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ORP-11242
Revision 5

RIVER PROTECTION PROJECT SYSTEM PLAN

Retrieve and Treat Hanford's Tank Waste and Close the Tank Farms to Protect the Columbia River

Prepared for the U.S. Department of Energy
Office of River Protection

Approved for Public Release;
Further Dissemination Unlimited

River Protection Project System Plan

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Office of River Protection

River Protection Project System Plan

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HISTORY SHEET

Revision	Date	Reason for Revision	Revised by
0	August 2002	Initial Issuance	K. R. Wells
1	April 2003	Reflect proposed changes and additions to the Waste Treatment Processes & Facilities to accelerate mission completion	K. R. Wells
2	September 2003	Reflect a Target Case which depicts the mission based on how ORP expects the WTP to perform and a Stretch Case which depicts the mission if significant increases in both WTP and non-WTP LAW treatment performance are realized.	P. J. Certa
3	May 2008	Reflects a Reference Case which depicts a mission scenario based on beginning full WTP operations in 2019, in conjunction with Supplemental LAW Treatment and Supplemental TRU packaging. Generally aligned with key features of the FY 2007 baseline.	P. J. Certa
3A	July 2008	Incorporate comments from the Office of Management and Budget	P. J. Certa
4	September 2009	Reflects a Baseline Case consistent with the Performance Management Baseline. An Initial Planning Case consistent with the Interim and draft Performance Measurement Baseline under the new Tank Operations Contract and an Unconstrained Case are used to evaluate program impacts against assumed “success criteria.”	M. N. Wells
5	November 2010	Reflects a Baseline Case, which provides the technical basis for the Performance Measurement Baseline; and a Sensitivity Case in which all potential TRU tank waste is processed through WTP.	M. N. Wells

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of River Protection (ORP) manages the River Protection Project (RPP). The RPP mission is to retrieve and treat Hanford's tank waste and close the tank farms to protect the Columbia River. As a result, ORP is responsible for the retrieval, treatment, and disposal of approximately 56 million gallons (Mgal)[1] of radioactive waste contained in the Hanford Site waste tanks and closure[2] of all the tanks and associated facilities.

This version of the RPP System Plan (Rev. 5) is a major update of the previous revision; System Plan (Rev. 4) was issued in September 2009. ORP has made a number of changes to the tank waste treatment strategy and plans since the last revision of this document, and additional changes are under consideration. The degree of integration with waste feed delivery and single-shell tank (SST) retrieval plans has been improved, as was the fidelity of the models for both tank farms and the Waste Treatment and Immobilization Plant (WTP).

ORP has contracts in place to implement the strategy for completion of the mission and establish the capability to complete the overall mission. The current strategy[3] involves a number of interrelated activities. ORP will reduce risk to the environment posed by tank wastes by:

- Retrieving the waste from the SSTs to double-shell tanks (DST) and delivering the waste to the WTP.
- Constructing and operating the WTP, which will safely treat all of the high-level waste[4] (HLW) fraction contained in the tank farms. About one-half of the low-activity waste (LAW) fraction separated from the HLW fraction in the WTP will be immobilized in the WTP LAW Vitrification Facility.
- Developing and deploying supplemental treatment capability, currently depicted as a second LAW vitrification facility in the baseline, to safely treat about one-half of the LAW contained in the tank farms. The facility is sized to treat up to about two-thirds of the LAW to allow for the potential acceleration of the treatment end date that would be gained by fully using the available HLW treatment capacity.

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[1] This is the total volume of tank waste as of January 2010. The volume varies depending on how much water and chemicals are added during waste retrieval and how much of that water has been removed by the waste evaporator.

[2] Selected words in the Glossary (Appendix A) appear in this document as blue underlined text, and are hyperlinked to the corresponding definitions in the glossary.

[3] DISCLAIMER: Some of the activities described herein may be subject to and/or undergoing analysis required by the *National Environmental Policy Act of 1969* (NEPA) (42 USC 4321 et seq.). They are included in this document for planning purposes only, not for decisional purposes, which will be conducted following the NEPA process.

[4] DOE has not yet made a waste determination under DOE O 435.1, *Radioactive Waste Management*, for tank waste. Until such determination has been made, the tank waste is managed as if it were HLW. As used in this System Plan, the term HLW refers to the fraction of the tank waste containing most of the radioactivity that will be immobilized into glass and disposed at an offsite repository—this includes the pretreated sludge plus the separated radionuclides. The term LAW refers to the fraction of the tank waste that will be immobilized into glass and disposed onsite—this includes the soluble portion of the tank waste less certain separated radionuclides. In this context, the HLW and LAW fractions do not include the tank residuals or any potential transuranic waste disposed of at the Waste Isolation Pilot Plant.

- Developing and deploying supplemental pretreatment capability currently assumed to be an Aluminum Removal Facility (ARF) using a lithium hydrotalcite (LiHT) process to mitigate sodium management issues.[5]
- Developing and deploying treatment and packaging capability for potential transuranic (TRU) tank waste interim storage at the Central Waste Complex pending determination of the final disposal pathway.[6]
- Deploying interim storage capacity for the immobilized high-level waste (IHLW) pending determination of the final disposal pathway.[7]
- Closing the SST and DST tank farms, ancillary facilities, and all associated waste management and treatment facilities.
- Optimizing the overall mission by resolution of technical and programmatic uncertainties, configuring the tank farms to provide a steady, well-balanced feed to the WTP, performing trade-offs of the required amount and type of supplemental treatment and pretreatment, and of the amount of HLW and LAW glass.

ORP has made and continues to make modifications to the WTP contract as needed to improve projected plant performance and address known or emerging risks. Key elements needed to implement the strategy described above are included within the scope of the Tank Operations Contract (TOC).

Interim stabilization of the SSTs was completed in March 2004. As of March 2010,[8] retrieval of seven SSTs has been completed. Three additional SSTs have been retrieved to the limits of technology, one SST was being retrieved, and one was in retrieval mode awaiting future disposition. Additionally, in September 2010, retrieval activities began in Tank C-111.

Award of the new contract for tank operations (TOC), ongoing tank waste retrieval experience, HLW disposal issues, and uncertainties in waste feed delivery and waste treatment led to a revision of the Performance Measurement Baseline (PMB) via Baseline Change Request (BCR) RPP-09-002,[9] which was approved by DOE Headquarters on June 18, 2010. This System Plan is aligned with the current WTP schedule, with hot commissioning beginning in 2018 and full operations beginning in late 2019.

The Baseline Case in System Plan (Rev. 4) was aligned with the then-draft PMB established by BCR RPP-09-002. System Plan (Rev. 5) develops and continues the alignment of a single operating scenario, called the Baseline Case, with the evolving life-cycle baseline. A new BCR will be prepared to align the life-cycle mission baseline with results of this System Plan.

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[5] It is anticipated that the need for the ARF may be avoided as a consequence of ongoing refinements to the RPP mission in the areas of WTP pretreatment design and flowsheet (referred to as the "WTP Equipment Option").

[6] The strategy includes options for treating potential TRU waste through the WTP and disposing it as IHLW.

[7] ORP planning with regard to final disposal of IHLW is subject to recognition of uncertainties with regard to an assumed, planned offsite geologic repository.

[8] March 2010 is the demarcation between historical and projected activities in this System Plan.

[9] RPP-09-002, 2010, Baseline Change Request, *FY 2010 - FY 2013 TOC Near Term Baseline*, Washington River Protection Solutions, LLC, Richland, Washington.

The schedule of certain activities in the Baseline Case may be adjusted to comply with funding guidance or other ORP direction or to address emerging plans and field conditions. For example, since the Baseline Case assumptions were locked down, substantial planning has been completed for C, A, and AX Farms that incorporates additional planning considerations that impact the retrieval end dates for these farms. These new dates are anticipated to be compliant with the milestones in the draft Consent Decree (No. 08-5085-FVS,[10] August 10, 2009) and proposed Tri-Party Agreement milestones. These and other emerging changes will be incorporated into the PMB using the baseline change control (BCR) process and promulgated into subsequent system plans.

Major decisions regarding the use of supplemental treatment and associated technology, the ultimate needed capacity, and its relationship to the WTP have not yet been finalized. This System Plan is consistent with the baseline by assuming that the outcome of these decisions will be to provide a second LAW vitrification facility. No final implementation decisions regarding supplemental treatment can be made until the Tank Closure and Waste Management Environmental Impact Statement is completed and a Record of Decision is issued by DOE.

Technical solutions are being developed to mitigate the impact of sodium to be added during pretreatment of the tank waste solids. This may involve one or more of the following options: (1) refining or modifying the flowsheet to reduce the required amount of additional sodium,[11] (2) increasing the overall LAW vitrification capacity, (3) increasing the incorporation of sodium into the LAW glass, (4) increasing the incorporation of aluminum in the HLW glass to reduce caustic leaching requirements, or (5) implementing other technical solutions. For planning purposes, the PMB and this System Plan assume that option (5) above, in the form of an ARF, will be successful in reducing the sodium required to be added during pretreatment of the tank waste; the other options may be evaluated as risk mitigation actions.

Purpose

The System Plan establishes a Baseline Case that is used as the technical basis for the budget and schedule baseline documented in the PMB. The Baseline Case describes how the RPP mission could be achieved given an underlying set of assumptions and conveys the potential mission impacts of key issues and uncertainties on the mission. The Baseline Case demonstrates the interactions of the ARF, the aluminum solubility in the WTP Pretreatment (PT) Facility, total sodium requiring vitrification, supplemental LAW treatment capacity, mission duration, WTP pretreatment throughput, and improvements in sludge blending and HLW glass formulation.[12]

The Baseline Case continues the integration and ongoing refinements of the PMB, plans for waste feed delivery, SST retrieval, the ARF, and supplemental LAW treatment with the hot commissioning plans for the WTP. Identification of areas that might require decisions or benefit from resolution of issues and uncertainties allows ORP to further improve its risk mitigation strategy.

