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Tank Farm Contractor Operation and Utilization Plan

R. A. Kirkbride et. al.
CH2M HILL Hanford Group, Inc.
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Key Words: Phase 1 Privatization, Phase 2 Privatization, pretreatment, low-activity waste, high-level waste, SST retrieval sequence, and feed envelopes.

Abstract: This document updates the operating scenario and plans for feed delivery to BNFL Inc. of retrieval and waste from single-shell tanks, and the overall process flowsheets for Phases 1 and 2 of the River Protection Project. The plans and flowsheets are updated with the most recent guidance from ORP and tank-by-tank inventory. The results provide the technical basis for the RTP-2 planning effort. Sensitivity cases were run to evaluate the effect of changes on key parameters.

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ABSTRACT

The U.S. Department of Energy Office of River Protection is responsible for conduct and oversight of the River Protection Project (RPP). The RPP mission is to store, treat, immobilize, and dispose of the highly radioactive Hanford Site tank waste (including current and future tank waste and cesium and strontium capsules) in an environmentally sound, safe, and cost-effective manner. This document, which has been prepared by CH2MHILL Hanford Group, Inc., the Office of River Protection's Hanford Site Tank Farm Contractor (TFC), is the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The TFC O&UP describes technical results from evaluating different scenarios for retrieving waste from the double-shell tanks and single-shell tanks, staging, delivering, treating, immobilizing, storing, and disposing of the tank waste, and possible impacts for accomplishing the RPP mission.

The constraints, assumptions, data inputs, results, findings, and other information reported in the TFC O&UP are organized into three main documents: a TFC O&UP Summary, which is intended primarily for use by headquarters and other senior decision makers; the TFC O&UP, Volume I, which is intended primarily for use in developing technical and programmatic planning information; and, the TFC O&UP, Volume II, which is intended primarily for use by engineers, scientists, and other technical personnel for use in preparing and managing data about waste processing. The purposes and structures of these documents are outlined below.

TFC Operation and Utilization Plan Summary

The purpose of the TFC O&UP Summary is to provide a broad overview of the objectives, functions, and results of the TFC O&UP, and to replace what would typically be presented in an Executive Summary. This summary document describes how the TFC O&UP supports tank waste retrieval and disposal planning, what information is needed, and what results are provided. It also summarizes the results for the principal waste processing scenario reported in the current revision of the TFC O&UP, and discusses comparative results for alternative cases used to assess planning sensitivities. The summary targets non-Hanford Site readers.

TFC Operation and Utilization Plan, Volume I

The TFC O&UP, Volume I, provides the technical details that describe, evaluate, and compare the results for various waste processing scenarios. Sensitivity analyses are included to assess RPP mission impacts associated with changes in assumptions, constraints, or other key parameters. Volume I is geared for a technical audience familiar with Hanford Site issues.

TFC Operation and Utilization Plan, Volume II

The purpose of Volume II of the TFC O&UP is to document key data, parameters of interest, and other information that are direct inputs and outputs for the computer simulation models and supporting calculations. Volume II provides a record repository and performs a configuration management role for the raw materials used to develop the results and findings presented in Volume I. Volume II is not generally distributed and is useful primarily for a reader researching background material.

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TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN SUMMARY

S1.0 BACKGROUND

Approximately 204,400 m^3 (54 Mgal) of highly radioactive waste have accumulated in 177 large underground tanks at the Hanford Site. Approximately 3,800 m^3 (1 Mgal) of waste have leaked into the ground from 67 of the tanks. All tanks are close to or have exceeded their design lives. Radionuclides from past tank leaks have moved through the soil and now have reached the groundwater that flows under the Hanford Site and into the Columbia River, approximately seven miles away. To address this threat to the Columbia River, the U.S. Department of Energy (DOE) established the River Protection Project (RPP). DOE's Office of River Protection (ORP) is responsible for conduct and oversight of the RPP. The RPP mission is to store, treat, immobilize, and dispose of the highly radioactive Hanford Site tank waste (including current and future tank waste and cesium and strontium capsules) in an environmentally sound, safe, and cost-effective manner.

This document has been prepared by CH2MHILL Hanford Group, Inc. (CHG), the Hanford Site Tank Farm Contractor (TFC), to summarize the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The TFC O&UP is a key technical baseline document that describes technical aspects of retrieving waste from the underground tanks and the results from treating and immobilizing tank waste to accomplish the RPP mission. The TFC O&UP uses computer-based simulations and calculations to evaluate proposed waste retrieval and processing scenarios. The TFC O&UP relies on tank waste inventory data to determine physical and chemical characteristics of tank waste liquids and solids. This and other information are used to model storage, retrieval, staging, delivery, immobilization, and immobilized waste product handling processes. Modeling results include estimates of as-delivered waste feed quantities and compositions, waste loading efficiencies for the immobilization processes, and quantities and composition of immobilized waste products. Outputs from the models and calculations can be used to verify the adequacy of waste feed delivery systems and components, schedules for retrieval and waste processing, and adequacy of tank waste storage and immobilized waste management capacities. The TFC O&UP documents these modeling and calculation efforts, reports the results and findings, and evaluates the impacts of different waste processing scenarios for the RPP mission.

S1.1 THE RIVER PROTECTION PROJECT

In 1989, DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) entered into an enforceable compliance agreement (Ecology et al 1996) (commonly called the Tri-Party Agreement) that set milestones for cleanup of the tank waste. In 1996, in accordance with the *National Environmental Policy Act*, DOE and Ecology issued the *Tank Waste Remediation System Final Environmental Impact Statement* (DOE 1996), which assessed the full range of reasonable alternatives for continued safe management and remediation of the wastes. DOE subsequently issued a Record of Decision

(62 FR 8693) which documented the selection of a "Phased Implementation" alternative. Ecology concurred in the selection of this alternative.

The Phased Implementation alternative (as currently defined) consists of two major phases of work for retrieving and immobilizing the double-shell tank (DST) and single-shell tank (SST) wastes and closing the tank farms:

- Phase 1 is an initial production phase, lasting until about 2018, during which the efficiency and effectiveness of the processes selected to treat the tank waste will be verified. The Phase 1 effort includes treatment of an initial "Minimum Order" quantity (which could be completed as early as 2012) and treatment of an "Extended Order" quantity if the initial effort is successful. BNFL Inc. is the privatization contractor (ORP 1999) currently responsible for the Phase 1 treatment and immobilization facilities. CHG is currently responsible for retrieving and delivering tank waste feed to the treatment and immobilization facilities, and for accepting, storing, and disposing of the immobilized waste product.

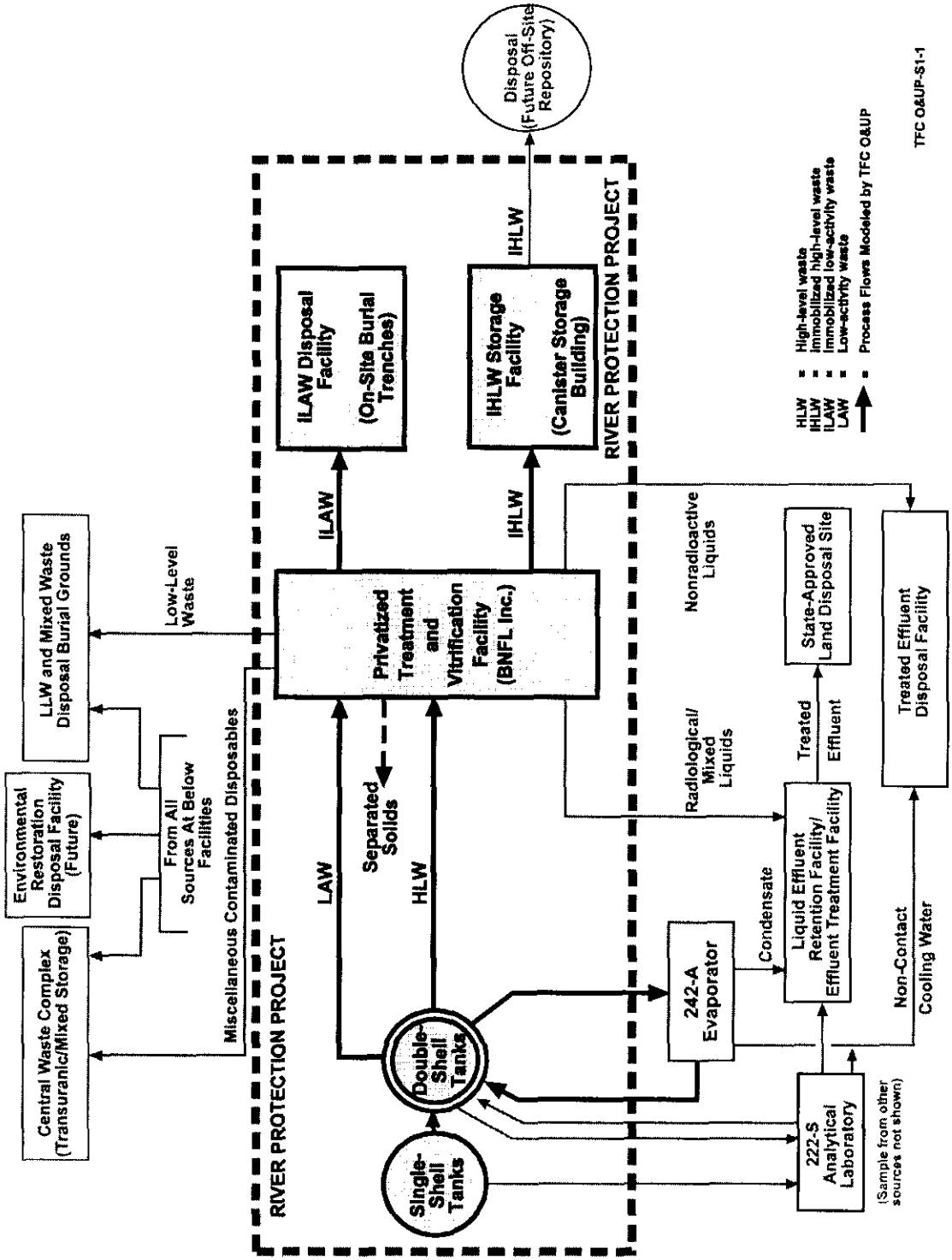
- Phase 2 is the full production phase when the majority of the waste will be treated. Phase 2 concepts include: scaling up of the treatment and immobilization facilities; transfer of SST wastes via waste receiving facilities into the DSTs for staging and delivery; final disposition of the immobilized products; closure (currently expected to be closure in-place) of emptied SSTs and then DSTs; and, transfer of the closed facilities to the Hanford Site cleanup program for long-term care and monitoring.

Most of the Phase 1 waste feed will originate in DSTs, with a relatively small contribution from selected SSTs (these transfers will help develop SST retrieval and closure technologies for use during Phase 2). Four different types of waste, will be processed in Phase 1 to demonstrate the viability of the waste treatment and immobilization processes. Low-activity waste (LAW) will be processed in three categories (designated Envelopes A, B, and C), and high-level waste (HLW) will be processed in one category (designated Envelope D). The treatment and immobilization processes being designed at this time rely on converting LAW and HLW into stable glass forms in a privately operated waste vitrification system. Immobilized low-activity waste (ILAW) will be disposed in near-surface disposal sites (to be constructed), and immobilized high-level waste (IHLW) will be stored in the existing Canister Storage Building (to be modified) and other facilities until shipment off-site. The major facilities and process flows associated with tank waste retrieval and disposal are depicted in Figure S1-1; the RPP components and the process flows addressed in the TFC O&UP are highlighted for clarity.

S1.2 PURPOSE OF THE TFC O&UP

Future tank waste remediation decisions require a thorough understanding of the operation and utilization of the SST, DST, treatment, storage, and disposal systems. The ability to easily consider and evaluate different tank waste retrieval and disposal scenarios is critical to designing optimal technology, environmental, cost, and schedule solutions for the RPP. To support this ability, ORP has directed its contractors to develop and maintain the TFC O&UP. Modeling and analyses of different waste processing scenarios is ongoing throughout the year, and the TFC O&UP is updated about annually to document and report current findings.

Figure S1-1. Major Facilities and Process Flows Associated with Tank Waste Retrieval and Disposal.



The TFC O&UP documents how information, engineering calculations, process models, and other capabilities have been developed and used to evaluate current RPP requirements and guidance on tank waste retrieval, treatment, storage, and disposal. Each update of the TFC O&UP describes the most current tank waste processing simulations, inputs to the simulations, limitations of the information and data used, and necessary assumptions. The TFC O&UP also describes and interprets the results of these simulations with respect to potential impacts on the RPP life-cycle, discusses the sensitivity of the results to changing conditions, makes recommendations for future improvements, and addresses other significant considerations. Thus, the TFC O&UP fulfills two main purposes:

- It defines the engineering tools and input data used to test different waste processing scenarios. The TFC O&UP provides a coherent methodology for integrating and evaluating the effects of varying waste properties, schedules, technologies, and other process constraints. The result is a consistent, defensible means by which managers and decision makers can compare, control, and optimize the technical baseline for those factors that significantly influence tank waste retrieval and disposal capabilities.

- It provides an engineering record of the work performed to define, test, and evaluate different waste processing scenarios. The TFC O&UP ensures that technical baseline planning efforts conducted to date are traceable and reproducible, and documents the technical baseline history as new events and information are accounted for. The TFC O&UP provides ongoing confirmation of the validity of the evolving plans for processing tank wastes and current recommendations derived from the scenario evaluations. The result is a continuously improving level of confidence that a credible plan, with a reasonable chance of success, has been devised and can be implemented for tank waste retrieval and disposal.

The TFC O&UP consists of this summary document, and Volumes I and II, which provide the complete engineering and technical details used to develop and evaluate alternative tank waste processing scenarios. Section S2.0 of this summary document describes how the TFC O&UP supports tank waste retrieval and disposal planning, what information is needed, and what results are provided. Section S3.0 summarizes the results for the principal waste processing scenario reported in the current revision of the TFC O&UP, and discusses comparative results for alternative cases used to assess planning sensitivities. Attachment 1 provides a section-by-section annotation of the TFC O&UP, Volumes I and II, and Attachment 2 presents sample calculations used to test and establish the reliability of the model results developed in the TFC O&UP.

S2.0 INTRODUCTION TO THE TFC O&UP

The TFC O&UP is an engineering document that analyzes key information and data and models the dynamic relationships between current and future tank waste operations. It provides a variety of calculations and other results that are used to evaluate different waste processing scenarios. This section explains how TFC O&UP helps support planning for tank waste retrieval and disposal, identifies the types of information and data needed to evaluate waste processing scenarios, and briefly describes the types of results provided by the TFC O&UP models and calculations. (Note that actual results and findings for the current revision of the TFC O&UP are discussed in Section S3.0.) This section provides information at a summary level; Volumes I and II of the TFC O&UP should be consulted for source details.

S2.1 HOW TFC O&UP SUPPORTS TANK WASTE RETRIEVAL AND DISPOSAL PLANNING

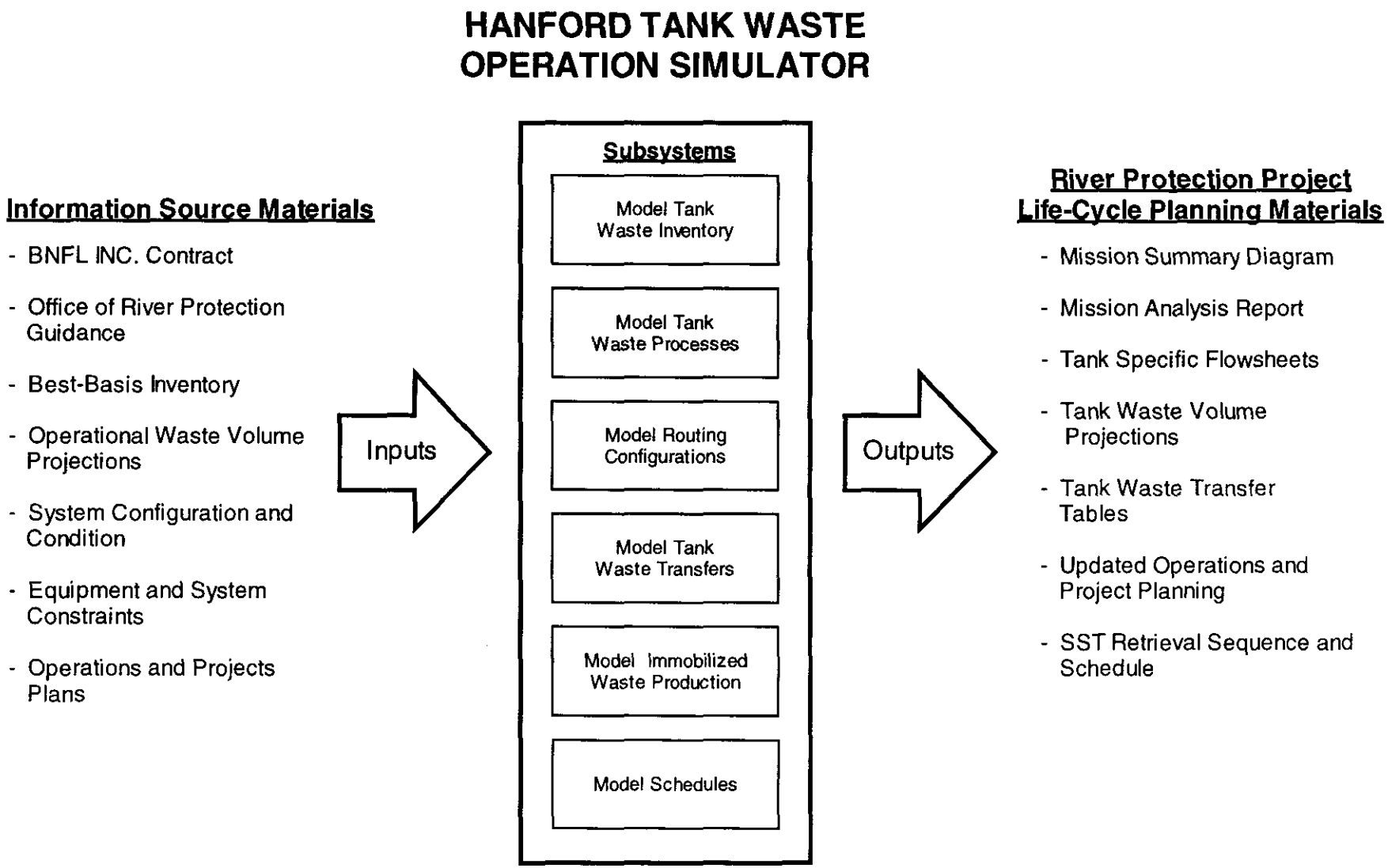
The TFC O&UP uses information about waste properties, tank system configurations, desired end states, target milestones, and other parameters associated with particular waste processing scenarios, to produce a variety of outputs, such as spreadsheets, figures, tables, and schedules. These outputs are used to evaluate the relationship between tank waste retrieval and disposal activities and the overall ability to accomplish the RPP mission. Much of this information is used to describe and bound existing and projected conditions for the major operating facilities and process flows within the RPP.

The principal tool used to perform the analyses and provide the results documented in the TFC O&UP is a computer-based model called the Hanford Tank Waste Operation Simulator (HTWOS). The HTWOS calls on several other models and computational subroutines to process data, simulate operating scenarios, perform chemical- and mass-balance calculations, and derive time estimates and processing schedules. Figure S2-1 provides a functional block diagram showing the main subsystems that support HTWOS, along with key sources from which input information is obtained, and key technical and program materials that use the outputs from HTWOS. Typical HTWOS tank waste processing simulations involve the following steps.

Establish the Characteristics of Source Tank Wastes

- **Produce Source Tank Inventory**. An accurate inventory of the parameters of interest for the waste in a source tank is needed before it is possible to determine whether applicable limits (e.g., envelope specifications, safety licenses, environmental permits) can be met during waste retrieval and upon delivery of waste feed to the treatment and immobilization facility. Information about tank waste is derived from the Best-Basis Inventory, which incorporates sample analytical data, process knowledge, and historical transfer data to compile and calculate tank-specific inventories for waste constituents, quantities, properties, and other parameters of interest. These parameters are partitioned between the liquid and solid phases of the source tank waste to produce the source tank waste inventory used by the HTWOS.

Figure S2-1. Functional Diagram of HTWOS Subsystems, Input Sources, and Output Materials.



- **Calculate Liquid Fraction (Supernate).** Both DST and retrieved SST waste will be comprised primarily of a liquid fraction, or supernate, and a solid fraction, or sludge. The HTWOS receives the tank inventory input data for the supernate portion and adjusts for the effects of interstitial liquid (between sludge particles) and entrained solids (small particles that remain suspended in the liquids). The model then calculates how much source tank waste is available as supernate, and how the parameters of interest (primarily chemical and radionuclide constituents) are distributed in the supernate. This information is subsequently combined with the sludge calculations from the next step to produce an "as is" composition for the source tank waste.

- **Calculate Solids Fraction (Sludge).** In most cases, source tank sludge will consist of a mixture of solids (soluble and insoluble) and interstitial liquid. The HTWOS receives the tank inventory input data for the sludge portion and adjusts the data using wash factors (to allocate the soluble sludge components to the interstitial liquid) and entrainment factors (to determine which sludge components occur as interstitial liquids between sludge particles and which as entrained solids). The model then calculates how the source tank waste is present as interstitial liquids between sludge particles, entrained solids, and sludge, and how the parameters of interest are distributed in these phases. This information is combined with the preceding supernate calculations to produce the "as is" composition for the source tank waste.

Model Tank Waste Storage, Retrieval, and Delivery

- **Model Storage and Decanting.** The HTWOS model accounts for the effects of different processes (e.g., gas releases, evaporation losses) that occur during long-term storage of waste in a source tank and adjusts the tank waste inventory accordingly. The HTWOS then models the decanting process for removing supernate from the source tank, calculating the quantities and inventory of constituents that leave the source tank with the supernate, and what components remain in the source tank as part of the sludge "heel." This inventory information is used in the next two steps to determine the composition of the feed delivered to the treatment and immobilization facility.

- **Model Delivery of LAW Supernate.** The HTWOS models the process for retrieving, transferring, staging, and delivering decantable supernate from the waste feed source tank to the treatment and immobilization facility. The HTWOS accounts for the effects of homogenizing the waste with mixer pumps, various water additions to support transfer (e.g., dilution water, pipeline flush water), and other process effects (e.g., staging in interim tanks). The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility, and calculates what residual waste remains behind as non-retrievable "heel." If a tank is being reused as a staging tank, the HTWOS calculates the quantity and composition of the combined "heel" and the added tank wastes. Similar "heel" calculations are also performed in the next two modeling steps.

- **Model Dissolution of Soluble Sludge and Delivery of LAW Supernate.** For specific tanks, the HTWOS models the process for dissolving soluble components of the sludge remaining in the waste feed source tank, then transferring, staging, and delivering the

consequent supernate to the treatment and immobilization facility. The HTWOS accounts for the effects of adding liquids and dissolving solids, homogenizing the waste with mixer pumps, and various other water additions (e.g., pipeline flush water) and process effects (e.g., interim staging). The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility. The HTWOS performs calculations, similar to those described above, to determine the impacts of residual "heels".

- **Model Mobilization and Delivery of HLW Sludge**. The HTWOS models the process for mobilizing HLW sludge, staging the sludge (sometimes as a mixture with other tank sludges), and remobilizing the sludge and delivering the resulting HLW feed to the treatment and immobilization facility. The HTWOS accounts for various water additions, and for the efficiency of mixer pumps, sluicers, and other waste retrieval technologies to mobilize and/or retrieve the waste from a HLW source tank. The HTWOS then calculates the tank waste quantity and composition "as delivered" to the treatment and immobilization facility and solids loading in the delivered slurry. The HTWOS performs calculations, similar to those described above, to determine the impacts of residual "heels."

Model Tank Waste Immobilization, Storage, and Disposal

- **Model Generation of Immobilized Waste Products**. The HTWOS models the process for converting the LAW and HLW feeds to immobilized (glass) products. The HTWOS employs a subroutine that predicts the waste loading in the glass and the resulting volume of waste glass produced. (Although this subroutine accounts for some information from BNFL Inc., the resulting predictions do not represent actual BNFL Inc. contract commitments.) The volumes of ILAW and IHLW glass are divided by the effective volumes of ILAW and IHLW containers to estimate the number of products of each type that must be stored or diposed.

- **Model Immobilized Waste Product Storage and Disposal**. The HTWOS models the generation rate of glass products. Comparisons of the availability of planned ILAW disposal capacity and planned IHLW storage capacity are used to evaluate the required disposal and storage facilities and identify if changes to current plans are needed.

The HTWOS processing simulations, described above, provide critical information (e.g., "as is" and "as delivered" waste feed compositions and quantities) needed to plan waste retrieval, treatment, immobilization, and disposal. Other subsystems of the HTWOS provide the TFC O&UP with additional information needed for program and project planning, including the following.

- **Routing Configurations**. The TFC O&UP helps verify planned tank farm system configurations (e.g., transfer lines, interim staging tanks, pumps) for routing tank wastes from retrieval to delivery. In effect, the HTWOS models all waste movements within the physical system needed to accomplish waste feed delivery. The time-dependent effects of and requirements for addressing dilution, residual heel additions, settling and precipitation, physical properties, and other critical waste parameters are accounted for in the HTWOS modeling and calculations. This information can help confirm the technical

and schedule viability of planned routing configurations and/or highlight potential anomalies or areas of concern for further attention.

- **Process Schedules**. The HTWOS calculates timeframes and develops schedule models for retrieving, staging, and delivering tank waste, and return of immobilized waste products for disposal or storage. System failures and other impacts, such as construction outages, can be modeled to assess effects on delivery and processing schedules. This information can be used to determine "start to finish" timelines, establish interim milestones, and assess the feasibility of delivering wastes in accordance with the contract schedule requirements being established in the ORP and BNFL Inc. contract (ORP 1999). This information also helps CHG coordinate project schedules for building and upgrading the facilities and infrastructure needed to deliver tank wastes, support BNFL Inc., and manage immobilized waste products.

- **DST Space Management**. The TFC O&UP uses HTWOS to develop information about how space in the DSTs would be utilized during the RPP life-cycle, accounting for the effects of waste retrieval, staging, and delivery. This information can be used to evaluate whether sufficient capacity exists, how to optimize use of this capacity for achieving the RPP mission, and potential impacts of significant events that could cause capacity reductions (e.g., one or more tank primary containment failures).

Information that serves as key inputs to the TFC O&UP must be collected, verified, compiled into formats compatible for data processing, and distributed to the appropriate models and calculation subroutines. Section S2.2 describes the input information needed. Key output information must be validated, assessed for potential limitations, and compiled into formats that are useful to planners, managers, and decision makers. Section S2.3 describes outputs and results provided by the TFC O&UP.

S2.2 INFORMATION SOURCES FOR TFC O&UP – KEY INPUT PARAMETERS

Technical information used to support the TFC O&UP is obtained from a variety of sources that range from large relational databases, to consensus standards in the scientific literature, to peer-reviewed engineering studies, to specialized laboratory and bench-scale tests. Sources for technical information are cited throughout the TFC O&UP, Volumes I and II, and noted in the references section. Of the many sources drawn upon, the following are of particular note:

- **Hanford Best-Basis Inventory**. The Best-Basis Inventory (Kupfer et al. 1999, and Tank Waste Information Network System) provides tank-specific and total tank (global) estimates for chemical and radionuclide components and waste characteristics in the 177 Hanford Site SSTs and DSTs. Tank-by-tank inventories include 25 chemical and 46 radionuclide components for each of the SSTs and DSTs. The global waste inventories include five additional chemicals and provide an independent estimate of the total amount of each chemical or radionuclide component presently stored in the tanks. The chemical analytes selected represent over 99 weight percent of the tank contents and the radionuclides represent over 99 percent of the radioactivity. Information used to establish global inventories originated from key historical records (e.g., essential material

purchase records), from various chemical flowsheets used in reprocessing of irradiated Hanford Site reactor fuels, and from calculations of radionuclide isotope generation and decay. Tank-by-tank inventories are most often based on sample analysis results. All updates to tank data are reviewed and approved with appropriate documentation. Issuance of the data is provided in Tank Characterization Reports and all data are entered into the Tank Characterization Database. Global and tank-by-tank inventories serve as waste composition data for RPP process flowsheet modeling work, safety analyses, risk assessments, and waste retrieval, treatment, and disposal system design.

- **Operational Waste Volume Projection**. The Operational Waste Volume Projection (Strode and Boyles 1999) presents a basis for evaluating future DST space needs through 2018. It relies on a computer simulation of site operations to estimate tank usage for three alternative cases, compares the projected tank space needs for the three cases, and describes the estimated differences and space saving alternatives. All three cases incorporate anticipated effects of the Phase 1 privatized waste retrieval and immobilization strategy. For purposes of consistency and configuration management, the same computer simulation model (i.e., HTWOS) is used to prepare the Operational Waste Volume Projection. The Operational Waste Volume Projection is updated at least annually with the latest DST storage information, and is used to generate projections of tank fill schedules, tank transfers, evaporator operations, tank waste retrievals, and aging-waste tank usage. Potential requirements for new DST construction, tank waste retrievals, facility schedules, waste generation reductions, Tri-Party Agreement milestones, and funding priorities can be reviewed in relation to the tank space availability projections.

- **SST Pumpable Liquid Volume Estimates**. The SST liquid estimates (Field and Vladimiroff 1999) are prepared in support of efforts to interim stabilize the SSTs by removing pumpable liquids and thus reducing leakage potential. Fewer than 30 SSTs still contain pumpable liquids, but they are projected to contribute approximately four million gallons of liquid wastes to the DSTs over the next five years. The liquid volume estimates are based on various tank- and waste-specific parameters, such as tank waste volume estimates; measured liquid levels; drainable porosity estimates; capillary height; unpumpable regions; and, pumping rates. A volume range has been estimated to reflect potential uncertainties in some of the assumptions about the tank waste characteristics, and the SST pumpable liquid volume estimates are updated as needed to incorporate new and changed data.

- **Waste Feed Delivery Technical Basis**. The waste feed delivery technical basis is part of the RPP technical baseline, and has been developed to ensure a consistent and well-configured technical approach to tank waste retrieval, staging, and feed delivery. The technical basis describes the set of technical analyses and requirements, science and engineering documentation, equipment, facilities, materials, qualified staff, and operating procedures needed to start up and complete the waste feed delivery objectives of the RPP mission. The technical approach and data for waste feed delivery are defined in three concept documents: the process flowsheets, the waste feed delivery system description, and the operations and maintenance concept. The process flowsheets outline the feed staging and delivery process, provide material and energy balance, and define detailed

process flow information for each source tank and waste batch transfer. The system description describes the physical tank farm infrastructure needed to support waste feed delivery, including the existing systems and components in the tank farms, and the systems and components being designed and constructed by various projects to complete the required retrieval, staging, and delivery system. The operations and maintenance concept describes the operational activities needed to accomplish waste feed delivery, and provides the methodology and process to identify, assess, and evaluate operations and maintenance risks within the waste feed delivery system.

Technical information sources, such as those noted above, are considered to be relatively stable and changes that could occur to this information are, with a few exceptions, not expected to significantly alter the HTWOS calculations and modeling results. Moreover, uncertainties or errors in this technical information are typically subject to correction by scientific or engineering means (e.g., laboratory analyses, field tests, trade studies), and changes are readily accomodated by the TFC O&UP with little or no interpretation or direction.

Other inputs to the TFC O&UP are based on programmatic information, such as overall project objectives, contractual agreements, regulatory commitments, expected (but not yet verifiable) technological designs and capabilities, and other planning assumptions. As the RPP matures over time, many programmatic inputs will stabilize and can be converted to technical information and data. In the meantime, changes to the TFC O&UP can be anticipated as programmatic inputs evolve. Key parameters used as programmatic inputs for the current revision of the TFC O&UP are provided below and in Table S2-1. These parameters are based on current (through March 8, 2000) Project Integration Office (PIO) guidance (PIO 2000), and are documented in Volume II, Appendix A, and other relevant sections of the TFC O&UP.

- Design basis for sodium oxide loadings in ILAW glass are 19.5 percent by weight (wt%) for Envelope A, 7.5 wt% for Envelope B, and 17.0 wt% for Envelope C.
- Design basis for waste oxide loading in IHLW glass is the Battelle Pacific Northwest National Laboratory "Glass Properties Model."
- Nominal vitrification rates are based on an average of 2.38 LAW packages/day and 0.28 IHLW canisters/day.
- Glass density is 2.66 metric tons (MT)/m^3, with an average of 6.0 MT of ILAW/package and 3.1 MT of IHLW/canister
- Immobilized glass product deliveries to CHG start when BNFL Inc. lag storage is 50 percent full for ILAW, and 50 percent full for IHLW.
- Minimum Order quantity for LAW processing is 6,000 units, and for HLW processing is 600 canisters.
- Phase 2 waste immobilization begins in 2018 and is completed in approximately 2030.

- During Phase 2, DSTs will fail at a rate of one for each five years past design life. Replacements will be constructed as required. Volume and transfer capacity equivalent to the existing DST system is assumed to be available through Phase 2.

- Phase 2 treatment will consist of two facilities, and processing capacities will increase to 120 MT and 12 MT of glass per day for ILAW and IHLW, respectively.

- Phase 2 SST Retrieval

  - SSTs are retrieved in a sequence driven by the objective to reduce long-term human health and environmental risk to the extent possible.

  - SST wastes are retrieved at a rate consistent with the rate that space is made available in DSTs by treating and immobilizing waste staged in the DSTs.

  - The rate of retrieval for SST waste is also consistent with historical rates achieved using past practice sluicing.

Table S2-1. Key Phase 1 Programmatic Input Parameters.[a]

Key Schedule Milestone Parameters		
Initiate Pretreatment Hot Start	4/30/06	
First LAW Batch Delivery[b]	4/30/06	
First HLW Batch Delivery[b]	10/31/06	
Second HLW Batch Delivery[b]	3/31/08	
Second LAW Batch Delivery[b]	2/28/09 (Earliest)	
End of Privatization Phase 1	February 2018	
Key Waste Feed Delivery Rate Ramp Up Parameters		
LAW Feed Delivery Ramp Up[c]	From – To	Units[d]
	11/30/06 – 11/30/07	278 (37%)
	11/30/07 – 11/30/08	832 (110%)
	11/30/08 – 11/30/09	1,012 (134%)
	Through Minimum Order	1,100 (146%)
	Through Extended Order	1,100 (146%)
HLW Feed Delivery Ramp Up[e]	From – To	No. of Canisters
	8/31/08 – 8/31/09	41 (40%)
	Through Minimum Order	120 (118%)
	Through Extended Order	120 (118%)

[a]Based on Project Integration Office guidance (through March 8, 2000) (PIO 2000).

[b]Dates shown are for completion of delivery; start of delivery is two months prior to completion.

[c]LAW rates are given as units of waste processed during a 12-month period and (in parentheses) as a percentage of BNFL Inc.'s nominal annual capacity (754 units/year).

[d]The term "unit" reflects the difficulty of processing LAW feed. One metric ton of elemental sodium contained in LAW Envelopes A, B, and C waste feed is equivalent to 1.0, 2.6, and 1.15 units, respectively.

[e]HLW rates are given as canisters of glass produced during a 12-month period and (in parentheses) as a percentage of BNFL Inc.'s nominal annual capacity (102 canisters/year).

The body of the TFC O&UP describes input parameters as well as secondary or derivative assumptions and constraints that were developed to apply these parameters in the HTWOS model (see TFC O&UP, Volume II, Appendix A for detailed documentation of these parameters, constraints, and assumptions). The alternative scenarios evaluated in the TFC O&UP are based primarily on varying some of the above parameters to evaluate program and project impacts relative to current planning.

S2.3 OVERVIEW OF THE TFC O&UP RESULTS

The results of the TFC O&UP are, primarily, informational representations and depictions that have been developed to compile and enhance the meaning of the technical data outputs produced by the HTWOS models and calculations. These representations and depictions are used by planners, managers, and decision makers for evaluating the impacts of different tank waste processing scenarios on the ability to achieve the RPP mission. The rest of this section briefly outlines some key results provided by the TFC O&UP and their relation to the HTWOS outputs.

The HTWOS provides various types of data and information outputs at numerous stages during each simulation run. More than 200 separate computer data files and records are generated in conjunction with conducting a typical HTWOS model scenario. Table S2-2 provides a sample printout of some of the file names for data sets and records produced by the HTWOS model and calculations. Note that the listed examples are provided only to demonstrate the extent and complexity of the HTWOS modeling and calculation processes; the files listed should not be interpreted as representative or typical of any particular HTWOS scenario evaluations.

Table S2-2. Example List of Output Files Produced by the HTWOS.[a]

EAST-RECEIPT-feed-tank-history.his	STAGING-feed-tank-history.his	HLW-WASH-SOLUTION-total-current-kgs
EAST-RECEIPT-total-current-kgs	STAGING-total-current-kgs	HLW-WASH-SOLUTION-total-input-kgs
EAST-RECEIPT-total-input-kgs	STAGING-total-input-kgs	HLW-WASH-SOLUTION-total-moved-kgs
EAST-RECEIPT-total-moved-kgs	STAGING-total-volume-history.his	
EAST-RECEIPT-total-volume-history.his	STAGING-transfers-in-history.his	HLW-GLASS-PLANT-feed-tank-history.his
EAST-RECEIPT-transfers-in-history.his		HLW-GLASS-PLANT-total-current-kgs
	LAW-STAGING-to-DILUTE-RECEIVERS	HLW-GLASS-PLANT-total-input-kgs
WEST-REC-1-feed-tank-history.his	LAW-STAGING-to-ENTRAINED-SOLIDS	HLW-GLASS-PLANT-total-moved-kgs
WEST-REC-1-transfers-in-history.his	LAW-STAGING-to-LAW-RECEIPT	
WEST-REC-2-feed-tank-history.his	LAW-STAGING-total-current-kgs	HLW-RECYCLE-total-current-kgs
WEST-REC-2-transfers-in-history.his	LAW-STAGING-total-input-kgs	HLW-RECYCLE-total-input-kgs
WEST-REC-3-feed-tank-history.his	LAW-STAGING-total-moved-kgs	HLW-RECYCLE-total-moved-kgs
WEST-REC-3-transfers-in-history.his		
	ENTRAINED-SOLIDS-total-current-kgs	LAW-GLASS-PLANT-feed-tank-history.his
X-SITE-REC-feed-tank-history.his	ENTRAINED-SOLIDS-total-input-kgs	LAW-GLASS-PLANT-total-current-kgs
X-SITE-REC-total-current-kgs	ENTRAINED-SOLIDS-total-moved-kgs	LAW-GLASS-PLANT-total-input-kgs
X-SITE-REC-total-input-kgs		LAW-GLASS-PLANT-total-moved-kgs
X-SITE-REC-total-moved-kgs	SLUDGE-WASH-feed-tank-history.his	
X-SITE-REC-total-volume-history.his	SLUDGE-WASH-total-input-kgs	LAW-RECYCLE-total-current-kgs
X-SITE-REC-transfers-in-history.his	SLUDGE-WASH-total-moved-kgs	LAW-RECYCLE-total-input-kgs
		LAW-RECYCLE-total-moved-kgs
MONTHLY-BATCHES-total-current-kgs	WASHED-SOLIDS-feed-tank-history.his	LAW-RECYCLE-total-volume-history.his
MONTHLY-BATCHES-total-input-kgs	WASHED-SOLIDS-total-input-kgs	
MONTHLY-BATCHES-total-moved-kgs	WASHED-SOLIDS-total-moved-kgs	WATER-monthly-output.his

[a]Randomly selected sampling from more than 200 separate output files and data records.

Some output files are used solely as inputs to other information-processing subroutines within the HTWOS, while others capture time-dependent "snapshots" of specific tank farm or waste processing conditions, predict future trends and circumstances, or compare predicted versus desired end-states. In many cases, outputs from several file sets are compiled together to create different formats and presentations of the information. These various "raw" and interpreted data outputs provide the bases for the results reported in the TFC O&UP. Following is a summary of TFC O&UP results that have been found by many program and project decision makers to have broad utility for planning, scheduling, and estimating purposes.

- **Mission Summary Diagrams**. Mission summary diagrams summarize schedule interfaces between Phase 1 project activities and the need dates driven by the Phase 1 feed staging, delivery, and processing scenarios. The diagrams help with identifying, integrating, and optimizing Phase 1 schedules for facility upgrades and construction; waste retrieval, delivery, certification, and processing; and immobilized product returns, storage, and disposal. The diagrams indicate where schedule dependencies, available "free" time (referred to as schedule "float"), and overlaps exist. Among other uses, such information can help with decisions about efficient obligation and utilization of limited resources and funds. Key HTWOS outputs used to build the mission summary diagrams include: tank farm transfer schedules; treatment and immobilization processing schedules; and, selected waste/product mass-balance calculations.

- **Waste Feed Staging Plans**. Waste feed staging plans describe the sequence in which different batches of tank waste will be retrieved, staged, and delivered to the treatment and immobilization facility, along with a description of the actions (e.g., mixing, decanting, solids dilution) required to accomplish this sequence in accordance with contractual specifications for the waste feed compositions, quantities, and delivery rates and schedules. A proposed waste feed delivery approach is developed first to help structure inputs to and model components of the HTWOS. HTWOS outputs are then used to evaluate the viability of the proposed staging plan, and further refine the plan as necessary to account for equipment, schedule, and other results until fully acceptable waste feed staging plans are produced. Among other uses, waste feed staging plans are of particular importance for defining the scopes of work to be accomplished by projects and operations that support waste feed delivery. Key HTWOS outputs used to refine and evaluate waste feed staging plans include: tank farm transfer schedules; waste feed delivery schedules; waste feed volume estimates; projected waste feed compositions; and, waste feed envelope compliance comparisons.

- **DST Usage Allocation Diagrams**. A range of potential needs compete for the physical waste storage space available in the DSTs. The DST usage allocation diagrams show the dependent needs, and current and future commitments for space in the DSTs. The diagrams depict how DST storage capacity changes over time, impacts of construction and other in-farm work that constrain the ability to use particular tanks, and the effects of waste retrieval, staging, and feed delivery activities on tank usage. The DST usage allocation diagrams are used to help ensure that available capacity will not be exceeded, to optimize the efficiency with which the available space is used, and to evaluate potential scenarios associated with temporary or permanent losses of storage capacity. The HTWOS outputs used to develop the usage diagrams include, primarily: tank farm

transfer schedules; waste feed delivery schedules; waste feed volume estimates; and DST volume plots.

- **System Performance Assessments**. System performance assessments are used to identify potential deficiencies in the ability of the current facilities, and planned upgrades, to support waste feed delivery and other requirements of the RPP mission. These assessments help operations and projects determine whether existing systems, structures, and components will function as required, whether known future upgrades include sufficient and correct work scope, and whether additional work is needed to repair, replace, or supplement tank farm facilities. The HTWOS outputs used to support these assessments include: waste transfer schedules; DST volume plots; DST usage allocation diagrams; and, project schedules.

- **Immobilized Waste Product Staging Plans**. Immobilized waste product staging plans describe the volumes and rates at which ILAW packages and IHLW canisters will be produced, along with information about the types, durations, and sequence of actions (e.g., transportation, acceptance, placement) required to receive and disposition the immobilized waste product in accordance with contractual requirements. The product staging plans are used to evaluate planned ILAW disposal capacity and planned IHLW storage capacity against projected capacity needs and schedules, and to help refine facility designs, construction schedules, and other plans accordingly. The HTWOS outputs used to develop these staging plans include: estimated ILAW quantity and composition; ILAW production schedules; estimated IHLW quantity and composition; IHLW production schedules; heat loading estimates; and, radionuclide content/dose estimates.

- **Required Equipment and Components Lists**. These lists are derived from the information (e.g., HTWOS outputs for waste staging and processing sequences for each tank) and assessments (e.g., system performance) described above. Once the requirements for and adequacy of existing systems and facilities has been evaluated, it is possible to produce a preliminary list of the equipment and components needed to ensure success of waste feed delivery and the RPP mission. Among other uses, these lists can help further define work scope for projects and operations, identify potential long-lead procurement items, and determine whether engineering or other studies may be needed to define component specifications. Key HTWOS outputs and TFC O&UP results used to develop equipment and components lists include: operations and project schedules; waste feed and waste product staging plans; and, system performance assessments.

- **Integrated Process Flowsheet**. An integrated process flowsheet is an anticipated future result of the TFC O&UP. Development depends on the availability of more complete information about the waste processing activities that will occur in the treatment and immobilization facility. As this information becomes available, it will be possible to devise a flowsheet to describe how tank wastes are processed from source to glass. This integrated process flowsheet will include essential information about waste chemical and radionuclide constituents, other significant waste parameters of interest, how these constituents and parameters are altered through the retrieval, staging, treatment, and immobilization steps, and how they finally are incorporated into the final ILAW packages and IHLW canisters. Among other uses, this information can help improve

selection of waste feed sources, sequences, and schedules; refine the entire waste process for optimal loading of waste constituents in the glass products; identify opportunities to improve waste processing efficiencies through waste blending or similar actions; and, assist ORP in evaluating different compensation models for determining fair payments to BNFL Inc. (for processing wastes that do not satisfy all applicable specifications). Key HTWOS outputs that will be used to develop integrated process flowsheets include: waste feed volume estimates; projected waste feed compositions; estimated ILAW quantity and composition; estimated IHLW quantity and composition; heat loading estimates, radionuclide content, and dose estimates; and, selected waste/product mass-balance calculations

Many other results are currently available in the TFC O&UP, or can be developed using the data outputs and information generated for the TFC O&UP. Interested parties should contact the TFC O&UP authors and their managers regarding other types of results that may be useful for assessing tank waste retrieval and disposal activities and the ability to successfully support the RPP mission.

S3.0 KEY RESULTS AND FINDINGS OF THE TFC O&UP

The TFC O&UP is a dynamic document that is updated periodically (e.g., annually) to account for adjustments to the RPP mission and waste retrieval and disposal objectives. The TFC O&UP provides results and findings that are used for planning waste retrieval, feed delivery, processing, and disposition, and identifies possible sensitivities with current planning by analyzing the consequences of alternative scenarios.

The principal scenario reported in the current revision of the TFC O&UP is referred to in this summary document as the PIO Guidance Case.[1] Key input parameters and PIO guidance (PIO 2000) associated with this case were described previously in Section S2.2. This section summarizes key results and findings from the TFC O&UP for the PIO Guidance Case, and summarizes important planning sensitivities for several alternative scenarios. The TFC O&UP provides substantially more details than can be included here and should be consulted for more complete information.

S3.1 EVALUATION OF THE PIO GUIDANCE CASE

The PIO Guidance Case has grown out of a preliminary waste feed delivery approach that was developed as follows.

- First, initial sets of source tanks were identified to satisfy contractual requirements and ORP planning direction. The most recent inventories in these tanks were used to evaluate compliance with specifications for the waste feed envelopes (Envelopes A, B, and C for LAW; Envelope D for HLW).
- Next, the selected candidate source tanks and preliminary tank waste retrieval sequences were improved based on additional criteria (e.g., ease of retrieval, collocation of retrieval equipment) and more flexible waste staging strategies.
- Next, different retrieval, staging, and delivery approaches were iteratively tested using the HTWOS model to identify flaws, find opportunities for improvement, and integrate modeled process flows.
- Finally, ORP used the results of this preliminary work to provide guidance to CHG (PIO 2000) on the waste feed delivery approach (including waste source tanks and delivery sequence) that was applied in the TFC O&UP.

Principal conclusions of the TFC O&UP for the PIO Guidance Case are as follows.

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[1]The PIO Guidance Case was modeled in the HTWOS and is identified within the body of the TFC O&UP as Case 3S6E. The different planning scenarios and sensitivity analyses are numbered to facilitate internal tracking and configuration control. Some of the figures, tables, or other materials in this summary may include references to Case 3S6E.

- The PIO Guidance Case is viable and can be achieved within anticipated technical and schedule constraints.

- The PIO Guidance Case includes a Phase 1 waste retrieval and delivery sequence that provides sufficient margin for storing waste feeds with no apparent cost penalty to ORP. The case ensures low risk of idle vitrification facilities during Phase 1 by providing adequate staging and backup staging tank capacity.

- The current waste feed delivery projects planned for Phase 1 will (with some potential scope addition) support delivery of feed to BNFL Inc. within reasonable bounds of schedule float and conservative flowsheet assumptions.

- A reasonable Phase 2 waste retrieval and delivery sequence has been identified that optimizes retrieval strategy criteria (e.g., minimize public and environmental risks, maintain feed rates to keep immobilization facilities operating) under current known constraints.

- Immobilized glass product facilities are expected to be available in time and to have sufficient ILAW disposal and IHLW storage capacities for Phases 1 and 2. Design and construction schedules for the initial disposal and storage facilities may need to be accelerated (by up to six months) if BNFL Inc. processes waste at the maximum rates allowed in the ORP and BNFL Inc. contract (ORP 1999).

These conclusions are discussed in more detail in the following sections. Table S3-1 provides an overall summary of the progress that, based on modeling results for the PIO Guidance Case, would be accomplished for tank waste processsing during Phase 1 and the total mission.

Table S3-1. Mission Progress for Tank Waste Processing.[a]

		Minimum Order Contract Quantities [b]	Completion of Phase 1 [c]	Total Mission (Phase 1 and 2)
In-Situ	Tank WasteVolume (m^3) / % of All Tank Waste	27,250 / 13.6%	59,050 / 29.6%	199,850 / 100%
	Curies [d] / % of All Tank Waste	4.72×10^7 / 20.7%	6.87×10^7 / 30.1%	2.28×10^8 / 100%
LAW	Tank Waste Quantity [e] (dry basis, MT)	16,340	36,380	177,000
	Curies Immobilized [d]	6.45×10^5	1.02×10^6	5.44×10^6
HLW	Tank Waste Quantity [e] (dry basis, MT)	1,040	2,090	23,740
	Curies Immobilized [d]	4.66×10^7	6.76×10^7	2.23×10^8

m^3 = cubic meters
MT = metric tons
[a]Does not include Cs and Sr capsules; Phase 2 processing alternatives are being evaluated by ORP.
[b]LAW Minimum Order quantity is 6,000 units; HLW Minimum Order quantity is 600 canisters.
[c]Based on PIO Guidance Case; includes all wastes staged and processed to fulfill Minimum and Extended Orders.
[d]Radionuclides decayed to 1/1/1994.
[e]As delivered to privatization contractor.

S3.1.1 Phase 1

As discussed in Section S2.3, mission summary diagrams are key results of the HTWOS model and the TFC O&UP evaluations. Figures S3-1 and S3-2 are the Phase 1 mission summary diagrams for the PIO Guidance Case, Minimum Order and Extended Order, respectively. The mission summary diagrams provide information about waste feed source and staging tanks, delivery sequences, schedules, immobilized waste handling, and project interfaces for waste retrieval and disposal. Tables S3-2 and S3-3 provide summaries of waste feed processing estimates for LAW and HLW, respectively, including the Minimum Order and Extended Order quantities of delivered feed and immobilized glass product. Key findings included in these figures and tables are outlined below.

- Vitrification of LAW feed delivered through the last tank in the Minimum Order sequence is projected to be completed by October 2015. A total of 8,509 units of LAW feed is planned for delivery, resulting in a total of 9,830 ILAW packages during the Minimum Order.

- Vitrification of HLW feed delivered through the last tank in the Minimum Order sequence is projected to be completed by May 2017. A total of 13,800 m^3 (3.6 Mgal) of HLW feed will be delivered during the Minimum Order. A total of 965 IHLW canisters will be produced during the Minimum Order, based on Pacific Northwest National Laboratory's glass properties model.

- Extended Order LAW vitrification is projected to be completed by April 2019 if all contingency waste is processed. During the Extended Order, an additional 3,837 units of LAW feed will be delivered, and an additional 4,432 ILAW packages will be produced.

- Extended Order HLW vitrification is projected to be completed by August 2018 if all contingency waste is processed. During the Extended Order, an additional 6,300 m^3 (1.7 Mgal) of HLW feed will be delivered, and an additional 465 IHLW canisters will be produced.

This revision of the TFC O&UP included an assessment of DST space requirements. A key finding of the HTWOS model and the TFC O&UP evaluations is the verification that waste retrieval and staging activities, in conjunction with continuing waste additions from SST salt well pumping and facility generated wastes, can be completed without exceeding available DST space. Figure S3-3 is a plot of the DST volume usage during Phase 1 and shows, among other information, that the available DST space (approximately 121,000 m^3 [32 Mgal]) is sufficient for future waste allocations. Empty DST space is estimated to be not less than about 15,000 m^3 (4 Mgal) and will typically be more. Space usage will be further controlled as Phase 1 proceeds by the rate at which SST waste is retrieved into the DSTs to fill newly available space. Based on these results, new tank construction is not required if the waste transfer and processing schedules modeled for the PIO Guidance Case are maintained.

The results of the HTWOS modeling of immobilized waste production under the PIO Guidance Case are presented in Figures S3-4 and S3-5 for ILAW package and IHLW canister receipt, respectively. The HTWOS projections indicate that ILAW disposal and IHLW storage facilities should be ready in time to begin receiving waste products from BNFL Inc., based on

the expectation that in-plant (lag) storage for immobilized product (up to 450 ILAW packages and up to 45 IHLW canisters) will be available at the treatment and immobilization facilities. If constraints are imposed on the available lag storage capacity, and if BNFL Inc. is assumed to process waste at the maximum rates allowed in the ORP and BNFL Inc. contract (ORP 1999), then the HTWOS projects that delivery of ILAW packages and IHLW canisters may begin sooner than previously planned.

The HTWOS model projects that fifty percent of available lag storage capacity could be exceeded for ILAW about four months before the earliest planned date for beginning to receive ILAW packages, and that seventy-two percent of the available capacity could be consumed before delivery to the ILAW disposal facility is planned to begin. The HTWOS model also projects that the fifty percent lag storage capacity could be exceeded for IHLW about five months before the earliest planned date for receiving IHLW canisters, and that ninety-one percent of the available lag storage capacity would be filled before delivery to the IHLW storage facility could begin. As noted, these estimates are based on BNFL Inc. processing waste at the maximum allowed contract rates.

S3.1.2 Balance of Mission

The HTWOS model was used to develop and evaluate difference approaches to accomplishing the Phase 2 (balance of mission) activities, which focus primarily on retrieval and processing of wastes remaining in SSTs. The approaches were based on the following criteria: meeting available ORP direction (key input parameters and ORP direction for Phase 2 were previously discussed in section S2.2); removing waste from those SSTs posing the greatest risk to the public and environment; and, retrieving additional SSTs whenever extra space becomes available in DSTs (referred to as DST backfilling). A scenario was developed that balanced these criteria and integrated Phase 1 and 2 activities.

To facilitate assessment of risk to the public and environment, a simplifying assumption was made that large inventories of ^{99}Tc, high degrees of waste solubility, and indicators of past leakage are all factors that correlate with increased risk. SSTs with high ^{99}Tc inventories and no leak history (the absence of past leakage implies the ability to retrieve with no or minimal loss of waste to the environment) were identified as early candidates for retrieval. Alternatively, SSTs with low ^{99}Tc inventories and known to have leaked large volumes of waste to the soil were identified as candidates for retrieval late in the sequence. Using this approach, ten SST categories were developed. Brief descriptions of these categories, along with a graphic that relates ^{99}Tc retrieval to total SST waste retrieval, are provided in Figure S3-6.

Figure S3-1. Mission Summary Diagram for Case 3S6E – Minimum Order.

Feed Delivery, Storage and Disposal Mission Summary for Case 3S6E R2A

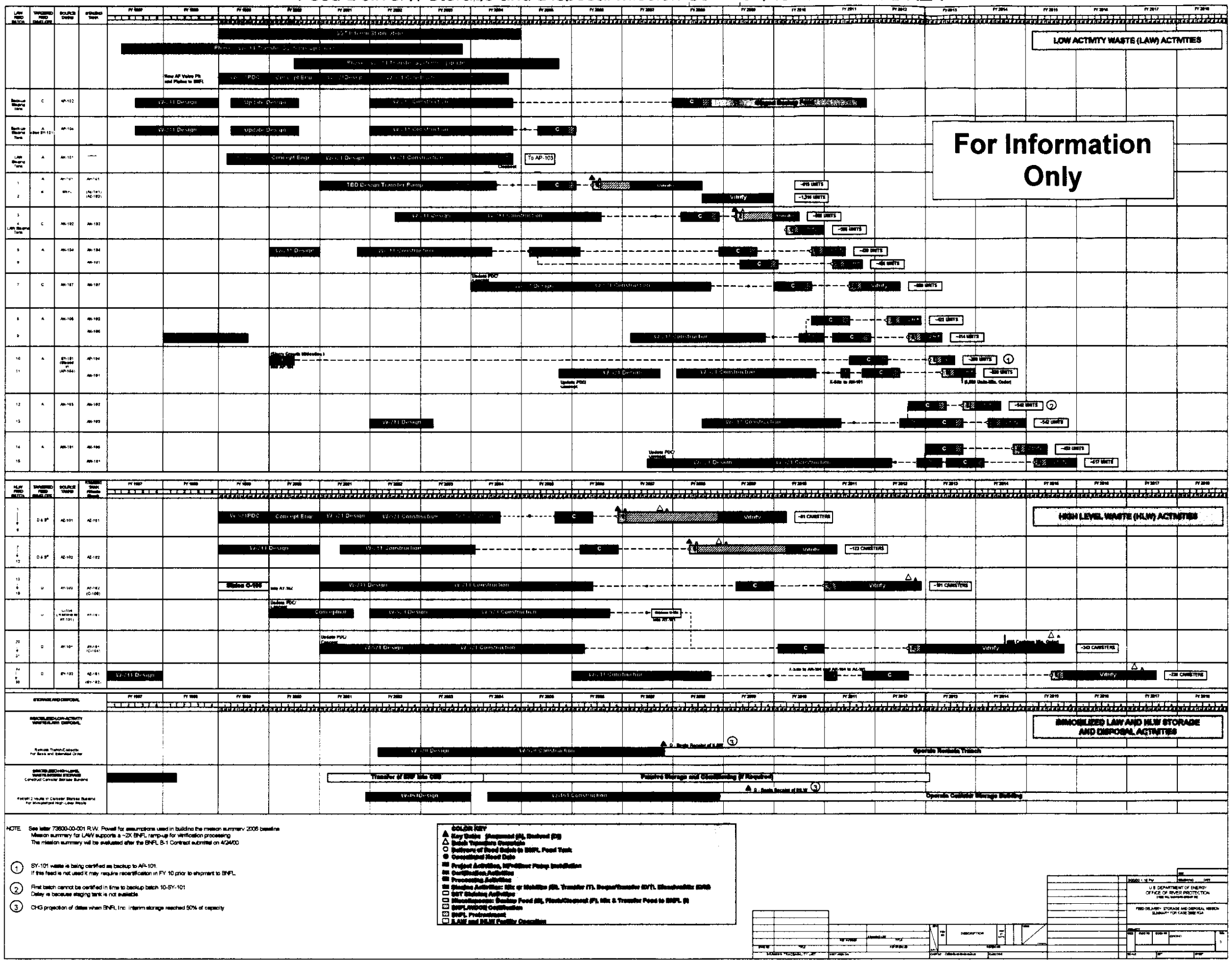
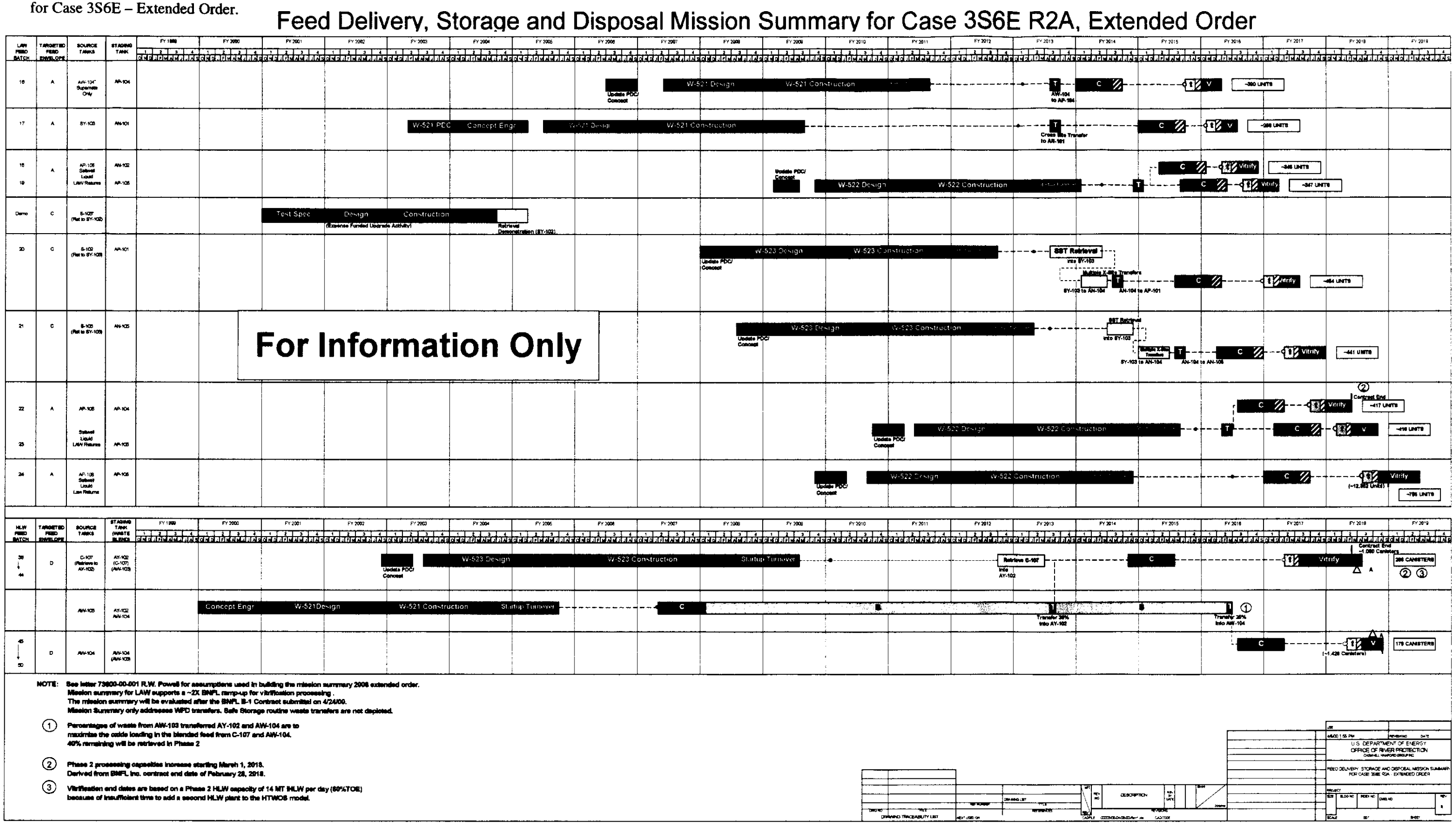


Figure S3-2. Mission Summary Diagram

for Case 3S6E – Extended Order.



NOTE: See letter 73600-00-001 R.W. Powell for assumptions used in building the mission summary 2006 extended order.
Mission summary for LAW supports a ~2X BNFL ramp-up for vitrification processing .
The mission summary will be evaluated after the BNFL II-1 Contract submittal on 4/24/00.
Mission Summary only addresses WPD transfers. Safe Storage routine waste transfers are not depicted.

(1) Percentages of waste from AW-103 transferred AY-102 and AW-104 are to maximize the oxide loading in the blended feed from C-107 and AW-104. 40% remaining will be retrieved in Phase 2

(2) Phase 2 processing capacities increase starting March 1, 2018. Derived from BNFL Inc. contract end date of February 28, 2018.

(3) Vitrification end dates are based on a Phase 2 HLW capacity of 14 MT IHLW per day (80%TOE) because of insufficient time to add a second HLW plant to the HTWOS model.

Table S3-2. Summary of Low-Activity Waste Feed Processing.

Envelope [a]	Feed source	Staging tank	Batch	Delivered LAW Feed			ILAW Glass Production		
				Units of LAW feed planned	Sodium delivered (MT)	Radioactivity [b] (Ci)	Mass of ILAW glass (MT)	Volume of ILAW glass [c] (m^3)	Number of ILAW packages [d]
Privatization Phase 1 Minimum Order									
A	AP-101	none	1	615	615	1.88E+04	4,272	1,606	711
B	AZ-101 AZ-102	none none	2a 2b	1,308	503	3.92E+04	9,080	3,414	1,511
C	AN-102	none none	3 4	556 556	484 484	9.30E+04 9.27E+04	3,862 3,861	1,452 1,451	643 642
A	AN-104	none AN-101	5 6	439 406	439 406	7.35E+03 6.78E+03	3,045 2,819	1,145 1,060	507 469
C	AN-107	none	7	808	703	1.38E+05	5,610	2,109	934
A	AN-105	AN-102 none	8 9	425 414	425 414	2.20E+04 1.61E+04	2,948 2,872	1,108 1,080	491 478
A	SY-101 [e]	AP-104 AN-101	10 11	298 529	298 529	1.64E+04 2.34E+04	2,070 3,672	778 1,380	344 611
A	AN-103	AN-102 none	12 13	542 542	542 542	1.03E+04 9.80E+03	3,760 3,765	1,414 1,416	626 627
A	AW-101	AN-105 none	14 15	453 617	453 617	1.51E+04 1.94E+04	3,146 4,283	1,183 1,610	523 713
Privatization Phase 1 Minimum Order (6,000 Units of LAW)				8,509	7,453				9,830
Privatization Phase 1 Extended Order									
A	AW-104 (saltwell liquor)	AP-104	16	390	390	1.18E+04	2,707	1,018	451
A	SY-103	AN-101	17	258	258	8.07E+03	1,791	673	298
A	AP-106 (saltwell liquor)	AN-102 none	18 19	346 347	346 347	1.60E+04 1.65E+04	2,405 2,406	904 904	400 400
C	S-102 (S-103, S-105)	AP-101	20	454	395	5.49E+04	3,152	1,185	525
C	S-105 (S-106, S-108)	AN-105	21	441	384	5.31E+04	3,062	1,151	510
A	AP-105	AP-104 none	22 23	417 418	417 418	1.38E+04 1.37E+04	2,897 2,901	1,089 1,091	482 483
A	AP-108 (saltwell liquor)	none	24	765	765	5.06E+04	5,311	1,997	884
Privatization Phase 1 Extended Order				3,837	3,720				4,432
Privatization Phase 1 Total				12,346	11,173				14,262

Values should be treated as estimates, due to uncertainties of input data (e.g., inventory), numerical rounding, and limitations of model assumptions and calculations.

Ci = Curies

ILAW = Immobilized low-activity waste

LAW = Low-activity waste

m^3 = Cubic meters

MT = Metric tons

none = The feed source tank performs the staging tank functions for the corresponding batch; feed will be delivered directly from the source tank to BNFL Inc.

[a]Assumed envelope is based on current contract specifications (ORP 1999) and currently available characterization data

[b]Decayed to calendar year of start of delivery

[c]glass density = 2.66 MT/m^3

[d]2.23 m^3 of ILAW glass per package

[e]The Minimum Order quantity is met midway through Batch 11.

Table S3-3. Summary of High-Level Waste Feed Processing.

