels.

# 9.0 GLASS FORMULATION

Several related LLW glass formulation efforts are in progress. The initial effort was to develop formulations to support Phase 1 melter testing and was limited to compositions with 25 wt% waste oxide loading and 20 wt% sodium oxide. Additional formulations are being investigated that cover a broader range of compositions. Formulation work to help resolve various process issues is also in progress and will be summarized herein.

## 9.1 LLW GLASS FORMULATION OVERVIEW

Baseline assumptions associated with tank waste retrieval and pretreatment indicate that the LLW waste stream transferred to the LLW vitrification facility will be characterized by high sodium content. Accordingly, glass compositions developed for LLW vitrification will be primarily high sodium glasses, to limit total waste glass volume, with all of the sodium component coming from the LLW stream rather than from glass-former additives. The LLW glass formulation activity was initiated by reviewing literature to determine durability characteristics and processability of high sodium glass compositions with emphasis on waste glass compositions rather than on commercial glass compositions. Most of the waste glass literature was related to HLW glasses, which generally have sodium contents lower than required for LLW glasses, but sufficient information was available to recommend potential LLW glass formulations.

Two LLW simulant compositions were developed to represent two average LLW streams. The simulants represent an average DSSF composition based on an average of six DSTs and a combined average of SST supernate compositions plus the remaining DST wastes. The latter simulant was designated "remaining inventory" (RI). The DSSF wastes had a better characterization history than the SST wastes and are earmarked to be the first LLW to be processed in the vitrification facility. For this reason, the first LLW glass formulations were developed from DSSF simulant compositions, with glass-former additives, based on literature guidance. These formulations were developed primarily to support Phase 1 melter testing needs. They are typically alkali aluminosilicates with 20 wt% sodium oxide. Several specific formulations were developed by Pacific Northwest Laboratory (PNL) and by individual melter vendors. Additional formulations are being developed for Phase 2 melter testing with a range of sodium oxide contents and waste loadings. These formulations are designed to accommodate DSSF and RI simulants and to consider variability in waste compositions.

The primary purpose of early LLW glass formulation efforts was to develop compositions for melter testing. Later, issues related to glass processability and durability then became important. Glass processing and durability issues help define limits on acceptable LLW glass composition regions. Glass composition definition helps provide interface guidelines for retrieval and pretreatment flowsheet work. This work helps ensures compatibility with vitrification plant feed requirements. Therefore the process works in a circle, all these issues influence each other.

Studies in progress that are related to these issues include (1) determination of minor components (e.g., phosphorus, sulfur, chlorine, fluorine) solubility limits in glass; (2) volatility of selected constituents such as technetium and cesium, as a function of composition; (3) various melt properties such as viscosity, electrical conductivity, devitrification tendency and homogeneity; (4) long-term durability studies on selected compositions; and (5) thermodynamic data acquisition of performance assessment-related radionuclides from selected compositions doped with radioactive components.

## 9.2 LLW GLASS COMPOSITION GUIDELINES

The literature review conducted to recommend candidate high sodium glass systems for LLW vitrification is documented in PNL-PVTD-C94-21.01C (PNL-94-47), *Evaluation and Recommendation of Candidate Glass Systems for LLW Vitrification* (Kim 1994). This review considered glass property versus composition relationships for compositions greater than about 15 wt% sodium oxide. DOE-EM-0177 (DOE 1994a) provides an additional review of glass formulation information related to corrosion characteristics with emphasis on a range of HLW glass compositions, but it also includes some compositions relevant to LLW formulations.

Glass formulations investigated in FY 1994 were based on 20 wt% sodium oxide concentrations and were developed primarily to provide guidance to vendors conducting phase 1 melter tests, but also included investigations of different glass-former alternatives. These compositions are listed in several PNL test plans such as PNL-PVTD-C94-21.01E, *Glass Formulation Investigation Plan, FY-94* (PNL 1994). In addition, some of the vendors conducting phase 1 melter tests elected to develop their own formulations, which are included in specific vendor test plans. The glass compositions developed by PNL and vendors for vendor tests are summarized in Table 9-1, Wilson et al. 1995.

Glass formulation work for FY 1995 includes an investigation of a broader range of compositions that is described in external letter PNL-94-187 9407184, *Investigation Plan for FY95 Glass Formulation Studies* (Westsik 1995) and also is discussed in a glass formulation strategy document (Kim et al. 1995). This glass formulation work is intended to support, in part, phase 2 melter testing as well as a number of other product and processing issues and to generate glass durability data. The glass composition region, in terms of major components, for the FY 1995 effort is summarized in Table 9-2.

As part of the glass formulation activity, additional investigations were conducted on selected LLW glass compositions to determine solubility limits of minor components such as phosphorus, sulfur, chlorine, and fluorine in the glass and on volatility behavior of elements such as cesium and technetium from melts. Excessive amounts of minor components result in phase separation in the glass melt which can impact processability and also result in devitrification that may reduce durability. Volatility is partly related to melt viscosity and redox state for certain constituents as well as to overall melt and cold cap chemistry. A literature review and some initial investigations are being conducted to evaluate volatility characteristics of some candidate LLW glasses.

A description of the minor component study conducted by PNL and Rensselaer Polytechnic Institute (RPL) is provided in PNL-PVTD-C95-02.01B, *Letter Report - Minor Component Study for Low-Level Radioactive Waste Glasses* (Li 1995) and by various quarterly reports by RPL through PNL. A summary of solubility limits determined for one representative LLW glass composition, L6-5412, is given in Table 9-3. The L6-5412 composition is $SiO_2$ = 56.78, $B_2O_3$ = 5.00, $Na_2O$ = 20.00, CaO = 4.00, $Al_2O_3$ = 12.00, and others = 2.22. The solubility limits of chlorine, fluorine, $P_2O_5$, $SO_3$, and $Cr_2O_3$ in this melt for three different temperatures is shown in Table 9-3.

Table 9-1. Phase I Vendor Test Target Glass Compositions, wt% Oxides.

| Oxide | Envitco | B&W | USBM | Duratek | PEI | WSTC | Vectra |
|---|---|---|---|---|---|---|---|
| $Na_2O$ (wt%) | 20.00 | 20.00 | 20.00 | 18.82 | 18.82 | 18.82 | 20.00 |
| $K_2O$ (wt%) | 1.52 | 1.52 | 1.52 | 3.68 | 1.43 | 1.43 | 1.52 |
| $Al_2O_3$ (wt%) | 12.00 | 10.00 | 10.00 | 6.14 | 6.00 | 18.22 | 10.00 |
| $B_2O_3$ (wt%) | 9.00 | 5.00 | 5.00 | 6.15 | -- | 9.45 | 8.00 |
| CaO (wt%) | -- | 5.00 | 5.00 | 7.80 | 9.77 | 4.65 | 2.90 |
| MgO (wt%) | -- | -- | -- | -- | -- | -- | 2.10 |
| $Fe_2O_3$ (wt%) | -- | -- | -- | 7.50 | 1.00 | -- | 1.00 |
| $Li_2O$ (wt%) | -- | -- | -- | -- | -- | 0.83 | -- |
| $TiO_2$ (wt%) | -- | -- | -- | 1.00 | -- | -- | -- |
| $ZrO_2$ (wt%) | -- | -- | -- | 5.09 | 2.00 | 2.10 | -- |
| $SiO_2$ (wt%) | 55.78 | 56.78 | 56.78 | 42.22 | 59.23 | 42.90 | 53.78 |
| Other* (wt%) | 1.70 | 1.70 | 1.70 | 1.60 | 1.75 | 1.60 | 1.70 |
| Total (wt%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Waste loading | 26.3 | 26.3 | 26.3 | 25.0 | 25.0 | 25.0 | 26.3 |
| PNL glass | LD4-912 | LD6-5510 | LD6-5510 | -- | -- | -- | -- |
| Temperature at 100 poise C | 1325 | 1296 | 1296 | 1096 | 1327 | 1215 | 1224 |
| PCT Na $g/m^2$-day | 0.046 | 0.074 | 0.074 | 0.102 | 0.242 | 0.034 | 0.078 |

*"Others" includes the sum of components representing constituents <1 wt% oxides each such as chromium, cesium, manganese, molybdenum, strontium, phosphorus, sulfur oxides, plus chlorine, fluorine, and iodine. The same composition of "other" was used in each formulation.

PCT = Product consistency test
PNL = Pacific Northwest Laboratory

Table 9-2. Low-Level Waste Glass Formulation Range for Fiscal Year 1995 Studies.

| Oxide | Composition range (wt%) |
|---|---|
| $SiO_2$ | 43 to 63 |
| $Na_2O$ | 15 to 35 |
| $Al_2O_3$ | 6 to 15 |
| $B_2O_3$ | 0 to 12 |
| CaO | 0 to 6 |
| ZrO | 0 to 6 |
| $Fe_2O_3$ | 0 to 6 |
| MgO | 0 to 4 |

A literature study was conducted on volatility behavior of iodine, strontium, cesium, and chlorine expected in LLW vitrification processing. This study (Langowski et al. 1995) also included a review of the aqueous chemistry and volatility of technetium along with a limited evaluation of rhenium as a proposed surrogate for technetium. A preliminary volatility study of technetium volatility from LLW glass compositions is also reported in Langowski et al. (1995) in which volatilities of technetium and rhenium >95% were observed.

## 9.3 STATUS

Glass formulation to support Phase 1 melter testing has been completed and additional formulation development work is in progress to support Phase 2 melter testing. In addition, LLW glass formulation studies are in progress to support disposal system design and disposal system performance assessment activities. These latter formulation studies are focused on issues such as waste loading impacts, waste compositional variability, product durability, and processability.

## 9.4 FUTURE PLANS

Work is in progress to determine an LLW waste reference glass formulation region that meets a variety of vitrification and disposal system requirements. A path forward strategy "Low-Level Waste Reference Glass Formulation Development" (Shade & Kelly, 1995) has been proposed. One major function of the reference glass will be to serve as an interface between the vitrification process and the disposal system needs. This will require confirmatory testing and database development of glass properties associated with the reference glass composition region. A reference glass formulation is required in June 1996 to meet Tri-Party Agreement milestones. In addition, a glass formulation strategy for LLW vitrification in subsequent years has been prepared (Kim et al. 1995). This will include strategies for modifying glass formulations based on updated waste characterization and also support glass property versus composition models. To date, all glass formulation has used nonradioactive waste simulants. Selected radioactive glass formulation and testing will be required to validate simulants and provide design data. Limited glass formulation will be conducted to support long-term durability studies and related performance assessment issues on an "as needed" basis.

Table 9-3. Solubility Limits of Minor Components in L6-5412 Glass, wt% (Li 1995)*.

| Minor component | 1300 °C | 1350 °C | 1400 °C |
|---|---|---|---|
| Cl | 0.56 | 0.57 | 0.52 |
| F | 0.77 | 0.92 | 0.91 |
| $P_2O_5$ | 1.94 | 2.10 | 2.28 |
| $SO_3$ | 0.75 | 0.75 | 0.75 |
| $Cr_2O_3$ | 0.46 | 0.48 | 0.48 |

*Li, H., 1995, *Letter Report - Minor Component Study for Low-Level Radioactive Waste Glasses*, PNL-PVTD-C95-02.01B, Pacific Northwest Laboratory, Richland, Washington.

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# 10.0 MELTER FEED SYSTEM

Melter feed systems are melter and vendor specific. They will not be addressed until after Phase I melter testing is complete.

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# 11.0 LLW MELTER

## 11.1 OVERVIEW

The following Tri-Party Agreement milestones are related to LLW melters:

1. Begin LLW melter testing simulants, September 1994 (complete)
2. Select reference melter concept, June 1996
3. Start melter facility construction, December 1997
4. Start vitrification of LLW, June 2005.

The first Preliminary Design Requirements Document (PDRD) was released to allow initiation of conceptual design of the LLW vitrification facility (Swanson 1995). This PDRD was developed in accordance with the systems engineering breakdown of the top four levels of functions, requirements, and architectural concepts necessary to accomplish the TWRS mission (DOE 1994). It is specified in Swanson (1995) that the design rate of the melter system be set at 140 MT/day of glass. This is at a 60% TOE and about 18% $Na_2O$ in the product. A minimum of two melters would be employed to achieve the production rate.

Currently, the melter selection effort is progressing through two phases of melter evaluation and selection. Phase I melter testing is a "proof-of-principle" test to demonstrate that a melter system technology can process a highly alkaline LLW simulant to a product of consistent quality. Phase I provides commercial melter vendors with an opportunity to become familiar with vitrification of a Hanford Site LLW stream and identifies specific issues associated with each melter technology.

In Phase II testing, the equipment and procedures will be optimized based on lessons learned during Phase 1. This will allow selected vendors to provide data needed for WHC selection of a reference LLW melter system and an alternate.

## 11.2 STATUS

Phase I LLW melter testing was initiated with a request for proposals for LLW melter technology demonstration issued by WHC in February 1994. Sixteen vendors submitted proposals, and testing of seven melter systems continued through April 1995 (the status date of this document). Evaluation of melter system technologies is available (Wilson 1994). Phase I is winding down in preparation for Phase II.

## 11.3 FUTURE PLANS

Completion of phase 1 melter testing and progression into phase II are planned by the end of 1995. This will allow the phase II and the second milestone (listed in Section 11.1) to be completed on time.

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# 12.0 MELTER OFFGAS

Melter offgas treatment is melter-specific and will not be addressed until phase I testing is completed, or the reference melter is selected.

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# 13.0 VITRIFIED PRODUCT

## 13.1 ROLE OF THE PRODUCT IN LLW DISPOSAL

The product can have a dual role in LLW disposal, but the roles are interrelated. The geometric form of the product and its durability characteristics determine the type of waste package design required which in turn influences the disposal system design. The product also functions as the source term in performance assessment of the disposal system. The source term includes the waste loading and durability properties which contribute to the rate of contaminant release per unit surface area of the product for contaminant transport analysis; however, transport analysis also requires assumptions about product form and package design.

The product can also have secondary roles in LLW disposal. The type of acceptance testing and frequency of acceptance testing to be implemented between the producer and disposal function is partly determined by composition and waste loading changes, package design, and product form. Some of these issues can impact lag storage and long-term storage requirements. Product durability and geometric form can be influenced by processing history and melt and glass characteristics. For example, devitrification tendency and related inhomogeneity characteristics can reduce durability while melt viscosity, liquidus temperature, and glass transition temperature can affect the ability to produce certain sizes of monolithic forms as well as impact volatility during processing. Melt volatility is related to final volatile component concentrations in the product.

## 13.2 GUIDELINES, OPTIONS, STATUS, AND FUTURE PLANS

The vitrified product will be part of the waste package system which will include the product, plus the container, at a minimum. The package system may alternatively include the product as part of a composite system with the product surrounded by an inert matrix that functions as a retardant to contaminant transport. Several alternative package designs are being considered, but for any design, two attributes of the product are important. These are the product durability characteristics and the ability to produce the product with the desired homogeneity, physical, and geometric characteristics. Studies related to these attributes are being conducted under either the glass formulation tasks or the LLW performance assessment tasks.

A product acceptance specification has not yet been developed for the LLW product but will have at least three types of specifications. One will include glass properties related to product homogeneity and processability. These will involve such characteristics as percent devitrification allowed, time-temperature-transformation (TTT) characteristics, glass transition temperature (Tg), liquidus temperatures, minor component limits, and melt viscosity. These properties are related to the ability to produce a chemically homogeneous product in a desired geometric shape with a minimum of post-melter operations. A second specification will focus on both short-term and long-term glass durability. Studies are in progress in both of these areas under the glass formulation and performance assessment activities. Short-term testing such as product consistency tests (PCT) are used as part of the glass formulation work to screen different glass compositions while more promising compositions are selected for the more time-consuming, long-term tests. Long-term tests include long-duration PCTs as well as accelerated tests, e.g., hydration tests. In addition, other testing to obtain data to support model development and calibration are in progress. This includes single-pass flow through testing to estimate forward reaction rates for use in the Agaard-Helgeson model, which is part of the AREST-CT code used in the performance assessment to calculate source term release. A third specification type should list testing methods required to determine an acceptable product and product quality control limits. Some of the acceptable test methods and limits are expected to follow from the ongoing studies supporting glass formulation and performance assessment activities.

Another area related to the vitrified product is matrix materials. Evaluations and studies are in progress through the performance assessment activity and other parts of the program to determine candidate matrix materials and other types of potential barrier materials for use in the waste package system. Materials being considered are sulphur polymer cement (SPC), tailored bentonites with zeolites or related ion-sorbing materials, and reductants or getters to retard contaminant transport. In addition, possible materials to chemically condition infiltrating water are being considered. These studies include determining material and hydraulic properties important to performance assessment activities and will include studies to evaluate material compatibility (e.g., product-matrix interaction) both during production and for long-term waste package durability.

# 14.0 DISPOSAL SYSTEM

The role of the disposal system for LLW is to provide a means of mitigating the release of radionuclides from the immobilized LLW waste into the environment.

The options will all include vitrified LLW in a specific disposal configuration based on waste form geometry (e.g., marbles, gems, cullet, monolith, etc.), performance assessment and feasible facility design (both processing facility and disposal facility), and stakeholders' input.

Options may also include the use of a matrix material (e.g., SPC) in addition to the glass waste form in the disposal configuration.

## 14.1 PRODUCTION OPTIONS

The following five glass production options were compared within the trade study, WHC-SD-WM-TI-686, *Immobilized Low Level Waste Disposal Options Configuration Study* (Boomer, 1994): cullet, gems, marbles, monolith, plate glass. Conceptual designs were developed for each production alternative and the designs used as a basis for evaluation.

- Cullet Production--The manufacturing process for cullet (glass nuggets, 0.5-cm minimum size) production requires simple mechanical components. Although a system of quench tanks, roll crushers, catch tanks, and cyclones were included for the basic process, it was recently determined after consultation with glass industry experts that the crushing and other downstream cullet handling equipment can be eliminated if quenched cullet is loaded directly into the waste packaging containers and dried rather than pumped to large day bins, and further handled. If desired, a matrix material such as SPC can be added to the cullet providing a secondary chemical barrier. During cullet production, cullet remains enclosed in the process systems.

- Gem Production--The manufacturing process for gem glass production requires many complex mechanical components. A system of feeder units from the melter, shearing mechanisms, conveyors, and annealing furnaces are required for this process. During gem production, gems are processed in opened systems. Gems are maintained in day bins to provide product material for waste form packaging.

- Marble Production--The manufacturing process for marble glass production requires many complex mechanical components. A system of feeder units from the melter, shearing mechanisms, conveyors, marble-making machines, and annealing furnaces are required for this process. During marble production, marbles are processed in opened systems. Marbles are maintained in day bins to provide product material for waste form packaging.