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[10] 08-5085-FVS, 2009, *Proposed Consent Decree No. 08-5058-FVS between the U.S. Department of Energy and the State of Washington*, U.S. District Court, Eastern District of Washington.

[11] Bechtel National, Inc. has recently been directed to implement the "WTP Equipment Option," which employs a combination of flowsheet, operating mode, and equipment changes to reduce the amount of sodium added in the WTP Pretreatment Facility. Future life-cycle baselines are anticipated to include this option.

[12] PNNL-18501, 2009, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*, Pacific Northwest National Laboratory, Richland, Washington.

This System Plan (Rev. 5) includes a scenario (Sensitivity Case A) that explores the impacts of eliminating supplemental treatment of the potential TRU tank waste. Instead, this waste would be treated at the WTP and disposed along with the HLW. This is in anticipation of a potential future decision to dispose of this material as HLW rather than to dispose of this material at the Waste Isolation Pilot Plant (WIPP).

The potential benefits of continued improvements in HLW glass formulation were also evaluated using a recently developed enhanced glass formulation model.[13] This evaluation is discussed in Section 5.11.1.

Results

The Baseline Case shows that WTP, together with the ARF, the second LAW facility, and the potential TRU tank waste treatment process, can treat the Hanford tank waste by 2045, with approximately 26 years of WTP operations. The projected completion date for all SST waste retrievals is in 2039. All schedule-based success criteria are projected to be met, with the exception that the date on which closure of all SST farms is complete is eight months late. Future work to improve the closure completion date will analyze the SST retrieval sequencing logic, retrieval infrastructure, and other applicable parameters to make better use of the available DST space near the end of the mission. Selected key issues and uncertainties with these results are summarized in Table ES-3 (located at the end of the Executive Summary).

A simplified flowsheet for the Baseline Case is shown in Figure ES-1. A comparison of the summary results for the System Plan (Rev. 4) Baseline Case and the System Plan (Rev. 5) Baseline Case and Sensitivity Case A is shown in Table ES-1.

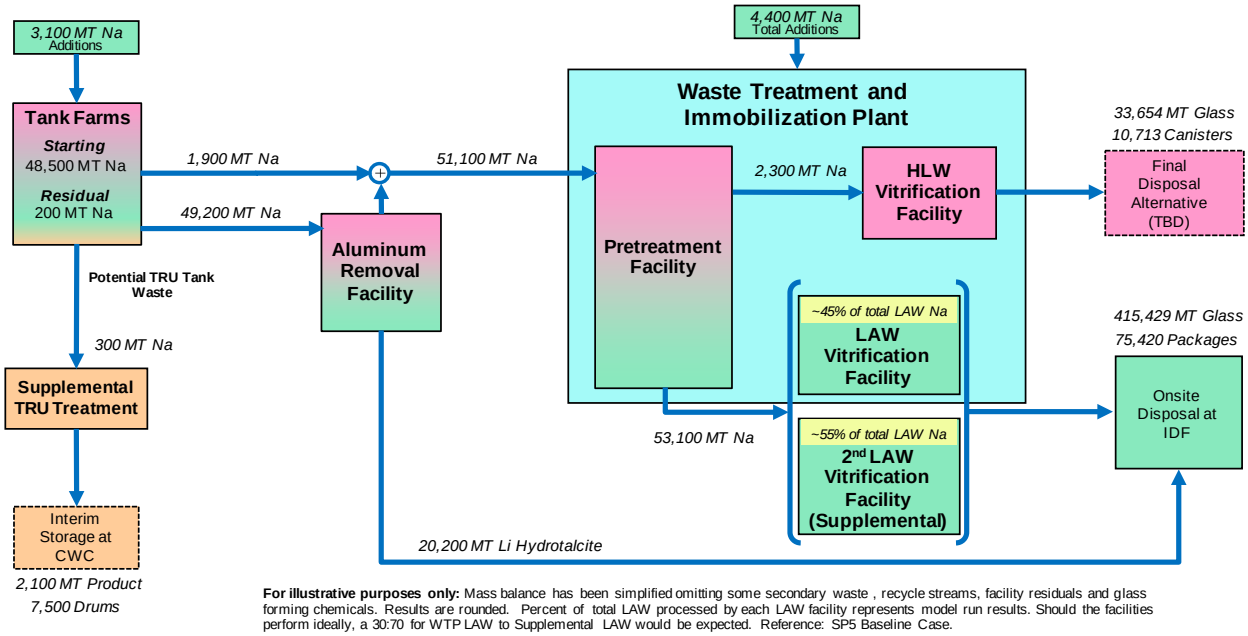

Figure ES-1. Simplified Flowsheet for Baseline Case.

[13] PNNL-19372, 2010, *Glass Composition Constraint Recommendations for Use in Life-Cycle Mission Modeling*, Pacific Northwest National Laboratory, Richland, Washington.

Table ES-1. Comparison of Summary Results.

Metric	System Plan (Rev. 4) Baseline Case	Success Criteria	System Plan (Rev. 5) Baseline Case	System Plan (Rev. 5) Sensitivity Case A
Complete C Farm retrievals	9/2014	9/30/2014	7/2013[a]	7/2013[a]
Start five additional SST retrievals	12/2016	12/31/2017	2/2015	2/2015
Close Waste Management Area C	FY 2019	6/30/2019	6/2019	6/2019
Complete nine additional SST retrievals	10/2017	9/30/2022	9/2017	9/2017
Complete all SST retrievals	10/2041	12/31/2040	10/2039	7/2040
Close all SSTs	FY 2048	1/31/2043	9/2043	≈ FY 2044
Treat all tank waste	1/2045	12/31/2047	8/2045	11/2046
Close all DSTs	FY 2049	9/30/2052	9/2049	≈ FY 2051
Potential TRU waste is packaged	5/2022	–	6/2023	–
LAW glass mass (MTG)[b]	448,800	–	415,430	416,037
LAW glass packages[c]	75,810	–	75,419	75,530
HLW glass mass (MTG)	42,899	–	33,654	37,994
HLW glass canisters[d]	14,111	–	10,713	12,095
Lithium hydrotalcite by-product (MT)[e]	23,900	–	20,201	20,232
Potential TRU waste drums	7,491	–	7,491	0
Sodium reporting to LAW glass (MT)	52,200	–	53,058	53,338
LAW glass sodium oxide loading	15.7%	–	17.2%[f]	17.3%[g]
HLW glass waste oxide loading	31.1%	–	37.6%	34.8%

[a] These projected dates are contingent on the successful deployment of the MARS vacuum tool and incorporation of lessons learned during MARS-sluicing operations in Tank C-107. This tool is still under development and the actual retrieval durations and deployment logic may be different than currently assumed.

[b] Total LAW glass projected from both the WTP LAW Vitrification Facility and the second LAW facility.

[c] System Plan (Rev. 4) packages are assumed to hold 5.92 MTG, while System Plan (Rev. 5) packages hold 5.51 MTG due to updated fill volume and glass density assumptions (see Section 5.9.1 for details).

[d] System Plan (Rev. 4) canisters are assumed to hold 3.04 MTG, while System Plan (Rev. 5) canisters hold 3.14 MTG due to updated fill volume (due to canister wall thickness) and glass density assumptions (see Section 5.9.2 for details).

[e] This is the mass of only the by-product, not the final waste form for disposal.

[f] This is the mass weighted average sodium oxide loading from the WTP LAW Vitrification Facility (17.7%) and the second LAW facility (16.9%).

[g] This is the mass weighted average sodium oxide loading from the WTP LAW Vitrification Facility (17.5%) and the second LAW facility (17.1%).

DST = double-shell tank.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
MARS = mobile arm retrieval system.
MT = metric ton.
MTG = metric tons of glass.
SST = single-shell tank.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

For most of the waste treatment mission, the duration the Baseline Case is driven by the HLW vitrification capacity, followed by the total LAW vitrification capacity and WTP pretreatment capacity. In the early years, through 2025, the waste treatment mission is driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and the second LAW facility, which limits the amount of HLW that can be pretreated and prepared for vitrification. (See Sections 5.3, 5.5.2.1, and 5.5.2.2 for more details.)

The current System Plan (Rev. 5) assumes the deployment of a second LAW vitrification facility in 2022 (delayed one year from Rev. 4), with its net capacity calculated such that LAW treatment would not drive the mission duration, assuming that HLW treatment was the predominant driver for the mission duration. The net capacity in System Plan (Rev. 5) is larger than System Plan (Rev. 4), since there is less time allocated to treat all of the waste: the start of the second LAW facility is delayed by one year, and the projected end date by which all HLW could be treated was almost five years earlier. This date moved from July 2043 in System Plan (Rev. 4) to October 2038 in System Plan (Rev. 5) due to the reduction in HLW glass mass.

The projected *mass* of HLW glass for the Baseline Case has decreased by about 22% relative to the System Plan (Rev. 4) Baseline Case. The primary reasons for this overall decrease in glass mass are due to three enhancements (see Section 5.9.2 for more details):

- Realignment with the WTP flowsheet (improved the modeled sludge wash efficiency and updated the melter partitioning assumptions)
- Enhanced intentional and incidental blending in both the DSTs and the WTP
- An updated glass formulation model, taking advantage of recent research and development test data.