Batch group	Batches	Feed source	Staging tank	Planned HLW Feed				IHLW Glass Production [d]				
				Liquids (ML)	Solids [a] (MT)	Volume [b] (ML)	Radioactivity [c] (Ci)	Non-volatile waste oxides [e] (MT)	Waste oxide loading [f] (%)	Mass of IHLW glass (MT)	Volume of IHLW glass [g] (m^3)	Number of IHLW canisters [h]
Privatization Phase 1 Minimum Order												
1	1-6	AZ-101	AZ-101	3.02	102	3.05	9.42E+06	84	30.6%	249	93	81
2	7-12	AZ-102	AZ-102	3.17	171	3.23	5.01E+06	134	30.9%	375	141	123
3	13-19	AY-102/C-106	AY-102	1.95	381	2.08	3.82E+06	192	29.0%	584	219	191
4 [i]	20-31	AY-101/C-104	AY-101	3.15	643	3.37	2.00E+06	359	32.4%	1,049	394	343
5	32-35	SY-102	AZ-101	2.02	168	2.08	6.79E+05	133	6.1%	696	262	227
Privatization Phase 1 Minimum Order (600 canisters of IHLW)												965
Privatization Phase 1 Extended Order												
6	36-44	C-107/AW-103 (35%)	AY-102	3.04	474	3.20	1.19E+06	287	29.3%	875	329	286
7	45-50	AW-104/AW-103 (25%)	AW-104	3.01	150	3.06	3.57E+05	150	25.7%	548	206	179
Privatization Phase 1 Extended Order												465
Privatization Phase 1 Total												1,430

Values should be treated as estimates, due to uncertainties of input data (e.g., inventory), numerical rounding, and limitations of model assumptions and calculations.

Ci = Curies

m^3 = Cubic meters

ML = Million liters

MT = Metric tons

[a] Total solids for batch group assuming expected retrieval efficiencies.

[b] Batch volumes delivered are 0.2 to 0.6 ML each including inhibited flush water.

[c] Based on delivered feed, including both solids and liquids, decayed to calendar year of start of delivery.

[d] Glass production based on the Pacific Northwest National Laboratory's glass properties model. This model provides a conservative basis for planning the quantity of HLW feed required to meet BNFL Inc. production needs.

[e] Not including glass frit, but including waste Na_2O and SiO_2.

[f] Not including waste Na_2O and SiO_2 contained in the waste feed.

[g] Glass density = 2.66 MT/m^3.

[h] 1.15 m^3 of IHLW glass per canister. Number of canisters assumes expected retrieval efficiencies of sludge from source tanks. Due to rounding, the sum of canisters may not equal the total (cumulative).

[i] The Minimum Order quantity is met about halfway through Batch Group 4.

Figure S3-3. Total Phase 1 Double-Shell Tank Volume Usage Plot.

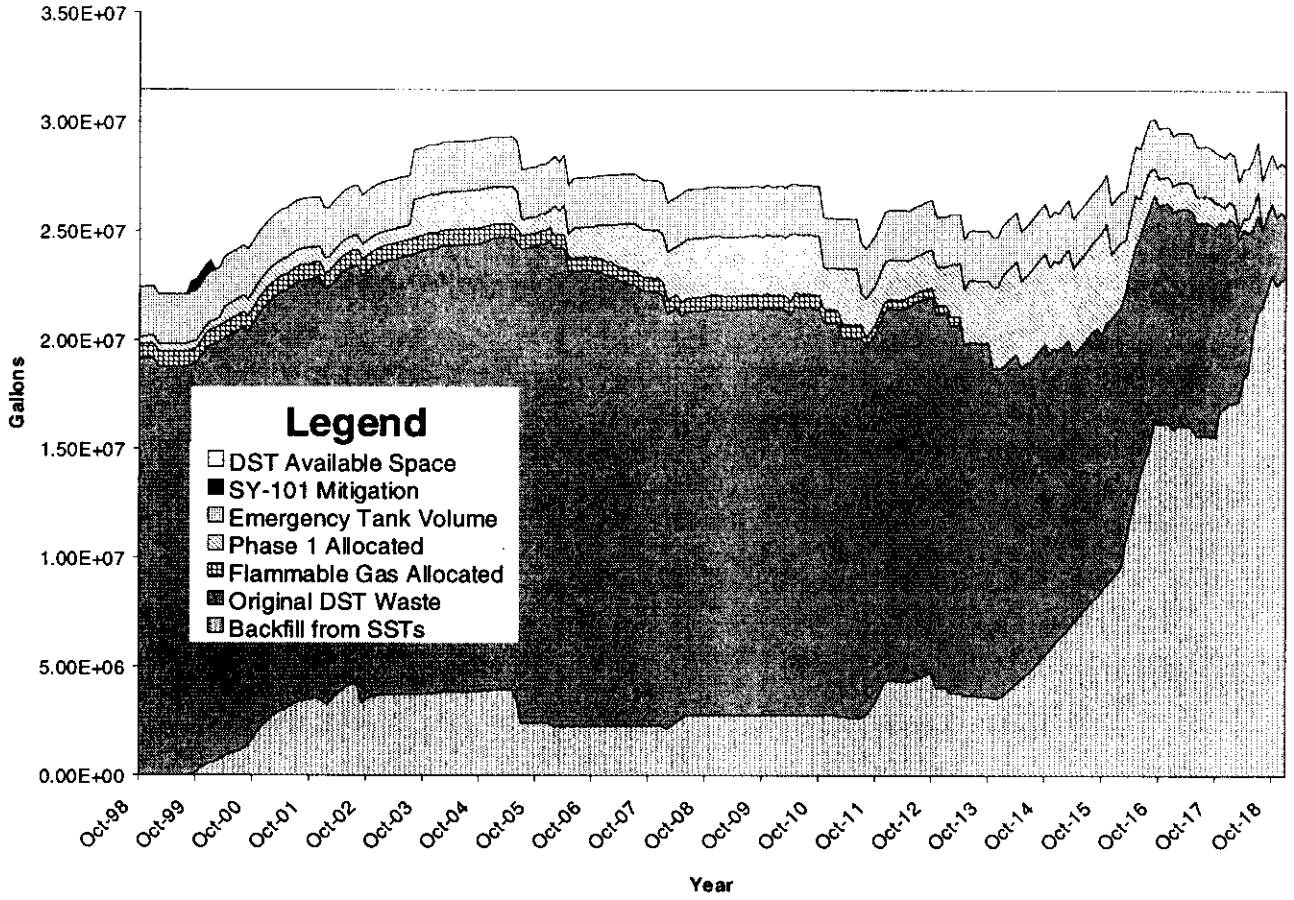


Figure S3-4. Immobilized Low-Activity Waste Package Receipt Schedule.

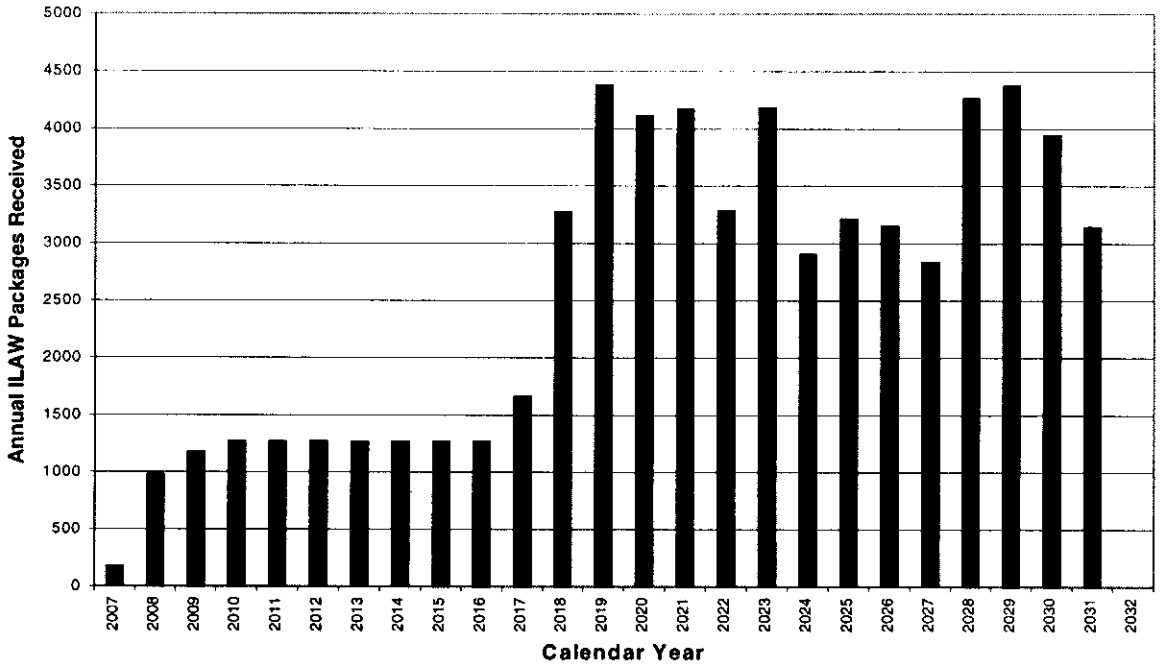


Figure S3-5. Immobilized High-Level Waste Canister Receipt Schedule.

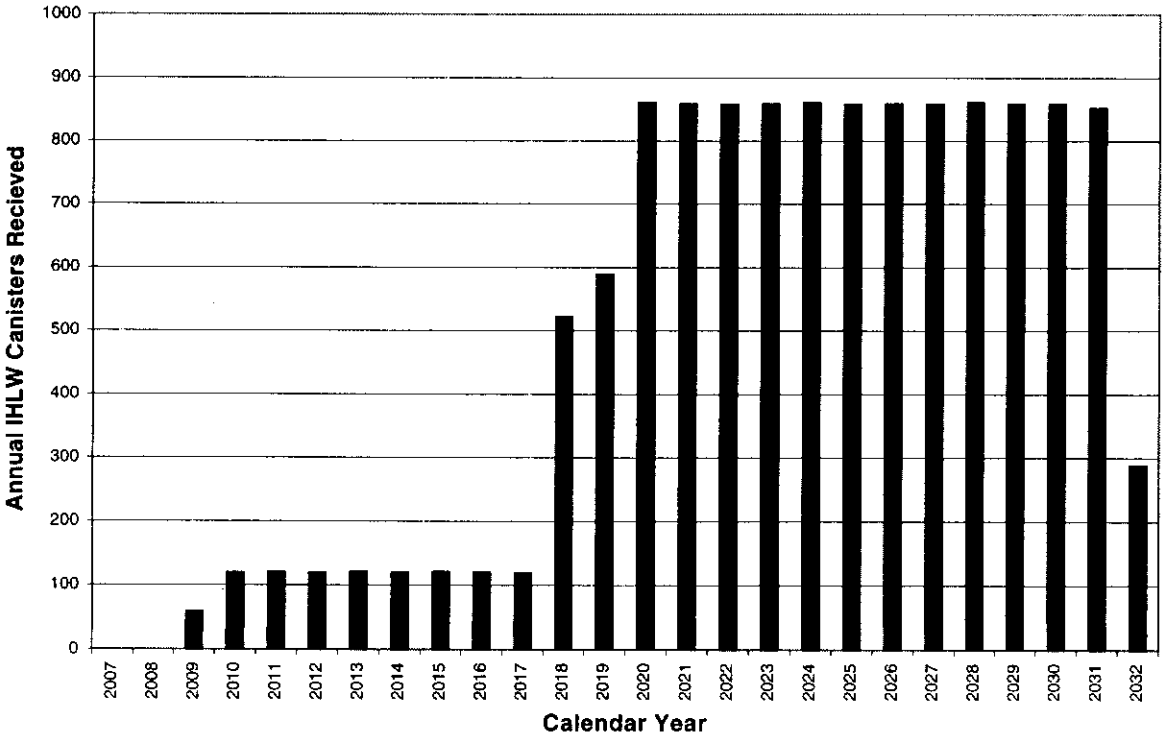
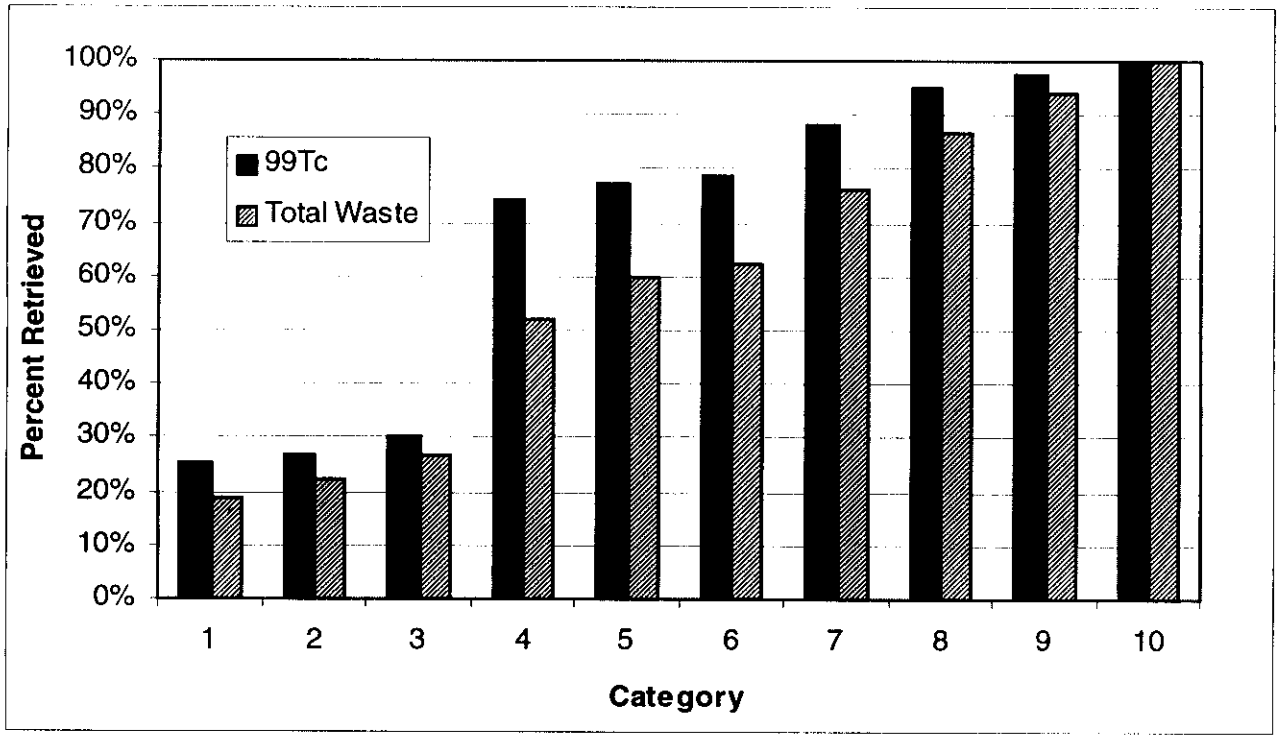


Figure S3-6. Cumulative Percent of Total Tank Waste and ^{99}Tc Retrieved from Single-Shell Tanks.*



Categories:

Category 1 - Sound salt cake tanks with high levels of ^{99}Tc

Category 2 - Sound sludge tanks with less than 1.8 m (6 ft) of sludge

Category 3 - Sound salt cake tanks with lower levels of ^{99}Tc.

Category 4 - Sound salt cake/sludge mixed tanks with less than 1.8 m (6 ft) of sludge

Category 5 - Sound sludge tanks with more than 1.8 m (6 ft) of sludge

Category 6 - Sound salt cake/sludge mixed tanks

Category 7 - Leaking salt cake tanks

Category 8 - Leaking salt cake/sludge mixed tanks

Category 9 - Leaking sludge tanks with less than 1.8 m (6 ft) of sludge

Category 10 - Leaking sludge tanks with more than 1.8 m (6 ft) of sludge

*Cumulative percent retrieved assumes each SST category is retrieved in progression from 1 to 10. For example, retrieving categories 1, 2, 3, and 4 SSTs, would result in approximately 75 percent of the ^{99}Tc being retrieved.

After satisfying ORP direction and accounting for risk reduction objectives, DSTs were assumed to be backfilled with SST waste as soon as DST space was made available by waste feed transfers to the treatment and immobilization facility. DST backfilling is important for maintaining steady availability of waste feed and orderly delivery, so that tank farm and waste processing facilities are not unnecessarily idle. To best meet the DST backfilling objective, consideration was given to the number of receiver tanks for staging retrieved waste; composition of the retrieved waste; importance of blending to reduce impacts of problem waste constituents; efficient usage of available retrieval equipment; desire to minimize the number of new systems and simultaneous retrievals; and, need to match feed specification to operational requirements of the waste processing facilities.

The TFC O&UP provides additional details on the SST retrieval sequence and the rationale for selecting this sequence. Alternative cases will continue to be run using the HTWOS model to further develop the Phase 2 waste retrieval and processing strategy. Key balance of mission findings include the following.

- Retrieval rates are not expected to be a constraining factor on the ability to deliver waste feed during Phase 2, assuming that facility equipment and upgrades are installed on time.

- SST waste retrieval will be completed by 2028 and waste processing will be completed by 2032, based on the identified SST retrieval sequence and ORP-directed processing rates.

- DST storage capacity is adequate to support Phase 2 needs, and is not a constraining factor relative to immobilization plant capacity and SST retrieval rates. This enables the use of available DST capacity for increased blending of waste from individual SSTs to achieve more optimal waste feeds.

- A total of about 49,800 packages of ILAW (average rate of about 3,890 packages per year) and a total of about 11,300 canisters of IHLW (average rate of about 830 canisters per year) will be produced during Phase 2, based on Phase 1 waste loading rates and container dimensions. The substantially increased production rates provided in the ORP direction will require correspondingly higher rates of transportation, packaging, receipt, storage, and disposal.

S3.2 ALTERNATIVE CASES – ANALYZING SENSITIVITY TO CHANGES

The sensitivity of current planning to changes in technical direction was assessed by running the HTWOS model with variations of the input parameters, then comparing the results of these alternative cases. Some of the variations included earlier processing start dates, faster processing rates, and changes in the effectiveness with which waste constituents are concentrated in the immobilized glass product (waste loading). Major findings from these sensitivity analyses are summarized below.

S3.2.1 Summary of Alternative Cases

The speed and flexibility of the HTWOS makes it possible to model a large number of alternative cases. More than a dozen alternatives have been modeled using the HTWOS for this revision of the TFC O&UP; they are summarized below as variations of three general scenarios:

- Changes in start-up schedules for the treatment and immobilization facilities. Start-up may be sooner or later than planned. Earlier start-up dates are often associated with a percent likelihood of success at achieving that earlier date (e.g., 50 percent chance of starting one year earlier).

- Changes in the rate at which the treatment and immobilization facilities are able to achieve their maximum sustainable operating rate. It is expected that a new facility can not immediately begin operating at maximum production efficiency, so common engineering practice is to assume ramp-up rates for a period of time after start-up.

- Changes in waste loading in the immobilized glass product. Higher loading factors reflect greater processing efficiencies and are generally desirable, but increasing the loading can have adverse effects on constituent leachability, glass durability, surface radiation levels, heat generation, secondary waste generation, and other factors.

The TFC O&UP details the alternative cases, input parameters, and associated results.

S3.2.2 Sensitivity Analyses

Low-Activity Waste Processing

The alternative cases that were evaluated found that LAW processing is not significantly impacted by a reasonable range of changes and variations. The alternatives did reveal a few variables that could have moderate impacts on LAW feed delivery scheduling and on ILAW package production. The significant variables and associated impacts are as follows:

- Accelerating the start of LAW processing by up to one year would require that LAW feed delivery be accelerated by 11 months. This earlier delivery could be addressed by a combination of reduced float in the delivery schedule, and moving up the completion dates for some of the planned facility projects and upgrades. No change in the quantity of ILAW package production is expected.

- Removal of sulfates from the LAW feed has the benefit of improving glass waste loading efficiencies. However, sulfate removal is a potentially burdensome technology that may have other unacceptable disadvantages. Relative to the PIO Guidance Case, sulfate removal could result in decreasing ILAW production by up to 873 packages. No changes in completion dates would occur, assuming that the decreased ramp-up rate modeled for this sensitivity analysis is maintained.

- Sodium washing will be used to reduce the amount of IHLW produced and the number of IHLW canisters to be stored and eventually disposed. Sodium washing generates a secondary waste stream that will be returned to the LAW processing system of the

vitrification plant. The effect of this additional treatment would be to extend processing completion by up to nine months, and increase ILAW production by up to 915 packages.

High-Level Waste Processing

The alternative cases revealed several variables that can have significant impacts on HLW feed delivery and IHLW production. Most of the variables are related to how effectively waste constituents can be loaded into the final glass product. Waste loading factors considered in the sensitivity analyses included increased waste oxide loading in the IHLW; blending of LAW precipitates (e.g., manganese and strontium from Envelope C pretreatment); presence of entrained solids; and, effects of blending different tank wastes. Factors related to processing ramp-up rates and early start of HLW vitrification were also important to the sensitivity analyses.

The overall conclusion of the HLW sensitivity analyses is that, for reasonably likely alternative scenarios, HLW feed delivery and IHLW storage can be accomplished within the existing tank farm system. However, some scenarios indicate potentially adverse impacts on the ability to deliver HLW feed in accordance with desired schedules. The sensitivity analyses resulted in the following key findings:

- Increasing loading factors for waste constituents in the immobilized glass product would require an increase in the rate at which HLW feed is delivered. Significant loading increases could surpass the ability of the HLW feed infrastructure to support delivery demands, possibly requiring acceleration of current projects and additional new equipment and upgrades.

- Substantial increases in waste loadings (e.g., to levels proposed by BNFL Inc.) could decrease the total amount of IHLW produced by up to 260 canisters. The net effect would be a reduction in the overall storage capacity required for IHLW. In the absence of other constraints (e.g., assuming sustainable waste feed delivery rates), HLW feed processing could be completed as much as 26 months sooner.

- The Pacific Northwest National Laboratory's glass properties model provides waste loading efficiencies that are higher than the ORP and BNFL Inc. contract (ORP 1999) currently requires. Using the contract specification requirements results in increased quantities of IHLW produced, which provides a more conservative planning basis for IHLW canister receipt and storage. During Minimum Order, up to 1,094 IHLW canisters could be produced (about 130 more canisters than calculated using the glass properties model), and up to 494 IHLW canisters could be produced during Extended Order (about 30 more canisters than calculated using the glass properties model).

- Earlier start-up accelerates HLW feed delivery dates and IHLW return dates by up to 16 months. Decreasing planned feed delivery processing ramp-up rates to match the BNFL Inc. ramp-up rates has the opposite effect, extending completion by up to nine months. Neither scenario affects the total quantity of IHLW that is produced.

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GLOSSARY OF TERMS AND ACRONYMS

COMMON TERMS AND DEFINITIONS

Backup Waste. Backup waste includes all LAW and HLW feed certified by both CHG and BNFL Inc. as acceptable for delivery to BNFL Inc. at any time as distinguished from the LAW and HLW feeds that are planned for delivery in the current sequence. Backup waste will be delivered to BNFL Inc. only when a problem occurs that prevents delivery of the waste feed in the planned sequence. Backup waste includes the next tank of waste in the delivery sequence (if it is certified) and a small number of tanks of waste certified well in advance of the delivery need dates.

Batch. The quantity of waste feed of a given type, and its associated flush and dilution water, requested by BNFL Inc. for transfer to its receiving tank at one time. Flush and dilution water sent to BNFL Inc. is added to the definition, because it will be part of the fluid received by BNFL Inc.

Best-Basis Inventory. A database of peer reviewed, accepted, and controlled information providing total tank and tank-specific estimates for chemical and radionuclide components, and selected waste parameters and characteristics in the 177 Hanford Site SSTs and DSTs.

Canister. A canister of immobilized HLW comprises a 4.5-m high, 0.61-m diameter metal container holding, on average, 3.1 MT of waste glass at a density of 2.66 MT/m^3.

Capillary Height. The maximum height to which an unsaturated layer of waste particles will draw liquid upward between the particles (i.e., through the capillaries). The finer the particles, the greater the capillary height.

Contingency Waste. Contingency wastes are the wastes planned for delivery after the minimum quantities needed to support the Minimum Order (i.e., 6000 units of LAW and 600 canisters of HLW) and Extended Order are delivered. The availability of contingency waste allows risks associated with inadequate waste feed delivery to be mitigated, including failure of a tank of waste feed to satisfy BNFL Inc. waste acceptance criteria, inadequate waste retrieval efficiency, and failure in the physical system, such as developing a leak in a tank or pipeline.

Envelope or **Waste Feed Envelope**. An approach to defining predetermined and agreed-upon chemical and radionuclide limits in the waste feed. The approach provides increased assurances about the range of waste compositions that the privatization contractor will be required to treat and immobilize, allows demonstration of different waste processing capabilities of the contractor's facilities, and enhances flexibility in deciding how to deliver waste. Three envelopes have been specified for LAW feed (Envelopes A, B, and C) and one envelope for HLW feed (Envelope D). Current specifications for each envelope are defined in the contract between ORP and BNFL Inc (ORP 1999).

Flowsheet or **Mass-Balance Flowsheet**. A flowsheet is an engineering document that describes each input and output process flow to the unit operations that make up an overall chemical

process. Ion exchange and waste pumping are examples of unit operations. The total mass of all components in the input streams must equal the total mass of all components in the output streams and include the residual components in a completed flowsheet. Hence, the mass is balanced across each unit operation and the total system. Similarly, the total energy input must equal the total energy output plus the net change in residual energy of the overall chemical process.

Heel or **Tank Waste Heel**. A heel or tank waste heel is the residual waste that remains in a tank following waste retrieval and/or waste feed delivery to BNFL Inc.

Interim Stabilization. The process of stabilizing SSTs to reduce leakage potential, using actions such as pumping interstitial liquids from SST wastes, stopping water additions, and minimizing other potential liquid inflows.

Interstitial Liquid. Interstitial liquid is the liquid fraction contained in the spaces (interstices) between individual solid particles in waste sludge.

Leach Factor. A leach factor is the fraction of a waste constituent removed (leached) from HLW sludge by mixing the sludge with a caustic solution (typically about 3 molar sodium hydroxide).

Mixer Pump. A modified centrifugal pump that draws in liquid waste and ejects the waste from two opposing ports in the impeller housing near the tank bottom at high rates. The tank contents are mixed as a consequence of the high rate of waste injection and changing the orientation of the ports.

Out-of-Specification Waste. Out-of-specification waste is LAW or HLW feed that does not meet the specifications contained in the ORP and BNFL Inc. contract (ORP 1999). The BNFL Inc. waste acceptance criteria for LAW and HLW feeds may be less constraining than the contract specifications.

Package. A package of immobilized LAW comprises a 2.3-m high, 1.22-m diameter metal container holding, on average, 6.0 MT of waste glass at a density of 2.66 MT/m^3.

Partitioning. When water is combined with a solid (e.g., salt cake, waste sludge), a fraction of the solid dissolves in accordance with the specific solubility of each chemical in the solid. Partitioning refers to the fraction of each chemical that dissolves in the water and the fraction that remains with the solid.

Sluicer and **Sluicing**. Sluicing is a method of mobilizing settled tank waste, usually to facilitate retrieval of the waste solids. The method employs a nozzle that directs a stream of liquids at the settled solids, thereby dislodging, dissolving, and suspending them in a liquid slurry, and pumping the slurry from the tank. A sluicer is the device that performs the waste sluicing.

Slurry. A mixture of waste liquids and suspended sludge particles.

Source Tank. A source tank is a SST or DST that contains a source of waste feed. A source tank usually requires retrieval actions (e.g., sluicing, mixing, dilution, dissolution, pumping) to

prepare and stage the waste for delivery to BNFL Inc. Waste qualification samples are taken from source tanks and analyzed to establish the preliminary acceptability of the waste for delivery to BNFL Inc. Certain DST source tanks may also serve as staging tanks if all or some fraction of the wastes contained in the tank can be certified as meeting the ORP and BNFL Inc. contract (ORP 1999) specifications, as applicable, and the CHG pumpability criteria.

Staging Tank. A staging tank is a DST that is used for preparing and containing waste feed prior to delivery. A staging tank usually is equipped with a mixing pump(s) to homogenize the waste prior to sampling and/or pumping to BNFL Inc. Waste certification samples are taken from staging tanks and analyzed to establish final acceptability of the waste feed for delivery to BNFL Inc.

Unit. The term "unit" reflects the difficulty of processing LAW feed. One metric ton of elemental sodium contained in LAW Envelopes A, B, and C waste feed is equivalent to 1.0, 2.6, and 1.15 units, respectively, as stated in the ORP and BNFL Inc. contract (ORP 1999).

Wash Factor. A wash factor is the fraction of a waste constituent removed from HLW sludge by actively washing the sludge with water or very dilute caustic solution (typically less than 0.1*M* sodium hydroxide).

Waste Certification. CHG waste certification is conducted using split, composited samples of staged waste feed to verify compliance with the ORP and BNFL Inc. contract (ORP 1999) specifications, as applicable. Waste certification activities are also conducted by BNFL Inc. on the other split, composited samples to verify compliance with environmental permit conditions and authorization basis limits.

Waste Feed Delivery System. The combination of the existing physical system and the future physical system that will be put in place to support tank waste retrieval and delivery to the treatment and immobilization facility.

Waste Feed Qualification. CHG waste feed qualification is conducted using samples of tank waste to qualify the tanks as candidate sources of waste feed. Qualification activities include waste sampling and laboratory analysis of the waste samples to the designated envelope specifications defined in the ORP and BNFL Inc. contract (ORP 1999) specifications. Qualification also includes laboratory testing of physical and chemical characteristics of the waste (e.g., rheology, settling rates, ease of dissolution) to establish preliminary design and operating parameters for retrieving and pumping the waste to BNFL Inc. Waste feed qualification activities are performed before the waste is certified to avoid the high cost of installing waste retrieval systems in tanks that are unsuited for waste retrieval and delivery of waste feed that may not be acceptable to BNFL Inc. Waste feed qualification should not be confused with the "waste qualification" process used by the Nuclear Regulatory Commission to determine if the waste is acceptable for emplacement in the Federal HLW respository.

Waste Transfer Day. The waste transfer day is the earliest day that BNFL Inc. will accept the transfer of a given batch of waste feed into its receiving tank. It is requested in writing and formally agreed to in accordance with the appropriate interface control documents.

LIST OF ACRONYMS

CHG	CH2MHILL Hanford Group, Inc.
DOE	U.S. Department of Energy
DST	Double-shell tank
HLW	High-level waste
HTWOS	Hanford Tank Waste Operation Simulator
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
LAW	Low-activity waste
ORP	Office of River Protection
PIO	Project Integration Office
RPP	River Protection Project
SST	Single-shell tank
TFC	Tank Farm Contractor
TFC O&UP	Tank Farm Contractor Operation and Utilization Plan
TWINS	Tank Waste Information Network System
wt%	percent by weight

ATTACHMENT 1

THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN, VOLUMES I AND II – ORGANIZATION AND CONTENT

ATTACHMENT 1

THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN, VOLUMES I AND II – ORGANIZATION AND CONTENT

This appendix provides section by section summaries of the contents of Volumes I and II of the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP). The summaries describe the purpose and intent of each section, with relevance to the overall objectives of the TFC O&UP. This roadmap enables a reader who first encounters the TFC O&UP to generally know where the methods, calculations, simulations, results, findings, and supporting information can be found in the document.

TFC O&UP – Volume I

1.0 INTRODUCTION TO THE OPERATING PLAN

This section briefly summarizes the different versions of events and tank waste processing scenarios (referred to as "cases") that have been evaluated in the current revision of the TFC O&UP. This section provides information on how different cases were evaluated and how the results contribute to technical baseline and multi-year work planning activities. Finally, this section introduces key elements used to define and distinguish the different scenarios that have been evaluated.

2.0 AN OVERVIEW OF HANFORD TANK WASTE OPERATION SIMULATOR

The Hanford Tank Waste Operation Simulator (HTWOS) is the primary computer simulation model used to develop and evaluate different cases. This section provides a general overview of how information is used by the HTWOS model to obtain the results presented in the TFC O&UP. Specific subsections are devoted to discussions of the following:

- Sources of information (e.g., contractual requirements, interface control documents) and their roles in assembling the constraints, requirements, and assumptions used to develop different cases for HTWOS evaluation.
- The Best-Basis Inventory, as the primary source of waste quantity, chemical, and radionuclide data used in the HTWOS model.
- Methods and limitations of the calculations used to determine the inventories of different waste feeds at the point of delivery.
- Generic bases and rationale for source tank selection.
- Approaches to staging low-activity waste feed prior to delivery and the influences affecting the choice of staging tanks.

- Assumptions and methods used to model the processing and incorporation of constituents into the final glass products.

- The criteria and logic for selecting retrieval sequences for single-shell tanks (SSTs).

Other general assumptions and constraints (e.g., minimum periods for waste degassing, time to complete laboratory analyses) that affect tank sequences and the waste feed delivery schedule are described throughout this section.

3.0 LOW-ACTIVITY WASTE FEED STAGING FOR CASE 3S6E

In this revision of the TFC O&UP, Case 3S6E, which is based on current (through March 2000) Project Integration Office (PIO) guidance (PIO 2000), represents the principal scenario for retrieving, staging, and delivering waste feed to BNFL Inc. This section of the TFC O&UP describes the results of Case 3S6E, and of different alternate cases, for low-activity waste processing. Information provided in this section includes the following:

- The waste source tanks, staging tanks, order and timing of retrieval.

- Projected quantities and characteristics of low-activity waste product.

- Estimates of how closely the low-activity waste feed will comply with Office of River Protection (ORP) and BNFL Inc. contract (ORP 1999) specifications.

- Identification of equipment needs and other capabilities required to support the selected retrieval and delivery scenario.

- Schedules for performing waste feed delivery, for required construction and upgrades to the tanks and delivery systems, and for coordinating with other operations and tank usage.

- Need for and relationship of the selected retrieval and delivery scenario to development of detailed, tank-specific flowsheets for each waste feed batch or sequence.

- Sensitivity analyses of the above results for alternative cases with different constraints and planning assumptions.

4.0 PHASE 1 HIGH-LEVEL WASTE FEED STAGING

This section of the TFC O&UP describes for high-level waste processing essentially the same types of results and findings provided in Section 3.0 for low-activity waste (e.g., tank sequencing, composition estimates, equipment needs, related schedules, sensitivity analyses).

5.0 PHASE 2 FEED STAGING

The majority of waste sources during Phase 2 will be SSTs that will be transferred to treatment and immobilization facilities via double-shell tanks (DSTs). This section of the TFC O&UP develops a plausible scenario for retrieving, staging, and delivering waste feed during Phase 2, and generally assesses the ability of this scenario to support River Protection

Project (RPP) mission objectives. The scenario is further developed with waste feed staging sequence and schedule strategies. Sluicing is the baseline retrieval technology assumed for SSTs (alternative SST retrieval technologies are being evaluated, and may be implemented depending on risk reduction, efficiency, cost, and other considerations). Equipment needs are developed in this section of the TFC O&UP to support sluicing retrieval. This section concludes with discussions of the key factors (e.g., glass formulation, physical systems, immobilization facility processing capacity) that contribute to sensitivities in the Phase 2 waste feed delivery analyses.

6.0 PRODUCT RECEIPT, STORAGE, AND DISPOSAL

This section of the TFC O&UP discusses how immobilized product from treatment and vitrification processes will be received and managed. The general management approach will be to dispose of immobilized low-activity waste product in a near-surface disposal site located on the Hanford Site, and to temporarily store immobilized high-level waste product at the Hanford Site until it can be accepted for final disposal at the national high-level waste repository being developed in Nevada. This section addresses key aspects of this management approach, relative to the Case 3S6E waste processing scenario. Information provided in this section includes the following:

- Impacts on the planned immobilized low-activity waste product disposal facility design, construction, and operation.
- Impacts on designing, constructing, and operating the immobilized high-level waste product storage facility.
- Issues regarding facility designs, construction schedules, and operation and maintenance plans in order to support the Case 3S6E waste processing scenario.
- Sensitivity analyses of the above results for alternative cases with different constraints and planning assumptions.

7.0 DOUBLE-SHELL TANK SPACE MANAGEMENT

This section of the TFC O&UP discusses how the Case 3S6E waste processing scenario may affect management of the storage capacity in the DSTs. Two broad uses for the available capacity need to be considered: receipt and storage of wastes generated during ongoing RPP operations and Hanford Site cleanup activities; and, receipt and storage of wastes retrieved from SSTs. Retrieval of SST waste is a stakeholder priority, due to the deteriorating condition of and past leaks from SSTs. In addition, having wastes staged and ready for future processing will be important for schedule and cost efficiencies as the Phase 2 waste treatment and disposal strategy evolves. Consequently, even though treatment of most SST wastes won't occur until Phase 2 processing, early transfer of SST wastes into the DSTs is a desirable objective. One key result of the Case 3S6E evaluation is a projection of volumes and schedules for tank space availability in the DSTs. After accounting for additions from ongoing work, the residual DST capacity can be used to receive retrieved SST wastes. This section concludes with recommendations on backfilling available DST capacity, as it becomes available, with SST wastes.

8.0 REFERENCES

Self-explanatory.

TFC O&UP – Volume II (Appendices)

APPENDIX A – BASES AND ASSUMPTIONS

As would be expected with any evolving system, there are numerous uncertainties which, depending on how they are resolved, could have significant impacts on how tank wastes will be treated and disposed. For example, analytical data are not complete, so the ability of some tanks to provide waste that meets envelope specifications must be assumed for certain constituents. Pending final resolution of such uncertainties, planning for waste retrieval and disposal must proceed by making reasonable assumptions, deriving secondary requirements, or imposing unilateral constraints for the physical systems and processes that are being modeled and evaluated. This appendix of the TFC O&UP documents the derived requirements, enabling assumptions, and other internal constraints that affect the processing scenarios and simulation models. This appendix also describes the guidance and assumptions used to develop the engineering calculations and computer simulations (e.g., HTWOS). Discussions of important issues, degree of uncertainty, and severity of potential impacts are also included.

APPENDIX B – INVENTORY

Appendix B documents the inventory basis used by the TFC O&UP models and simulations to estimate DST waste ("as is") compositions, project waste feed ("as delivered") compositions, and perform other inventory-dependent calculations. This inventory basis is developed using the information and data in the Hanford Best-Basis Inventory. Appendix B includes extensive spreadsheets that provide tank-by-tank inventory data, wash and leach factors, and other significant parameters of interest for chemical and radionuclide constituents in each tank's waste.

APPENDIX C – CHARACTERIZATION DATA NEEDS

Developing and evaluating different waste processing scenarios, such as Case 3S6E, helps to highlight key areas where additional characterization data are required. These characterization data may be needed for various reasons, such as the following:

- Confirming that the waste in selected source tanks will meet contractual requirements
- Refining inventory information needed for mass balance calculations and process flowsheets
- Determining chemical or physical properties of tank waste that are important to design or operate retrieval, delivery, treatment, storage and disposal processes
- Identifying constituents and concentrations needed for environmental, safety, or other permitting and licensing needs.

This appendix describes additional tank waste and other characterization data needs.

APPENDIX D – HIGH-LEVEL WASTE SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different high-level waste feed alternatives. Materials provided in this appendix include inventory data, delivered waste batch composition tables, glass composition tables, and other supporting documentation for high-level waste (summarized in Sections 4.0 and 5.0 of the TFC O&UP).

APPENDIX E – LOW-ACTIVITY WASTE SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different low-activity waste feed alternatives. Materials provided in this appendix include inventory data, waste batch delivery tables, waste envelope specification compliance tables, modeling results, calculations, and other documentation used to identify source tanks and retrieval and delivery sequences for low-activity waste (summarized in Sections 3.0 and 5.0 of the TFC O&UP).

APPENDIX F – SINGLE-SHELL TANK RETRIEVAL SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating different SST retrieval alternatives. Materials provided in this appendix include source data, tables, figures, analyses, calculations, simulation and modeling results, and other documentation used to develop a recommended SST retrieval sequence and DST backfilling strategy (summarized in Section 7.0 of the TFC O&UP).

APPENDIX G – STORAGE AND DISPOSAL SUPPORTING DOCUMENTATION

This appendix provides an engineering record that supports traceability, reproducibility, and reliability of the work associated with evaluating immobilized waste product storage and disposal requirements. Materials provided in this appendix include inventory tables for immobilized low-activity and high-level waste products, delivery schedules, capacity modeling, calculations, and other documentation used to develop and evaluate facilities for receiving and managing immobilized waste product (summarized in Section 6.0 of the TFC O&UP).

APPENDIX H – CASE 3S6E SUPPLEMENTAL INFORMATION

This appendix provides a place for collecting a variety of other types of information developed by or in support of TFC O&UP, primarily to assist technical operations and management decision makers. Materials assembled in Appendix H include summary-level graphics prepared to support RPP mission analyses; plots of DST volumes and usage; detailed tables projecting waste transfers during Phase 1; mass balance sheets for modeling process flows, constituent and materials movements, and blended waste compositions; and, figures depicting physical systems and configurations for tank waste retrieval, staging, and delivery.

APPENDIX I – PROCESS TECHNICAL BASIS

This appendix collects relevant background information (not already included in Appendix A) used to establish the technical basis for the tank waste retrieval and disposal process. Information provided in Appendix I includes, but is not limited to: a master set of components to be used by the TFC O&UP models and simulations; methods for calculating various waste physical properties (e.g., density, viscosity); relevant information on phase equilibrium phenomena that occur in Hanford Site tank wastes; current knowledge base for solubility and caustic leaching of constituents in solids; and, methodology for determining waste oxide loading in the immobilized waste glass products.

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ATTACHMENT 2

SAMPLE CALCULATIONS--ESTABLISHING THE RELIABILITY OF RESULTS IN THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

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ATTACHMENT 2

SAMPLE CALCULATIONS--ESTABLISHING THE RELIABILITY OF RESULTS IN THE TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

Section S2.0 of this summary document describes how the Hanford Tank Waste Operation Simulator (HTWOS) models tank waste processing activities to provide information used in the *Tank Farm Contractor Operation and Utilization Plan* (TFC O&UP) for evaluating various waste feed retrieval, delivery, and immobilization scenarios. The purpose of this attachment is to test and demonstrate the reliability of the models and calculations by performing a limited assessment of the HTWOS results for a selected waste processing event. The assessment documents a series of independently developed numerical results (sample calculations) that demonstrate traceability of source information used in HTWOS calculations, and confirm the definition and performance of some of the calculation methods (algorithms) embedded in the HTWOS. The results of the sample calculations and the HTWOS results are compared for significant differences that, if present, could indicate errors in the models and/or algorithms.

This attachment describes calculations used to transform the quantity of the waste in double-shell tank (DST) 241-AZ-101 into the quantities of immobilized low-activity waste (ILAW) and immobilized high-level waste (IHLW) projected by the HTWOS and reported in the TFC O&UP. DST 241-AZ-101 was selected for this assessment because it is a source of both low-activity waste (LAW) and high-level waste (HLW) feed, and thus allows the preparation of sample calculations for both types of waste processes. This assessment presented in this attachment is limited in two key ways:

- For brevity's sake, sample calculations are not provided for all of the tank constituents. Only a few of the most significant parameters have been included out of more than one hundred chemicals and radionuclides modeled in the HTWOS.

- DST 241-AZ-101 waste processing is relatively straightforward and does not require use of all the process models and algorithms that may be employed by the HTWOS. DST 241-AN-104 calculations are significantly more complex due to multiple waste dissolution, chemical partitioning, and blending steps. A description of the HTWOS steps for DST 241-AN-104 is provided in the TFC O&UP based on the specific parameter and stream code names used in the HTWOS.

The limited assessment provided in this attachment shows the effectiveness of using sample calculations to confirm reliability of the TFC O&UP results. This particular assessment also helps establish reliability of the HTWOS modeling and calculations for processing the DST 241-AZ-101 waste.

Summary of DST 241-AZ-101 Processing[1]

The current DST 241-AZ-101 tank waste consists of a layer of settled solids (sludge) overlain by a layer of liquid (supernate). Mixer pumps will be operated to prepare a waste slurry by mixing and suspending most of the settled solids in the liquid fraction. Most of the slurry will be pumped as combined waste feed Envelope B (LAW) and D (HLW) to the treatment and immobilization facility. The combined slurry will be separated by filtration into a LAW liquid fraction and a HLW solids fraction. The solids fraction will be washed, vitrified, and then poured into metal canisters to produce the IHLW product. The chemicals leached out of the solids in the washing process will be combined with the LAW liquid fraction. The combined LAW liquid waste will be vitrified and then poured into metal packages to produce the ILAW product.

Calculations (For Selected Waste Species)

1. Define Starting Total Inventory of Waste (Liquids plus Solids) in DST 241 AZ-101

Waste species	Total inventory
Total Sodium (Na)	3.54×10^5 kg
Total Aluminum (Al)	4.90×10^4 kg
Total Iron (Fe)	2.32×10^4 kg
Total Zirconium (Zr)	8.22×10^3 kg

Source: Tank Waste Information Network System (TWINS), available via Internet at http://twins.pnl.gov:8001/twins.htm; also reported in TFC O&UP, Vol. II, Table B1-2.

2. Define Partitioning of Waste Species Between Liquid and Solid Phases

Waste species	Total quantity in liquids	Total quantity in solids*
Na	3.33×10^5 kg	2.10×10^4 kg
Al	3.23×10^4 kg	1.67×10^4 kg
Fe	3.50×10^1 kg	2.32×10^4 kg
Zr	—	8.22×10^3 kg

* Defined as in the sludge layer.

Source: TWINS; also reported in TFC O&UP, Vol. II, Tables B3-1 and B3-2

[1]The described waste treatment and immobilization activities are based on information provided through March 2000 by BNFL Inc. about anticipated in-plant processing activities. The treatment and immobilization steps modeled in the HTWOS are subject to change pending further BNFL Inc. process definition and facility design.

3. Calculate the Quantity of Solids Mobilized by Mixer Pumps

Equation 1
(Mobilization Factor)(Total Quantity in Solids) = (Quantity of Mobilized Solids)

Mobilization Factor = 0.9 (fraction of solids that can be mobilized by mixer pumps as currently designed is assumed to be 90% of total solids quantity)

Source: TFC O&UP, Vol. II, Appendix A, Assumption A7.14

Waste species	Calculation	Quantity of mobilized solids
Na	$(0.9)(2.10 \times 10^4$ kg)	1.89×10^4 kg
Al	$(0.9)(1.67 \times 10^4$ kg)	1.50×10^4 kg
Fe	$(0.9)(2.32 \times 10^4$ kg)	2.09×10^4 kg
Zr	$(0.9)(8.22 \times 10^3$ kg)	7.40×10^3 kg

4. Calculate Quantity of Delivered Solids (Fraction of Mobilized Solids That Are Transferred to BNFL Inc.)

Equation 2
[(Starting Waste Volume – Ending Waste Volume)/(Starting Waste Volume)](Quantity of Mobilized Solids) = (Quantity of Delivered Solids)

Starting Waste Volume = 3,024 m^3 (799,000 gal)

Source: Hanlon 1999

Ending Waste Height = 0.25 m (10 in.)

Source: TFC O&UP, Vol. II, Appendix A, Assumption A3.5

Waste Volume = (Waste Height)(Volume per Vertical Tank Meter)

Volume per Vertical Meter of 23-m (75-ft) Diameter Tank = 415 m^3/m (2,750 gal/in.)

Ending Waste Volume = (0.25)(415) = 104 m^3

[(Starting Waste Volume – Ending Waste Volume)/(Starting Waste Volume)] = (3,024 – 104)/(3,024) = 0.966

Waste species	Calculation	Quantity of delivered solids
Na	(0.966)(1.89 x 10^4 kg)	1.82 x 10^4 kg
Al	(0.966)(1.50 x 10^4 kg)	1.45 x 10^4 kg
Fe	(0.966)(2.09 x 10^4 kg)	2.02 x 10^4 kg
Zr	(0.966)(7.40 x 10^3 kg)	7.15 x 10^3 kg

5. Calculate Quantity of Solids After Washing (Fraction of Delivered Solids That Remain After Washing by BNFL Inc.)

Equation 3
(1 – Wash Factor)(Quantity of Delivered Solids) = (Quantity of Solids After Washing)

Waste species	Wash factor*
Na	7.89 x 10^{-1}
Al	1.31 x 10^{-1}
Fe	2.01 x 10^{-5}
Zr	0

* Fraction of waste species washed from the solids fraction, including interstitial liquid.

Source: TWINS; also reported in TFC O&UP, Vol. II, Tables B5-1 and B5-2

Waste species	Calculation	Quantity of solids after washing
Na	(1 – 0.789)(1.82 x 10^4)	3.84 x 10^3 kg
Al	(1 – 0.131)(1.45 x 10^4)	1.26 x 10^4 kg
Fe	(1 – 0.00002)(2.02 x 10^4)	2.02 x 10^4 kg
Zr	(1 – 0)(7.15 x 10^3)	7.15 x 10^3 kg

6. Calculate the Quantity of IHLW Glass Produced

There are two methods for calculating the quantity of IHLW glass produced. One method employs the Pacific Northwest National Laboratory's Glass Properties Model (see description in TFC O&UP, Vol. II, Appendix A, Assumption A7.13). This complex method is believed to more closely approximate expected IHLW glass quantities than the second method, which is defined in the ORP and BNFL Inc. contract (ORP 1999) (see Specification 1). The second method provides a more conservative (larger) estimate of IHLW glass quantities and entails a three step process:

a) Convert the quantity of solids that remains after washing by BNFL Inc. (elemental basis) to an oxides quantity (i.e., Na_2O, Al_2O_3, Fe_2O_3, and ZrO_2). For this waste, only Al_2O_3, Fe_2O_3, and ZrO_2 are important. These conversions are presented below in the *Equation 4* calculations.

b) For each component (or sum of components) in Specification 1 of the ORP and BNFL Inc. contract (ORP 1999) (see contract Table TS-1.1), divide the oxides quantity (calculated in step a), above) by the corresponding limiting factors for waste loading (shown in Table TS-1.1 and referred to as the maximum weight fraction in IHLW glass) to determine the projected IHLW glass quantity. These projections are presented below in the *Equation 5* calculations.

c) Identify the component or sum that results in the largest projected quantity of IHLW glass. This quantity is used for future calculations as the (more conservative) quantity of IHLW glass produced. This largest quantity value is identified below after the calculations.

Equation 4

[(Oxide Molecular Weight)/(Sum of Element Molecular Weight)](Quantity of Solids After Washing) = (Oxides Quantity)

Chemical	Molecular weight*
Al	26.97
Fe	55.85
Zr	91.22
Al_2O_3	101.94
Fe_2O_3	159.70
ZrO_2	123.22

* Reproduced in and available from various handbooks of chemistry and physics.

Chemical	Calculation	Oxides quantity
Al	$[(101.94)/(2)(26.97)](1.26 \times 10^4)$	2.38×10^4 kg (Al_2O_3)
Fe	$[(159.70)/(2)(55.85)](2.02 \times 10^4)$	2.89×10^4 kg (Fe_2O_3)
Zr	$[(123.22)/(91.22)](7.15 \times 10^3)$	9.66×10^3 kg (ZrO_2)
All		6.24×10^4 kg (combined)

Equation 5

(Oxide Quantity)/(Maximum Weight Fraction in IHLW Glass) = (Projected IHLW Glass Quantity)

Component	Maximum weight fraction in IHLW glass
Al_2O_3	0.11
Fe_2O_3	0.125
ZrO_2	0.10
$Al_2O_3 + Fe_2O_3 + ZrO_2$	0.21

Source: Table TS-1.1 of the ORP and BNFL Inc. contract (ORP 1999).

Component	Calculation	Projected IHLW glass quantity
Al_2O_3	$2.38 \times 10^4 / 0.11$	2.16×10^5 kg
Fe_2O_3	$2.89 \times 10^4 / 0.125$	2.31×10^5 kg
ZrO_2	$9.66 \times 10^3 / 0.10$	9.66×10^4 kg
$Al_2O_3 + Fe_2O_3 + ZrO_2$	$6.24 \times 10^4 / 0.21$	2.97×10^5 kg *

*This value is assumed to be the largest quantity of IHLW glass produced for subsequent calculation purposes. Note that this calculation agrees closely with the HTWOS value of 299 MT reported in the TFC O&UP, Vol. I, Table 4.1-1, Column 23, Batch Group 1. The two MT difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

7. Calculate the Quantity of IHLW Canisters Produced

Equation 6
(IHLW Glass Quantity)/(Average Glass Quantity per IHLW Canister) = (Number of IHLW Canisters)

Average Glass Volume in Canister = 1.15 m^3

Source: TFC O&UP, Vol. I, Section 4.1.2

Average Glass Density = 2.66 MT per m^3

Source: TFC O&UP, Vol. I, Section 4.1.2

Average Glass Quantity per IHLW Canister = (1.15 m^3) x (2.66 MT/m^3) x (1,000 kg/MT) = 3.06×10^3 kg

Calculation	Number of IHLW canisters
$(2.97 \times 10^5) / (3.06 \times 10^3)$	97 *

*Note that this calculation agrees closely with the HTWOS value of 98 canisters reported in the TFC O&UP, Vol. I, Table 4.1-1, Column 25, Batch Group 1. The one canister difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

8. Calculate the Quantity of Sodium in the Combined Liquid Fraction (LAW Feed from DST 241-AZ-101)

Equation 7
(Total Sodium) - (Sodium in Solids After Washing) = (Sodium Quantity in Liquid Fraction)

Total Sodium = 3.54×10^5 kg

Source: TWINS; also reported in O&UPTFC, Vol. II, Table B1-2 (See Step 1, above)

Sodium in Solids After Washing = 3.84×10^3 kg

Source: Calculated quantity for Sodium reported in Step 5, above.

Calculation	Sodium quantity in liquid fraction
$(3.54 \times 10^5) - (3.84 \times 10^3)$	3.50×10^5 kg

9. Calculate the Quantity of ILAW Glass Produced from the Combined Liquid Fraction (LAW Feed)

Equation 8
[(Sodium Quantity in Liquid Fraction) (Ratio of Sodium Oxide to Sodium)] / (Sodium Oxide Loading in Glass) = (ILAW Glass Quantity)

Ratio of Sodium Oxide to Sodium = 62 / 46 = 1.35

Source: Available from various handbooks of chemistry and physics.

Sodium Oxide Loading in Glass = 7.5 weight %

Source: TFC O&UP, Vol. II, Appendix A, Assumption A7.14

Calculation	ILAW glass quantity
$[(3.5 \times 10^5)(1.35)] / (0.075)$	6.30×10^6 kg

10. Calculate the Quantity of ILAW Packages Produced

Equation 9
(ILAW Glass Quantity)/(Average Glass Quantity per ILAW Package) = (Number of ILAW Packages)

Average Glass Quantity per ILAW Package = 6.0 MT = 6,000 kg

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Number of ILAW packages
$(6.3 \times 10^6) / (6.0 \times 10^3)$	1,050 *

*Note that this calculation includes only the sodium contribution from DST 241-AZ-101, and so it is less than the HTWOS value of 1,511 ILAW packages that is reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 15, for Batch 2a/2b (this batch represents processing of supernates from both DST 241-AZ-101 and 241-AZ-102). Calculating sodium contributions from DST 241-AZ-102 in the same manner as described in Step 8, above, results in 153 MT (153,000 kg) of sodium being delivered from DST 241-AZ-102. Calculating the quantity of ILAW glass in the same manner as described in Step 9, above, results in 459 ILAW packages being produced from processing the DST 241-AZ-102 supernate. Adding the 1,050 ILAW packages from DST 241-AZ-101 supernate processing and the 459 ILAW packages from DST 241-AZ-102 supernate processing yields a total of 1,509 ILAW packages. The two package difference is accountable by the rounding of preceding calculations to two significant figures. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

11. Calculate the Units of LAW Delivered

Equation 10
(Total Sodium Quantity Delivered) (Equivalent Units per Metric Ton of Sodium) = (Units of LAW Delivered)

Total Sodium Quantity Delivered = 350 MT + 153 MT = 503 MT

Source: From calculations in Steps 8 and 10, above.

Envelope B Equivalent Units = 2.6 Units/MT

Source: ORP and BNFL Inc. contract (ORP 1999), Section 7.2.3 (b)

Calculation	Units of LAW delivered
(503) (2.6)	1,308 Units *

*Note that this calculation agrees with the HTWOS value of 1,308 Units reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 11, Batch 2a/2b. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

12. Calculate the Quantity of ILAW Glass Produced

Equation 11
(Number of ILAW Packages) (Average Quantity of Glass per Package) = (Quantity of ILAW Glass)

Number of ILAW Packages = 1,509

Source: From calculations in Step 10, above.

Average Quantity of Glass per Package = 6.0 MT

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Quantity of ILAW glass
(1,509) (6.0)	9,054 MT *

*Note that this calculation is reasonably close to (within about 0.3% of) the HTWOS value of 9,080 MT reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 13, Batch 2a/2b. The difference is accountable by the rounding of preceding calculations and differences in other calculations that have been carried forward to this step. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

13. Calculate the Volume of ILAW Glass Produced

Equation 12
(Quantity of ILAW Glass) / (Average ILAW Glass Density) = (Volume of ILAW Glass)

Quantity of ILAW Glass = 9,054 MT

Source: From calculations in Step 12, above.

Average ILAW Glass Density = 2.66 MT/m^3

Source: TFC O&UP, Vol. I, Section 3.1.2

Calculation	Volume of ILAW glass
(9,054) / (2.66)	3,404 m^3 *

*Note that this calculation is reasonably close to (within about 0.3% of) the HTWOS value of 3,414 m^3 reported in the TFC O&UP, Vol. I, Table 3.1-1, Column 14, Batch 2a/2b. The difference is accountable by the rounding of preceding calculations and differences in other calculations that have been carried forward to this step. The results show that "hand" calculations corroborate the data reported by the HTWOS and support its reliability.

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Revision 2

TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

Volume I

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R. A. Kirkbride
G. K. Allen
B. A. Higley
R. M. Orme
R. S. Wittman
Numatec Hanford Corporation
Richland, Washington

J. H. Baldwin
T. W. Crawford
J. Jo
J. N. Strode
CH2MHILL Hanford Group, Inc.
Richland, Washington

T. M. Hohl
S. L. Lambert
D. E. Place
J. A. Seidl
COGEMA
Richland, Washington

Prepared for:
U.S. Department of Energy
Office of River Protection
Richland, Washington

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TERMS

AGA	Alternative generation and analysis
BBI	Best-Basis Inventory
BBIM	Best-Basis Inventory Maintenance
CHG	CH2MHILL Hanford Group, Inc.
CSB	Canister Storage Building
DOE	U.S. Department of Energy
ESP	Environmental Simulation Program[1]
DST	Double-shell tank
FY	Fiscal year
GPM	Glass property model
HDW	Hanford Defined Waste
HLW	High-level waste
HTWOS	Hanford Tank Waste Operation Simulator
I&C	Instrumentation and control
ICD	Interface Control Document
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
IWFST	Intermediate Waste Feed Staging Tank
LAW	Low-activity waste
MAR	Mission Analysis Report
MSD	Mission Summary Diagram
MYWP	Multi-Year Work Plan
NCAW	Neutralized current acid waste
O&M	Operations and Maintenance
ORP	Office of River Protection
OSD	Operational Specification Document
OWVP	Operational Waste Volume Projection
PCT	Product Consistency Test
PIO	Project Integration Office
PNNL	Pacific Northwest National Laboratory
RAM	Reliability, availability, and maintainability
RPP	River Protection Project
RTP	Readiness-to-Proceed
RTP-2	Readiness-to-Proceed 2
SMM	Supernatant Mixing Model
SST	Single-shell tank
SWL	Salt well liquid
TLM	Tank Layer Model
TEC	Total estimated cost
TFC	Tank Farm Contractor

[1]ESP is a trademark of OLI Systems, Inc.

TERMS (CONTINUED)

TOE	Total operating efficiency
TRU	Transuranic
TWRS	Tank Waste Remediation System
TFC O&UP	Tank Farm Contractor Operation and Utilization Plan
WFD	Waste Feed Delivery
WIR	Waste Incidental to Reprocessing
WOL	Waste oxide loading
WRF	Waste Retrieval Facility
WTD	Waste Transfer Date
WTP	Waste Treatment Plant

TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

1.0 INTRODUCTION TO THE OPERATING PLAN

This Tank Farm Contractor (TFC) Operation and Utilization Plan (O&UP) updates the *Tank Waste Remediation System Operation and Utilization Plan* (TWRSO&UP), Revision 1 (Kirkbride et al. 1999), using the latest information to model the March 8, 2000, River Protection Project (RPP) Key Planning Assumptions (PIO 2000). This scenario also is identified as Case 3S6E for internal tracking of Hanford Tank Waste Operation Simulator (HTWOS) model scenarios.

1.1 PURPOSE OF THE SIMULATION

The TFC O&UP documents multiple flowsheet scenarios used to validate the formal technical baseline documented in the Readiness-To-Proceed (RTP) effort. The TFC O&UP does not define the baseline; rather, it generates data used to assess the baseline against the input basis and assumptions. The primary scenario, Case 3S6E, was developed to incorporate additional changes to the TWRSO&UP, Revision 1, Case 3 (Kirkbride et al. 1999) to resolve feed staging tank issues, to include changes in assumptions, and to include additional Hanford waste tank system and programmatic constraints in the model. Results from Case 3S6E will be used to confirm the technical baseline, to verify the scope of planned facility upgrades, to direct the development or revision of specifications and supporting engineering studies, to prepare operational plans, and to verify project schedules for feed delivery and product receipt.

1.2 BACKGROUND – THE PRIVATIZATION CONTRACT

In August 1998, the DOE signed contractual obligations with BNFL Inc. to proceed with Part B, Phase 1, of Tank Waste Remediation System (TWRS) privatization. These obligations include staging low-activity waste (LAW) feed, staging high-level waste (HLW) feed, and receiving various final and intermediate waste products and miscellaneous waste streams from the contractor. During the first half of fiscal year (FY) 1999, the U.S. Department of Energy, Richland Operations Office (RL), and BNFL Inc. completed value engineering studies regarding the feed receipt tanks, entrained solids, and the storage of Pretreated Envelope B. Pretreated Envelope B waste is waste that has been processed through the low-activity waste (LAW) pretreatment process to remove radionuclides and is ready for vitrification. The RL issued revised planning guidance (April 1, 1999) that was incorporated in TWRSO&UP, Revision 1, Case 3 (Kirkbride et al. 1999). After Revision 1 was issued, several intermediate cases were developed for the following purposes (details on these intermediate uses were documented as part of the effort they supported and the references are provided below).

- Incorporate the single-shell tank (SST) retrieval program risk-based retrieval strategy (Boston 1999a).

- Provide information to support planning for constrained funding and unconstrained funding planning for FY 2000 Multi-Year Work Plan (MYWP) submittal (LMHC 1999).

- Provide information early in FY 2000 to support the Readiness-To-Proceed 2 (RTP-2) planning effort (Poppiti 1999).

Ongoing negotiations between BNFL Inc. and DOE-ORP and formation of the Project Integration Office (PIO) led to further changes in the feed delivery schedule and DOE-ORP deferred implementation of the HLW blending assumed in the previous cases. These changes have been incorporated into the 2006 Hot Start scenario and into the sensitivity cases built around it.

1.2.1 Programmatic Integration

Use of the HTWOS model to analyze a scenario and produce a staging plan is a central part of related efforts to define the ORP mission and implement the mission through the RPP. Figure 1.2-1 shows how the TFC O&UP fits within the RPP document hierarchy and Figure 1.2-2 shows additional detail about specific relationships within the hierarchy.

1.2.2 Minimum Versus Extended Order Definitions

Several terms are used to define schedule and processing progress in phase 1. These terms and phrases are defined below.

- Phase 1 Contract Completion

  Phase 1 is contractually over from a schedule standpoint on 2/28/18.

- Minimum Order Quantities

  The contract defines the minimum order quantities as 6000 units of LAW waste processed and 600 canisters of HLW processed. It is likely that these quantities will be processed well before the 2018 contract completion date.

- Minimum Order Tanks

  The list of source tanks selected to provide the minimum order quantity plus additional contingency waste is referred to as the minimum order tanks. This contingency waste insures CHG has an adequate supply of feed to stay abreast of the processing contractor rates.

- Extended Order Tanks

  If BNFL Inc. completes processing of the minimum order quantity before the end of the contract, DOE may request additional waste be processed. This period of time is called the extended order period. The tanks processed (with contingency) are referred to as extended order tanks.

Figure 1.2-1. Relationship of TFC Operation and Utilization Plan to River Protection Project Document Hierarchy.