- Monolith Production--The manufacturing process for monolith glass production requires a single complicated mechanical system. The melter/canister interface requires a complicated fill system capable of filling multiple canisters at one time. During monolith production, glass remains enclosed in the process systems. Monolith waste forms are processed by canister process facilities that provide product material for waste form packaging.

- Plate Glass Production--The manufacturing process for plate glass production requires several complex mechanical components. A system of glass rollers, conveyors, annealing lehrs, scorers, score breakers, and automated plate glass handling devices are required for this process. During plate glass production, plate glass is processed in opened systems. Plate glass is maintained in lag storage areas to provide product material for waste form packaging.

## 14.2 WASTE FORM PACKAGE CONFIGURATIONS

Decision logic is used to identify thirteen packaging configurations for the low-level glass waste forms. The packaging configurations were developed after technical evaluation of glass waste form production alternatives in order to minimize non-feasible packaging alternatives. The first eight alternatives represent packaged waste forms specifically developed to provide containment of the waste form and facilitate decontamination of the waste form package. These configurations were developed by considering a combination of package configurations including unshielded canisters, unshielded and shielded overpacks, and shielded casks. These options permit onsite transfer and pad storage as all exterior surfaces are decontaminated. The last five package alternatives were configured specifically for a contaminated waste processing environment. These alternatives varied by waste form (several required an immobilizing matrix added to the loose waste form), waste packaging/transfer method, and storage concept. The following cases summarize the package configurations considered in this study:

Case Description

- Unshielded canister and shielded overpack cask

- Shielded cask

- Unshielded canister, unshielded overpack canister

- Unshielded canister

- Unshielded canister, unshielded overpack canister, concrete shielded cask

- Unshielded canister, concrete shielded cask

- 125-MT shielded cask

- Unshielded canister and unshielded overpack canister

- Pumping waste transfer, SPC*
- Hopper waste transfer, SPC*
- Non-load bearing canister, SPC*
- Load bearing canister, SPC*
- Hopper waste transfer.

Guidelines that have been used to determine the suitability of a particular waste package configuration are: the immobilized low-level waste (ILLW) should be disposed of near-surface, onsite; the effective dose equivalent release rate from the disposal system cannot exceed 4 mr/year in order to meet groundwater criteria; the ILLW should be retrievable for the first 50 years after disposal.

Status: To date, a variety of mitigating disposal systems based on vitrified product geometry, packaging configurations, and chemical barriers have been considered. A preferred mitigating disposal system will be selected by October 1995 at which time a "disposal decision document" will be issued to document the decision process.

Future Plans: This will be an iterative process between optimization of the disposal facility design and performance assessment.

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*Indicates SPC added to glass waste form.

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# 15.0 PERFORMANCE ASSESSMENT

## 15.1 OVERVIEW

DOE Order 5820.2A (DOE 1988b) mandates the requirements for the disposal of radioactive waste on DOE sites. One requirement is to develop and maintain a site-specific performance assessment of the disposal facility. The performance assessment needs to provide reasonable assurance that public health and environmental resources will be protected consistent with local, state, and federal environmental regulations. The performance assessment documents must contain defensible data and supporting analyses as evidence that requirements have been met. The data must be site- and waste form-specific as much as possible. The analyses will be for 10,000 years.

The Hanford Site low-level tank waste disposal facility performance assessment will be conducted in three phases. The first phase is the interim performance assessment, which is not part of the DOE performance assessment process as outlined in DOE Order 5820.2A. The purpose of the interim performance assessment is to indicate before any LLW facility construction, that there will be a high likelihood that the final performance assessment will be approved. The interim performance assessment will identify the approaches that will be taken on the next phases of the Hanford Site low-level tank waste performance assessment. All available data (which are limited) on the disposal facility, waste package, and surrounding area will be used in the interim performance assessment.

The second phase is the preliminary performance assessment that is required by the DOE Order. The draft revision of DOE Order 5820.2B, *Waste Management*, DRAFT (DOE 1994b) requires the U.S. Department of Energy, Richland Operations Office (RL) to approve the preliminary performance assessment before construction starts on the disposal facility.

The third phase is the final performance assessment, which must be approved by DOE-Headquarters before the disposal facility is in operation. After the final performance assessment, the performance assessment will be revised about every 5 years for incorporation of new information. Sources of new information would be "as-built" design changes, actual inventory in the waste form, and long-term testing data.

The success or failure of each performance assessment analysis will be judged against selected performance objectives, which are the criteria that the disposal system must meet. These criteria are developed before the performance assessments are made and are based on regulations, past performance assessments, and public input. The criteria to be used for the interim performance assessment are contained in WHC-EP-0826, *Performance Objectives of the Tank Waste Remediation System Low-Level Waste Disposal Program* (Mann et al. 1995c). The document will be updated for the preliminary and final performance assessments.

Each performance assessment is based on exposure scenarios and the various pathways that radionuclides and other hazardous substances use to reach the environment. The exposure scenarios are based on demographics and land use. The pathways and scenarios are based on regulations, past practices, and public input. The pathways and scenarios are the objects which are analyzed in the performance assessment. The pathways and scenarios to be used for the interim performance assessment are documented in WHC-EP-0828, *Scenarios of the TWRS Low-Level Waste Disposal Program* (Mann et al. 1995d). The document will be updated for the preliminary and final performance assessments. The performance objectives and exposure scenarios are summarized in WHC-EP-0827, *Overview of the Performance Objectives and Scenarios of the TWRS Low-Level Waste Disposal Program* (Mann et al. 1995e).

## 15.2 ROLE WITHIN TWRS DISPOSAL PROGRAM

The performance assessment function is an integral part of the TWRS disposal program. This function not only includes conducting the performance assessments but also providing early guidance to the designers of the waste treatment and disposal systems. The performance assessment project is also involved with the Site Characterization Plan for the TWRS Complex. The Site Characterization Plan is discussed in section 4.0.

### 15.2.1 Status-Guidance to Designers

The performance assessment process provides guidance based on analyses. The performance assessment team does not make any design decisions. The team only provides information based on the guidance analyses and the performance assessments.

Techniques similar to those to be used for the performance assessments were used in a scoping study termed the "white paper" (Rawlins et al. 1994). The study identifies key technical issues and uncertainties related to the disposal system. It also discusses the potential impacts of waste processing and disposal system design options on the technical feasibility and performance of a near-surface disposal system. Later, a memo summarizing the important parameters for the LLW disposal performance assessment was written (Eiholzer 1995).

The white paper discussed what may and may not work for the disposal facility. A few points are mentioned herein. The white paper indicated that the waste glass alone was not likely to meet the performance objectives unless the corrosion rate improved. However, a waste disposal system incorporating several potential constituent release control measures (barriers and moisture diverters) is capable of meeting the performance objectives. A release rate of 1 part/million/year of contaminant release from the disposal facility will meet the drinking water standards. However, the white paper cautions that the design may need a lesser release rate because many assumptions were made in the analysis.

The white paper notes that technetium-99 ($^{99}$Tc) is normally the largest contributor to the peak dose and for the dose before 10,000 years. The main reason is that the vadose zone does not chemically retard the technetium movement toward the groundwater. The vadose zone also does not retard the iodine-129 ($^{129}$I) movement. Iodine-129 also contributes to the peak drinking water dose that can occur before 10,000 years. However, the $^{99}Tc$ inventory is larger than the $^{129}I$ inventory. As implied above, the total peak dose will depend on the disposal facility design. Thus, the white paper suggested that extensive pretreatment may not be necessary. Engineered measures could aid in controlling radioisotope release to the vadose zone. It was suggested that a system-wide cost benefit analysis should be performed to determine the optimum level of pretreatment. The white paper also noted that if all the $^{99}Tc$ were removed, $^{129}I$ would become the main issue.

Another white paper will be produced during the summer of 1995 and is scheduled for release on September 30, 1995. This guidance paper will differ from the first white paper in the following ways. A disposal facility design concept recommended by Disposal Engineering will be modeled for a first estimate of the contaminant release rates from the disposal system. The effects three different waste forms will have on the performance of the disposal facility will be modeled. The waste forms will be glass monolith, glass cullet with SPC, and glass based on the privatization draft specifications. The second white paper will attempt to address various questions and concerns submitted by Disposal Engineering.

### 15.2.2 Status-Data Packages for Interim Performance Assessment

Most of the work performed during FY 1995 focused on compiling input for the interim performance assessment. All data, designs, and computer codes that will be used for the interim performance assessment have been documented and compiled into a package (Mann et al. 1995b).

Throughout FY 1995 and beyond, data are being collected for understanding the disposal system. Examples of testing are transport parameters in the vadose zone, glass corrosion, waste packaging materials (e.g., SPC) behavior and degradation, and recharge (how much water passes beyond the deep roots of plants and toward the groundwater). Inventory of the waste is being studied. The statements of work planned for FY 1995-FY 2000 are contained in WHC-SD-WM-PAP-061, *Statements of Work for FY95-FY00* (Mann et al. 1994). This reference will give an overview of what testing and tasks are being performed. An update to the statement of work summarizes the fiscal year 1995 accomplishments (Mann et al. 1995a).

### 15.2.3 Future Work

Future work (FY 1996 and beyond) will focus on four areas. Advising the Program Office on the effects of design options and other choices of the program will continue. Also, the data will be obtained for the preliminary and final performance assessments. Data packages are scheduled for completion by September 30, 1997, and March 30, 1999, respectively. Three performance assessments--interim, preliminary, and final--will be performed. These will be released for internal review by September 30, 1996; March 30, 1998; and June 30, 1999, respectively. After the final performance assessment is completed, the focus will be on maintaining the document. The details and schedule of future work for FYs 1996-2001 are documented in the updated statement of work (Mann et al. 1995a).

# 16.0 SECONDARY WASTE STREAM STABILIZATION

The current TWRS flowsheet indicates that secondary waste streams from the melter off gas will be recycled to the melter. The type of chemical components in the off gas will vary with the type of melter chosen. As an option and contingency, technical investigations were generated to obtain the information required for the bases for stabilization, treatment, and disposal of hard-to-vitrify waste streams, such as the condensate in the melter offgas. This work is not part of the existing flowsheet but is an alternative to melter recycle. The concerns with melter recycle include concentration of volatile components to the point where they exceed recommended feed limits, see chapter 6.

## 16.1 NON-VITRIFIABLE LLW FACILITY PRODUCT STABILIZATION

During the operation of the LLW vitrification plant, water will be evaporated and volatile materials will be carried into the offgas system. In addition to the generation of aerosols (that may carry waste feed), there will be the transport of volatile elements (Tables B-1 and B-2, Appendix B show some ROM estimated values). Quite a number of the elements will return to the vapor streams even if recycling from the offgas system is attempted. Therefore, an activity was identified with a goal to gather the information required to generate the bases for stabilization, treatment, and disposal of these non-vitrifiable products. The products from the offgas system can be stabilized in a low-melting vitreous material or in durable cementitious solids.

## 16.2 BACKGROUND

Most current research on vitrification of mixed waste has focused on borosilicate glasses originally developed for immobilization of high-level radioactive waste. Even though borosilicate glasses were originally developed for their coefficients of thermal expansion, they have been qualified as acceptable waste forms for disposal in the harsh conditions of a geologic repository. Unfortunately, they demand high process temperatures (i.e., 1200 °C to 1500 °C) and this presents the inconvenience of dealing with the volatilization of certain isotopes (e.g., technetium-99, iodine-129, cesium-137, radium-226, and selenium-79) and heavy metals (e.g., cadmium, mercury, lead, selenium, and technetium). Therefore, secondary treatment systems necessary to capture and stabilize these offgas species must be considered. The presence of minor amounts of phosphates (>1.5 mole%) in the waste stream has caused process upsets (Brouns et al. 1986; Jantzen 1986) in borosilicate melts and is exacerbated by small concentrations of calcia and rare earth oxides. Additionally, wastes containing >0.3 mole% $Cr_2O_3$, >16 mole% $Al_2O_3$, or >19 mole% $Fe_2O_3$ are suspect (Kalia 1992; Wiemers et al. 1992) and have been flagged as being outside the borosilicate concentration envelope. In light of this, alternative vitrification processes or products are desirable for the treatment of the secondary wastes that will be generated during the operation of the LLW vitrification facility. Thus, the purpose of this activity is to undertake a series of experimental studies, the results of which will allow the LLW disposal program to validate that performance standards will be achieved, to optimize waste form performance, and to model long-term waste form properties and behavior.

Estimates of the offgas waste stream are given in Appendix B based on the following assumptions.

- The vitrification plant will be operated under reducing conditions so that most nitrate and nitrite should be reduced to nitrogen.
- All water in the original waste stream is evaporated and recovered, and some will be recycled to dissolve the volatile elements.
- There will be some physical carryover of the original waste stream. The components in the original DSSF waste stream will be in the same proportions but at a different level of concentration. It is estimated that 5% of wastes are transported as aerosols.
- The furnace temperature is assumed to be in excess of 1200 °C so there will be additional carryover of volatile elements: sodium (as either $Na_2CO_3$, NaOH), phosphorus (as $PO_x$), carbon (as $CO_2$), chlorine (as NaCl), and nitrogen (as $NO_x$).

## 16.3 STATUS

In past work Oak Ridge National Laboratory reported on lead-iron phosphate glass nuclear waste form (Sales and Boatner 1984, 1986, 1988). Although lead phosphate glasses had been studied since the mid-1950's, their poor durability in water made them of little interest. The vitrified waste forms containing iron oxide offer certain advantages as immobilization hosts. These phosphate glasses can be processed at lower temperatures (e.g., 100 °C to 250 °C) than the borosilicates using melting technology that was developed for the borosilicates. The phosphate waste forms have dissolution rates in water (i.e., 90 °C and a pH between 5 and 9) that are one thousand-fold lower than comparable borosilicate formulations. Concurrently, metal ions are retained in the melts to >99.9% of the original amounts with the exceptions being ruthenium (94% to 99%) and cerium (99%), which appeared in the offgas condensate.

Iron addition to lead phosphate glasses was found to offer the greatest effects on chemical durability of the glass. This was discovered from the tested variety of metal oxide modifiers (MgO, $Al_2O_3$, CaO, $Se_2O_3$, $TiO_2$, $VO_2$, $Cr_2O_3$, $MnO_2$, CoO, NiO, $Cu_2O$, ZnO, $Ga_2O_3$, $Y_2O_3$, $ZrO_2$, $In_2O_3$, $La_2O_3$, $CeO_2$, and $Gd_2O_3$). The inclusion of 9 wt% $Fe_2O_3$ caused a $10^4$ increase in durability. Also, the tendency of phosphate glasses to crystallize upon cooling was greatly suppressed. Lead metaphosphate glasses will crystallize completely at 300 °C in air after a few hours. By contrast, lead-iron phosphate glasses, which have been heated in air at 500 °C for several hundred hours, show no signs of devitrification.

## 16.4 FUTURE PLANS

A task [Cao and Adams 1995] to investigate low melting temperature phosphate glasses as an alternative to borosilicate glass compositions for the immobilization of low-level tank wastes was assigned to Brookhaven National Laboratory. The current year work (1995) will provide a detailed assessment of phosphate glass technology with the proposition of alternative glass compositions based on reducing melt temperatures and improving durability or compatibility with specific waste stream components.

Corning, Inc., investigated tin-fluorophosphate glasses having extremely low transition temperatures and good aqueous corrosion resistance (Tick 1984). During this fiscal year, there will be crucible-scale testing to verify the results and to provide performance indices for developing new glass waste formulations.

Another task is to undertake a series of experimental studies (over a 3-year period), on a cement matrix for disposal of melter condensate. The results may allow the LLW disposal program to validate that performance standards will be achieved (specifically in refining the formulation of cementitious systems, optimizing waste form performance, and modeling waste form properties and behavior for the long term [Young et al. 1994]). At the conclusion of these studies, the following information will have been developed:

- The kinetics of phase formation during hydration and hardening of the matrix, including activation energies and the heat evolution associated with these reactions
- The influence of composition on rheology and setting behavior
- The composition and structure of the reaction products, and the form and characteristic sites assumed by each of the major waste species within the hardened cementitious structure
- The steady-state composition of the aqueous phase in the pores and its relation to equilibrium compositions
- Quantitative characterization of the microstructure
- Data relating to the stability of the solid phases and the major waste components under anticipated environmental degradation
- Information on transport properties of the stabilized waste (e.g., permeability and diffusivity).

This study is scheduled to be completed in the summer of 1996. To date studies with cementacious waste forms have passed WAC-173-303 required TCLP, and exceed ANSI 16.1 requirements for leach resistance of six by at least an order of magnitude.

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# 17.0 ENVIRONMENTAL, REGULATORY, AND SAFETY REQUIREMENTS

## 17.1 BACKGROUND

This section describes the various regulatory requirements applicable to the LLW vitrification facility. During operations, a LLW vitrification facility will be subject to extensive environmental regulatory limitations that apply to the glass product, as well as to airborne emissions, and secondary solid and liquid wastes resulting from vitrification.

### 17.1.1 Mixed Waste Regulations

The waste streams from pretreatment will have both radioactive and hazardous components. Wastes that have both hazardous and radioactive components are called mixed waste and are regulated as hazardous wastes by federal and state environmental authorities and as radioactive wastes by DOE. Radionuclides in waste from non-DOE facilities are regulated by the NRC. Regulations for identifying and listing hazardous/dangerous wastes are found in 40 CFR 261 (EPA 1989a) and WAC 173-303-070, respectively.

### 17.1.2 Hazardous Waste Regulations

Hazardous wastes are regulated by the EPA and, as delegated, to Ecology. Federal legislation governing hazardous wastes exist under the *Resource Conservation and Recovery Act of 1976* (RCRA) and the *Hazardous and Solid Waste Amendments* to RCRA. Regulations for the federal control of hazardous wastes are published in 40 CFR 260. Washington Sate has received delegation of authority from the EPA for enforcement of federal hazardous waste regulations through the publication of comparable standards within the WAC. These regulations of hazardous wastes are published in WAC 173-303, *Dangerous Waste Regulations*.

Characteristic wastes are categorized based on ignitability, corrosivity, reactivity, and toxicity. Regulations governing designation of characteristic hazardous/dangerous waste are found in Subpart C of 40 CFR 261/WAC 173-303-070. To qualify the glass product for disposal under these regulations, the primary characteristic of concern is toxicity. (Shade et al. 1995)

### 17.1.3 Radioactive Waste Regulations

The disposal of radioactive waste is regulated by DOE. Primary guidance for such control is contained in DOE Order 5820.2A, *Radioactive Waste Management*. In general, this order classifies wastes into HLW, LLW, and TRU. Specific guidance includes controls on the near-surface disposal of LLW and deep geological disposal of TRU and HLW.