The projected *number* of HLW glass canisters for the Baseline Case has decreased by about 24% (from 14,111 to 10,713 canisters) relative to the System Plan (Rev. 4) Baseline Case. About 22% of the reduction in the number of canisters is due to the reduction in glass mass (see Section 5.9.2). The remaining 2% reduction in canister count is due to a change in the canister fill assumption from the 3/8-inch wall canister used in System Plan (Rev. 4) to a thin-walled (10-gauge nominal) canister used in System Plan (Rev. 5), plus small changes in the assumed glass density.

The waste oxide loading for HLW glass achieved for the Baseline Case was higher than from System Plan (Rev. 4) due to the updated glass formulation model and improved blending, which allowed more waste to be loaded into the HLW glass. The waste oxide loading did not increase by the same amount that the total glass mass decreased, because the mass of pretreated HLW feed, on a waste oxides basis, was reduced from that in System Plan (Rev. 4) due to improvements in the modeled sludge wash efficiency. This resulted in fewer accompanying dissolved solids to be routed to the HLW melters. The reduction in pretreated HLW waste oxides decreased the final mass of HLW glass beyond the improvements in waste oxide loading because there were fewer waste oxides to load into the glass.

The Baseline Case in System Plan (Rev. 4) ***assumed*** that all of the tank waste would be treated by January 2045, extrapolating results using spreadsheet calculations from an earlier Hanford Tank Waste Operations Simulator (HTWOS) model run. The Baseline Case in System Plan (Rev. 5) ***projected*** that the waste would be treated by August 2045 using rigorous HTWOS

modeling. The extrapolation used in System Plan (Rev. 4) assumed how closely the WTP HLW Vitrification Facility would follow its net capacity curve and how much reduction might occur in the HLW glass mass. Although, in retrospect, System Plan (Rev. 4) overestimated the former and underestimated the later; these offset each other, yielding similar treatment end dates for both Rev. 4 and Rev. 5 of the System Plan, in spite of the observed 24% reduction in HLW glass mass.

The LAW glass *mass* for the Baseline Case was about the same as the Baseline Case from System Plan (Rev. 4). The slight decrease of approximately 7% was due to several interrelated causes (see Section 5.9.1):

- Updates to the partitioning assumptions for the LAW melter
- Improved sludge washing efficiencies in the ultrafiltration system as modeled
- Increases in incidental blending throughout the Waste Treatment Complex.

The total *number* of LAW packages remained about the same as the Baseline Case from System Plan (Rev. 4) in spite of the reduction in total glass mass because of a coincidental 7% reduction in the fill mass of glass in each package, due to changes in both filled volume and glass density. System Plan (Rev. 4) packages were assumed to hold 5.92 MTG, while System Plan (Rev. 5) packages were assumed to hold 5.51 MTG (see Section 5.9.1).

The Baseline Case shows that there is adequate DST space to meet the near-term success criteria of completing C Farm retrieval by 2014 and completing retrieval of nine additional tanks, currently assumed to be from A and AX Farms, by fiscal year (FY) 2017. The DST space is made available by regular operation of the 242-A Evaporator, efficient use of the remaining space in tanks that receive the retrieved SST waste, and development of appropriate buoyant-displacement gas release event (BDGRE) controls specific for sludge.

At the point of retrieval completion in these C, A, and AX Farm tanks, there will be minimal DST space available to proceed with additional SST retrievals. This condition exists until waste treatment processing rates have reached full operating capacity and enough waste has been removed from the DSTs to allow SST retrieval to resume.

Although there is between 1.5 and 3 Mgal of unallocated DST space available from 2015 to 2022, that space is not readily usable. The available space is distributed among several tanks and not always directly usable without a complicated series of waste transfers and evaporator staging operations. As the DST system nears capacity, it is increasingly difficult to conduct SST retrieval, evaporator, and feed staging operations. It may be prudent to reserve a portion of the DST tank space to support initial feed staging and waste feed delivery operations rather than attempting to backfill all available space with retrieved SST waste (see Section 5.4.2.3). To continue retrievals between 2018 and 2025, additional storage or treatment pathways are needed.

Management of DST space is one of the key issues and uncertainties. Factors that need to be considered include the BDGRE controls for sludge, the assumption that the evaporator can on average be run to reach 1.43 SpG without precipitation of problematic quantities of solids or exceeding its source term, waste compatibility constraints (e.g., those applied to high-phosphate waste), uncertainties in the inventory and as-retrieved volumes of the SSTs retrieved before 2025, potential delays in startup of WTP, and changes in mission configuration (e.g., early additional pretreatment and LAW treatment capacity, need for the ARF). Because DST space is

so limited, small perturbations or uncertainties in assumptions, waste feed delivery plans, or actual field operations can cause large shifts in near-term plans as the available space approaches zero. If this risk is fully realized, the completion of the nine additional retrievals might be delayed until after 2025.

In Sensitivity Case A, the potential TRU tank waste was assumed to be retrieved into the DST system, allowed to blend incidentally with other sludge, processed in the ARF, and delivered to the WTP for treatment. Sensitivity Case A exhibits similar behavior as the Baseline Case for both the near-term and overall mission drivers, including the demand on tank space. Sensitivity Case A also produces significantly more HLW glass (13%) than the Baseline Case due to the increased amount of tank waste processed through the WTP, and consequently completes the treatment mission about 15 months later. The mission duration did not increase in proportion to the increase of HLW glass mass since some of the "extra" glass was accommodated by periods of less than full HLW vitrification capacity.

Further revisions to the 2009 glass formulation model are recommended based on a recent evaluation performed by Washington River Protection Solutions (WRPS) and Pacific Northwest National Laboratory (PNNL). An evaluation was performed to assess the impacts on the HLW glass mass of adopting that enhanced HLW glass formulation model. The mass of HLW projected by the enhanced model was 30,602 MTG, or 9,746 canisters, about 9% less than the System Plan (Rev. 5) Baseline Case. This analysis shows promising results for the impact of future glass formulation enhancements.

Assumptions

Selected assumptions from the Baseline Case and from the System Plan (Rev. 4) are summarized in Table ES-2. Detailed assumptions are provided in Appendix B.

Planning assumptions for the SST retrieval sequence were aligned with more detailed, updated, assumptions documented in RPP-PLAN-40145[14] and SVF-1647.[15] On the average, the total of the minimum retrieval durations for each of the SSTs is 24% longer (less optimistic) in System Plan (Rev. 5) than in System Plan (Rev. 4). Near-term retrieval rates, before C Farm retrievals are complete, reflect recent field experience in terms of overall retrieval durations and water additions for sound SSTs. The retrieval rates for SSTs retrieved after C Farm were established as initial performance requirements to support the success criteria for the retrieval and waste treatment completion dates. The Baseline Case assumes that improvements would be made to the operating conditions, plans, and procedures for all retrieval operations after C Farm so that the initial performance requirements are achieved.

The initial performance requirements for SST retrievals were established by iterating over the minimum retrieval durations. First, the total operating efficiency (TOE) for each retrieval process was estimated based on experience and assumed future operating conditions. These estimated TOEs were low and inadequate to support future retrieval goals; using these original TOEs, all SSTs were projected to be retrieved by 2044 and all waste treated by 2049.

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[14] RPP-PLAN-40145, 2010, *Single-Shell Tank Waste Retrieval Plan*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

[15] SVF-1647, 2010, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3B.xlsx'," Rev. 3B, Washington River Protection Solutions LLC, Richland, Washington."

Table ES-2. Comparison of Selected Assumptions.

Item	System Plan (Rev. 4)	System Plan (Rev. 5)
Highlighted cases	Baseline Case[a]	Baseline Case, Sensitivity Case A
Projected funding	Performance Measurement Baseline RPP-09-002[b]	Performance Measurement Baseline RPP-09-002[b] as updated.
Supplemental pretreatment	ARF using lithium hydrotalcite: Start 2022	ARF using lithium hydrotalcite: Start 2022
Supplemental LAW treatment	Second WTP ILAW facility: Start 2021	Second WTP ILAW facility: Start 2022
Supplemental TRU tank waste treatment	Potential TRU tank waste to WIPP	Potential TRU tank waste interim stored in Central Waste Complex
WTP normal operations	12/2019	12/2019
SST retrieval sequence	Staggered, overlapping, farm-by-farm (logistically favorable) RPP-PLAN-40145, Rev. 0[c]	Staggered, overlapping, farm-by-farm (logistically favorable) RPP-PLAN-40145, Rev. 1[d]
SST retrieval rates	New technology for assumed leakers Updated operating shifts and learning curves per SVF-1647, Rev. 2[e]	New technology for assumed leakers Updated operating shifts and learning curves per SVF-1647, Rev. 3B[f]
WTP feed screening	Not screened[g]	Screened for Specification 7, 8, HGR and criticality
HLW canisters	3.04 MTG/canister (baseline)	3.14 MTG/canister (thin-walled)
HLW capacity	4.2 MTG/day net, then 5.25 MTG/day net with second generation melter	4.2 MTG/day net, then 5.25 MTG/day net with second generation melter
LAW capacity (WTP)	21 MTG/day net	21 MTG/day net
Supplemental LAW treatment capacity	Second LAW facility sized as needed (≈ 37 MTG/day)	Second LAW facility sized as needed (≈ 63 MTG/day)

[a] System Plan (Rev. 4) included two exploratory cases, the Initial Planning Case and the Unconstrained Case.

[b] RPP-09-002, 2010, Baseline Change Request, *FY 2010 - FY 2013 TOC Near Term Baseline*, Washington River Protection Solutions, LLC, Richland, Washington.