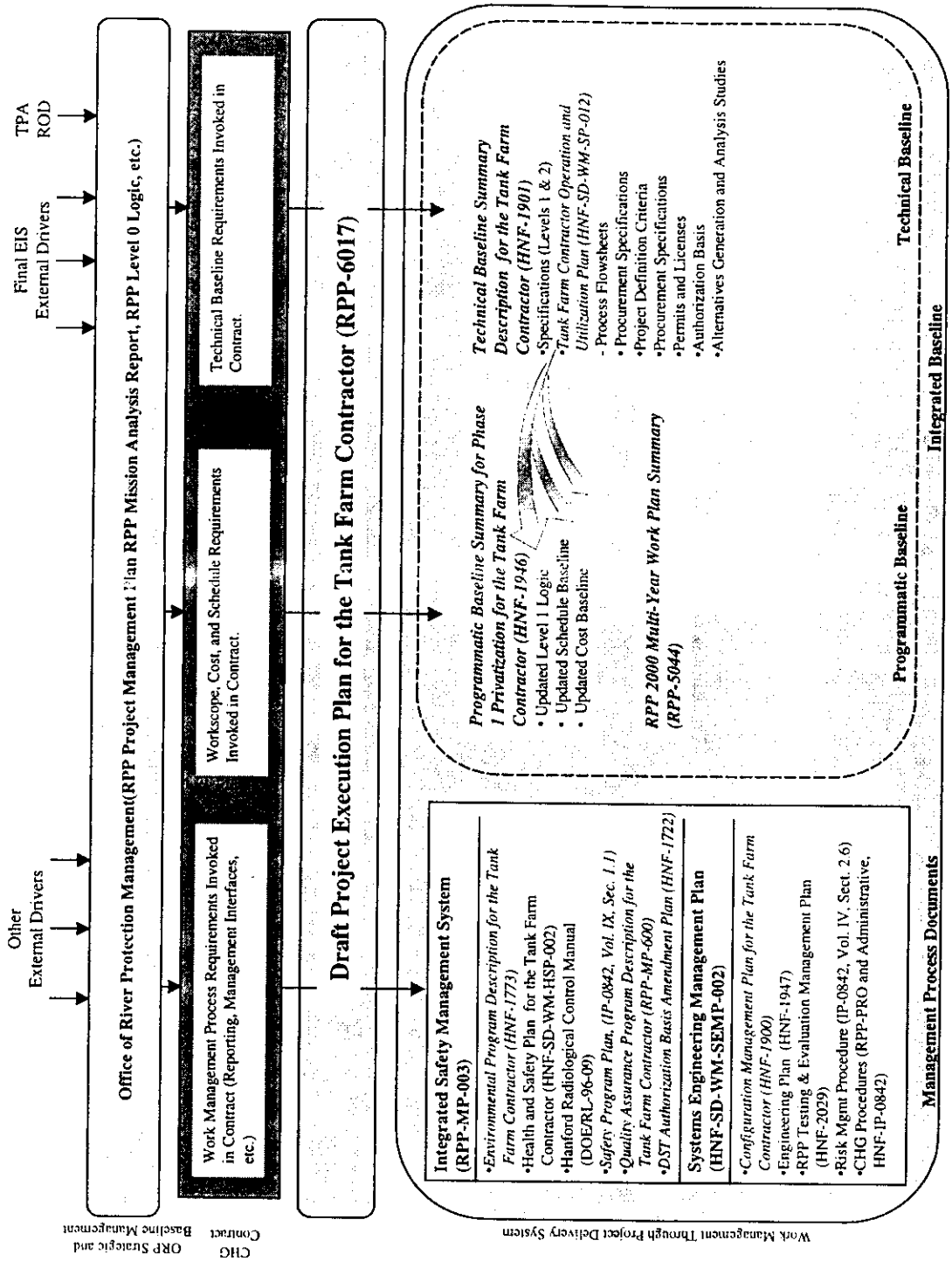
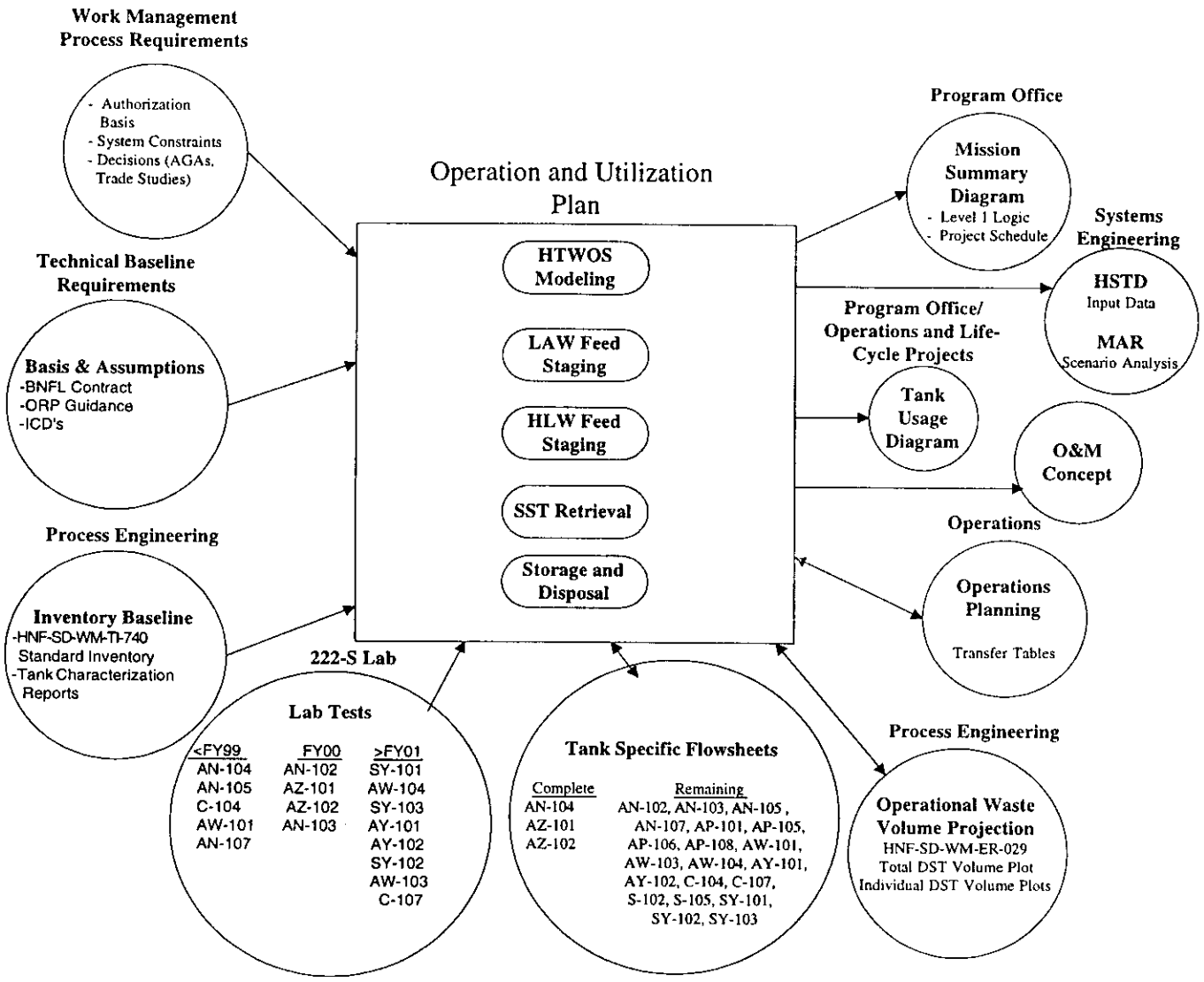


Figure 1.2-2. Relationship of Operation and Utilization Plan to Other River Protection Project Activities.



AGA = Alternative generation and analysis
DST = Double-shell tank
HLW = High-level waste
HSTD = Hanford Site Technical Database
HTWOS = Hanford Tank Waste Operations Simulator
ICD = Interface control document
LAW = Low-activity waste
MAR = Mission Analysis Report
O&M = Operations and maintenance
ORP = Office of River Protection
SST = Single-shell tank.

1.2.3 Waste Envelope Definitions

Four waste feed envelopes were developed to support the privatization contract (McKee et al. 1995 and Patello et al. 1996). Envelope A, B, and C define Phase 1 LAW feeds and Envelope D defines Phase 1 HLW feed.

- Envelope A represents waste that will test the production capacity and fission product removal efficiency of the plants while producing a final product in which the waste loading will be limited by sodium.

- Envelope B waste is similar to Envelope A but this waste will produce a final product in which the waste loading will be limited by minor component concentrations.

- Envelope C represents waste with complexing agents that may interfere with ^{90}Sr and/or TRU decontamination requiring demonstration of organic destruction or some other acceptable mitigation technology.

- Envelope D defines the HLW solids composition.

1.3 SUMMARY ASSUMPTIONS AND RESULTS

Case 3S6D (the 2006 Hot Start Scenario) implements planning guidance provided by DOE-ORP on January 26 (French 2000) and provides the technical basis for the RTP-2 planning effort. Later, direction was provided on March 8, 2000 (PIO 2000). Although the RTP-2 deliverables could not be adjusted to meet the new guidelines, the differences in the cases are not significant. The March 8, 2000, guidance is accommodated in Case 3S6E.

1.3.1 Case 3S6D Guidance and Assumptions

The following text provides the major assumptions for Case 3S6D. Comparisons in the text are with Case 3, which is documented in the previous revision of the TWRSO&UP (Kirkbride et al. 1999).

1. BNFL Inc. will build its own LAW feed receipt tanks.

2. BNFL Inc. will keep the Envelope B feed (instead of returning it to the double-shell tank [DST] system) and vitrify it early in the sequence using Envelope A sodium loadings.

3. BNFL Inc. will store the entrained solids at its facility rather than returning them to the DST system.

4. The waste in tank 241-AN-102 is delivered before that in tank 241-AN-107. The two tanks exchange places in the LAW feed delivery sequence. Section 3.0 provides a detailed discussion of LAW feed staging.

5. Caustic will be added to the waste in tanks 241-AN-102 and 241-AN-107 to meet corrosion specifications (within available space). The waste will be certified in these tanks and delivered to BNFL Inc. by a direct transfer.

6. Additional staging tanks will be used. Tanks 241-AP-104 and 241-AN-105 will be used to stage LAW feed to BNFL Inc. Tank 241-AY-101 will be used to stage HLW feed to BNFL Inc.

7. The waste in tank 241-C-104, an SST, is delivered as part of the HLW minimum order quantity. Section 4.0 provides a detailed discussion of HLW feed staging.

8. A longer duration is assumed to be needed to certify the feed before delivery to BNFL Inc. than was assumed in previous processing scenarios (seven months for LAW and nine months for HLW).

9. The saltwell liquor volume to be pumped has been reduced from approximately 22,700 m^3 (6 Mgal) to approximately 15,100 m^3 (4 Mgal) and the October 1, 1999 (file SWL_10_1_99R4.itm, cited in Harmsen 1999), pumping schedule is being used.

10. Crust-growth problems in tank 241-SY-101 were mitigated by retrieval and dilution. Mitigation retrieval was assumed to consist of a total of 1,140 m^3 (300,000 gal) of waste retrieved using two transfers. Each transfer was accompanied by equal-volume dilution of the retrieved waste and back dilution of the remaining waste. Retrieval of waste from tank 241-SY-101 started at the same time as and extended past the 3S6D modeling effort. A total of 1,995 m^3 (525,000 gal) of waste has been removed from 241-SY-101 and will be included in future modeling efforts.

11. The 242-A Evaporator campaigns will be scheduled eight months apart with a year-long outage for a life-extension upgrade occurring in FY 2004.

12. The SSTs used for extended-order quantity feed support implementation of the SST program's risk-based retrieval strategy.

13. Extended-order HLW feeds are blended to minimize immobilized high-level waste (IHLW) per DOE direction. No HLW feeds are blended as part of the minimum order quantities.

14. CHG will plan the delivery schedule assuming the sodium delivered from LAW source tanks is the only source of sodium in the LAW glass (i.e., ignore any sodium added by BNFL Inc. during pretreatment or delivered in

the HLW slurry carrier liquids; 241-AZ-101 and 241-AZ-102 supernates are LAW sources).

1.3.2 Comparing 3S6D and 3S6E

Case 3S6E implements final planning guidance provided by DOE-ORP (PIO 2000). The following text provides the major differences between Case 3S6E and Case 3S6D. Table 1.3-1 provides a detailed comparison of guidance that defines Case 3S6E and Case 3S6D for Phase 1. Table 1.3-2 provides the same comparison for Phase 2.

1. The same BNFL Inc. start-up schedule as Case 3S6D (2006 Hot Start Scenario)

2. CHG will plan to deliver LAW feed faster (at nearly twice the rate) than BNFL Inc.'s planned LAW treatment ramp up (see Table 1.3-1).

3. BNFL Inc. will vitrify Envelope B feed at low sodium loadings consistent with high sulfate concentrations (no sulfate removal).

4. Phase 2 processing will start March 1, 2018, and will proceed based on an operating efficiency of 60 percent, a LAW melter design capacity of 120 MT glass per day, and a HLW melter design capacity of 12 MT glass per day.

These changes in the guidance between the 2006 Hot Start scenario (Case 3S6D, the basis for RTP-2) and Case 3S6E have no significant impact on the planned Phase 1 feed delivery schedule but do increase the amount of ILAW from 12,500 to 13,500 canisters. The increase is seen in processing the AZ tank supernates as Envelope B LAW waste. The increased LAW ramp-up rate causes the BNFL Inc. ILAW lag storage to fill to 50 percent of capacity by August 2007 or five months sooner than in Case 3S6D.

Table 1.3-1. Comparison of 3S6D and 3S6E Guidance and Results – Phase 1.

Phase 1 Guidance		
Cases	FY 2000 Contract Guidance[1,2,3] (Case 3S6D)	April PIO Planning Guidance[4] (Case 3S6E)
Key Differences	1) Sulfate Removal and 2) 1 times BNFL Inc. Integrated Master Plan Ramp-up Rates for LAW	1) No Sulfate Removal and 2) ~2 times the BNFL Integrated Master Plan Ramp-up Rates for LAW
Low-Activity Waste		
Initiate PT Hot Start	4/30/06	4/30/06
First LAW Delivery AP-101	4/30/06	4/30/06
Initiate LAW Hot Start	11/30/06	11/30/06
Initiate LAW Vit. Services	3/1/08	3/1/08
LAW Treatment Ramp Up -Nominal rate = 754 units/yr -2.38 ILAW packages/day	From – To Units/Yr 11/30/06 – 11/30/07 151(20%) 11/30/07 – 11/30/08 452(60%) 11/30/08 – 11/30/09 754(100%) Through Ext. Order 1100(146%)	From – To Units/Yr 11/30/06 – 11/30/07 279(37%) 11/30/07 – 11/30/08 830(110%) 11/30/08 – 11/30/09 1011(134%) Through Ext. Order 1100(146%)
BNFL Inc. Sulfate Removal -Na_2O Loading in Envelope B	Yes 19.5 wt.%	No 7.5 wt.%
Product Return Starts When BNFL Inc. Lag Storage is X% Full	(ILAW/IHLW) 50%/50%[5]	(ILAW/IHLW) 50%/50%
High-Level Waste		
First HLW Delivery AZ-101	10/31/06	10/31/06
Initiate HLW Hot Start	5/31/07	5/31/07
Initiate HLW Vit. Services	9/1/08	9/1/08
HLW Treatment Ramp Up -Nominal rate = 102 cans/yr -0.28 IHLW canisters/day	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)
HLW Waste Oxide Loading	Glass Properties Model Calc.	Glass Properties Model Calc.
Phase 1 Projections Through the BNFL Inc. Contract Period (2/28/18)		
#ILAW Packages	12,500	12,500
#IHLW Packages	1,060	1,070
Date When BNFL Lag Product Storage is 50% Full	ILAW – January 2008 IHLW – April 2009	ILAW – August 2007 IHLW – April 2009
LAW Feed Delivery Dates	All tanks are delivered on the same dates for both cases	
HLW Feed Delivery Dates	All tanks are delivered on the same dates for both cases	

FY = Fiscal year
HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
PIO = Project Integration Office
[1]Multi-Year Work Plan Update Guidance for FY2000 (Erickson 1999)
[2]Lockheed Martin Hanford Corporation Work Authorization for FY 2000 (ORP 1999)
[3]Mission Planning Guidance for FY 2002 (ORP 2000)
[4]Project Integration Office April 2000 Guidance (PIO 2000)
[5]Appendix A Modeling Assumption A6.13.

Table 1.3-2. Comparison of 3S6D and 3S6E Guidance and Results – Phase 2.

Phase 2 Guidance		
Cases	FY 2000 Contract Guidance[1,2,3] (Case 3S6D)	April PIO Planning Guidance[4] (Case 3S6E)
Key Differences	2X/4X LAW/HLW Phase 2 Rates	4X/8X LAW/HLW Phase 2 Rates
Vitrification Rates	2X LAW/4X HLW Phase 1 rates	~4X LAW/8X HLW Phase 1 rates
Na_2O Loading in ILAW	20 wt.%	20 wt.%
Phase 2 Projections		
LAW Completion	March 2042	September 2031
HLW Completion	April 2043	May 2032
Total ILAW Production (# ILAW Packages)	63,200	64,100
Total IHLW Production (# IHLW Canisters)	12,600	12,700

FY = Fiscal year
HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
[1]Multi-Year Work Plan Update Guidance for FY 2000 (Erickson 1999b)
[2]Lockheed Martin Hanford Corporation Work Authorization for FY 2000 (ORP 1999)
[3]Mission Planning Guidance for FY 2002 (ORP 2000)
[4]Project Integration Office April 2000 Guidance (PIO 2000).

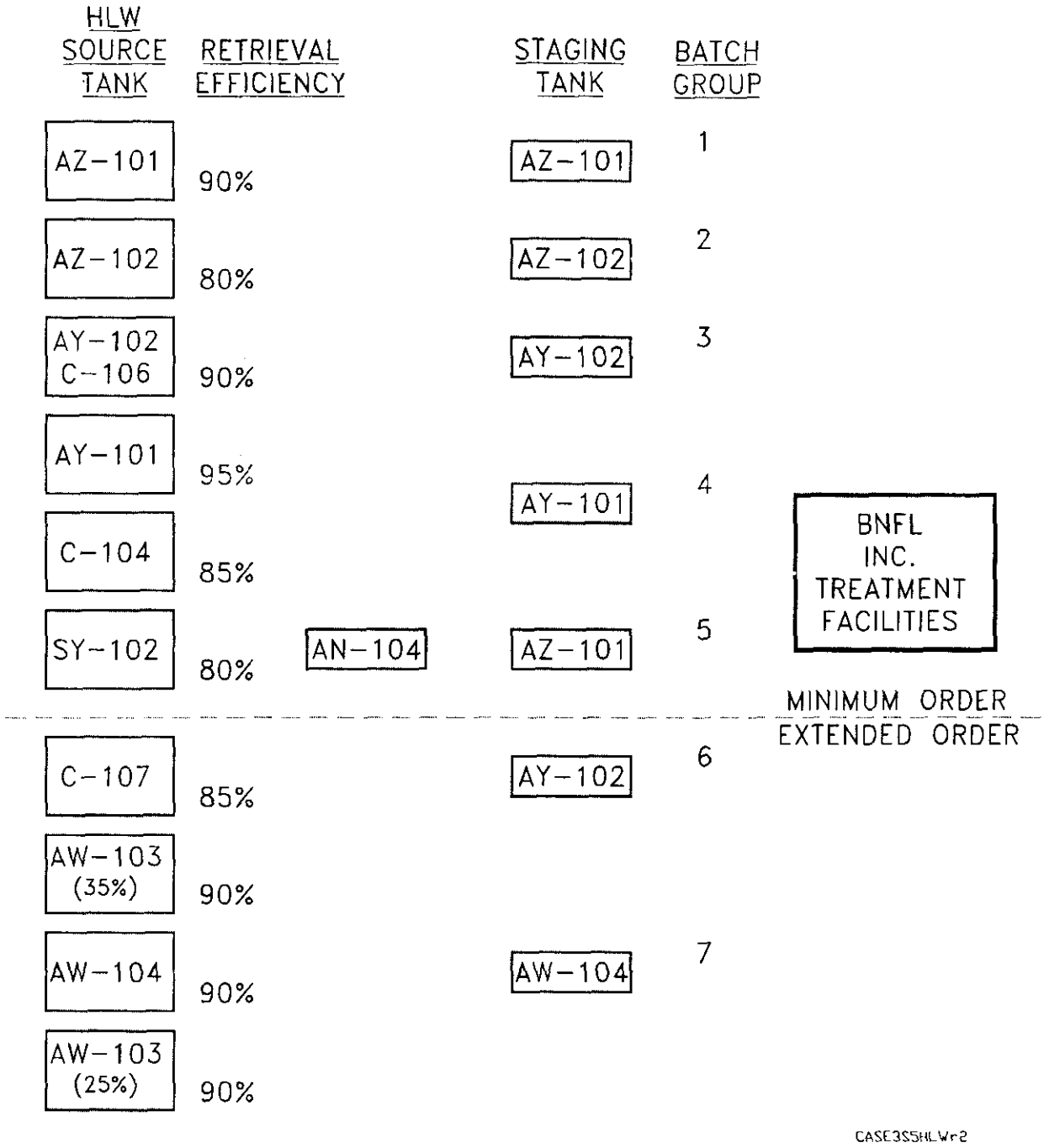
Figure 1.3-1. Low-Activity Waste Feed Staging Diagram.

ENVELOPE	SOURCE TANK				STAGING TANK	BATCH	
A	AP-101	SUPERNATE				1	
B		AZ-101, AZ-102 SUPERNATE			B WASTE	2	
C	AN-102	SUPERNATE SUPERNATE				3 4	
A	AN-104	DISSOLVED SOLIDS SUPERNATE			AN-101	5 6	
C	AN-107	SUPERNATE				7	
A	AN-105	SUPERNATE DISSOLVED SOLIDS			AN-102	8 9	
A	SY-101	SUPERNATE SUPERNATE	SY-102 SY-102		AP-104 AN-101	10 11	BNFL INC. TREATMENT FACILITIES
A	AN-103	SUPERNATE DISSOLVED SOLIDS			AN-102	12 13	
A	AW-101	SUPERNATE DISSOLVED SOLIDS			AN-105	14 15	
							MINIMUM ORDER
A	AW-104 (SWL)	SUPERNATE			AP-104	16	EXTENDED
A	SY-103	SUPERNATE			AN-101	17	
A	AP-106 (SWL)	SUPERNATE SUPERNATE			AN-102	18 19	
C'	S-102 (S-103, S-105)	SALTCAKE DISSOLUTION	SY-103	AN-104	AP-101	20	
C	S-105 (S-106, S-108)	SALTCAKE DISSOLUTION	SY-103	AN-104	AN-105	21	
A	AP-105 (SWL)	SUPERNATE SUPERNATE			AP-104	22 23	
A	AP-108	SUPERNATE				24	

'PO_4 IS OUT OF SPEC
SWL - SALTWELL LIQUOR
(S-103, S-105) - WASTE FROM TANKS S-103 & S-105 ARE INCLUDED
(S-106, S-108) - WASTE FROM TANKS S-106 & S-108 ARE INCLUDED

CASE3S6LAWr2

Figure 1.3-2. High-Level Waste Feed Staging - Case 3S6E.



HLW = High-level waste.

Phase 1 Progress

Completion of the minimum order quantity achieves about thirteen percent of the total mission on a volume basis, eleven percent of the total mission by mass of ILAW and five percent of the mission by mass of IHLW. Additional information is shown in Table 1.3-3.

Table 1.3-3. Phase 1 Processing Progress (3S6E).

		Minimum order contract quantities 6000 units LAW 600 canisters HLW	End of Phase 1 contract processing 02/28/18	Completion of Minimum and Extended Order tanks	Total mission[a] Phase 1 and 2
LAW	Mass of Waste[b] (dry basis, MT)	16,340	32,440	36,380	177,000
	Curies immobilized[c]	6.45E+05	9.28E+05	1.02E+06	5.44E+06
	Mass of ILAW (MT)	42,260	77,500	85,700	380,000
HLW	Mass of Waste[b] (dry basis, MT)	1,040	1,640	2,090	23,740
	Curies immobilized[c]	4.66E+07	5.92E+07	6.76E+07	2.23E+08
	Mass of IHLW (MT)	1,840	3,260	4,370	38,930
Total	In-situ volume[d] %	27,250 m^3 13.5%	48,450 m^3 24.2%	59,050 m^3 29.6%	199,850 m^3
	Curies[c] %	4.72E+07 20.7%	6.01E+07 26.4%	6.87E+07 30.1%	2.28E+08
	Number of DSTs	10	16	19	28
	Number of SSTs	2	5[e]	5	149

[a]Does not include Cs and Sr capsules processed in Phase 2 (1.78E+08 Ci, decayed to 1/1/1994).
[b]As delivered to private contractors.
[c]Radionuclides decayed to 1/1/1994.
[d]Hanlon volumes (September 30, 1999) for waste delivered minus fraction left behind (Hanlon 1999a).
[e]Does not include other SSTs retrieved to "backfill" DSTs and that contribute to Phase 1 feed as a result of blending during simultaneous retrievals.
[f]6000 units of LAW for Case 3S6E processed by 6/13/13.
[g]600 canisters of HLW for Case 3S6E processed by 4/21/14.

1.3.3 Compliance with Feed Delivery Guidance (3S6E)

Tables for LAW and HLW from the PIO Guidance are shown below (Tables 1.3-4 and 1.3-5) with the modeling results for units delivered at the delivery date.

Table 1.3-4. Low-Activity Waste.

PIO Guidance				Results	
Delivery sequence	Source tank	Expected envelope	Estimated delivered quantity (units)	Modeled units delivered	Modeled delivery date
1	AP-101	A	615	615	04/29/06
2	AZ-101	B	869	866	07/08/07
3	AZ-102	B	447	445	03/29/08
4	AN-102	C	1112	1112	04/10/08
5	AN-104	A	845	845	09/29/10
6	AN-107	C	808	808	07/08/11
7	AN-105	A	839	839	04/01/12
8[a]	SY-101	A	826	827	01/16/13
9	AN-103	A	1084	1084	10/08/13
10	AW-101	A	1070	1070	10/04/14

LAW = Low-activity Waste
PIO = Project Integration Office
[a]Minimum delivery order of 6000 units is reached during processing SY-101 waste. The subsequent tanks provide contingency waste feed.

Table 1.3-5. High-Level Waste.

PIO Guidance				Results	
Delivery sequence	Source tank[(a)]	Expected envelope	Estimated delivered quantity (canisters)[(b)]	Modeled delivery quantity (canisters)	Modeled delivery date
1	AZ-101	D	81	81	09/01/05
2	AZ-102	D	123	123	02/01/08
3	AY-102	D	191	191	10/01/10
4[(c)]	C-104 and AY-101	D	343	343	06/01/12
5	SY-102	D	226	227	04/01/15

HLW = High-level waste
PIO = Project Integration Office
[a] Sodium in supernates in AY-102, C-104/AY-101, and SY-102 is not included in the estimated quantity of low-activity waste (LAW).
[b] Includes impacts of strontium and manganese additions for pretreating Envelope C waste, use of the Pacific Northwest National Laboratory (PNNL) Glass Properties Model, and results of sludge washing testing for predicting waste loading in glass.
[c]The minimum delivery order of 600 canisters is reached during processing C-104/AY-101 waste. The subsequent tank provides contingency waste feed.

The contract specifications for HLW and LAW waste were originally based on known tank characterization data in the 1994 time frame. New characterization data and new feed source tanks make some batches out of specification. Adjustments to meet specifications prior to delivery through blending, dilution, or treatment are not practical due to cost and technical viability. The contract specification will eventually have to be adjusted to bracket the waste in the tanks.

Clause H43 in the contract requires a treatability determination by BNFL Inc. based on technical ability to process the waste, facility permits, and the facility safety authorization basis. Current waste inventories must be checked to determine if the processing features can accommodate them even though they may be out of specification in some cases.

Item 25 in the PIO Guidance (PIO 2000) states that "all LAW and HLW feed delivered by CHG will be accepted and processed by BNFL Inc. unless the waste does not meet permitting and/or authorization basis requirements for the BNFL Inc. facilities ORP will develop an approach for compensating BNFL Inc. for accepting nearly all off-specification waste. No more than one staged tank of LAW or HLW will be rejected by BNFL Inc. CHG will prepare for retaining a maximum of one rejected staged tank of LAW feed or one rejected staged tank of HLW feed within the DST system during the Minimum Order."

Details of the specification compliance issue for LAW and HLW are discussed in Sections 3.1.3 and 4.1.3 respectively. Batches are compared to the specifications on the basis of compositions projected to be present in the staging tank at the time of delivery. Key issues are summarized in Table 1.3-6 and in the text below.

Table 1.3-6. Specification Compliance (Minimum Order Tanks).

		Off-Specification	
Waste	Batch/Tank	Chemicals	Radionuclides
LAW-B	2A/AZ-101 Supernatant	N/A	TRU, ^{60}Co, ^{90}Sr
LAW-B	2B/AZ-102 Supernatant	SO_4	TRU, ^{154}Eu + ^{155}Eu
LAW-C	7/AN-107	N/A	TRU, ^{154}Eu + ^{155}Eu
HLW-D	4/AY-101 + C-104	N/A	^{233}U
HLW-D	6/C-107 + AW-103	V	N/A
HLW-D	7/AW-104 + AW-103	V	N/A

Envelope D feed is projected to be out of specification in batch groups 4, 6, and 7 each in a single component. Batch Group 4 has a concentration of ^{233}U seven times the limit. Batch Groups 6 and 7 may have elevated vanadium concentrations of 100 percent and 5 percent above the limit. The reported vanadium concentrations are based on "less than" values from sample analyses and, therefore, should be viewed as upper bounds.

The supernatants used to slurry each batch of HLW solids to BNFL Inc. are least apt to fit the current LAW envelope. The current delivery guidance and plan both include the AZ supernatants (LAW batch 2A and 2B). However, the remaining supernatants are assumed to be sent to BNFL Inc., not returned, not counted in feed delivery quantities, and not addressed by PIO (2000). The model run for Case 3S6E assumes these feeds are stored indefinitely by BNFL Inc.

In summary, the contract specification should be adjusted to bracket the Phase 1 wastes. If the BNFL Inc. treatability study excludes some feeds, the sequences should be adjusted.

1.4 PROGRAMMATIC SENSITIVITIES

The results from Case 3S6E show that CH2MHILL Hanford Group, Inc. (CHG) can support the privatization contract by delivering waste feed to BNFL Inc. in accordance with the direction provided by DOE-ORP (PIO 2000). CHG can meet the feed delivery requirements in the contract within the physical constraints of the existing DST system and within the planned upgrades to the DST system. The excess DST space available for SST retrieval during Phase 1 was identified and used to support a risk-based retrieval strategy. Case 3S6D, which differs from 3S6E by how BNFL Inc. handles LAW Envelope B feeds, provides the technical basis for the detailed RTP-2 planning effort. A comparison of these two cases is provided in Section 1.3.

The sensitivity of the mission outcome to changes in key technical assumptions was assessed by running the HTWOS model with revised assumptions and comparing the results from the sensitivity cases to the baseline results. Descriptions of cases analyzed for this sensitivity analysis are shown in Table 1.4-1 and Figure 1.4-1. The major findings from this sensitivity analysis are summarized below in Table 1.4-2. Additional details are discussed in Sections 1.4.1, 1.4.2, and 1.4.3, and in appropriate topical sections of this document. Results from Case 3S6E are provided in the discussions below as a reference for the comparisons.

Major attributes of the sensitivity analyses include start dates for BNFL Inc. pretreatment and vitrification services, delivery dates of first LAW and HLW feed batches, ramp-up rates for LAW and HLW treatment, and sodium oxide (Na_2O) loading in ILAW. Four major cases shown in Table 1.4-1 have two primary differences that distinguish the cases, including start dates and flowsheets. Cases 3S6E and 3S6C form conservative planning bases for waste feed delivery by assuming DOE-ORP flowsheet conditions that minimize the amount of ILAW and IHLW produced by BNFL Inc.

Table 1.4-1. Sensitivity Case Attributes.

	50% Trend - Case 3S6A	90% Current - Case 3S6B	50% Trend - Case 3S6C	90% Trend - Case 3S6E
	Integrated BNFL Inc.		WFD Planning[1]	
Initiate Pretreatment Hot Start	5/31/05	9/30/06	5/31/05	4/30/06
AP-101 Delivery[2]	5/31/05	9/30/06	5/31/05	4/30/06
Initiate LAW Hot Start	7/31/05	12/31/06	7/31/05	11/30/06
Initiate LAW Vit. Services	7/31/06	12/31/07	7/31/06	3/1/08
LAW Treatment Ramp Up[3]	From – To MT ILAW/day 7/31/05 – 7/31/06 4.28(30%) 7/31/06 – 7/31/07 8.57(60%) Through Min. Order 14.28[4](100%) Through Ext. Order 20.85(146%)	From – To MT ILAW/day 12/31/07 – 12/31/08 4.28(30%) 12/31/08 – 12/31/09 8.57(60%) Through Min. Order 14.28(100%) Through Ext. Order 20.85(146%)	From – To Units/Yr 7/31/05 – 7/31/06 226(30%) 7/31/06 – 7/31/07 452(60%) 7/31/07 – 7/31/08 754(100%) Through Ext. Order 1100(146%)	From – To Units/Yr 11/30/06 – 11/30/07 279(37%) 11/30/07 – 11/30/08 830(110%) 11/30/08 – 11/30/09 1011(134%) Through Ext. Order 1100(146%)
Na_2O Loading	$Na_2O \times SO_3 < i$; i=5(A,C); i=8(B)	$Na_2O \times SO_3 < i$; i=5(A,C); i=8(B)	A, B, C: 0.195, 0.075, 0.17	A, B, C: 0.195, 0.075, 0.17
Units/MT Na	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15
Product Return Starts When BNFL Lag Storage is X% full (ILAW/IHLW)	50%/50%	50%/50%	50%/50%	50%/50%
AZ-101 Delivery[2]	9/30/05	1/31/07	9/30/05	10/31/06
Initiate HLW Hot Start	1/31/06	2/28/08	1/31/06	5/31/07
Initiate HLW Vit. Services	3/31/07	3/31/08	3/31/07	9/1/08
HLW Treatment Ramp Up[5]	From – To # Canisters 3/31/07 – 3/30/08 20(20%) 3/31/08 – 3/30/09 102(100%) Through Min. Order 102[4](100%) Through Ext. Order 120(117%)	From – To # Canisters 3/31/08 – 3/30/09 20(20%) 3/31/09 – 3/30/10 102(100%) Through Min. Order 102(100%) Through Ext. Order 120(117%)	From – To # Canisters 3/31/07 – 3/30/08 20(20%) 3/31/08 – 3/30/09 102(100%) Through Ext. Order 120(117%)	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)
HLW WOL	Glass Properties Model Calc.	Glass Properties Model Calc.	Glass Properties Model Calc.	Glass Properties Model Calc.

HLW = High-level waste ILAW = Immobilized low-activity waste WOL = Waste oxide loading
IHLW = Immobilized high-level waste WFD = Waste Feed Delivery

[1]There are several differences between WFD Planning scenarios and the BNFL Inc. Integrated scenarios that provide a conservative basis for WFD: a) Higher ILAW Na_2O loading in BNFL Inc. Basis of Design than new BNFL Inc. experimental data supports (no sulfate removal in all cases), b) a 2X increase in the HLW ramp up rate and a 1.8X increase in the LAW ramp up rate for Case 3S6E compared to BNFL Inc. ramp up rates in the 3/8/00 PIO assumptions document, c) indefinite storage of LAW entrained solids, d) indefinite storage of HLW pretreatment wash solutions, e) higher maximum capacities during minimum order processing (1100 Units/Yr Vs 754 Units/Yr and 120 HLW canisters/Yr Vs 102 canisters), f) LAW vitrification rates do not include treatment of sodium in the liquid fraction of HLW slurry feed (except for Env. B feed) nor the sodium from HLW solids washing which is inconsistent with BNFL Inc. contract Specification 12.2.7, g) LAW vitrification rates also do not include the addition of sodium by BNFL Inc. during LAW pretreatment, and h) caustic leach factors for tanks C-104 and C-106 are different than experimental leach factors determined by BNFL Inc., which may result in less IHLW glass produced.

[2]Delivery dates shown are completion of the delivery with start of delivery two months prior to completion.

[3]LAW rates are given as units of waste processed during the period, as an annual rate for extended periods (754 or 1,100), or in parentheses as a percentage of BNFL's capacity.

[4]Nominal vitrification rates are based on 2.38 LAW containers/day at 6.0 MT ILAW/container and 0.28 IHLW canisters/day at 3.06 MT/canister.

[5]HLW rates are given as canisters of glass produced during the period, as an annual production rate (102 or 120) for extended periods, or in parentheses as a percentage of BNFL Inc.'s capacity.

Assumptions of minimum glass production per unit feed increases the apparent rate that tank waste must be fed to the treatment facilities. Cases 3S6A and 3S6B are labeled Integrated BNFL Inc. cases because they more closely represent integrated flowsheet cases by including some major side streams generated during processing in BNFL Inc. facilities. The major streams are (1) sodium from HLW feed that will be processed through the LAW melters, and (2) entrained solids separated from LAW feed that will be processed through the HLW melters. Other minor flowsheet related differences between WFD Planning cases and Integrated BNFL Inc. cases are shown in footnote 1 of Table 1.4-1. Cases 3S6A and 3S6C have earlier BNFL Inc. start dates than Cases 3S6B and 3S6E, respectively.

Figure 1.4-1 provides further refinement of sensitivity analysis definition. Case 3S6B R2 was analyzed to evaluate the impact of new proposed BNFL Inc. minimum Na_2O loadings in ILAW. Case 3S6B R3 evaluates the impact of sulfate concentration limitations on the quantity of ILAW produced and subsequent Phase 2 completion dates. Case 3S6E Specification 1 assumes the waste loading in IHLW follows the minimum requirement set forth in Specification 1 of BNFL Inc.'s contract (RL 1996). Case 3S6E R2.1 evaluates the ability to balance the HLW and LAW Phase 2 plant capacities so the completion times are closer. Case 3S6E R2.2 evaluates the processing capacity needed to complete the Phase 2 mission by 2028. Case 3S6E R2.3 evaluates the impact of increasing SST retrieval rates on SST blending (quantity of products) and Phase 2 retrieval completion dates. Case 3S6E R2.4 evaluates the use of tank specific leach factors on HLW during Phase 2.

1.4.1 Phase 1 Feed Staging

Vitrification of LAW feed delivered through the last tank in the minimum order sequence is completed by September 2015 producing a total of 9,830 immobilized low-activity waste (ILAW packages) for the planning case 3S6E (March 8 PIO Guidance Case). The effect of changes in key assumptions on the ILAW package count and the completion date for the minimum order tanks are given in Table 1.4-2.

Figure 1.4-1. Sensitivity Case Definition.

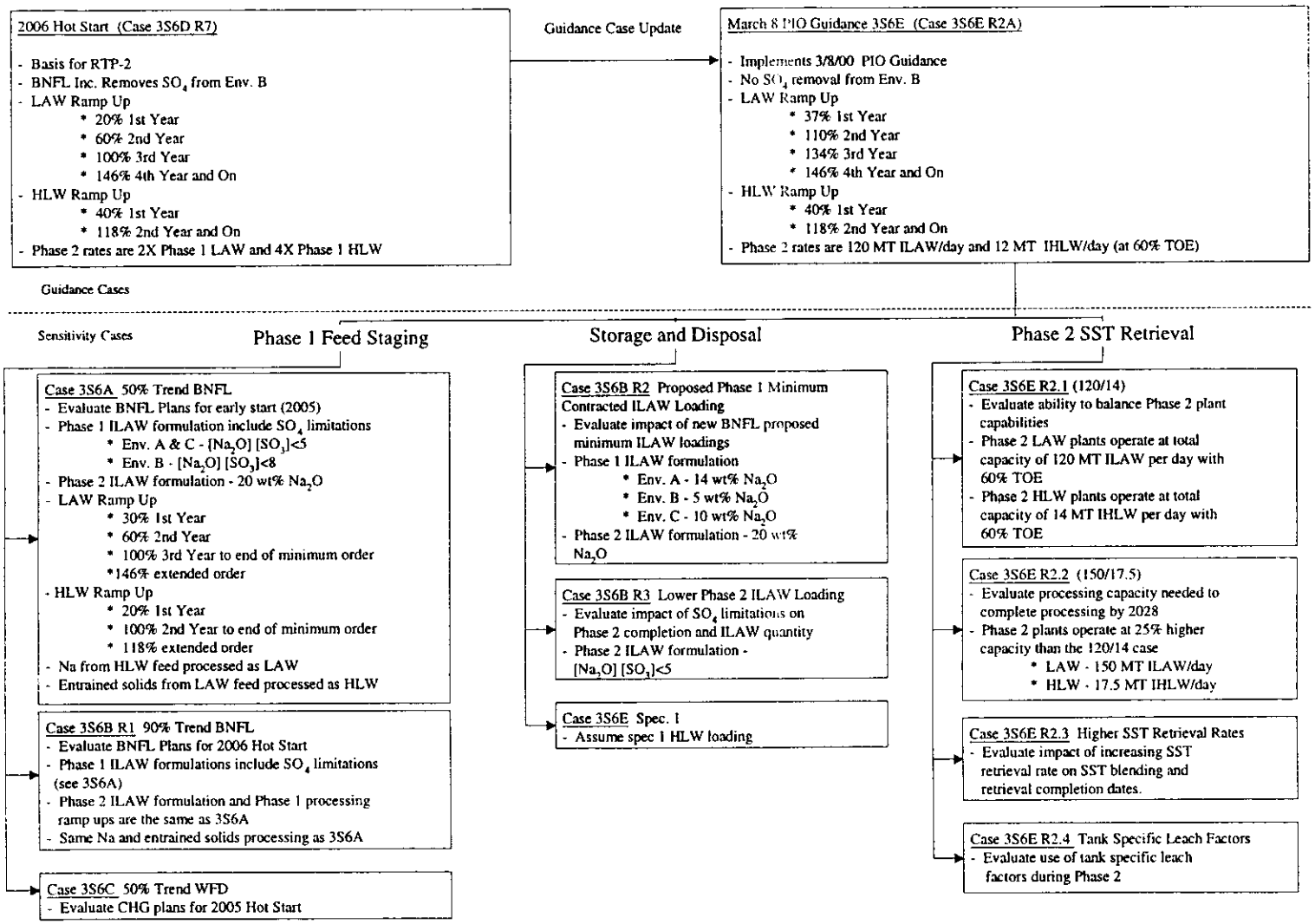


Table 1.4-2. Sensitivity Analysis Summary Results.

Case	Phase 1[1]		Total mission			
	# ILAW packages	# HLW canisters	# ILAW packages	# HLW canisters	Vitrification completion	
					LAW	HLW
Guidance Cases						
3S6E R2A	13,500	1,070	64,100	12,700	Sep. 2031	May 2032
3S6D R7	12,500	1,060	63,200	12,600	Mar. 2042	Apr. 2043
Phase 1 Feed Staging Cases						
3S6A	10,700	1,500	67,000	12,900	Oct. 2032	Jul. 2033
3S6B R1	7,900	990	66,800	12,500	May 2033	Feb. 2034
3S6C	14,400	1,420	64,100	12.500	Nov. 2031	Apr. 2032
Storage and Disposal						
3S6B R2	11,000	990	73,500	12,600	Apr. 2034	Dec. 2034
3S6B R3	7,900	990	99,000	12,400	Jun. 2039	Dec. 2039
3S6E Spec1	13,500	1,070	64,100	17,500	Mar. 2036	Jun. 2037
Phase 2 SST Retrieval						
3S6E R2.1	13,500	1,070	64,300	12,700	May 2030	Nov. 2030
3S6E R2.2	13,500	1,070	64,600	12,800	May. 2028	Aug. 2028
3S6E R2.3	13,500	1,070	64,000	13,400	Oct. 2032	Jun. 2033
3S6E R2.4	13,500	1,070	64,400	24,700	Dec. 2043	Nov. 2045
	Shaded cells indicate major differences from Case 3S6E R2A.					

HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
[1]Quantities of ILAW and IHLW produced by the end of the BNFL Inc. contract period, February 28, 2018.

Table 1.4-3. Low-Activity Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the results of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 9,830 ILAW canister by September 2015 from minimum order feed tanks.
Case 3S6D R7 Sulfate removal	This is the 2006 "hot" start case and CHG delivery system could support BNFL LAW process. Case 3S6D represents a scenario with sulfate removal capacity, therefore, increasing sodium oxide loading (0.195, 0.195, and 0.17 for Envelopes A, B, and C, respectively) thus creating less glass. The ramp-up rate is about 1.8 times slower than Case 3S6E.	Decrease the number of ILAW packages by 1,049 assuming feed from minimum order tanks. A negligible change in the completion date because the slower ramp-up rate is offset by the decrease in the amount of ILAW produced.
Case 3S6C 50% Trend WFD Early start	This case evaluates the CHG plans for 2005 hot start. This case starts LAW delivery 11 months earlier than Case 3S6E.	No changes in number of ILAW packages and accelerate completion of LAW minimum order feed tanks by 11 months
Case 3S6B R1 Wash Na from HLW Processing	Additional LAW feed is generated from liquids in HLW feed and HLW sludge washing.	Increases number of ILAW packages by 915 and delays completion by nine months relative to the LAW feed from minimum order tanks.

CHG = CH2MHILL Hanford Group, Inc.
HLW = High-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste.

Vitrification of HLW feed delivered through the last tank in the minimum order sequence (241-SY-102 in Figure 1.3-2), is completed by May 2017 producing a total of 960 IHLW canisters for the planning case 3S6E (March 8 PIO Guidance case). The effect of changes to key assumptions on the IHLW canister count and completion dates for the minimum order feed tanks are given in Table 1.4-3. The following sensitivities are compared to the planning case 3S6E.

Table 1.4-4. High-Level Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the result of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 960 IHLW canisters by May 2017 assuming feed from minimum order tank.
Case 3S6E R2A Blending Option for 241-SY-102	The option of blending 40 percent of 241-AW-103 sludge (currently not planned for vitrification during Phase 1) with 241-SY-102 sludge is expected to increase the waste oxide loading in the blended waste. Blending may decrease the total number of IHLW canisters produced from these tanks by 200 at a life-cycle cost reduction of $2 to 3 million per canister.	Phase 1 tanks would increase feed for IHLW by 120 canisters and the corresponding contingency processing duration of 12 months. Overall mission reduction of 200 canisters and accelerate completion by 20 months.
Case 3S6E R2A Blending of manganese and strontium precipitates	If manganese and strontium precipitates produced from the pretreatment of Envelope C LAW waste are not blended with HLW feed (disposed as separate waste form or vitrified separately), then the amount of HLW glass BNFL Inc. produces could decrease. The planning case assumes blending of the precipitates with HLW feed.	Decrease IHLW by 60 canisters and accelerate completion by six months if disposed of as separate waste form. Insufficient information is available to authors at this time to quantify IHLW produced by separate vitrification.
Case 3S6B R1 Entrained solids	BNFL Inc. treatment of LAW entrained solids with HLW feed would have a minor impact on the amount of IHLW glass produced.	Increase IHLW by 10 canisters and delay completion of minimum order tanks by one month.
Case 3S6B R1 Slower ramp-up	Decreasing the HLW processing ramp-up rate to match the BNFL Inc. plan for ramp-up rate would defer IHLW production and delivery of later HLW feed tanks.	No change to IHLW quantity and delay completion of minimum order tanks by nine months.
Case 3S6C Early start	The effect of starting HLW vitrification 17 months earlier than Case 3S6E is expected to be negligible since this schedule was supported during fiscal year 1999.	No change to IHLW quantity and accelerate completion of minimum order tanks by 17 months.

HLW = High-level waste
IHLW = Immobilized high-level waste
LAW = Low-activity waste.

1.4.2 Phase 2 Single-Shell Tank Retrieval

Phase 2 SST retrieval is projected from the model to complete in June 2028 and processing to complete in February 2032. A total of 64,100 ILAW packages and 12,700 IHLW canisters are produced at the end of the mission from processing all of the wastes in the DSTs and SSTs. The effect of changes in key assumptions on SST retrieval completion dates, immobilized product quantities, and mission completion dates are given in Table 1.4-5.

Table 1.4-5. Phase 2 Single-Shell Tank Retrieval Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2.1 Increase HLW processing capacity from 12 to 14 MT IHLW per day	Phase 2 HLW processing capacity effects LAW melter operating efficiency and completion dates.	LAW melter efficiency increased 12 percent to 96 percent of desired capacity. SST retrieval completes 13 months earlier. Phase 2 mission completes 17 months earlier.
Case 3S6E R2.2 Increase LAW processing capacity to 150 MT per day and HLW processing capacity to 17.5 MT per day (from 120 MT/day and 12 MT/day respectively.	Phase 2 processing capacities effect completion dates for SST retrieval and waste processing.	SST retrieval completes 23 months earlier. Waste processing completes 42 months earlier.
Case 3S6E R2.3 Increase SST retrieval rates.	SST retrieval rates effect SST waste blending and SST retrieval completion dates.	Processing and SST waste retrieval do not complete earlier when SST retrieval rates are increased. Processing rates used in the planning case (3S6E R2A) are the primary constraints for determining completion dates.
Case 3S6E R2.4 Use tank-specific leach factors instead of global leach factors in Phase 2 HLW sludge pretreatment.	Leach factor data effect quantity of IHLW produced and processing completion dates due to differences in chromium removal efficiencies.	SST waste retrieval completes 12 years later. HLW and LAW processing complete 14 and 12 years later, respectively. The amount of IHLW for the entire mission doubled with only a negligible increase in ILAW.

HLW = High-level waste
IHLW = Immobilize high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
SST = Single-shell tank.

1.4.3 Storage and Disposal

The effect of changes in key assumptions on quantities of immobilized product produced and the schedule for receipt are given in Table 1.4-6.

Table 1.4-6. Storage and Disposal Sensitivities. (2 Sheets)

Description	Sensitivity	Ramification
Case 3S6E R2A March 8,2000 PIO Guidance	Implements March 8, 2000 PIO Guidance (planning case).	- The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate imbalance between the HLW and LAW vitrification plants. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6E R2A Spec. 1 The waste oxide loading of HLW glass is less than that projected by the Glass Properties Model	The waste oxide loading of HLW glass only meets the minimum limits specified by Specification 1 of the contract.	- The number of IHLW canisters is significantly increased due to the low waste loading in Specification 1 of the contract. - The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate imbalance between the HLW and LAW vitrification plants. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6E R2.1 Increased Phase 2 HLW vitrification rates from 12 to 14 MT/day.	The design rates of the LAW and HLW vitrification plants are set at 120 MT/d glass and 14 MT/d glass respectively.	- Few of the ILAW vitrification production outages apparent in Phase 2 Case 3S6E remain, indicating that the 120/14 ratio is near optimum - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6B R1 BNFL Inc. proposed schedule, ramp-up rates and flowsheet.	This scenario imposes the condition specified in Case 3S6B	- BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to assumed initial shipping date of September 2009. - Significantly fewer ILAW packages are made in Phase 1 relative to Case 3S6E. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 11/10/2008 and 4/14/2009 respectively.

Table 1.4-6. Storage and Disposal Sensitivities. (2 Sheets)

Description	Sensitivity	Ramification
Case 3S6B R3 Sulfate impacts to LAW glass are imposed on Phase 2.	The Phase 2 LAW glass is limited by the following condition [wt% Na_2O][wt% SO_3} ≤ 5.	- BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to the assumed initial shipping date September 2009. - The number of ILAW packages made in Phase 2 increases significantly. - The Phase 2 LAW vitrification facility is significantly underutilized. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 11/10/2008 and 4/14/2009 respectively.
Case 3S6B R2 The waste oxide loading of LAW glass is less than that stated in the BNFL Inc. flowsheet.	During Phase 1 the waste oxide loading of LAW glass only meets the minimum contract limits proposed by BNFL Inc. The Phase 2 waste oxide loading is 20 wt% Na_2O.	- A significant increase in the Phase 1 LAW vitrification rate is needed to meet the minimum contract order. - The number of ILAW packages made is increased significantly. - BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to the assumed initial shipping date of September 2009. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2008 and 4/14/2009 respectively.
Case 3S6A 50% Trend BNFL Planning Assumptions.	Evaluates BNFL plans for a 2005 hot start	- BNFL Inc. will fill the ILAW and IHLW in-plant storage space in December 2006 and June 2008 respectively. These dates are 12 and 15 months prior to the assumed initial shipping dates of December 2007 and September 2009. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 6/11/2006 and 4/13/2008 respectively.

HLW = High-level waste
IHLW = Immobilized low-activity waste
ILAW = Immobilized high-level waste
LAW = Low-activity waste.

1.5 KEY FINDINGS

A summary of findings from each major section of the document are listed below. The purpose is to highlight the findings of the work that identify: (1) noteworthy accomplishments, (2) the need for further integration or engineering work, and (3) new issues for possible addition to the program's issues management process and critical risk list.

1.5.1 General

- Late Changes in RTP-2 Guidance – The TFC O&UP plan is based on guidance received in on March 8 (PIO 2000). There were no significant ramifications in the late guidance relative to the program planning baseline. Feed delivery dates did not change. (See discussion in Section 1.3.1.)

- Contingency in Feed Delivery – A number of guidance features (PIO 2000) and assumptions ensure that project upgrades are in place in advance of feed delivery actions. These are visible on the mission summary diagram schedule (Figure 3.2-1) and discussed in the notes on Table 1.4-1. In addition, the staging strategy has been modified so that feeds are available from multiple sources in the event a failure occurs in a tank or a farm. This contingency provides good assurance that feed delivery will not result in an idle facility penalty for shutting down a processing facility.

- Flowsheet Variables – The quantity of glass produced (and the processing schedule) are influenced by uncertainties in waste inventory characterization, retrieval efficiencies, blending strategies, HLW solids wash/leach factors, and key glass loading concentrations. Sensitivity cases have been run to bracket these variables such that where uncertainties exist, the impacts are understood (i.e., cases with and without sulfate removal have different, but predictable, glass volumes). Glass quantities and schedules are generally reliable for Phase 1. (See summary discussion in Section 1.4.)

1.5.2 Low-Activity Waste Waste Feed Staging

- Meeting LAW Feed Specifications - The current tank sequence may not comply with the contract specifications for every tank. These issues appear to be manageable and can probably be resolved by expanding the specification limits to fit the waste feeds after the processing impacts are reviewed. (See summary in Section 1.3.4 and discussion in Section 3.1.3)

- Watch List Tanks – Six of the eleven Envelope A feeds are on the watch list for flammable gas concerns. Transfer of waste from these tanks requires written approval by Nuclear Safety and DOE. On the other hand, transfer of waste *into* a watch-list tank requires written approval by the Secretary of Energy. These actions are part of the planned baseline for RTP2, but success is not solely under the control of the Tank Farm Contractor. (See discussion in Section 3.2.1).

- HLW Supernates - The supernatants used to slurry each batch of HLW solids to BNFL Inc. are least apt to fit the current LAW envelope. The current delivery guidance and plan both include the AZ supernatants (LAW batch 2A and 2B). However, the remaining supernatants are assumed to be sent to BNFL Inc., not returned, not counted in feed delivery quantities, and not addressed by PIO (2000). The model run for Case 3S6E assumes these feeds are stored by BNFL Inc. during Phase 1 and processed during Phase 2.

1.5.3 High-Level Waste Feed Staging

- Meeting HLW Feed Specifications - The current tank sequence may not comply with the contract specifications for every tank. These issues appear to be manageable and can probably be resolved by expanding the specification limits to fit the waste feeds after the processing impacts are reviewed by BNFL Inc. (See summary in Section 1.3.4 and discussion in Section 4.1.3.)

1.5.4 Phase 2 Feed Staging

- Risk Based Retrieval Sequence – SST retrieval is prioritized in 10 categories to retrieve tanks that: (1) have the greatest environmental hazard (high ^{99}Tc), and (2) least complicated to retrieve (leaking tanks last). The sequence is optimized to keep LAW and HLW feed balanced to avoid processing shutdowns and to enhance incidental blending that occurs during retrieval. (See discussion in Section 5.2.)

- Number of Simultaneous Retrievals – Case 3S6E is based on a Phase 2 processing rate that enables completion of the mission by 2032. The modeling assumes seven simultaneous retrieval machines are available for operation (RTP-1 assumed a maximum of 5). This assumption is used for all cases. Retrieval does not constrain processing in any case. The risk based retrieval sequence does add simultaneous retrievals per farm and per quadrant. (See discussion in Section 5.1.1.)

1.5.5 Product Receipt Storage and Disposal

- Product Return Dates – The PIO guidance (PIO 2000) for both HLW and LAW product returns are premised on start dates, rates, and 50 percent filling of the BNFL, Inc. storage capacity. This information was a basis to model a return date. The program planning baseline for RPT-2 is based on prior guidance (Cusack 2000). TFC storage and disposal facilities are available to support product returns under the program planning baseline, but BNFL Inc. interim storage facilities are projected to be over 50 percent full. (See discussion in Section 6.0.)

- 90 Day Storage – RCRA requires a maximum 90 day storage on IHLW canisters and ILAW packages unless BNFL, Inc. delists the waste or obtains permits for dangerous waste storage. The current scenarios exceed 90 days for the start of product returns.

BNFL Inc. does expect to be successful in delisting the waste or gaining a permit for dangerous waste storage. (See discussion in Section 6.0.)

1.5.6 Double-Shell Tank Space Management

- DST Design Life – The PIO guidance assumes a DST's will reach the end of their design life and fail at a rate of one for each five years past the design life in Phase 2. This assumption has no impact on completion of processing for Case 3S6E. DST space does not constrain the feed delivery system once the initial batches are transferred. Impacts of specific failures on feed delivery are manageable. (See discussion in Section 7.5.)

- Product Returns – Case 3S6E assumes (per PIO 2000) no return streams from BNFL, Inc. and existing spare space in the DSTs provides adequate space to pump waste from BNFL Inc.'s facilities should an emergency arise. This guidance relieves peak tank space concerns just prior to initial feed delivery and must be preserved. The routings and provisions to make transfers back to the tank farms are still intact.

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2.0 AN OVERVIEW OF HANFORD TANK WASTE OPERATION SIMULATOR

This section has been included to provide a generic overview of how information is used by the HTWOS model to obtain results and prepare the TFC O&UP.

2.1 ASSEMBLING CONSTRAINTS, REQUIREMENTS, AND ASSUMPTIONS

Changes to the baseline drivers are identified by reviewing key documents against past assumptions. Examples of the documents or information that are reviewed include the following:

- DOE-ORP planning guidance
- Project schedules
- Operations plans and schedules
- Characterization data (best-basis inventory [BBI])
- BNFL Inc. process data
- *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1996) Milestone Schedules.

Changes to requirements are identified by the authors of this document and incorporated into the HTWOS model and Appendix A. Management and technical personnel are consulted when necessary to obtain clarification or to resolve conflicts. Appropriate technical and management review of the changes is obtained to confirm the accuracy of the changes. Any outstanding issues that are identified are communicated to management for resolution. The final requirements and assumptions are used to define the constraints in the HTWOS model and the scenarios simulated using the model.

2.2 INVENTORY BASIS (USE OF UPDATED BEST-BASIS INVENTORY, HISTORY UPDATING)

The HTWOS inventory for both the SST and DSTs was updated on January 25, 2000. This inventory estimate represents waste in the tanks as of October 1, 1999. The updated inventory is being used in the modeling of the 3S6 cases. Sections 2.2 and 2.3 explain how the HTWOS model calculated the DST inventory using the BBI data. Step numbers corresponding to those in Figure 2.2-1 will be shown in the descriptive text below, in brackets: **<example>**

The data for the HTWOS inventory used in the modeling of case 3S6E were gathered from the BBI summary and calculation detail reports as of January 11, 2000. The BBI data included waste transfer updates through October 1, 1999, for 175 of the 177 tanks. The two exceptions, 241-C-106 and 241-AY-102, included transfers only through July 31, 1999. A

number of sources supplied data to the BBI. The first sources supplied sample data, **<i>**, gathered from tank samples. The second supplied process knowledge about what was put into or taken from the tank at different times **<ii>**. Process knowledge includes recent tank transfers, flowsheet estimates, and data for similar wastes in other tanks. The third supplied Hanford Defined Waste (HDW) model data, **<iii>**, which were based on historical waste transfers. Engineering evaluations determined which data source was most appropriate to use for calculation of the tank inventory. In general, sample data were the preferred source.

The Best-Basis Inventory Maintenance (BBIM) tool, a database, **<iv>**, compiled and documented the data from the sources mentioned above and calculated inventories for each analyte. These inventories were reported in the BBI. For the DSTs, the data were split by the BBIM as supernatant/drainable liquid and sludge/slurry/solids/saltcake. A few radionuclides and analytes were reported only as tank totals for the DSTs. In these cases, tank- and analyte-specific solubility factors, if available, were applied to the data to partition the analytes into soluble and insoluble fractions **<v>**. When solubility factors were unavailable, a general solubility rule was applied. This general rule was that ^{3}H, ^{14}C, ^{79}Se, ^{99}Tc, ^{129}I, ^{134}Cs, ^{137}Cs, ^{137m}Ba, Cl, CO_3, F, K, Na, NO_2, NO_3, PO_4, SO_4, and TOC are all completely soluble. Everything else was considered completely insoluble.

The U-Total value reported by the BBI included isotopic uranium in the inventory. For the HTWOS inventory, isotopic uranium was subtracted from the BBI U-Total value, leaving the remainder to be called UTOTAL. If the HTWOS UTOTAL calculation resulted in a value less than 0 kg, the inventory was set to zero. Free hydroxide values were reported in the BBI as charge balance calculations as opposed to sample values. This information was not useful to the HTWOS inventory. Free hydroxide values, based on sample data, were found in the BBIM for some tanks. When no sample data were available for the free hydroxide, a generic rule was assigned to calculate the free and bound hydroxide. For the supernatant (soluble) layer, this rule was (Free OH) = 0.9*(OH TOTAL). For the sludge (insoluble) layer, the rule was (Free OH) = 0.1*(OH TOTAL). Bound hydroxide was then calculated by subtracting the free hydroxide from the OH TOTAL reported by the BBI. The BBIM and partitioned information were copied directly into the DST inventory used by HTWOS, with the liquids being referred to as soluble and solids as insoluble layers **<vi>**.

For the SSTs, the HTWOS inventory data were also imported from the BBI. The SST BBI is being updated to include liquid and solid fractions. However, this effort has been completed only for a nominal number of tanks. When liquid/solid data were available, they were incorporated into the HTWOS SST inventory as such. Five of the SSTs to be saltwell pumped did not have liquid/solid phase information available through the BBI as of October 1, 1999. This issue was resolved by applying a combination of Environmental Simulation Program (ESP[1]) results, HDW model data, and analytical calculations to the BBI data for these tanks. The remainder of the SSTs were reported in the HTWOS inventory as having the analytes in the solid phase.

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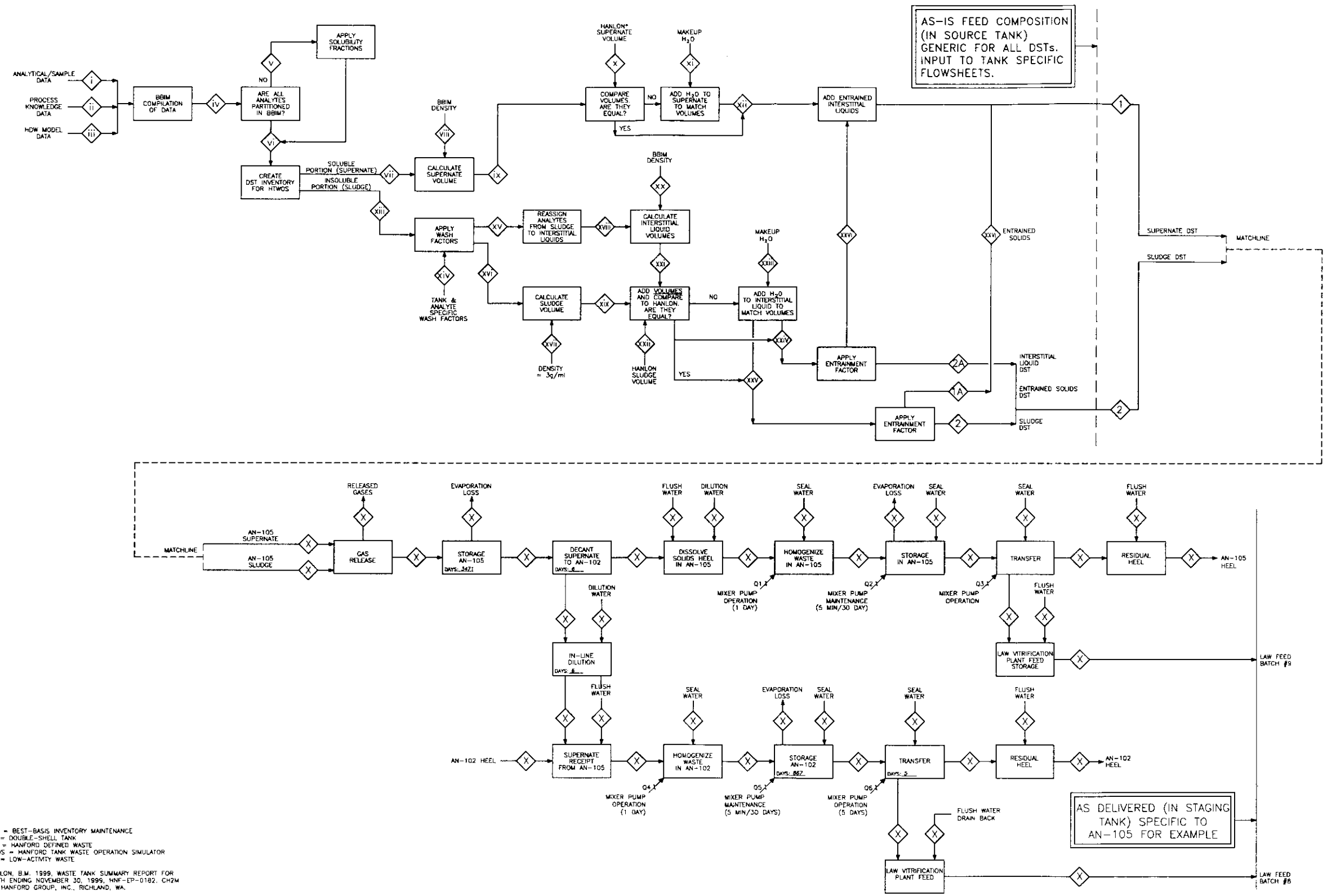
[1]ESP is a trademark of OLI Systems, Inc.

Figure 2.2-1. Hanford Tank Waste Operation Simulator Calculation Flowsheet for Generic Double-Shell Tank.



BBIM = BEST-BASIS INVENTORY MAINTENANCE
DST = DOUBLE-SHELL TANK
HDW = HANFORD DEFINED WASTE
HTWOS = HANFORD TANK WASTE OPERATION SIMULATOR
LAW = LOW-ACTIVITY WASTE

*HANLON, B.M. 1999. WASTE TANK SUMMARY REPORT FOR MONTH ENDING NOVEMBER 30, 1999. HNF-EP-0182. CH2M HILL HANFORD GROUP, INC., RICHLAND, WA.

The inventory and solid and liquid fractions for the cyanide ion (derived from the ferrocyanide ion) and ammonia were provided by the HDW model using the HDW model's Tank Layer Model (TLM) and Supernatant Mixing Model (SMM) calculation methods. The SMM included saltcake as well as liquid. The SMM values were considered to be soluble; the TLM values were considered insoluble.

2.3 LIQUID SOLID DISTRIBUTION

Once the DST data are imported into HTWOS, **<vi>**, the model takes the soluble portion of the inventory, **<vii>**, uses the BBIM density given for the supernate, **<viii>**, and calculates a supernate volume, **<ix>**. The model also imports the Hanlon (1999b) supernatant volume for the tank, **<x>**, which is then compared to the calculated volume. If these volumes are not the same, makeup water is adjusted, **<xi>**, in the supernate layer to make them equal, resulting in stream **<xii>**. If they are the same, no action is taken. To the sludge layer, **<xii>**, the model applies what is known as a wash factor, **<xiv>**. The wash factors are tank and analyte specific and were derived by Hendrickson (1998) from compilations of available analytical data and ESP[1] predictions. This factor reassigns a portion, **<xv>**, of the sludge layer into an interstitial liquid layer, **<xviii>**, associated with the sludge. This interstitial liquid layer does not mix with the supernate layer until retrieval. The composition of the interstitial liquid layer is not necessarily the same as that of the supernatant layer in the tank. The wash factor assumes that all dissolvable material originally in the sludge layer gets assigned to the interstitial liquids. During retrieval and dilution, no more material will be dissolved by the model.

At this point, the model takes the sludge layer, **<xvi>**, and calculates a sludge volume, **<xix>**, using the assumed density of 3 g/mL, **<xvii>**. A BBIM density, **<xx>**, is used to calculate a volume for the interstitial liquid layer, **<xxi>**. These two values are added and compared to the Hanlon sludge volume, **<xxii>**. If the volumes are not equal, makeup water, **<xxiii>**, is adjusted in the interstitial liquid layer, resulting in the interstitial liquid stream **<xxiv>**. Otherwise, no action is taken. The inventory for the sludge layer, **<xxv>**, does not change, regardless of whether the volumes are equal. The model then applies an entrainment factor to both the interstitial liquids and the sludge. This entrainment is applied to the sludge until solids constitute ½ weight percent of the supernate. Entrained interstitial liquids, **<xxvi>**, are added to the tank supernate. This addition results in the as-is tank supernatant stream, **<1>**, as recognized by HTWOS. The entrained solids, **<1A>**, sludge, **<2>**, and interstitial liquids, **<2A>**, are also now the as-is feed compositions for the DST. These four streams comprise the initial conditions used by the tank-specific flowsheets (see Sections 3.3 and 4.3) and HTWOS to calculate the as-delivered inventories.