#### 17.1.3.1 DOE Requirements.

DOE Order 5820.2A (DOE 1989) established policies, guidelines, and minimum requirements for management of radioactive or mixed waste facilities.

Specific requirements include the following limits: (1) External exposure to waste and concentrations of radioactive material that may be released into surface water, groundwater, soil, plants or animals is limited to an effective dose equivalent not to exceed 25 mrem/year to any member of the public. (2) Atmospheric releases are required to comply with the limits specified in 40 CFR 61 (EPA 1989b), and. (3) Limits are also imposed on the committed effective dose received by an individual after loss of active institutional control, 100 years. (Shade et al. 1995)

**17.1.3.2 NRC Requirements.**

The NRC regulates and licenses the disposal of radioactive materials from non-DOE facilities. NRC guidance on waste classification is contained in 10 CFR 61. DOE disposal of LLW is not currently regulated by the NRC. (Shade et al. 1995)

**17.1.3.3 Airborne Emissions.**

Airborne emissions are expected from facilities involving waste storage, waste evaporation, waste vitrification, and glass storage. Federal, state, and local regulations control the release of airborne pollutants of three general categories: radionuclides, priority air pollutants (conventional), and toxic air pollutants. The offgases from these operations must be treated to meet the appropriate and applicable emission standards. Offgas systems and air emissions abatement equipment design has not been selected for the LLW vitrification facility. (Shade et al. 1995)

## 17.2 ISSUES

### 17.2.1 LLW Designation for DST Waste

The NRC was empowered by the *Energy Reorganization Act of 1974*, section 202, to exercise licensing and regulatory authority over "Facilities authorized for the express purpose of subsequent long-term storage for high level radioactive wastes generated by (DOE), which are not used for, or are part of Research and Development activities." A decision had to be made as to whether the tank waste intended for the LLW vitrification facility actually was LLW or HLW and subject to NRC jurisdiction.

DOE presented an approach to the NRC for classifying Double Shell Slurry Feed (DSSF) waste, in the September 22, 1988, meeting on the disposal of Hanford defense waste. Comments were provided on the proposal and an alternative approach was recommended in a November, 1989 letter from Mr. Michael J. Bell, of the Nuclear Regulatory Commission (NRC) to Mr. Ronald E. Gerton of the Department of Energy (DOE). The approach agreed to by DOE was described in a letter from Mr. A. J. Rizzo of DOE to Mr. Robert M. Bernero of the NRC, March, 1989.

DOE has proposed to the NRC an approach for classifying Double Shell Slurry Feed (DSSF) waste. The approach uses an overall material balance of tank waste at the Hanford Site to demonstrate that the largest practical amount of the total site activity attributable to "first-cycle solvent extraction" wastes would be segregated so that only the residuals would be grouted (vitrified). The concentration of radionuclides present in the residuals would be comparable to Class C for cesium and transuranic, and to Class A or B for the remainder. The residuals would then be classified as LLW and NRC licensing would not be required.

In 58 FR 12342 (Appendix B), the NRC found that DOE's plans for handling DST wastes were consistent with their principles of waste decontamination and protection of the public (Boomer et al. 1995). The NRC ruled the DST wastes would be incidental waste and would not be regulated by the NRC, provided that the key radionuclides are removed to maximum extent technically and economically practical and will be in solid physical form at concentrations not exceeding Class C LLW. The waste would also need to be managed to safety requirements comparable to performance objectives in 10 CFR 61.

### 17.2.2 LLW Designation for SST Waste

The NRC still needs to evaluate the treatment and disposal plans for SST wastes. In 58 FR 12344, the NRC explicitly did not rule on the waste classification of SST wastes. The NRC indicated that "the appropriate classification of some Hanford wastes remains to be determined -- specifically, any single shell tank wastes.... a case-by-case determination of the appropriate waste classification might be necessary." As such, some consideration may be required for the regulation of SST wastes by the NRC. (Shade et al. 1995)

Precedence indicates that SST waste handling consistent with DST waste handling (not greater than Class C waste disposal in near-surface disposal units) would yield NRC interpretation of these wastes as being incidental wastes and not regulated by the NRC. If the wastes are deemed to be HLW, the NRC would regulate the wastes under 10 CFR 60. (Shade et al. 1995)

### 17.2.3 Delisting Waste

The two general categories of hazardous/dangerous waste are characteristic and listed. Characteristic wastes are categorized based on ignitablity, corrosivity, reactivity, and toxicity. Regulations governing designation of characteristic hazardous/dangerous waste are found in Subpart C of 40 CFR 261/WAC 173-303-070.

The LLW feed stream anticipated for the LLW vitrification facility is expected to contain both types. Because the tank waste being treated is listed waste, the final glass product will be listed waste until it is delisted (40 CFR 261.3(a)(2)(ii)). For this reason the final product will be land disposal restricted until it is delisted or otherwise approved for land disposal (e.g., no-migration petition, treatability variance). A proposal has been suggested to develop the regulatory mechanism that should be pursued (delisting petition, no-migration petition, treatability variance) to allow for land disposal of the LLW product (internal memo #71220-95-012).

## 17.3 PERMITS/PLANS

A draft permitting plan for the LLWVP (Gretsinger 1994) was prepared by Westinghouse Hanford Company in accordance with DOE Order 4700.1, *Project Management System* (DOE 1987a), to provide a plan and schedule for meeting applicable environmental documentation requirements for the LLWVP and to ensure integration of technical work scope. An overview of the environmental reviews, permits, and approvals potentially required by the regulatory agencies is provided in the subsections that follow.

### 17.3.1 Dangerous Waste Permit (RCRA Part A)

Hanford is considered one site for RCRA permitting purposes. Specified TSD units, including the DST farms are operating under interim status. Existing Hanford TSD units are receiving final status RCRA Part B permits in accordance with the Tri-Party Agreement. LLWVP will require submittal of RCRA Part A & Part B permit applications. Under the Tri-Party Agreement, LLWVP is granted interim status for construction (Gretsinger and Colby 1994).

Status:

The Part A for the LLWVP is scheduled to be prepared and submitted by the LLW Program Office in FY 1997 (10/1/97).

### 17.3.2 Dangerous Waste Permit (RCRA Part B)

The Part B consists of detailed design, technical, operational, maintenance, engineering, training, closure, and other relevant information concerning the waste management facility, in accordance with the Part B checklist provided by Ecology. The information is presented in narrative format, often utilizing extensive figures, tables, and design media.

Status:

The Part B permit will be required before beginning hot operations. In the event the melter selected meets the definition of an incinerator, additional steps may be necessary to obtain a final permit. The Part B permit will be prepared and finalized by LLWVP Projects by 2003. WHC RCRA Unit Permitting will be enlisted to provide expertise and support throughout the process. (Gretsinger and Colby 1994)

The following document has been prepared concerning the generation of secondary liquid dangerous wastes from the LLWVP:

- CWBS 2021 Regulatory Requirements for the Disposition of Secondary Liquid Dangerous Wastes (Transmitted from Fluor 3/27/95).

### 17.3.3 National Environmental Policy Act (NEPA)

The NEPA, 10 CFR 1021, requires that actions taken by the federal government be evaluated for environmental impacts. A NEPA review is required for all proposed actions at the Hanford Site before detailed design and construction. The proposed TWRS facility will require that an EIS be prepared because it is a major DOE action that has the potential for significant impacts on the environment and human health (Boomer 1994, Appendix J).

Status:

The TWRS EIS is being prepared under the direction of TWRS Compliance Planning. Future supplemental analyses and subsequent documentation required under NEPA will be the responsibility of LLWVP Projects & WHC NEPA Documentation (Gretsinger and Colby 1994). The draft TWRS EIS is scheduled to be distributed in November 1995.

### 17.3.4 State Environmental Policy Act (SEPA)

The SEPA, WAC 197-11, requires that environmental impacts associated with a project be evaluated before approval. Based on the results of the evaluation, a state EIS may be required, or the agency will issue a determination of nonsignificance. An EIS will be required for any project that may have a probable significant adverse environmental impact. Completion of a SEPA review process will be required before construction (Boomer 1994, Appendix J).

Status:

SEPA will be satisfied via preparation of the TWRS EIS, for which Ecology and DOE are co-preparers. SEPA documentation associated with the TWRS EIS is the responsibility of TWRS Compliance Planning (Gretsinger and Colby 1994).

### 17.3.5 Air Emissions

Emissions to the atmosphere from Hanford Site activities are regulated by the Federal Clean Air Act, 42 U.S.C. 7401 et seq., as amended, and by the Washington Clean Air Act, RCW 70.94. The LLWVP represents a new source of Hanford Site airborne emissions of radioactive and nonradioactive (including air toxic) pollutants (Gretsinger and Colby 1994). The LLWVP testing, design, construction and operation will require several permits and approvals before construction, treatment and disposal of the influent waste stream. These permits and approvals will be issued by several regulatory agencies, including the EPA, Ecology, the Washington State Department of Health, and the Benton County Air Pollution Control Authority.

Permitting and emission standards administered by these agencies appear in the following regulations:

- "National Emission Standards for Hazardous Air Pollutants (NESHAPs)" (40 CFR 61 Subpart H)
- "Radiation Protection--Air Emissions" (WAC 246-247)
- "Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480)
- "Controls for New Sources of Toxic Air Pollutants (TAPs)" (WAC 173-460)
- "Prevention of Significant Deterioration (PSD) of Air Quality" (40 CFR 52.21) and "General Regulations for Air Polllution (WAC 173 be required for any project that may have a probable significant adverse environmental impact. Completion of a SEPA review process will be required before construction (Boomer 1994, Appendix J).

Status:

SEPA will be satisfied via preparation of the TWRS EIS, for which Ecology and DOE are co-preparers. SEPA documentation associated with the TWRS EIS is the responsibility of TWRS Compliance Planning (Gretsinger and Colby 1994).

### 17.3.5.1 Notice of Construction (NOC).

Nonradioactive air emissions of concern are expected to fall into one of two categories: TAPs and criteria pollutants. A Notice of Construction (NOC) is an application to permit construction of a new source or modification of an existing source. An NOC for the emission of TAPs and/or criteria pollutants will be required by Ecology (WAC 173-400, "General Regulations for Air Pollution;" WAC 173-401, "Operating Permit Regulation;" and WAC 173-460, "Controls for New Sources of Toxic Air Pollutants") (Boomer 1994, Appendix J).

TAPs are regulated by Ecology pursuant to WAC 173-460. Over 500 carcinogenic and toxic pollutants are included in this regulation. Because emissions will occur during both the melter testing and operation of the LLWVP, WAC 173-460 will apply. The TAPs regulations require the installation of Best Available Control Technology for Toxics (T-BACT). In addition, if controlled emissions of pollutants exceed the small quantity emission rates, modeling must demonstrate that they do not exceed the Acceptable Source Impact Levels. A Notice of Construction (NOC) will be required under WAC 173-460.

Criteria pollutants are those criteria pollutants subject to the PSD program, enforced in Washington State by Ecology. Criteria pollutants include NOx, SO2, and CO, among others. Ecology has incorporated by reference most of the federal PSD requirements. If any criteria pollutant approaches its trigger level, the information required by the PSD process will be included in the NOC required under the TAPs regulations.

Status:

The NOC for nonradioactive emissions is scheduled to be submitted to Ecology in October of 1996 and approved by December of 1997.

**17.3.5.2 National Emission Standards for Hazardous Air Pollutants (NESHAP).**

An approval to construct under the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations is required under 40 CFR 61, Subpart H, if radionuclide emissions from a new or modified stationary source will result. If delegation of NESHAP authority to the Washington State Department of Health occurs, the above requirements will be satisfied with the submission of one NOC to the WDOH for radioactive air emissions for each TWRS facility (Boomer 1994, Appendix J).

The LLWVP offgas system will be constructed to the NESHAPs sampling and monitoring standards if the estimated dose equivalent from the facility to the maximally exposed offsite individual is greater than 0.1 mrem per year under routine operations with no emission control equipment operating.

**17.3.5.3 Radiation Protection - Air Emissions.**

Under the WDOH regulations, new construction or modification of emission units emitting radionuclides are required to submit a Notice of Construction (NOC) (Boomer 1994, Appendix J). In addition, new emission units must employ best available radionuclide control technology (BARCT) and must demonstrate compliance with radionuclide emission standards in 40 CFR 61, Subpart H, or WAC 173-480, whichever is more stringent (WAC 246-247-040) (Boomer 1994, Appendix J).

Before starting the BARCT assessment, extensive information on the processes and expected emissions from those processes must be developed. Information not normally available until definitive design (particularly concerning sampling equipment and expected emissions) is crucial to the preparation of the BARCT analysis and NOCs.

Status:

The NOC required under WAC 246-247 is scheduled to be submitted to the WDOH in October of 1996 and approved by July of 1997. The NESHAPs application is scheduled to be submitted to the EPA in October of 1996 and approved by December of 1997.

**17.3.5.4 Prevention of Significant Deterioration (PSD).**

A significant increase in emission of criteria pollutants from a new or modified source triggers the requirement for a NOC application under the PSD program, as defined by 40 CFR 52.21 and WAC 173-400. Expected increases must be considered in conjunction with total Hanford Site emissions.

Preconstruction approval of the NOC application is required by the Washington State Department of Ecology (Ecology) for any significant new or modified source or criteria pollutant emissions. The criteria pollutants include the following: carbon monoxide, nitrogen oxides, sulfur dioxides, particulate matter & PM-10, ozone (volatile organic compounds), lead (elemental), fluorides, sulfuric acid mist, total reduced sulfur compounds (including $H_2S$), chlorofluorocarbons 11, 12, 113, 114, 115, halons 124, 1301, 2402. (Gretsinger and Colby, WHC-SD-WM-PLN-090, 1994)

**17.3.5.5 Title V Permit Modification.**

The air operating permit program is implemented in WAC 173-401 and requires all major sources to have air operating permits in place. These permits will address air emissions from all units that emit any of the criteria pollutants listed in the federal Clean Air Act (e.g., NOx, SOx) or any of the 189 hazardous air pollutants listed in the federal CAA (including radionuclides). The air operating permit for the Hanford Site will establish emission limits and operational restrictions for all Hanford Site operational units. If a unit becomes operational after the permit is issued by Ecology, an application to modify the permit will be required.

Status:

To date, the following documents have been prepared concerning potential emissions from the LLWVP:

Appendix J, *Environmental Compliance*, of Boomer, et. al. 1994, *TWRS Facility Configuration Study*, WHC-SD-WM-ES-295, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

CWBS 2021 Regulatory: PSD Pollutant Inventory for a Low Level Waste Vitrification Facility (Transmitted from Fluor 4/11/95)

CWBS 2021 Regulatory: TAP Pollutant Emissions Inventory for a Low Level Waste Vitrification Facility (Transmitted from Fluor 4/12/95)

CWBS 2013: Preliminary Evaluation of Melter Offgas Quenching

CWBS 2013, Subtask #3: Environmental Assessment Preliminary Offgas Clean-up Studies, SO2 Abatement

CWBS 2013, Subtask #3: Environmental Assessment Preliminary Offgas Clean-up Studies, NOx Abatement

Slaathaug, E. J., 1995, *Chloride Removal from Vitrification Offgas*, WHC-SD-WM-TI-702, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

T. J. DeForest, L. M. Peurrung, and J. R. Richards, 1995, *Process System Evaluation Consolidated Letter Reports*, Vol. 1, Alternatives for the Offgas Treatment System for the Low Level Waste Vitrification Process, PVTD-C95-03.02A, Battelle Pacific Northwest Laboratory, Richland, Washington.

The following trade studies have been identified and scheduled:

"Offgas Treatment Trade Study" (4.2.3.2 Required Analysis 1, WBS #ID54030203, Activity I.D. SDW7470, Scheduled Completion - 7/18/95)

"Establish Emission and/or Waste Form Requirements for Components that are not Readily Incorporated into HLW Glass (e.g., I-129, Hg, C-14)" (4.2.2.2 04 Issue I, Required Analysis I, Title: Low Temperature Glass for Hanford Tank Waste, WBS #1.1.1.3.02.02.05, Activity I.D. L2090101)

### 17.3.6 Soil Column Waste Water Disposal

#### 17.3.6.1 State Waste Discharge Permit (SWDP).

An SWDP is required before discharging waste materials from industrial, commercial, and municipal operations into ground and surface waters of the state and into municipal sewerage systems. The LLWVP may be required to obtain a SWDP or modify another Hanford facility SWDP to allow acceptance of LLWVP waste. (Gretsinger and Colby 1994) WAC 173-216

Construction and operation of the LLWVP should not produce any waste streams that will require a SWDP, because most liquid streams will be radiologically contaminated and will be routed back to Double-Shell Tank (DST) storage. However, if wastewater streams meet the waste acceptance criteria, they may be sent directly to the 200 Area Effluent Treatment Facility (ETF), from which they are discharged to a State Approved Land Disposal System (SALDS). To do this, the ETF permits would need to be modified. (Gretsinger and Colby 1994)

### 17.3.7 Domestic Wastewater Disposal

#### 17.3.7.1 Spetic Systems Capacity Design Approval (WAC 246-272).

Domestic waste water for the LLWVP is planned to be discharged to the 200 area Sanitary Sewer System, which is currently envisioned as servicing the 200 East and 200 West Areas as well as nearby 600 Areas facilities, if it becomes necessary to provide interim domestic wastewater disposal, sewage systems may be required to comply with either these requirements or the requirements identified in the following sections. (Gretsinger, Colby, WHC-SD-WM-PLN-090, 1994) Plans and specifications for construction of a new sanitary sewer system or modification of an existing system shall be submitted and approved by the Washington State Department of Health before construction.

#### 17.3.7.2 Pretreatment Permit.

Effluent from domestic wastewater treatment facilities, except for subsurface septic tank systems with capacities <54,888 L/day (<14,500 gal/day), must meet the discharge standards established in WAC 173-221. If the LLWVP must employ an interim or small-scale septic system, and if this system exceeds 54,888 L/day, then WAC 173-216 must be complied with. (Gretsinger and Colby 1994) Septic systems having capacities less than 54,888 L/day must comply with WAC 246-272.

### 17.3.8 Drinking Water Supply

**17.3.8.1 Approval of Engineering Reports, Plans, and Specifications.**

Washington Administrative Code 246-290 requires that engineering reports, plans, and specifications for a drinking water supply system be approved by the DOH before construction. In accordance with DOH regulations, the WHC water purveyor is responsible for ensuring compliance with federal, state, and local laws and the applicable DOE orders governing protection of potable and raw water systems (Gretsinger and Colby 1994).