[c] RPP-PLAN-40145, 2009, *Single-Shell Tank Waste Retrieval Plan*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[d] RPP-PLAN-40145, 2010, *Single-Shell Tank Waste Retrieval Plan*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

[d] SVF-1647, 2009, "Single-Shell Tank Retrieval Assumptions for Mission Modeling," Rev. 2, Washington River Protection Solutions, LLC, Richland, Washington.

[e] SVF-1647, 2010, "Single-Shell Tank Retrieval Assumptions for Mission Modeling," Rev. 3B, Washington River Protection Solutions, LLC, Richland, Washington.

[g] However, the Initial Planning Case was screened for Specification 7, 8, HGR, and criticality.

ARF = Aluminum Removal Facility.
HGR = hydrogen generation rate.
HLW = high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
MTG = metric tons of glass.
SST = single-shell tank.
TRU = transuranic.
WIPP = Waste Isolation Pilot Plant.
WTP = Waste Treatment and Immobilization Plant.

A parametric study iterated over the minimum retrieval durations using various sets of assumed TOEs; the TOEs required to support the SST retrieval and waste treatment success criteria were about double the current estimates (or about 60% nominal).

Previous changes in the configuration of the Waste Treatment Complex increased the demand on the WTP PT Facility. These changes included the removal of supplemental pretreatment capacity previously assumed to be provided by the interim pretreatment system, and the assumption that the potential remote-handled TRU tank waste will be treated at the WTP rather than disposed at WIPP. As in System Plan (Rev. 4), the impacts from these changes continue to be mitigated by the use of the ARF to partially pretreat the tank waste and remove a portion of the aluminum before delivery to the WTP.

Opportunities

Under the assumptions for the Baseline Case, the RPP mission duration is driven primarily by the HLW vitrification capacity, followed by the total WTP and second LAW facility vitrification capacity and WTP pretreatment capacity. Key efforts being pursued by ORP to address issues with the underlying assumptions and shorten the treatment mission duration or reduce life-cycle cost include the following:

- Increasing the waste oxide loading of HLW glass through continued glass development and by improved sludge blending through one or more techniques: (1) intentional blending in DSTs or waste receiver facilities, and/or (2) intentional blending of sludge in a new feed characterization project. Additionally, increasing the aluminum loading in HLW glass may allow for a reduction in caustic leaching requirements, which may shorten the mission duration.
- Accelerating the decisions for providing the required supplemental LAW treatment and pretreatment capacity, including a decision as to the continued need for the ARF.
- Evaluating alternatives for providing additional LAW treatment capacity.
- Improving sodium management with one or more of several techniques currently being evaluated by DOE (e.g., refining the design and operating modes of the WTP PT Facility) to maintain mission completion in the event that the LiHT process is not effective or the ARF is not implemented.
- Accelerating the startup of LAW treatment (either the WTP LAW Vitrification Facility or the second LAW facility) to decrease the required size of the supplemental LAW vitrification facility and to increase DST space availability during the critical period between 2018 and 2022.
- Evaluating and implementing options to improve management of DST space.
- Increasing the sodium oxide loading of LAW glass through continued glass development work.
- Demonstrating new SST retrieval technologies with higher TOEs (shorter durations) than currently realized to support sustained waste feed delivery and uninterrupted WTP operations.

Changes in mission strategy could require completion of additional National Environmental Policy Act (NEPA) analyses.[16]

Key Issues and Uncertainties

The System Plan provides single-value estimates for key mission metrics such as the treatment end date and the quantity of glass produced.

Some of the assumptions used for the Baseline Case present issues and uncertainties that need to be successfully addressed to further reduce ORP's risk of achieving the desired performance for the RPP mission. These challenges are discussed in more detail together with potential mitigating actions in Section 7.0. Selected key issues and uncertainties and potential mitigating actions are summarized in Table ES-3. The issues and uncertainties identified for the Baseline Case will assist ORP in the management of the programmatic and technical risks associated with the waste treatment mission.

Table ES-3. Selected Key Issues and Uncertainties. (4 pages)

Key Issues and Uncertainties	Potential Mitigating Actions
Sodium management is integral to the successful completion of the waste treatment mission. The Baseline Case and PMB assumes that the LiHT precipitation process will be developed and implemented in the ARF by 2022 and that it will fully mitigate the sodium management issue and reduce the demand on the WTP PT Facility. It also assumes that the LiHT by-product can be successfully decontaminated and disposed of at the IDF.	• Develop the LiHT process to TRL 3 in FY 2010 to facilitate the decision-making process. • Determine the need (by end of FY 2010) and technologies (by end of FY 2011) for supplemental LAW treatment and pretreatment, including the need for the ARF. This decision should take into account the emerging changes to the design and operating modes of the WTP to reduce sodium additions by operating the PT Facility at a higher temperature (known as the "WTP Equipment Option"). • If the ARF remains in the baseline, determine the acceptability of the LiHT by-product for disposal at the IDF. The disposition may need to consider potential reuse as a portion of the LAW glass formers.
If the start of operations is delayed or the capacity of the WTP is lower than projected, the duration of the treatment mission may increase. Depending on the current mission duration driver, more waste may have to be processed through supplemental treatment.	• Revisit programmatic assumptions, such as the amount and timing of supplemental treatment, if the projected mission duration exceeds the life of WTP or if the mission duration is otherwise unacceptable.

[16] 42 USC 4321, et seq., *National Environmental Policy Act of 1969.*

Table ES-3. Selected Key Issues and Uncertainties. (4 pages)

Key Issues and Uncertainties	Potential Mitigating Actions
The WTP PT Facility, LAW Vitrification Facility, or HLW Vitrification Facility may not achieve the assumed design or net treatment capacities. Supplemental pretreatment capacity beyond that provided by the WTP may be needed to fully use the assumed LAW and HLW treatment capacity. The Baseline Case provides this capacity with the ARF.	• Provide supplemental pretreatment and supplemental LAW vitrification capacity, or other means, to treat the majority of the LAW. • If the ARF is removed from the baseline, evaluate ways to reduce the demand on the WTP PT Facility so that HLW vitrification continues to drive the mission duration. This includes trading-off the mass of HLW glass against the mass of LAW glass, reducing variability in the projected WTP feed, refinements to the design and operating modes of the WTP, and providing supplemental pretreatment. • Incorporate updated models of the WTP flowsheet and operating modes[a] into future versions of the System Plan via updates to HTWOS.
Management of DST space is critical to success of the RPP mission. If the DST system reaches capacity, SST retrievals must stop until WTP is operational. Small perturbations in assumptions or uncertainties in assumptions, plans, or actual field operations affecting DST space management will have a disproportionate effect on the early SST retrieval schedule as available DST space approaches zero.	• Continue existing waste management initiatives to increase usable storage space in existing DSTs, such as implementing new BDGRE controls specific to sludge. • Implement some or all of the options identified in RPP-RPT-45825.[b] • Continue tank integrity and chemistry control programs. • Ensure 242-A Evaporator viability. • As needed, provide supplemental waste concentration capacity through an alternative technology. • Use SST retrieval experience and technology development to increase waste retrieval volumetric efficiencies. • Consider staging SST waste into sound SSTs determined to be fit-for-use. • Evaluate the proposed feed characterization project or increase the lag-storage capacity or provide additional waste receiver facilities.
Waste feed delivery capabilities to meet WTP requirements have not been demonstrated.	• Include technology development activities in the baseline to address mixer pump performance and feed sampling capabilities. Include indexing or incremental insertion systems for the mixer pumps in deep sludge tanks. • Evaluate the ability and robustness of the waste feed delivery system to supply feed on-demand. Revisit the need for a 180-day dwell time per ICD-19.[c] • Perform an external technical review of the Tank AZ-101 mixer pump test, current and future scaled tests, and future mixing testing strategy. • Evaluate the proposed feed characterization project. • Continue development of the WFD system operations research model to identify system bottlenecks and implement strategies to improve WFD system availability.

Table ES-3. Selected Key Issues and Uncertainties. (4 pages)

Key Issues and Uncertainties	Potential Mitigating Actions
The amount of caustic needed to adequately leach aluminum and keep aluminum soluble through cesium ion exchange is uncertain. The Baseline Case assumes that this issue is mitigated by the ARF.	ORP has an ongoing effort to assess sodium use in the WTP, an approved sodium management plan, and an ongoing assessment to: • Consider operating the PT waste treatment processes at a higher temperature to help keep the aluminum in solution, thereby reducing the amount of sodium hydroxide that must be added. • Develop refined LAW glass formulation models to increase sodium oxide loading and consider ways to increase total LAW treatment capacity. • Evaluate caustic recycle after pretreatment or other caustic management strategies. • Provide additional supplemental LAW pretreatment and treatment capacity. • Trade-off the mass of HLW glass against the mass of LAW glass to reduce demand on pretreatment and potentially reduce mission duration. • Develop improved HLW glass formulation models that can accommodate higher alumina loadings. Increasing alumina waste loading in glass may reduce the number of batches or fraction of alumina that must be leached, which reduces NaOH added in processing.
Packaged potential TRU tank waste will be acceptable for interim storage at the Central Waste Complex pending a determination of final disposition.	• Develop bases for TRU waste classification. • Pursue TRU waste classification agreement with regulators and stakeholders. • Secure Class III permit modification.
Based on retrieval system experience, waste in some tanks will be difficult to retrieve. Use of multiple technologies may be required in a single tank to meet retrieval (tank residual) requirements, including retrieval rates. The retrieval technologies may not be as efficient or effective as assumed. "Special case" SSTs and SSTs assumed to have leaked may present retrieval challenges.	• Incorporate lessons learned into retrieval system designs and operations to meet the assumed TOEs and associated retrieval durations. If the overall required retrieval rates cannot be met with improvements in the TOEs and associated retrieval durations, then other alternatives may need to be explored (e.g., increasing the number of simultaneous retrievals). • Develop, test, and deploy new SST retrieval technologies. • Revisit the designation of the SSTs that are assumed to have leaked, and if supported by evidence, revise those designations.