When the SST inventory is imported by HTWOS, it brings along tank- and analyte-specific wash factors, as well as a required volume of water to be added for retrieval. At the time of retrieval, the additional water is added to the tank. The quantity of water added is just enough to result in a mixture that is less than or equal to 5*M* sodium and 10 wt% solids concentration.

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[1]ESP is a trademark of OLI Systems, Inc.

The wash factors are applied in a similar manner to those for the DSTs, in which they assign a portion of the solids layer into the retrieval water.

The wash factors reported by Hendrickson may not adequately represent the physical occurrences in the tanks during retrieval. Basic chemistry predicts that the salt layers, included in the insoluble portion of the initial DST splits, will dissolve after supernates are retrieved and fresh diluent is added. Therefore, wash factors being re-defined for Phase 1 tanks use the DST and SST inventories, the thermodynamic package ESP,[1] and available process test data as part of the tank-specific flowsheet effort. Once completed, there should be at least two sets of wash factors that can be considered as-is factors to report the actual tank conditions for most sludge-bearing Phase 1 tanks. One set would determine the amount of analytes in the interstitial liquid layer. The second would specify the fraction of solids that would dissolve on dilution by water or caustic addition.

The process steps documented in the tank-specific flowsheets will coincide with those performed by the HTWOS model. As tank-specific flowsheets are developed, various data inputs are used, including the HTWOS initial inventories and HTWOS projected inventories for tank retrievals happening in the far future. Tank-specific flowsheet effort results may need to be fed back to HTWOS, with the data being worked iteratively between the two models (HTWOS and ESP) until the as-delivered feed compositions to BNFL Inc. are reconciled. New ESP wash factors should better predict the amount of solids able to be dissolved for retrieval and will replace the wash factors now used in HTWOS. Laboratory process tests also may offer some improved wash factors for certain tanks.

2.4 INTEGRATION WITH OPERATIONS/OPERATIONS WASTE VOLUME PROJECTION

Retrieval Engineering maintains an interface with Process Engineering as the main source for near-term operational plans and for long-term waste generation plans. Data from the most recent Operational Waste Volume Projection (OWVP) document are used as input. Retrieval Engineering personnel work with Process Engineering personnel to identify changes in the plans or data, and Process Engineering personnel are involved in reviews of bases and assumptions, staging plans, use of DSTs, etc., before scenarios are simulated with the HTWOS model. Data are shared electronically between the two organizations to facilitate the information exchange and minimize errors. Process Engineering personnel also are involved in reviews of the results from the model and as contributors to the final document. The same modeling activity and use definition now support both the TFC O&UP and the OWVP.

2.5 RATIONALE FOR SOURCE TANK SELECTION

DOE-ORP provided the guidance for the selection of specific source tanks and the delivery sequence (PIO 2000). Their direction is based on past work that has tried to identify. Several generic rationales for source tank selection are applicable in addition to those specific to

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[1]ESP is a trademark of OLI Systems, Inc.

LAW and HLW feed delivery. Waste that is easy to retrieve, easy for BNFL Inc. to process, resolves storage safety issue by its retrieval, decreases storage risk by its retrieval because of its high radionuclide content, and frees up DST space by its retrieval. Furthermore, retrieving waste tanks in the same tank farm would simplify design and construction activities associated with Projects W-211 and W-521.

Three LAW feed envelopes, A, B, and C, and one HLW envelope, D, are established by the privatization contract (RL 1996). Each envelope provides a different technical challenge for BNFL Inc. Each DST was examined for chemical and radionuclide composition to determine the envelope classification of waste. Six tanks (241-AP-101, 241-AW-101, 241-SY-101, and 241-AN-103, -104 and -105) contain Envelope A feed; two tanks (241-AN-102 and –107) contain Envelope C feed; and two tanks (241-AZ-101 and 241-AZ-102) contain Envelope B feed to meet minimum order quantities during Phase 1. Tanks with high quality projections, including waste that is static, are delivered earlier in the sequence. Tanks with a large amount of sodium that can be easily retrieved were selected to be first. The source tanks that contained significant quantities of insoluble solids that can cause difficulty in retrieving the waste were neglected.

Six tanks (241-AZ-101, 241-AZ-102, 241-AY-102, 241-AY-101, 241-C-104 and 241-SY-102) contain Envelope D feed to meet minimum order quantities during Phase 1. Tanks that contain waste with high concentrations of radionuclides and that contain waste that is static are delivered earlier in the sequence (241-AZ-101, 241-AZ-102, 241-AY-102, and 241-AY-101). Tanks with a large amount of sludge that can be easily retrieved were selected for early delivery (241-AY-102 and 241-C-104). Tanks that have strategic operations functions as a result of waste compatibility issues are delivered in the minimum order quantity (241-SY-102). Potential source tanks that contain significant quantities of soluble solids that provide very little insoluble feed were neglected as an HLW feed source.

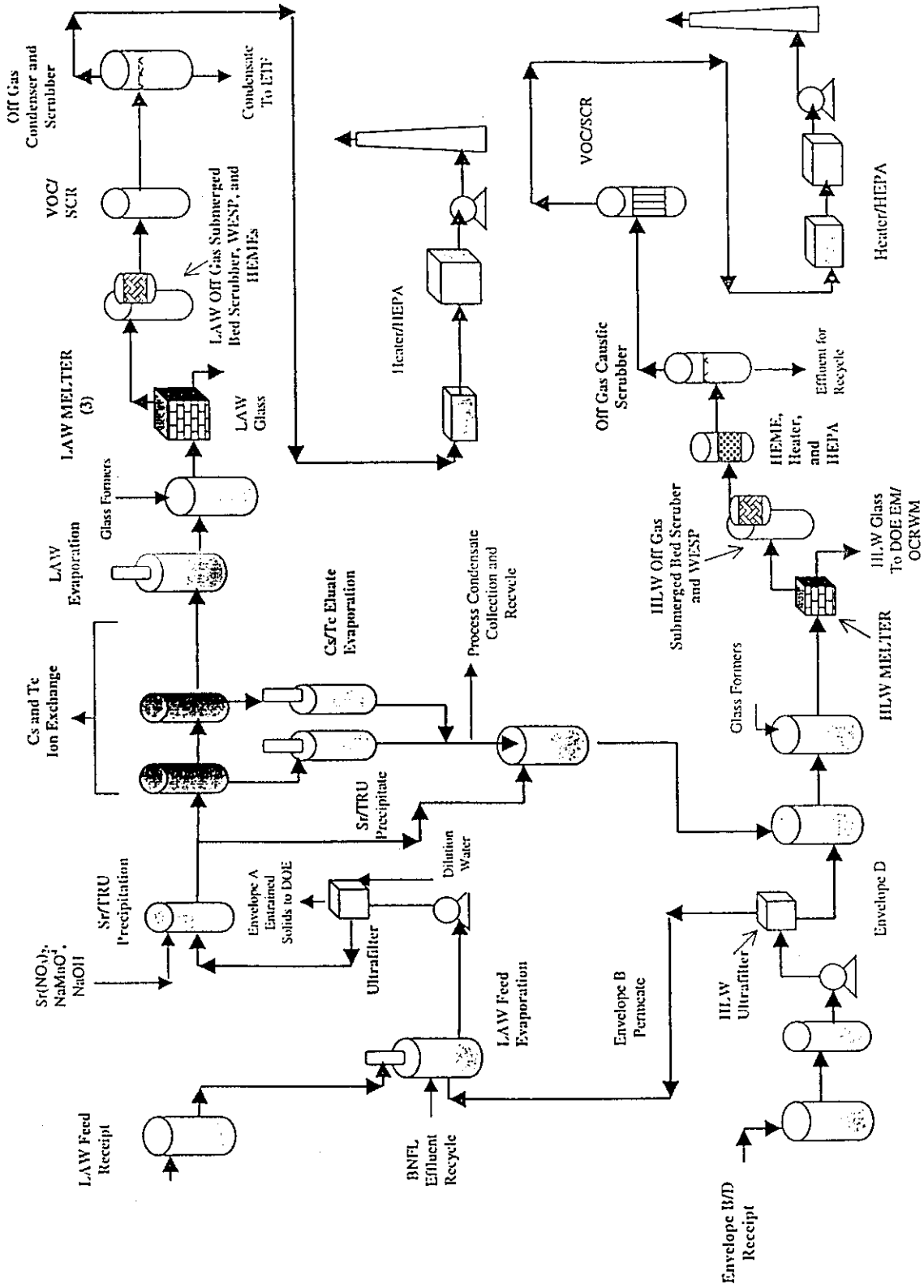
2.6 STAGING TANK SELECTION LOW-ACTIVITY WASTE

The staging approach for Case 3S6E is to provide reliable LAW feed delivery to BNFL Inc. while meeting privatization contract requirements. The number and location of staging tanks improves the reliability of LAW feed delivery by providing backup staged feed capability from independent tanks farms. Feed staging capability is provided from AN and AP tank farms to minimize the probability of a single-point failure in the delivery system resulting in loss of feed capability. Tanks 241-AN-101, 241-AN-102, and 241-AP-104 will be used initially as LAW staging tanks. Tank 241-AP-102 is a backup staging tank. Other tanks are to be used for staging feed as they become available.

2.7 TRANSURANIC, STRONTIUM, CESIUM, AND TECHNETIUM SEPARATION FROM LOW-ACTIVITY WASTE

The liquid fraction of Waste Treatment Plant (WTP) feeds (LAW) contains many radioisotopes. The WTP has provisions for separating only a few: transuranic (TRU), strontium, cesium, and technetium. A simple flowsheet of BNFL Inc.'s process is provided in Figure 2.7-1.

Figure 2.7-1. Summary BNFL Inc. Flowsheet.



The WTP adds $NaMnO_4$ to Envelope C waste that is too high in aqueous TRU. Permanganate attacks complexants and releases complexed TRU, which then coprecipitates with the MnO_2 reaction product. Feeds that are too high in aqueous ^{90}Sr are treated with a $Sr(NO_3)_2$ addition. This treatment works by isotopic dilution and by exploiting the high carbonate concentration of Envelope C to precipitate $SrCO_3$. The following factors are used in HTWOS to account for the material balance effect of the TRU/strontium separation:

- 1*M* of manganese per 100*M* of waste sodium, and
- 1.5*M* of strontium per 100*M* of waste sodium.

Envelope A, Envelope B, and the treated Envelope C (see previous paragraph) are clarified through ultrafiltration.

Clarification of Envelope B discharges Envelope D HLW solids. The entrained solids discharged from Envelope A and C are handled in different ways depending on the case. BNFL Inc. will separate the entrained solids and the TRU/strontium precipitates using different process steps. It may blend them together into the HLW glass depending on incentives provided by DOE. Case 3S6E segregates entrained solids from the TRU/strontium precipitates that become HLW feed. In other cases, TRU/strontium precipitates with entrained solids become HLW feed.

The ultrafiltration permeate goes on to cesium ion exchange. BNFL Inc. has selected a regenerable ion exchange process that consumes caustic, nitric acid, and ion exchange resin.

Cesium-depleted effluent goes on to technetium removal. A regenerable adsorption process has been selected. Aqueous technetium is assumed to be in the form of TcO_4^-, and $NaTcO_4/KTcO_4$ load onto the resin. This process also consumes caustic, nitric acid, and the adsorption medium.

The cesium concentrate from ion exchange and the technetium product are worked off as feeds into HLW treatment.

The authority for the above separations is derived from DOE Order 435.1, *Radioactive Waste Management*. The order allows HLW waste originating from fuel reprocessing to be designated as waste incidental to reprocessing (WIR)[1] subject to the following conditions.

- Key radionuclides have been removed to the maximum extent technically and economically practical.

- Safety - disposal performance objectives are met comparable to10 CFR Part 61, Subpart C.

- Immobilized solid waste form does not exceed concentration limits for Class C waste (10 CFR 61.55) or alternative requirements.

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[1]In the context of privatization, treated LAW feeds are ILAW, and ILAW is equivalent to WIR.

Waste recognized as WIR need not be managed as HLW and is suitable for near-surface disposal. WIR principles have been applied to privatization so that the greater part of the caustic-soluble chemical inventory can be solidified for onsite disposal and most of the caustic-insoluble/radioactive inventory goes to the HLW repository.

Separations requirements are not stated explicitly in the privatization contract. The "technically and economically practical" and safe disposal criteria have been translated into objective product requirements that are more stringent than Class C, namely

- ^{90}Sr may not be more than 20 Ci/m^3 in the ILAW.
- ^{137}Cs may not be more than 3 Ci/m^3 in the ILAW.
- ^{99}Tc may not be more than 0.1 Ci/m^3 in the ILAW.

These three limits are applied on a running average. Individual packages may exceed the limits as long as the average for total ILAW production complies. In addition, the radionuclide profile of each ILAW package must qualify for a Class C designation. More than 100 nCi/g TRU (alpha-emitting, >5-year half-life) in the ILAW disqualifies the product from Class C consideration.

The radionuclide separations are modeled in HTWOS at a rudimentary level. HTWOS accounts for chemical additions (such as manganese and strontium) that have an effect on IHLW production. However, some chemical additions that affect total sodium are absent from the model. As noted above, WTP's cesium and technetium separations add chemicals to the waste, the net effect of which is to increase the $NaNO_3$ and water in the feed to LAW vitrification. These chemical additions are not tracked. Consequently, HTWOS under-projects the total ILAW.[1]

2.8 HIGH-LEVEL WASTE WASHING

To prepare HLW feeds for immobilization in Phase 1, BNFL Inc. will separate sludge into HLW and LAW fractions using a separation process referred to as sludge washing. The purpose of sludge washing is to minimize the amount of material for HLW immobilization by dissolving and removing primarily non-radioactive chemicals from the HLW feeds.

Caustic washing, sometimes referred to as caustic leaching, is performed by adding sodium hydroxide solution to the waste and mixing to dissolve caustic soluble compounds. Separation of large fractions of aluminum, present as gibbsite, as well as other non-radioactive chemicals from tank sludge, has been successfully demonstrated. The caustic leach solution is washed from the sludge with very dilute caustic wash water.

Sludge washing without caustic leaching (sometimes referred to as dilute caustic washing or water washing) represents the minimum pretreatment for HLW sludge. It is performed by initially separating the transport fluid from the solids. The solids then are washed with a very

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[1]CHG is building the WTP flowsheet into the next generation of the HTWOS model. This "integrated flowsheet" will address WTP operations in a much higher level of detail. The only Na addition currently tracked in HTWOS is that required for caustic leaching.

dilute caustic solution to remove the water-soluble components from the sludge, mainly sodium salts. Wash solutions from both washing processes become part of the LAW feed.

Additional LAW glass is produced as a result of the added and leached sodium in the wash solutions. Caustic leach and water wash tests will be performed by BNFL Inc. on sludge samples from each HLW staging tank to determine the most cost effective washing process by comparing the amount of HLW and LAW glass that would be produced.

An initial comparison by BNFL indicated that water washing is most cost effective for tanks 241-AZ-101 and 241-AZ-102, but that caustic leaching is most cost effective for other minimum order HLW tanks. At this point, caustic leaching also is assumed to be the most cost effective for the remaining HLW tanks.

2.9 LOW-ACTIVITY WASTE PRODUCT VOLUMES (DRIVEN BY 20 PERCENT Na_2O)

The estimated volume of LAW glass is generally controlled by the amount of sodium oxide (Na_2O) in the glass. Three different composition envelopes have been defined for LAW waste. Envelope A consists of LAW wastes that fall into the normal composition range where sodium (and more specifically the leachability properties of sodium) control the composition of the glass. Envelope B initially was developed to represent a more challenging range of compositions characterized by high Cl, PO_4 and SO_4 content. Envelope C encompasses all of the LAW wastes with high organic content. The target compositions for ILAW produced from Envelope A, B, and C feeds in the Phase 1 vitrification contract are 19.5 percent, 7.5 percent, and 17 wt% Na_2O, respectively. These limits are used in the HTWOS model to estimate the volume of LAW glass that can be produced from each batch of LAW.

2.10 HIGH-LEVEL WASTE GLASS VOLUME (DRIVEN BY Cr, Zr, Fe, Al, PO_4)

The HTWOS model uses the glass property models (GPM) developed by the Pacific Northwest National Laboratory (PNNL) to estimate the volume of HLW glass. The GPM is used to determine the expected composition of the HLW glass at the defined operating limits for the melter and at the specified limits for the IHLW product. These limits are normally expressed or defined in terms of the limiting glass properties for the HLW glass. The most important glass properties are viscosity, electrical conductivity, liquidus temperature, and sodium product consistency test (PCT) release. The PCT was developed to measure the durability and general quality of the IHLW product. The most critical property, aside from PCT, is usually the liquidus temperature of the glass. This temperature is defined as the temperature where the first crystals tend to precipitate in the molten glass. This condition is important because crystals might settle and cause sludge-forming conditions in the melter. If these conditions were to occur over a long period of time, they could easily affect the performance and operability of the melter. The GPM therefore can be used to estimate the limiting composition of the HLW glass, the corresponding waste oxide loading, and the minimum volume of HLW glass that can be produced from each batch of HLW.

The GPM appears to be generally reliable for estimating the properties of HLW glass (if the component concentrations fall within the defined composition limits of the models). The GPM may not be accurate for HLW glasses currently being developed by the vitrification contractor. These glasses typically contain only 32 to 33 percent SiO_2, compared to 42 to 57 percent SiO_2 in the glasses that were used to develop the GPM models. This difference appears to be relatively unimportant for reliable estimates of viscosity, electrical conductivity and PCT performance, but significant discrepancies may occur when the GPM is used for estimating the liquidus temperature of low SiO_2 glasses. This issue is important because it can lead to overly conservative estimates with the HTWOS model (predicting glass volumes that may be higher than the actual volume produced from certain wastes).

Fe, Cr, and Ni are often the limiting components in the waste because of their combined effect on the liquidus temperature of the glass. These components tend to form metal oxide crystals (or spinel) and thus limit the allowable waste oxide loading of the glass. Zirconium may be another limiting component if zircon (zirconium silicate) or zirconia (zirconium oxide) precipitate because the zirconium concentration is too high. Other components such as Al have a more complicated effect. Aluminum tends to improve the durability of the glass (as measured by the sodium PCT release), but also increases the viscosity and liquidus temperature of the glass. Aluminum also can affect the solubility limit for PO_4 in the glass. Because of these combined affects, Al can become the limiting component if caustic sludge washing processes are not used to remove excessive amounts of Al. Sulfate and PO_4 are sometimes the limiting components (at high concentration) because these impurities can separate and form a molten salt layer on top of the glass. This salt layer is highly corrosive to the refractory lining in the melter. Other compositions also need to be excluded from the allowable composition space because of the possibility of precipitating nepheline (sodium aluminum silicate) in the glass. When nepheline is formed, the durability of the glass may be reduced because of the corresponding depletion of Al. Most of the glass formulation problems that have been described are ones that usually can be solved by diluting the waste with inert glass formers (and reducing the waste oxide loading of the glass). However, such dilution also increases the volume and final disposal costs for the IHLW product.

2.11 SINGLE-SHELL TANK RETRIEVAL

The proposed sequence for retrieving SSTs is based on the logic developed in the *Single-Shell Tank Retrieval Program Mission Analysis Report* (MAR) (Stokes 1998). The SST Retrieval Program MAR suggests that CHG and DOE-ORP pursue a SST waste retrieval sequence that in the early waste retrievals focuses on sound saltcake tanks. Risk is reduced early in the mission by retrieving waste that has high levels of ^{99}Tc. These tanks should provide plenty of material for LAW feed. After reducing the ^{99}Tc risk in sound saltcake SSTs, then retrieval should proceed to sludge-containing sound SSTs, followed by sound saltcake tanks with lower levels of ^{99}Tc, and then sound tanks with a mixture of saltcake and sludge. After the wastes have been retrieved from sound tanks, the process should move to assumed-to-have-leaked tanks containing saltcake, followed by assumed-to-have-leaked tanks containing salt sludges, and then to known-to-have-leaked SSTs containing waste. By this time, experience with SST retrieval will be quite high so it should not matter whether the tanks contain low or high levels of mobile, long-lived radionuclides. To ensure that there is sufficient feed for HLW immobilization

processing, some early sludge retrieval may be needed. The SST retrieval sequence categories are described in Section 5.2.1. The reason for focusing on saltcake tanks is that there is a lot of saltcake waste, it is expected that the use of liquids during retrieval can be closely controlled (relative to the amount of free liquid available for leaking into the vadose zone during retrieval), and it is expected not to require major time or money investments.

2.12 THE MISSION SUMMARY DIAGRAM SCHEDULE

The Mission Summary Diagram (MSD) (see Section 3.2, Figures 3.2-1 and 3.2-2) is a graphical representation of the feed delivery plans, supporting activities, and project schedules. The feed staging portion of the MSD uses feed delivery transfer dates obtained from an HTWOS model run. Retrieval and transfer system operational need dates were determined from considerations of the vitrification process duration(s), waste certification duration(s), a desired minimum schedule float, and an acceptable waste backup strategy. Project schedules were provided by the Projects organization. Input took into account baseline project durations and integration of field activities. Intermediate activities, such as waste certification and feed staging transfers, are placed on the diagram to obtain a desired amount of float in the schedule or on the basis of projected transfer dates from HTWOS. Activities and programmatic float are adjusted to resolve conflicts or to maintain contract schedule constraints, where necessary.

The following are examples of general schedule constraints or assumptions used to prepare the MSD. Any specific schedule constraints or assumptions beyond these are identified on the MSD or in the bases and assumptions in Appendix A.

- Provide a minimum of six months of float before and after waste certification (12 months total). This is a preliminary assumption of the float necessary to achieve an 80 percent probability of success.

- Feed delivery transfers occur within a two-month window. This window was negotiated in preparing interface control documents (ICDs) for the feed delivery process.

- BNFL Inc. pretreatment requires one month (one-month lag between completion of the first batch feed delivery window and the waste vitrification process bar). This approximation is based on conversations with BNFL Inc. technical staff.

- The certification of waste in a subsequent feed source or staging tank must be completed on or before the first batch transfer date of the prior tank to have the waste in the subsequent tank available as backup feed.

- When waste from one tank is staged into two tanks, the lag time between certification of waste in both tanks is equal to the time required to vitrify the waste from the first staging tank (of the two) delivered to BNFL Inc. An example is tank 241-AN-104. This is a simplifying assumption for planning purposes.

- Waste certification cannot be completed more than two years before the first batch of waste is delivered to BNFL Inc. This constraint was negotiated through the feed delivery certification process.

- Two-month windows are assumed for each of the following activities, except where noted. These durations were assumed as a starting point for planning.
  - Decanting and degassing
  - Installing mixer pumps
  - Decanting and mixing (eight months are assumed for 241-AN-104)
  - Transferring waste from a source tank to an intermediate waste feed staging tank

  A three-month window is assumed for the clean out of tank 241-AN-101.

3.0 LOW-ACTIVITY WASTE FEED STAGING FOR CASE 3S6E

The Phase 1 privatization contract establishes specific requirements for the delivery of LAW feed to BNFL Inc. These requirements provide objectives for retrieval, staging and delivery of LAW waste. To meet these objectives, a staging scenario identified as Case 3S6E was evaluated by computer simulation. Case 3S6E represents the March 8, 2000, Planning Guidance (PIO 2000) and supersedes previous cases. Results and conclusions of the evaluation are discussed in this section. Summary of the LAW evaluations is discussed below.

Vitrification of LAW feed delivered through the last tank (241-AW-101) in the minimum order sequence is completed by September 2015, producing a total of 9,830 ILAW packages for Case 3S6E. If sulfate is removed, higher sodium oxide loading will occur, creating approximately 1,049 fewer ILAW packages. If the HLW wash solution and LAW portion from HLW were processed, the expected LAW glass would increase the duration by approximately nine months and increase the number of ILAW packages by approximately 915 compared to the baseline case. The minimum order tanks include 241-AP-101, LAW portion of 241-AZ-101/241-AZ-102, 241-AN-102, 241-AN-104, 241-AN-107, 241-AN-105, 241-SY-101, 241-AN-103, and 241-AW-101.

Case 3S6E is viable and provides a wider margin for CHG feed storage needs with no apparent cost penalty for the ORP. This case will lower the risk of idling the LAW vitrification facility by providing three staging tanks and one backup staging tank in the beginning.

The liquid fractions of Batches 2a, 2b, and 7 may not currently meet the criteria for Envelopes A, B, or C. Batches 2a and 2b were projected to be Envelope B feed but, because of high TRU, ^{90}Sr, and ^{60}Co concentrations in tank 241-AZ-101 and high SO_4, TRU, and ^{154}Eu concentrations in tank 241-AZ-102. These batches may not meet Envelope B specifications. The waste in tank 241-AN-107 (Batch 7) is not projected to meet the feed specification for its targeted envelope, Envelope C, because of high TRU and $^{154/155}Eu$. The second batch from 241-AN-104 is projected to meet the feed specifications. However, decanting the supernate from tank 241-AN-104 leaves settled solids that are high in sulfate. The diluted supernate will be returned and mixed multiple times with saltcake left in tank 241-AN-104 to ensure Envelope A feed is provided.

3.1 LOW-ACTIVITY WASTE STAGING SCENARIO

The staging approach for Case 3S6E is to provide reliable LAW feed delivery to BNFL Inc. while meeting privatization contract requirements. The number and location of staging tanks selected for Case 3S6E improve the reliability of LAW feed delivery by providing backup staged feed capability from independent tank farms. Feed staging capability is provided from AN and AP tank farms to minimize the probability of a single-point failure in the delivery system resulting in loss of feed capability.

Identification of LAW source and staging tanks for Case 3S6E Phase 1 is shown in Figure 3.1-1. Phase 1 LAW source tanks were specified by ORP (1999). Case 3S6E uses LAW from ten DSTs to meet the minimum order quantity of 6,000 units of LAW with some

contingency. Waste from five DSTs and five SSTs provides LAW feed in the extended order of Phase 1 until February 2018.

This case provides additional tank space for tank farm storage needs with no apparent cost penalty compared to previous cases. In addition, it provides a lower risk of idling the LAW vitrification facility by providing three staging tanks and one backup staging tank at the beginning of treatment services. This staging scenario uses tanks 241-AN-101, 241-AN-102 and 241-AP-104 as feed staging tanks as well as tank 241-AP-102 for backup staging tank. Other tanks will be used as staging tanks as they become available.

Tank 241-AN-105 and other tanks as they become available will be used as feed staging tanks as shown in Figure 3.1-1. Waste retrieved from most of the DSTs will be transferred to the staging tanks and certified before delivery to BNFL Inc.'s feed tank (ICD-19). Waste from tanks 241-AN-102 and 241-AN-107 will be certified before delivery to BNFL Inc.'s feed receipt tanks without going through a staging tank.

Feed delivered from each source tank is discussed in Section 3.1.1. Information on ILAW glass products is shown in Section 3.1.2. The composition of each feed batch is compared against contract specifications in Section 3.1.3.

The tank-specific staging plan, the retrieval and transfer equipment needed to support the staging plan, and the work execution schedule are discussed in Section 3.2. The waste transfers and certain precedent relationships directly needed to implement the LAW portion of the operating scenario are shown on the MSD in Section 3.2.3. Waste volume plots with denoted transfers as a function of time for all Phase 1 DSTs are also provided in Section 3.2.3. Major assumptions governing this staging scenario are discussed in Appendix A. A full description of all Phase 1 transfers including dates, volumes, and destinations is included in Appendix H.

Figure 3.1-1. Low-Activity Waste Fee Staging Diagram.

LOW-ACTIVITY WASTE FEED STAGING SEQUENCE CASE 3S6 PHASE I

ENVELOPE	SOURCE TANK				STAGING TANK	BATCH	
A	AP-101	SUPERNATE				1	
B	AZ-101	SUPERNATE			B WASTE	2	
	AZ-102	SUPERNATE					
C	AN-102	SUPERNATE				3	
		SUPERNATE				4	
A	AN-104	DISSOLVED SOLIDS				5	
		SUPERNATE			AN-101	6	
C	AN-107	SUPERNATE				7	
A	AN-105	SUPERNATE			AN-102	8	
		DISSOLVED SOLIDS				9	
A	SY-101	SUPERNATE	SY-102		AP-104	10	BNFL INC. TREATMENT FACILITIES
		SUPERNATE	SY-102		AN-101	11	
A	AN-103	SUPERNATE			AN-102	12	
		DISSOLVED SOLIDS				13	
A	AW-101	SUPERNATE			AN-105	14	
		DISSOLVED SOLIDS				15	MINIMUM ORDER
A	AW-104 (SWL)	SUPERNATE			AP-104	16	EXTENDED
A	SY-103	SUPERNATE			AN-101	17	
A	AP-106 (SWL)	SUPERNATE			AN-102	18	
		SUPERNATE				19	
C[1]	S-102 (S-103, S-105)	SALTCAKE DISSOLUTION	SY-103	AN-104	AP-101	20	
C	S-105 (S-106, S-108)	SALTCAKE DISSOLUTION	SY-103	AN-104	AN-105	21	
A	AP-105 (SWL)	SUPERNATE			AP-104	22	
		SUPERNATE				23	
A	AP-108	SUPERNATE				24	

[1] PO_4 IS OUT OF SPEC
SWL - SALTWELL LIQUOR
(S-103, S-105) - WASTE FROM TANKS S-103 & S-105 ARE INCLUDED
(S-106, S-108) - WASTE FROM TANKS S-106 & S-108 ARE INCLUDED

CASE3S6LAW-2

3.1.1 Low-Activity Waste Feed Delivery

The LAW portion of the staging scenario refers to the waste transfers and other operational activities needed to deliver LAW feed to BNFL Inc. Table 3.1-1 summarizes the operating scenario for Case 3S6E minimum order and extended order. For each batch of feed the table lists the units of feed, the envelope classification, and the nominal date on which CHG expects to deliver the feed.

The CHG Team will use tanks 241-AN-101, 241-AN-102, 241-AP-102, and 241-AP-104 for waste management during the same time frame that a project is preparing them for use as feed staging tanks. The details will change as waste management needs evolve and construction activities proceed. A detailed construction schedule that is to be prepared will accommodate the waste management activities.

Tanks 241-AN-103, -104, -105, and 241-AW-101 will be used as feed staging tanks after approximately half of the waste has been removed from each tank. For example, after approximately half the waste in tank 241-AN-105 has been removed to 241-AN-102 for staging, the remaining waste in tank 241-AN-105 will be diluted and certified. Once the waste in 241-AN-105 is removed, the tank will be used as a staging tank for other waste.

Figure 7.3-1 (Section 7.0) displays space that is not available for use in staging waste feed (e.g., head space in watch list tanks, spare tank space). This figure also shows the total volume of waste stored in the DST system as a function of time. Available tank space is improved by approximately 7,570 m^3 (2 Mgal) over previous DST volume projections. Projected waste volume does not exceed the tank space at any time even though it includes the planned 3,785 m^3 (1 Mgal) volume increase from retrieving and diluting tank 241-SY-101 waste to the mitigation of the crust level growth.

Case 3S6E offers an improved approach to management of tank space over previous cases. BNFL Inc.'s tanks (instead of tank 241-AP-106) are used for feed receipt, adding much needed tank space. Furthermore, Envelope B waste would not be returned to CHG. Entrained solids separated from LAW feed by BNFL also will be stored at the BNFL Inc. facility instead of returning to CHG. However, the capability to return entrained solids to the tank farms is retained in the transfer system.

Three sets of waste compositions, initial snapshot, final snapshot and staged feed, were compared to these limits and classified according to envelope (or classified as excluded if no envelope was satisfied). Waste with compositions that fell within 20 percent of any limit was further classified as borderline. The initial and final snapshot results are found in Appendix I. Additionally, Appendix E, Tables E1-2 through E1-9 compare the estimated composition of the retrieved liquid phase against the envelope limits on an analyte-by-analyte basis. These tables show which compositions satisfy the envelope limits and which are borderline cases.

Table 3.1-1. Summary of Low-Activity Waste Feed Staging and Delivery - Case 3S6E - R2A

Envelope[a]	Feed source	Staging tank	Batch	Dates[b]						Delivered LAW feed[d]						
				Start retrieval	Begin staging	Batch ready[c]	Start delivery	Start of vitrification	End of vitrification	Units of LAW delivered	Sodium delivered (MT)	Mass of LAW glass (MT)	Volume of LAW glass[e] (m^3)	Number of LAW packages[f]	Cumulative LAW packages[f]	Radioactivity[g] (Ci)
Privatization Phase 1 Minimum Order																
A	AP-101	none	1	--	--	7/29/05	4/29/06	11/30/06	4/26/08	615	615	4,272	1,606	711	711	1.88E+04
B	AZ-101	none	2a	--	--	--	7/8/07	4/26/08	9/20/09	1,308	503	9,080	3,414	1,511	2,222	3.92E+04
	AZ-102	none	2b	--	--	--	3/29/08									
C	AN-102	none	3	--	--	7/11/07	4/10/08	9/20/09	3/30/10	556	484	3,862	1,452	643	2,865	9.30E+04
		none	4	--	--	6/27/09	3/28/10	3/28/10	9/29/10	556	484	3,861	1,451	642	3,507	9.27E+04
A	AN-104[h]	none	5	12/2/04	9/1/08	12/29/09	9/29/10	9/29/10	2/22/11	439	439	3,045	1,145	507	4,014	7.35E+03
		AN-101	6	8/9/05	3/1/09	5/24/10	2/22/11	2/22/11	7/7/11	406	406	2,819	1,060	469	4,483	6.78E+03
C	AN-107	none	7	--	--	10/7/10	7/8/11	7/8/11	4/1/12	808	703	5,610	2,109	934	5,417	1.38E+05
A	AN-105	AN-102	8	3/30/10	4/2/10	7/2/11	4/1/12	4/1/12	8/21/12	425	425	2,948	1,108	491	5,907	2.20E+04
		none	9	--	--	11/21/11	8/21/12	8/21/12	1/6/13	414	414	2,872	1,080	478	6,385	1.61E+04
A	SY-101[i]	AP-104	10	11/15/99	1/15/00	4/7/12	1/6/13	1/6/13	4/15/13	298	298	2,070	778	344	6,730	1.64E+04
		AN-101	11	7/5/11	7/9/11	7/15/12	4/15/13	4/15/13	10/8/13	529	529	3,672	1,380	611	7,341	2.34E+04
A	AN-103	AN-102	12	4/3/12	4/8/12	1/7/13	10/8/13	10/8/13	4/6/14	542	542	3,760	1,414	626	7,967	1.03E+04
		none	13	--	--	7/6/13	4/6/14	4/6/14	10/4/14	542	542	3,765	1,416	627	8,593	9.80E+03
A	AW-101	AN-105	14	8/23/12	8/26/12	1/3/14	10/4/14	10/4/14	3/4/15	453	453	3,146	1,183	523	9,117	1.51E+04
		none	15	--	--	6/3/14	3/4/15	3/4/15	9/25/15	617	617	4,283	1,610	713	9,830	1.94E+04
Privatization Phase 1 Minimum Order (6,000 Units of LAW)										8,509	7,453					
Privatization Phase 1 Extended Order																
A	AW-104 (saltwell liquor)	AP-104	16	1/8/13	1/11/13	12/25/14	9/25/15	9/25/15	2/2/16	390	390	2,707	1,018	451	10,280	1.18E+04
A	SY-103	AN-101	17	5/1/13	5/3/13	5/4/15	2/2/16	2/2/16	4/28/16	258	258	1,791	673	298	10,578	8.07E+03
A	AP-106 (saltwell liquor)	AN-102	18	10/11/13	10/14/13	7/29/15	4/28/16	4/28/16	8/21/16	346	346	2,405	904	400	10,979	1.60E+04
		none	19	--	--	11/22/15	8/22/16	8/22/16	12/15/16	347	347	2,406	904	400	11,379	1.65E+04
C	S-102[j] (S-103, S-105)	AP-101	20	12/11/13	11/12/14	3/16/16	12/15/16	12/15/16	5/15/17	454	395	3,152	1,185	525	11,904	5.49E+04
C	S-105 (S-106, S-108)	AN-105	21	11/13/14	9/7/15	8/15/16	5/16/17	5/16/17	10/9/17	441	384	3,062	1,151	510	12,413	5.31E+04
A	AP-105	AP-104	22	9/28/15	10/2/15	1/8/17	10/9/17	10/9/17	2/25/18	417	417	2,897	1,089	482	12,895	1.38E+04
		none	23	--	--	5/28/17	2/26/18	2/26/18	7/15/18	418	418	2,901	1,091	483	13,378	1.37E+04
A	AP-108 (saltwell liquor)	none	24	--	--	10/14/17	7/15/18	7/15/18	3/26/19	765	765	5,311	1,997	884	14,262	5.06E+04
Privatization Phase 1 Extended Order										3,837	3,720					
Privatization Phase 1 Total										12,346	11,173					
DST Backfill for Phase 2[k]																
A	TX-112[l]		25	10/1/11	--	--	--	--	--	--	886	--	--	--	--	--
A	S-109[l]		26	9/8/15	--	--	--	--	--	--	624	--	--	--	--	--
A	S-112[l]		27	4/29/16	--	--	--	--	--	--	584	--	--	--	--	--
A	BY-112[l]		28	12/28/16	--	--	--	--	--	--	537	--	--	--	--	--
A	A-101[l]		29	3/11/18	--	--	--	--	--	--	954	--	--	--	--	--
A	BY-111[l]		30	9/12/18	--	--	--	--	--	--	657	--	--	--	--	--
A	AX-101[l]		31	10/28/18	--	--	--	--	--	--	839	--	--	--	--	--
Double-Shell Tank Backfill for Privatization Phase 2											5,081					
Privatization Phase 1 and Double-Shell Tank Backfill											16,254					

[a] Assumed envelope is based on current contract specifications and currently available characterization data.

[b] Dates are derived from the Mission Summary Diagram.

[c] The date where batch qualification has been completed and first batch of the batch group is ready to be delivered to BNFL.

[d] ILAW production based on sodium delivered from staged LAW feed.
e Glass density = 2.66 MT/m3

[f] 2.259 m^3 of LAW glass per package.

[g] Decayed to date of delivery.

[h] Decantation of the supernatant liquid from tank AN-104 leaves settled solids that are high in sulfate. Retrieval and mixing of all the waste in this tank as a slurry should alleviate the high sulfate problem. The diluted supernate will be returned and mixed multiple times with saltcake left in AN-104 to ensure Envelope A feed.

[i] The minimum order quantity is met midway through Batch 11.

[j] PO_4 is out of specification. Negotiate price with BNFL to process out-of-spec feed or find different feed.

[k] DST backfill list for Phase 2 is preliminary and subject to change.

[l] 100 percent of sodium assumed to be retrieved and delivered to the Phase 2 contractor. Retrieval efficiencies vary in other tanks.

The first set of compositions represents an initial snapshot of the targeted, as-retrieved fraction of waste projected to be present in the DSTs on October 1, 2004. For tanks with little or no metal oxide sludge, the entire tank contents were targeted for retrieval. For tanks with significant amounts of sludge, the sludge was excluded from retrieval. The initial snapshot was used to establish the processing sequence for Case 3S6E described in Section 3.2.1.

The amount of dilution water needed to retrieve the targeted waste fraction was determined as the amount of water needed to dilute the waste to reach a maximum liquid-phase sodium concentration limit for transfer. The maximum sodium concentration for the four DSTs containing Envelope A feed were selected to be roughly midway between the concentration at which no more solids dissolve and the concentration at which gibbsite begins to precipitate. This point was determined by computer model, using the Environmental Simulation Program (ESP)[1] package (see Section 3.3 for a discussion of solid-liquid equilibria). A matrix of 'wash-factors' that represents the end result of the solid-liquid equilibria calculations used by Hendrickson (1998) was used to repartition the liquid and solid components. The maximum sodium concentration for wastes was the proxy limit of 7.0*M*. The amount of dilution water added for each transfer is found in Appendix H.

3.1.2 Projected Low-Activity Waste Product

Three feed envelopes, entitled Envelope A, B, and C are established by the privatization contract (RL 1996). Each envelope provides a different technical challenge for BNFL Inc. Envelope A waste represents waste that will test the production capacity and fission-product removal efficiency of the plant and will produce a final product in which waste loading will be limited by sodium. Envelope B waste is similar to Envelope A, except that it was defined so that the waste loading in the final product will be limited by minor component concentrations. Working with a high-activity/high-heat waste composition, however, will challenge BNFL Inc. At least one of the Envelope A maximum limits for ^{90}Sr, ^{60}Co, ^{154}Eu, ^{155}Eu, or TRU must be exceeded for waste to be delivered as Envelope C.

Vitrification of LAW feed delivered through the last tank in the minimum order sequence, AW-101, is completed by September 2015, producing a total of 9,654 ILAW packages for Case 3S6E. This case represents a scenario with sodium oxide loadings of 0.195, 0.075, and 0.17 for Envelopes A, B, and C, respectively. The product contains 2.42 m^3 of glass in a 100 percent full package at a glass density of 2.66 MT/m^3. The minimum order tanks include 241-AP-101, 241-AZ-101/241-AZ-102 supernate mixture, 241-AN-102, 241-AN-104, 241-AN-107, 241-AN-105, 241-SY-101, 241-AN-103, and 241-AW-101.

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[1]ESP is a trademark of OLI Systems, Inc.

3.1.3 Feed Compliance With Contract Specifications

The LAW feeds will contain liquids that must meet the criteria set forth in Section C, Specification 7, of the contract for Envelope A, B, or C waste feed (RL 1996). The analytical and radiological concentration limits from Specification 7 and the predicted compositions for the 24 batches delivered in Phase 1 are presented in Tables 3.1-2 and 3.1-3. The concentration of sodium is presented as well.

In Tables 3.1-2 and 3.1-3, the concentration of a component is compared to the maximum concentration allowed for that component for Envelopes A, B, and C for the minimum order and extended order feed batches, respectively. There are three columns that follow the concentration data from each batch group that correspond to the three envelopes. If the concentration for a component meets the criteria for an envelope, a "Y" is indicated in the cell of the table. Conversely, if the specification limit is not met, a "N" is placed in the cell and the background of the cell is shaded to call attention to it. A shaded cell background with "5" identifies components within 50 percent of a specification and a shaded cell background with "8" identifies components within 80 percent of a specification

Concentration data represented by zero values may be due to engineering assessments of sample data. The sample data may have been reported as "less-than" values or may not have been reported at all. The concentration data pedigree is addressed in Appendix B. The radionuclide data presented are decayed to the time of feed delivery to reflect what is spelled out in Specification 7 of the contract.

Table 3.1-2 shows that the liquid fractions of Batches 2a, 2b, and 7 do not meet the criteria for Envelopes A, B, or C. Batches 2a and 2b were intended to be Envelope B feed. Batch 2a may be out of specification in TRU, ^{90}Sr, and ^{60}Co. Batch 2b may be out of specification in SO_4, TRU, and ^{154}Eu and ^{155}Eu. Batch 7 may be out of specification in TRU and ^{154}Eu and ^{155}Eu. During the certification process, the analysis should be performed to verify whether these batches do meet the feed specification. If the waste is out-of-specification and treatable within the facility, a price for processing the out of specification feed will be negotiated (RL 1996).

Table 3.1-2. The Low-Activity Waste Feeds Minimum Order – Case 3S6E.

From Tables TS-7.1 and TS-7.2 of Contract				AP-101	AZ-101	AZ-102	AN-102		AN-104		AN-107	AN-105		SY-101		AN-103		AW-101	
Chemical Analyte	Envelope A	Envelope B	Envelope C	LAW-1	LAW-2a	LAW-2b	LAW-3	LAW-4	LAW-5	LAW-6	LAW-7	LAW-8	LAW-9	LAW-10	LAW-11	LAW-12	LAW-13	LAW-14	LAW-15
	moles of analyte to moles of sodium										moles of analyte to moles of sodium								
Al	2.5E-01	2.5E-01	2.5E-01	5.63E-02	8.41E-02	2.34E-02	5.16E-02	5.16E-02	1.13E-01	1.15E-01	2.79E-02	1.27E-01 5 5 5	9.02E-02	9.83E-02	9.28E-02	1.50E-01 5 5 5	1.51E-01 5 5 5	9.75E-02	1.00E-01
Ba	1.0E-04	1.0E-04	1.0E-04	4.11E-07	4.09E-06	1.31E-13	2.01E-05	2.01E-05	1.19E-05	1.27E-05	0.00E+00	1.82E-05	8.28E-06	0.00E+00	3.91E-07	1.12E-05	1.09E-05	2.08E-06	0.00E+00
Ca	4.0E-02	4.0E-02	4.0E-02	1.52E-04	2.54E-06	4.66E-05	1.39E-03	1.39E-03	9.56E-05	9.97E-05	1.55E-03	2.13E-04	2.10E-04	3.27E-04	4.43E-04	6.72E-05	6.28E-05	1.81E-04	1.72E-04
Cd	4.0E-03	4.0E-03	4.0E-03	1.46E-06	8.72E-06	2.80E-13	5.20E-05	5.20E-05	1.47E-06	1.53E-06	0.00E+00	4.93E-06	8.33E-07	0.00E+00	4.35E-08	1.91E-06	1.82E-06	2.03E-07	0.00E+00
Cl	3.7E-02	8.9E-02	3.7E-02	5.84E-03	1.17E-03	1.11E-04	9.65E-03	9.65E-03	2.07E-02 5 5	2.07E-02 5 5	5.73E-03	2.50E-02 5 5	2.55E-02 5 5	2.80E-02 5 5	2.73E-02 5 5	1.73E-02	1.70E-02	1.68E-02	1.39E-02
Cr	6.9E-03	2.0E-02	6.9E-03	3.27E-04	3.10E-03	8.11E-03 N N	7.28E-04	7.28E-04	5.19E-04	5.25E-04	6.35E-04	4.65E-04	6.50E-04	4.55E-03 5 5	5.23E-03 5 5	7.21E-04	7.29E-04	3.62E-04	2.64E-04
F	9.1E-02	2.0E-01	9.1E-02	1.90E-02	2.06E-02	2.32E-02	8.73E-03	8.73E-03	2.94E-03	2.68E-03	1.93E-02	3.31E-03	8.92E-03	5.00E-03	6.20E-03	3.70E-03	3.71E-03	8.14E-03	7.88E-03
Fe	1.0E-02	1.0E-02	1.0E-02	1.09E-05	4.18E-05	8.01E-05	3.51E-04	3.51E-04	3.23E-05	3.40E-05	5.46E-03 5 5 5	5.65E-05	1.85E-05	3.48E-04	6.18E-04	1.92E-05	1.81E-05	4.69E-05	5.66E-05
Hg	1.4E-05	1.4E-05	1.4E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-07	0.00E+00	0.00E+00	2.34E-08	4.36E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K	1.8E-01	1.8E-01	1.8E-01	7.20E-02	2.50E-02	3.36E-02	8.85E-03	8.85E-03	1.22E-02	1.25E-02	4.56E-03	1.45E-02	1.21E-02	8.41E-03	8.29E-03	2.47E-02	2.50E-02	6.38E-02	8.14E-02
La	8.3E-05	8.3E-05	8.3E-05	0.00E+00	4.67E-11	8.26E-06	0.00E+00	0.00E+00	1.21E-06	1.30E-06	2.71E-05	6.26E-14	3.41E-13	4.09E-06	4.35E-08	3.40E-07	3.81E-07	9.52E-13	1.16E-12
Ni	3.0E-03	3.0E-03	3.0E-03	1.69E-05	1.85E-07	1.51E-05	6.17E-04	6.17E-04	1.23E-05	1.30E-05	9.13E-04	5.33E-05	1.56E-05	1.68E-04	2.92E-04	8.36E-06	6.99E-06	2.00E-05	2.16E-05
NO_2	3.8E-01	3.8E-01	3.8E-01	1.38E-01	2.96E-01 5 5 5	2.78E-01 5 5 5	1.60E-01	1.60E-01	2.38E-01 5 5 5	2.39E-01 5 5 5	1.43E-01	2.40E-01 5 5 5	2.42E-01 5 5 5	2.63E-01 5 5 5	2.77E-01 5 5 5	2.26E-01 5 5 5	2.25E-01 5 5 5	2.13E-01 5 5 5	2.03E-01 5 5 5
NO_3	8.0E-01	8.0E-01	8.0E-01	3.34E-01	2.55E-01	1.58E-01	3.25E-01	3.25E-01	2.75E-01	2.72E-01	3.80E-01	2.56E-01	2.82E-01	2.87E-01	2.40E-01	2.45E-01	2.45E-01	2.65E-01	2.59E-01
Pb	6.8E-04	6.8E-04	6.8E-04	2.39E-06	0.00E+00	0.00E+00	8.64E-05	8.63E-05	1.88E-05	1.96E-05	2.09E-04	2.65E-05	1.44E-05	3.03E-04	3.47E-05	2.33E-05	2.33E-05	2.76E-05	3.21E-05
PO_4	3.8E-02	1.3E-01	3.8E-02	1.64E-03	3.22E-03	5.96E-04	4.60E-03	4.60E-03	4.13E-03	3.97E-03	4.19E-03	2.17E-03	5.34E-03	8.73E-03	7.29E-03	1.88E-03	1.87E-03	2.20E-03	1.13E-03
SO_4	1.0E-02	7.0E-02	2.0E-02	5.61E-03 5	3.93E-02 N 5 N	7.92E-02 N N N	1.47E-02 N 5	1.47E-02 N 5	9.69E-03 8	9.02E-03 8	9.64E-03 8	4.35E-03	7.33E-03 5	7.47E-03 5	4.80E-03	2.28E-03	2.22E-03	3.44E-03	2.12E-03
TIC	3.0E-01	3.0E-01	3.0E-01	3.66E-02	1.18E-01	2.44E-01 8 8 8	1.03E-01	1.03E-01	7.87E-02	7.21E-02	1.35E-01	4.04E-02	1.09E-01	5.58E-02	7.22E-02	3.23E-02	3.21E-02	5.06E-02	3.07E-02
TOC	5.0E-01	5.0E-01	5.0E-01	4.13E-02	2.49E-02	5.56E-02	1.98E-01	1.98E-01	2.43E-02	2.42E-02	3.46E-01 5 5 5	5.63E-02	4.53E-02	6.19E-02	8.82E-02	1.36E-02	1.23E-02	2.95E-02	2.41E-02
U	1.2E-03	1.2E-03	1.2E-03	1.68E-05	4.46E-06	2.72E-04	6.84E-05	6.84E-05	6.08E-06	5.65E-06	6.38E-05	5.51E-06	8.96E-07	1.49E-05	8.57E-06	1.20E-06	1.07E-06	5.90E-05	7.88E-05
Radionuclide	Becquerels of radionuclide to moles of sodium										Becquerels of radionuclide to moles of sodium								
TRU	4.8E+05	4.8E+05	3.0E+06	7.92E+03	2.14E+06 N N 5	3.29E+06 N N N	7.10E+05 N N	7.03E+05 N N	9.29E+03	8.99E+03	3.48E+06 N N N	4.47E+04	1.60E+03	2.82E+05 5 5	1.41E+04	2.39E+04	2.33E+04	1.24E+04	1.57E+04
^{137}Cs	4.3E+09	2.0E+10	4.3E+09	7.58E+08	1.23E+10 N 5 N	1.33E+10 N 5 N	8.80E+08	8.38E+08	1.39E+09	1.40E+09	1.01E+09	9.55E+08	9.80E+08	8.16E+08	8.24E+08	1.07E+09	1.07E+09	1.01E+09	1.00E+09
^{90}Sr	4.4E+07	4.4E+07	8.0E+08	5.86E+05	2.83E+08 N N	3.13E+06	2.16E+08 N N	1.94E+08 N N	3.84E+05	3.64E+05	3.71E+08 N N	1.38E+07	9.59E+06	1.01E+07	1.18E+07	1.36E+06	9.88E+05	7.02E+06	6.25E+06
^{99}Tc	7.1E+06	7.1E+06	7.1E+06	4.56E+05	2.32E+06	2.74E+06	7.15E+05	7.16E+05	9.49E+05	9.55E+05	5.02E+05	1.42E+06	1.50E+06	1.81E+06	1.25E+06	8.09E+05	7.88E+05	1.08E+06	9.41E+05
^{60}Co	6.1E+04	6.1E+04	3.7E+05	3.80E+03	1.58E+05 N N	3.17E+02	9.46E+04 N N	7.34E+04 N N	1.31E+04	1.32E+04	1.22E+05 N N	6.71E+03	3.19E+03	3.07E+03	1.53E+03	6.97E+03	6.57E+03	3.24E+03	3.33E+03
$^{154}Eu + ^{155}Eu$	1.2E+06	1.2E+06	4.3E+06	2.00E+05	1.10E+01	1.57E+06 N N	6.27E+05 5 5	5.22E+05	1.30E+05	1.32E+05	4.53E+06 N N N	4.35E+04	7.80E+03	1.59E+05	4.65E+03	5.70E+04	5.42E+04	5.96E+04	7.38E+04
From Spec 7.2.2.1	mol/L										mol/L								
Na	3 to 10			6.51	2.36 N N N	1.48 N N N	9.00	9.00	6.89	6.88	8.45	6.93	7.00	4.59	6.83	6.75	6.70	6.99	7.00
					A	B	B	C	C	A	A	C	A	A	A	A	A	A	A
Overall:					Y Y Y	N N N	N N N	N N Y	N N Y	Y Y Y	Y Y Y	N N N	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y	Y Y Y
N's					0 0 0	6 4 3	6 4 5	4 3 0	4 3 0	0 0 0	0 0 0	4 4 2	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
>80%					0 0 0	6 4 3	7 5 6	4 3 0	4 3 0	1 0 0	1 0 0	5 4 2	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
>50%					1 0 0	7 7 5	8 7 7	5 4 1	4 3 1	3 1 2	3 1 2	7 6 4	3 2 3	3 1 2	5 2 3	3 1 3	2 2 2	2 2 2	1 1 1	1 1 1

LEGEND:

- ☐ Meets Spec, < 50% of maximum
- [5] Meets Spec, > 50% of maximum
- [8] Meets Spec, > 80% of maximum
- [N] Does not meet Spec

Table 3.1-3 The Low-Activity Waste Feeds Extended Order – Case 3S6E.

From Tables TS-7.1 and TS-7.2 of Contract				AW-104	SY-103	AP-106		S-102	S-105	AP-105		AP-108
Chemical Analyte	Envelope A	Envelope B	Envelope C	LAW-16	LAW-17	LAW-18	LAW-19	LAW-20	LAW-21	LAW-22	LAW-23	LAW-24
	moles of analyte to moles of sodium			moles of analyte to moles of sodium								
Al	2.5E-01	2.5E-01	2.5E-01	1.03E-01	9.45E-02	8.91E-02	8.62E-02	5.57E-02	7.18E-02	1.13E-01	1.14E-01	1.42E-01
Ba	1.0E-04	1.0E-04	1.0E-04	4.59E-08	2.28E-08	5.97E-07	6.63E-08	1.68E-08	5.39E-07	2.05E-08	1.95E-08	2.70E-07
Ca	4.0E-02	4.0E-02	4.0E-02	3.17E-04	2.23E-04	1.70E-04	1.75E-04	2.92E-04	1.08E-04	1.59E-04	1.53E-04	1.38E-04
Cd	4.0E-03	4.0E-03	4.0E-03	3.27E-08	2.78E-09	1.33E-07	6.63E-08	5.03E-08	5.39E-08	1.46E-08	1.39E-08	1.80E-07
Cl	3.7E-02	8.9E-02	3.7E-02	1.87E-02 [5]	3.50E-02 [8]	2.03E-02 [5]	2.05E-02 [5]	1.71E-02	1.24E-02	2.18E-02 [5]	2.19E-02 [5]	2.34E-02 [5]
Cr	6.9E-03	2.0E-02	6.9E-03	2.43E-03	1.09E-03	3.16E-03	3.28E-03	2.33E-03	4.27E-03 [5]	1.69E-03	1.66E-03	2.44E-03
F	9.1E-02	2.0E-01	9.1E-02	4.85E-02 [5]	6.88E-03	9.69E-03	9.98E-03	2.29E-02	2.21E-02	2.86E-02	2.79E-02	4.56E-03
Fe	1.0E-02	1.0E-02	1.0E-02	9.04E-05	6.05E-05	9.86E-05	1.02E-04	5.62E-05	1.73E-05	5.64E-05	5.51E-05	5.81E-05
Hg	1.4E-05	1.4E-05	1.4E-05	9.24E-09	2.60E-10	9.35E-09	9.80E-09	1.53E-10	3.87E-08	2.51E-08	2.57E-08	9.01E-08
K	1.8E-01	1.8E-01	1.8E-01	1.64E-02	1.04E-02	2.52E-02	2.52E-02	6.95E-03	1.84E-02	2.87E-02	2.92E-02	1.56E-02
La	8.3E-05	8.3E-05	8.3E-05	2.53E-06	3.56E-09	5.44E-06	5.64E-06	2.33E-07	1.97E-08	1.16E-06	1.10E-06	1.71E-06
Ni	3.0E-03	3.0E-03	3.0E-03	5.72E-05	7.95E-05	6.73E-05	7.02E-05	2.24E-05	6.35E-06	3.74E-05	3.66E-05	5.98E-05
NO_2	3.8E-01	3.8E-01	3.8E-01	2.10E-01 [5]	3.23E-01 [8]	2.17E-01 [5]	2.17E-01 [5]	1.59E-01	1.34E-01	2.81E-01 [5]	2.84E-01 [5]	2.70E-01 [5]
NO_3	8.0E-01	8.0E-01	8.0E-01	2.56E-01	3.20E-01	3.34E-01	3.39E-01	4.60E-01 [5]	4.37E-01 [5]	4.35E-01 [5]	4.41E-01 [5]	2.78E-01
Pb	6.8E-04	6.8E-04	6.8E-04	1.04E-04	2.68E-05	2.45E-04	2.56E-04	6.35E-06	7.37E-06	3.95E-05	3.71E-05	5.08E-05
PO_4	3.8E-02	1.3E-01	3.8E-02	3.90E-03	1.45E-02	6.94E-03	7.18E-03	3.90E-02 [N]	2.72E-02 [5]	4.24E-03	4.26E-03	5.69E-03
SO_4	1.0E-02	7.0E-02	2.0E-02	7.65E-03 [5]	6.68E-03 [5]	9.23E-03 [8]	9.57E-03 [8]	1.23E-02 [N]	1.10E-02 [N]	7.75E-03 [5]	7.75E-03 [5]	6.13E-03 [5]
TIC	3.0E-01	3.0E-01	3.0E-01	8.72E-02	6.35E-02	8.14E-02	8.38E-02	3.60E-02	4.33E-02	5.25E-02	5.12E-02	3.55E-02
TOC	5.0E-01	5.0E-01	5.0E-01	5.17E-02	1.06E-01	3.66E-02	3.77E-02	4.18E-02	2.37E-02	3.15E-02	3.07E-02	3.89E-02
U	1.2E-03	1.2E-03	1.2E-03	2.28E-04	7.00E-06	2.52E-05	2.63E-05	1.17E-05	2.09E-05	4.49E-05	3.79E-05	3.33E-04
Radionuclide	Becquerels of radionuclide to moles of sodium			Becquerels of radionuclide to moles of sodium								
TRU	4.8E+05	4.8E+05	3.0E+06	2.16E+05	2.47E+04	2.52E+05 [5]	2.63E+05 [5]	1.79E+04	6.83E+03	3.37E+04	2.68E+04	1.40E+05
^{137}Cs	4.3E+09	2.0E+10	4.3E+09	5.46E+08	9.82E+08	7.02E+08	7.02E+08	4.62E+08	4.49E+08	5.59E+08	5.58E+08	7.42E+08
^{90}Sr	4.4E+07	4.4E+07	8.0E+08	3.69E+06	6.52E+06	4.10E+06	4.20E+06	5.29E+07 [N]	5.44E+07 [N]	5.77E+06	5.81E+06	9.60E+06
^{99}Tc	7.1E+06	7.1E+06	7.1E+06	7.98E+05	1.39E+06	8.53E+05	8.60E+05	7.38E+05	6.74E+05	6.72E+05	6.66E+05	5.07E+05
^{60}Co	6.1E+04	6.1E+04	3.7E+05	1.02E+03	5.25E+03	7.06E+03	6.87E+03	1.32E+03	6.31E+02	2.06E+03	2.01E+03	2.68E+03
$^{154}Eu + ^{155}Eu$	1.2E+06	1.2E+06	4.3E+06	4.37E+04	2.07E+02	1.14E+05	1.14E+05	5.71E+03	1.17E+04	6.51E+04	6.35E+04	9.81E+04
From Spec 7.2.2.1	mol/L			mol/L								
Na	3 to 10			6.75	6.98	6.99	6.99	4.58	4.63	6.99	6.99	8.32
				A	A	A	A	C	C	A	A	A
				Y Y Y	Y Y Y	Y Y Y	Y Y Y	N N N	N N Y	Y Y Y	Y Y Y	Y Y Y
				0 0 0	0 0 0	0 0 0	0 0 0	3 1 1	2 1 0	0 0 0	0 0 0	0 0 0
				0 0 0	2 1 2	1 0 0	1 0 0	3 1 1	2 1 0	0 0 0	0 0 0	0 0 0
				4 1 3	3 1 2	4 2 2	4 2 2	4 2 3	5 2 4	4 2 3	4 2 3	4 2 3

LEGEND:

- ☐ Meets Spec, < 50% of maximum
- [5] Meets Spec, > 50% of maximum
- [8] Meets Spec, > 80% of maximum
- [N] Does not meet Spec

The waste in tank 241-AN-107 (Batch 7) is not projected to meet the feed specification (Envelope C) due to high TRU and $^{154/155}$Eu. A large ^{155}Eu detection limit for the liquid was originally included in the calculation of the solid layer ^{155}Eu concentration from the centrifuged solid and liquid data. This caused high ^{155}Eu value and is not expected to be high. During the certification process, analysis should be performed to verify that the TRU does not meet the feed specification and $^{154/155}$Eu does meet the feed specification. If the waste is treatable within the facility, a price for processing the out of specification feed should be negotiated (RL 1996).

The second batch from 241-AN-104 is projected to meet the feed specifications. However, decanting the supernate from tank 241-AN-104 leaves settled solids that are high in sulfate. The diluted supernate will be returned and mixed multiple times with saltcake left in tank 241-AN-104 to ensure Envelope A feed.

The batch from tank 241-S-102 (mixture of 241-S-102, -103, and -105) is not classified as belonging to any envelope because of the high PO_4 concentration. Transferring wastes from 241-S-102, -103, and -105 as soon as the retrieval systems are operational for each tank will provide additional time to negotiate a price for processing the out-of-specification feed (RL 1996), if needed.

There is a risk that WFD may not consistently be able to deliver waste that meets Envelopes A, B, or C feed requirements as required by Specification 7 of the BNFL Inc. contract. Refinement of component partition factors between liquid and solid phases used for retrieval modeling is necessary to confirm the extent to which the composition of the retrieved waste is out of specification.

While clause H.43 in the BNFL Inc. contract (RL 1996) provides some latitude for processing out of specification waste, it does not remove the risk of a rejected feed batch. Clause H.43 states that if (1) the waste can technically be processed and (2) the waste complies with facility permits and (3) the waste falls within BNFL Inc.'s facility safety authorization basis, then a treatment price will be negotiated based on incremental effects on BNFL Inc. costs and processing rates.

The DOE Waste Disposal Division planning guidance (PIO 2000) contains the following statement: "Assume that delivered LAW and HLW feed is within the BNFL Inc. facility permits and safety authorization basis; therefore, no feed blending or adjustments are required" (Section 3.3.1,[1] p. 15). So clause H.43 by itself does not remove any risk from delivery of tank waste out of specification. There are no specific criteria written for the assumption stated above. Nor are estimates available for the size of the incremental cost impacts as discussed in the previous paragraph.

The LAW feed specifications should be modified so that the delivered LAW feed composition meets contract specifications. Specification 7 in the BNFL contract should be modified so that all Hanford tank farm waste, when retrieved to a staging tank, falls within component specifications.

3.2 TANK-SPECIFIC STAGING STRATEGY, EQUIPMENT, AND SCHEDULE

3.2.1 Tank-Specific Staging Plan

The DOE-ORP provided guidance (PIO 2000) for the sequence of source tanks to be used to provide LAW feed to BNFL Inc. That guidance is based on the following assumptions.

- Waste from tank 241-AP-101 is processed first.
- Pretreated Envelope B waste
  - Pretreated waste is processed as the second batch.
  - Pretreated waste is not returned to CHG.
- Tanks 241-AN-101 and -102, and 241-AP-104 used as staging tanks. Tank 241-AP-102 is used as a backup staging tank. Other tanks are to be used as staging tanks as they become available.
- Entrained solids are stored in BNFL facility.
- Stage tanks that are easier to retrieve early.
- Avoid moving onto a subsequent feed tank when only a small amount is remaining in the current tank (tank-hopping). Finish emptying each DST promptly.
- Simplify Projects W-211 and W-521design and construction activities by grouping tanks from the same farm together.

The tank-staging plan was reviewed for consistency with the above criteria; deviations from the above criteria were made when appropriate. These deviations are discussed below. See Appendix I, Figure I-1, for the LAW feed staging and delivery schedule. Appendix H contains a table showing the detailed transfer from the feed batches. Appendix A, Table A-17, contains detailed proposed staging actions, process issues, and equipment considerations. The operational need dates also are included in this table.

As shown in Section 3.1, for Minimum Order Case, six tanks (241-AP-101, 241-AW-101, 241-SY-101, 241-AN-103, -104 and -105) contain Envelope A feed, two tanks (241-AN-102 and 241-AN-107) contain Envelope C feed; and BNFL Inc.'s tank (holding pretreated 241-AZ-101 and 241-AZ-102 tank waste) contains pretreated Envelope B feed for Case 3S6E. All of these feeds must be used towards the minimum order quantity to satisfy the 6,000 unit requirement in the contract (RL 1996). All of Envelope A feeds, with the exception of that from tank 241-AP-101, are on the watch list for flammable gas concerns. Transfer of waste from a hydrogen/flammable gas tank requires written approval by Nuclear Safety and DOE. This is a self-imposed requirement contained in the Operating Specification Document (OSD). It is not required by law or by the authorization basis. On the other hand, transfer of waste *into* a watch-list tank requires written approval by the Secretary of Energy (OSD-T-151-00030, CHG 1999). It is important that all actions needed to obtain these approvals be completed well in

advance of the planned transfer dates (these actions are identified on the Mid-Level Logic Diagrams [Diediker 2000]).

For this case, the following sequence will be used.

The first tank waste was selected from tank 241-AP-101. This tank contains only supernate, classified as Envelope A waste. The waste in the tank is assumed to be retrievable without any modification to the tank or existing pump. Tank 241-AP-101 was chosen to be the first tank to support potential LAW hot operations in April 2006, one-and-a-half years before the target schedule date stipulated in BNFL Inc. contract per direction from the PIO.

The second batch of LAW feed will be the supernate from tanks 241-AZ-101 and 241-AZ-102, which contain Envelope B waste (the neutralized current acid waste [NCAW] supernate). Wastes from these tanks are delivered early to support HLW feed processing. These wastes are processed early to alleviate the absence of BNFL Inc.'s tank space for storage of the pretreated waste. The waste from tanks 241-AZ-101 and 241-AZ-102 will be delivered as a slurry. BNFL Inc. will separate the supernate from the solids, pretreat the liquids, and vitrify the pretreated liquid. Details on the delivery of the contents of those tanks are discussed in Section 4.2.