### 17.3.9 All Media

The following clearances, permits and studies are required for the LLWVP, they are detailed in Gretsinger and Colby 1994.

**17.3.9.1 Preoperation Monitoring of Facilities, Sites, and Operations.**

An environmental study shall be conducted before startup of a site, facility, or process which has the potential for significant adverse environmental impact. This study should begin not less than 1 year and preferably 2 years before startup of a facility to evaluate seasonal changes. The study precedes the conceptual design report and can include data acquired in the site selection process, excavation permit process, and NEPA/SEPA process. The required study is in progress and is detailed in section 4.6, Site Characterization.

**17.3.9.2 Cultural Resource Review Clearance.**

A Cultural Resource Review must be performed before initiating any potential surface disturbing activities onsite (36 CFR 800). Cultural Resource Review requirements are addressed in WHC-CM-7-5, *Environmental Compliance Manual*, and WHC-CM-8-7, *Operations Support Services*.

**17.3.9.3 Excavation Permit.**

An excavation permit is required before initiating any potential surface disturbing activities onsite (36 CFR 800). The WHC Excavation Permit requirements are addressed in WHC-CM-8-7, *Operations Support Services*.

**17.3.9.4 Endangered Species Approval.**

Under 50 CFR 402, a site assessment should be made to determine whether any planned activities have the potential to disturb any critical habitat used by threatened or endangered species. An Ecological Resource Review is required under 36 CFR 800 before performing any excavation on the Hanford Site. Site assessments and ecological resource reviews will be required for the LLWVP.

#### 17.3.9.5 Radiation Protection Standards.

The DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1990b), establishes standards and requirements that must be followed with respect to protection of members of the public and environment against undue risk from radiation. The LLWVP must be designed to meet these standards.

### 17.3.10 Underground Storage Tanks

#### 17.3.10.1 Tank Permit.

New underground storage tanks (UST) that store regulated substances must obtain a permit from Ecology (WAC 173-360).

## 17.4 SAFETY EVALUATIONS

The major safety documentation required for the LLWVP are facility hazards category, site evaluation report (see Section 4.0, Site Selection); preliminary and final safety analysis reports (PSAR and FSAR, respectively); fire hazards analysis; and single failure evaluation and technical safety requirements. Requirements and guidance on safety documentation are located in WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, and DOE Orders 6430.1A (DOE 1989), 5480.1B (DOE 1986), 5480.21 (DOE 1991), 5480.22 (DOE 1992a), 5480.28 (DOE 1993), and DOE RL 5480.7 (RL 1994d). The requirements for developing a Safety Equipment List are located in WHC-CM-1-3, *Management Requirements and Procedures*, MRP 5.46, "Safety Classification of Systems, Components, and Structures." Safety evaluations are usually conducted on a project-by-project basis.

## 17.5 FACILITY HAZARD CATEGORY

As noted in Swanson (1995), the facility hazards category (HC) for the LLWVP was found to warrant an HC 2 according to DOE Standard DOE-STD-1027-92, (DOE 1992b). The calculation of hazard category from the DOE standard is provided in WHC-SD-WM-ES-295, *Tank Waste Remediation System Facility Configuration Study*, Appendix I, September 1994 Draft (Boomer 1994). Hazard category is a function of the feed specification and required throughput. Facility hazard categories are defined in DOE Order 5480.23 (DOE 1992c) and their interpretation and guidelines are provided in DOE-STD-1027-92.

An HC has not yet been determined for the onsite disposal facility.

## 17.6 SAFETY STATUS

The following investigations are being pursued for inclusion into existing and future documentation.

- WHC-SD-WM-ES-350, Draft Melter Concept Comparative Safety report. The document compares individual melter safety items and issues with comparable melters.

- Draft Worker Safety-Maintenance and Operations Philosophy Study Methodology (document has not been assigned a WHC number). This document describes a methodology for evaluating limited contact maintenance. It is intended that DOE will evaluate this methodology and agree that it is appropriate for the application.

- Inventory development for the following:
  - Shielding
  - Pool spill
  - Airborne dispersion
  - Non-rad toxins.

When inventory development is more complete, it may be incorporated into potentially limiting waste definition documentation such as WHC-SD-WM-RD-052 (Shade et al. 1995), WHC-SD-W378-DRD-001 (Swanson 1995), and PSAR and FSAR evaluations.

## 17.7 FUTURE SAFETY WORK

The PSAR and safety analysis report are the long-term safety-related items requiring the most technical input and intensive development.

### 17.7.1 PSAR

The PSAR is the document that defines commitments governing preliminary design, procurement, construction, and preoperational testing of facilities. The PSAR also identifies the preliminary safety commitments to a facility's ultimate design and operation.

The PSAR is required prior to start of construction in accordance with DOE Order 4700.1 (DOE 1987) and DOE Order 6430.1A (DOE 1989). Dedicated work has not yet begun on the PSAR for the LLWVP, or on the disposal facility project.

### 17.7.2 FSAR

The FSAR is a risk management tool that will define the final basis for safety and risk acceptance for the facility or operations. FSARs include the operating envelope defined by technical safety requirements, safety design bases, commitments to applicable codes and standards, facility management controls, and institutional and human factors safety provisions.

Dedicated work has not yet begun on any FSARs. The FSAR is required prior to initiation of facility operation in accordance with DOE Order 4700.1 and DOE Order 6430.1A.

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# 18.0 TECHNOLOGY DEVELOPMENT NEEDS

## 18.1 BACKGROUND

The Draft *Tank Waste Remediation System Integrated Technology Plan* (ITP), DOE/RL-92-61 (RL 1994b) is part of the systems engineering approach to identify and define TWRS technology activities so they can be completed in time to successfully implement the TWRS program. The ITP reflects the current best estimate of technology activities required throughout the life cycle of the TWRS program. Revision 1 of the ITP reflects the revised technical strategy developed during renegotiation of the Tri-Party Agreement during 1993 and into 1994.

The objectives of the ITP are generally as follows.

- Identify TWRS functions and requirements that drive technology planning.
- Identify key technical uncertainties.
- Summarize reference and alternative systems.
- Provide top-level estimates of scope, schedule, and cost for technology activities.

## 18.2 LLW IMMOBILIZATION ISSUES

General issues concerning LLW immobilization are identified in the ITP. They are as follows:

- Performance allocation and assessment activities required to determine the necessary performance of the disposal facility waste form and allowable waste form radionuclide loading
- Developing glass compositions for vitrification of LLW
- Developing a melter system for LLW vitrification
- Developing a system for retrievably disposing of vitrified LLW.

In a breakdown of the above issues, at least 15 individual issues require some level of investigation. Refer to the ITP for a better definition, breakout, and cost estimate.

Further prioritization and selection of technologies will rely on a decision analyses framework that combines information from multiple sources, including formal analysis, expert judgement, program logic, and stakeholder values.

## 18.3 STATUS

Refer to the specific sections in this document for more information on the status of the above items.

## 18.4 FUTURE PLANS

Refer to the specific sections in this document for more information on the future plans of the above items. Also, see WHC-SP-1101, *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994) for future planning.

# 19.0 ALTERNATIVES

Some major alternatives and uncertainties are outlined in the next sections which could change the thrust of the LLW Program effort. The alternatives covered are major enough that they could change the strategy of the LLW program.

## 19.1 LOW LEVEL WASTE VITRIFICATION PLANT (LLWVP) DESIGN UNCERTAINTIES

LLWVP technical uncertainties for the project are outlined in Swanson and Johnke (1995) and include:

1. Disposition of Hanford site tank wastes. An EIS is required to determine the final destination of Hanford tank wastes. See regulatory section for more information.
2. Determine whether immobilized low-level waste can be disposed in the 200 areas.
3. Classification of single-shell tank wastes by the NRC. See regulatory section.
4. Determination of the immobilized low-level waste disposal configuration, which determines that the waste may or may not need to be disposed of retrievably.
5. Final determination of the low-level waste form is critical to the process. A trade study (Determine Low-Level Waste Form, WHC-SD-WM-ES-319) is proceeding to determine the waste product form.

## 19.2 "SINGLE LINE" PLANT TO PROCESS LLW THEN HLW

The concept of this alternative is to build a processing plant that can be used for LLW then HLW. This concept has not been developed enough before this document cut-off date to expand on the idea. No references are available.

## 19.3 PRIVATIZATION AND CONTRACTING STRATEGY

As noted in Claghorn and Powell (1994), the reference contracting strategy is competitive bid, government financed, design and construction with operations provided by the site operating contractor. Alternatives that are being evaluated include:

- A commercialization strategy where a single contract is awarded for design and construction management. The site operating contractor would operate the facilities.

- A privatization strategy where the capital needed for design and construction comes from the private sector. The private investors are paid by the quantity of material processed by their facilities.

In general, commercialization and privatization strategies are designed to shift ownership from the government to the contractors who perform and/or finance the work. The shift in ownership is designed to provide meaningful incentives to contractors to provide products that are on time and within cost projections. The down side of these approaches is that the LLW vitrification program is much less responsive to changes that are often demanded by interests outside of the project. The program is particularly vulnerable to changes due to its 20-year duration.

The traditional approaches are better suited for a changing regulatory environment. Ownership of the project is diffused, and input from all interests is readily accommodated throughout the duration of the program. The down side of this approach is that the program becomes vulnerable to cost overruns and schedule slippages. For more information on this subject, see Claghorn and Powell (1994).

## 19.4 SEPARATE VERSUS COMBINED FACILITIES

A recommendation cited in the draft TRS document is that a combined pretreatment and LLW vitrification facility be selected based on the results of WHC-SD-WM-ES-295, *Tank Waste Remediation System Facility Configuration Study* (Boomer 1994). However, the TWRS program and Multi-Year Work Plan (WHC 1994) cost estimates were based on separate facility concepts. The RL has declined the WHC recommendation to combine the LLWVP and the separations facility (i.e., Pretreatment) with the expectation that the facility configuration decision be fully justified in the context of TWRS systems engineering process.

The TRS represents the systems engineering process for providing selected architecture. The facility concept will be documented in the TRS. Approval of the selected concept may require additional analyses that are not yet identified.

# 20.0 REFERENCES

10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," *Code of Federal Regulations*, as amended.

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

10 CFR 61.55, "Waste Classification, Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

36 CFR 800, "Protection of Historical and Cultural Properties," *Code of Federal Regulations*, as amended.

40 CFR 52.21, "Prevention of Significant Deterioration of Air Quality," *Code of Federal Regulations*, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

40 CFR 260, "Hazardous Waste Management System - General," *Code of Federal Regulations*, as amended.

40 CFR 261, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*, as amended.

40 CFR 264, Subpart F, "Releases from Solid Waste Management Units," *Code of Federal Regulations*, as amended.

40 CFR 403, "General Pretreatment Regulations for Existing and New Sources of Pollution," *Code of Federal Regulations*, as amended.

50 CFR 402, "Interagency Cooperation - Endangered Species Act," *Code of Federal Regulations*, as amended.

58 FR 12344, "States of Washington and Oregon: Denial of Petition for Rulemaking," *Federal Register*.

Agnew, S., 1994, *Hanford Defined Waste: Chemical and Radionuclide Compositions*, LAUR-94-2657, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

Alumkal, W. T., 1994, Internal Memo, *Tank Waste Remediation Technical Strategy*, March 18, Westinghouse Hanford Company, Richland, Washington.

ANSI/ANS, 1986, *Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure*, ANS 16.1, American Nuclear Society, La Grange Park, Illinois.

Bailey, J. W., 1994, *Functional Design Criteria for Tank 241-C-106 Waste Retrieval, Project W-320*, WHC-SD-W320-FDC-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Bagaasen, L. M., and W. J. Powell, 1993, "Pilot-Scale Verification Tests for Hanford Grout," *Proceedings of Waste Management '93*, March 3, 1993, Tucson, Arizona.

Ballinger, M. Y., and R. B. Hall, 1991, *A History of Major Hanford Facilities and Processes Involving Radioactive Material*, PNL-6964 HEDR, Pacific Northwest Laboratory, Richland, Washington.

Bledsoe, K. W., and A. K. Kruger, 1995, *The Low-Level Waste Disposal Program Technical Strategy*, WHC-SD-WM-PLN-076, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Boomer, K. D., 1994, *Tank Waste Remediation System Facility Configuration Study*, Draft, WHC-SD-WM-ES-295, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Boomer, K. D., S. K. Baker, A. L. Boldt, J. D. Galbraith, J. S. Garfield, C. E. Golberg, H. A. Higley, L. J. Johnson, M. J. Kupfer, R. M. Marusich, R. J. Parazin, A. N. Praga, G. W. Reddick, J. A. Reddick, E. J. Slaathaug, L. M. Swanson, T. L. Waldo, and C. E. Worcester, 1993, *Tank Waste Technical Options Report*, WHC-EP-0616, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Brouns, R. A., J. M. Perez, Jr., and B. M. Wise, 1986, "Selection of a Glass/Feed Composition for the West Valley Demonstration Project Slurry-Fed Melter," *Proceedings of the American Nuclear Society International Topical Meeting*, SPECTRUM '86, vol. II, pp. 1107-1125.

Letter, Holbrook, J., H. Cao, and J. W. Adams, 1995, *Low Temperature Glasses for Hanford Tank Wastes*,: WBS 1.1.1.3.02.02.05 (Level 6) Miscellaneous Technology Studies, Fiscal Year Work Plan (FYWP) FY 1995, February, 13, 1995.

Certa, P. J., 1995, *Select Retrieval Sequence and Blending Strategy Decision Analysis Frame*, WHC-SD-WM-RPT-107, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Claghorn, R. D., and W. J. Powell, 1994, *Alternative Concepts for Treatment and Disposal of Hanford Site High-Level Wastes in Tanks*, WHC-SD-WM-TA-159, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

*Clean Air Act of 1955*, as amended, 42 USC 7401, et seq.

*Clean Air Act Amendments of 1990*, 42 USC.

Conner, J. M, 1995, *Investigation of Variability in the LLW Stream* (internal memo 74610-95-014 to P. J. Certa and Distribution, May 8), Westinghouse Hanford Company, Richland, Washington.

DOE, 1986, *Environment, Safety, and Health Program for Department of Energy Operations*, DOE Order 5480.1B, U.S. Department of Energy, Washington, D.C.

DOE, 1987, *Project Management System*, DOE Order 4700.1, U.S. Department of Energy, Washington, D.C.

DOE, 1988a, *General Environmental Protection Program*, DOE Order 5400.1, U.S. Department of Energy, Washington, D.C.

DOE, 1988b, *Radioactive Waste Management*, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C.

DOE, 1989, *General Design Criteria*, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

DOE, 1990a, *Low Level Waste Management Handbook Series: Environmental Monitoring for Low Level Waste Disposal Sites*, DOE-LLW-13Tg, Rev. 2, U.S. Department of Energy, Washington, D.C.

DOE, 1990b, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE, 1991, *Unreviewed Safety Questions*, DOE Order 5480.21, U.S. Department of Energy, Washington, D.C.

DOE, 1992a, *Technical Safety Requirements*, DOE Order 5480.22, U.S. Department of Energy, Washington, D.C.

DOE, 1992b, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92, U.S. Department of Energy, Washington, D.C.

DOE, 1992c, *Nuclear Safety Analysis Reports*, DOE Order 5480.23, U.S. Department of Energy, Washington, D.C.

DOE, 1993, *Natural Phenomena Hazards Mitigation*, DOE Order 5480.28, U.S. Department of Energy, Washington, D.C.

DOE, 1994a, *High-Level Waste Borosilicate Glass-A Compendium of Corrosion Characteristics*, DOE-EM-0177, vols. 1-3, U.S. Department of Energy, Washington, D.C.

DOE, 1994b, *Waste Management*, DRAFT, DOE Order 5820.2B, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1989, *Hanford Site Groundwater Protection Management Program*, DOE/RL 89-12, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *Fiscal Year 1995 Hanford Mission Plan*, DOE/RL-93-102, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *Tank Waste Remediation Systems (TWRS) Systems Engineering Management Plan*, DOE/RL-93-0106, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

Drummond, M. E., 1992, *The Future for Hanford: Uses and Cleanup--The Final Report of the Hanford Site Uses Working Group*, Chaired by M. E. Drummond, President of Eastern Washington University, Cheney, Washington.

Eager, K. M., and D. L. Penwell, 1994, *Preliminary Flowsheet: Ion Exchange Process for the Separation of Cesium from Hanford Tank Waste using Duolite™ CS-100 Resin*, WHC-SD-WM-TI-667, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Eiholzer, C. R., 1995, *Monthly Status - Important Parameters in Performance Assessment* (internal letter OM621-95-CRE-005 to J. S. Garfield, March 1), Westinghouse Hanford Company, Richland, Washington.

*Energy Reorganization Act of 1974*, 42 USC 5801.

EPA, 1992, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance*, EPA/530-R-93-003, U.S. Environmental Protection Agency, Washington, D.C.

Geeting, J.G.H. and D.E. Kurath, *Preliminary Assessment of Blending Hanford Tank Wastes*, PNL-8589, March 1993, Pacific Northwest Laboratory, Richland, WA.

Gretsinger, W. T., 1994, *Draft Low-Level Waste Vitrification Plant Environmental Permitting Plan*, WHC-SD-WM-PLN-009, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

*Hazardous and Solid Waste Amendments of 1984*, 42 USC 6901, et seq.

Hoza, M., 1993, *Optimal Waste Loading Models for Vitrification of Hanford High-Level Waste*, Pacific Northwest Laboratory, Richland, Washington, November 1993, PHTD-693.03.01M.

Hoza, M., 1994, *Study of Potential Blending Strategies for Immobilization of Hanford High-Level Waste*, TWRSPP-94-087, September 1994, Pacific Northwest Laboratory, Richland, WA.

Hoza, M. and J.G.H Geeting, 1993, *Blending Analysis Using the Optimal Waste Loading Model*, Pacific Northwest Laboratory, Richland, Washington, September 1993, TWRSPP-93-058.

Huang, F. H., D. E. Mitchell, and J. M. Conner, 1993, *Quality Verification Report for Phosphate/Sulfate Waste Grout*, WHC-SD-WM-RPT-066, Westinghouse Hanford Company, Richland, Washington.

Jantzen, C. M., 1986, "System Approach to Nuclear Waste Glass Development," *Journal of Non-Crystalline Solids*, vol. 84, pp. 215-225.

Johnson, M. E., M. L. Grygiel, P. A. Baynes, J. P. Bekemeier, B. D. Zimmerman, and M. B. Triplett, 1993, *Tank Waste Decision Analysis Report*, DRAFT, WHC-EP-0617, Westinghouse Hanford Company, Richland, Washington.