Table ES-3. Selected Key Issues and Uncertainties. (4 pages)

Key Issues and Uncertainties	Potential Mitigating Actions
The potential exists for an SST to leak during retrieval operations. The discovery of a leak may require the implementation of response actions, including the potential use of a different retrieval technology, and might delay retrievals in nearby tanks.	• Address leak response actions for tank leaks in the tank waste retrieval work plans and process control plans. • Retrieve sound tanks adjacent to a tank that is assumed to have leaked before retrieving the tank that may have leaked.
The current ETF is inadequate to treat the projected liquid secondary waste stream that will be generated by the WTP. Currently planned ETF upgrades may not be adequate to treat secondary waste streams for the Waste Treatment Complex. Of particular importance is the ability to safely dispose of the ETF solid product in the IDF.	• The Secondary Liquid Waste Treatment Project will provide the needed treatment capability. An alternative analysis will support the technology down-select process as part of CD-1. Additional NEPA[d] documentation may be required for the upgrades; a categorical exclusion will be written to address the upgrade design. • Implement alternative technologies for treatment of WTP recycle streams to reduce the demand on the ETF.

[a] 24590-WTP-RPT-PT-02-005, 2008, *Flowsheet Bases, Assumptions and Requirements*, Rev. 5, Bechtel National, Inc., Richland, Washington, and 24590-WTP-MDD-PR-01-002, *Dynamic (G2) Model Design Document*, Rev. 10, Bechtel National, Inc., Richland, Washington.

[b] RPP-RPT-45825, 2010, *Tank Space Alternatives Analysis Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[c] 24590-WTP-ICD-MG-01-019, 2007, *ICD 19 – Interface Control Document for Waste Feed*, Rev. 4, Bechtel National, Inc., Richland, Washington.

[d] 42 USC 4321, et seq., National Environmental Policy Act of 1969.

ARF = Aluminum Removal Facility.
BDGRE = buoyant displacement gas release event.
CD = critical decision.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
FY = fiscal year.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
ORP = U.S. Department of Energy, Office of River Protection.
PMB = performance measurement baseline.
PT = pretreatment.
RPP = River Protection Project.
SST = single-shell tank.
TOE = total operating efficiency.
TRL = Technology Readiness Level.
TRU = transuranic.
WFD = waste feed delivery.
WTP = Waste Treatment and Immobilization Plant.

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TERMS

ALARA	as low as reasonably achievable
ARF	Aluminum Removal Facility
ARRA	*American Recovery and Reinvestment Act of 2009*
ATL	Advanced Technologies and Laboratories International, Inc.
BBI	Best-Basis Inventory
BCR	baseline change request
BDGRE	buoyant displacement gas release event
BNI	Bechtel National, Inc.
BOF	balance of facilities
CD	Critical Decision
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CH-TRU	contact-handled transuranic
CLIN	contract line item number
CSL	criticality safety limit
CWC	Central Waste Complex
D&D	deactivation and decommissioning
DOE	U.S. Department of Energy
DSA	documented safety analysis
DST	double-shell tank
EA	environmental assessment
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EM	U.S. Department of Energy, Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FY	fiscal year
G	Guide
GCS	gas characterization system
GFM	glass formulation model
HAMTC	Hanford Atomic Metal Trades Council
HEPA	high-efficiency particulate air
HFFACO	*Hanford Federal Facility Agreement and Consent Order* (also known as Tri-Party Agreement)
HGR	hydrogen generation rate

HLW	high-level waste
HSF	Hanford Shipping Facility
HTRH	hard-to-remove heel
HTWOS	Hanford Tank Waste Operations Simulator
HVAC	heating, ventilation, and air conditioning
ICD	interface control document
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHSF	Interim Hanford Storage Facility
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
INL	Idaho National Laboratory
ITV	in-tank vehicle
Lab	Analytical Laboratory
LAW	low-activity waste
LCM	life-cycle cost model
LERF	Liquid Effluent Retention Facility
LiHT	lithium hydrotalcite
LLW	low-level waste
M	Manual
MAR	mission analysis report
MARS	mobile arm retrieval system
MARS-S	mobile arm retrieval system-sluicing
MARS-V	mobile arm retrieval system-vacuum
MRS	mobile retrieval system
MTG	metric tons of glass
MUST	miscellaneous underground storage tank
NEPA	*National Environmental Policy Act of 1969*
NRC	U. S. Nuclear Regulatory Commission
NWPA	*Nuclear Waste Policy Act of 1982*
O	Order
OCRWM	Office of Civilian Radioactive Waste Management
OR	operations research
ORP	U.S. Department of Energy, Office of River Protection
PA	performance assessment
PMB	performance measurement baseline
PNNL	Pacific Northwest National Laboratory
PT	pretreatment

PUREX	Plutonium-Uranium Extraction (Plant)
R&D	research and development
RA	Recovery Act
RCRA	*Resource Conservation and Recovery Act of 1976*
RH-TRU	remote-handled transuranic
RL	U.S. Department of Energy, Richland Operations Office
RMP	risk management plan
ROD	Record of Decision
RPP	River Protection Project
SALDS	State Approved Land Disposal Site
SGE	surface geophysical exploration
SHMS	standard hydrogen monitoring system
SpG	specific gravity
SRS	Savannah River Site
SST	single-shell tank
SSTIP	single-shell tank integrity project
TC & WM	Tank Closure and Waste Management
TDEM	time-domain electromagnetics
TEDF	Treated Effluent Disposal Facility
TISB	T Farm interim surface barrier
TOC	Tank Operations Contract
TOE	total operating efficiency
TPA	Tri-Party Agreement (*Hanford Federal Facility Agreement and Consent Order*)
TRL	Technology Readiness Level
TRU	transuranic
TWINS	Tank Waste Information Network System
TWRS	Tank Waste Remediation System
WBS	work breakdown structure
WD	waste determination
WESF	Waste Encapsulation and Storage Facility
WFD	waste feed delivery
WFE	wiped-film evaporator
WIPP	Waste Isolation Pilot Plant
WIR	waste incidental to reprocessing
WMA	waste management area
WMA C	Waste Management Area C
WOL	waste oxide loading

WRF	waste retrieval facility
WRPS	Washington River Protection Solutions, LLC
WTP	Waste Treatment and Immobilization Plant

1.0 INTRODUCTION

At the Hanford Site, 56 million gallons of nuclear waste are stored in aging underground tanks, threatening the Columbia River.

One of the world's largest environmental cleanup projects is underway at the Hanford Site in Washington State. A fully integrated system of waste storage, treatment, and disposal facilities is in varying stages of design, construction, operation, or future planning. These facilities are needed to complete the U.S. Department of Energy's (DOE) mission to protect the Columbia River, the largest river system in the Pacific Northwest. Many hurdles must be overcome to achieve site cleanup and closure.

The DOE has two Federal offices at Hanford – the DOE Office of River Protection (ORP), which is responsible for cleanup of Hanford Site tank waste, and the DOE Richland Operations Office (RL), which is responsible for nuclear waste and facility cleanup, and overall management of the Hanford Site. Each DOE office oversees separate contracts held by private companies.

1.1 HANFORD SITE BACKGROUND

The 586-square-mile Hanford Site is located along the Columbia River in southeastern Washington State (Figure 1-1) and is home to the world's first plutonium production complex. Beginning with the Manhattan Project and throughout the Cold War, Hanford played a pivotal role in providing nuclear materials for the nation's defense program. However, more than 40 years of plutonium production also yielded a challenging nuclear waste legacy: approximately 56 million gallons (Mgal) of radioactive and chemically hazardous wastes are stored in 177 underground tanks located on Hanford's Central Plateau. Of the 177 tanks, seven tanks have been retrieved, three have been retrieved to the limits of technology, and two are currently in retrieval status.

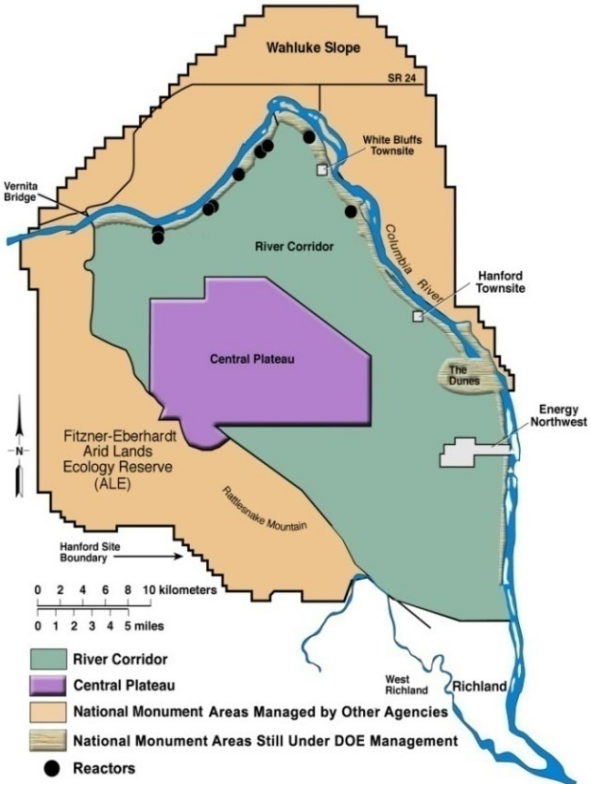


Figure 1-1. Hanford Site Map.