The third and fourth batches delivered to BNFL Inc. will be Envelope C waste from tank 241-AN-102. Envelope C represents waste with high SO_4, ^{60}Co, ^{90}Sr, $^{154,155}Eu$ and/or TRU contents that will be segregated and removed (except SO_4) to blend with HLW to be treated as HLW. Therefore, Envelope C waste must be treated near the beginning of the process to ensure that segregated Envelope C waste is vitrified before the completion of the HLW vitrification. Furthermore, this tank is needed as a staging tank for other LAW waste. Caustic addition is required to bring this waste to within the tank farm corrosion specifications. The feed batches from tank 241-AN-102 will be delivered to BNFL Inc. after they have processed enough Envelope B (Batch 2) to make enough room to receive Batch 3 in BNFL Inc.'s facility.

Tank 241-AN-104 was selected as the fourth tank for Case 3S6E. Tanks 241-AN-105 and 241-AW-101 are good candidates also. Tank 241-AW-101 was skipped to permit Project W-211 to obtain design and construction efficiencies by upgrading two tanks in the AN Tank Farm, tanks 241-AN-105 and 241-AN-104, on a similar schedule. Once its waste has been retrieved, this tank is needed as the slurry cross-site receiver tank. Therefore, the second portion of the waste will be delivered to BNFL Inc. first while the first batch will be staged in tank 241-AN-101. The first staged waste is projected to meet the feed specifications; however, the second batch from 241-AN-104 is not projected to meet the feed specifications. Present retrieval plans call for decanting the supernate from tank 241-AN-104 and preventing a gas-release event, leaving settled solids that are high in sulfate. The liquid feed produced by dissolution of those solids is outside the sulfate limit in the feed specifications. Decanting the supernate to prevent gas release, returning the supernate to tank 241-AN-104, and mixing the waste to recover all of the tank waste should alleviate the high sulfate problem. Staging 241-AN-104 early (before processing begins) will provide additional time to negotiate a price for processing the out-of-specification feed, if needed. The waste from this tank will be Batches 5 and 6.

The fifth tank quantity of waste delivered to BNFL Inc. will be Envelope C waste, by default from tank 241-AN-107. Caustic addition is required to bring this waste to within tank

farm corrosion specifications. The waste in tank 241-AN-107 (Batch 7) is not projected to meet the feed specification (Envelope C) because of high TRU and $^{154/155}$Eu content. A large ^{155}Eu detection limit for the liquid originally was included in the calculation of the ^{155}Eu concentration in the solid layer from the centrifuged solid and liquid data. The use of a high value in the calculation resulted in a higher ^{155}Eu content than is really expected. During the certification process, analysis should be performed to verify that the TRU does not meet the feed specification and the $^{154/155}$Eu does meet the feed specification. If the waste is treatable within the facility, a price for processing the out-of-specification feed should be negotiated (RL 1996). The waste from this tank will be Batch 7.

The sixth quantity of tank waste was selected from tank 241-AN-105. Once the waste has been retrieved, this tank will be used as a staging tank as needed. Tank 241-AN-105 contains waste that is within 20 percent of the sulfate envelope limit. The waste from this tank will be Batches 8 and 9.

The seventh quantity of tank waste was selected from tank 241-SY-101. This batch is pre-staged in 241-AP-104 and was delivered earlier to accommodate the mitigation of level growth. Waste from 241-SY-101 was transferred to 241-SY-102 containing SWL, and then transferred via the cross-site system to 241-AP-104. The amount of waste estimated for transfer from tank 241-SY-101 to tank 241-SY-102 by the HTWOS model (1,140 m^3 [300,000 gal]) was based on preliminary planning information and is lower than the actual amount of waste transferred (1,990 m3 [500,000 gal]). Future modeling efforts will include actual amounts of waste transferred. This batch is expected to be an Envelope A feed. The second batch from tank 241-SY-101, which is Envelope A waste, will be transferred to 241-SY-102 and then transferred via the cross-site system to 241-AN-101. The waste from this tank will be Batches 10 and 11.

The eighth tank selected for waste removal was tank 241-AN-103. The waste in it may be the most difficult to retrieve since it is the most concentrated of the five Envelope A wastes (it contains double-shell slurry [DSS]; the others contain only double-shell slurry feed [DSSF]). The crust may complicate retrieval operations. Once the waste has been retrieved, this tank could be used as a staging tank as needed. The waste from this tank will be Batches 12 and 13.

The Envelope A feed for the last Minimum Order tank will come from tank 241-AW-101, the ninth tank selected. This tank will supply the first feed for the Extended Order tank if not used as the feed for the Minimum Order. The waste from this tank will be Batches 14 and 15.

The tenth tank selected for waste removal is tank 241-AW-104, which contains Envelope A waste. Only the liquid portion of the waste in tank 241-AW-104 will be used for LAW feed. The sludge portion will be supplied as HLW feed. The waste from this tank will be Batch 16.

The eleventh tank selected for waste removal is tank 241-SY-103, which contains Envelope A waste. Only the supernate portion of the waste in tank 241-SY-103 will be used for LAW feed. The waste from this tank will be Batch 17.

The twelfth tank selected for waste removal is tank 241-AP-106, which contains saltwell liquor from the SST stabilization program that is classified as Envelope A waste. The waste from this tank will be Batches 18 and 19.

The waste from tanks 241-S-102, -103 and –105 are blended and are identified as the waste from the thirteenth tank, tank 241-S-102. Only the soluble portion of the waste from these tanks will be used for LAW feed. The blended waste will be stored in the staging tank 241-AP-101. The blended waste in the tank is not classified as belonging to any envelope because of its high PO4. Transferring wastes from 241-S-102, -103, and -105 as soon as the retrieval systems are operational for each tank will provide additional time to sample the staged waste, identify any out-of-specification conditions, and to negotiate a price for processing the out-of-specification feed, if needed. The waste from tank 241-S-102 will first be transferred into tank 241-SY-103 where it will be mixed with waste either from tank 241-S-103 or -105; this activity will be followed by cross-site transfer into tank 241-AN-104, and finally into tank 241-AP-101 for staging. The waste from these tanks (241-S-102, -103 and –105) will be labeled Batch 20.

The waste from tanks 241-S-105, -106 and –108 are blended and are identified as the waste from the fourteenth tank, tank 241-S-105. Only the soluble portion of the waste from these tanks will be used for LAW feed. The blended waste will be stored in the staging tank 241-AN-105. The blended waste in the tank is classified as envelope C waste. The waste from tank 241-S-105 will first be transferred into tank 241-SY-103 where it will be mixed with waste from tank 241-S-106; this activity will be followed by cross-site transfer into tank 241-AN-104, and finally into tank 241-AN-105 for staging. The waste from tank 241-S-106 will first be transferred into tank 241-SY-103 where it will be mixed with waste from tank 241-S-108; this activity will be followed by cross-site transfer into tank 241-AN-104, and finally into tank 241-AN-105 for staging. The waste from these tanks (241-S-105, -106 and –108) will be labeled Batch 21.

The fifteenth tank selected for waste removal is tank 241-AP-105, which contains saltwell liquor from the SST stabilization program; this waste is classified as Envelope A waste. Tank 241-AP-104 will be used as the staging tank. The waste from this tank will be Batches 22 and 23.

The last tank selected for Extended Order processing is tank 241-AP-108, which contains saltwell liquor from the SST stabilization program; this waste is classified as Envelope A waste. The waste from this tank will be Batch 24. This information is summarized in Table 3.2-1.

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AP-101	AP-101	• Grab sample to certify supernate • Transfer to BNFL Inc. with in-line dilution if needed	• Waste from AP-101 should not need dilution to transfer to BNFL Inc.	• Has operational Flexi-float pump • W-522 replaces so it works in 2015 Ready date April 2004 Op need date August 2005 • Ability to transfer from AP-101 to BNFL Inc. (need pump upgrade?) • Replacement pump has dilution water piped to the suction inlet
AZ-101	AZ-101	• Deliver supernate with HLW solids (see Table 4.2-1)	• See Table 4.2-1	• See Table 4.2-1
AZ-102	AZ-102	• Deliver supernate with HLW solids (see Table 4.2-1)	• See Table 4.2-1	• See Table 4.2-1
AN-102	AN-102	• Caustic Addition (0.5*M*) within available freeboard • Mix contents • Settle solids • Sample and certify supernate • Decant and deliver to BNFL Inc. with in-line dilution • Clean out heel to AP-107 with 530 m^3 (140.4 kgal) of wash water.	• Room available for NaOH needed to meet corrosion spec.? (303 m^3 [80 kgal] of freeboard now) • What is the plan for caustic addition? (assumed 10/1/2001) • Deliver as 2 batches (keep the decant step and flush cleanout) • Move residual (clean out) to AP-107 • How clean does it need to be for staging tank use? • No firm agreement in place for BNFL to process entrained solids • Alternate adjustment and dilution could send all AN-102 waste to BNFL • The actual sludge volume in the tank may be higher. • Eliminate need to clean out solids heel • May still need a flush of the tank because of Envelope change • Need to dilute more to dissolve $NaCO_3$ • Sodium carbonate precipitation not a serious issue below 2*M* Na OH	• Alternative Generation and Analysis (AGA) in progress • What equipment do we need? - should only need one mixing or agitation device - destination of solids may drive transfer pump selection - need decant pump for later use as staging tank • AN-102 may not be suitable for use as staging tank because of past corrosion • May need "Fitness of Use" evaluation for use as staging tank • Elimination of decant step may save operations dollars by getting rid of decant pump and subsequent replacements (better overall to send all solids to BNFL) • W-211 to install retrieval system Ready Date May 2006 Op Need Date June 2007

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AN-104	AN-101 (supernate) AN-104 (dissolved solids)	• Decant supernate to AN-101 with in-line dilution. • Install mixer pumps (by sluicing). • Transfer 1,140 m^3 (300 kgal) of diluted supernate from AN-101 to AN-104. • Mix the waste and allow solids to settle. • Decant 1,140 m^3 (300 kgal) from AN-104 to AN-101. • Mix the waste in AN-101. • Sample both AN-101 and AN-104 for Na and SO_4 • Add water to each tank to dilute Na to 7*M* - 715 m^3 (189 kgal) H_2O to AN-101 - 416 m^3 (110 kgal) H_2O to AN-104 • Transfer 1,140 m^3 (300 kgal) from AN-101 to AN-104 • Mix the waste in AN-104 and allow solids to settle • Transfer 1,140 m^3 (300 kgal) from AN-104 to AN-101 • Mix the waste in AN-101 • Transfer 1,140 m^3 (300 kgal) from AN-101 to AN-104 • Mix the waste in AN-104 and allow solids to settle • Sample AN-104 to see if SO_4 is within specification • If within specification, sample both AN-101 and AN-104 to certify • Decant AN-104 to deliver to BNFL Inc. • Transfer AN-101 to deliver to BNFL Inc. • Remove solids heel from AN-104 using SY-102 supernate and transfer to AZ-101 (clean out for subsequent use)	• Would like to sample while settling to be able to see what solids are. May be able to send undissolved solids rather than letting settle and decanting. • Degassing occurs by decanting supernate • Use as cross-site receiver may cause problems for use as backup staging tank (heels). • High SO_4 in dissolved solids part (adjust retrieval volumes to fix). • Preliminary calculations show that 3 to 6 transfers are needed to blend SO_4 • Assume 6 transfers as planning basis until tank-specific flowsheet confirms ability to blend SO_4 with 3 transfers • HTWOS only needed to add 1,874 m^3 (495 kgal) of water to dissolve solids and dilute waste to 7*M*.	• Need mixer pump and decant pump • May have problem inserting mixer into settled solids; sluice into place • Existing transfer pump won't do the needed job. • Junk equipment (sampling debris); will its presence cause mixing problems or damage equipment? • Another east area cross-site receiver is needed • W-211 will replace that pump March 2004 (turnover) Op need date Dec. 2004 - Transfer back and forth between DST's to dilute SO_4 - Certify feed in both DST's to send to BNFL • Proposed staging actions implement Interim Guidance provided by Russ Treat, June 21, 1999. • <u>Interim Guidance</u> - Use AN-104 to demonstrate degassing - Install outside-of-tank equipment. - Sluice in decant pump per degassing constraints - Decant supernate (with in-line dilution) - Install mixer pump into solids with sluicing (1 to 2 days/pump) - Add dissolution H_2O, mix to dissolve, and settle - Transfer back and forth between DSTs to dilute SO_4 - Certify feed in both DSTs to send to BNFL Inc.

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AN-107	AN-107	• Caustic addition (0.5*M*) within available freeboard • Mix contents • Settle solids • Sample and certify supernate • Decant and deliver to BNFL Inc.	• Is room available for NaOH needed to meet corrosion spec.? (363 m^3 [96 kgal] of freeboard now) • What is the schedule for caustic addition? (assumed 10/1/2001) • $NaCO_3$ precipitation after NaOH added – will solids settle? – Still meet spec.? • How close to settled solids can we decant? (25 cm [10 in.] above current solids layer – same in AN-102) • How long to settle the solids? • Final solids density after settling • No use restrictions on tank after retrieval for feed delivery. • Env. C - Out of specification • Deliver as 1 batch (in-line dilution, if necessary) • Doing detailed calculations for AN-107 - May get more feed, could make 2 batches - May need additional dilution to deliver	• AGA in progress • What equipment do we need? - should only need 1 mixing or agitation device (who will confirm?, 2/7-AN AGA. • Sludge weight in bottom—potential for pump damage if there is a cable - Assume not a problem for staging • W-521 to install retrieval system Ready date July 2008 Op need date April 2009
AN-105	AN-102 (supernate) AN-105 (dissolved solids)	• Remove supernate to AN-102 (Degas by decanting) • In-line dilute as transferred • Certify in AN-102 • Install mixer pump • Add H_2O to slurry (left in AN-105) • Mix to dissolve salts • Settle solids • Certify new supernate in AN-105 • Decant supernate and deliver to BNFL Inc.	• Sample while settling to determine what solids are. May be able to send undissolved solids rather than letting settle and decanting. • May need to blend supernate and dissolved solids to dilute SO_4 (feed from dissolved solids is just under the SO_4 limit.)	• Need mixer pump and decant pump • May have problem inserting mixer into settled solids • Existing transfer pump won't do the needed job. • W-211 will replace that pump Ready date August 2009 Op need date October 2009 • Latest project plan (interim guidance provided in late July) - Install outside-of-tank equipment. - Sluice in decant pump per degassing constraints - Decant supernate (with in-line dilution) - Install mixer pump into solids with sluicing (1 to 2 days/pump) - Add dissolution H_2O, mix to dissolve, and settle - Certify feed in both DSTs to send to BNFL

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
SY-101	AP-104	Initial mitigation retrieval • 339 m^3 (89.5 kgal) to SY-102 with 318 m^3 (84 kgal) of diluent (H_2O) • Add 235 m^3 (62 kgal) of H_2O to SY-101 • Mix SY-101 (1st retrieval gets mixed with saltwell liquor (SWL) in SY-102, SY-102 will go to AP-104)	• Combining 1st retrieval with SWL in SY-102 could turn waste into Env. C. • Homogeneity problem in SY-102 (impact of transfer line routing decision) • Transfer through SY-102 introduces significant risk.	• Has mixer pump and transfer pump (to support retrieval and back dilutions) • SY farm needs transfer lines upgraded (now non-compliant), vent system upgraded, and retrieval equipment installed • Not sure which project upgrades lines and vent system • W-521 puts in retrieval and transfer equipment for transfers to AN-101 Ready date Aug. 2010 Op. need date November 2010 • Assume transfer line problems and vent system problems are fixed or don't limit ability to retrieve and stage for delivery. • No data available to team to model the effect of line and vent system problems in HTWOS • May want to configure SY-101 for cross-site transfers • 2nd SY-101 batch could be retrieved ~1 year earlier than now shown if the SY valve pit is configured to allow use of all SY tanks for cross-site transfers (after SY-101 installation work is done)
	AP-104	Second Mitigation • Retrieve approximately 908 m^3 (240 kgal) to SY-102 to AP-104 with 750 m^3 (198 kgal) H_2O in-line dilution • Certify waste in AP-104 for delivery to BNFL Inc. • Add H_2O to SY-101 to replace volume removed • Mix SY-101		
	AN-101	• Decant to SY-101 supernate to SY-102 then transfer to AN-101 • Certify stage for delivery (post W-521 upgrade)		

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AN-103	AN-102 (supernate) AN-103 (dissolved solids)	• Remove supernate to AN-102 (Degas by decanting) • In-line dilute as transferred • Certify in AN-102 • Add H_2O to slurry (left in AN-103) • Mix to dissolve salts • Settle solids • Certify new supernate in AN-103 • Decant supernate and deliver to BNFL	• Sample while settling to determine what solids are. May be able to send undissolved solids rather than letting settle and decanting.	• Need mixer pump and decant pump • May have problem inserting mixer into settled solids • Existing transfer pump won't do the needed job. • W-211 will replace that pump Ready date February 2011 Op need date May 2011 • Latest project plan (interim guidance provided in late July 1999) - Install outside-of-tank equipment. - Sluice in decant pump per degassing constraints - Decant supernate (with in-line dilution) - Install mixer pump into solids with sluicing (1 to 2 days/pump) - Add dissolution H_2O, mix to dissolve, and settle - Certify feed in both DSTs to send to BNFL • Assume AN-104 experience allows mixer pump installation before supernate decant step. Project schedules are being adjusted to provide time for two-stage equipment installation if necessary.
AW-101	AN-105 (supernate) AW-101 (dissolved solids)	• Remove supernate to AN-105 (Degas by decanting) • In-line dilute as transferred • Certify in AN-105 • Add H_2O to slurry (left in AW-101) • Mix to dissolve salts • Settle solids • Certify in AW-101 • Decant and deliver to BNFL Inc.	• Sample while settling to determine what solids are. May be able to send undissolved solids rather than letting settle and decanting. • Failed pump in AW-101 may interfere with mixing.	• Need mixer pump and decant pump in AW-101 • May have problem inserting mixer into settled solids • Existing transfer pump won't do the needed job. • W-211 will replace AW-101 pump Ready date February 2012 Op need date March 2012 • Latest project plan (interim guidance provided in late July 1999) - Install outside-of-tank equipment. - Sluice in decant pump per degassing constraints - Decant supernate (with in-line dilution) - Install mixer pump into solids with sluicing (1 to 2 days/pump) - Add dissolution H_2O, mix to dissolve, and settle • Certify feed in both DSTs to send to BNFL Inc.

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AW-104 (supernate)	AP-104	• Decant to evaporator feed tank • Concentrate and return waste to AW-104 (combines with some SWL in the Evaporator) • In-line dilute to transfer • Certify in AP-104 • Transfer supernate to BNFL Inc.	• Tank contains dilute supernate that needs to be concentrated • May have to stage supernate earlier (than needed for LAW feed delivery) to use AW-104 to stage HLW solids or deliver both LAW and HLW together	• Need mixer pump and decant pump • Existing transfer pump has failed • Need to replace transfer pump earlier to stage SWL for concentration in evaporator • Operations will fix existing transfer pump by ~6/20/2001 • W-521 Ready date September 2011 Op need date December 2012
SY-103	AN-101	• Decant supernate to SY-102 (with in-line dilution) • Cross-site supernate to AN-101 • Certify in AN-101 • Transfer to BNFL Inc.	• Need to go through SY-102? (upgrade timing) • Env. A – within specification	• SY-103 has transfer pump (probably failed) • W-521 replaces transfer pump Ready date June 2009 Op. need date November 2012 • Need decant pump for when SST wastes are moved through SY-103 • W-521 should install a dual-function pump • May want to configure SY-103 for cross-site transfers • May need or want mixing device for Phase 2 solids • SY valve pit should have been reconfigured by now (as part of SY-101 work) to allow use of SY-103 for cross-site transfer. • Will transfer pump being put into SY-103 support its use for direct cross-site transfers? Need to look at pump-intake (a.k.a. in-line) dilution requirements also.
AP-106 (concen-trated SWL accumula-tion; all supernate)	AN-102 AP-106	• Mix supernate (no solids expected) • Transfer ~ ½ to AN-102 with in-line dilution • Certify first ½ in AN-102 • Transfer to BNFL • Add H_2O to dilute second ½ • Certify in AP-106 • Transfer to BNFL Inc.	• Can we qualify the waste in AP-106 and transfer with in-line dilution? • Could use only 1 DST if we do not dilute the waste with water • Receive 265,000 L (70,000 gal) less from AW-106.	• Maintained by Operations to serve as SWL receiver • W-522 upgrades transfer pump for transfer of waste for phase 1B prime feed Ready date Nov. 2013 Op need date Mar. 2014 • Ability to transfer from AP-106 to BNFL Inc. (need pump upgrade?)

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
S-102 (S-103, S-105)	AN-101	• Retrieve into SY-103 (use past-practice sluicing parameters in model; assume retrieval with H_2O) • Dissolve salts in SY-103 heel (SY-103 is receiving several SST wastes at one time; S-103, S-102, and S-105) • <u>Periodically</u> Settle solids, decant supernate, transfer cross-site to an available DST, and transfer to AN-105 through the AN-104 pump pit	• Need to get only salts for LAW feed. Will assume complete SST retrieval of all S-farm waste. • Limit on simultaneous retrievals into one destination tank? • What in SY-103 dissolves? • Latest BBI/Hanlon (1999b) says more OH solids than before. - Terminology: salt solids have been called sludge - The term "sludge" should be reserved for metal hydroxide solids • SST retrieval may require NaOH addition to meet DST corrosion specifications - Especially in low pH, phosphate-containing wastes - BBI not account for OH consumption over time	• AN-101 equipment already in place in AN-101 and maintained by Operations. • May have failed pump in bottom of SY-103 - Problems with mixing - Tank damage by fluid moving the failed pump? • W-523 (S-102) Ready date July 2012 Op need date February 2013
S-105 (S-106, S-108)	AN-101	• Retrieve into SY-103 (use past-practice sluicing parameters in model; assume retrieval with H_2O) • <u>Periodically</u> Settle solids, decant supernate, transfer cross-site to AN-104 and then to AW-101 • SY-103 is receiving several SST wastes at one time (S-105, S-106, and S-108)	• Need to get only salts for LAW feed. Will assume complete SST retrieval of all S-farm waste. • Limit on simultaneous retrievals into one destination tank? - Latest BBI/Hanlon (1999b) says more OH solids than before. Terminology: salt solids have been called sludge • SST retrieval may require NaOH addition to meet DST corrosion specifications.	• Need mixer pump and decant pump in SY-103 • May have failed pump in bottom of SY-103 - Problems with mixing - Tank damage by fluid moving the failed pump? • W-523 Ready date February 2013 Op need date May 2013
AP-105 (concen-trated SWL accumul-ation; all supernate)	AP-104	• Mix supernate (no solids expected) • Transfer ~ ½ to AP-104 with in-line dilution • Certify first ½ in AP-104 • Transfer to BNFL Inc.	• There will be solids that will require a mixer pump to redissolve before feed delivery • Precipitation occurs during the 10 years of storage because of natural evaporation and cooling.	• Existing transfer pump in AP-104 has problems • Assume it will work until W-211 replaces; some risk if SY-101 isn't Env. A; we need to move it on, and pump fails) • Need mixer pump and decant pump • May get by with a stick pump (depends on accumulated solids levels) • W-211 (AP-104) Ready date August 2004 Op need date November 2004 (for use as backup feed)

Table 3.2-1. Low-Activity Waste Feed Preparation. (8 Sheets)

Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
AP-105 (Continued) (concen-trated SWL accumul-ation; all supernate)	AP-105	• Add H_2O to dilute second ½ • Certify in AP-105 • Transfer to BNFL Inc.	• Ability to transfer from AP-105 to BNFL Inc. (need pump upgrade?)	• Maintained by Operations to serve as concentrated waste receiver (until FY 2000) • W-522 upgrades AP-105 transfer pump Ready date June 2015 Op need date September 2015
AP-108 (concentrat ed SWL accumula-tion)	AP-108	• Mix supernate (no solids expected) • Certify • Transfer to BNFL Inc.	• There will be solids that will require a mixer pump to redissolve before feed delivery • Precipitation occurs during the 10 years of storage because of natural evaporation and cooling.	• Need new transfer pump and jumpers, and Instrumentaion and Control (I&C) system • W-522 provides upgrades Ready date September 2014 Op need date April 2016

AGA= Alternative generation and analysis
BBI = Best-basis inventory
DST = Double-shell tank
I&C = Instrumentation and control
IWFST = Intermediate Waste Feed Staging Tank
LAW = Low-activity waste
SST = Single-shell tank
SWL = Salt well liquid.

3.2.2 Equipment

Table 3.2-2 summarizes a preliminary assessment of the equipment needed for WFD performed for Case 3S6E. Most of the work is covered by an existing project. The installation of a transfer pump, jumpers, and an instrument and control (I&C) system to tank 241-AP-101 is not scoped or funded under an existing project. Project validations will be completed between FY 2000 and FY 2002. Projects that fall with this category are W-521, W-522, and W-523. Retrieval equipment for 241-AP-101 will be provided and installed by Tank Waste Operations with expense funding.

Other equipment issues still unresolved include primary ventilation for AY/AZ and SY tank farms, toxic gas treatment, and electrical distribution. As formal decisions are made for these issues, the work scope will be assigned to current projects or to a new project yet to be validated.

Implementation of the Extended Order quantity assumes that backup staging tanks would still be required in AP tank farm to support staging of backup feed. W-211 has completed the design and some equipment procurement for these tanks.

Implementing the Extended Order quantities would require the following work scope changes: Tanks 241-AN-101 and -102 would be upgraded with mixer pumps, new waste transfer pumps, jumpers and instrumentation. These upgrades will be required to support use of the tanks as LAW staging tanks.

Table 3.2-2. Equipment Required for Case 3S6E/Phase 1B for Low-Activity Waste.

Tank or project number	Equipment required	Cost (in millions of dollars)
AP-102 & 104 (W-211)[1] • LAW Backup Feed Staging Tanks	• One mixer pump per tank • One transfer pump per tank • Jumpers in central pump pit • I&C system	$21
AP-101 (TBD)[2] • LAW source tank	• One transfer pump plus jumpers • I&C system	$5
AN-101 (W-521) • LAW intermediate waste feed staging tank	• Two mixer pumps (150 hp) • New transfer pump and jumpers • I&C system	$22[3]
AN-102 (W-211)[2] • LAW source tank • LAW intermediate waste feed staging tank	• Two mixer pumps • New Transfer pump and jumpers • I&C system	$15
AN-104 (W-211)[2] • LAW source tank • Intermediate staging tank for cross-site slurry transfers	• Two mixer pumps • New transfer pump and jumpers • I&C system	$17
AN-107 (W-521)[2] • LAW source tank	• New transfer pump and jumpers • I&C system	$17[3]
AN-105 (W-211)[2] • LAW source tank	• Two mixer pumps • New transfer pump and jumpers • I&C system • Chemical addition/dilution system	$18
SY-101 (W-521)[2] • LAW source tank	• Two mixer pumps • New transfer pump and jumpers • Re-jumper SY-A & B valve pit • Replace SN pipelines for SY-101, -102, and –103	$32[3]
AN-103 (W-211)[2] • LAW source tank	• Two mixer pumps • New Transfer pump and jumpers • I&C system	$18
AW-101 (W-521)[2]	• Two mixer pumps • New transfer pump and jumpers • I&C system • Chemical addition/dilution system • Does not include removal of failed submersible pump	$26[3]
AW-104 (W-521)[1] • LAW source tank – supernate retrieval	• Two mixer pumps • New transfer pump and jumpers • I&C system	$28[3]

Table 3.2-2. Equipment Required for Case 3S6E/Phase 1B for Low-Activity Waste.

Tank or project number	Equipment required	Cost (in millions of dollars)
SY-103 (W-521)[1] • LAW source tank • S Farm receiver tank	• Two mixer pumps • New transfer pump and jumpers • I&C system	$23[3]
AP-106 (W-522)[1] • LAW source tank	• One mixer pump • New transfer pump and jumpers • I&C system	$17[3]
S-103 (Expense-funded retrieval Demonstration)	• Salt cake dissolution system, "rain-bird" and dilution water addition system • Waste transfer pump • Pits and jumpers • New pipelines to SY-103	$15[3]
S-102 (W-523)[1] • LAW source tank	• Baseline sluicing and dilution water addition system • Waste transfer pump • Pits and jumpers • New pipelines to SY-103	$83[3]
S-105 (W-523)[1] • LAW source tank	• Baseline sluicing and dilution water addition system • Waste transfer pump • Pits and jumpers • New pipelines to SY-103	$83[3]
AP-105 (W-522)[1] • LAW source tank	• New transfer pump and jumpers • I&C system	$17[3]
AP-108 (W-522)[1] • LAW source tank	• New transfer pump and jumpers • I&C system	$17[3]
W-314 Phase 1	• AN-A & B valve pit jumpers • Reroute Cross-site to AN-101 & 104 • Pipelines from AN-101 to AZ V.P. • New AZ V.P. • Pipelines from AN-104-04A to new AP valve pit provided by W-521 • Pipelines from AZ V. P. to new AP valve pit provided by W-521 • AW-A & B V. P. jumpers • AY pipelines to AZ V.P. • AZ pipelines to AZ V.P. • MPS system	$157
W-314 Phase 2	• AN Tanks 102, 103, 105, 106 & 107 A pit drain seal, SPC & LDE upgrades; new primary HVAC system, plus selected instrumentation, alarm, and electrical upgrades • AP tanks 101, 102, 103, 105, 106, 107, & 108 selected pit drain seal, SPC & LD upgrades; new primary HVAC system, plus selected instrumentation, alarm, and	$127.8

Table 3.2-2. Equipment Required for Case 3S6E/Phase 1B for Low-Activity Waste.

Tank or project number	Equipment required	Cost (in millions of dollars)
	electrical upgrades • AW tanks 101, 102, 103, 105, & 106 selected pit drain seal, SPC & LD upgrades; new primary HVAC system, plus selected instrumentation, alarm, and electrical upgrades • AY Farm selected instrumentation, alarm, and electrical upgrades • AZ Farm selected instrumentation, alarm, and electrical upgrades • SY tanks 101, 102, & 103 selected pits plus SY-A & B valve pit drain seal, SPC & LD upgrades; new annulus HVAC system, plus selected instrumentation, alarm, and electrical upgrades • 244-S pit drain seal, SPC & LD upgrades; new primary and annulus HVAC system, plus selected instrumentation, alarm, and electrical upgrades	
W-521 (New AP Valve Pit)	• New AP valve pit • Two new pipelines to existing AP V.P. • Upgrade existing AP valve pit jumpers and valve position indication • Tie required instrumentation into W-314 MPS • BNFL Inc. 4 pipelines (LAW & HLW)	$35[3]

HLW = High-level waste
HVAC = Heating, ventilating, and air conditioning
I&C = Instrumentation and control
LAW = Low-activity waste
LDE = Leak Detection Element
MPS = Master Pump System
SPC = Special Protective Coating
[1]Staged backup feed
[2]Minimum order
[3]Cost shown is preconceptual rough-order-of-magnitude estimate. Costs are not validated.

A number of alternative generation and analysis (AGA) studies are under way or planned that address open issues related to DST infrastructure systems. The studies will assess the following systems: electrical power distribution, transfer system valve control/operation, primary ventilation requirements, annulus ventilation of aging-waste tanks, transfer pump design, waste transfer system jumper needs, and sluicing/mixer pump interface at 241-AY-101 and -102.

Table 3.2-2 summarizes equipment needed for WFD during Extended Order of the privatization mission. The identified tanks provide additional waste to meet maximum waste feed quantities as specified in the contract.

3.2.3 Schedules

Waste feed delivery schedules for LAW have been established to support continuous BNFL Inc. operations for Case 3S6E at Phase 1 rates between 2000 and 2018. A summary of Phase 1 project operational need dates and proposed construction dates for source and staging tanks is shown in Figures 3.2-1 and 3.2-2. Operation need dates are established by a BNFL Inc. processing schedule calculated from HTWOS modeling with an allowance for time to transfer, blend, and qualify waste as required. Proposed construction dates support transfers, qualification, and delivery of feed, but need to be further coordinated with projects. The coordination with projects is necessary to minimize construction interferences within a tank farm and to improve project Budge Authority/Budget Outlay profiles by minimizing abrupt changes and severe peaks.

3.2.3.1 Mission Summary. Mission summary diagrams for Case 3S6E are shown in Figures 3.2-1 and 3.2-2 for Phase 1B and Phase 1B-Extended Order, respectively. The diagrams summarize the schedule interface between project actions and the need dates driven by the feed staging scenarios. Tanks supporting LAW feed delivery are shown on the upper portion of each figure and HLW tanks are shown on the lower portion. Storage and disposal activities are shown at the bottom of Figure 3.2-2. Magenta-colored bars represent project activities. Blue-colored bars represent tank farm operations and characterization activities. Green-colored bars represent BNFL Inc. processing periods as calculated by the HTWOS model.

Figure 3.2-1. Mission Summary Diagram. Feed Delivery, Storage and Disposal Mission Summary for Case 3S6E R2A

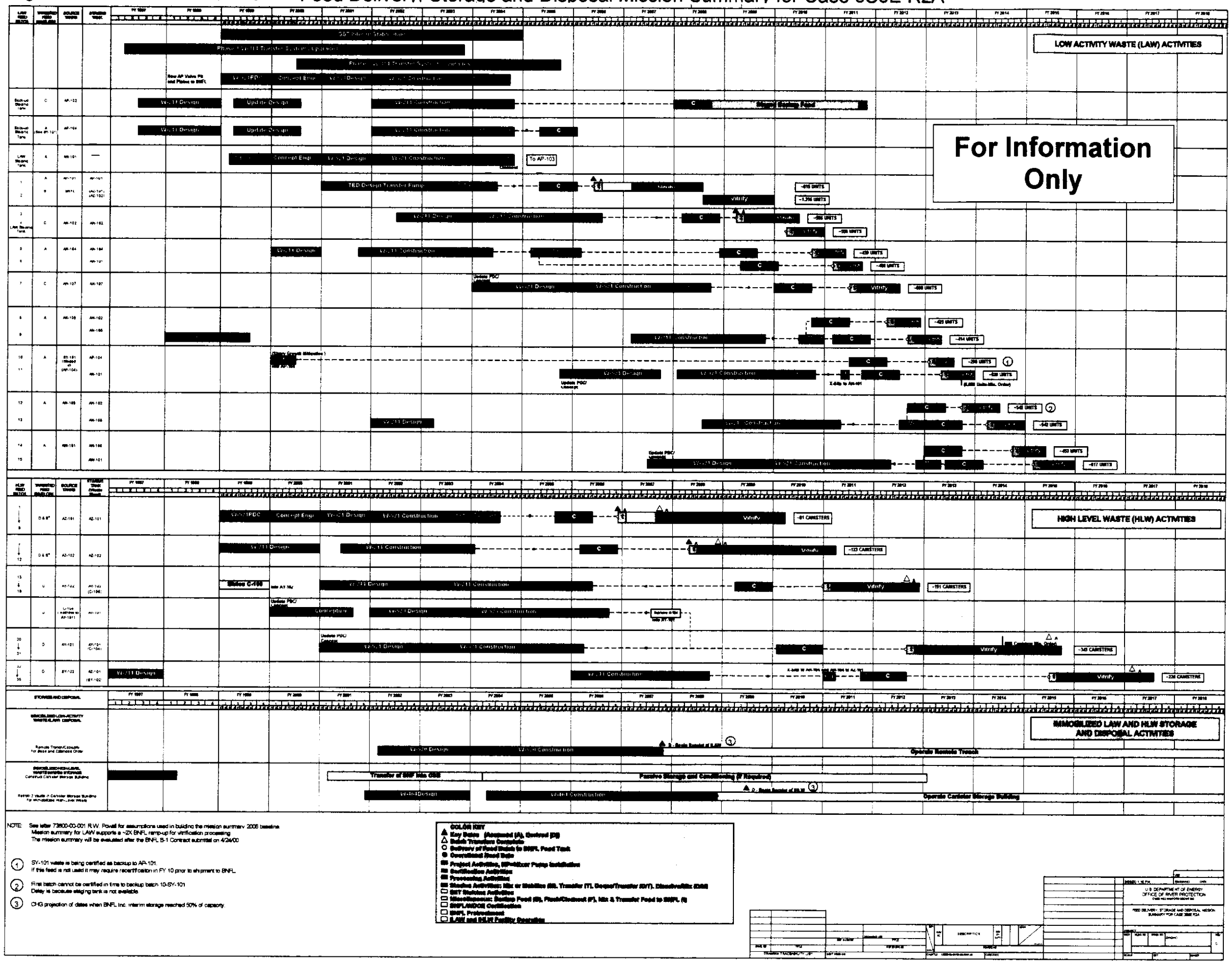


Figure 3.2-2. Mission Summary Diagram (Extended Order).

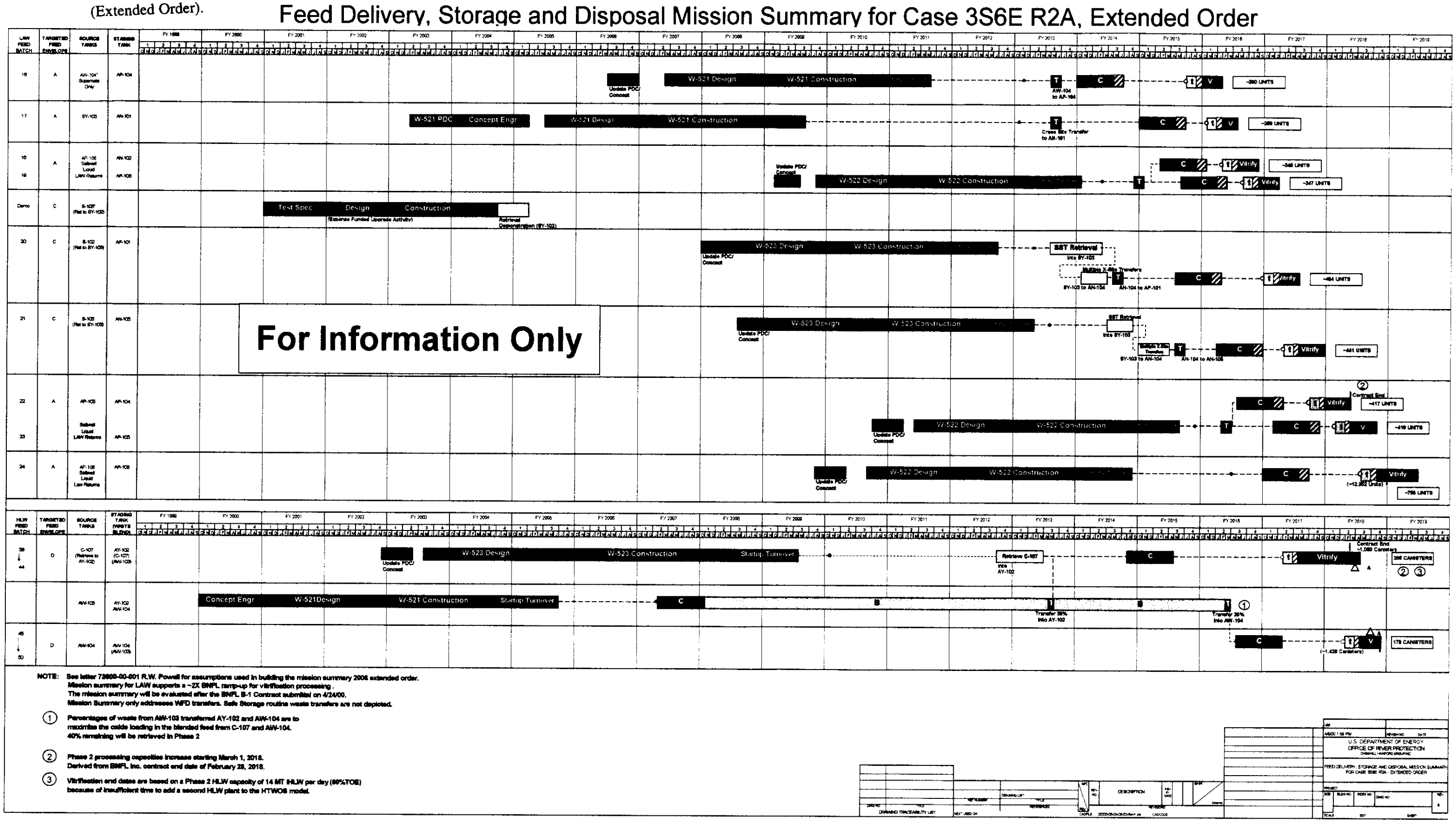
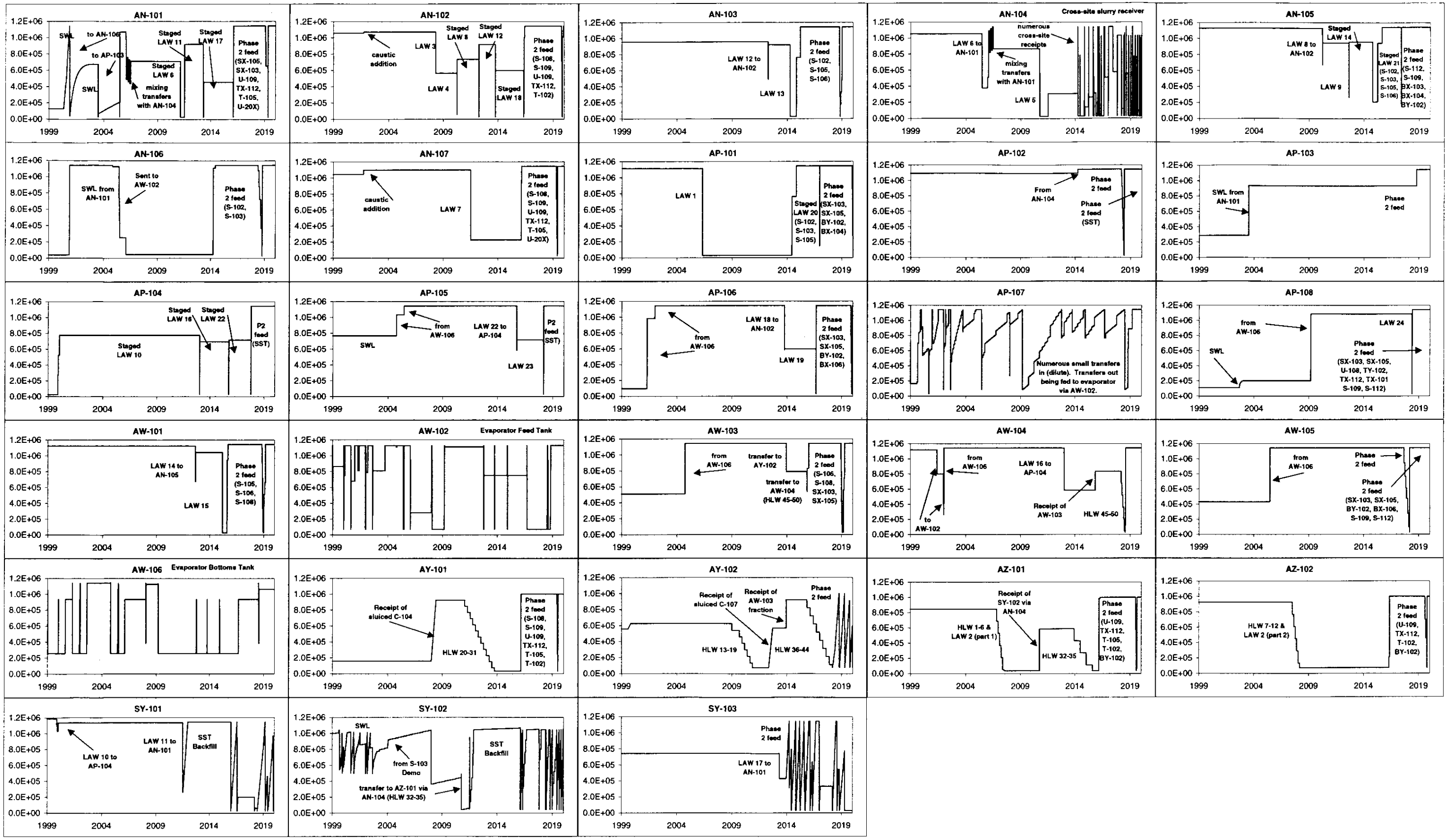


Figure 3.2-3. Tank Volume Plots for Case 3S6E.



Note: Figure contains transfers for phase 2 HLW.

Backup feed is provided for all LAW and HLW source tanks throughout the minimum order processing. Tank 241-AP-102 provides additional backup LAW feed capability from an independent tank farm should a single-point failure occur between AN tank farm and the new AP valve pit. Tank 241-AW-103 provides additional backup HLW feed capability from an independent tank farm should a single-point failure occur between AZ or AY tank farms and the new AP valve pit.

Figure 3.2.3 shows projected use of DSTs through the end of Phase 1. Notes on the figure indicate all tank-to-tank transfers performed for staging and delivery transfers to BNFL Inc. during Phase 1. Backfilling DSTs near the end of Phase 1 for early Phase 2 feed is also shown on the figure.

3.2.3.2 Coordination of Tank Usage and Construction Activities. Tank usage diagrams for Case 3S6E are shown in Appendix H. The diagrams summarize the schedule interface between project actions and the need dates driven by the feed staging scenarios for each DST. Colored bars are used to represent project, tank farm operations, and characterization activities. Every transfer of more than 189 m^3 (50,000 gal) is shown on the chart, providing the transfer is tank-to-tank or tank-to-BNFL Inc. When multiple transfers occur in the same month, they are moved to the previous month or to the next month depending on the date (transfer order is preserved). For example, five transfers occur in the same month for tank 241-AN-104; they are artificially placed into adjacent months.

3.3 LOW-ACTIVITY WASTE FLOWSHEET

Figure 3.3-1 depicts the interfaces between the CHG and BNFL Inc. The CHG's operations consist of retrieving waste, blending and delivering feed, receiving IHLW for interim storage, and receiving ILAW for disposal. Phase 1 functions performed by the CHG now include the following:

1. Sluicing and/or mixer pump retrieval of sludge from five tanks (sometimes including carrier liquid that is also LAW feed), adjustment of HLW slurry properties (as needed for specification compliance or to facilitate transfers), blending (as needed), and staging of feed batches to BNFL Inc. (Section 4.0).

2. Retrieval of LAW supernate with simultaneous adjustment of properties (as needed), and dissolution of salt slurry followed by retrieval of the dissolates, and staging of feed batches to BNFL Inc. (Section 3.0).

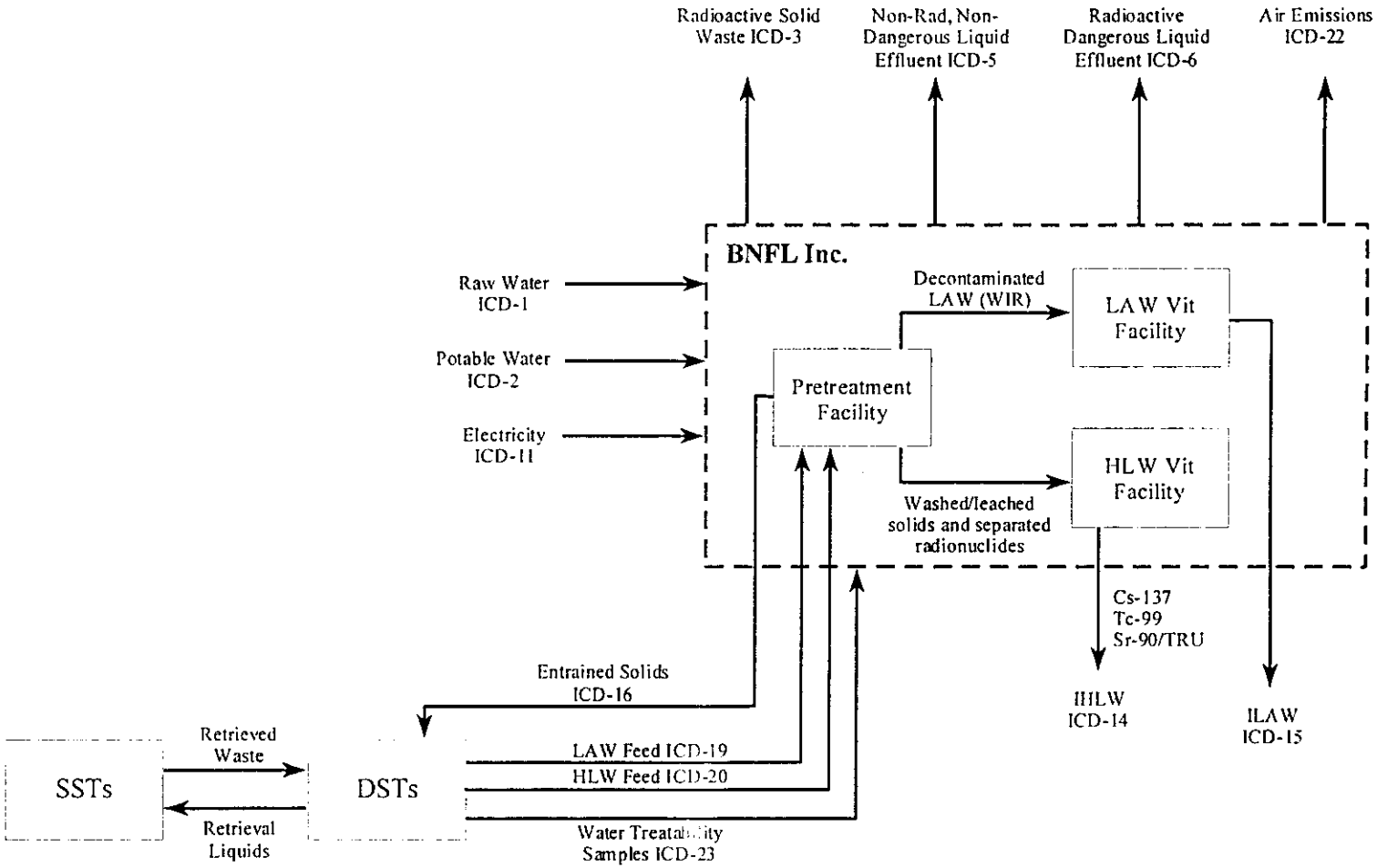
Phase 1 processing by BNFL Inc. includes the following:

1. Pretreatment to recover LAW and HLW fractions from feed materials

2. Vitrification of the LAW fraction and packaging for disposal

3. Vitrification of the HLW fraction and packaging for disposal

Figure 3.3-1. Phase 1 Process Interfaces.



DST = Double-shell tank
HLW = High-level waste
ICD = Interface control document
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
SST = Single-shell tank
TRU = Transuranic
Vit = Vitrification
WIR = Waste Incidental to Reprocessing (per DOE Order 435.1)

4. Disposal of waste components not vitrified (including components intentionally separated from feed because of incompatibilities with glass; volatile components evolved during vitrification; and large amounts of waste water evolved throughout the process).

The HTWOS model incorporates numerous assumptions pertaining to operations for which BNFL Inc. is responsible. Some assumptions are obtained from BNFL Inc., and some are based on past flowsheeting experience. Key modeling assumptions are discussed in Appendix A. The HTWOS model contains only a simplified flowsheet for retrieval, feed delivery, pretreatment, and vitrification. The preparation of separate, detailed, tank-specific flowsheets began in FY 1999. Flowsheets were prepared for tanks 241-AN-104, 241-AN-105, and 241-AZ-101 (Orme 1999a, 1999b, 1999c). Those flowsheets are being revised in FY 2000, and additional flowsheets are being prepared.

The effort to prepare tank-specific flowsheets is being streamlined by classifying the source tanks according to the similarity of feed delivery steps. Each class is described in the text below, and Figure 3.3-2 identifies which source tanks belong to which flowsheet class.

Class 1 tanks contain LAW liquids and sometimes a sludge layer. Supernate layers are delivered with in-line dilution (as needed). The sludge layer may or may not be Phase 1 feed, so the disposal of the sludge layer varies from tank to tank. A non-feed sludge layer may be left in place. A feed sludge can be either LAW or HLW and is usually blended with some other material before delivery.

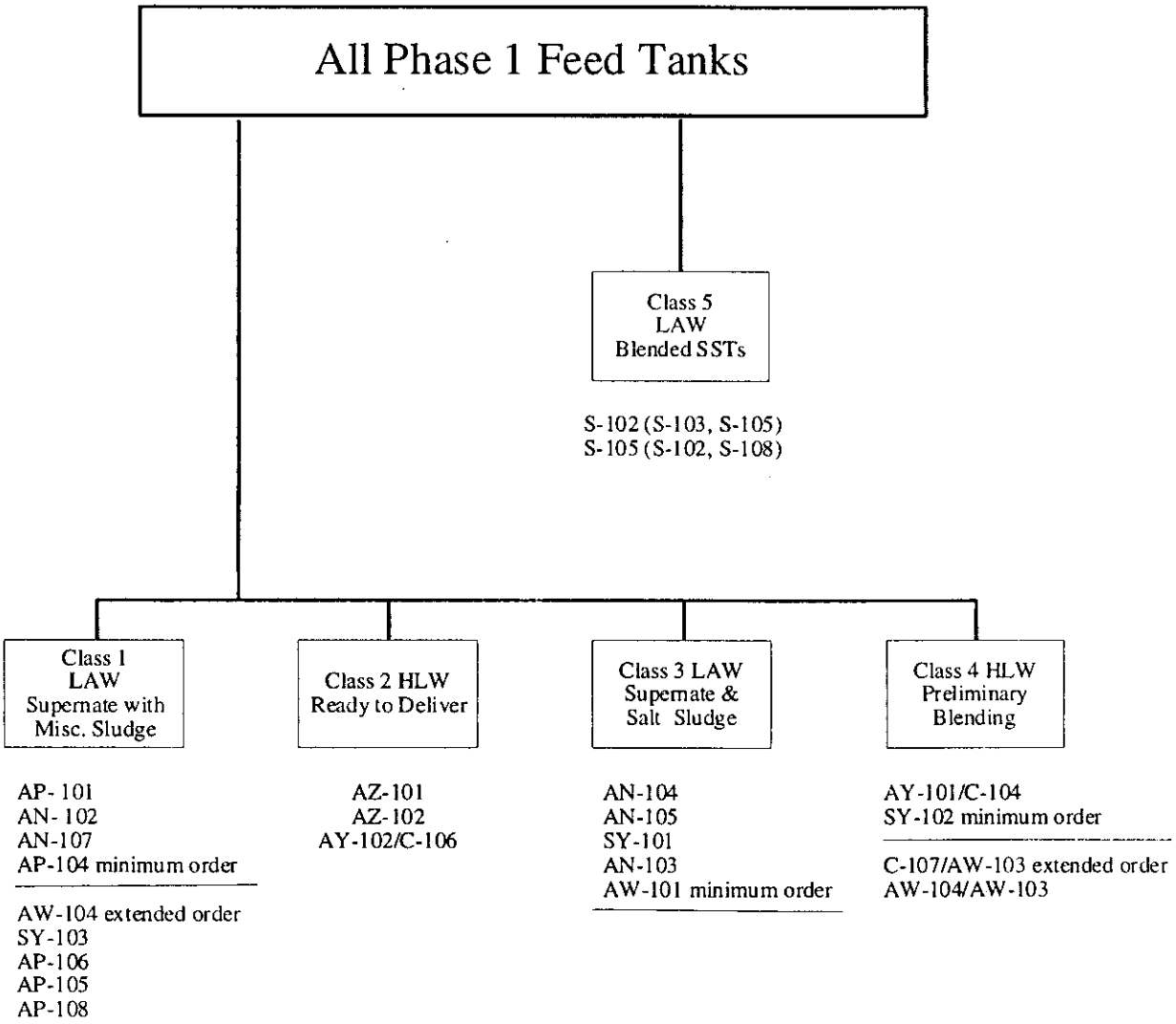
Class 2 tanks contain HLW feeds that can be mobilized into a slurry and transferred directly to BNFL Inc. without any blending or preliminary staging transfers.

Class 3 tanks contain distinct supernate and salt sludge layers, both layers being LAW feed. The layers are retrieved sequentially. Supernate layers are normally retrieved with in-line dilution into a staging tank. The diluted supernate is certified in the staging tank and delivered to BNFL Inc. Salt sludge is dissolved, mixed with decanted supernate, if necessary, certified in place, and transferred directly to BNFL Inc.

Class 4 tanks contain HLW feeds that need to be blended or moved to a staging tank.

Class 5 tanks contain SST salt sludges that are retrieved into DSTs. Wastes from several source tanks are blended to produce one LAW batch because some SST wastes are being retrieved simultaneously to support the SST retrieval program schedule. The blended LAW liquids are certified in the staging tank and transferred to BNFL Inc.

Figure 3.3-2. Phase 1 Source Tank Flowsheet Classification.



HLW = High-level waste
LAW = Low-activity waste
SST = Single-shell tank

3.4 LOW-ACTIVITY WASTE SENSITIVITIES

The sensitivity of the mission outcome to changes in key technical assumptions was assessed by running the HTWOS model with revised assumptions and comparing the results from the sensitivity cases to the baseline results. The major findings from this sensitivity analysis are summarized below. Results from Case 3S6E are provided in the discussion below as a reference for the comparisons.

Vitrification of LAW feed delivered through the last tank in the minimum order sequence is completed by September 2015 producing a total of 9,830 ILAW packages. The following sensitivities are compared to the planning case:

Vitrification of LAW feed delivered through the last tank in the minimum order sequence is completed by September 2015 producing a total of 9,830 ILAW packages for the planning case 3S6E (March 8 PIO Guidance case). The effect of changes in key assumptions on the ILAW canister count and the completion date for the minimum order quantities are given in Table 3.4-1.

Table 3.4-1. Low-Activity Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the results of implementing March 8, 000 PIO guidance (planning case).	None – Produce 9,830 ILAW canister by September 2015 from minimum order feed tanks.
Case 3S6D R7 Sulfate removal	This is the 2006 "hot" start case and CHG delivery system could support BNFL LAW process. Case 3S6D represents a scenario with sulfate removal capacity, therefore, increasing sodium oxide loading (0.195, 0.195, and 0.17 for Envelopes A, B, and C, respectively) thus creating less glass. The ramp-up rate is about 1.8 times slower than Case 3S6E.	Decrease the number of ILAW packages by 1,049 assuming feed from minimum order tanks. A negligible change in the completion date because the slower ramp-up rate is offset by the decrease in the amount of ILAW produced.
Case 3S6C 50% Trend WFD Early start	This case evaluates the CHG plans for 2005 hot start. This case starts LAW delivery 11 months earlier than Case 3S6E.	No changes in number of ILAW packages and accelerate completion of LAW minimum order feed tanks by 11 months.
Case 3S6B R1 Wash Na from HLW Processing	Additional LAW feed is generated from liquids in HLW feed and HLW sludge washing.	Increases number of ILAW packages by 915 and delays completion by nine months relative to the LAW feed from minimum order tanks.

CHG = CH2MHILL Hanford Group, Inc.
HLW = High-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste.

4.0 PHASE 1 HIGH-LEVEL WASTE FEED STAGING

The Phase 1 privatization contract establishes specific requirements for the delivery of HLW feed to BNFL Inc. These requirements provide objectives for retrieval, staging and delivery of HLW slurry. To meet these objectives, a staging scenario identified as Case 3S6E was evaluated by computer simulation. Results and conclusions of the evaluation are discussed in this section. Case 3S6E implements final planning guidance (PIO 2000) and therefore supersedes previous cases.

4.1 HIGH-LEVEL WASTE FEED STAGING SCENARIO

The staging approach for Case 3S6E is to provide reliable feed delivery to BNFL Inc. while meeting privatization contract requirements. The number and location of staging tanks selected for Case 3S6E improve the reliability of HLW feed delivery by providing backup staged feed capability from independent tank farms. Feed staging capability is provided from AZ, AY, and AW tank farms to minimize the probability of a single-point failure in the delivery system resulting in loss of feed capability.

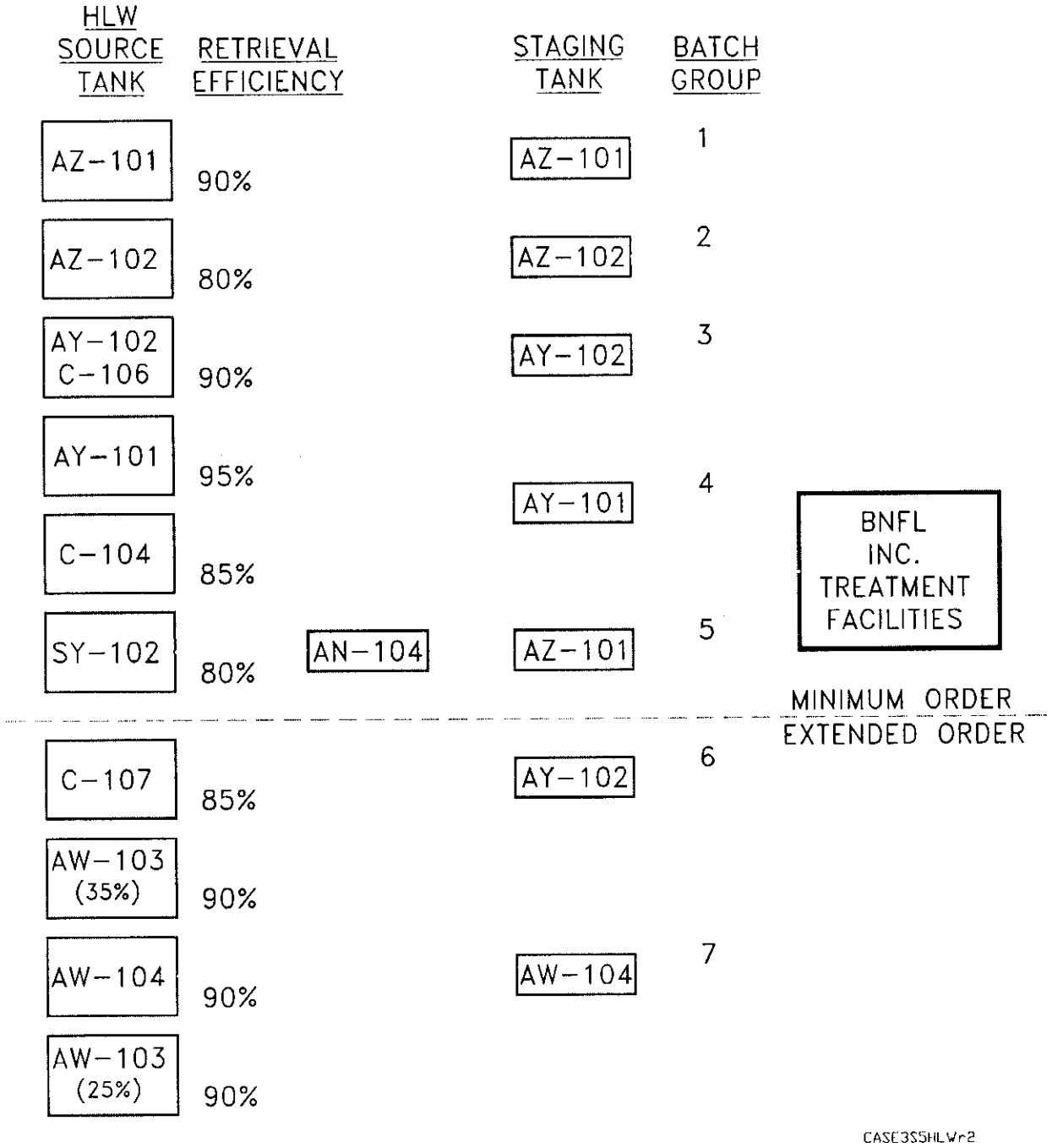
Identification of HLW source and staging tanks for Case 3S6E Phase 1B is shown in Figure 4.1-1. Phase 1B HLW source tanks were specified by ORP (1999). Case 3S6E uses HLW from five DSTs and one SST (241-C-104) to meet the minimum order quantity of 600 canisters of IHLW plus a contingency of 365 canisters of IHLW. Waste from two DSTs and one SST provides HLW feed in the extended order of Phase 1. Tanks 241-AZ-101, 241-AZ-102, 241-AY-101, and 241-AY-102 are used as staging tanks with 241-AW-103 prepared as a backup staging tank.

Several batches of slurry are delivered from a single staging tank of HLW feed. This group of individual batches delivered from a staging tank is referred to as a batch group. Five batch groups constitute the minimum order Phase 1B HLW feed. Wastes from individual source tanks 241-AZ-101, 241-AZ-102, 241-AY-102/241-C-106, and 241-SY-102 are staged unblended to make Batch Groups 1, 2, 3, and 5. Waste from source tank 241-C-104 is blended in tank 241-AY-101 to make Batch Group 4. Two batch groups constitute the Phase 1B extended order HLW feed. Waste from SST 241-C-107 is blended with a portion of the waste from 241-AW-103 in 241-AY-102 to make Batch Group 6. A portion of waste from 241-AW-103 is blended in 241-AW-104 to make Batch Group 7.

Feed delivered from each batch group is discussed in Section 4.1.1. Information on IHLW glass products is shown in Section 4.1.2. The composition of each feed batch group is compared against contract specifications in Section 4.1.3.

The tank-specific staging plan, the retrieval and transfer equipment needed to support the staging plan, and the work execution schedule are discussed in Section 4.2. The waste transfers and certain precedent relationships directly needed to implement the HLW portion of the operating scenario are shown on the MSD in Section 3.2.3. Waste volume plots with denoted transfers as a function of time for all Phase 1 DSTs are also provided in Section 3.2.3.

Figure 4.1-1. High-Level Waste Feed Staging – Case 3S6E.



HLW = High-level waste.

A full description of all Phase 1 transfers, including dates, volumes, and destinations, is included in Appendix H.

4.1.1 High-Level Waste Feed Delivery

The baseline HLW operating scenario refers to the waste transfers and other operational activities needed to deliver HLW feed to BNFL Inc. The major bases and assumptions governing this operating scenario are discussed in Appendix A. The feed delivery plan is summarized in Table 4.1-1.

The quantity of unwashed solids delivered will depend on retrieval efficiency. The expected DST retrieval efficiencies are 95 percent for 241-AY-101; 90 percent for 241-AZ-101, 241-AY-102/C-106, 241-AW-103, and 241-AW-104; 80 percent for 241-AZ-102 and 241-SY-102. In addition, a retrieval efficiency of 85 percent was assumed for SSTs 241-C-104 and 241-C-107. To ensure that enough unwashed solids are delivered to BNFL Inc. to produce 600 HLW glass canisters, the expected retrieval efficiencies are used for planning purposes instead of the assumption that 100 percent of the waste is retrieved.

Supplemental retrieval systems should be implemented with mixer pumps in tanks 241-AW-103 and 241-SY-102 to increase retrieval efficiencies. Retrieval efficiencies shown above for these tanks assume that the supplemental retrieval systems are implemented. Modeling of the effective cleaning radius (ECR) of two mixer pumps alone in these tanks predicts low retrieval efficiencies as a result of the high shear strength of the sludge. A newer ECR model shows a lower dependence of shear strength on the effective cleaning radius of mixer pumps, but the model cannot be validated yet because of inadequate data on waste viscosity. As viscosity data become available through laboratory measurements of tank samples, the newer ECR model will be re-evaluated.

Table 4.1-1 summarizes, by batch group, quantities of liquids, unwashed solids, and sodium delivered to BNFL Inc. by batch group. Batch Groups 1 though 5 are delivered to meet the minimum order quantity and Batch Groups 6 though 7 are delivered for the extended order. Approximately 2,100 MT of unwashed solids will be delivered during Phase 1. This quantity represents a 30-percent decrease from the quantity of solids projected in revision 1 of the TFC O&UP. The decrease in delivered solids is due primarily to two factors. The number of source tanks decreased from ten to seven and the inventory changed significantly in tank 241-AY-101.