Kalia, J., 1992, *Hanford Waste Vitrification Plant Project Technical Data Package*, WHC-SD-HWV-DP-001, Rev. 6, Westinghouse Hanford Company, Richland, Washington.

Kim, D., 1994, *Evaluation and Recommendation of Candidate Glass Systems for LLW Vitrification*, PNL-PVTD-C94-21.01C (PNL-94-47), Pacific Northwest Laboratory, Richland, Washington.

Kim, D., P. Hrma, and J. H. Westsik, Jr., 1995, *PNL-PVTD Glass Formulation Strategy for LLW Vitrification*, PVTD-C95-02.01AD, Pacific Northwest Laboratory, Richland, Washington.

Kincaid, C.T., et al., 1994, *Performance Assessment of Grouted Double-Shell Tank Waste Disposal At Hanford*, WHC-SD-WM-EE-004, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Lambert, S.L. and D.S. Kim, 1994, *Tank Waste Remediation System High-Level Waste Feed Processability Assessment Report*, WHC-SP-1143, Rev 0, December 1994, Westinghouse Hanford Company, Richland, WA.

Langowski, M. H., 1994, *Glass Formulation Investigation Plan, FY-94*, PNL-PVTD-C94-21.01E, Pacific Northwest Laboratory, Richland, Washington.

Langowski, M. H., J. G. Darab, and P. A. Smith, 1995, *Volatility Literature of Iodine, Strontium, Cesium, Technetium, Rhenium, and Chlorine; Technetium and Rhenium Volatility Testing*, Draft, PNL-PVTD-C95-02.03E, Pacific Northwest Laboratory, Richland, Washington.

Leach, C. E., 1995, *Facility Design Philosophy: TWRS Process Support and Infrastructure Definition*, Draft, WHC-SD-W378-ES-002, Westinghouse Hanford Company, Richland, Washington.

Lee, J. L., 1994, *Grout Facilities Restart Plan* (internal letter 9309102B R2 to L. Erickson, September 30), Westinghouse Hanford Company, Richland, Washington.

Li, H., 1995, *Letter Report - Minor Component Study for Low-Level Radioactive Waste Glasses*, PNL-PVTD-C95-02.01B, Pacific Northwest Laboratory, Richland, Washington.

Mann, F. M. et al., 1994, R. A. Karnesky, R. Khaleel, A. H. Lu, B. P. McGrail, M. G. Piepho, J. A. Rawlins, S. P. Reidel, R. D. Rittmann, F.A. Schmittroth, G. F. Williamson, *Statements of Work for FY95-FY00*, WHC-SD-WM-PAP-061, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Mann, F. M. et al., 1995a, C. R. Eiholzer, F.N. Hodges, R. Khaleel, N. W. Kline, A. H. Lu, B. P. McGrail, S. P. Reidel, R. D. Rittmann, F. A. Schmittroth, G. F. Williamson, *Statements of Work for FY 1996 to 2001*, WHC-SD-WM-PAP-061, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Mann, F. M., 1995b, *Data Package for the Hanford Low-Level Tank Waste Interim Performance Assessment*, WHC-SD-WM-RPT-166, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Mann, F. M., et al., 1995c, C. R. Eiholzer, F.N. Hodges, R. Khaleel, N. W. Kline, A. H. Lu, B. P. McGrail, S. P. Reidel, R. D. Rittmann, F. A. Schmittroth, G. F. Williamson, *Performance Objectives of the Tank Waste Remediation System Low-Level Waste Disposal Program*, WHC-EP-0826, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Mann, F. M., et al., 1995d, C. R. Eiholzer, F.N. Hodges, R. Khaleel, N. W. Kline, A. H. Lu, B. P. McGrail, S. P. Reidel, R. D. Rittmann, F. A. Schmittroth, G. F. Williamson, *Scenarios of the TWRS Low-Level Waste Disposal Program*, WHC-EP-0828, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Mann, F. M., et al., 1995e, C. R. Eiholzer, F.N. Hodges, R. Khaleel, N. W. Kline, A. H. Lu, B. P. McGrail, S. P. Reidel, R. D. Rittmann, F. A. Schmittroth, G. F. Williamson, *Overview of the Performance Objectives and Scenarios of the TWRS Low-Level Waste Disposal Program*, WHC-EP-0827, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

McDaniel, E., 1995, *Technical Seminar, History of Waste Disposal*, WHC-MR-0492, Westinghouse Hanford Company, Richland, Washington.

Muller, M. E., 1973, *Functional Design Criteria - 242-A Evaporator/ Crystallizer Facilities*, ARH-2952, Atlantic Richfield Hanford Company, Richland, Washington.

*National Environmental Policy Act of 1969*, 42 USC 4321, et seq.

Ohl, P. C., 1994, *The 242-A Evaporator/Crystallizer Tank System Integrity Assessment Report*, WHC-SD-WM-ER-124, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Orme, R. M., 1994, *TWRS Process Flowsheet*, WHC-SD-WM-TI-613, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Peiffer, W.A., 1995, *Sludge Washing*, WHC-SD-W236B-TI-006, prepared by British Nuclear Fuels Ltd for Westinghouse Hanford Company, Richland, Washington.

Penwell, D. L., and K. M. Eager, 1994, *Preliminary Flowsheet: Ion Exchange Process for the Separation of Cesium from Hanford Tank Waste using Resorcinol-Formaldehyde Resin*, WHC-SD-TI-638, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Rawlins, J. A., et al., 1994, *Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance*, WHC-EP-0810, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Raytheon/BNFL, 1995, *Initial Pretreatment Module Trade Studies, Out-of-Tank Radionuclide Separation*, E/B-SD-W236B-RPT-023, Rev. 1, Raytheon/British Nuclear Fuels Ltd, Richland, Washington.

*Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.

RL, 1993, *Hanford 200 Areas Development Plan*, DOE/RL-92-29, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL, 1994a, *Tank Waste Remediation System Functions and Requirements*, DOE/RL-92-60, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL, 1994b, *Tank Waste Remediation System Integrated Technology Plan*, Draft, DOE/RL-92-61, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL, 1994c, *Hanford Site Development Plan*, RL-W94-044 (DRAFT), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RL, 1994d, *Fire Protection*, DOE RLID 5480.7, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Sales, B. C., and L. A. Boatner, 1984, *Science*, vol. 226, pp. 45-48.

Sales, B. C., and L. A. Boatner, 1986, *Journal of Non-Crystalline Solids*, vol. 79, pp. 83-116.

Sales, B. C., and L. A. Boatner, 1988, "Lead-Iron Phosphate Glass," *Radioactive Waste Forms for the Future*, pp. 193-231.

Schultz, W. W., et al., 1995, *In-Tank Processes for Destruction of Organic Complexants and Removal of Selected Radionuclides*, WHC-SD-WM-ES-321, Westinghouse Hanford Company, Richland, Washington.

Shade, J. W., J. M. Conner, D. W. Hendrickson, W. J. Powell, and R. A. Watrous, 1995, *Preliminary Low-Level Waste Feed Definition Guidance Low-Level Waste Pretreatment Interface*, WHC-SD-WM-RD-052, Westinghouse Hanford Company, Richland, Washington.

Internal Memo, Shade, J. W., S. Kelly to R. J. Murkowski, *Path Forward Strategy; Low-Level Waste Reference Glass Formulation Development*, 74610-95-016, July 21, 1995.

*State Environmental Policy Act of 1971*, Revised Code of Washington 43.21c, Olympia, Washington.

Swanson, L. M., 1995, *Preliminary Design Requirements Document for the Low-Level Waste Vitrification Plant, Project W-378*, WHC-SD-W378-DRD-001, Westinghouse Hanford Company, Richland, Washington.

Tick, P. A., 1984, *Physics and Chemistry of Glasses*, vol. 25, pp. 149-154.

WAC 173-216, "State Waste Discharge Permit Program," *Washington Administrative Code*, as amended.

WAC 173-218, "Underground Injection Control Program," *Washington Administrative Code*, as amended.

WAC 173-221, "Discharge Standards and Effluent Limitations for Domestic Wastewater Facilities," *Washington Administrative Code*, as amended.

WAC 173-240, "Submission of Plans and Reports for Construction of Wastewater Facilities," *Washington Administrative Code*, as amended.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-360, "Underground Storage Tank Regulations," *Washington Administrative Code*, as amended.

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, as amended.

WAC 173-401, "Operating Permit Regulation," *Washington Administrative Code*, as amended.

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended.

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, as amended.

WAC 246-247, "Radiation Protection--Air Emissions," *Washington Administrative Code*, as amended.

WAC 246-272, "On-site Sewage System," *Washington Administrative Code*, as amended.

WAC 246-290, "Public Water Supplies," *Washington Administrative Code*, as amended.

*Washington Clean Air Act of 1967*, Revised Code of Washington, Chapter 70.94, Olympia, Washington.

Waters, E. D., and E. H. Kohlman, 1992, *Functional Design Criteria Tank 101-AZ Waste Retrieval System*, WHC-SD-W151-FDC-001, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Welsh, T. L., 1993, *Tank 241-AP-102 Characterization Results*, WHC-SD-WM-TRP-168, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *242-A Evaporator/Crystallizer Safety Analysis Report*, WHC-SD-WM-SAR-023, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Tank Waste Remediation System Multi-Year Work Plan*, WHC-SP-1101, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

WHC-CM-8-7, *Operations Support Services*, Westinghouse Hanford Company, Richland, Washington.

External letter, Westsik, Jr., J H., to R. J. Murkowski, *Transmittal of Milestone C95-02.01H - Issue Investigation Plan for FY Glass Formulation Studies*, December 21, 1994, PNL-94-187 9407184.

Wiemers, K. D., J. E. Mendel, A. A. Kruger, L. R. Brunell, and G. B. Mellinger, 1992, *Preliminary Assessment of Candidate Immobilization Technologies for Retrieved Single-shell Tank Wastes*, PNL-7918, Pacific Northwest Laboratory, Richland, Washington.

Wilson, C. N., 1994, *Evaluation of Melter System Technologies for Vitrification of High Sodium Content Low-Level Radioactive Liquid Wastes*, WHC-SD-WM-RD-004, Westinghouse Hanford Company, Richland, Washington.

Wilson, C. N., et al. 1995, *Melter Technology Evaluation for Vitrification of Hanford Site Low-Level Waste, WHC-SA-2757*, Westinghouse Hanford Company, Richland, Washington.

Young, J. F., 1994, *Project No. MJG-SVV-097600* (Incoming Correspondence 94-02530 to A. A. Kruger April 4, 1994) University of Illinois, Urbana, Dept. of Material Science & Engineering.

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# 21.0 BIBLIOGRAPHY

Baynes, P. A., et al., 1993, *Tank Waste Remediation System Mission Analysis*, WHC-EP-0627, Westinghouse Hanford Company, Richland, Washington.

Brantley, W. M., 1994, *Functional Design Criteria for Project W-058, Replacement of Cross-Site Transfer System*, WHC-SD-W058-FDC-001, Westinghouse Hanford Company, Richland, Washington.

Burgess, J. S., 1994, *Engineering Study for 242-A Evaporator Embedded Piping Upgrade*, WHC-SD-OWM-ES-292, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Cline, M. W., A. R. Tedeschi, and A. K. Yoakum, 1988, *Phosphate/Sulfate Waste Grout Campaign Report*, WHC-SD-WM-ER-059, Westinghouse Hanford Company, Richland, Washington.

Duffy, L. P., 1991, *Secretary Decision Concerning the Tank Waste Remediation System, Hanford Site*, December 20, U.S. Department of Energy-Headquarters, Washington, D.C.

Johnson, M. E., 1994, *Tank Waste Remediation System Program Decisions and Risk Assessment*, DRAFT, WHC-EP-0786, Westinghouse Hanford Company, Richland, Washington.

Johnson, L. J., J. D. Galbraith, H. J. Goldberg, and J. D. Ludowise, 1993, *Engineering Study for Hanford Site Tank Waste Blending*, WHC-SD-WM-ES-267, Westinghouse Hanford Company, Richland, Washington.

Lavender, J. C., 1994, *242-A Evaporator/Crystallizer Safety Analysis Report*, WHC-SD-WM-SAR-023, Rev. 1-B, Westinghouse Hanford Company, Richland, Washington.

Martin, P.F.C., and R. O. Lokken, 1993, *Characterization of Phosphate/Sulfate Waste Grout Cores*, PNL-8620, Pacific Northwest Laboratory, Richland, Washington.

Phillips, J. D., *Statement of Work for Conceptual Design for the Low-Level Waste Vitrification Plant Project* (Draft), WHC-SD-W378-SOW-001, Rev. 0F, Westinghouse Hanford Company, Richland, Washington.

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# 22.0 GLOSSARY

## ABBREVIATION AND ACRONYMS

| | |
|---|---|
| ANL | Argonne National Laboratory |
| CAA | Clean Air Act |
| CAM | cost account manager |
| CC | complexant concentrate |
| CEDE | committed effective dose equivalent |
| DOE | U.S. Department of Energy |
| DQO | data quality objective |
| DRD | design requirements document |
| DSSF | double-shell slurry feed |
| DST | double-shell tank |
| Ecology | Washington State Department of Ecology |
| EIS | environmental impact statement |
| EPA | U.S. Environmental Protection Agency |
| ETF | Effluent Treatment Facility |
| FSAR | final safety analysis report |
| FY | fiscal year |
| HC | hazards category |
| HLLTWPA | Hanford Low-Level Tank Waste Performance Assessment |
| HLW | high-level waste |
| ILLW | immobilized low-level waste |
| ITP | integrated technology plan |
| LLTWDS | Low-Level Tank Waste Disposal Site |
| LLW | low-level waste |
| LLWVP | Low-Level Waste Vitrification Plant |
| ND | No data |
| NEPA | National Environmental Policy Act |
| NESHAP | National Emission Standards for Hazardous Air Pollutants |
| NOC | Notice of Construction |
| NOI | Notice of Intent |
| NRC | U.S. Nuclear Regulatory Commission |
| O&M | Operation and Maintenance |
| PCT | product consistency test |
| PDRD | preliminary design requirements document |
| PFD | process flow diagram |
| PHP | precoat filter |
| PNL | Pacific Northwest Laboratory |
| PSAR | preliminary safety analysis report |
| PSD | prevention of significant deterioration |
| PSW | phosphate/sulfate waste |
| PUREX | Plutonium-Uranium Extraction (Facility) |
| PUREX | plutonium uranium reduction and extraction |
| RCRA | Resource Conservation and Recovery Act |
| REDOX | reduction oxidation |
| R-F | resorcinol-formaldehyde |
| RI | remaining inventory |
| RL | U.S. Department of Energy, Richland Operations Office |
| RPL | Rensselaer Polytechnic Institute |
| SEPA | State Environmental Policy Act |

| | |
|---|---|
| SPC | sulfur polymer cement |
| SST | single-shell tank |
| SWDP | State Waste Discharge Permit |
| Tg | transition temperature |
| TOE | total operating efficiency |
| TRS | technical requirements specification |
| TRU | transuranic |
| TSD | treatment, storage, and disposal |
| TTT | time-temperature-transformation |
| TWRS | Tank Waste Remediation System |
| UST | underground storage tank |
| WDOH | Washington State Department of Health |
| WHC | Westinghouse Hanford Company |
| WSSF | waste staging and sampling facility |

# APPENDIX A

## LOW-LEVEL WASTE LOGIC DIAGRAMS

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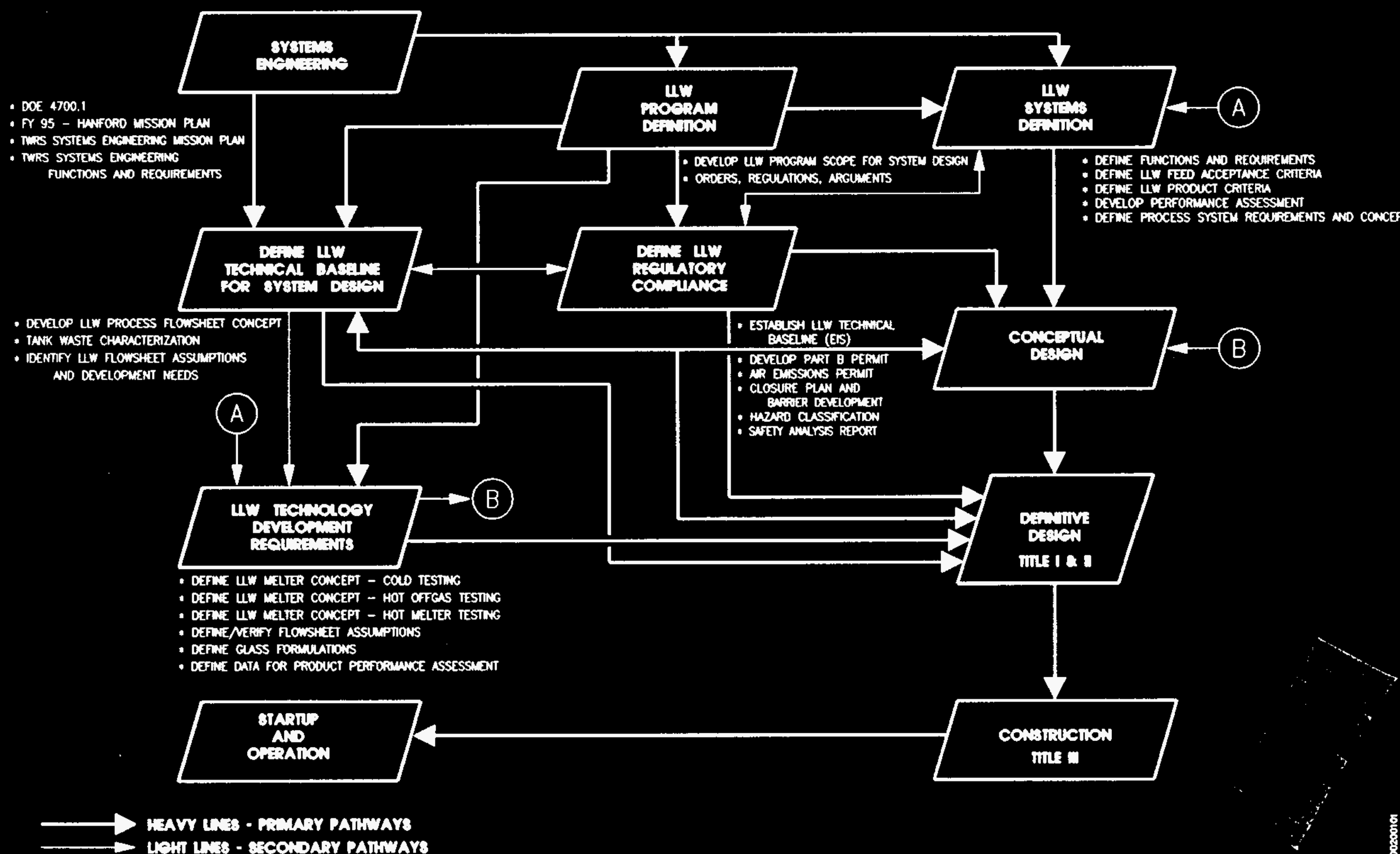
# LLW PROGRAM LOGIC DIAGRAM