The waste composition varies widely, necessitating a variety of unique waste retrieval and treatment methods. In addition, 149 of these tanks are decades past their intended useful life. Some tanks are known or are assumed to have leaked. In the 1950s and 1960s, approximately 1 Mgal of liquid radioactive waste may have been inadvertently released into the environment, contaminating the soil and groundwater, and threatening the Columbia River. Today, under the direction of DOE, Hanford contractors are performing one of the world's largest environmental cleanup projects and face many overlapping technical, regulatory, and financial hurdles.

1.2 RIVER PROTECTION PROJECT SYSTEM PLAN PURPOSE

Successful management of the River Protection Project (RPP) requires the careful coordination of multiple private contractors that are responsible for the design, construction, operation, and maintenance of the RPP facilities and support services; integration with the Plateau Remediation Contractor and the Mission Support Contractor under RL; and the cooperation of several external organizations, including the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), Hanford Citizens Advisory Board, the Indian Nations, and the general public.

The purpose of this document, hereinafter referred to as the System Plan (Rev. 5), is to provide a basis for the alignment of program costs, scope, and schedules, from upper-tier contracts to individual facility operating plans. In particular, System Plan (Rev. 5) serves to define the issues that must be resolved by ORP to ensure the success of the cleanup mission. Mitigating actions and plans to address these issues, including a summary of selected technology development initiatives, are also included in this plan. It is important to note that strategic planning is ongoing; therefore, the System Plan will be revised periodically to reflect recent progress, current plans, responses to emergent issues, changes in the regulatory environment, and budgeting constraints.

1.3 PRIME CONTRACTS

At this time, ORP manages three prime contracts within the RPP system:

- The Tank Operations Contract (TOC) (DE-AC27-08RV14800), held by Washington River Protection Solutions, LLC (WRPS), includes the construction, operation, and maintenance activities necessary to store, retrieve, and transfer tank wastes; provide supplemental pretreatment for tank waste; provide treatment, storage, and/or disposal of glass product and secondary waste streams; and provide Waste Treatment and Immobilization Plant (WTP) support to ORP.
- The WTP contract (DE-AC27-01RV14136), held by Bechtel National, Inc. (BNI), includes the design, construction, and commissioning of a pretreatment facility, two vitrification facilities (one for high-level waste [HLW] and one for low-activity waste [LAW]), a dedicated laboratory, and supporting facilities to convert radioactive tank wastes into glass for long-term storage or final disposal.
- The 222-S Analytical Laboratory Analytical Services and Testing contract (DE-AC27-10RV15051) held by Advanced Technologies and Laboratories International, Inc. (ATL), includes operation of the site's primary laboratory for highly radioactive samples in support of cleanup and closure activities.

1.4 RECENT PLANNING IMPROVEMENTS

Long-range planning for the Waste Treatment Complex is a multifaceted, iterative process. Each revision of the System Plan builds on the best strategies identified in previous plans, thereby increasing planning confidence. Several important planning improvements identified during or after the development of System Plan (Rev. 4) have been incorporated in the planning basis for Revision 5.

- The overall configuration of the RPP system has been updated to reflect current plans, as depicted in Figure 1-2.

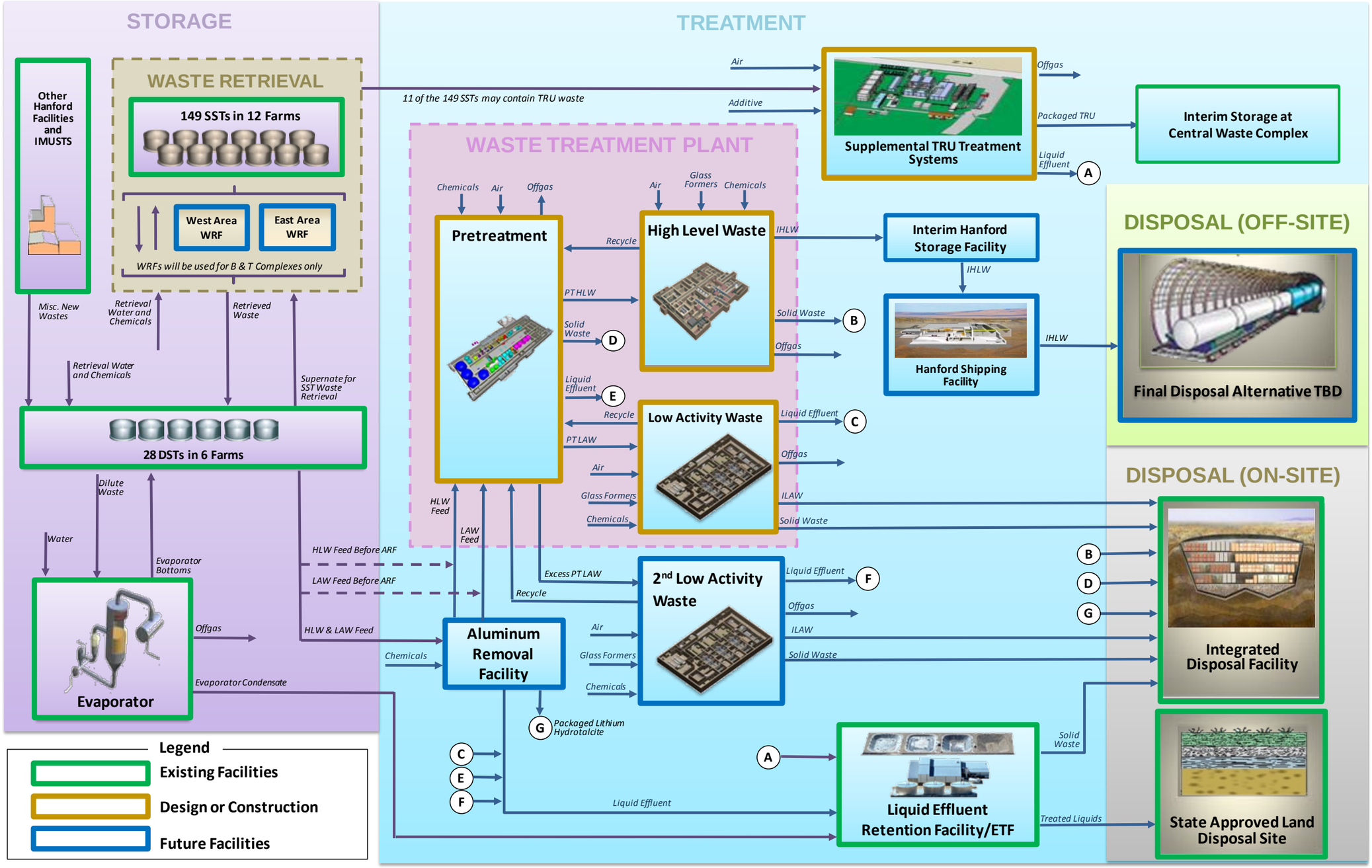


Figure 1-2. Simplified Process Flow Diagram.

- "Interim storage at the Central Waste Complex" has replaced the Waste Isolation Pilot Plant (WIPP) in New Mexico as the assumed interim destination of treated, solidified tank waste that may be designated as transuranic (TRU) waste.[17]
- A "final disposal alternative" has replaced the "planned geologic repository" previously shown in the figure, pending a decision from the federal government regarding a future national repository.

• The System Plan is integrated with three key RPP documents. These documents were updated as part of the System Plan (Rev. 5) effort:

- RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*, which provides the strategy for removing radioactive and chemical wastes from single-shell tanks (SST), has been updated. Revision 1 includes the basis for detailed SST retrieval assumptions, waste volumes and durations for each tank, and a logical methodology for selecting the best waste retrieval process for deployment in a given SST, based on the tank's structural integrity, design attributes, operating history, waste characterization, and other criteria. This System Plan is integrated with RPP-PLAN-40145 (Rev. 1).[18] Additional details are provided in Section 3.1.1.
- RPP-40149, *Integrated Waste Feed Delivery Plan*, which defines the scope of work and project management approach to provide optimized and reliable feed of retrieved waste from the tank farms to the Hanford WTP or other treatment facilities, has been updated. Revision 1 provides an integrated system approach to waste retrieval, treatment, and delivery. A hardware baseline was established, in which existing double-shell tank (DST) farm conditions were evaluated to document the current status of site infrastructure and storage/retrieval systems. An update of system functions and requirements was completed, which added new constraints concerning the maximum height (70 in.) of settled solids that can be mobilized without incremental insertion, the minimum slurry heel (36 in.) needed for reliable mixer pump operation, and the minimum slurry heel (72 in.) assumed to be needed to maintain a well-mixed slurry for delivery to the WTP or Aluminum Removal Facility (ARF). Follow-up from a value engineering workshop in 2009 led to direct

[17] In System Plan (Rev. 4), ORP indicated that nine potential remote-handled transuranic (RH-TRU) waste tanks were at high regulatory risk for TRU designation; therefore, System Plan (Rev. 4), assumed that those wastes would be comingled with other tank waste and processed through the WTP, immobilized in glass, and disposed at a national repository. In addition, eleven tanks were identified as containing potential contact-handled transuranic (CH-TRU) tank waste. In System Plan (Rev. 4), these wastes were assumed to be processed through a separate supplemental CH-TRU treatment and packaging process, then packaged and shipped to WIPP for disposal. This treatment path would have allowed these tank wastes to be treated and disposed entirely independently of the WTP process. System Plan (Rev. 5) explores the impacts of two possible paths forward regarding treatment and disposal of the CH-TRU waste, hereinafter referred to as "potential TRU tank waste." In the Baseline Case, potential CH-TRU waste is kept segregated, treated at a proposed supplemental TRU treatment facility, and transported to the Central Waste Complex for interim storage pending a final disposal decision. In Sensitivity Case A, the potential TRU tank waste is retrieved and treated along with the high-level waste at the WTP.