The source feed for the first three HLW batch groups exist in the staging tanks. Timing for staging of the first three batch groups is determined by (1) project schedules for providing equipment required for mixing and feeding and (2) sampling and sample analysis necessary for feed certification.

Overall timing for staging the remaining feed batch groups is determined by the assumed HLW processing rates, waste oxide loading in the IHLW glass, and the quantity of waste oxides in the feed. Knowledge of actual processing rates, including the planned ramp-up, is important for establishing the final timing for these feed batches.

In general, sources of HLW slurry are retrieved and transferred to the HLW staging tanks as soon as the HLW staging tank is emptied of its previous batch. The waste is mixed and sampled for certification before delivery to BNFL Inc.'s feed receipt tanks. The certification process and requirements for feed transfer from the HLW staging tank to BNFL Inc.'s feed receipt tanks are specified in ICD-20 (BNFL 2000). The overall operating logic and timing for the certification and delivery of a single batch of feed is shown in Figure 4.1-2.

There are several authorization basis issues associated with consolidation and storage of HLW solids. Some examples of these issues are tank bumps, aerosol generation, and changes in source terms for several types of accidents. These issues were identified and evaluated in Grams et al. (1997), and were further addressed in subsequent evaluations and studies (Ryan 2000).

4.1.2 Projected High-Level Waste Product

Based on expected retrieval efficiencies described previously, the expectation is that 965 IHLW glass canisters will result from the treatment of waste in Batch Groups 1 through 5, the minimum order quantity tanks. An additional 465 canisters of IHLW would be produced by the extended order tanks, with approximately 95 of the canisters produced by the end of the Phase 1 contract period in February 2018. The remaining waste is staged as contingency feed. This amount of IHLW glass includes a 57-canister incremental increase resulting from the blending of strontium and manganese precipitates with HLW feed. The precipitates result from the pretreatment of Envelope C waste feed originating in tanks 241-AN-107 and 241-AN-102. The precipitates are blended with waste from tanks 241-AY-102/241-C-106 and 241-AY-101/241-C-104 because of the time-phased processing of LAW and HLW. The time-phased processing of waste from these LAW and HLW feed tanks is best illustrated in Figure 3.2.1. The calculations used for IHLW glass canister projections assumes water washing of sludge from tanks 241-AZ-101 and 241-AZ-102, and caustic washing of the remaining HLW tanks in both Phase 1 and Phase 2. Utilization of only water washing of all HLW feed would be expected to produce more IHLW glass. The product contains 1.15 m^3 of glass in a 95-percent-full canister at a glass density of 2.66 MT/m^3.

For each batch group, Table 4.1-1 summarizes source tanks, staging tank, mass of waste oxides, waste oxide loading (WOL), mass and volume of glass, and the number of canisters of IHLW. Waste oxide loadings are calculated by means of a glass properties model. Waste oxide loading is defined as the mass of non-volatile waste oxides excluding oxides of sodium and silicon divided by the total mass of glass. Oxide loadings calculated from the glass properties model are higher than would result from just meeting minimum WOL as defined in Specification 1 of the BNFL Inc. contract. A detailed discussion of the potential effects of relatively large differences in WOL is provided in TWRSO&UP, Revision 1 (Kirkbride et al. 1999), Appendix G. To ensure that enough HLW slurry is delivered for BNFL Inc. to produce 600 IHLW canisters, the glass properties model is used for planning purposes to calculate WOL and volumes of glass. The WOL in Batch Groups 1 and 2 is limited by the spinel liquidus temperature with iron oxide loadings of 11.6 wt% and 14.3 wt% respectively. An iron oxide concentration of 15 wt% limits the oxide loading in Batch Group 3. Batch Group 4 is limited by both the spinel and zirconia liquidus temperatures (1050 °C).

Table 4.1-1. Summary of High-Level Waste Feed Staging and Delivery - Case 3S6E - R2A

Batch group	Batches	Feed source	Staging tank	Dates[a]						Delivered Feed				Expected IHLW Product - Glass properties model[f]						Maximum IHLW Product - Specification 1[g]					
				Start retrieval	Begin staging	First batch ready[b]	Start delivery	Start of vitrification	End of vitrification	Liquids (ML)	Solids[c] (MT)	Volume[d] (ML)	Radioactivity[e] (Ci)	Non-volatile waste oxides[h] (MT)	Waste oxide loading[i] (%)	Mass of HLW glass (MT)	Volume of HLW glass[j] (m^3)	Number of HLW canisters[k]	Cumulative HLW canisters[k]	Non-volatile waste oxides[h] (MT)	Waste oxide loading[i] (%)	Mass of HLW glass (MT)	Volume of HLW glass[j] (m^3)	Number of HLW canisters[k]	Cumulative HLW canisters[k]
Privatization Phase 1 Minimum Order																									
1	1-6	AZ-101	AZ-101	--	--	2/28/06	9/1/06	9/1/08	12/31/09	3.02	102	3.05	9.42E+06	83.7	30.6%	249	93.5	81	81	83.7	25.5%	299	112.3	98	98
2	7-12	AZ-102	AZ-102	--	--	9/1/06	2/1/08	12/31/09	1/10/11	3.17	171	3.23	5.01E+06	134	30.9%	375	141	123	204	134	24.7%	469	176	153	251
3	13-19	AY-102/C-106	AY-102	--	--	10/1/09	10/1/10	1/10/11	8/8/12	1.95	381	2.08	3.82E+06	192	29.0%	584	219	191	395	193	23.8%	716	269	234	485
4[l]	20-31	AY-101/C-104[m]	AY-101	5/1/07	5/1/07	10/1/10	6/1/12	8/8/12	6/8/15	3.15	643	3.37	2.00E+06	359	32.4%	1,049	394	343	738	359	29.1%	1,167	439	381	866
5	32-35	SY-102	AZ-101	9/29/10	10/1/10	9/1/12	4/1/15	6/8/15	4/16/17	2.02	168	2.08	6.79E+05	133	6.1%	696	262	227	965	132	5.9%	696	262	227	1,094
Privatization Phase 1 Minimum Order (600 canisters of IHLW)																		965						1,094	
Privatization Phase 1 Extended Order																									
6	36-44	C-107[m]/AW-103 (35%)	AY-102	7/1/12	7/1/12	5/1/15	2/1/17	4/16/17	5/14/18[n]	3.04	474	3.20	1.19E+06	287	29.3%	875	329	286	1,251	287	29.0%	884	332.5	289	1,383
7	45-50	AW-104/AW-103 (25%)	AW-104	3/1/16	3/1/16	2/1/17	2/1/18	5/14/18[n]	7/29/18[n]	3.01	150	3.06	3.57E+05	150	25.7%	548	206	179	1,430	150	22.5%	625	235	204	1,587
Privatization Phase 1 Extended Order																		465						494	
Privatization Phase 1 Total																		1,430						1,587	
DST Backfill for Phase 2[o]																									
8	--	U-109	--	7/19/11	--	--	--	--	--	--	282	--		--	--	--	--	--	--	--	--	--	--	--	--
9	--	T-105	--	10/1/11	--	--	--	--	--	--	107	--		--	--	--	--	--	--	--	--	--	--	--	--
10	--	T-102	--	1/1/12	--	--	--	--	--	--	125	--		--	--	--	--	--	--	--	--	--	--	--	--
11	--	BX-104	--	7/18/16	--	--	--	--	--	--	291	--		--	--	--	--	--	--	--	--	--	--	--	--
12	--	TX-101	--	10/18/16	--	--	--	--	--	--	146	--		--	--	--	--	--	--	--	--	--	--	--	--
13	--	SX-102	--	6/3/17	--	--	--	--	--	--	131	--		--	--	--	--	--	--	--	--	--	--	--	--
14	--	U-108	--	11/23/17	--	--	--	--	--	--	298	--		--	--	--	--	--	--	--	--	--	--	--	--
15[p]	--	S-111	--	1/26/18	--	--	--	--	--	--	561	--		--	--	--	--	--	--	--	--	--	--	--	--

[a] Dates are derived from the Mission Summary Diagram except for the start and end of vitrification which are derived from HTWOS. All dates are supported by glass volumes calculated with the glass properties model.
[b] The date where batch qualification has been completed and first batch of the batch group is ready to be delivered to BNFL (nine months prior to delivery).
[c] Total solids for batch group assuming expected retrieval efficiencies.
[d] Batch volumes delivered are 0.2 to 0.6 ML each including inhibited flush water.
[e] Based on delivered feed, including both solids and liquids, decayed to date of delivery.
[f] Glass production estimates based on the PNNL glass properties model (GPM). The GPM is used by Waste Feed Delivery to provide a conservative basis for planning the quantity of HLW feed required to meet the production needs of BNFL.
[g] Glass production based on Specification 1 of the BNFL contract. Specification 1 provides the upper limit of glass production for a given HLW feed.
[h] Not including glass frit
[i] Not including Na_2O and SiO_2
[j] Glass density = 2.66 MT/m^3
[k] 1.15 m^3 of HLW glass per canister. Number of canisters assumes expected retrieval efficiencies of sludge from source tanks. Due to rounding, the sum of canisters may not equal the total (cumulative).
[l] The minimum order of 600 HLW canisters is met about halfway through Batch Group 4. Batch Group 5 is included in the minimum order because it provides contingency feed to mitigate waste feed delivery risks.
[m] 85 percent of the sludge in these tanks is assumed to be retrieved and delivered to BNFL Inc. Retrieval efficiencies vary in other tanks.
[n] HLW vitrification rate starting on 3/1/2018 is about 8 times the Phase 1 rate.
[o] DST backfill list for Phase 2 is preliminary and subject to change.
[p] Retrieval of 18 other single-shell tanks containing HLW feed solids are started during Phase 1 in addition to the SSTs listed here. The 8 SSTs listed contain larger quantities of solids than the other SSTs retrieved during this time.
DST - double-shell tank
HTWOS - Hanford Tank Waste Operation Simulator
IHLW - immobilized high-level waste

Filename: Phase 1 HLW Case 3S6E R2A.xls
Sheet: HLW

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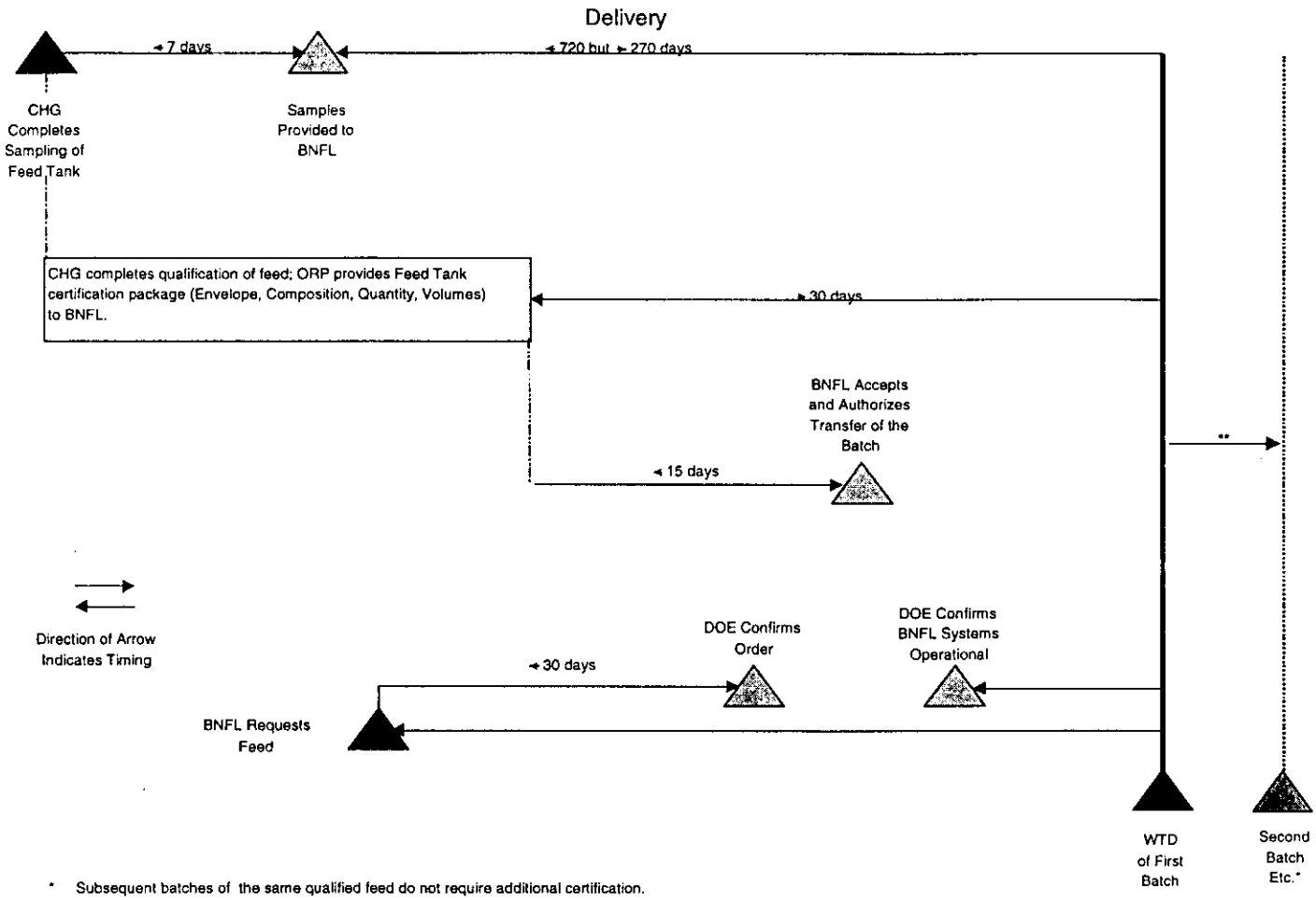
Figure 4.1-2. Logic and Timing for Certification and Delivery of High-Level Waste Feed.



* Subsequent batches of the same qualified feed do not require additional certification.

** The minimum duration between successive transfers of HLW feed deliverys from the same tank of qualified feed must be consistant with the contract.

CHG = CH2MHILL Hanford Group, Inc.
DOE = U.S. Department of Energy
ORP = Office of River Protection
WTD = Waste transfer date.

Four technical uncertainties influence the probability of delivering HLW on time throughout Phase 1: (1) retrieval efficiency, (2) concentration of glass-limiting component(s) in delivered solids, (3) solubility of glass-limiting component(s) during the pretreatment washing process, and (4) solubility of limiting component(s) in glass. Retrieval efficiency estimates are based on calculations using models derived from scaled mixer pump tests. Iron in the waste has a very limited solubility in the pretreatment washing process, which significantly decreases the pretreatment uncertainty for Batch Groups 1, 2, and 3. Similarly, zirconium in the waste has a very limited solubility in the pretreatment washing process, which significantly decreases the pretreatment uncertainty for Batch Groups 4, 6, and 7. The zirconium content of Batch Groups 4, 6, and 7 is at or near the GPM limit.

Batch Group 5 presents the highest uncertainty overall. This batch group has the highest uncertainty in both the concentration of glass-limiting component (chromium) in delivered solids and in the solubility of chromium during the pretreatment washing process. Waste Feed Delivery's largest uncertainty is the ability to deliver a known mass of glass-limiting components from a specific tank. This uncertainty can be managed by adequately characterizing the sludge, meeting expected retrieval efficiencies, and planning contingency feed.

The potential benefits of blending waste are large. Blending of HLW in 241-SY-102 may reduce the Phase 1 HLW glass produced by about 200 canisters at a cost for treatment and disposal of approximately $2 to 3 million per canister (Crawford et al. 1999; GAO 1999). Without blending, waste from 241-SY-102 would have a 6 wt% WOL.

The expected HLW glass production if minimum WOL is just achieved as required by Specification 1 of the BNFL Inc. contract is shown in the right-hand six columns of Table 4.1-1. Under these conditions, approximately 1,100 canisters of IHLW are produced after delivery of Batch Group 5 and approximately 1,600 canisters at the end of Batch Group 7. Glass estimates using Specification 1 are higher than estimates using the glass properties model because of lower WOL. This difference in the quantity of IHLW produced for the minimum-order tanks is approximately 140 canisters of IHLW and approximately 170 canisters for all of Phase 1.

The WOL in Batch Groups 1 and 2 is limited by the sum of aluminum, zirconium, and iron oxides (21 wt%). An iron oxide concentration of 12.5 wt% limits Batch Group 3. Batch Group 4 is limited by a calcium oxide concentration of 7 wt%. The concentration and the Specification 1 limit of calcium oxide were used to simulate the effects of strontium addition to the waste as there is no limit for strontium specified and the two are chemically similar. Large quantities of strontium are used for pretreating Envelope C LAW feed. High chromium oxide concentration (0.5 wt%) limits the WOL in Batch Group 5. Waste oxide loading in Batch Groups 6 and 7 is limited by the zirconium oxide concentration of 10 wt%.

4.1.3 Feed Compliance With Contract Specifications

The HLW feeds will contain a mixture of solids and liquids. The solid fraction must meet the criteria set forth in Section C, Specification 8, of the contract for Envelope D solids. The liquid fraction must meet, with some minor exceptions, the criteria set forth in Section C, Specification 7, of the contract for Envelope A, B, or C liquids (RL 1996).

The analytical and radiological concentration limits from Specification 8 and the predicted solids compositions for the nine batch groups of Case 3S6E are presented in Tables 4.1-2, 4.1-3, 4.1-4, and 4.1-5. These tables respectively correspond with Tables TS-8.1, TS-8.2, TS-8.3, and TS-8.4 of Specification 8. In these four tables, a shaded cell identifies any component that is out of specification and bold font identifies components within 50 percent of a specification. The concentrations of unwashed solids in the batch groups are listed in Table 4.1-6.

The data presented in Tables 4.1-2 and 4.1-3 represent the concentration of non-volatile and volatile components in the HLW feed for Case 3S6E. These data indicate that all of the criteria from Tables TS-8.1 and TS-8.2 of Specification 8 are met for the solids in the feeds, with the exceptions of vanadium in Batch Groups 6 and 7. The vanadium concentration may exceed the limit by a value ranging from 10 to 100 percent. Batch Group 3 is within 60 percent of the limit for carbonate. Batch Group 6 is within 75 percent of the arsenic limit and within 50 percent of the thallium limit.

Table 4.1-2. High-Level Waste Feed Unwashed Solids Maximum Non-Volatile Component Composition - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Non-volatile element	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
As	0.16	1.75E-02	1.05E-07	1.38E-36	2.50E-71	7.12E-04	**1.20E-01**	6.54E-02
B	1.3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-02	4.32E-02
Be	0.065	5.27E-04	3.16E-09	4.16E-38	7.55E-73	2.17E-05	6.67E-03	3.65E-03
Ce	0.81	0.00E+00	0.00E+00	2.85E-41	2.84E-17	2.56E-05	1.23E-01	6.67E-02
Co	0.45	3.48E-02	2.09E-07	2.75E-36	4.99E-71	1.42E-03	2.44E-02	1.34E-02
Cs	0.58	5.06E-03	2.30E-03	2.34E-03	3.84E-04	3.26E-03	2.53E-04	6.94E-04
Cu	0.48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-02	6.67E-03
Hg	0.1	0.00E+00	0.00E+00	7.80E-03	1.65E-02	3.04E-08	9.18E-03	9.06E-09
La	2.6	1.14E-01	2.91E-01	1.41E-01	1.11E-01	9.53E-03	7.17E-02	3.18E-02
Li	0.14	2.23E-03	1.34E-08	1.76E-37	3.19E-72	9.06E-05	1.20E-02	6.56E-03
Mn	6.5	9.13E-02	1.85E-01	1.91E+00	9.15E-01	2.36E-01	2.30E-01	1.42E-01
Mo	0.65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.09E-02	3.33E-02
Nd	1.7	8.20E-02	4.50E-07	6.46E-36	1.17E-70	3.34E-03	1.20E-01	6.54E-02
Pr	0.35	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu	0.054	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb	0.19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sb	0.84	8.20E-02	4.50E-07	6.46E-36	1.17E-70	3.34E-03	8.43E-02	4.61E-02
Se	0.52	5.52E-02	2.25E-07	4.35E-36	7.90E-71	2.25E-03	2.08E-02	1.14E-02
Sr	0.52	1.91E-02	2.45E-02	3.31E-02	1.66E-02	4.96E-03	2.51E-02	6.45E-03
Ta	0.03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.96E-03	4.35E-03
Tc	0.26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te	0.13	5.85E-02	4.50E-07	4.61E-36	8.38E-71	2.38E-03	2.08E-02	1.14E-02
Th	0.52	3.75E-02	2.25E-07	2.96E-36	5.38E-71	1.53E-03	2.08E-02	1.14E-02
Tl	0.45	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**2.39E-01**	1.31E-01
V	0.032	7.89E-04	4.73E-09	6.22E-38	1.13E-72	3.19E-05	**6.30E-02**	**3.45E-02**
W	0.24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y	0.16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zn	0.42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-02	7.50E-03

Table 4.1-3. High-Level Waste Feed Unwashed Solids Maximum Volatile Component Composition - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Volatile components	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Cl	0.33	1.76E-03	9.29E-07	5.18E-05	4.63E-06	4.83E-04	1.14E-05	5.32E-06
CO_3^{-2}	30	1.91E-04	1.55E+00	**1.91E+01**	1.18E+00	6.50E-01	1.16E+00	4.79E-03
$NO_2 + NO_3$	36	7.38E-01	3.39E-02	2.22E-02	4.26E-02	2.70E-01	3.41E+00	6.09E-02
TOC	11	1.94E-01	1.47E-01	2.10E+00	3.24E-03	1.35E-04	6.71E-06	2.56E-03
CN	1.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NH_3	1.6	0.00E+00	0.00E+00	2.76E-01	1.46E-01	3.23E-04	1.27E-01	8.72E-08

Table 4.1-4 shows the concentration of radionuclides in the solids and how they compare to Table TS-8.3 of Specification 8. This table indicates that for Batch Group 4, the ^{233}U specification may not be met. The ^{233}U in Batch Group 4 is about seven times the limit.

Table 4.1-4. High-Level Waste Feed Unwashed Solids Maximum Radionuclide Composition - Case 3S6E.
(Curies per 100 grams non-volatile waste oxides).

Isotope	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
^{3}H	6.5E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
^{14}C	6.5E-06	3.26E-08	1.95E-13	1.55E-08	2.44E-07	4.48E-09	2.85E-08	2.86E-14
^{60}Co	1E-02	9.67E-05	9.55E-05	2.84E-06	1.73E-05	2.22E-06	3.52E-06	3.20E-09
^{90}Sr	1E+01	5.86E-01	4.63E-01	9.07E-01	2.01E-01	2.83E-02	1.07E-01	2.39E-04
^{99}Tc	1.5E-02	1.88E-05	1.77E-10	2.64E-06	3.75E-06	1.18E-05	3.93E-06	9.99E-07
^{125}Sb	3.2E-02	5.07E-04	4.55E-04	1.27E-06	7.22E-08	3.61E-06	2.40E-08	6.11E-09
^{126}Sn	1.5E-04	8.52E-06	6.19E-06	5.99E-06	2.00E-05	2.00E-06	3.87E-06	2.67E-09
^{129}I	2.9E-07	0.00E+00	0.00E+00	1.55E-08	3.13E-09	6.35E-09	3.33E-10	3.28E-16
^{137}Cs	1.0E+01	5.41E-02	3.89E-02	4.87E-02	7.55E-03	2.75E-02	2.23E-03	5.44E-04
^{152}Eu	4.8E-04	1.80E-05	1.18E-05	6.56E-06	1.20E-05	1.04E-06	1.15E-07	8.37E-09
^{154}Eu	5.2E-02	2.57E-03	1.27E-03	3.08E-04	4.56E-04	8.05E-05	4.10E-06	1.59E-07
^{155}Eu	2.9E-02	1.46E-03	6.43E-04	9.56E-05	1.23E-04	2.60E-05	1.16E-06	1.66E-07
^{233}U	9.0E-07	2.20E-08	1.08E-08	1.78E-09	**6.34E-06**	1.24E-07	9.55E-09	1.78E-09
^{235}U	2.5E-07	6.05E-09	2.90E-08	1.06E-08	6.10E-08	1.87E-09	4.37E-08	4.72E-08
^{237}Np	7.4E-05	2.52E-06	1.94E-06	1.91E-08	1.57E-08	1.68E-07	2.83E-09	4.49E-10
^{238}Pu	3.5E-04	1.79E-05	2.84E-05	1.64E-05	2.55E-05	8.31E-07	4.98E-06	8.08E-06
^{239}Pu	3.1E-03	1.18E-04	2.18E-04	3.54E-04	5.85E-04	3.34E-04	1.31E-04	7.95E-05
^{241}Pu	2.2E-02	5.75E-04	1.53E-03	6.17E-04	8.35E-04	2.09E-05	1.64E-04	3.06E-04
^{241}Am	9.0E-02	2.78E-03	2.40E-03	7.92E-04	8.72E-04	1.49E-03	1.27E-04	2.64E-07
$^{243+244}Cm$	3.0E-03	7.77E-06	4.51E-06	1.01E-05	1.71E-06	2.44E-07	3.64E-07	4.65E-10

Table 4.1-5 shows the concentrations of a select group of analytes. These analytes are drawn from Table TS-8.4 of Specification 8 and represent components that are also important to HLW glass production but will not be used as a basis for determining whether the feed meets specification requirements. This table indicates that for Batch Group 5, the chromium specification may not be met. The chromium exceeds the limit by 30 percent. Batch Group 4 is within 80 percent of the limit for aluminum.

Table 4.1-5. Additional High-Level Waste Feed Composition for Non-Volatile Components - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Non-volatile element	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Ag	0.55	0.00E+00	0.00E+00	0.00E+00	1.61E-20	6.74E-15	3.26E-02	1.79E-02
Al	14	1.88E+00	4.50E+00	**8.76E+00**	**1.16E+01**	3.75E+00	4.23E+00	4.32E-01
Ba	4.5	0.00E+00	0.00E+00	2.87E-03	1.24E-04	4.78E-03	6.10E-02	3.33E-02
Bi	2.8	0.00E+00	0.00E+00	1.52E-04	2.97E-03	7.10E-02	**1.65E+00**	1.42E-02
Ca	7.1	7.31E-02	1.91E-01	7.74E-01	5.08E-01	1.58E-01	2.14E-01	2.41E-01
Cd	4.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-03	6.13E-03	3.35E-03
Cr	0.68	2.56E-02	9.39E-02	2.43E-01	2.41E-01	**8.97E-01**	1.55E-01	1.44E-01
F	3.5	2.02E-02	1.90E-02	2.85E-02	7.04E-03	2.65E-02	1.03E+00	7.10E-01
Fe	29	3.00E+00	8.44E+00	**1.57E+01**	5.39E+00	8.36E-01	4.68E+00	4.36E-01
K	1.3	1.08E-01	9.22E-02	1.41E-01	1.71E-01	4.69E-01	5.44E-02	1.88E-02
Mg	2.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-01	6.67E-02
Na	19	5.75E-01	2.38E+00	**1.51E+01**	**1.27E+01**	**1.41E+01**	6.27E+00	1.61E-01
Ni	2.4	1.76E-01	5.72E-01	1.88E-01	3.61E-01	3.49E-02	1.52E-01	1.77E-01
P	1.7	4.56E-03	2.74E-08	2.66E-01	1.28E-01	2.07E-01	**1.04E+00**	3.67E-02
Pb	1.1	5.89E-02	7.03E-02	5.47E-01	1.34E-01	6.29E-02	3.32E-01	6.89E-02
Pd	0.13	5.52E-08	3.31E-13	4.35E-42	7.90E-77	2.25E-09	5.48E-15	2.28E-59
Rh	0.13	1.32E-02	7.93E-08	1.04E-36	1.89E-71	5.38E-04	4.98E-02	2.72E-02
Ru	0.35	2.68E-02	1.61E-07	2.11E-36	3.84E-71	1.09E-03	6.23E-03	3.41E-03
S	0.65	4.25E-02	1.79E-02	1.79E-02	4.41E-03	7.04E-02	1.30E-02	4.07E-02
Si	19	2.76E-02	2.82E-01	2.45E+00	1.31E+00	1.71E-01	1.17E+00	1.47E-01
Ti	1.3	1.98E-02	1.19E-07	1.56E-36	2.84E-71	8.07E-04	1.15E-02	6.32E-03
U	14	3.16E-01	1.58E+00	6.39E-01	3.89E+00	1.39E-01	2.45E+00	2.56E+00
Zr	15	1.06E+00	1.17E+00	2.08E-01	**1.02E+01**	5.09E-02	7.44E+00	4.04E+00

There is a risk that WFD may not be able to consistently deliver solids that meet Envelope D and liquids that meet Envelope A, B, or C as required by specification 8 of the BNFL Inc. contract. The feed envelope assessments in Tables 4.1-2 through 4.1-4 and 4.1-6 indicate that the HLW feed from three out of seven batch groups may fall outside the envelope specifications for solids and outside all except two batch groups for liquids. Refinement of component partition factors between liquid and solid phases used for retrieval modeling is necessary to confirm the extent to which the composition of the retrieved waste may be out of specification.

Envelope D feed is projected to be out of specification in Batch Groups 4, 6, and 7 each in a single component. Batch Group 4 has a concentration of ^{233}U seven times the limit. Batch Groups 6 and 7 may have elevated vanadium concentrations of 100 percent and 5 percent above the limit. The reported vanadium concentrations are based on "less than" values from sample analyses and therefore should be viewed as upper bounds. Blending HLW source tanks not only increases WOL but has the additional benefit of reducing component concentrations of the feed. However, even after blending waste from source tanks in Batch Groups 4, 6, and 7, HLW feed in the staging tanks may not meet feed specifications for Envelope D.

While clause H.43 in the BNFL Inc. contract provides some latitude for processing out-of-specification waste, it does not remove the risk of a rejected feed batch. Clause H.43 states that if (1) the waste can technically be processed and (2) the waste complies with facility permits and (3) the waste falls within BNFL Inc.'s facility safety authorization basis, then a treatment price will be negotiated based on incremental impacts to BNFL Inc. costs and processing rates. So, clause H.43 by itself does not remove any risk from delivery of tank waste out of specification. There are no specific criteria written for the assumption stated above. Nor are estimates available for the size of the incremental cost impacts as discussed in the previous paragraph.

The RPP Key Planning Assumptions (PIO 2000) guidance directs us to assume that delivered LAW and HLW feed that is within the BNFL Inc. facility permits and safety authorization basis will be accepted and processed by BNFL Inc. Therefore, it is assumed that no feed blending or adjustments are required.

It is the intent of CHG to deliver feed that meets contract specifications. However, if the feed does not meet the specifications, it will be processed under contract clause H.43 (PIO 2000). There are no plans to alter the waste composition to bring out-of-specification feed into compliance.

The HLW feed specifications should be modified so that the delivered HLW feed composition meets contract specifications. Specification 8 in the BNFL Inc. contract should be modified so that all Hanford tank farm waste, when retrieved to a staging tank, falls within component specifications.

The concentrations of solids in the HLW feeds are listed in Table 4.1-6 for Case 3S6E. Specification 8 requires that the unwashed solids concentration in the HLW feed be between 10 and 200 g/L. The solids concentrations for all of the batch groups, with the exception of Batch Group 4, fell well within this specification. The solids concentration of Batch Group 4 is within 3 percent of the maximum limit. In a previous revision of the TFC O&UP (Kirkbride et al. 1999) avoided this problem by splitting the large quantity of sludge (approximately 1,100 m^3 [300 kgal]) from tank 241-C-104 into two DSTs. The current staging plans for 241-C-104 and 241-AY-101 were specified by ORP (1999).

Table 4.1-6. Unwashed Solids Concentrations in High-Level Waste Batch Groups - Case 3S6E.

	Phase 1 Minimum Order					Phase 1 Extended Order	
	Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
	AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Volume of batch group (liters):	3.05E+06	3.23E+06	2.08E+06	3.37E+06	2.05E+06	3.20E+06	3.06E+06
Mass of solids (g):	1.02E+08	1.71E+08	3.81E+08	6.53E+08	1.68E+08	4.74E+08	1.50E+08
Unwashed solids (g/L):	33.5	53.0	183.7	193.6	82.2	148.1	49.1

The analytical and radiological concentration limits from Specification 7 and the predicted liquid compositions for the nine batch groups are presented in Table 4.1-7. This table corresponds with limits presented in Tables TS-7.1 and TS-7.2 of Specification 7. The concentration of sodium is presented as well. In Table 4.1-7, the concentration of a component is compared to the maximum concentration allowed for that component for Envelopes A, B, and C. This comparison is made for each batch group. There are three columns that follow the concentration data from each batch group that correspond to the three envelopes. If the concentration for a component meets the criteria for an envelope, a "5" or an "8" is indicated in the cell of the table or the cell is left blank. If the cell is blank the component concentration is less than 50 percent of the specification limit. If the cell contains a "5" or an "8" the component concentration is greater than 50 percent or 80 percent of the specification, respectively. If the specification limit is not met, an "N" is placed in the cell and the background of the cell is shaded to call attention to it. Table 4.1-7 shows that the liquid fractions of Batch Groups 1, 2, 3, 4, and 6 do not meet the criteria for Envelopes A, B, or C. However, Batch Group 5 meets Envelope B and C specifications, and Batch Group 7 meets Envelope A, B, and C specifications.

Concentration data represented by zero values may be due to engineering assessments of sample data. The sample data may have been reported as less-than values or may not have been reported at all. The concentration data pedigree is addressed in Appendix C. The radionuclide data presented are decayed to the time of feed delivery to reflect what is spelled out in Specifications 7 and 8 of the contract.

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Table 4.1-7. Comparison of High-Level Waste Liquid Fraction with Criteria for Envelopes A, B, and C - Case 3S6E

Chemical Analyte	From Tables TS-7.1 and TS-7.2 of Contract			Phase 1 Minimum Order																					Phase 1 Extended Order						
	Envelope A	Envelope B	Envelope C	Batch Group 1	A	B	C	Batch Group 2	A	B	C	Batch Group 3	A	B	C	Batch Group 4	A	B	C	Batch Group 5	A	B	C	Batch Group 6	A	B	C	Batch Group 7	A	B	C
	moles of analyte to moles of sodium																														
Al	2.5E-01	2.5E-01	2.5E-01	8.41E-02				2.34E-02				3.47E-02				8.23E-03				1.01E-01				8.01E-02				9.83E-02			
Ba	1.0E-04	1.0E-04	1.0E-04	4.09E-06				1.31E-13				3.53E-55				3.18E-103				3.78E-06				1.20E-06				4.00E-07			
Ca	4.0E-02	4.0E-02	4.0E-02	2.54E-06				4.66E-05				5.91E-05				8.88E-04				1.11E-04				3.46E-04				3.33E-04			
Cd	4.0E-03	4.0E-03	4.0E-03	8.72E-06				2.80E-13				7.52E-55				6.78E-103				8.71E-07				1.63E-07				7.37E-08			
Cl	3.7E-02	8.9E-02	3.7E-02	1.17E-03				1.11E-04				1.50E-02				6.08E-03				2.16E-02	5		5	1.71E-02				1.80E-02			
Cr	6.9E-03	2.0E-02	6.9E-03	3.10E-03				8.11E-03	N		N	2.73E-03				6.64E-04				3.49E-03	5		5	2.92E-03				2.46E-03			
F	9.1E-02	2.0E-01	9.1E-02	2.06E-02				2.32E-02				9.29E-03				3.19E-01	N	N	N	4.76E-03				1.74E-01	N	8	N	7.83E-02	8		8
Fe	1.0E-02	1.0E-02	1.0E-02	4.18E-05				8.01E-05				3.18E-05				3.56E-05				4.00E-05				8.11E-05				8.87E-05			
Hg	1.4E-05	1.4E-05	1.4E-05	0.00E+00				0.00E+00				2.54E-07				4.19E-06				2.67E-07				3.56E-08				1.66E-08			
K	1.8E-01	1.8E-01	1.8E-01	2.50E-02				3.36E-02				5.17E-03				2.53E-03				8.69E-03				2.82E-02				2.03E-02			
La	8.3E-05	8.3E-05	8.3E-05	4.67E-11				8.26E-06				1.15E-05				2.71E-06				1.65E-06				3.30E-06				2.71E-06			
Ni	3.0E-03	3.0E-03	3.0E-03	1.85E-07				1.51E-05				3.35E-04				4.10E-04				3.11E-05				1.36E-04				8.09E-05			
NO_2	3.8E-01	3.8E-01	3.8E-01	2.96E-01	5	5	5	2.78E-01	5	5	5	1.17E-01				2.36E-01	5	5	5	2.28E-01	5	5	5	1.92E-01	5	5	5	1.98E-01	5	5	5
NO_3	8.0E-01	8.0E-01	8.0E-01	2.55E-01				1.58E-01				7.07E-03				1.15E-01				3.33E-01				2.24E-01				2.46E-01			
Pb	6.8E-04	6.8E-04	6.8E-04	0.00E+00				0.00E+00				1.64E-04				2.02E-04				2.47E-04				9.08E-05				8.55E-05			
PO_4	3.8E-02	1.3E-01	3.8E-02	3.22E-03				5.96E-04				2.94E-02	5		5	1.16E-02				5.24E-03				3.46E-02	8		8	4.01E-03			
SO_4	1.0E-02	7.0E-02	2.0E-02	3.93E-02	N	5	N	7.92E-02	N	N	N	1.65E-02	N		8	1.50E-02	N		5	1.05E-02	N		5	8.49E-03	8			6.71E-03	5		
TIC	3.0E-01	3.0E-01	3.0E-01	1.18E-01				2.44E-01	8	8	8	3.61E-01	N	N	N	1.91E-01	5	5	5	5.22E-02				3.94E-02				7.34E-02			
TOC	5.0E-01	5.0E-01	5.0E-01	2.49E-02				5.56E-02				1.90E-01				8.81E-02				3.21E-02				6.86E-02				4.99E-02			
U	1.2E-03	1.2E-03	1.2E-03	4.46E-06				2.72E-04				7.27E-04	5	5	5	8.55E-05				2.08E-04				5.21E-04				2.28E-04			
Radionuclide	Becquerels of radionuclide to moles of sodium																														
TRU	4.8E+05	4.8E+05	3.0E+06	2.14E+06	N	N	5	3.29E+06	N	N	N	3.85E+05	8	8		4.96E+05	N	N		1.91E+05				1.26E+06	N	N		1.86E+05			
^{137}Cs	4.3E+09	2.0E+10	4.3E+09	1.23E+10	N	5	N	1.33E+10	N	5	N	5.97E+08				3.13E+08				1.30E+09				5.03E+08				5.07E+08			
^{90}Sr	4.4E+07	4.4E+07	8.0E+08	2.83E+08	N	N		3.13E+06				1.15E+07				8.14E+08	N	N	N	3.83E+07	8	8		1.12E+07				3.68E+06			
^{99}Tc	7.1E+06	7.1E+06	7.1E+06	2.32E+06				2.74E+06				2.42E+05				2.47E+05				6.73E+05				4.46E+05				4.49E+05			
^{60}Co	6.1E+04	6.1E+04	3.7E+05	1.58E+05	N	N		3.17E+02				1.22E+04				1.48E+04				7.02E+03				8.03E+02				6.97E+02			
$^{154}Eu + ^{155}Eu$	1.2E+06	1.2E+06	4.3E+06	1.10E+01				1.57E+06	N	N		8.26E+05	5	5		9.37E+05	5	5		1.09E+05				2.00E+06	N	N		3.14E+04			
From Spec 7.2.2.1	mol/L																														
Na	3 to 10			4.82	Y	Y	Y	2.36	N	N	N	1.48	N	N	N	1.59	N	N	N	4.67	Y	Y	Y	3.45	Y	Y	Y	8.18	Y	Y	Y
Overall:					N	N	N		N	N	N		N	N	N		N	N	N		N	Y	Y		N	N	N		Y	Y	Y
N's					5	3	2		6	4	5		3	2	2		5	4	3		1	0	0		3	2	1		0	0	0
>80%					5	3	2		7	5	6		4	3	3		5	4	3		2	1	0		5	3	2		1	0	1
>50%					6	6	4		8	7	7		7	5	5		8	7	6		5	2	4		6	4	3		3	1	2

LEGEND:

- [ ] Meets Spec, < 50% of maximum
- [5] Meets Spec, > 50% of maximum
- [8] Meets Spec, > 80% of maximum
- [N] Does not meet Spec

4.2 TANK-SPECIFIC STAGING STRATEGY, EQUIPMENT, AND SCHEDULE

The tank-specific staging plan, retrieval and transfer equipment needed to support the staging plan, and the work execution schedule are discussed in this section.

4.2.1 Tank-Specific Staging Plan

The discussion below describes how each batch group is uniquely staged and delivered to BNFL Inc.

4.2.1.1 Minimum Order - Batch Groups 1-5. Batch Group 1: Tank 241-AZ-101 is the only source tank in this batch group. The waste is static and is staged in place for delivery directly to BNFL through the new AZ and AP valve pits. The tank is first in the HLW sequence because it has a large portion of the equipment required to retrieve the waste already installed. The waste contains large quantities of ^{137}Cs and ^{90}Sr, which cause problems during sampling because of high radiation dose rates involved. The liquid fraction of the tank is a portion of Envelope B feed for LAW treatment.

Batch Group 2: Tank 241-AZ-102 is the only source tank in this batch group. The waste is static and is staged in place for delivery directly to BNFL Inc. through the new AZ and AP valve pits. The tank is second in sequence because it also contains large quantities of ^{137}Cs and ^{90}Sr. The liquid fraction of the tank is also a portion of Envelope B feed for LAW treatment.

Batch Group 3: Tank 241-AY-102 is the only source tank in Batch Group 3. The contents of tank 241-C-106 were sluiced into 241-AY-102 during FY 1999. Batch Group 3 will be staged in 241-AY-102 for delivery to BNFL directly through the new AZ and AP valve pits. The WOL from waste in this tank will be limited by its iron concentration. Strontium and manganese precipitates from Envelope C pretreatment are assumed to start blending in the last three batches from this batch group and continue through Batch Group 4. The precipitation process and blending is performed in BNFL Inc.'s facility.

Batch Group 4: Wastes from tanks 241-AY-101 and 241-C-104 are blended to make Batch Group 4. After the retrieval system is ready in 241-AY-101, sludge in 241-AY-101 will be mobilized prior to retrieval of waste in 241-C-104. After waste from 241-C-104 is retrieved into 241-AY-101, Batch Group 4 is mixed and staged in 241-AY-101 for delivery to BNFL Inc. The delivery route goes through the central pump-pit above 241-AY-102 and then uses the same route as Batch Group 3.

Batch Group 5: Tank 241-SY-102 is the only source tank in Batch Group 5. After the retrieval system is ready in 241-SY-102 and after 241-AN-104 is emptied of LAW feed, the waste will be transferred as a slurry via a cross-site transfer line to 241-AN-104. The cross-site transfer will be the first time the slurry transfer is performed. The waste will be remobilized in 241-AN-104 and transferred into 241-AZ-101. Batch Group 5 will be staged in 241-AZ-101 for delivery directly to BNFL Inc. through the new AZ and AP valve pits.

4.2.1.2 Case 3S6E, Phase 1B-Extended Order - Batch Groups 6-7. Batch Group 6: Contents of tanks 241-C-107 and 241-AW-103 are blended to make Batch Group 6. Wastes from these tanks are blended to increase WOL and therefore decrease the amount of glass produced from 539 to 286 canisters. Tank 241-C-107 will be sluiced into 241-AY-102 after Batch Group 3 is delivered and the waste in tank 241-C-104 is retrieved. Batch Group 6 will be staged and fed to BNFL Inc. from 241-AY-102.

Batch Group 7: Wastes from tanks 241-AW -104 and 241-AW-103 are blended to make Batch Group 7. Waste from these tanks are blended to increase WOL and therefore decrease the amount of glass produced from 390 to 179 IHLW canisters. After the retrieval system is ready in 241-AW-104, a portion of the supernatant is decanted from the tank for LAW feed. At this time sludge in 241-AW-104 will be mobilized before transfer of waste from 241-AW-103 into 241-AW-104. After the waste in 241-AW-103 is retrieved into 241-AW-104, Batch Group 4 is staged in 241-AW-104 for delivery to BNFL Inc. The delivery route goes through valve pits in AW and AP farms and then through the new AP farm valve pit. Table 4.2-1 describes proposed staging action for each Phase 1 source tank along with process and equipment considerations.

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
1	241-AZ-101	241-AZ-101	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batchwise)	• Non-mobilized solids (retrieval efficiency) • Mixer pump performance (head) • Have spec. compliance issues on AZ-101 • Env. B – out of specification • 6 batches in batch group	• Has mixer pumps (need to test, W-151) • May need to replace mixer pumps after completion of test • W-521 provides transfer pump and I&C upgrades. • Assume equipment adequate for blending HLW (SY-102 and AW-103, if desired) • Down the road, failed equipment is replaced by Operations with no impact to schedule (for Phase 2) • W-521 Ready date May 2004 Op need date December 2004 • Mixer pump issue paper being drafted. - Need 3 to 5 m (10 to 15 ft) of head to operate mixer pump - Potential problem in mixing last third to half of tank
2	AZ-102	AZ-102	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batch wise)	• Non-mobilized solids (retrieval efficiency) • Mixer pump performance • Env. B – out of specification • 6 batches in batch group	• Need mixer pumps and transfer pumps • W-211 Ready date November 2003 Op Need date January 2005 • Mixer pump issue paper being drafted. - Need 10 to 15 feet of head to operate mixer pump - Potential problem in mixing last third to half of tank
3	AY-102 (with C-106)	AY-102	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batch wise)	• Non mobilized solids (retrieval efficiency) • Mixer pump performance • LAW Env. - Out of specification for Envelopes A, B, and C • 7 batches in batch group Note: Fe in solids results in little or no HLW impact from addition of Mn/Sr by BNFL Inc.	• Has one transfer pump (barely operational) • Has a mixer pump (failed) • Has a sluice pump • Need to install four 150-hp mixer pumps • Need to add a "sluicer" pump and transfer pump • W-211 Ready date March 2006 Op Need date April 2007 • Mixer pump NPSH issue, need certain liquid height to get desired flow. (May be less of a problem in this tank) • May not mobilize already-compacted AY-102 solids - Issue is ability to start mixer pump rather than the amount of AY-102 solids mobilized for feed to BNFL Inc.

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
					- High shear sludge - Any alternate retrieval technology would have to be demonstrated here - Could cause other impacts 1. Waste homogeniety 2. Higher potential for batches to be out of specification (e.g., Ag).
4	AY-101	AY-101	(Leave contents in tank to blend with C-104) • Add fluid if necessary • Mobilize solids prior to receiving C-104 waste	• Mobilization efficiency (mixer pump performance) • Needs to be modified for use as sluicing receiver • Sluicing efficiency	• Has two transfer pumps • Needed capability is provided by W-521 Ready date July 2006 Op. need date April 2007 • Need to install three 150 to 300-hp mixer pumps • Need to add a "sluicer" pump and transfer pump • May be able to use one pump to support sluicing and transfer function
	C-104		• Retrieve C-104 in AY-101 • Periodically mix tank contents in AY-101 while retrieving C-104 • Mix to blend • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batchwise)	• Env. D –Out of specification • LAW Env. –Out of specification for Env. A, B, and C • 12 batches in batch group (all minimum batch size) • Note: Mn/Sr addition by BNFL Inc. will affect IHLW produced – approximately 60 more cans. • Beneficial to be able to certify at high solids loading and transfer with in-line dilution to meet maximum solids loading in contract • HTWOS doesn't stop C-104 retrieval for mixing or interim sampling during retrieval, interim sampling could lengthen retrieval duration • Need to add OH during sluicing (C-106 experience)	• How will C-104 waste be retrieved? - Assume "past-practice" sluicing - Use C-106 data/lessons learned - Use AY-101 supernate as sluicing fluid - Add H_2O if more liquid is needed • W-523 (C-104) Ready date July 2006 Op Need date April 2007 • May demonstrate alternate retrieval technology in C-104 if available; remote vehicle with sludge pump and sluicing nozzles • AGA on alternate retrieval made no decision • Recent paper estimated retrieval at 2 times that of past-practice sluicing • Schedule issue regarding mixer pump installation and timing for sluicing - Mixer pump and sluiced liquid need the same risers • DST space may not be available to support complete C-104 retrieval (99.9%)

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
5	SY-102 (solids)	AZ-101	• Add transport fluid if needed • Mobilize with mixer pumps • Cross-site slurry to AN-104 • Mobilize and transfer to AZ-101 for staging • Sample and certify SY-102 in AZ-101 • Remix contents and transfer to BNFL Inc. (batchwise)	• How much can we mobilize? High shear strength sludge • IHLW produced is limited by Cr (~6% waste oxide loading) • Don't assume BNFL Inc. uses oxidative leaching to remove additional chromium • LAW – Out of specification Env. A • 4 batches in batch group	• Supplemental retrieval technology may be useful to achieve high retrieval efficiency (from SY-102) - Remove TRU-solids to prevent TRU-contamination of SWL added to tank after solids retrieval (SY-101 specification compliance issue, Phase 1 B prime specification compliance issue) • W-211 does not have supplemental technology in its baseline scope. • Staging equipment already in place in AZ-101and maintained by Operations Ready date July 2008 Op Need date September 2009
6	C-107	AY-102	• Retrieve C-107 into AY-102 (use sluicing parameters to model the retrieval) • 85% retrieval from C-107	• C-106 showed higher retrieval efficiency, we can expect to do better than 85% • May not have enough risers for sluicing receiver equipment and mixer pumps • Use inhibited H_2O as sluicing fluid if dilute non-complexed, low PO_4 waste is not available. • Need to add OH during sluicing (C-106 experience)	• Equipment already in place in AY-102 and maintained by Operations • W-523 (C-107) Ready date May 2009 Op need date Nov. 2009
	AW-103 (31.5% of total inventory)	AY-102	• Mix C-107 solids in AY-102 while transferring AW-103 • Mobilize and transfer AW-103 waste to AY-102 (use non-complexed low PO_4 concentrated waste as transfer fluid) • Sample and certify C-107/ AW-103 blend in AY-102 • Remix and transfer to BNFL Inc. (batchwise)	• Non-complexed low PO_4 available? • AW-103 sludge is high TRU, high F <u>Blended Waste</u> • Out of specification for Env. D • LAW – out of specification for Env. A, B, and C • 9 batches in batch group	<u>AW-103</u> • 2 mixer pumps; may need supplementary mobilization due to high shear sludge • ~ 31.5% retrieved (plan 90% retrieval eventually) • W-521 (AW-103) Ready date July 2005 Op need date Feb. 2007

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
7	AW-104 (solids)	AW-104	• Add transport fluid if needed • Mobilize with mixer pump before and during transfer of AW-103 waste into AW-104	• How much can we mobilize? High shear strength sludge • May be zeolite layer in sludge • Change to AW-104 LAW changes what liquid is available to mobilize solids	• Need mixer pump and decant pump • Existing transfer pump has failed • Need to replace transfer pump earlier to stage SWL for concentration in evaporator • There may be a zeolite layer in the middle of the sludge that causes problems with retrieval. • Tight schedule between LAW delivery and solids mobilization
	AW-103 (22.5% of total inventory)	AW-104	• Mobilize (use non-complexed low PO_4 concentrated waste received in tank as transport fluid) and transfer to AW-104 • Sample and certify AW-104/ AW-103 blend in AW-104 • Remix and transfer to BNFL Inc.	• Non-complexed conc. waste may not be available because of mixing SWL from different sources • Bottom sludge layers in AW-103 are harder to get Blended Waste • 6 batches in batch group	• Alternate Strategy: Deliver AW-104 solids with LAW feed? (combined delivery at appropriate times) - May not be blended with AW-103 solids if AW-104 LAW and HLW delivered together. • 2 mixer pumps, need supplementary mobilization – high shear sludge • ~ 22.5% retrieved (plan 90% retrieval eventually • Need to upgrade AW-102 Central Pump Pit (AW-102-02A), or replace SN-271 (between AW-A and AW-B) and renovate AW-A and AW-B jumpers to provide direct transfer route.

AGA = Alternative Generation and Analysis
DST = Double-shell tank
HLW = High-level waste
HTWOS = Handford Tank Waste Operation Simulator
I&C = Instrumentation and Control
IHLW = Immobilized high-level waste
LAW = Low-activity waste
NPSH = Net positive suction head
SWL = Saltwell liquid
TRU = Transuranic.

4.2.2 Equipment

Table 4.2-2 summarizes a preliminary assessment of the equipment needed for WFD was performed for Case 3S6E/Phase 1. Baseline change requests and project estimates have not been initiated to support Case 3S6E/Phase 1. Additionally it should be noted that the aforementioned costs do not include W-314 Phase 2 costs. At present it is assumed that the W-314 Phase 2 upgrades will be required to support the WFD mission regardless of variations in tank sequences. Details of how Case 3S6E/Phase 1 was interpreted for project actions are discussed below.

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
	MINIMUM ORDER TANKS	
AZ-101 (W-521) • HLW source tank • HLW staging tank	• New transfer pump in AZ-02A central pump pit and jumpers • I&C system • *Replace existing mixer pumps previously installed by W-151.* • AY/AZ annulus ventilation upgrade	$17[1]
AZ-102 (W-211) • HLW source tank • HLW staging tank	• Two mixer pumps • New transfer pump and jumpers • I&C system	$16[1]
AY-102 (W-211) • HLW source tank • HLW staging tank • Slurry receiver for C-107 retrieval	• Four mixer pumps • New transfer pump and jumpers • I&C system	$22[1]
AY-101 (W-521) • HLW source tank (to be mixed with C-104) • *Slurry receiver for C-104 tank farm retrieval* • HLW staging tank	• Four mixer pumps • New transfer pump and jumpers • I&C system	$32[1]
C-104 (W-523) • HLW source tank	• New transfer pump, jumpers and pit • Sluicer, jumpers, pipelines, and pit • Associated equipment/I&C system • Uses AY-101 as slurry receiver tank	$83[1]
SY-102 (W-211) • HLW source tank	• Two mixer pumps • New transfer pump and jumpers • I & C system • *Supplemental retrieval system (not included in current scope)*	$20[1] ($5 – 10)[1]

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
EXTENDED ORDER TANKS		
C-107 (W-523) • HLW source tank • *To be blended with waste from AW-103.*	• New transfer pump, pipelines, jumpers and pit • Sluicer, jumpers, pipelines, and pit(s) • Associated equipment/I&C	$83[1]
AW-103 (W-521) • HLW source tank • Backup HLW staging tank • Two fractions of tank sludge to blending independently with sludge from C-107 and AW-104	• New transfer pump and jumpers • I&C system • *Supplemental retrieval system (not included in current scope*	$28[1]
AW-104 (W-521) • HLW source tank – sludge retrieval (to be blended with AW-103)	• Two mixer pumps • New transfer pump and jumpers • I&C system	$28[1]
W-314 Phase 1	• AN-A & B valve pit jumpers • Reroute Cross-site to AN-101 & 104 • Pipelines from AN-101 to AZ valve pit. • New AZ valve pit • Pipelines from AN-104-04A to new AP valve pit provided by W-521 • Pipelines from AZ V. P. to new AP valve pit provided by W-521 • AW-A and B valve pit jumpers • AY pipelines to AZ valve pit • AZ pipelines to AZ valve pit • MPS system	$157
W-314 Phase 2	• AN Tanks 102, 103, 105, 106 & 107 A pit drain seal, SPC & LD upgrades; new primary HVAC System, plus selected instrumentation, alarm, and electrical upgrades • AP Tanks 101, 102, 103, 105, 106, 107, & 108 selected pit drain seal, SPC & LD upgrades; new primary HVAC system, plus selected instrumentation, alarm, and	$127.8

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
	electrical upgrades • AW Tanks 101, 102, 103, 105, & 106 selected pit drain seal, SPC & LD upgrades; new primary HVAC System, plus selected instrumentation, alarm, and electrical upgrades • AY Farm selected instrumentation, alarm, and electrical upgrades • AZ Farm selected instrumentation, alarm, and electrical upgrades • SY Tanks 101, 102, & 103 selected pits plus SY-A & B valve pit drain seal, SPC & LD upgrades; New Annulus HVAC system, plus selected instrumentation, alarm, and electrical upgrades • 244-S pit drain seal, SPC & LD upgrades; New Annulus HVAC System, plus selected instrumentation, alarm, and electrical upgrades	
W-521 (New AP valve pit)	• New AP valve pit • Two new pipelines to existing AP valve pit. • Upgrade existing AP valve pit jumpers and valve position indication • Tie required instrumentation into W-314 MPS • BNFL 4 pipelines (LAW & HLW)	$35[1]

HLW = High-level waste
I&C = Instrumentation and control
MPS = Master pump shutdown
SPC = Special pit conditioning
HVAC = Heating, ventilating, and air conditioning

[1]Cost shown is preconceptual rough-order-of-magnitude estimate. Costs are not validated.
Italicized text indicates work that is not currently part of project scope.

4.2.2.1 Potential Project Integration Issues. Project W-211 has completed the design and some procurements for a retrieval system in tank 241-SY-102. Costs incurred to date include design cost of $3.2M and procurement of $3.0M. If requirements change for the retrieval system in this tank, additional design and procurement costs could be incurred.

However, an evaluation needs to be performed to determine whether two mixer pumps with multi-level deployment are required to retrieve high-volume solids from 241-AW-103 and 241-AY-101. This work will be done as part of the early design phase for these tanks. If enhancement technologies, outside of the current project baseline, are required in addition to two mixer pumps with multi-level deployment per DST, the retrieval system costs for 241-AW-103 and/or 241-AY-101 could increase.

Project W-521 will modify the current 200 E Waste Transfer System design by adding a new valve pit north of the AP tank farm. The new valve pit would provide a transition point for new pipelines from the AN/AY/AZ to AP tank farm. The cost for the pit addition is provided in Table 4.2-2. Waste transfer pipelines will connect this pit to BNFL Inc. pipelines at their property boundary. Details of the BNFL Inc. interface are provided in ICD-20 (BNFL 2000).

4.2.2.2 Open Issues. A number of AGA studies are under way, or are planned, that address open issues related to DST infrastructure systems. The studies will assess the following systems: electrical power distribution, transfer system valve control/operation, primary ventilation requirements, annulus ventilation of aging waste tanks, transfer pump design, waste transfer system jumper needs, and sluicing/mixer pump interface at 241-AY-101 and 241-AY-102.

4.2.2.3 Primary Ventilation System Upgrades (Includes Toxic Gas Treatment). The table below provides a comparison of ROM cost impacts related to required tank farm exhauster system upgrades. At present the preliminary assessment of the DST primary ventilation system needs has concluded that upgrades will be required. The ROM cost provided assumes a replacement of the ventilation system from the de-entrainer through to the stack. The upgrade accounts for the addition of toxic gas treatment and monitoring.

Tank farm exhauster systems	Cost (millions)
AW Tank Farm	$10 - 30
AY/AZ Tank Farm 702-AZ	$20 - 30
SY Tank Farm	$10 - 30
TOTAL COST	$40 - 90

4.2.2.4 Basis for System Configuration. This section summarizes sources of failure in the feed delivery system hardware and how the failures are managed to ensure consistent performance.

Reliability, availability, and maintainability (RAM) analysis and Operations and Maintenance (O&M) concept documents are in preparation to quantify component failure frequencies, guide design redundancy, and quick-turnaround maintenance and repair strategies for retrieval and delivery of waste from the minimum order tanks. The current value place on privatization facility idle time (an ORP risk for failing to deliver feed) is $2.5M/day. Thus, the system configuration and degree of design conservatism is driven by the following:

Risk = Probability (RAM of design and O&M) X Consequences (idle penalty).
Note: Consequence = number of days idle x $2.5M/day.

There are five subsystems that are sources of component failure in the feed delivery system:

1. Transfer pumps (including tank specific I&C)
2. Mixer pumps (including tank specific I&C)
3. Transfer routes (lines, valves, jumpers, leak detectors, etc.)
4. Farm support systems (HVAC, water, nitrogen, electric, chemical makeup, etc.)
5. Instrumentation and control.

The philosophy used to minimize failure consequences in the tank farm design approach is summarized below.

4.2.2.5 Pumps. Pump design (items 1 and 2) is tank-specific. Although mixer and transfer pumps see little total operational time, failures historically have occurred and should be anticipated. Currently, the HTWOS model does not consider RAM inpacts on waste feed delivery. The effects of pump failures can be mitigated by providing multiple (>2) staging tanks and alternate/backup feed/source tanks. The failure of any one pump in the system can be overcome by employing redundant transfer pumps or delivering feed from another source tank or feed staging tank. The turnaround to replace a failed pump is approximately 70 days with staff and material prepared in advance (Shaw 1998, Appendix H, for basis and assumptions). Shorter turnaround times may be achievable given the high priority for avoiding idle facilities cost penalties.

The major portion of the Case 3S6E/Phase 1 HLW waste is stored in or will be transferred to the AZ and AY tank farms, and it will be staged therefore in AZ and AY tank farms. The alternate/backup staging tank for HLW will be in the AW tank farm. For Case 3S6E, when the 241-AZ-101 and 241-AY-102 tanks are emptied they will be used again for staging future feed for processing. Ensuring that multiple tanks are ready for retrieval and staging operations during the same time frame reduces the risk of a failed pump situation.

4.2.2.6 Transfer Routes. Transfer routes (item 3 above) are not as prone to failure as pumps unless the waste being transferred poses a high risk of plugging. Lines have failed in the past from plugging and from steam entering lines not designed to handle the temperature stress. These situations have resulted in failures/leaks. The current system generally is protected from line failures by redundant routes with some exceptions as noted below.

HLW tanks 241-AZ-101 and 241-AZ-102 use a common single line for a 60-m (200-ft) section of the HLW transfer route. Alternate source tanks located in the AW and AY tank farms can provide redundancy once the tanks have been upgraded with waste retrieval systems; upgrades will occur two years after HLW processing begins.

HLW tanks 241-AY-101 and 241-AY-102 use a common single line for a short section of the HLW transfer route. Alternate source tanks in the AW and AZ tank farms once the tanks have been upgraded with waste retrieval systems.

4.2.2.7 Farm Infrastructure. Failure of a tank farm infrastructure component (items 4 and 5 above) could result in removal of all tanks in a given farm from service under a worst-case scenario. The redundancy planned to mitigate this circumstance is to provide HLW backup feed staging capabilities in AW tank farm. Backup feed for HLW is assumed to be 241-AW-103 waste that could be delivered, if needed, directly from 241-AW-103 instead of blending it with other waste.

4.2.2.8 Equipment Conclusions. A single HLW route from 241-AZ-101 and 241-AZ-102 to the nearest transfer pit appears acceptable, because of the low potential for line plugging. However, plugging or failure of the first 60-m (200-ft) section of the route would disable initial HLW feed delivery. The AY tanks would not be available at the beginning of the campaign, and 241-AW-103 would not be equipped early enough to provide alternate feed. Options to provide alternate routes or feeds (pending further RAM work) are as follows:

- Provide two lines from the AZ tanks to the AZ transfer pit so that backup exists for the entire route. This option is not part of current project baselines.

- Accelerate construction of the 241-AW-103 mixer pump installation so that unblended feed from this tank would be available early in the schedule from an alternate farm not affected by an AY/AZ infrastructure failure. This option is included in the current project W-521 baseline as indicated on Figure 3.2-2.

An AY/AZ infrastructure failure (vent system) could take all the aging-waste tanks out of service. This risk appears acceptable for Phase 1. The fallback position would be to accelerate construction of the 241-AW-103 mixer pump installation so that unblended feed from this tank would be available early in the schedule from an alternate farm not affected by an AY/AZ infrastructure failure.

4.2.3 Schedule

4.2.3.1 Mission Summary. The waste feed delivery schedule projection for HLW indicates that BNFL Inc. operations will be supported continuously for Case 3S6E at Phase 1 rates.

Operational need dates are established by a BNFL Inc. processing schedule calculated from HTWOS modeling with an allowance for time to transfer, blend, and certify waste as required. Construction dates in current project baselines support transfers, feed certification, and delivery of feed.

This schedule information is depicted on mission summary diagrams shown in Figures 3.2-1 and 3.2-2 (Section 3.2.3) for Phase 1 and Phase 1-Extended Order, respectively. The diagrams summarize the schedule interface between project actions and the need dates driven by the feed staging scenarios. Tanks supporting HLW feed delivery are shown on the lower portion of each diagram.

Figure 3.2-3 (Section 3.2.3) shows projected use of DSTs through the end of Phase 1. Notes on the figure indicate all tank-to-tank transfers for staging and delivery transfers to BNFL Inc. during Phase 1. Backfilling DSTs near the end of Phase 1 for early Phase 2 feed also is shown on the figure.

4.2.4 Tank Allocation Diagrams

Double-shell tank usage allocation diagrams found in Appendix H have been updated to include additional information regarding construction dates, transfer destination tanks, and tank volumes. Tanks of interest in all DST forms have been incorporated.

4.3 HIGH-LEVEL WASTE FLOWSHEET

See Section 3.3 for a description of the HLW flowsheet.

4.4 HIGH-LEVEL WASTE SENSITIVITY ANALYSIS

The sensitivity of the mission outcome to changes in key technical assumptions was assessed by running the HTWOS model with revised assumptions and comparing the results from the sensitivity cases to the baseline results. The major findings from this sensitivity analysis are summarized below. Results from Case 3S6E are provided in the discussion below as a reference for the comparisons.

Vitrification of HLW feed delivered through the last tank in the minimum order sequence (241-SY-102 in Figure 4.1-1), is completed by May 2017 producing a total of 960 IHLW canisters for the planning Case 3S6E (March 8 PIO Guidance case). The effect of changes to key assumptions on the IHLW canister count and completion dates for the minimum order feed tanks are given in Table 4.4-1. Descriptions of cases analyzed for this sensitivity analysis are shown in Table 1.3-1 and Figure 1.4-1. The following sensitivities are compared to the planning case 3S6E.

Table 4.4-1. High-Level Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the result of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 960 IHLW canisters by May 2017 assuming feed from minimum order tank.
Case 3S6E R2A Blending Option for 241-SY-102	The option of blending 40 percent of 241-AW-103 sludge (currently not planned for vitrification during Phase 1) with 241-SY-102 sludge is expected to increase the waste oxide loading in the blended waste. Blending may decrease the total number of IHLW canisters produced from these tanks by 200 at a life-cycle cost reduction of $2 to 3 million per canister.	Phase 1 tanks would increase feed for IHLW by 120 canisters and the corresponding contingency processing duration of 12 months. Overall mission reduction of 200 canisters and accelerate completion by 20 months.
Case 3S6E R2A Blending of manganese and strontium precipitates	If manganese and strontium precipitates produced from the pretreatment of Envelope C LAW waste are not blended with HLW feed (disposed as separate waste form or vitrified separately), then the amount of HLW glass BNFL Inc. produces could decrease. The planning case assumes blending of the precipitates with HLW feed.	Decrease IHLW by 60 canisters and accelerate completion by six months if disposed of as separate waste form. Insufficient information is available to authors at this time to quantify IHLW produced by separate vitrification.
Case 3S6B R1 Entrained solids	BNFL Inc. treatment of LAW entrained solids with HLW feed would have a minor impact on the amount of IHLW glass produced.	Increase IHLW by 10 canisters and delay completion of minimum order tanks by one month.
Case 3S6B R1 Slower ramp-up	Decreasing the HLW processing ramp-up rate to match the BNFL Inc. plan for ramp-up rate would defer IHLW production and delivery of later HLW feed tanks.	No change to IHLW quantity and delay completion of minimum order tanks by nine months.
Case 3S6C Early start	The effect of starting HLW vitrification 17 months earlier than Case 3S6E is expected to be negligible since this schedule was supported during fiscal year 1999.	No change to IHLW quantity and accelerate completion of minimum order tanks by 17 months.