## SUMMARY



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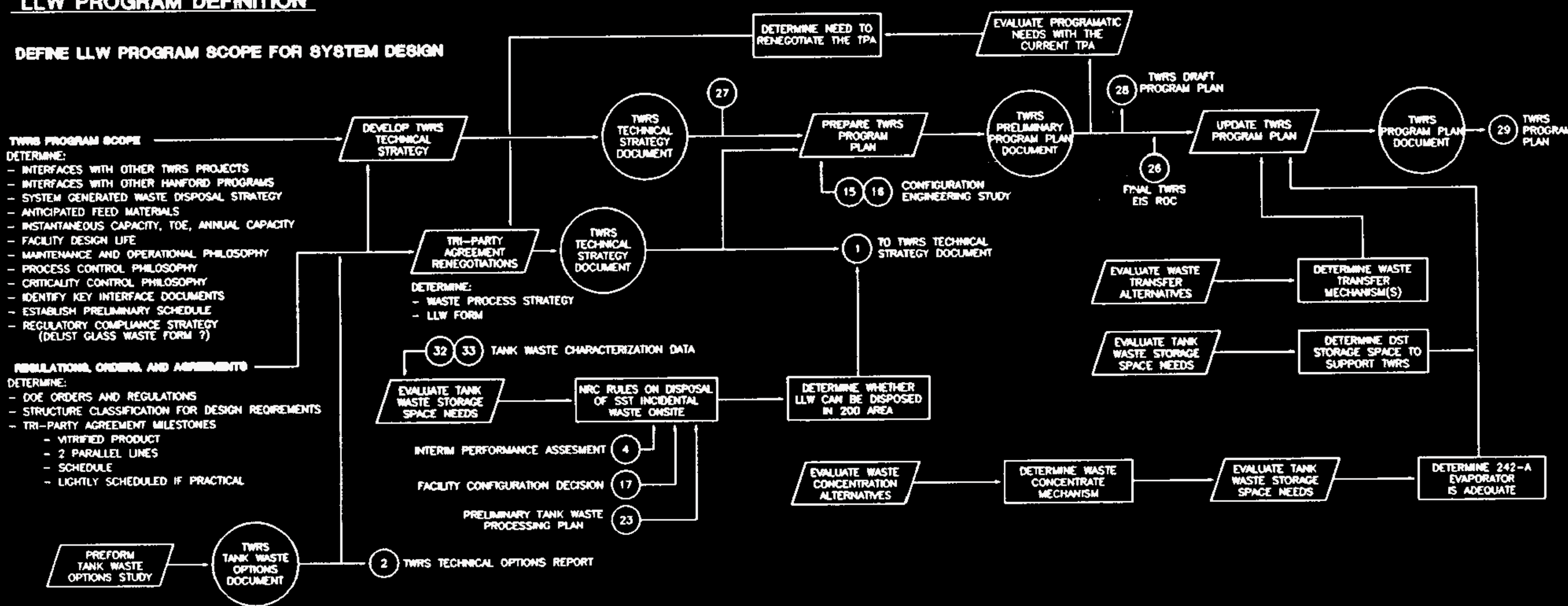

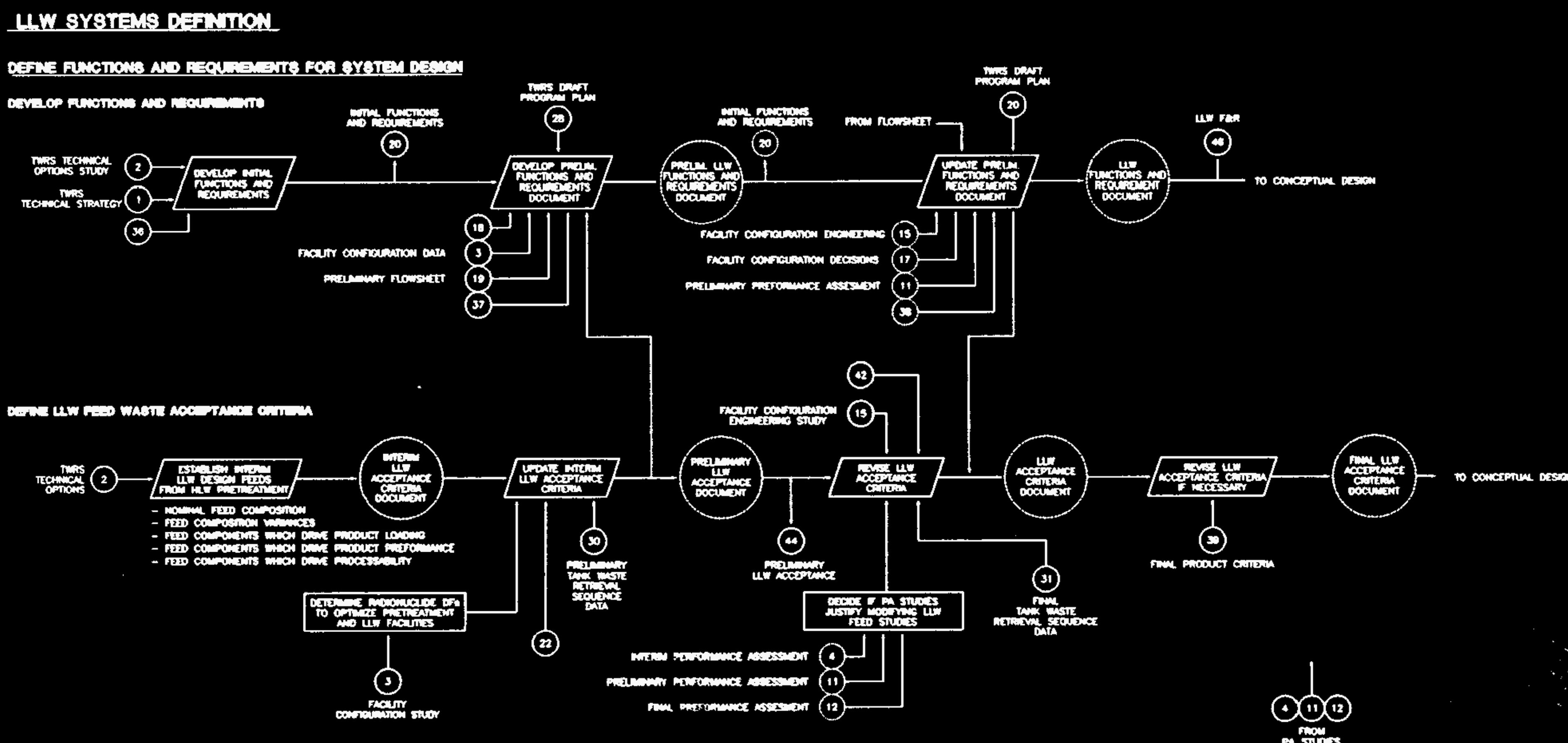
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TWRS TECHNICAL STRATEGY
DEVELOP INITIAL FUNCTIONS AND REQUIREMENTS
INITIAL FUNCTIONS AND REQUIREMENTS
TWRS DRAFT PROGRAM PLAN
DEVELOP PRELIM. FUNCTIONS AND REQUIREMENTS DOCUMENT
FACILITY CONFIGURATION DATA
PRELIMINARY FLOWSHEET
PRELIM. LLW FUNCTIONS AND REQUIREMENTS DOCUMENT
FROM FLOWSHEET
UPDATE PRELIM. FUNCTIONS AND REQUIREMENTS DOCUMENT
FACILITY CONFIGURATION ENGINEERING
FACILITY CONFIGURATION DECISIONS
PRELIMINARY PREFORMANCE ASSESMENT
LLW FUNCTIONS AND REQUIREMENT DOCUMENT
LLW F&R
TO CONCEPTUAL DESIGN
DEFINE LLW FEED WASTE ACCEPTANCE CRITERIA
TWRS TECHNICAL OPTIONS
ESTABLISH INTERIM LLW DESIGN FEEDS FROM HLW PRETREATMENT
- NOMINAL FEED COMPOSITION
- FEED COMPOSITION VARIANCES
- FEED COMPONENTS WHICH DRIVE PRODUCT LOADING
- FEED COMPONENTS WHICH DRIVE PRODUCT PREFORMANCE
- FEED COMPONENTS WHICH DRIVE PROCESSABILITY
INTERIM LLW ACCEPTANCE CRITERIA DOCUMENT
DETERMINE RADIONUCLIDE DFs TO OPTIMIZE PRETREATMENT AND LLW FACILITIES
FACILITY CONFIGURATION STUDY
UPDATE INTERIM LLW ACCEPTANCE CRITERIA
PRELIMINARY TANK WASTE RETRIEVAL SEQUENCE DATA
PRELIMINARY LLW ACCEPTANCE DOCUMENT
PRELIMINARY LLW ACCEPTANCE
FACILITY CONFIGURATION ENGINEERING STUDY
REVISE LLW ACCEPTANCE CRITERIA
DECIDE IF PA STUDIES JUSTIFY MODIFYING LLW FEED STUDIES
INTERIM PERFORMANCE ASSESSMENT
PRELIMINARY PERFORMANCE ASSESSMENT
FINAL PREFORMANCE ASSESMENT
FINAL TANK WASTE RETRIEVAL SEQUENCE DATA
LLW ACCEPTANCE CRITERIA DOCUMENT
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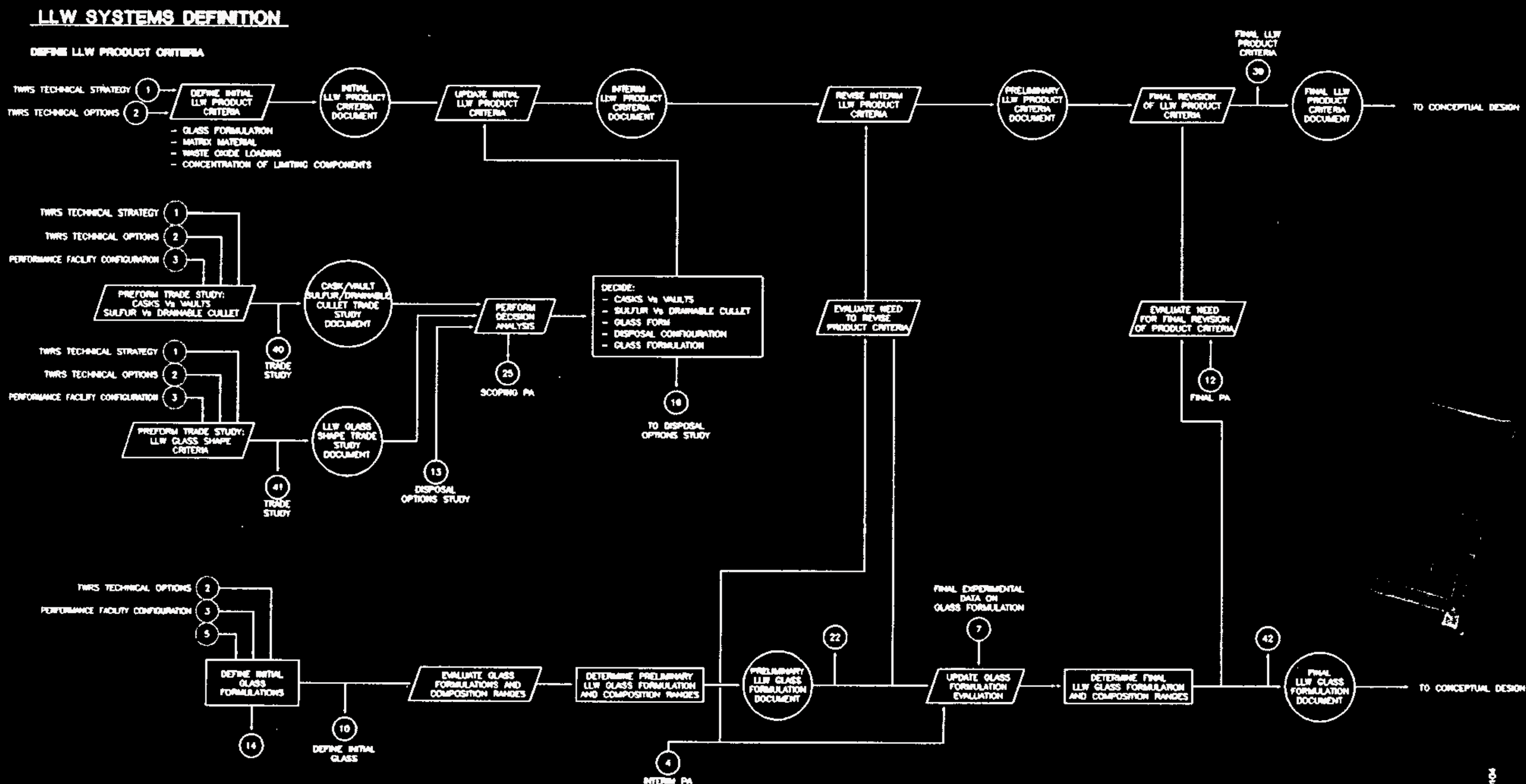
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- MATRIX MATERIAL
- WASTE OXIDE LOADING
- CONCENTRATION OF LIMITING COMPONENTS
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25 SCOPING PA
DECIDE:
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EVALUATE NEED FOR FINAL REVISION OF PRODUCT CRITERIA
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EVALUATE GLASS FORMULATIONS AND COMPOSITION RANGES
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## LLW SYSTEMS DEFINITION

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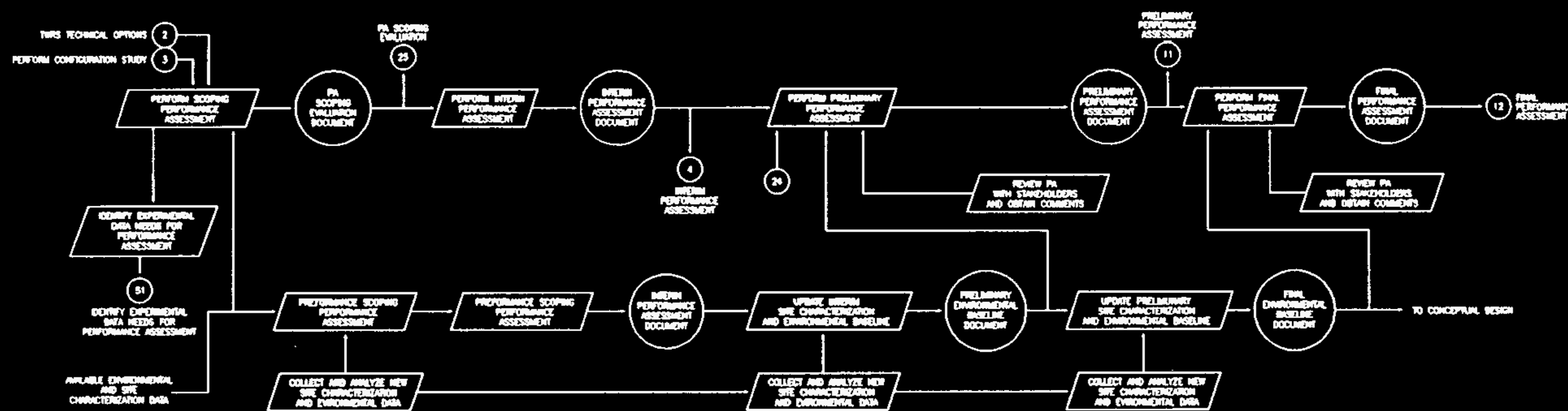