[18] RPP-PLAN-40145 is used in conjunction with two related documents to foster this integration. They are RPP-40545, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*, which provides the technical assumptions and their bases for estimating the waste retrieval volumes and minimum durations and SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF 1647 Rev 3B.xlsx'," which performs the calculations.

communication with Savannah River Site (SRS) personnel, with emphasis on SRS mixer pump experience. SRS lessons learned have been incorporated into Hanford planning. This System Plan is integrated with RPP-40149 (Rev. 1). Additional details are provided in Sections 3.1.2 and 5.4.2.2.

- TFC-PLAN-39, *Risk Management Plan* (RMP), describes the systematic process used by WRPS to assess and manage project risks within the RPP program. This RMP supports prudent and effective project management through minimization of risk and maximization of opportunities inherent in the TOC life-cycle scope, schedule, and cost baseline. Risks and opportunities currently associated with the RPP program are addressed in this System Plan. For each risk or opportunity identified, attendant assumptions, issues and uncertainties, and potential mitigating actions are also articulated. Additional details are provided in Section 7.0.

- The Hanford Tank Waste Operations Simulator (HTWOS) model was significantly upgraded and these model improvements are reflected in this System Plan. Additional details are provided in Section 4.1.1. Improvements include:
  - SST waste retrieval plans were aligned[19] with RPP-PLAN-40145 (Rev. 1) and SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3B.xlsx'."
  - DST functions were aligned with RPP-40149 and anticipated field constraints. Revision 1 of the Integrated Waste Feed Delivery Plan was developed and is expected to be issued in parallel with the System Plan (Rev. 5).
  - 242-A Evaporator logic in HTWOS has been improved to balance availability of dilute feed, availability of DST space to store the concentrate, and waste acceptance criteria specified by WTP.
  - Minimum tank waste emergency storage space in DSTs is ensured by improvements in modeling logic.
  - A simplified flowsheet for the proposed ARF was incorporated, replacing the spreadsheet that was used for System Plan (Rev. 4).
  - The waste treatment processing facility flowsheet used by HTWOS was updated to more closely align with the current WTP facility design and operating modes.
  - The new 2009 glass formulation model (GFM) for HLW glass, based on recent work completed by Pacific Northwest National Laboratory (PNNL), was implemented in the model.
  - Two LAW GFMs, the DOE 2004 LAW glass model and the WTP baseline LAW glass model, are included in HTWOS and can be used to provide comparison predictions. The DOE 2004 model was used for this System Plan.

[19] Refinements to the SST retrieval and DST utilization plans will help maintain a ready supply of feed to the ARF and WTP. DSTs are dynamically reassigned as needed to support a variety of waste retrieval operations, including early SST waste retrieval, receiving cross-site waste transfers, settling sludge slurry and decanting excess liquid, supporting evaporator operations, and staging HLW feed or LAW feed for delivery to the ARF and WTP PT Facility.

- During the development of System Plan (Rev. 5), additional RPP documents have been revised or newly created as part of a systems engineering approach to mission planning. These documents include, but are not limited to:
  - RPP-PLAN-43988, *WRPS Technology Development Roadmap*, identifies technology gaps in the RPP system and highlights ongoing technology development activities that have been undertaken to close those gaps, including initiatives that may, if successful, accelerate RPP mission completion. A listing of select technologies is provided in Section 6.0.
  - RPP–RPT-41742, *River Protection Project Mission Analysis Report* (MAR), is being updated in parallel with System Plan (Rev. 5). The MAR defines the mission objectives, identifies the top-level functions needed to accomplish the mission, and specifies the requirements that must be met to achieve those functions. The role of the MAR in the system planning process is discussed in Section 1.8.
  - RPP-46506, *Preliminary Decision Framework*, was developed to document the technical decisions that have already been made and decisions that are required to be made for the projects that support the RPP mission as defined in the MAR. This document will be updated as the RPP mission evolves, decisions are made, and the need for new decisions emerges. The role of the Preliminary Decision Framework in the system planning process is discussed in Section 1.8.

Summary schedules (see Section 9.0) are now included in the System Plan to illustrate major project activities over the course of the RPP mission, including tank-by-tank SST retrievals and closure, 242-A Evaporator operations, DST operations, construction and operation of various waste pretreatment and treatment facilities, and the timing of key decisions.

1.5 RECENT ACCOMPLISHMENTS

In the past year, a number of important advancements have been made in the field, including:

- Waste retrieval projects for SSTs C-104, C-107, and C-111 are underway. Obsolete equipment was removed from Tanks C-104 and C-111, supporting infrastructure upgrades were completed, and retrieval equipment was installed (see Figure 1-3 for Tank C-104). Waste retrieval operations on Tank C-104 began in January 2010 and succeeded in retrieving approximately 195 kgal of waste before being interrupted by a transfer pump failure in receipt Tank AN-101. The transfer pump was replaced and retrieval operations are anticipated to begin on Tank C-111 by the end of fiscal year (FY) 2010.

Figure 1-3. New Equipment Being Installed in Tank C-104 for Waste Retrieval.

On completion of waste retrieval from Tank C-111, retrieval operations will resume in Tank C-104. The retrieval project for Tank C-107 is currently in the design and construction phase.

- Extensive facility upgrade projects were completed for the 242-A Evaporator, including upgrading the raw water system and decontaminating the condenser room. Facility operations in 2009 yielded more than 750 kgal of recovered tank space. Two additional campaigns planned in 2010 are expected to produce 450 kgal of recovered space.
- *American Recovery and Reinvestment Act of 2009* (ARRA) funds totaling $326 million were allocated to ORP and WRPS to improve facilities that handle liquid waste. Thirty separate projects (including the two 242-A Evaporator facility upgrades described above) were undertaken to improve a variety of tank farm facilities and infrastructure systems. Many ARRA projects are already complete. Additional details are provided in Section 3.1.9.
- Vadose zone program activities have been focused on providing support for Waste Management Area[20] C (WMA C), improving soil characterization data for a number of areas to support placement of interim surface barriers, and significant technology development and field implementation efforts, particularly with regard to direct push boreholes, surface geophysical exploration, and construction of an interim surface barrier over TY Farm.
- A full-scale demonstration of the mobile arm retrieval system (MARS), a "transformational technology" (see Figure 1-4, and Table 6-1 in Section 6.0), occurred at the Cold Test Facility on the Hanford Site. This new tool represents an important advancement in waste retrieval technology, because it is expected to effectively access almost all regions of a waste tank, including working around some obstructions. Design of a deployable unit is in progress.
- The 222-S Laboratory has provided support to the tank farms for routine operations and for technology development needs. The facility is also undergoing extensive upgrades to improve its ability to support the additional needs projected for tank farm

Figure 1-4. Mobile Arm Retrieval System Testing at Cold Test Facility.

[20] Hanford's 149 SSTs are grouped into 12 farms, which are further grouped by similar geography into seven waste management areas (WMA) for purposes of closure planning and execution. Each WMA includes some combination of underground storage tanks, aboveground structures, ancillary equipment, and contaminated soil.

operations over the next several decades as tank waste characterization, retrievals, and feed preparation activities increase.

- The SST Tank Integrity Panel, comprised of independent experts from the national laboratories, government contractors and academia, met twice in 2009 and once in 2010. Their work produced two reports containing important recommendations and commentary in support of programs to extend the useful lives of SSTs. Additional details are provided in Section 3.1.1.
- Laboratory testing of the lithium hydrotalcite (LiHT) process succeeded in elevating the technology to a Technology Readiness Level (TRL) 3. Additional details are provided in Section 3.2.3 and Table 6-1 (in Section 6.0).

Additional information regarding the above activities is provided in Section 3.0.

1.6 DRIVERS FOR ISSUING SYSTEM PLAN REVISION 5

A number of factors led to this routine revision of the System Plan:

- Provides an updated technical basis for the performance measurement baseline (PMB)
- Incorporates the recent major realignment of HTWOS model with updated process flowsheets for the WTP and to explicitly model the ARF
- Provides better integration with the updated SST Waste Retrieval Plan and Integrated Waste Feed Delivery (WFD) Plan (RPP-PLAN-40145 and RPP-40149, respectively)
- Reflects recent progress in SST retrieval and evaporator operations
- Incorporates an updated HLW GFM (also referred to as the 2009 GFM)
- Explores a sensitivity case to support future decisions regarding the disposition of potential TRU tank waste
- Discusses the sensitivity of HLW glass mass to further enhancements of the HLW GFM to support future decisions on continued improvement of glass formulation.

1.7 REFERENCE DATES

Several dates are essential to understanding the basis of this System Plan:

- ORP approved the System Plan key assumptions and success criteria (Appendix B) on April 16, 2010 (Charboneau 2010a), with a minor update on June 30, 2010 (Charboneau 2010b).
- March 2010 is the demarcation between completed[21] historical and projected activities in the System Plan. There was one DST-to-DST transfer completed in February 2010.
- The description of the RPP system status is current as of June 1, 2010.
- January 1, 2010 is the effective date for the current inventory of tank waste (RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste*

[21] All other activities, including retrieval progress of Tank C-104, are relative to the January 1, 2010 effective date for the tank waste inventory.