HLW = High-level waste
IHLW = Immobilized high-level waste
LAW = Low-activity waste.

5.0 PHASE 2 FEED STAGING

The DOE's strategy for Phase 2 is to procure services from contractors for retrieval and treatment of all waste remaining in the tank farms after the Phase 1 contract has been completed. The SST waste retrieved into DSTs before the current BNFL Inc. contract completes (February 28, 2018) will be processed in Phase 2. All waste in SSTs and DSTs is assumed to be retrieved without regard to waste classification.

The general approach calls for retrieval of all remaining SST waste into DSTs, interim storage in and staging from the DSTs, and all pretreatment and immobilization operations in contractor-provided facilities. Detailed specifications for Phase 2 feed separation requirements and product specifications have not been established yet. Phase 2 feed deliveries are not constrained to meet Phase 1 feed envelope specifications. Phase 1 separation requirements and product specifications are applied to Phase 2 for estimating purposes.

Cases have been analyzed to cover Phase 2 processing, although firm guidance and commitment to the necessary projects are not fully defined. The HTWOS model allows full integration with Phase 1 by retrieving waste from SSTs as DST space is made available and sequencing the SST waste retrieval according to a risk-based strategy coupled with a bias to minimize HLW and LAW processing facility down time.

The analyses yielded the following key findings.

The inventory, wash factors, and glass loading are based on the best information used in Phase 1. The accuracy of these data will affect the processing duration by ± 5 to 15 percent.

In Case 3S6E the Phase 1 LAW and HLW processing capacities increase in 2018 by the addition of second LAW and HLW processing facilities. Processing is completed by 2032 and SST retrieval is completed by 2028 in this scenario. The corresponding total Phase 2 melter design rates, if a 60 percent total operating efficiency (TOE) is assumed, are 120 MT/day for LAW and 12 MT/day for HLW based on PIO assumptions (PIO 2000). This equates to actual processing rates of 72 MT/day for LAW and 7.2 MT/day for HLW. This scenario is constrained by the HLW and LAW processing rates.

The same retrieval sequence can be used to complete processing by 2028 (Erickson 1999) with SST retrieval completing in 2026. The corresponding processing rates are 90 MT/day (150 MT/day at 60 percent TOE) for LAW and 10.5 MT/day (17.5 MT/day at 60 percent TOE) for HLW. This is a 25 percent increase in the LAW production rate and a 46 percent increase in the HLW production rate guidance stated in the PIO assumptions (PIO 2000). Analysis of this scenario revealed that even with the higher melter rates, the mission was constrained by the HLW and LAW processing rates and not by the SST waste retrieval rates.

Section 5.1 documents the Phase 2 feed staging sequence and includes the projected HLW and LAW glass produced. Section 5.2 provides detail on the SST waste retrieval and staging strategy, including the staging sequence, equipment, and schedule of SST retrieval. Section 5.3 presents SST Retrieval Program sensitivities including glass formulation, architecture, and plant capacities.

5.1 PHASE 2 RETRIEVAL AND FEED STAGING SCENARIO

A detailed analysis of Phase 2 feed staging has not been performed at this time. The general approach to Phase 2 feed staging is to minimize HLW glass volume, keep the LAW and HLW glass plants operating, retrieve waste from those tanks posing the greatest environmental risk early in the schedule (see Section 5.2 for more information), and complete retrieval of the SST waste as early as possible. SST waste retrieval supporting Phase 1 feed delivery and occurring before 2018 has been analyzed in detail to support the Phase 1 effort.

5.1.1 Phase 2 Feed Delivery

The Management Assessment (Payne 1998) performed during the first RTP effort and the MAR (Acree 1998) associated with it recommended that a maximum of five SSTs could be retrieved simultaneously. This recommendation was further broken down by quadrants; one SST to be retrieved simultaneously in the NE (B, BX, and BY farms), SW (S, SX, and U farms), and SE (A, AX, and C farms) quadrants, with two simultaneous retrievals in the NW (T, TX, and TY farms) quadrant. If these limits are maintained, SST waste retrieval and processing will extend out until around 2040.

In order to model the completion of processing by the year 2030 as directed by DOE-ORP (PIO 2000), it was required to increase the overall number of simultaneous retrievals to seven, and increase the number of simultaneous retrievals occurring in each quadrant and tank farm as well. The issues that led to the recommendation in the Management Assessment (coordination of multiple construction activities within a farm, and the operational complexity associated with simultaneous retrievals) need to be addressed when planning for Phase 2 to complete retrieval and processing by 2030.

If the construction timing and operational complexity issues are resolved, the planned equipment would allow the following to happen. When in S, SX, A, AX, and C farms, there will be a maximum of two simultaneous retrieval activities while in an SST farm. The waste from these two simultaneous tank retrieval activities will go into one DST. For all other farms, there can be more than two simultaneous retrieval activities, but the waste retrieved from one tank will go into its own 570-m^3 (150,000-gal) receiver tank inside a WRF. This constraint only applies to the NW, NE, and SW quadrants.

In the NW and NE quadrants, there could be a maximum of six simultaneous retrieval activities per quadrant (there are six individual receiver tanks planned for waste receipt in the NW and NE quadrants). This constraint assures that the waste from one SST will be retrieved into its own receiver tank in the WRF.

For the SW quadrant, a maximum of six simultaneous retrieval activities may be needed (no more than two simultaneous activities per farm). For U farm, waste from a source tank will be retrieved into its own receiver tank. In S or SX farms, waste from two source tanks will be placed into one DST receiver tank.

In the SE quadrant, there will be a maximum of two simultaneous retrieval activities, with waste from A, AX, and C farms going into one DST receiver tank. See Sections A6.1 and

A6.2 of Appendix A for more information. Table 5.1-1 provides a breakdown of SST farms into quadrants and identifies their designated receivers. Future work can be done to optimize the use of DSTs as waste receivers.

Table 5.1-1 Designated Receivers and Quadrants of Single-Shell Tank Farms.

Quadrant	Designated receiver	Single-shell tank farms
NW	NW Waste Retrieval Facility (WRF) (six 570-m^3 [150,000-gal] tanks)	T, TX, TY
NE	NE WRF (six 570-m^3 [150,000-gal] tanks)	B, BX, BY
SW	241-SY-101	SX
	SW WRF (two 570-m^3 [150,000-gal] tanks)	U
	241-SY-103	S
SE	241-AY-102, 241-AY-101	A, AX, C

Waste retrieved from SSTs will be transferred to the East Area DSTs for staging as feed to the Phase 2 treatment vendors. Figure 5.1-1 displays the assumed Phase 2 process flow configuration for SST waste retrieval and WFD using the WRFs. An overview of the proposed piping system and how it relates to the existing system is shown in Figure 5.1-2. Sampling and feed certification will take place in the East Area DSTs before the delivery of feed. The details of sampling and feed certification are not assumed to constrain Phase 2 feed deliveries.

No program goals have been established to direct the sequence for retrieving the waste remaining in DSTs after Phase 1 or for delivering SST waste staged in the DSTs. The selection of DSTs from which waste is retrieved and processed, including ones storing retrieved SST waste, occurs automatically during Phase 2 modeling. It is based on the need to provide sufficient waste so the LAW and HLW facilities continue operating (i.e., minimize facility downtime) and meet the anticipated DST spare space requirements.

5.1.2 Projected Phase 2 Product

The LAW glass is produced from decontaminated LAW feeds and decontaminated wash and leach solutions. The estimated amount of LAW glass produced during Phase 2 is based on a 20 wt% Na_2O loading in the glass. For Case 3S6E, production is estimated to be 142,700 m^3: 32,200 m^3 in Phase 1; and 110,500 m^3 in Phase 2. See Section 6.1 for more details about LAW glass production and packaging.

The HLW glass is produced to encapsulate washed solids, radionuclides removed from LAW feeds (and wash/leach solutions), and Cs and Sr capsules. The washed solids, separated radionuclides, and Cs and Sr capsules are accumulated in four 1,890,000-m^3 (500,000-gal) tanks before being vitrified. This is a simplifying modeling assumption based a past assumption that two DSTs will be used to store washed solids. The washed solids were retained to facilitate waste blending and reduce the amount of HLW glass produced. The estimated amount of HLW glass produced is based on the PNNL glass properties model. For Case 3S6E, production is estimated to be 14,640 m^3 of HLW glass from all the waste: 1,640 m^3 in Phase 1 and 13,000 m^3 in Phase 2. See Section 6.2 for more details about HLW glass production and packaging.

Figure 5.1-1. Retrieval Model Configuration.

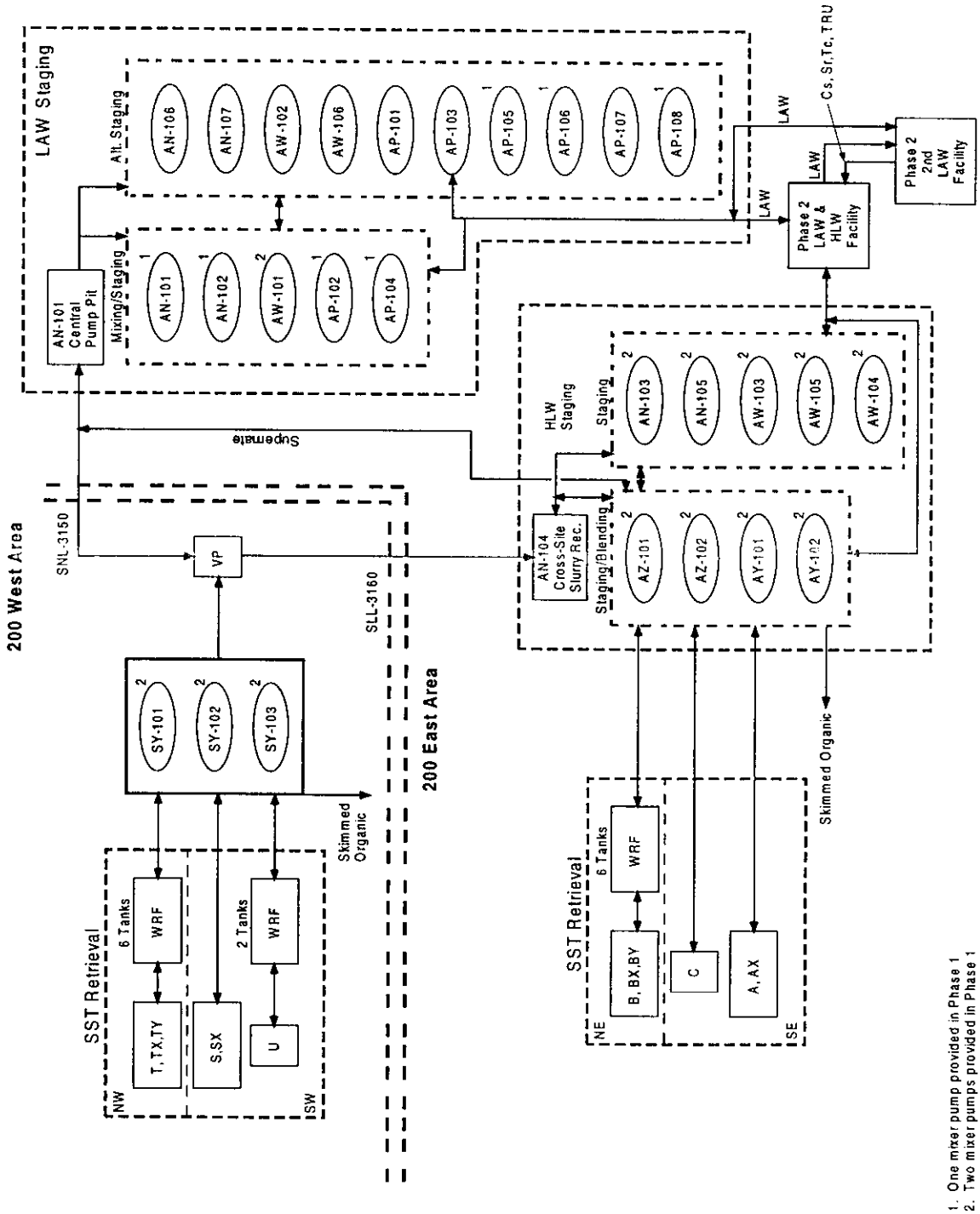
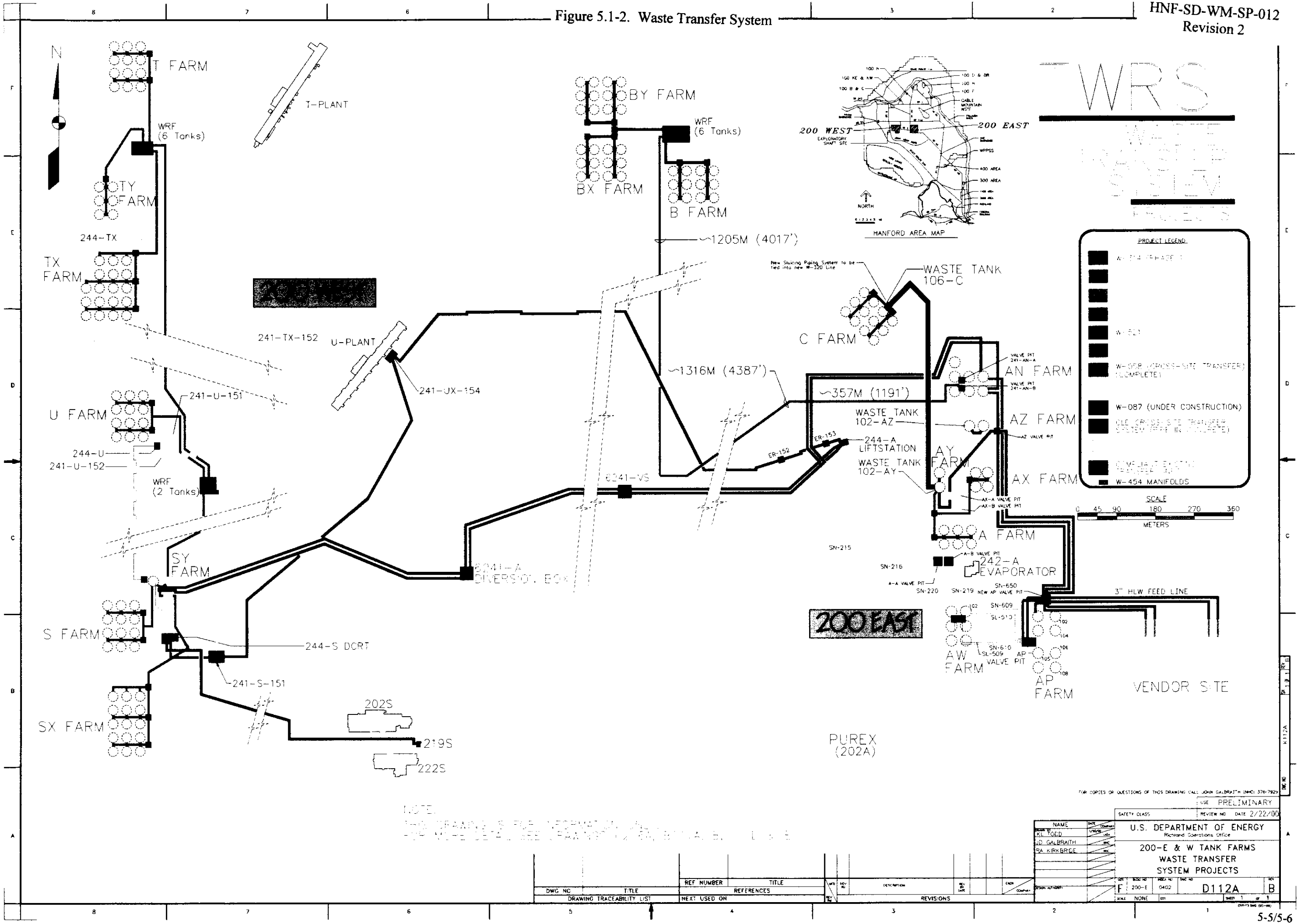


Figure 5.1-2. Waste Transfer System



5.1.3 Phase 2 Feed Compliance

It is assumed that the BNFL Inc. contract for Phase 1 is not binding for WFDs during Phase 2 operations. There are no feed envelope specifications that have to be met during Phase 2. See Section A4.3 of Appendix A for more information.

5.2 PHASE 2 RETRIEVAL AND STAGING STRATEGY

The SST program has embarked on a retrieval strategy (Haas 2000) that addresses risk in a reasonable manner by applying the following criteria.

- First, focus on high-risk waste in sound tanks (with high ^{99}Tc content), predominantly saltcake wastes.
- Next, focus on sound tanks that contain mixed sludge and saltcake wastes.
- Finally, focus on tanks that have leaked or are assumed to have leaked. Interim stabilization will have reduced the risk of release from such tanks providing time to develop retrieval technologies and experience to minimize the risk of leakage during retrieval.

Other elements employed in creating a retrieval logic are as follows:

- Retrieve that type of waste necessary to keep the LAW and HLW processing plants operating.
- Retrieval of waste is prioritized by category unless constrained by other programmatic considerations.
- Once retrieval in a tank begins, continue retrieval from that tank until the tank waste volume is reduced to 0.4 m^3 (100 gal) or less.
- Waste will be retrieved simultaneously from up to seven tanks.
- Waste from multiple SSTs will be mixed in the staging tanks to increase incidental blending.

This logic is consistent with that used in TWRSO&UP, Revision 1 (Kirkbride et al. 1999) and the letter report on completion of Tri-Party Agreement Interim Milestone M-45-02D, Submit Annual Update of SST Retrieval Sequence Document (Boston 1999a). This logic has been applied in all cases from 3S3 to 3S6.

5.2.1 Tank-Specific Staging Sequence

As a result of the criteria and elements presented in Section 5.2, the ten categories of waste were updated for this analysis based on inventory changes and on the *Single-Shell Tank Program Plan* (Haass 2000). These categories are presented in Table 5.2-1.

Table 5.2-1. Single-Shell Tank Waste Retrieval Categories in Order of Retrieval Priority.

Retrieval priority	Category
1	Category 1 - Sound saltcake tanks with elevated levels of ^{99}Tc
2	Category 2 - Sound sludge tanks with less than 1.83 m (6 ft) of sludge
3	Category 3 - Sound saltcake tanks with lower levels of ^{99}Tc.
4	Category 4 - Sound saltcake/sludge mixed tanks with less than 1.83 m (6 ft) of sludge
5	Category 5 - Sound sludge tanks with more than 1.83 m (6 ft) of sludge
6	Category 6 - Sound saltcake/sludge mixed tanks
7	Category 7 - Leaking saltcake tanks
8	Category 8 - Leaking saltcake/sludge mixed tanks
9	Category 9 - Leaking sludge tanks with less than 1.83 m (6 ft) of sludge
10	Category 10 - Leaking sludge tanks with more than 1.83 m (6 ft) of sludge

The descriminator of 1.83 m (6 ft) for sludge depth was selected as a preliminary value to discriminate the difficulty of sludge retrieval pending further evaluation.

On the basis of the current BBI as the primary source and supplemented by Hanlon (1999b), all SSTs were placed in the appropriate categories. It is this listing that becomes the input for sequencing SST waste retrievals using the HTWOS model. A list of the tanks in each category is presented in Table 5.2-2.

Table 5.2-2. Category Tank Listing.

Category	Tanks	
Category 1-Sound saltcake tanks with elevated levels of ^{99}Tc	241-TX-112 241-S-102 241-S-103 241-S-105 241-S-106 241-S-108 241-S-109 241-S-112 241-BY-102 241-BY-111	241-BY-112 241-AX-101 241-AX-103 241-A-101 241-C-104* 241-C-107* *These are sludge tanks from which waste needs to be retrieved early to provide HLW feed during Phase 1.
Category 2 -- Sound sludge tanks with less than 1.83 m (6 ft) of sludge	241-T-102 241-T-105 241-TX-101 241-U-201 241-U-202 241-U-203 241-U-204	241-BX-103 241-BX-104 241-BX-106 241-B-108 241-C-102 241-C-108 241-C-109
Category 3—Sound saltcake with lower levels of ^{99}Tc	241-TY-102 241-TX-102 241-TX-104 241-TX-106	241-TX-108 241-TX-111 241-TX-118
Category 4 -- Sound saltcake/sludge mixed tanks with less than 1.83 m (6 ft) of sludge	241-U-102 241-U-103 241-U-105 241-U-106 241-U-107 241-U-108 241-U-109 241-U-111 241-S-107 241-S-110 241-S-111 241-SX-101	241-SX-102 241-SX-103 241-SX-105 241-SX-106 241-BY-101 241-BY-104 241-BY-109 241-BY-110 241-BX-105 241-A-102 241-B-102 241-B-106
Category 5 -- Sound sludge tanks with more than 1.83 m (6 ft) of sludge	241-T-104 241-T-110 241-T-201 241-T-202 241-T-203 241-T-204 241-TX-103 241-TX-109 241-BX-107	241-BX-109 241-BX-112 241-B-109 241-B-202 241-A-106 241-C-103 241-C-105 241-C-112

Table 5.2-2. Category Tank Listing.

Category	Tanks	
Category 6 -- Sound saltcake/sludge mixed tanks with more than 1.83 m (6 ft) of sludge	241-S-101	241-B-104
Category 7 -- Assumed leaker saltcake tanks	241-TX-105 241-TX-107 241-TX-110 241-TX-113 241-TX-114 241-TX-115	241-TX-116 241-TX-117 241-SX-109 241-B-101 241-B-103
Category 8 -- Assumed leaker saltcake/sludge mixed tanks	241-SX-104 241-SX-114 241-BY-103 241-BY-105 241-BY-106 241-BY-107	241-BY-108 241-BX-110 241-BX-111 241-AX-102 241-B-105 241-B-107
Category 9 -- Assumed leaker sludge tanks with less than 1.83 m (6 ft) of sludge	241-T-101 241-T-103 241-T-106 241-T-107 241-T-108 241-T-109 241-T-112 241-TY-101 241-TY-103 241-TY-104 241-TY-106 241-U-101 241-U-104 241-U-110 241-U-112 241-SX-107 241-SX-108 241-SX-110	241-SX-111 241-SX-112 241-SX-113 241-SX-115 241-BX-101 241-BX-102 241-BX-108 241-AX-104 241-B-112 241-C-101 241-C-110 241-C-111 241-C-201 241-C-202 241-C-203 241-C-204 241-A-104 241-A-105
Category 10--Assumed leaker sludge tanks with more than 1.83 m (6 ft) of sludge	241-T-111 241-TY-105 241-S-104 241-B-110 241-B-111	241-B-201 241-B-203 241-B-204 241-A-103

5.2.2 Application of Phase 2 Tank Retrieval Sequencing and Schedule

Case 3S6E (2006 Hot Start) was developed to integrate DOE's Phase 1 guidance with the Risk-Based SST Retrieval Strategy. The 2006 Hot Start scenario supports SST waste retrieval after the Phase 1 feed delivery commitments have been satisfied. The SST waste retrieval will transfer waste into DSTs as space becomes available or into WRFs as those facilities come on line. At the beginning of Phase 2, the design capacity of the existing HLW and LAW glass plants will be increased and additional higher-capacity LAW and HLW glass plants will be added as well. On 3/1/2018, the two LAW glass plants will have a design capacity of 60 MT/day each (120 MT/day total), and the two HLW glass plants will have a design capacity of 6 MT/day each (12 MT/day total). Past direction led to the assumption that the second LAW glass plant would become available in 2012 (Erickson 1999). However, Phase 1 delivery commitments tie up staging tanks and prevent effective use of the second LAW plant until 2018.

Under these constraints, SST waste retrieval is completed in 2028. Processing of LAW is completed in 2031, and HLW processing completes in 2032. The projected retrieval sequence and timing for the 2006 Hot Start Case is presented in Figure 5.2-1. The SST waste retrieval data associated with Figure 5.2-1, including the timing, duration, and quantity of waste retrieved, is presented in Table F1-1 in Appendix F.

5.2.3 Equipment

Retrieval of the sludges and saltcakes the SSTs is modeled with past-practice sluicing according to an algorithm defined in Section A6.3 of Appendix A. This method uses a remote-controlled water nozzle to dislodge and mobilize the waste solids. The mobilized material is pumped from the SST by an immersible transfer pump and then by a booster pump.

A promising alternative to past-practice sluicing is removing solids from the SSTs with a remote vehicle equipped with a localized sluicing nozzle and transfer pump. This technology is promising for future sluicing activity and is predicted to provide better retrieval efficiency along with a shorter retrieval duration (Bogen et al. 1999). Also, this method minimizes the amount of free liquid in a SST at any one time compared with past-practice sluicing. Minimization of the amount of free liquid serves to decrease the magnitude of risk for a leak from an SST. After more information is obtained on this technology, future modeling may use it instead of past-practice sluicing to determine the retrieval durations.

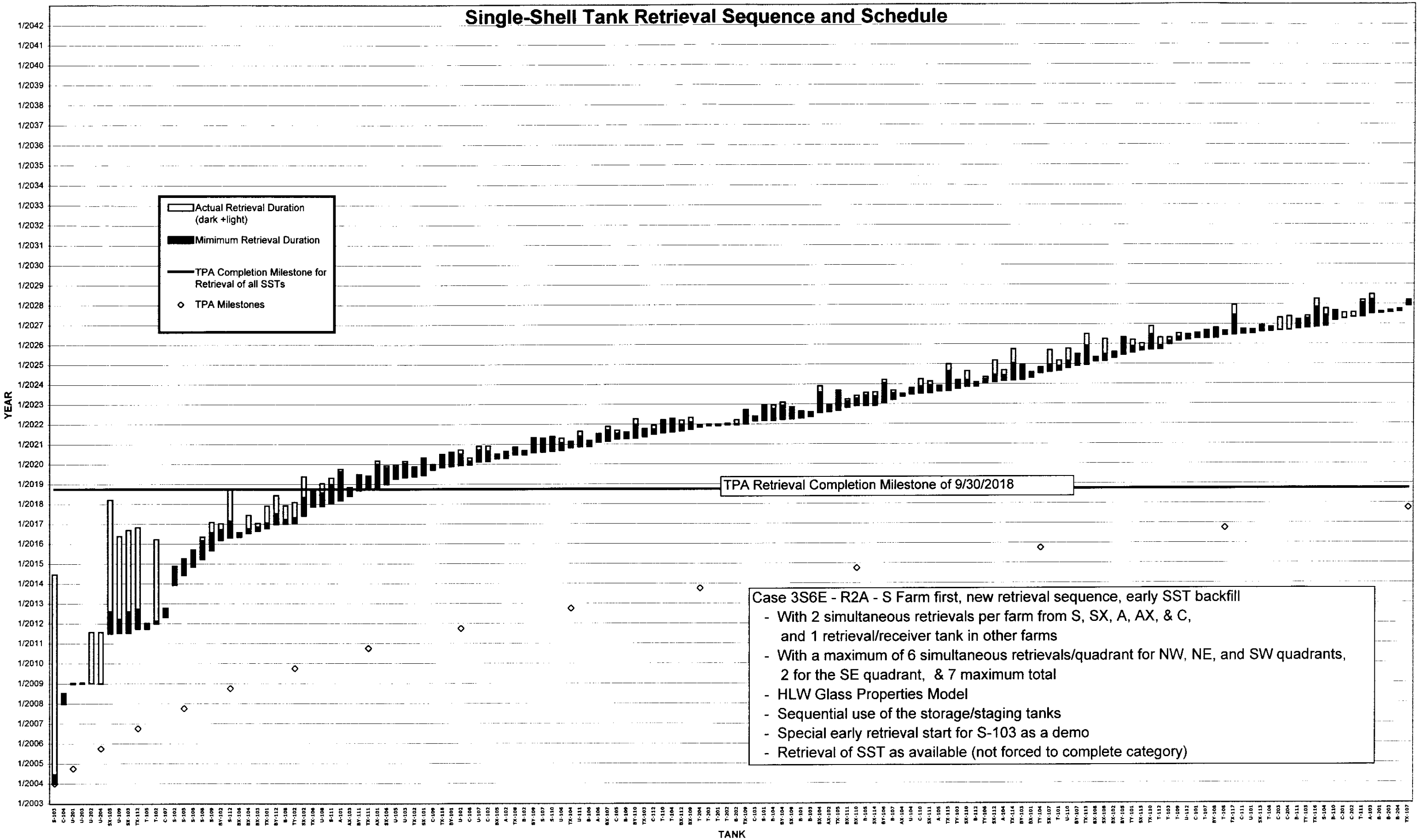
One other retrieval technology is being developed for dissolving saltcakes with a water distributor and saltwell pump. This method slowly and controllably dissolves the saltcake by sprinkling the saltcake and allowing the liquid to percolate through the waste solids. The saturated solution then is pumped from the tank as if it were being saltwell pumped. This method also lowers the potential magnitude of a leak from the tank, when compared to past-practice sluicing, by controlled, localized application of liquid and by balancing the rate of dissolution by controlled water addition.

During Phase 2, the sluiced SST waste will be transferred to the DST system in one of two ways. Waste will go either into designated DSTs or into newly built WRFs, which then will be transferred to a DST.

5.2.4 Cost Estimate

A rough-order-of-magnitude (ROM) construction cost for the retrieval process infrastructure based on past-practice sluicing has been prepared. This estimate does not include the piping from the jumper manifold pits at the edge of the tank farms to the SSTs, or the waste retrieval equipment and modifications to the tanks associated with the installation of the waste retrieval equipment (Garfield 1999a). Also, a total life-cycle cost estimate for the entire SST program has been prepared as well. The SST Program Plan (Haas 2000) provides schedules and costs for the required activities.

Figure 5.2-1. Case 3S6E Single-Shell Tank Retrieval.



5.3 SINGLE-SHELL TANK WASTE RETRIEVAL PROGRAM SENSITIVITIES

The estimated volume of HLW glass produced depends on many factors, such as the composition of waste in a batch, the total inventory, the sludge wash factors, and the glass model used. It also depends on the overall process model used for the estimate with the resultant estimated blending results.

5.3.1 Inventory and Glass Formulation

The initial chemical and radiological inventory has an obvious effect on the amount of glass that will be produced. Changes in the inventory can affect the category assignment of SSTs within the risk-based staging strategy, resulting in retrieval of waste from individual SSTs earlier or later than previously scheduled. Also, the wash and leach factors relationship to the inventory becomes more suspect. The wash and leach factors have not been adjusted to correspond to the updated inventory, which may lead to greater error in the fractions of solid and liquid within the wastes. A comparison of Case 3 from Rev. 1 of the TFC O&UP (Kirkbride et al. 1999) with the 2006 Hot Start case is presented in Table 5.3-1.

Table 5.3-1. Comparison of 2006 Hot Start Scenario with Case 3.

Scenario	2006 Hot Start	Case 3
SST waste retrieval complete	6/28	9/33
HLW vitrification complete	2/32	2/41
LAW vitrification complete	7/31	7/35
HLW glass (MT)	38,900	35,700
LAW Glass (MT)	385,000	420,000

5.3.2 Architecture

The total number of retrieval systems that can be operated concurrently is required to be seven. In the NW, NE, and SW quadrants, up to six retrieval systems can be operating. Only four operating retrieval systems are allowed in the SE quadrant.

The retrieval rate used, based on past-practice sluicing, is the same as that used for cases documented in Revision 1 of the TWRSO&UP (Kirkbride et al. 1999). Increased retrieval rates have been modeled, but the net result has been that SST waste retrieval actually took longer to complete and produced more glass. The increased retrieval rates have the effect of reducing the amount of incidental blending that occurs during waste retrievals and staging. This reduction in blending would naturally generate more glass, and since the vitrification process is the rate-limiting step, the overall mission would take longer to complete. The HTWOS model actually creates this effect artificially. The effect could be minimized or even eliminated by modeling additional mixing transfers between DSTs to enhance blending. These mixing transfers are very likely to be performed during the actual mission, tank space permitting, to achieve the same result. However, with the vitrification process remaining as the rate-limiting step, little improvement can be expected from increasing the retrieval rates.

Waste Retrieval Facilities (WRF) will be used to accumulate retrieved SST waste from SSTs that are relatively distant from DST tanks. The *Tank Waste Technical Options Report* (Boomer et al. 1993) recommended that WRFs be used in association with SST waste retrieval involving slurry transfer. The use of WRFs allow waste accumulation and conditioning at a location near the SST before long-distance transfers.

Retrieval of waste from some tank farms should be possible using existing DSTs as receiver tanks. Therefore, WRFs were assumed for the NE and NW quadrants (B complex and T complex, respectively), and for one farm in the SW quadrant, U farm. Each of the WRFs for the NE and NW quadrants will have six tanks with an operating volume of 570 m^3 (150,000 gal) per tank. In HTWOS, the NE and NW WRFs are targeted to be available on October 1, 2011. Meanwhile, the WRF supporting the U tank farm will have two tanks with an operating volume of 570 m^3 (150,000 gal) per tank. In HTWOS, the WRF for the U tank farm is targeted to be available earlier, on January 1, 2009. Early availability of the WRFs is assumed to support the PIO guidance that waste processing be completed by 2030. The early availability also supports the backfilling of DSTs with retrieved SST waste during Phase 1. The SST program is constrained by funding for the WRFs and this issue will need to be addressed either by funding the design and construction of the WRFs or providing guidance to define when the WRFs need to be available. Figures 5.3-1 and 5.3-2 show the basic layout and configuration proposed for the WRFs. See Sections A11.4, A11.5, and A11.6 of Appendix A for more information.

The Phase 2 contractor stores washed HLW solids during Phase 2. This task previously was planned for tanks 241-AZ-101 and 241-AZ-102. Storage of the washed HLW solids by the Phase 2 contractor will free the space in these tanks for storing retrieved SST waste and staging it for processing.

Waste Retrieval Facility (NE and NW Quadrants) Plan and Section.

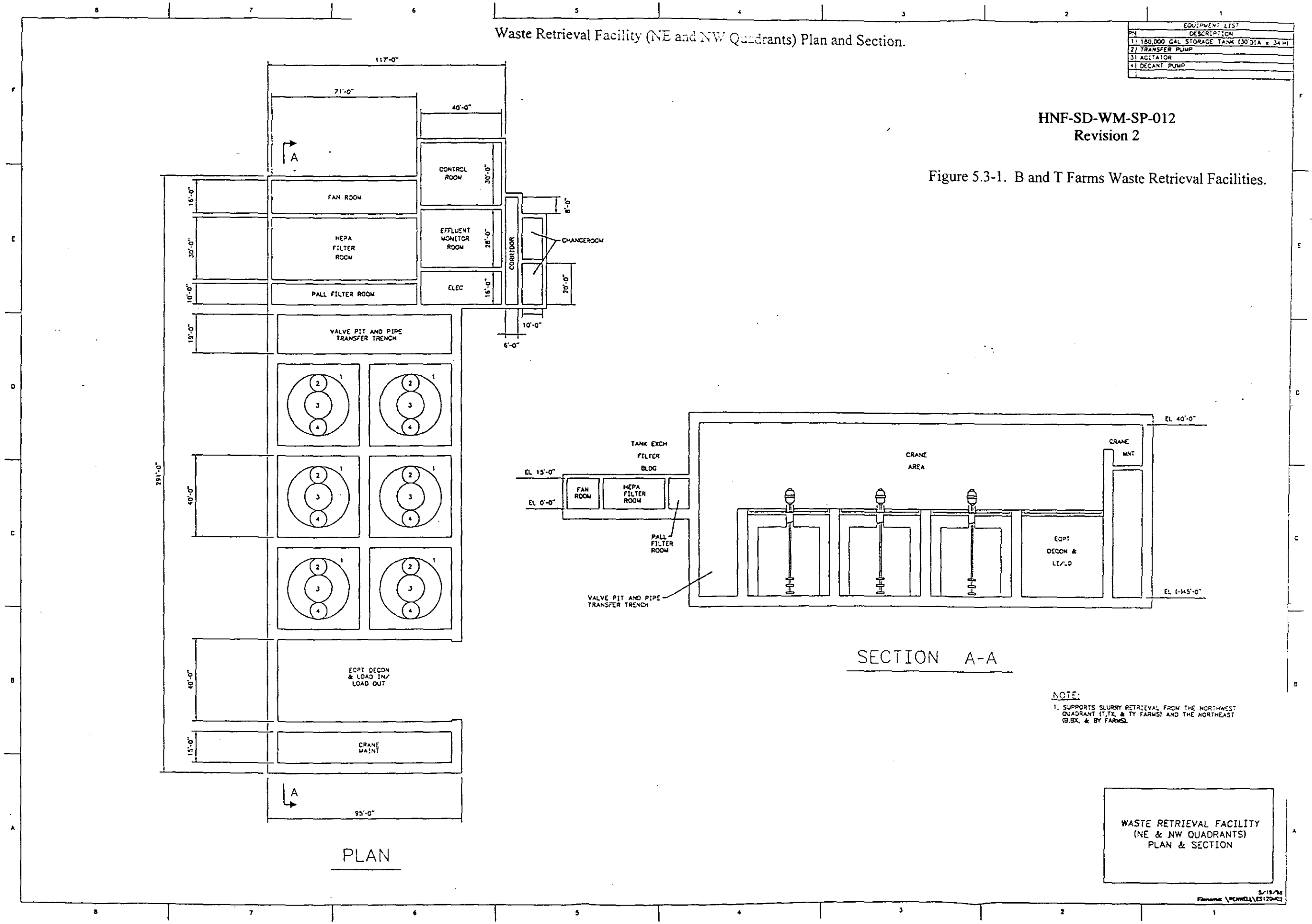


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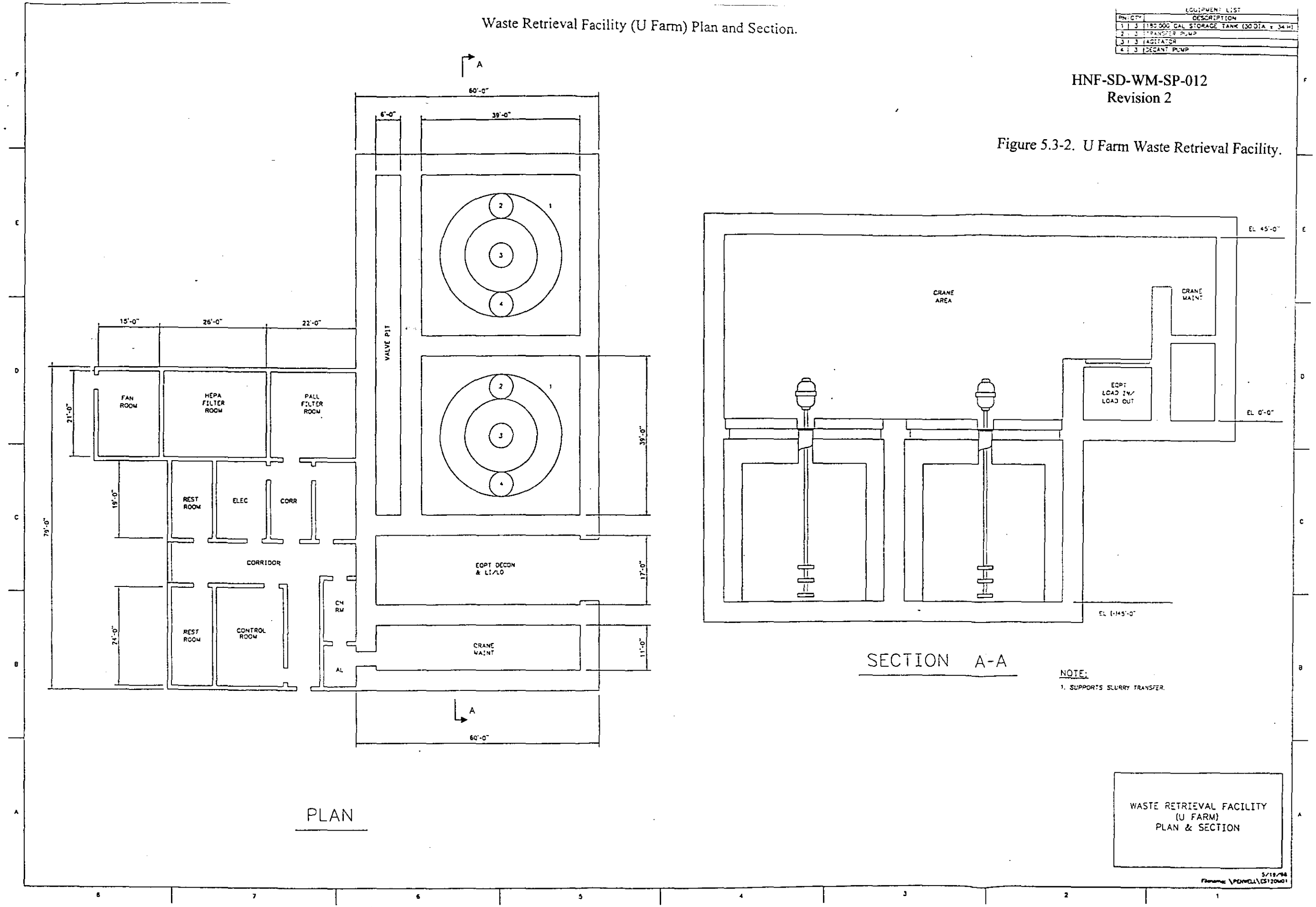
Figure 5.3-1. B and T Farms Waste Retrieval Facilities.

Waste Retrieval Facility (U Farm) Plan and Section.

Figure 5.3-2. U Farm Waste Retrieval Facility.



5.3.3 High-Level Waste Plant Capacities

During Phase 2 of Case 3S6E, the Phase 1 IHLW production rate is increased to 7.2 MT/day (12 MT/day design capacity operating at 60 percent TOE). Similarly, the Phase 1 ILAW production rate is increased to 72 MT/day (120 MT/day design capacity operating at 60 percent TOE). Based on the current tank inventories, wash/leach factors, and production rates, HTWOS model runs have shown that the HLW plants are undersized relative to the LAW production rate. This discrepancy in size results in LAW production slowdowns or even shutdowns during the mission. Therefore, a sensitivity case was run that shows the effect of increasing HLW capacity. Analysis of the data shows that an increase of the Phase 2 HLW melter throughput from 7.2 to 8.4 MT/day (12 to 14 MT/day at 60 percent TOE) was enough to keep the LAW plant operating at 96 percent of capacity (72 MT/day) during Phase 2. Retrieval of SST waste is completed in 2027 and both HLW and LAW processing complete in 2030. The SST waste retrieval sequence and timing for this sensitivity case is presented in Figure F2-1 in Appendix F. The SST waste retrieval data associated with Figure F2-1 is presented in Table F2-1 in Appendix F.

5.3.4 Increase Waste Plant Capacities to Complete Processing by 2028

The PIO guidance (PIO 2000) gave direction to complete processing of HLW and LAW by 2028 along with assumed Phase 2 immobilization facility capacities. Both the 2006 Hot Start scenario and the increased HLW plant capacities sensitivity case (Section 5.3.3) failed to achieve this goal. Increased HLW and LAW plant capacities were modeled to achieve processing completion by 2028. The IHLW and ILAW production rates from the increased HLW plant capacities sensitivity case (Section 5.3.3) were increased by 25 percent to 10.5 MT/day (17.5 MT/day at 60 percent TOE) and 90 MT/day (150 MT/day at 60 percent TOE), respectively. The resulting HLW production rate is 46 percent higher than the 2006 Hot Start scenario. Under these parameters, retrieval of SST waste is completed two years earlier, in 2026, than the 2006 Hot Start scenario. More importantly, both HLW and LAW processing complete in 2028, at least three years earlier than the 2006 Hot Start scenario. The SST waste retrieval sequence and timing for this sensitivity case is presented in Figure F2-2 in Appendix F. The SST waste retrieval data associated with Figure F2-2 is presented in Table F2-2 in Appendix F.

5.3.5 Increased Single-Shell Tank Waste Retrieval Rates

The purpose of this sensitivity case is to show the effect of increased SST waste retrieval rates on the mission. The increased rates were modeled using an algorithm that reflects more realistic retrieval durations (less than one year). Insoluble solids (sludges) are retrieved as 10 wt% solids slurry at 1.32 m^3/min (350 gal/min) to maintain sufficient transfer velocities in 3-inch piping to avoid settling solids and to support high-volume/high pressure sluicing. Soluble salts (saltcake) are retrieved as 5*M* caustic concentrations at 0.19 m^3/min (50 gal/min).

The increased retrieval rates have the effect of reducing the amount of incidental blending that occurs during waste retrievals and staging. This reduction in blending would naturally generate more glass, and since the vitrification process is the rate-limiting step, the

overall mission takes longer to complete. The HTWOS model actually creates this effect artificially. The effect could be minimized or even eliminated by modeling additional mixing transfers between DSTs to enhance blending. This additional blending is very likely to be performed during the actual mission, tank space permitting, to achieve the same result. However, with the vitrification process remaining as the rate-limiting step, little improvement can be expected from increasing the retrieval rates at these processing rates.

Under these parameters, retrieval of SST waste is completed almost a year later, in 2029, than the 2006 Hot Start scenario. HLW processing completes in 2033 and LAW processing completes in 2032, a year later than the 2006 Hot Start scenario. The SST waste retrieval sequence and timing for this sensitivity case is presented in Figure F2-3 in Appendix F. The SST waste retrieval data associated with Figure F2-3 is presented in Table F2-3 in Appendix F.

5.3.6 Application of Tank-Specific Leach Factors during Phase 2

The purpose of this sensitivity case is to determine the impact of applying tank-specific caustic leach factors to HLW retrieved from tanks during Phase 2. Case 3S6E applies global caustic leach factors to HLW during Phase 2. The global leach factors were developed as a mass-weighted average by grouping tanks having similar wastes or waste sources and assuming laboratory test data from selected tanks would represent the behavior of other tanks in the group. The tank grouping, the testing performed, and the factors developed are reported by Colton (1997). The current tank inventory estimates indicate that waste tank groupings need to be revised to accurately extrapolate laboratory data to represent untested wastes. This has not been performed yet.

An effort was made in fiscal years 1998 and 1999 (Hendrickson 1998) to develop wash and leach factors that are consistent with the best-basis inventory to improve the predictive capability of the HTWOS model. The data used to develop the global leach factors were supplemented with water wash data from Hanford process information and with results from ESP[1] model predictions of wash behavior. Additional work is being done beyond Hendrickson's work to incorporate new data from Tanks Focus Area laboratory tests and BNFL Inc. waste treatability tests. Also, the data set needs to be coupled with chemical reactions so a mass balance can be performed. This modified set of tank-by-tank leach factors is still being developed and this sensitivity case was run to understand the uncertainty with the available data sets.

The quantity of HLW glass produced is determined by the fraction of leached sludge that will dissolve into the molten glass (waste oxide loading = mass of waste oxides/mass of glass). The quantity of HLW glass produced during Phase 2 is largely determined by the chromium content of the sludge.

The impact of applying tank-specific caustic leach factors to HLW retrieved from tanks during Phase 2 is an increase of 12,000 IHLW canisters – an approximate 100 percent increase over 3S6E. This significant increase in IHLW canisters is caused largely by a proportional

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[1]ESP is a trademark of OLI Systems, Inc.

decrease in the amount of chromium leached from HLW sludge. Since HLW glass has a 0.5 wt% limit of chromium oxide, the chromium content in leached HLW sludge can have a major impact on the amount of HLW glass produced. Another sludge pretreatment process, referred to as oxidative leaching, has been shown to remove more chromium from Hanford tank sludge than does caustic leaching. However, development of the oxidative leaching process is immature and data are not available to predict how oxidative leaching can be applied on a tank-by-tank basis.

Under these parameters of this sensitivity case, retrieval of SST waste is completed 12 years later, in 2040, than the 2006 Hot Start scenario. HLW processing completes about 14 years later, in 2045, and LAW processing completes about 12 years later, in 2043, than the 2006 Hot Start scenario. The SST waste retrieval sequence and timing for this sensitivity case is presented in Figure F2-4 in Appendix F. The SST waste retrieval data associated with Figure F2-4 is presented in Table F2-4 in Appendix F.

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6.0 PRODUCT RECEIPT, STORAGE, AND DISPOSAL

The ILAW will be disposed of directly by near-surface land disposal in dedicated facilities. IHLW will be stored on site until it can be shipped to the geologic HLW repository at Yucca Mountain, Nevada.

BNFL Inc. currently plans to provide in-plant storage space for up to 45 IHLW canisters and 450 ILAW packages. During operation of the BNFL Inc. facilities, the inventory of the in-plant storage areas are assumed to be at 50 percent of capacity.(PIO 2000) The Case 3S6E scenario indicates that the LAW vitrification plant will reach 50 percent of its in-plant storage capacity on August 13, 2007. The project baseline date for the first shipment date is December 2007. The scenario indicates that the inventory of in-plant stored ILAW packages would reach 72 percent of the in-plant storage space if shipping does not begin until December 2007. For IHLW, the 3S6E scenario indicates that the HLW vitrification plant will reach 50 percent of its in-plant storage capacity on April 2, 2009. The project baseline date for the first shipment date is September 2009. The scenario indicates that the inventory of in-plant stored IHLW canisters would occupy 91 percent of the in-plant storage space if shipping does not begin until September 2009.

The regulatory status of the BNFL Inc. in-plant storage areas for ILAW packages and IHLW canisters is not know. BNFL Inc. has indicated during informal discussion that they do not expect to be subject to the dangerous waste ninety day storage limits on these areas.

The current CHG storage and disposal project baselines are based on Phase 1 maximum order quantities of 13,336 ILAW packages and 1,120 IHLW canisters (Cusack 2000). These limits have not been imposed on the cases modeled by this report. The Case 3S6E scenario indicates that 13,500 ILAW packages and 1,070 IHLW canisters would be filled by the end of the Phase 1 contract period.

6.1 IMMOBILIZED LOW-ACTIVITY WASTE DISPOSAL

The ILAW packages will be disposed of in the ILAW Disposal Facility, Project W-520. The ILAW Disposal Facility consists of a series of modules to be constructed on an as-needed basis.

6.1.1 Immobilized Low-Activity Waste Package and Disposal Facility Design

BNFL Inc. will deliver the ILAW product in 1.22-m diameter by 2.28-m tall right cylindrical packages. The sidewall of each container is 0.343-cm (10-gauge) steel. All packages are disposed of as remote-handled waste in near-surface disposal modules. Project W-520 is being rebaselined to a remote-handled trench concept (Taylor 1999b). Each trench (or module) will hold 13,366 packages. The remote-handled trench concept applies the operating concepts in use in the solid-waste disposal grounds. This concept uses portable shielding and earth covers to protect workers from radiation. A shielded transfer bell and crane are used to move the ILAW package from the truck to the trench.

Figures 6.1-1, 6.1-2, and 6.1-3 show the operating concept, the module design, and the site layout. These figures are updated versions of the figures shown in Boston (1999b). The first near surface disposal module is scheduled to be turned over to Operations on September 1, 2007, and will begin receiving ILAW packages in December 2007.

Assumptions concerning package contents are provided in Appendix A, Section 7.19. Based on the assumption that the packages are filled to 90 percent of the 2.51 m^3 internal volume, each package will hold 2.23 m^3 of glass. Based on a density of 2.66 MT/m^3, each package would hold 6.0 MT of glass. The BNFL Inc. planned in-plant storage capacity for ILAW packages is 450. It is assumed that BNFL Inc. will operate the storage area at 50 percent of capacity (PIO 2000). For Phase 1 ILAW package delivery dates are based on the assumption that packages will be shipped when more than 225 packages are in in-plant storage. For Phase 2, the in-plant storage capacity is assumed to be 1,800 positions (90-day storage at 100 percent TOE). The Phase 2 ILAW package delivery dates are based on the assumption that packages will be shipped when more than 900 packages are in-plant storage.

6.1.2 Immobilized Low-Activity Waste Receipt and Disposal Schedules

The Case 3S6E scenario indicates that the initial Phase 1 ILAW package is filled on December 1, 2006. The BNFL Inc. in-plant storage reaches 50 percent of capacity on August 13, 2007. Case 3S6E predicts that BNFL Inc. will run out of in-plant storage space on January 18, 2008, if ILAW packages are not shipped. The project baseline assumes that shipping of ILAW package will start in December 2007. During Phase 1, the shipment of ILAW packages is consistent with production equivalent to the Case 3S6E assumptions for ramp-up of LAW treatment. During Phase 1, the nominal ILAW package receipt rate is ramped up to approximately 1,270 packages per year.

Phase 1 – Contract Minimum Order Quantities

The contract minimum order quantity for Phase 1 is LAW is 6,000 units of Na processed. The HTWOS model predicts that with the Case 3S6E scenario, the minimum order quantity of LAW makes approximately 6,930 ILAW packages. The last package from the minimum order quantity is filled on June 13, 2013 and is delivered August 17, 2013. The ILAW receipt schedule that corresponds to the minimum quantity order is shown in Figure 6.1-4.

Phase 1 – Contract Completion Period

The Phase 1 contract is completed on February 28, 2018. The Case 3S6E scenario indicates that approximately 12,600 ILAW packages would be produced from the waste in the Phase 1 extended order tanks by this date. Figure 6.1-5 shows the number of ILAW packages received each calendar year by the Project W-520 ILAW disposal facilities.

Figure 6.1-1. Project W-520 Immobilized Low-Activity Waste Disposal Site Operating Concept.

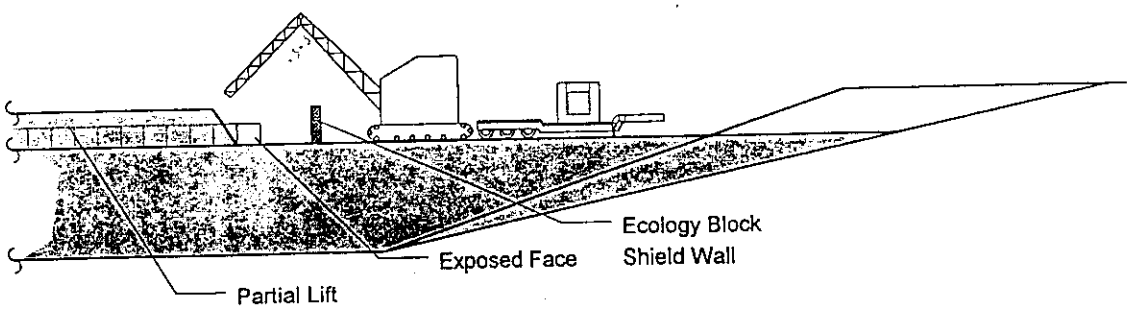


Figure 6.1-2. Project W-520 Immobilized Low-Activity Waste Disposal Site Construction Concept.

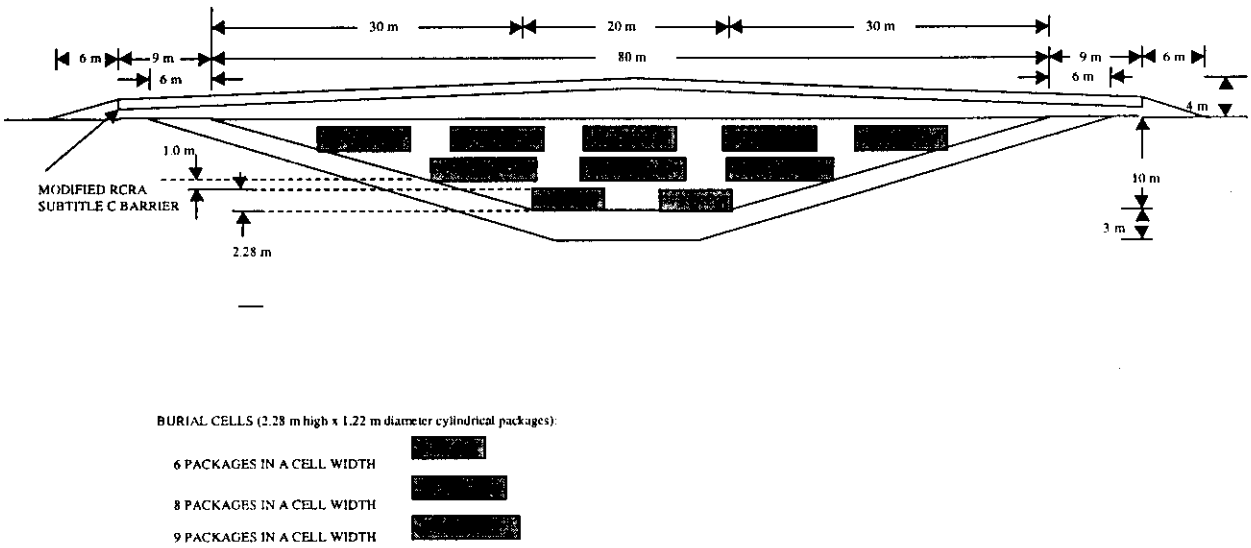


Figure 6.1-3. Project W-520 Immobilized Low-Activity Waste Disposal Site Layout.

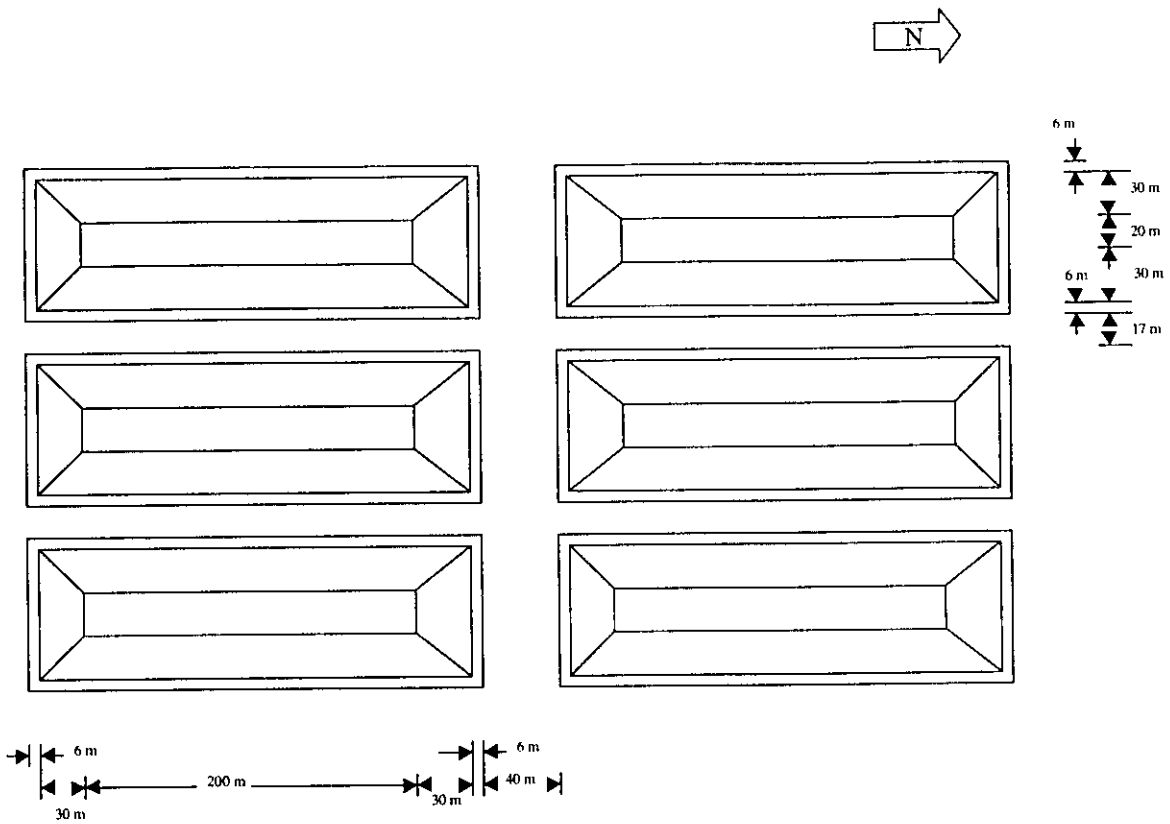


Figure 6.1-4. Case 3S6E Phase 1 Contract Minimum Order Quantity. Immobilized Low-Activity Waste Receipt Schedule.

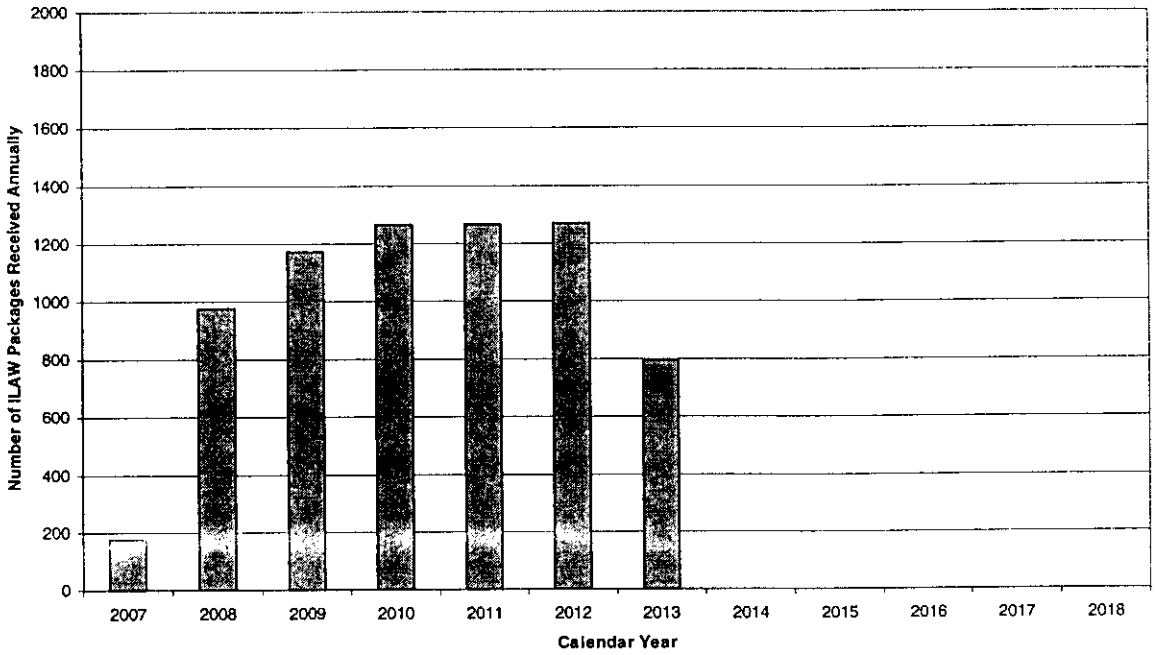
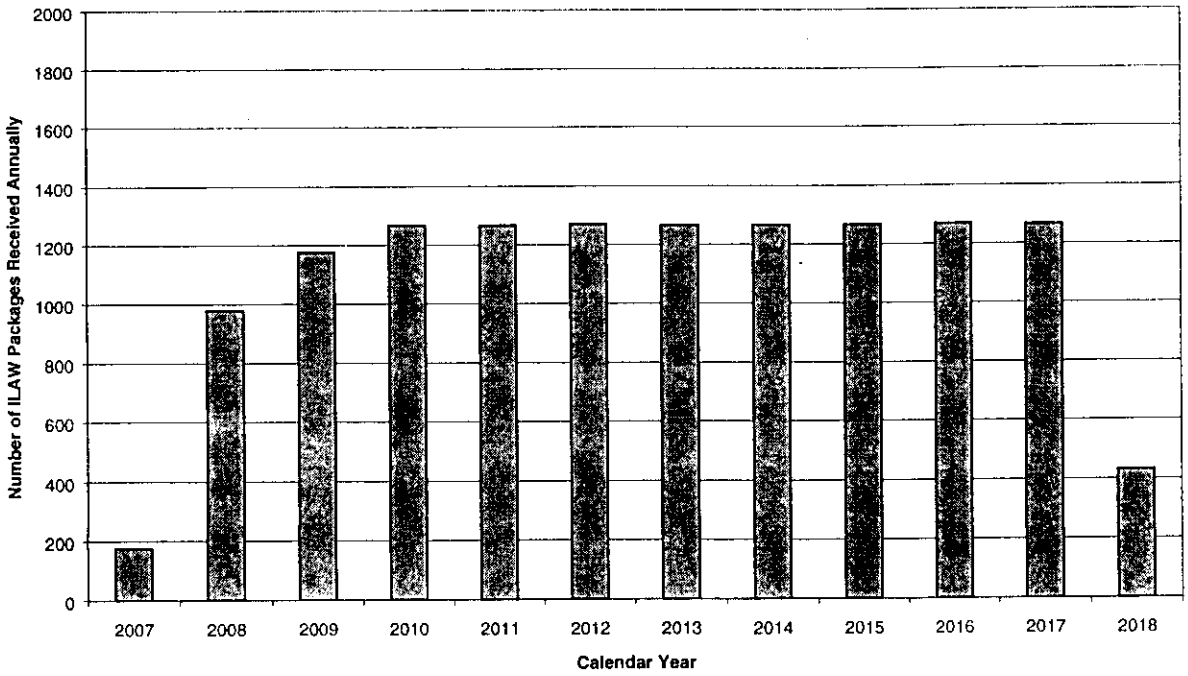


Figure 6.1-5. Case 3S6E Phase 1 Contract Completion Period. Immobilized Low-Activity Waste Receipt Schedule.



Phase 1 – Extended Order Tanks

The tanks identified for the extended order quantity would allow processing after the February 28, 2018, date. The Case 3S6E scenario indicates that approximately 14,300 ILAW packages would be produced from the waste in the extended order tanks. The final Phase 1 ILAW package from the extended order is filled October 13, 2018, and is shipped December 28, 2018. Figure 6.1-6 shows the number of packages received each calendar year from the extended order tanks.

Total Phase 1 and Phase 2 Mission

Case 3S6E generates from the Phase 1 and Phase 2 approximately 64,100 ILAW packages. Figure 6.1-7 shows the number of packages received each calendar year for the total mission. Figure 6.1-8 shows the number of ILAW packages in the disposal site at the end of each calendar year. To assure that Phase 2 HLW vitrification could be started up at an increased process rate on March 1, 2018, it was necessary to assume that Phase 2 waste separations and LAW vitrification started before that date. This assumption is discussed in detail in Appendix A. Thus the first Phase 2 ILAW package is filled September 2, 2017, and is shipped October 5, 2017. However, the final Phase 1 ILAW package from the extended order is not filled October 13, 2018. In the combined Phase 1 and Phase 2 processing 13,500 ILAW packages are filled by the end of the Phase 1 contract period. This is 900 more ILAW packages than are produced by the end of the Phase 1 contract period from Phase 1 extended order tank waste only.

Several production outages, and operation past 2030, caused by a lack of feed are evident in Phase 2. In Phase 2 the ILAW package shipments are, on the average, approximately 80 percent of that expected for LAW vitrification facilities sized to manufacture 120 MT/d glass. In Phase 2, at 120 MT/d glass and 60 percent TOE equivalent, the ILAW package shipment rate would be about 4,380 packages per year for a 20 wt% Na_2O glass. However, HTWOS predicts that in Phase 2 of Case 3S6E, the ILAW shipment rate will vary from 2,800 to 4,380 packages per year. This shortage of LAW feed is due to bottlenecking of the overall flowsheet by the HLW vitrification facility. Increasing the capacity of the HLW vitrification facility is evaluated in Section 6.3.