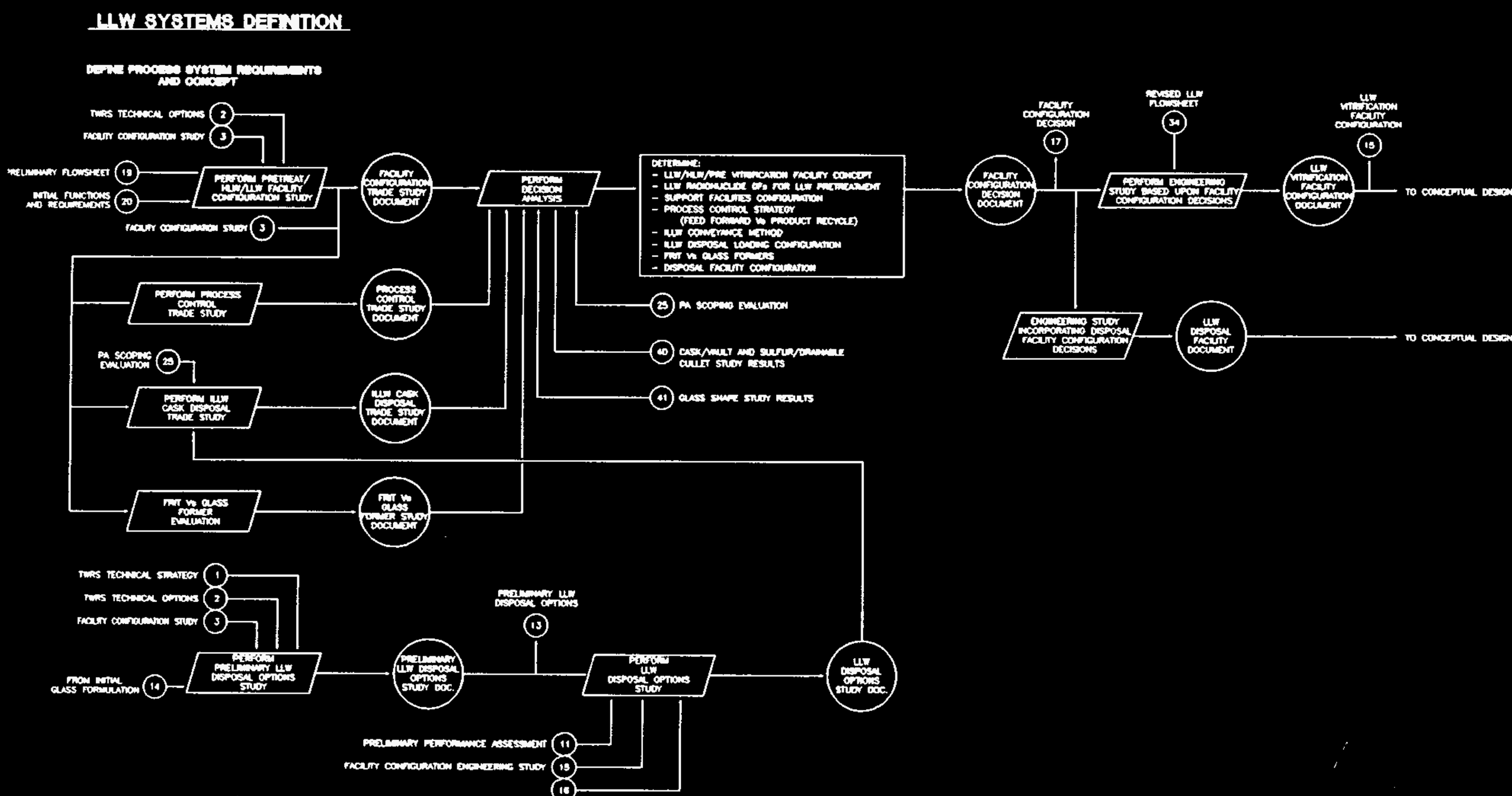
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PROCESS CONTROL TRADE STUDY DOCUMENT
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FRIT Vs GLASS FORMER EVALUATION
FRIT Vs GLASS FORMER STUDY DOCUMENT
PERFORM DECISION ANALYSIS
DETERMINE:
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- LLW RADIONUCLIDE DFs FOR LLW PRETREATMENT
- SUPPORT FACILITIES CONFIGURATION
- PROCESS CONTROL STRATEGY (FEED FORWARD Vs PRODUCT RECYCLE)
- ILLW CONVEYANCE METHOD
- ILLW DISPOSAL LOADING CONFIGURATION
- FRIT Vs GLASS FORMERS
- DISPOSAL FACILITY CONFIGURATION
25 PA SCOPING EVALUATION
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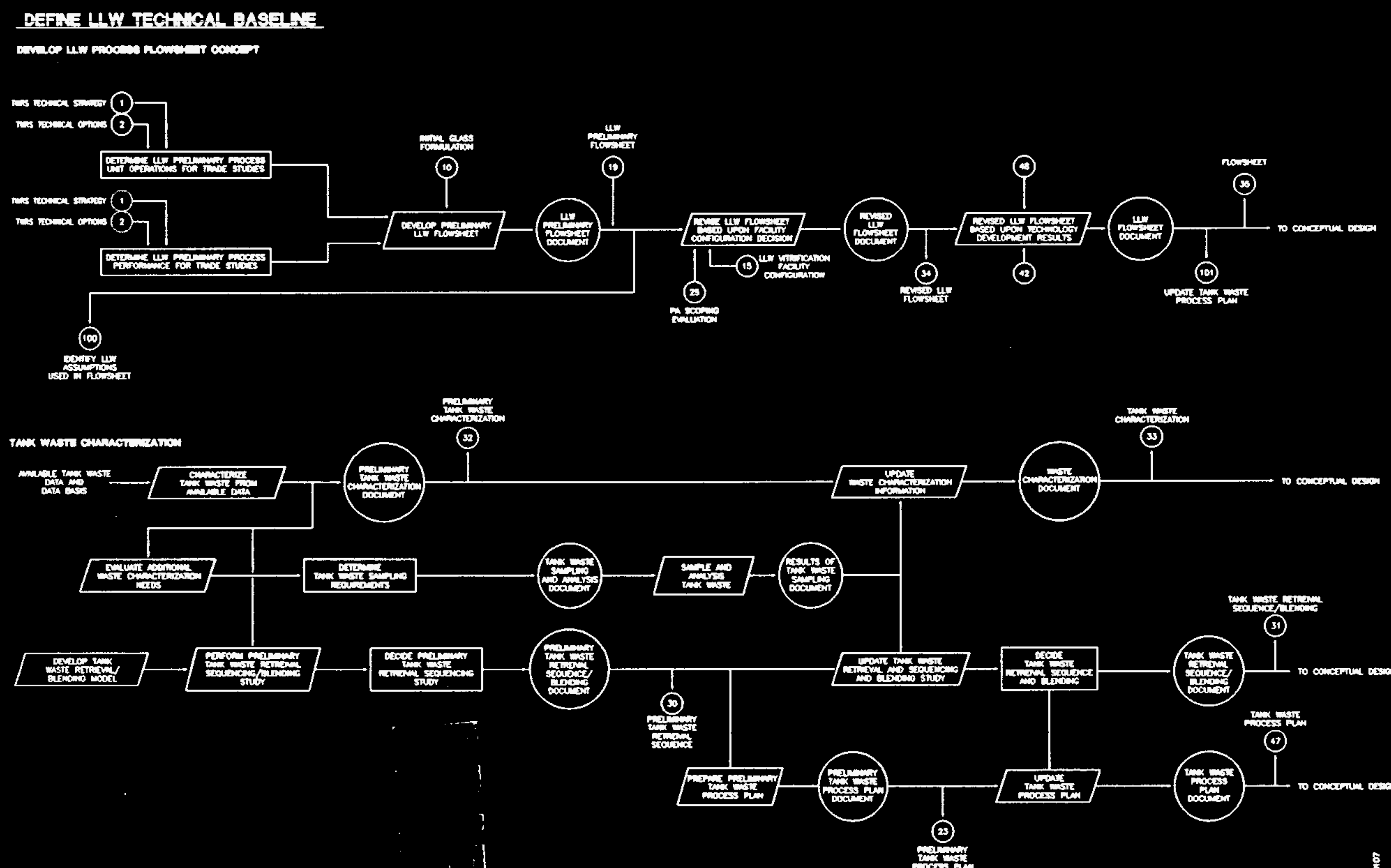
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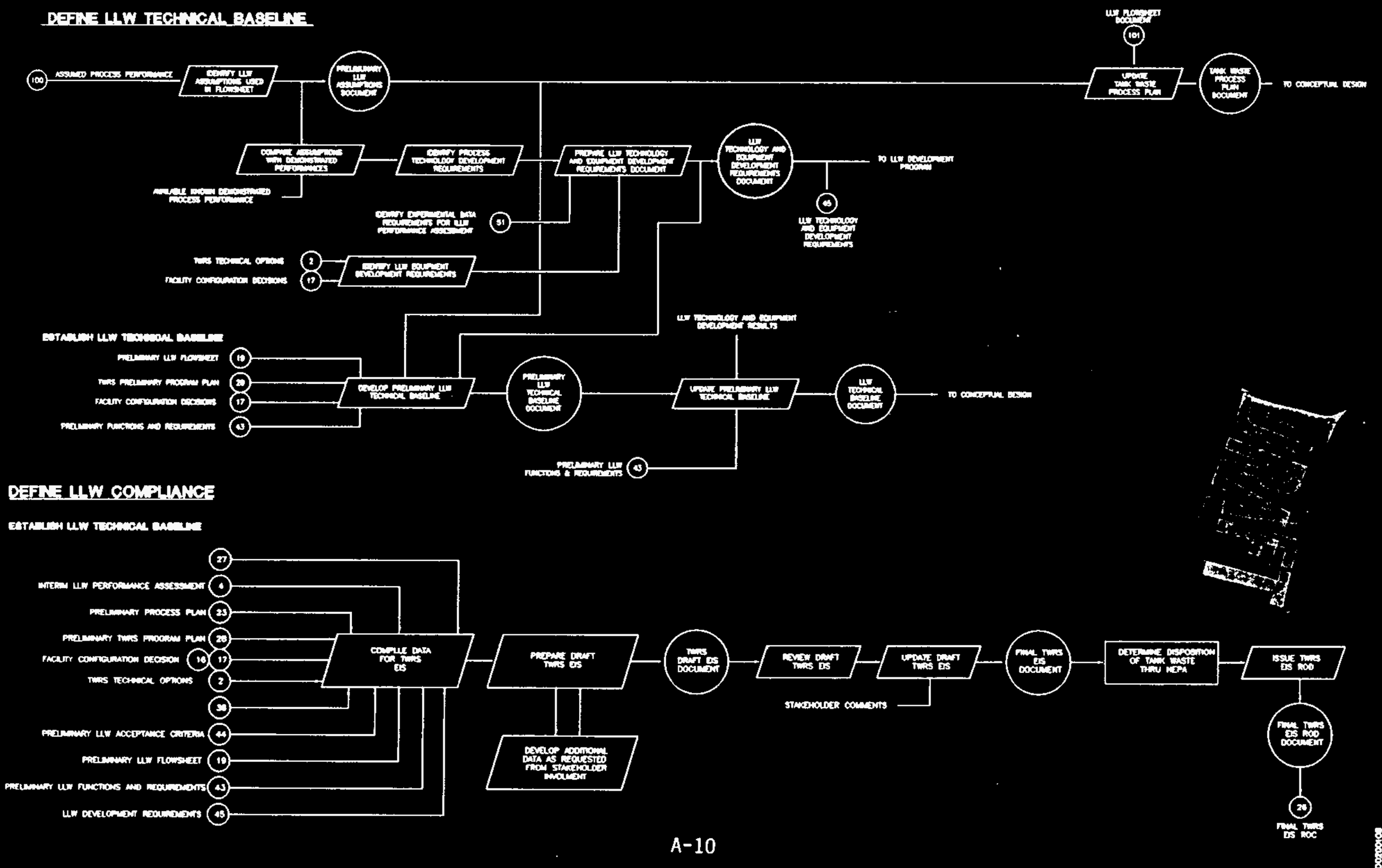
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PRELIMINARY LLW TECHNICAL BASELINE DOCUMENT
LLW TECHNOLOGY AND EQUIPMENT DEVELOPMENT RESULTS
UPDATE PRELIMINARY LLW TECHNICAL BASELINE
LLW TECHNICAL BASELINE DOCUMENT
TO CONCEPTUAL DESIGN
PRELIMINARY LLW FUNCTIONS & REQUIREMENTS
DEFINE LLW COMPLIANCE
ESTABLISH LLW TECHNICAL BASELINE
INTERIM LLW PERFORMANCE ASSESSMENT
PRELIMINARY PROCESS PLAN
PRELIMINARY TWRS PROGRAM PLAN
FACILITY CONFIGURATION DECISION
TWRS TECHNICAL OPTIONS
PRELIMINARY LLW ACCEPTANCE CRITERIA
PRELIMINARY LLW FLOWSHEET
PRELIMINARY LLW FUNCTIONS AND REQUIREMENTS
LLW DEVELOPMENT REQUIREMENTS
COMPILE DATA FOR TWRS EIS
PREPARE DRAFT TWRS EIS
DEVELOP ADDITIONAL DATA AS REQUESTED FROM STAKEHOLDER INVOLMENT
TWRS DRAFT EIS DOCUMENT
REVIEW DRAFT TWRS EIS
UPDATE DRAFT TWRS EIS
STAKEHOLDER COMMENTS
FINAL TWRS EIS DOCUMENT
DETERMINE DISPOSITION OF TANK WASTE THRU NEPA
ISSUE TWRS EIS ROD
FINAL TWRS EIS ROD DOCUMENT
FINAL TWRS EIS ROC
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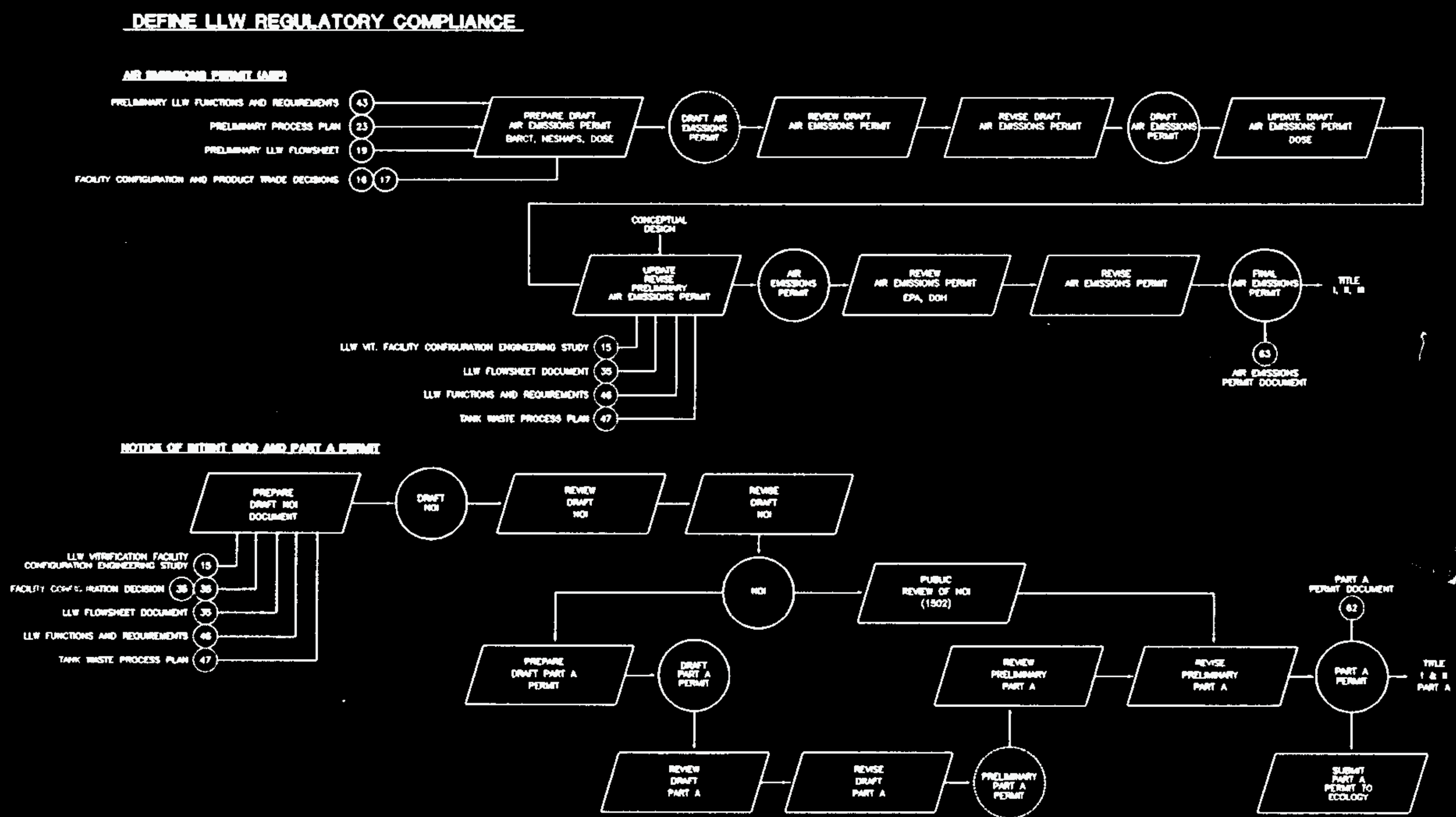
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PART A PERMIT
TITLE I & II PART A
SUBMIT PART A PERMIT TO ECOLOGY



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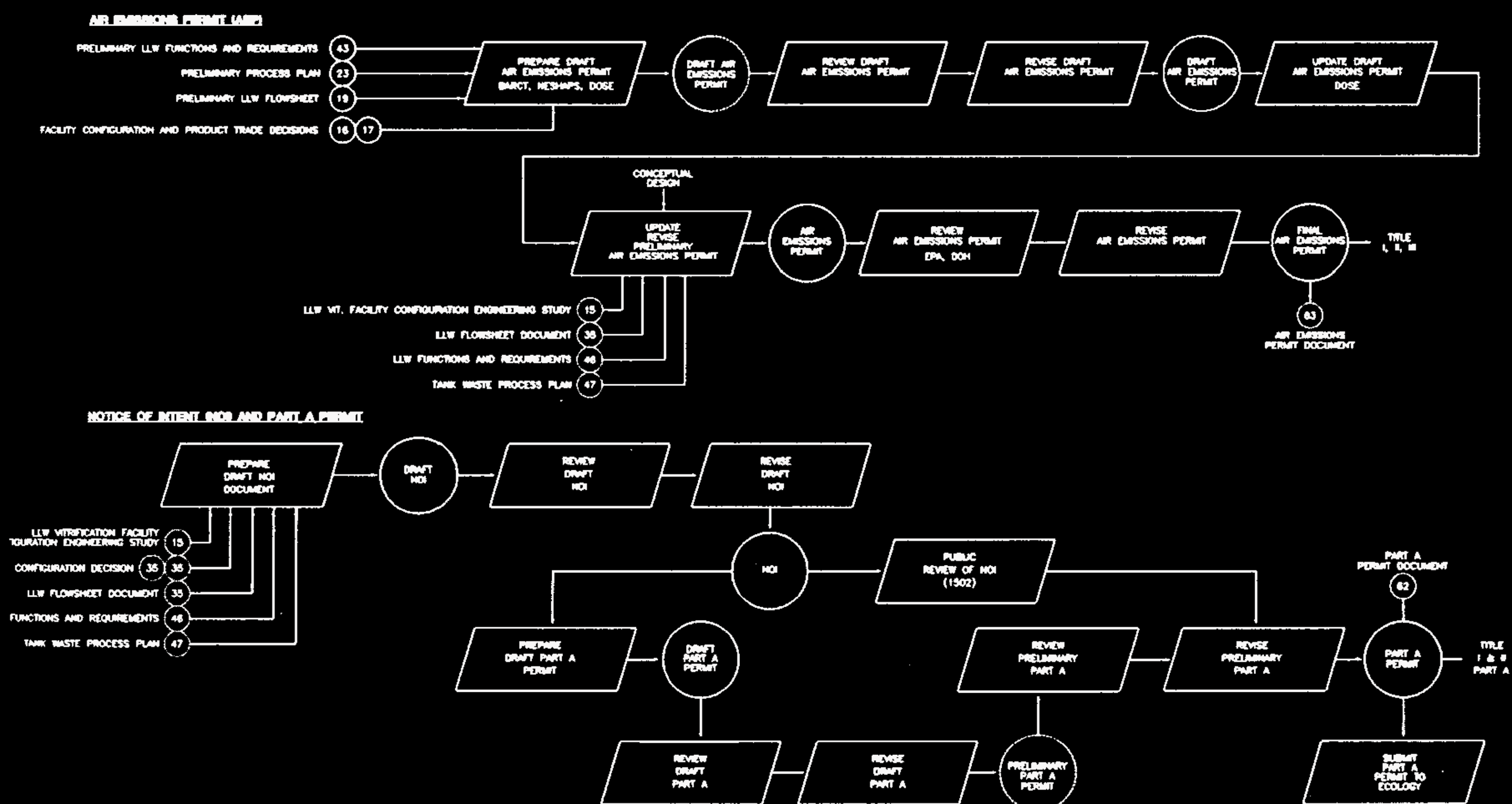
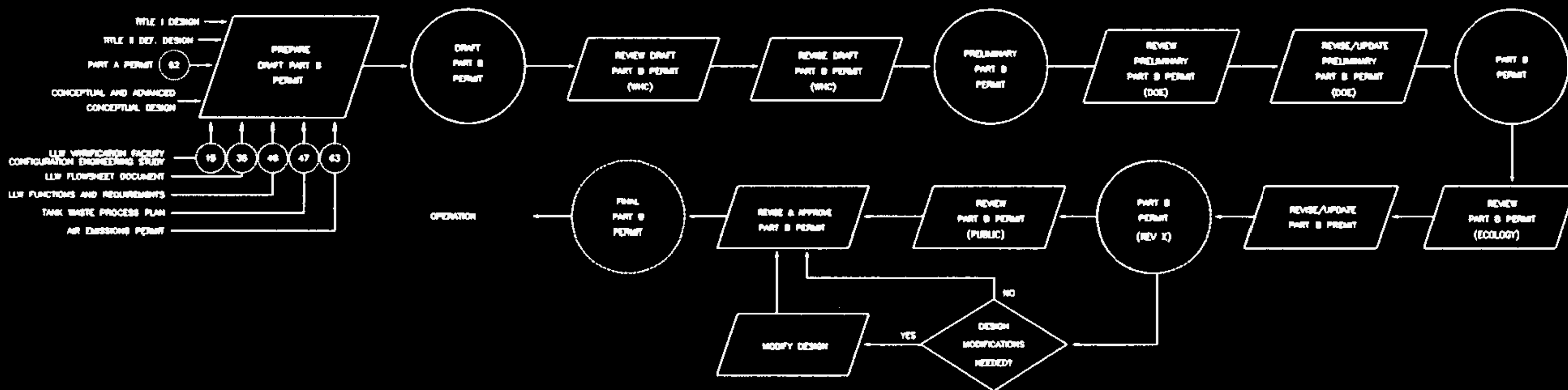
# DEFINE LLW COMPLIANCE