Figure 6.1-9 provides an order-of-magnitude comparison of the surface dose rate for ILAW packages from each feed batch. The dose rate is specific to a glass waste form inside a container with 0.343 cm steel walls. The limitations of the shielding analysis methodology are discussed in Appendix G. The total dose rate estimates are based on the contributory dose of 10 key radionuclides. Only the total dose and the dose from the three largest contributors, ^{137}Cs, ^{134}Cs, and ^{154}Eu, are shown in the figure. The dose rates are plotted against the shipping date of the first canister from each batch. This assumption is being reviewed. The characteristics and key radionuclide inventories for each batch are compiled in Appendix G. The two large peaks in the ^{154}Eu dose and total dose values are not entirely understood at this time. Europium is not generally expected to partition to liquid phases and thus is not normally found in large quantities in the ILAW feed. The peak in 2011 is from waste in tank 241-AN-107 and may be caused by a conservative solids dissolution assumption by the HTWOS model. The cause for the cluster of high dose rate values that occur in 2030 is from inactive miscellaneous storage tank waste and

Figure 6.1-6. Case 3S6E Phase 1 Extended Order Tanks.
Immobilized Low-Activity Waste Receipt Schedule.

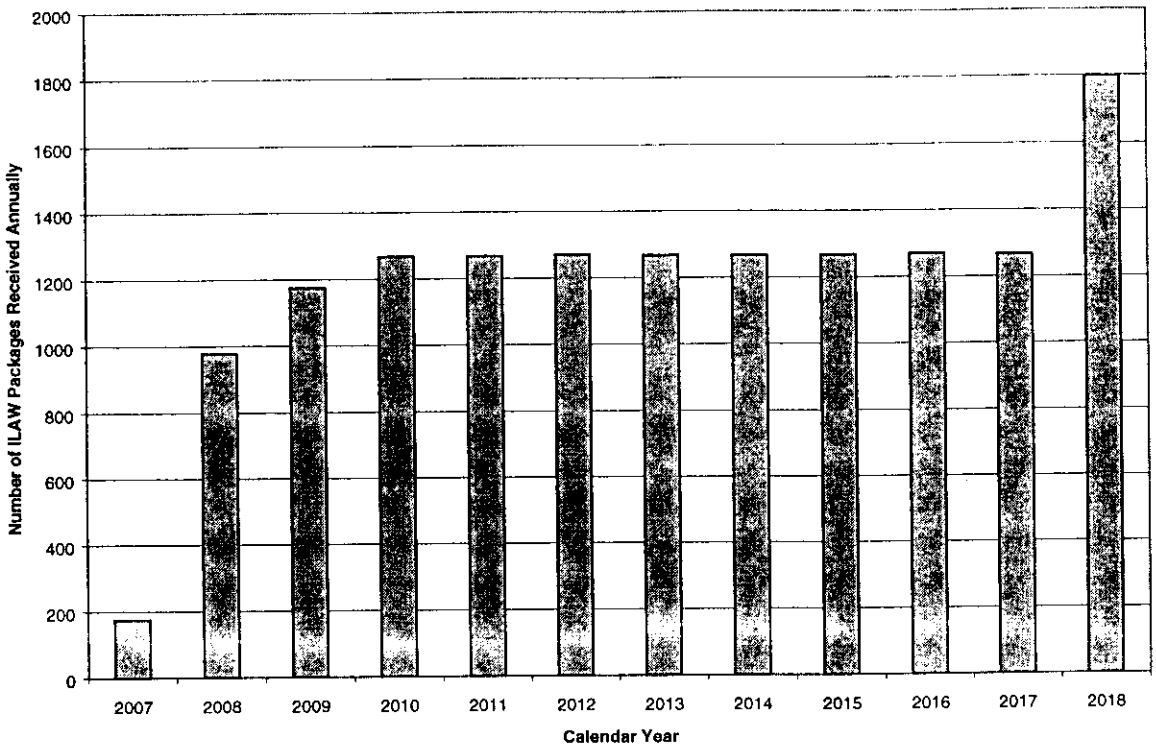


Figure 6.1-7. Case 3S6E Total Phase 1 and Phase 2 Mission.
Immobilized Low-Activity Waste Receipt Schedule.

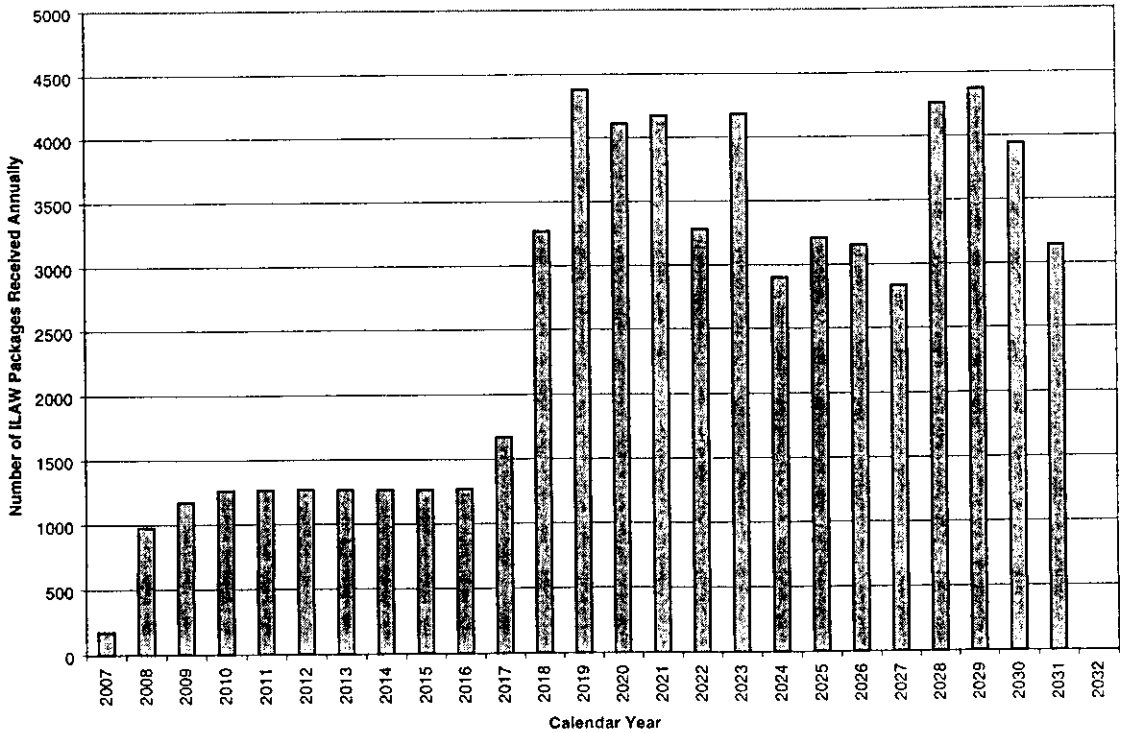


Figure 6.1-8. Case 3S6E Total Phase 1 and Phase 2 Mission. Immobilized Low-Activity Waste Packages in Storage.

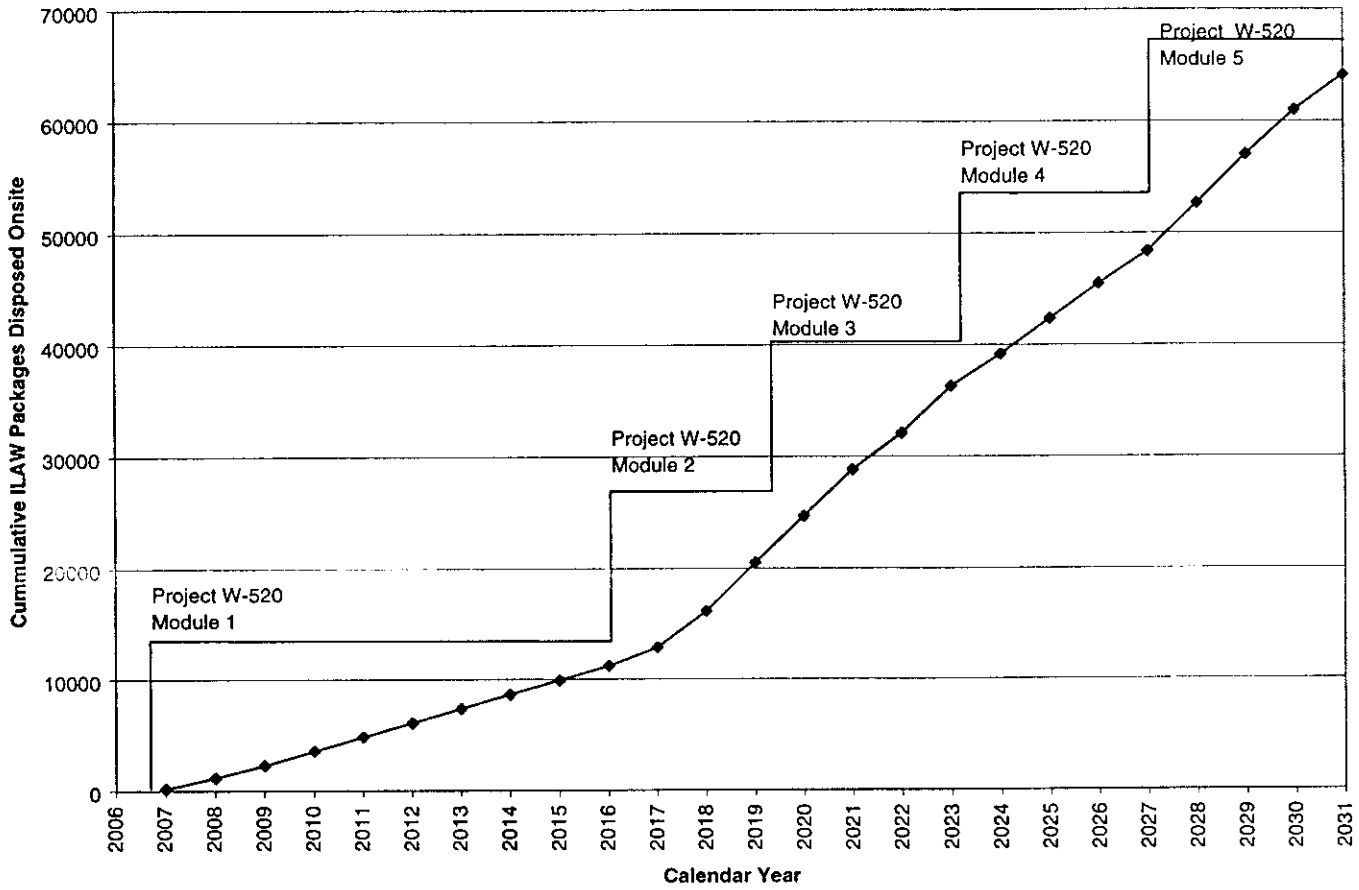
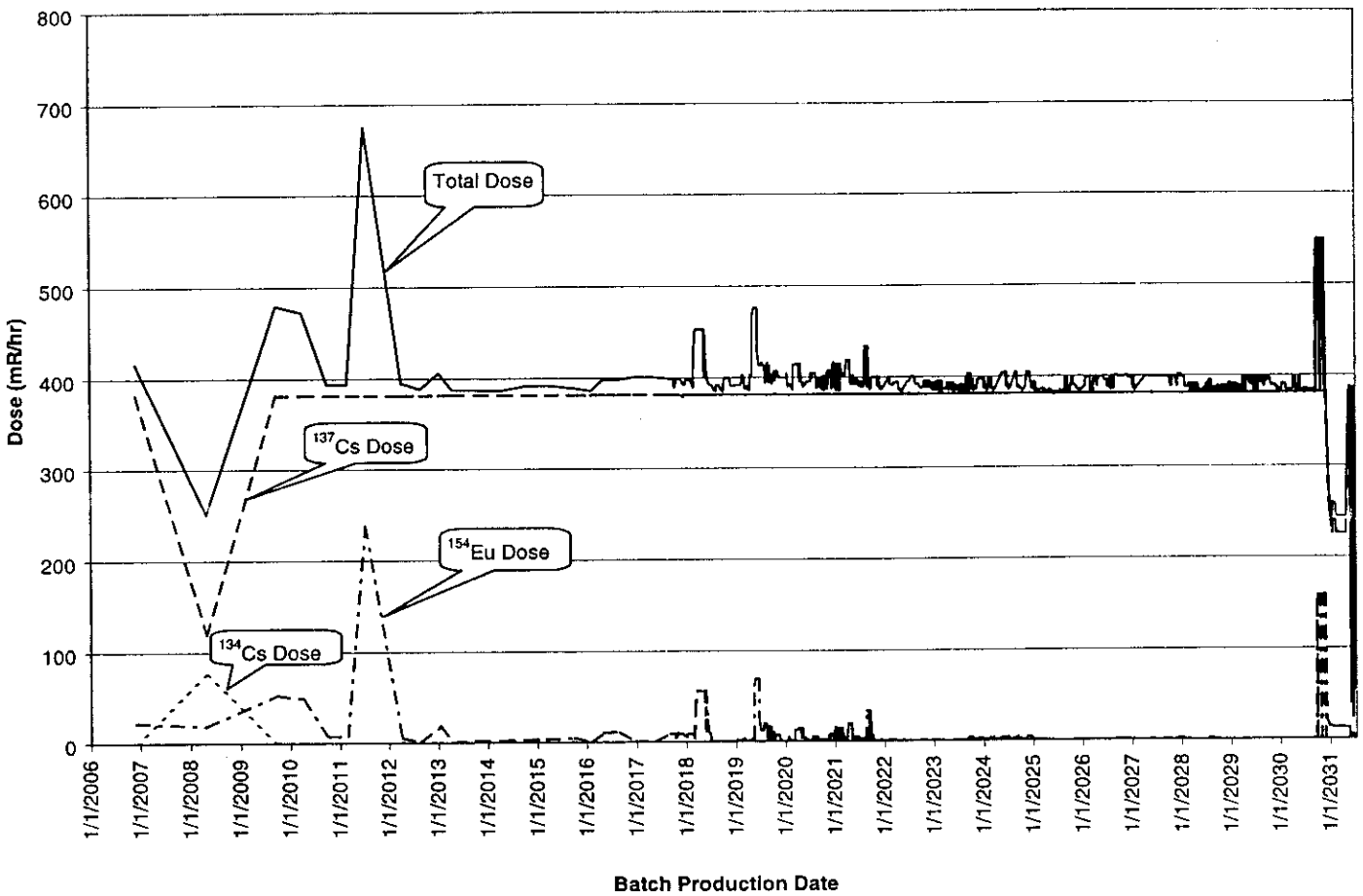


Figure 6.1-9. Case 3S6E Total Phase 1 and Phase 2 Mission.
Total and Contributing Surface Dose Rates from Immobilized Low-Activity Waste Packages.
(Packages with 0.343 cm Steel Side Walls)



may be caused by an error in interpretation of the original data. Both peaks are being investigated at this time.

Specification 2 of the contract requires that BNFL Inc. maintain the running average concentration of ^{137}Cs and ^{90}Sr in the ILAW product at less than 3 Ci/m^3 and 20 Ci/m^3 respectively. Individual packages may exceed these limits if the running average requirement is met. The separation requirements for Phase 2 are currently unknown. It is assumed Phase 1 separations requirements are applicable to Phase 2 for the purpose of modelng. The HTWOS model, on which Figure 6.1-6 is based, assumes that whenever possible the ^{137}Cs and ^{90}Sr concentrations in the ILAW glass are at, but not in excess of, the 3 Ci/m^3 and 20 Ci/m^3. The possibility that the ^{137}Cs and ^{90}Sr concentrations oscillate above and below the average limits is not modeled and thus is not indicated by the figure.

6.2 IMMOBILIZED HIGH-LEVEL WASTE STORAGE

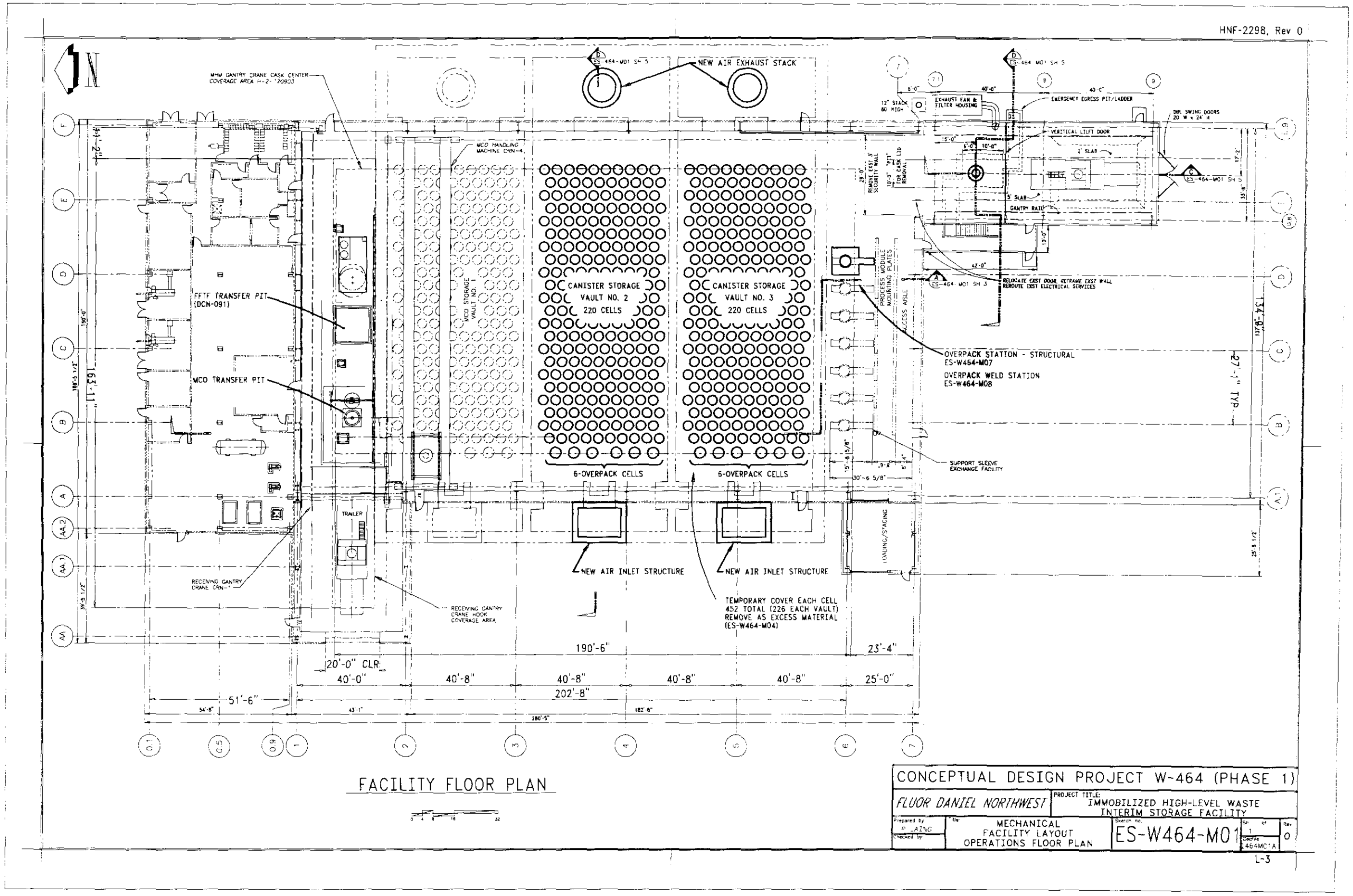
The IHLW canisters will be stored in the Canister Storage Building (CSB) under Project W-464. Additional IHLW interim storage for extended-order quantities in excess of the CSB capacity (i.e., 880 canisters) and the Phase 2 order quantity will be provided by new construction.

6.2.1 Immobilized High-Level Waste Canister and Storage Facility Design

BNFL Inc. will deliver the IHLW product in 0.61-m diameter by 4.5-m long right cylindrical canisters. The first canisters from Phase 1 processing are stored in the CSB. A plan view of the CSB is shown in Figure 6.2-1. The CSB consists of three storage vaults. One vault is committed for storage of K Basin spent fuel, and two vaults are committed to storage of IHLW. Project W-464 provides for transportation of the IHLW from BNFL Inc. to the CSB and for the CSB modifications necessary to store the IHLW canisters (Burgard 1998). Each vault contains 220 storage cells. A cell will hold two 4.5-m canisters for a total of 440 canisters per vault. Each vault also contains positions for six overpack cells that could hold two overpacked canisters each. Thus, the RPP has reserved space for 880 IHLW canisters and can accommodate an additional 24 IHLW canisters in overpack positions if needed. The CSB is scheduled to be turned over to Operations on September 1, 2008, and will begin receiving IHLW canisters September 2009. Plans are to construct additional CSBs. Each would have six vaults and hold 2,640 IHLW canisters (Project W-XXX). The Case 3S6E processing assumptions indicate a need for additional storage space for IHLW canisters by November 2016.

The nominal characteristics of the canister include a fill volume of 1.15 m^3 based on a 95 percent fill factor. Each canister will hold 3,060 kg of glass based on a glass density of 2.66 MT/m^3. The BNFL Inc. planned in-plant storage capacity for IHLW canisters is 45. It is assumed that BNFL Inc. will operate the storage area at 50 percent of capacity (PIO 2000). For Phase 1 the IHLW canister delivery dates are based on canisters being shipped when more than 23 canisters are in in-plant storage. For Phase 2, the in-plant storage capacity is assumed to be 350 positions (90 days storage at 100 percent TOE). The Phase 2 IHLW canister delivery dates are based on the assumption the canisters will be shipped when more than 175 canisters are in tank plan storage.

Figure 6.2-1. Project W-464 Canister Storage Building Plan View.



6.2.2 Immobilized High-Level Waste Receipt and Storage Schedules

The Case 3S6E scenario indicates that the first IHLW canister is filled on September 10, 2008. The BNFL Inc. in-plant storage space reaches 50 percent of capacity on April 2, 2009. Case 3S6E predicts that BNFL Inc. will run out of in-plant storage space on September 13, 2009 if IHLW canisters are not shipped. The project baseline assumes that IHLW canister receipt will start in September 2009. The CSB is filled to capacity (880 canisters) on October 26, 2016.

Phase 1 – Contract Minimum Order Quantities

The contract minimum order quantity for Phase 1 is HLW is 600 canisters. The HTWOS model predicts, that with the Case 3S6E scenario, the last canister from the minimum order quantity is filled on April 21, 2014 and is delivered June 30, 2014. The ILAW receipt schedule that corresponds to the minimum quantity order is shown in Figure 6.2-2.

Phase 1 – Contract Completion Period

The Phase 1 contract is completed on February 28, 2018. The Case 3S6E scenario indicates that approximately 1,070 IHLW canisters would be produced from the waste in the Phase 1 extended order tanks by this date. The CSB is filled to capacity (880 canisters) on October 26, 2016. Figure 6.2-3 shows the number of IHLW canisters received each calendar year from BNFL Inc.

Phase 1 – Extended Order Tanks

The tanks identified for the extended order quantity would allow processing after the February 28, 2018 date. The Case 3S6E scenario indicates that approximately 1,430 IHLW canisters would be produced from the waste in the extended order tanks. The final Phase 1 IHLW canister from the extended order is filled July 31, 2018, and is shipped October 31, 2018. Figure 6.2-4 shows the number of canisters received each calendar year from the extended order tanks.

Total Phase 1 and Phase 2 Mission

Case 3S6E generates from the Phase 1 and Phase 2 approximately 12,700 IHLW canisters. Figure 6.2-5 shows the number of canisters received each calendar year for the total mission. Figure 6.2-6 shows the number of IHLW canisters in storage at the end of each calendar year. Figure 6.2-6 also shows the effect on to onsite storage of shipping the IHLW canisters to the national geologic repository at Yucca Mountain, Nevada. Shipping is assumed to start October 1, 2034, and be completed in 10 years (Calmus 1999).

Figure 6.2-2. Case 3S6E Phase 1 Contract Minimum Order Quantity. Immobilized High-Level Waste Receipt Schedule.

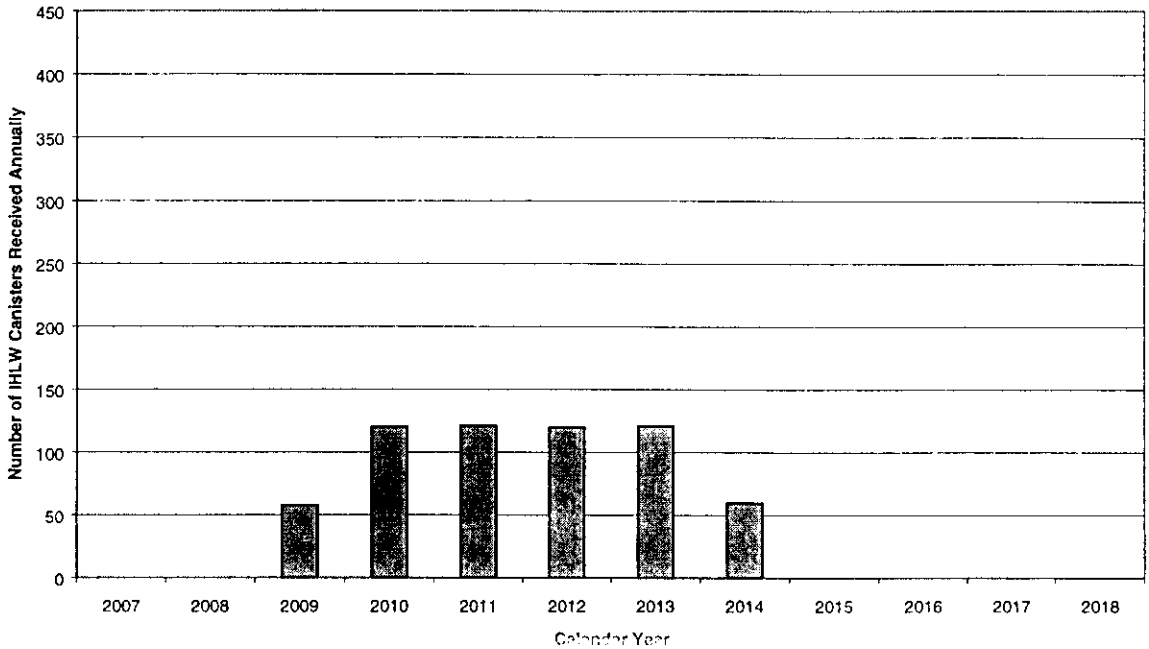


Figure 6.2-3. Case 3S6E Phase 1 Contract Completion Period. Immobilized High-Level Waste Receipt Schedule.

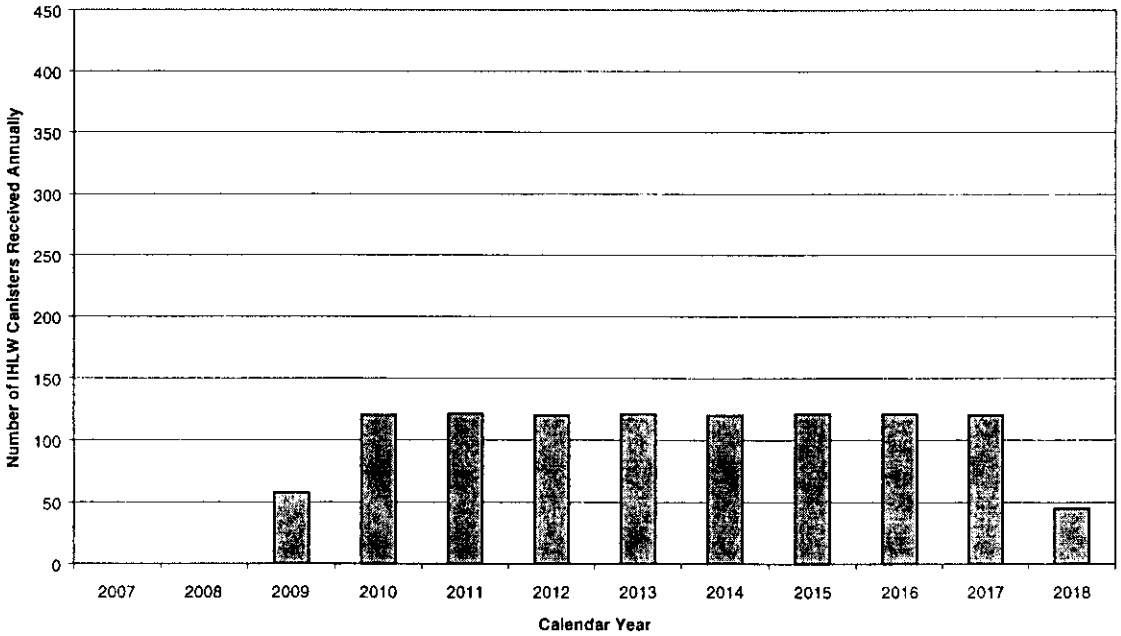


Figure 6.2-4. Case 3S6E Phase 1 Extended Order Tanks.
Immobilized High-Level Waste Receipt Schedule.

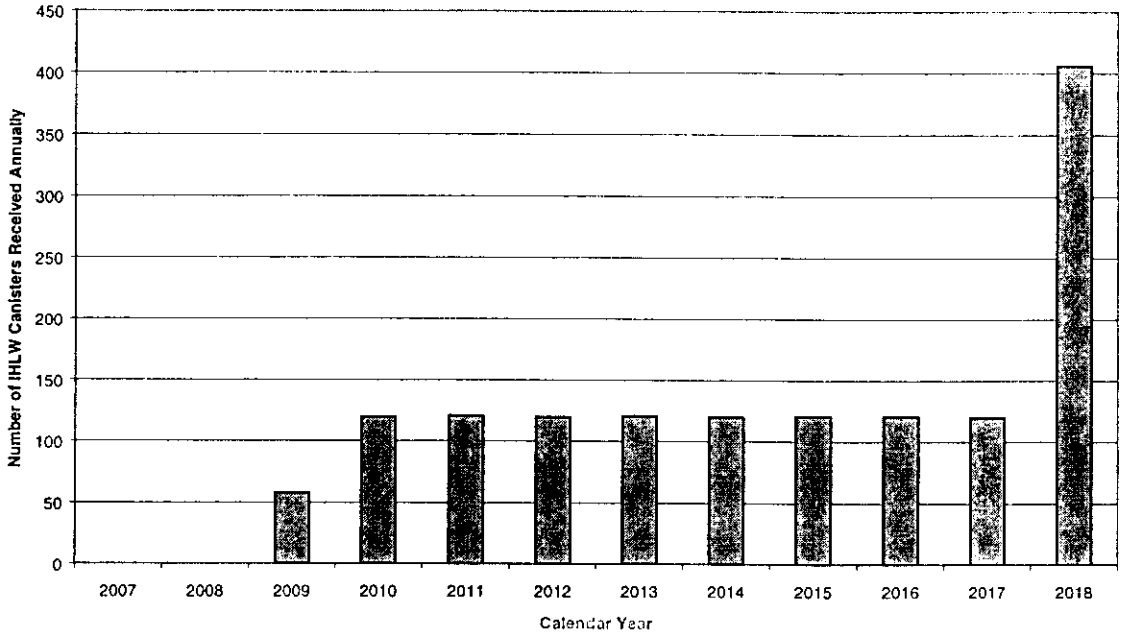


Figure 6.2-5. Case 3S6E Total Phase 1 and Phase 2 Mission.
Immobilized High-Level Waste Receipt Schedule.

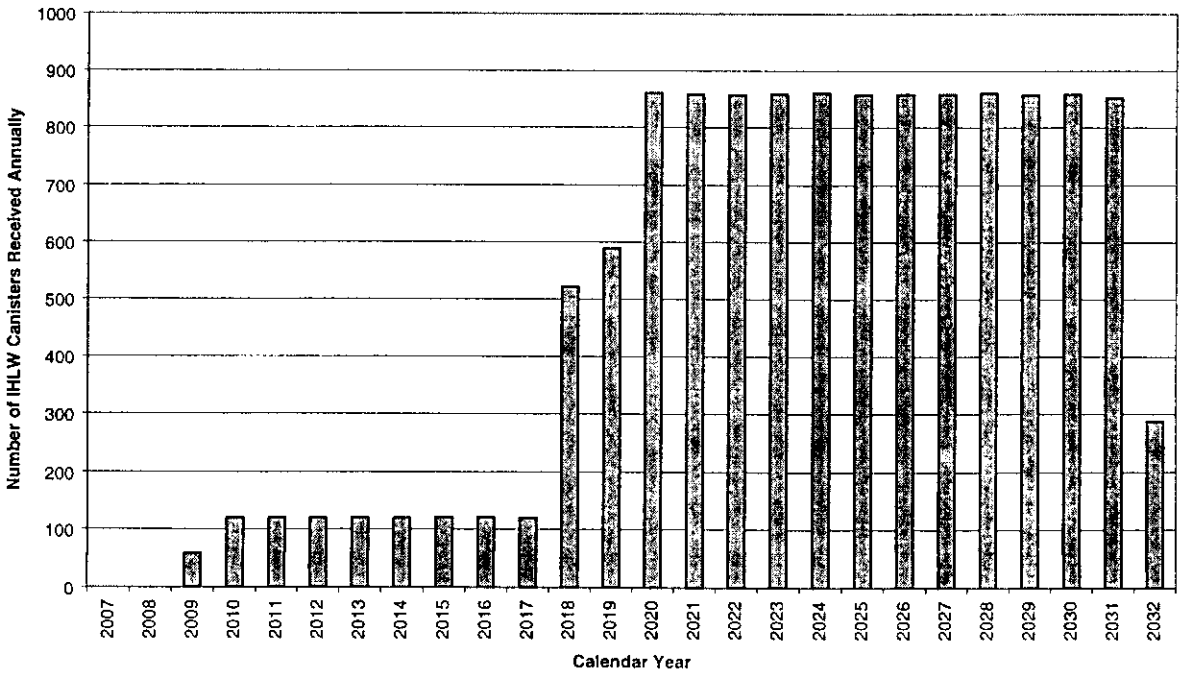


Figure 6.2-6. Case 3S6E Total Phase 1 and Phase 2 Mission. Immobilized High-Level Waste Canisters in Storage.

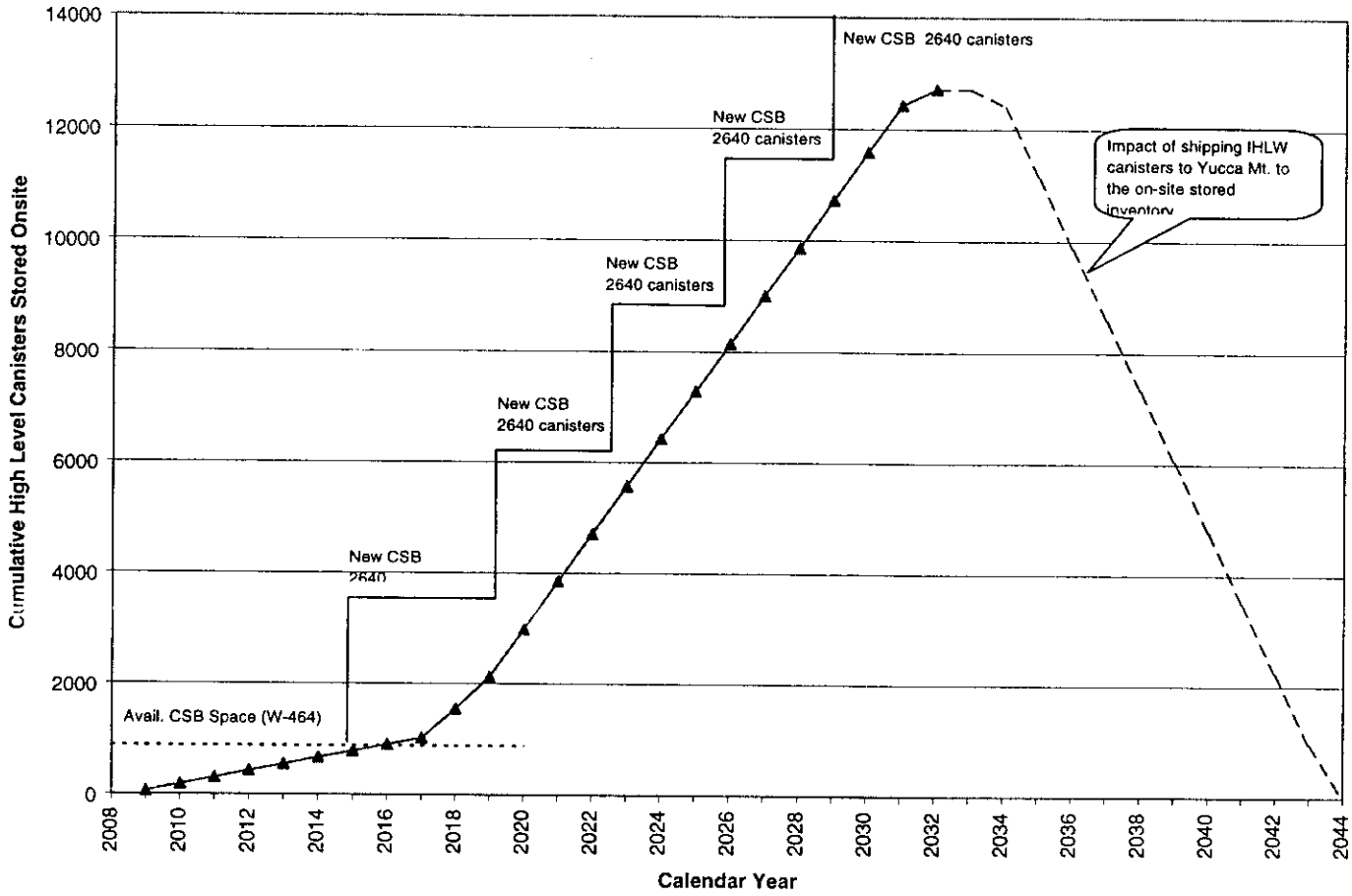


Figure 6.2-7 provides an estimate of the average IHLW canister decay heat for each feed batch. The decay heats are indexed to January 1 of the year the first canister in each batch is shipped and also to January 1, 2010. The maximum predicted heat load of an IHLW canister at the time it is received is 660 watts per canister. Figure 6.2-8 shows the radiolytic heat load, indexed to January 1, 2010, of the IHLW canisters in storage versus the shipment dates. Figure 6.2-9 shows the radiolytic heat load of IHLW canisters in storage, indexed to January 1, 2010, versus the number of canisters received. Appendix G includes a table that shows the number of IHLW canisters in each batch, the initial shipment date, the average decay heat load of each canister in a batch, and the cumulative thermal load of the canisters shipped.

6.3 SENSITIVITY RESULTS

Case 3S6E R2A Evaluation of the PIO Guidance

The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate inbalance between the HLW and LAW vitrification plants. Product receipt schedules are provided in Appendix G.

Case 3S6E R2A predicts the generation of approximately 64,100 ILAW packages. However, only 13,500 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on December 1, 2006. The BNFL Inc in-plant storage reaches 50 percent of capacity on August 13, 2007. Case 3S6E R2A predicts that BNFL Inc. will run out of in-plant storage on January 18, 2008, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 1,270 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The final ILAW package is shipped in September 2031.

Case 3S6E R2A predicts the generation of approximately 12,700 IHLW canisters. However, only 1,070 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on September 10, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 2, 2009. Case 3S6E R2A predicts that BNFL Inc. will run out of in-plant storage on September 13, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 861 canisters/year. The final IHLW canister is shipped in May 2032.

Case 3S6E R2A Spec. 1 Evaluation of a Reduced HLW Waste Oxide Loading

The HLW oxide loading limits estimated by the Glass Properties Model are replaced by the minimum limits stated in Specification 1 of the contract.

The number of IHLW canisters is significantly increased due to the low waste loading in Specification 1 of the contract. The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate imbalance between the HLW and LAW vitrification plants. Product receipt schedules are provided in Appendix G.

Figure 6.2-7. Case 3S6E Total Phase 1 and Phase 2 Mission.
Decay Heat Characteristics of Immobilized High-Level Waste Canisters.

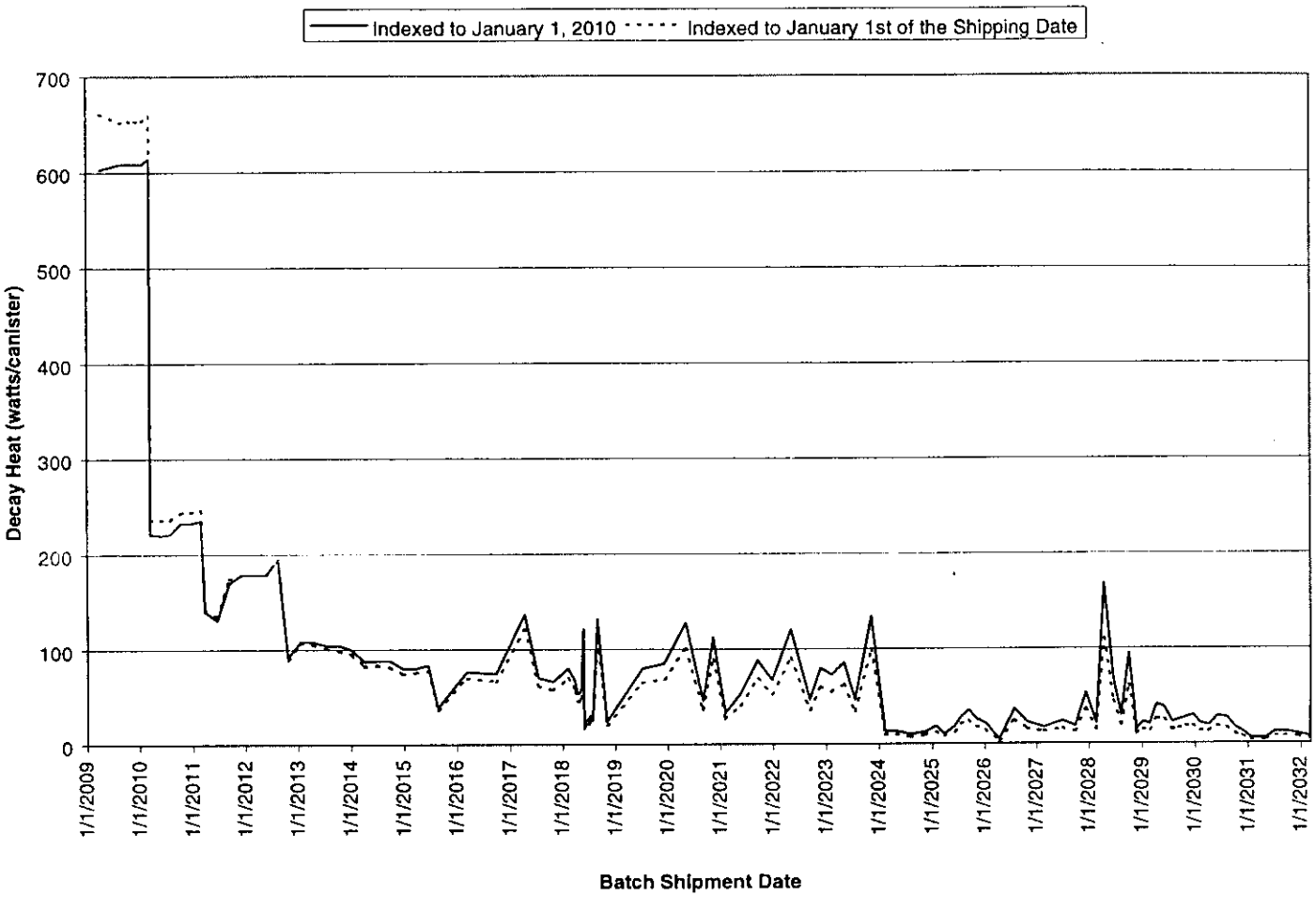


Figure 6.2-8. Case 3S6E Total Phase 1 and Phase 2 Mission.
Radiolytic Heat Load from Immobilized High-Level Waste Canisters in Storage Versus Time--Indexed to January 1, 2010.

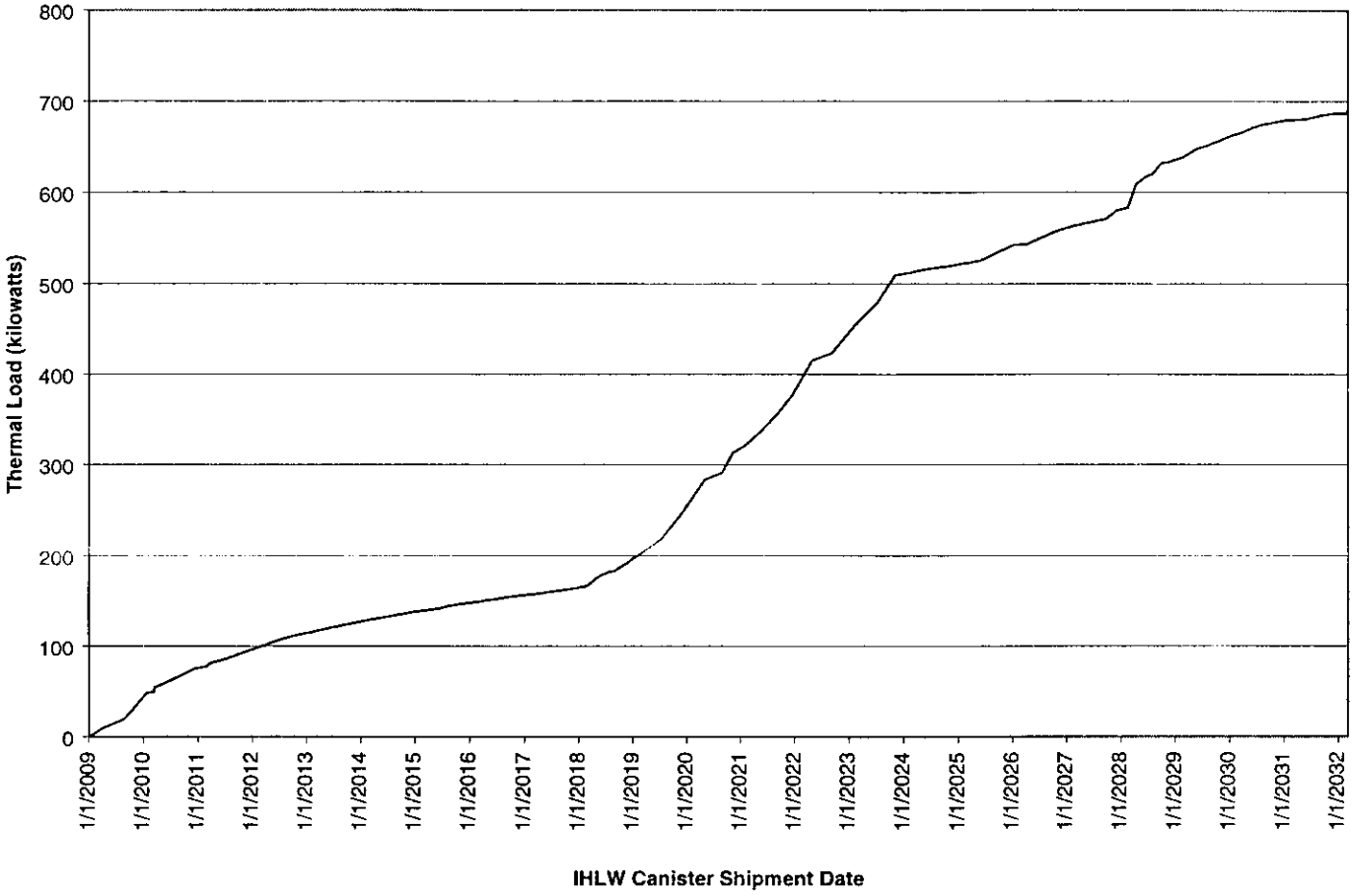


Figure 6.2-9. Case 3S6E Total Phase 1 and Phase 2 Mission.
Radiolytic Heat Load from Immobilized High-Level Canisters in Storage Versus
Canisters Received--Indexed to January 1, 2010.

Case 3S6E R2A Spec. 1 predicts the generation of approximately 64,100 ILAW packages. However, only 13,500 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on December 1, 2006. The BNFL Inc. in-plant storage reaches 50 percent of capacity on August 13, 2007. Case 3S6E R2A Specification 1 predicts that BNFL Inc. will run out of in-plant storage on January 18, 2008, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 1,270 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The Phase 2 LAW vitrification facility is significantly underutilized. The final ILAW package is shipped in March 2036.

Case 3S6E R2A Spec. 1 predicts the generation of approximately 17,500 IHLW canisters. However, only 1,070 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on September 10, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 2, 2009. Case 3S6E R2A Specification 1 predicts that BNFL Inc. will run out of in-plant storage on September 13, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 865 canisters/year. The final IHLW canister is shipped in June 2037.

Case 3S6E R2.1 Evaluation of Increasing the Phase 2 HLW Vitrification Plant to 14 MT/day.

The maximum Phase 2 vitrification rates are set at 120 MT/d glass for LAW and 14 MT/d glass for HLW. All other conditions are the same as Case 3S6E R2A.

Few of the ILAW vitrification production outages apparent in Phase 2 Case 3S6D R2A remain, indicating that the 120/14 ratio is near optimum. Product receipt schedules are provided in Appendix G.

Case 3S6E R2.1 predicts the generation of approximately 64,300 ILAW packages. However, only 13,500 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on December 1, 2006. The BNFL Inc. in-plant storage reaches 50 percent of capacity on August 13, 2007. Case 3S6E R2.1 predicts that BNFL Inc. will run out of in-plant storage on January 18, 2008 if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 1,270 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The final ILAW package is shipped in May 2030.

Case 3S6E R2.1 predicts the generation of approximately 12,700 IHLW canisters. However, only 1,070 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on September 10, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 2, 2009. Case 3S6E R2.1 predicts that BNFL Inc. will run out of in-plant storage on September 13, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 1,004 canisters/year. The final IHLW canister is shipped in November 2030.

Case 3S6D R7 Evaluation of the Basis for RTP-2, (2006 Hot Start)

Sulfate is assumed to be removed from Phase 1 LAW feed. The Envelope B waste loading is increased to 19.5 wt% Na_2O. A LAW vitrification ramp-up of 141, 452, and 754 units of Na/yr is assumed.

The number of ILAW packages made is 900 less than in Case 3S6E R2A PIO Guidance. The number of IHLW canisters made is 100 less than in Case 3S6E R2A PIO Guidance.

Case 3S6D R7 is essentially the same as Case 3S6E R2A except 3S6D R7 assumes that sulfate is removed from Envelope B LAW feed and that vitrification process rates were revised for Case 3S6E R2A. Case 3S6D R7 predicts the generation of approximately 63,200 ILAW packages and 12,600 IHLW canisters. The schedule predictions of Case 3S6D R7 are not meaningful due to the differences in the process rate assumptions used in Cases 3S6D R7 and 3S6E R2A PIO Guidance.

Case 3S6B R1 Evaluation of BNFL Inc. Plans for 2006 Hot Start (90% Trend)

BNFL Inc. will fill the IHLW in-plant storage space in June 2009, three months prior to the assumed initial shipping date of September 2009. Significantly fewer ILAW packages are made in Phase 1 relative to Case 3S6E R2A PIO Guidance. Product receipt schedules are provided in Appendix G.

Case 3S6B R1 predicts the generation approximately 66,800 ILAW packages. However, only 7,900 ILAW packages are filled by the end of the Phase 1 contract period. BNFL Inc makes the initial ILAW package is filled on January 1, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on November 10, 2008. Case 3S6B R1 predicts that BNFL Inc. will run out of in-plant storage on May 11, 2009, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 871 packages/year. The peak annual production rate in Phase 2 is 4,391 packages/year. The final ILAW package is shipped in May 2033.

Case 3S6B R1 predicts the generation of approximately 12,500 IHLW canisters. However, only 990 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on April 18, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 14, 2009. Case 3S6B R1 predicts that BNFL Inc. will run out of in-plant storage on June 28, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 861 canisters/year. The final IHLW canister is shipped in February 2034.

Case 3S6B R2 Evaluation of the Phase 1 Minimum Contracted LAW Loading

The ILAW glass formulation limits from the BNFL Inc. flowsheet are replaced by the minimum limits proposed for Specification 2 of the contract.

A significant increase in the Phase 1 vitrification rate is needed to meet the minimum contract order. The number of ILAW packages made is significantly increased. BNFL Inc. will

fill the IHLW in-plant storage space in June 2009, three months prior to the assumed initial shipping date of September 2009 (PIO 2000). Product receipt schedules are provided in Appendix G

Case 3S6B R2 predicts the generation of approximately 73,500 ILAW packages. However, only 11,000 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on January 1, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on August 13, 2008. Case 3S6B R2 predicts that BNFL Inc. will run out of in-plant storage on February 11, 2009, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 1,216 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The final ILAW package is shipped in April 2034.

Case 3S6B R2 predicts the generation of approximately 12,600 IHLW canisters. However, only 990 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on April 18, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 14, 2009. Case 3S6B R2 predicts that BNFL Inc. will run out of in-plant storage on June 28, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 861 canisters/year. The HLW vitrification facility is significantly underutilized in this scenario. The final IHLW canister is shipped in December 2034.

Case 3S6B R3 Evaluation of a Reduced Phase 2 LAW Waste Loading

The Phase 2 ILAW glass formulation is limited to [wt% Na2O][wt% SO3] < 5.

BNFL Inc. will fill the IHLW in-plant storage space in June 2009, three months prior to the assumed initial shipping date of September 2009 (PIO 2000). The number of ILAW packages made in Phase 2 increases significantly. Product receipt schedules are provided in Appendix G.

Case 3S6B R3 predicts the generation of approximately 99,000 ILAW packages. However, only 7,900 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on January 1, 2008. The BNFL Inc. in-plant storage reaches 50 percent of capacity on November 10, 2008. Case 3S6B R3 predicts that BNFL Inc. will run out of in-plant storage on May 11, 2009, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 871 packages/year. The peak annual production rate in Phase 2 is 4,395 packages/year. The final ILAW package is shipped in June 2039.

Case 3S6B R3 predicts the generation of approximately 12,400 IHLW canisters. However, only 990 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on April 18, 2008. The BNFL Inc in-plant storage reaches 50 percent of capacity on April 14, 2009. Case 3S6B R3 sulfate predicts that BNFL Inc. will run out of in-plant storage on June 11, 2009, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 856 canisters/year. The HLW vitrification facility is significantly underutilized in this scenario. The final IHLW canister is shipped in December 2039.

Case 3S6A Evaluation of BNFL Inc. Plans for an Early (2005) Hot Start (50% Trend)

BNFL Inc. will fill the ILAW and IHLW in-plant storage space in December 2006 and June 2008 respectively. The dates are twelve and fifteen months prior to the assumed initial shipping dates of December 2007 and September 2009 (PIO 2000). Product receipt schedules are provided in Appendix G.

Case 3S6A predicts the generation of approximately 67,000 ILAW packages. However only 10,700 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on August 1, 2005. The BNFL Inc in-plant storage reaches 50 percent of capacity on June 11, 2006. Case 3S6A predicts that BNFL Inc. will run out of in-plant storage on December 10, 2006, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 871 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The final ILAW package is shipped in October 2032.

Case 3S6A predicts the generation of approximately 12,900 IHLW canisters. However, only 1,500 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on April 18, 2007. The BNFL Inc. in-plant storage reaches 50 percent of capacity on April 13, 2008. Case 3S6B predicts that BNFL Inc. will run out of in-plant storage on June 27, 2008, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 862 canisters/year. The final IHLW canister is shipped in July 2033.

Case 3S6C Evaluation of WFD Plans for an Early (2005) Hot Start (50% Trend)

BNFL Inc. will fill the ILAW and IHLW in-plant storage space in December 2006 and June 2008 respectively. These dates are twelve and fifteen months prior to the assumed initial shipping dates of December 2007 and September 2009 (PIO 2000). Product receipt schedules are provided in Appendix G.

Case 3S6C predicts the generation of approximately 64,100 ILAW packages. However, only 14,400 ILAW packages are filled by the end of the Phase 1 contract period. The initial ILAW package is filled on August 1, 2005. The BNFL Inc. in-plant storage reaches 50 percent of capacity on June 11, 2006. Case 3S6C predicts that BNFL Inc. will run out of in-plant storage on December 10, 2006, if ILAW is not shipped to the ILAW Disposal Site. The maximum production rate of ILAW packages in Phase 1 is 1,274 packages/year. The peak annual production rate in Phase 2 is 4,380 packages/year. The final ILAW package is shipped in November 2031.

Case 3S6C predicts the generation of approximately 12,500 IHLW canisters. However, only 1,420 IHLW canisters are filled by the end of the Phase 1 contract period. The initial IHLW canister is filled on April 18, 2007. The BNFL Inc. in-plant storage reaches 50 percent of capacity on April 13, 2008. Case 3S6B predicts that BNFL Inc. will run out of in-plant storage on June 27, 2008, if IHLW is not shipped to the CSB. The maximum production rate of IHLW canisters in Phase 1 is 121 canisters/year. The peak annual production rate in Phase 2 is 861 canisters/year. The final IHLW canister is shipped in April 2032.

7.0 DOUBLE-SHELL TANK SPACE MANAGEMENT

7.1 PRIOR WORK

The 1999 OWVP document (Strode and Boyles 1999) presented three waste volume projection cases both with and without SST waste retrieval. "Without" SST waste retrieval refers to a projection case with no additional SST waste retrieval beyond that required for feed during Phase 1B. All projection cases "without" additional SST waste retrieval beyond that needed for Phase 1 feed indicated that the available tank space would meet the needs for the RPP planning waste processing assumptions. Most projections were near the available tank space limit during FY 2001 to 2005 because of the number of tanks required for salt well liquid (SWL) pumping and storage.

A tank space study completed in 1999 listed a number of space saving alternatives (Garfield 1999b). Changes in some assumptions accomplish some of the recommendations listed in the OWVP document and in the tank space study. These alternatives are summarized below.

1. Review/reduce DST waste additions. One of the alternatives listed in the OWVP document and the tank space study recommended that waste additions to DSTs be reviewed or reduced. Operating experience led to a re-evaluation of the volume of SWL remaining to be pumped and reduced the estimated remaining volume from 6.2 Mgal to 4.0 Mgal (Field and Vladimiroff 1999).

2. Optimize LAW waste feed sequence. The tank space study also recommended that the LAW waste feed sequence be optimized to work off dilute waste first thus freeing DST space more quickly since the waste would not have to be diluted before processing. The latest LAW feed sequence accomplishes this goal by processing the dilute waste in tank 241-AP-101 first.

Both of these changes have been incorporated in the projection Case 3S6E assumptions.

The Washington State Department of Ecology issued a review letter (Valero and Dahl 1999) in response to the 1999 OWVP document requesting among other things that an updated waste volume projection case be completed to incorporate the reduced SWL pumping volume and include a discussion of how much volume on a year-by-year basis would be available for SST retrieval beyond that incorporated to meet Phase 1B feed requirements. The updated waste volume projection information presented in this chapter can be used to furnish much of the requested information.

7.2 SPARE SPACE PHILOSOPHY

Spare space is space reserved in case a DST leaks, in accordance with DOE Order 5820.2A. Contingency space historically has been set aside to account for possible inaccuracies in the software when waste generations and/or waste volume reduction factors are projected.

A total of 8,631 m^3 (2.28 Mgal) (one aging and one non-aging tank) of spare/contingency space was reserved for all the 1999 OWVP projection cases. CHG also has been asked to provide the capability to receive up to 3,785 m^3 (1 Mgal) of BNFL Inc. waste returns (either HLW or LAW returns) on an emergency basis within the 8,631 m^3 (2.28 Mgal) of total spare space (PIO 2000). In the Case 3S6E projection, approximately 3,785 m^3 (1 Mgal) of dedicated tank space has been set aside within the aging-waste tanks to receive HLW (or LAW) returns. The remaining 3,785 m^3 (1 Mgal) of space is space distributed within operational and storage tanks.

7.3 PROJECTION RESULTS

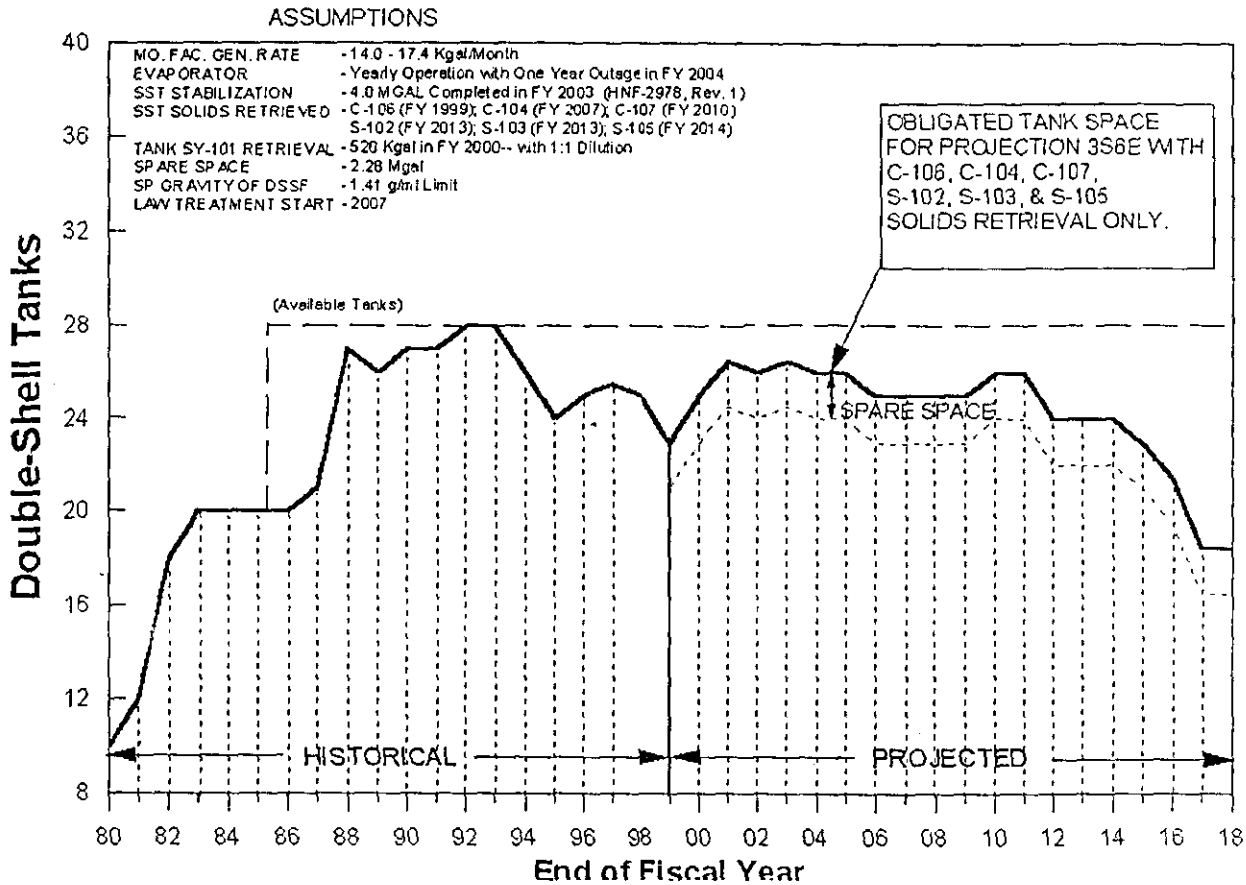
The tank space needs for projection Case 3S6E are depicted in Figure 7.3-1. Only the SST waste retrieval required to provide feed for Phase 1B have been included in this projection so that the space available for additional SST solids retrieval can be more easily identified. The projected tank space is less than that required for the 1999 OWVP projections, which means with greater reliability that DST space will be available to meet the RPP waste processing assumptions. Key assumptions for this projection have been summarized at the top of Figure 7.3-1.

7.4 SINGLE-SHELL TANK BACKFILL CAPACITY RECOMMENDATIONS

The amount of space available for additional SST waste retrieval beyond that incorporated into Phase 1B, is listed in Table 7.4-1. The space shown is the maximum amount of space available for retrieval of additional SST wastes, on the assumption that six tanks will be sufficient for feed staging of the retrieved wastes beyond FY 2018 and that no additional tanks will be required for retrieval operations. For this projection it is assumed that the feed staging tanks are empty in 2017 and 2018. Therefore, some additional space is available for SST retrieval if it is assumed that some SST waste is staged.

Actions for optimizing tank use are being reviewed; these could free additional tank space by reducing the number of feed staging tanks and operational tanks. It is too early to predict the exact magnitude of the space saving that might be accomplished, but it could be up to two additional tanks during FY 2002 through 2018.

Figure 7.3-1. Waste Volume Projection 3S6E Without Single-Shell Tank Solids Retrieval.



DSSF = Double-shell slurry feed
LAW = Low-activity waste

Table 7.4-1. Number of Tanks Available for Additional Single-Shell Tank Retrieval Waste (Numbers of Tanks Are Not Additive).

Fiscal year	Number of tanks available on a year-by-year basis
2004	1
2005	2
2006	2
2007	2
2008	2
2009	2
2010	2
2011	2
2012	4
2013	4
2014	4
2015	5
2016	6
2017	9
2018	9

7.5 PHASE 2 DOUBLE-SHELL TANK AVAILABILITY

Past direction from DOE-ORP (Taylor 1999) was "Twenty-eight sound DSTs will be available for Phase II (sic). No DSTs will develop leaks, and no new DSTs will be constructed." The HTWOS model runs made early in FY 2000 used this assumption. The latest guidance from DOE-ORP (PIO 2000) gave direction to account for DST failures in Phase 2. **"DST Design Life**-DSTs will be used for feed accumulation and conditioning activities. The DSTs will reach end of design life and begin to fail at a rate of one for each five years past design life. In the future, a RAM analysis will need to be performed. Replacements will be constructed as required." A simplifying modeling assumption was made that DSTs will be replaced as they fail and the replacement storage and transfer system performance will be equivalent to that of the existing system. This simplifying assumption was made to maintain consistency with previous model runs and because of a priority to focus on modeling Phase 1 to resolve issues over defining the Phase 2 part of the mission in additional detail.

Past studies have shown that the Phase 2 processing capacity is the main parameter affecting the Phase 2 completion dates. The failure of DSTs and the loss of storage capacity would not delay either the LAW or HLW processing completion dates. The only real impact from losing a DST is that the Phase 2 SST retrieval completion date would be delayed by months. Processing would finish on the same schedule.

Most major specific impacts from losing DSTs from service that would be highlighted in detailed RAM analysis are listed below. The impacts can be considered " manageable" from a mission perspective on cost, schedule and operability impacts. There is no scenario where construction of new DSTs would be required because of a failure at the rate of one every five years once several tanks have been delivered as feed and the DST specification issue is resolved.

- Moving the contents of a failed DST is an impact currently dealt with by the storage mission. Spare equipment to make the transfer and space to accommodate the material is maintained.

- Loss of one of the sending tanks (SY farm tanks) and/or receiving tank (241-AN-104, slurry receiver tank) for the cross-site line can be overcome by using the supernate cross-site line. Depending on the failure scenario, some hardware reconfiguration could be required to connect booster pumps to a different line. The slurry line is routed directly to 241-AN-104; replacement of this line or tank implies routing the line to another tank. Loss of one of the sending tanks could be overcome by routing changes with jumpers and valve settings.

- Loss of a tank outfitted with mixer pump would likely lead to upgrading another tank with similar capability.

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