## DEFINE LLW COMPLIANCE

### PART B PERMIT

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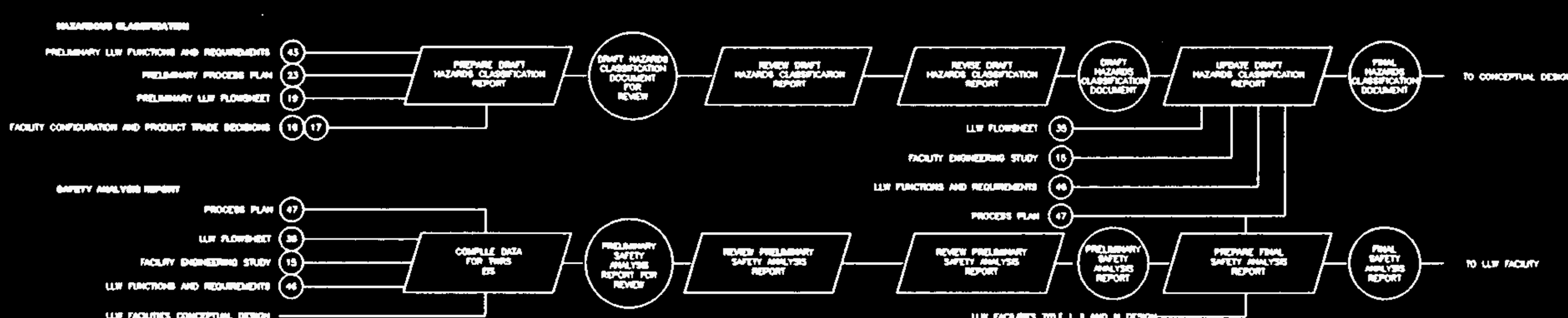


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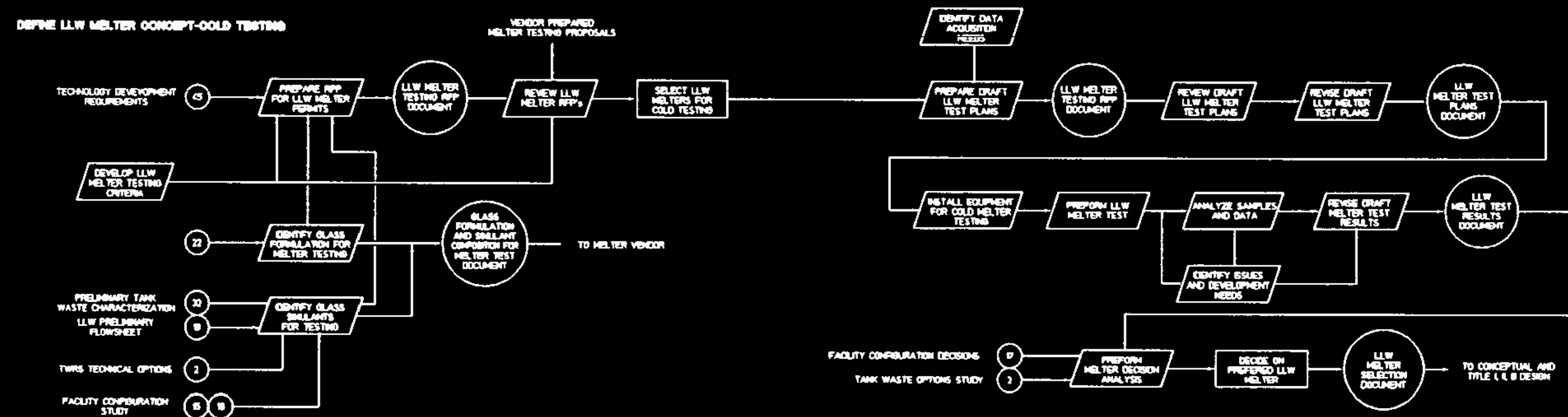
## LLW TECHNOLOGY DEVELOPMENT REQUIREMENTS

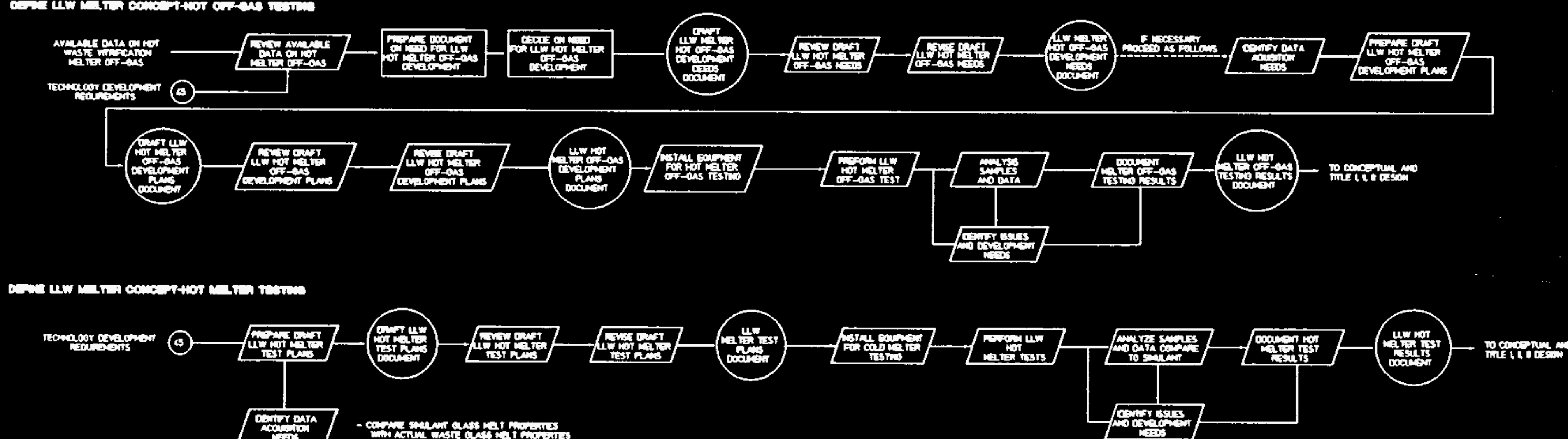
DEFINE LLW MELTER CONCEPT-COLD TESTING




## LLW TECHNOLOGY DEVELOPMENT REQUIREMENTS

DEFINE LLW MELTER CONCEPT-HOT OFF-GAS TESTING

DEFINE LLW MELTER CONCEPT-HOT MELTER TESTING



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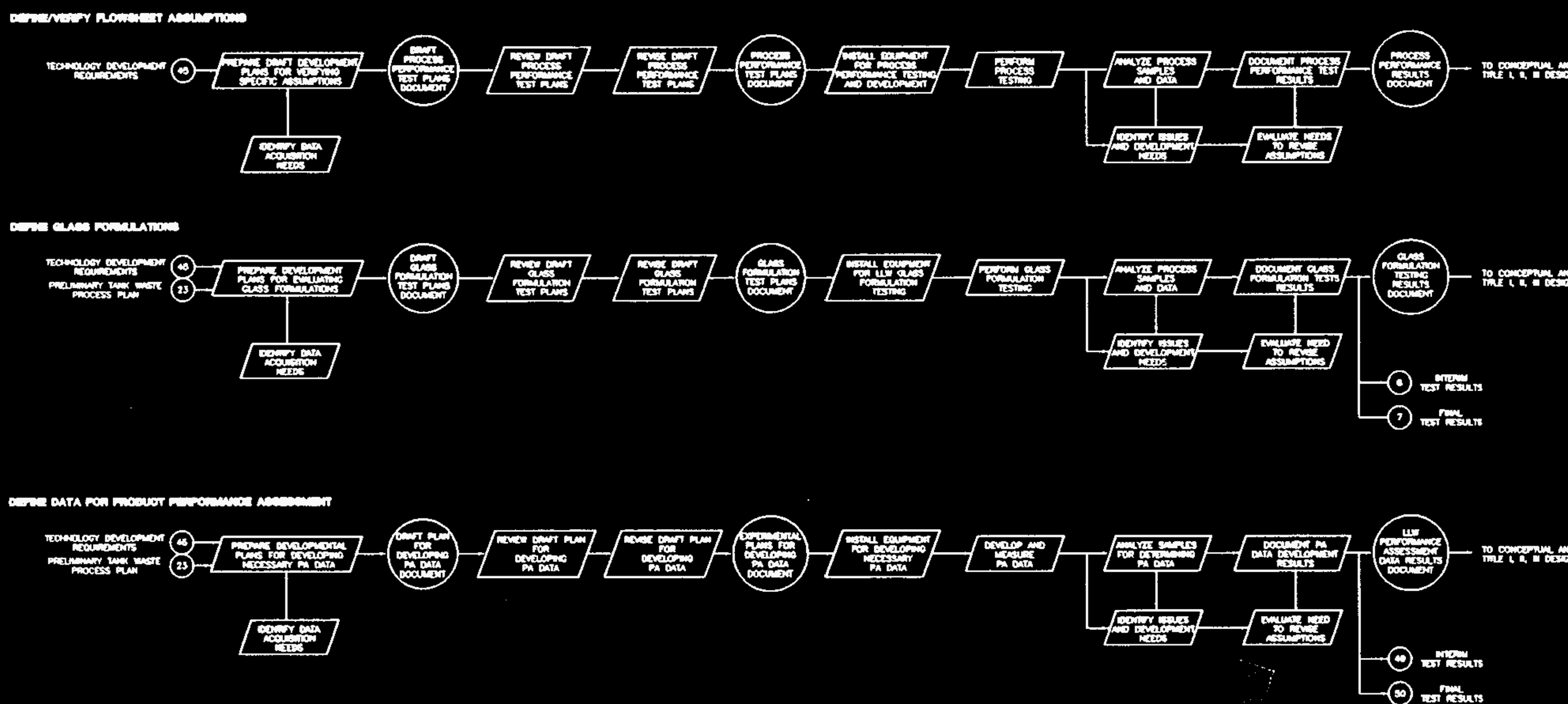
## LLW TECHNOLOGY DEVELOPMENT REQUIREMENTS




D0200113

Definition of LLW Program Logic Diagram numerical designators

1 TWRS Technical Strategy Document
2 TWRS Technical Options Report (TOR)
3 Perform Pretreat/HLW/LLW Facility Configuration Study
4 Interim Performance Assessment Document (IPA)
5
6 Glass Formula Interim Test Results
7 Glass Formula Final Test Results
8
9
10 Define Initial Glass formulations
11 Preliminary PA Document
12 Final PA Document
13 Preliminary LLW Disposal Options Study Document
14
15 LLW Vitrification Facility Configuration Engineering Study
16
17 Facility Configuration Decision Document
18
19 LLW Preliminary Flowsheet Document
20 Initial Functions and Requirements development
21
22
23 Preliminary Tank Waste Process Plan Document (and Retrieval?)
24
25 PA Scoping Evaluation Document
26 Final TWRS EIS ROC Document
27
28- TWRS Draft Program Plan Document
29 TWRS Program Plan Document
30 Preliminary Tank Waste Retrieval Sequence/Blending Document
31 Tank Waste Retrieval Sequence/Blending Document
32 Preliminary Tank Waste Characterization Document/Data Base
33 Tank Waste Characterization Document/Data Base
34 Revised LLW Flowsheet Document
35 LLW Flowsheet Document
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39 Final LLW Product Criteria Document
40 Trade study, Casks vs Vaults & sulfur vs Drainable cullet

Definition of LLW Program Logic Diagram numerical designators (continued)

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44 Preliminary LLW Acceptance Document
45 LLW Technology & Equipment Development Requirements Document
46 LLW F&R Document
47 Tank Waste Process Plan Document
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50 PA Preliminary Test Results
51 Identify Experimental Data Needs for PA
52 LLW Disposal Facility Configuration Document (new)
53
54 PA Final Test Results (NEW)
55 Final LLW Acceptance Criteria Document (NEW)
56 Identify Melter cold testing issues and Development Needs (NEW)
57 Identify Melter hot off-gas testing issues and development needs (NEW)
58 Identify Melter hot testing issues and development needs (NEW)
59 Identify flowsheet assumptions, issues and Development Needs (NEW)
60 Identify Glass Formulation assumptions, issues and Development Needs (NEW)
61 Identify PA data issues & Development Needs (NEW)
62 Part A Permit Document
63 Air Emissions Permit Document

110 Preliminary PA
111 PA-Internal
112 Final PA

# APPENDIX B

# SIMULATED AND ASSUMED WASTE COMPOSITION

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## Appendix B-Compositions of Off-gas Condensate

Table B-1. Simulated Waste Stream Compositions (g/L).

| Compound | Original[a] | Carryover[b] | Offgas solutions | |
|---|---|---|---|---|
| | | | w.volatiles (1)[c] | w.volatiles (2) |
| NaOH (50%)$^+$ | 149.7 | 8.22 | 23.2 | -- |
| $Al(NO_3)_3 \cdot 9H_2O^+$ | 128.0 | 7.03 | 7.03 | 7.03 |
| $Na_3(PO_4) \cdot 12H_2O^+$ | 74.4 | 4.09 | 22.7 | 22.7 |
| $NaNO_2^+$ | 36.9 | 2.03 | 11.2 | -- |
| $Na_2CO_3^+$ | 36.2 | 1.99 | 5.6 | 35.5 |
| $NaNO_3^+$ | 8.58 | 0.47 | 15.5 | 28.8 |
| $Na_3$(HEDTA)$^+$ | 5.293 | 0.29 | 0.29 | -- |
| $Na_2SO_4$ | 3.89 | 0.21 | 0.21 | -- |
| $NaCl^+$ | 2.50 | 0.14 | 0.27 | 0.46 |
| $Na_3$(citrate)$\cdot 2H_2O^+$ | 2.50 | 0.14 | 0.14 | -- |
| $KCl^+$ | 1.83 | 0.10 | 0.19 | -- |
| $Na_4$(EDTA)$\cdot 2H_2O^+$ | 1.415 | 0.08 | 0.08 | -- |
| Glycollic acid$^+$ | 0.645 | 0.035 | 0.03 | -- |
| $Ca(NO_3)_2 \cdot 4H_2O$ | 0.438 | 0.02 | -- | -- |
| $Ni(NO_3)_2 \cdot 6H_2O$ | 0.302 | 0.02 | -- | -- |
| $Na_2B_4O_7$ | 0.131 | 0.01 | -- | -- |
| $Mg(NO_3)_2 \cdot 6H_2O$ | 0.028 | -- | -- | -- |

[a]106-AN/102-AP waste recipe used in Hanford Site Grout Disposal Program.

[b]Assuming 5% of waste is physically carried over as an aerosol, there is 0.86 L free water per liter of waste. Thus, dilution factor is 0.05 ---> 0.91 L.

[c]Assume those compounds marked with (+) are volatilized (see Table 16-2, Case 1).

EDTA = Ethylenediametetraacetic acid

Table B-2. Assumed Volatility of Compounds.

| Compound | Decomposition | Volatility temperature (°C) | Volatilized (wt%)* | Species formed | |
|---|---|---|---|---|---|
| | | | | Case 1 | Case 2 |
| NaOH | subl. 1,275 | 10 | $Na_2O$ | NaOH | $Na_2CO_3$ |
| $Na_2CO_3$ | >850 | 10 | $CO_2$ | $H_2CO_3$ | $Na_2CO_3$ |
| NaCl | boils 1,413 | 5 | NaCl | NaCl | NaCl |
| $NaNO_3$ | d380 | 25 | $NO_x$ | $HNO_3$ | $NaNO_3$ |
| $NaNO_2$ | d320 | 25 | $NO_x$ | $HNO_3$ | $NaNO_2$ |
| Organic salts | d<500 | 25 | $CO_2$ | $H_2CO_3$ | $Na_2CO_3$ |
| $Al(NO_3)_3 \cdot 9H_2O$ | d150 | 25 | $NO_x$ | $HNO_3$ | $Na_2NO_3$ |
| $Ca(NO_3)_2 \cdot 4H_2O$ | d561 | 25 | $NO_x$ | $HNO_3$ | $Na_2NO_3$ |
| $Na_3(PO_4) \cdot 12H_2O$ | 204 | 25 | $PO_x$ | $H_3PO_4$ | $Na_3PO_4$ |
| KCI | subl. 1,500 | 5 | KCl | KCI | KCl |

*Percentages of masses in original waste feed allow for changes in formula mass where appropriate.