Operations Simulator Model – 2010 Update); this data was downloaded into the HTWOS model as the 2010 inventory on May 5, 2010.

- The status (integrity) of the waste tanks is current as of December 31, 2009 (HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2009*, Rev. 261).
- The decay date for reporting radionuclides is January 1, 2008, unless stated otherwise.

1.8 SYSTEM PLANNING PROCESS

Figure 1-5[22] is a simplified depiction of the system planning process that illustrates the integration of key documents and the iterative nature of the planning process, focusing on the WTP and TOC workscope. Within this section, terms in **bold** refer to items shown on the figure.

Through the **WTP Contract** and **Tank Operations Contract**, ORP establishes its expectations for the contractor to provide safe, compliant, cost-effective, and energy-efficient services for a specific scope of work. At Hanford, this scope includes the storage, retrieval, treatment of wastes, storage, and disposal of treated wastes, and closure of tank farm waste management areas (WMA) to protect the Columbia River.

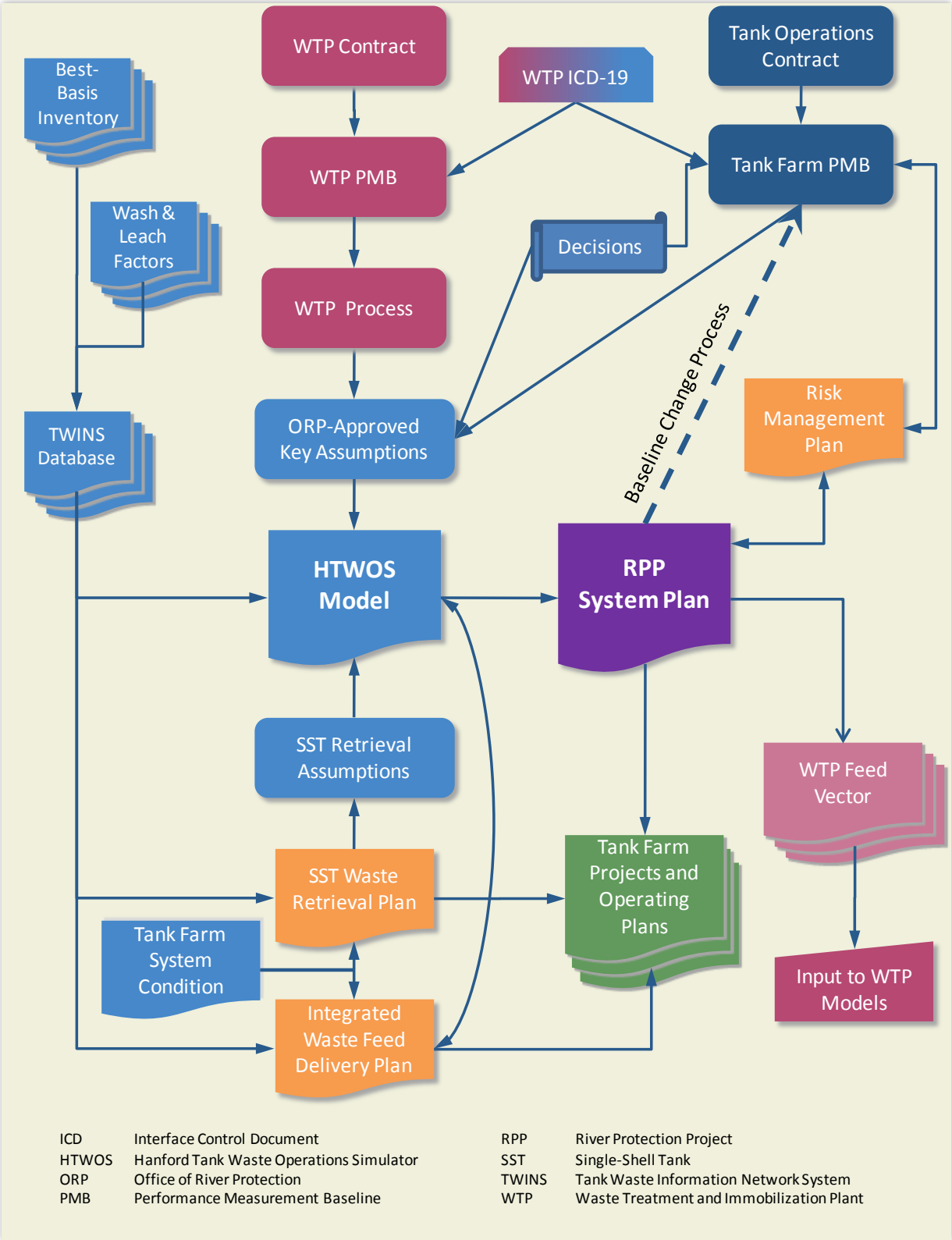
The ORP contractors each prepare and maintain a PMB (the **WTP PMB** and **Tank Farm PMB**) to align the cost, scope, and schedule of the work to be completed. An iterative relationship exists between the PMBs and the **RPP System Plan**; PMB planning bases are incorporated into the System Plan as appropriate, and the results of system planning may be incorporated in subsequent revisions to the PMB. Both the System Plan and PMB may be updated to reflect the outcome of key technical and programmatic decisions (**Decisions**) and the results of risk-handling activities (**Risk Management Plan**). The PMB may adjust the schedule of certain activities in the Baseline Case to comply with funding guidance or other ORP direction or to address emerging plans and field conditions.

WTP ICD-19 (24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed*) plays a key role by establishing interface requirements that are implemented through the **WTP PMB** and the **Tank Farm PMB**.

The annual system planning process begins with the development of a set of **ORP-Approved Key Assumptions**. The starting points for these assumptions are (1) the **WTP Contract**, the **WTP PMB**, and detailed **WTP Process** technical assumptions (flowsheet and modeling) and (2) the **Tank Operations Contract**, **Tank Farm PMB**, and any new **Decisions**. ORP adjusts the assumptions based on funding or policy guidance, emerging plans and field conditions, and the assumed outcome of various technology development efforts and risk mitigating actions.

The **HTWOS Model** is at the center of the system planning process. This model incorporates numerous technical and programmatic planning parameters. ORP provided direct input to system planning via their formal approval (Charboneau 2010a) of the key assumptions and success criteria; these were formulated prior to this System Plan revision and included in the model.

[22] This figure is necessarily simplified to show primarily the iterations that result from making key technical and programmatic decisions and tradeoffs, evolution of the more detailed SST Retrieval and Integrated WFD Plans (RPP-PLAN-40145 and RPP-40149, respectively), and the results of risk-handling activities.



DOE-ORP priorities are integrated throughout the planning process

Figure 1-5. River Protection Project System Planning.

Waste characterization data is taken from the **Best-Basis Inventory** (BBI),[23] which is the preferred database for waste characterization at Hanford. In addition to the BBI, **wash and leach factors** and other supplemental characterization data are combined in the Tank Waste Information Network System (**TWINS**) and entered into HTWOS.

Tank farm system conditions (e.g., current tank integrity status), transfer routes, selected WTP waste acceptance criteria, and other data are incorporated into HTWOS, as documented in RPP-17152, *Hanford Tank Waste Operations Simulation (HTWOS) Version 6.0 Model Design Document*. Application of various combinations of assumptions constitute specific proposed operating scenarios; the feasibility of these scenarios are evaluated by running the HTWOS model, which tracks the movement of waste throughout the RPP system from the present day through the program end date, approximately 40 years from now. WRPS analyzes the HTWOS modeling results to determine how well the various assumptions are integrated, identifying any mismatches. This fosters better integration, both within the TOC and across the entire RPP. Additional information about the HTWOS model is provided in Section 4.1.1.

The results of the latest **HTWOS Model** run supporting the **RPP System Plan** provide input to and receive input from facility-level documents, including the **SST Waste Retrieval Plan** (RPP-PLAN-40145) and the **Integrated WFD Plan** (RPP-40149). The plans outlined in these documents will be translated into detailed **Tank Farm Projects and Operating Plans** that will be used to construct and execute waste retrieval and WFD actions. **SST Retrieval Assumptions** are further developed by RPP-40545, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*, which provides the technical assumptions and their bases for estimating the waste retrieval volumes and minimum durations and SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3B.xlsx'," which performs the calculations.

The Baseline Case in the System Plan is one of the key inputs to systems engineering process, starting with the MAR (RPP–RPT–41742). The MAR defines the mission objectives, identifies the top-level functions needed to accomplish the mission, and identifies the requirements that must be met to achieve those functions. This sets the context for framing the decisions (RPP-46506) and technologies (RPP-PLAN-43988) needed to advance the RPP mission. The item named **Decisions** is a simplified representation of how decisions are reflected in the system planning process. These **Decisions** may result from the system engineering process, adoption of different technologies, implementation of potential mitigating actions from the **Risk Management Plan**, or from the DOE project management process (this is a non-inclusive list).

The data developed by the HTWOS model and presented in the System Plan is also used to create **WTP feed vectors**. This electronic file describes over 100 unique chemical and radiological characteristics in both soluble and insoluble forms, and other attributes, in approximately 400 separate batches of waste projected to be delivered to the WTP over the life of the program. The contents of the WTP feed vectors are used as **Input to [the] WTP**

[23] Maintenance of the BBI is an ongoing effort, comprising 25 chemicals and 46 radionuclides in the 177 Hanford Site underground storage tanks. The BBI provides waste composition data necessary as part of the RPP process flowsheet modeling work, safety analyses, risk assessments, and system design for waste retrieval, treatment, and disposal operations.

[Dynamic] Model. The results from the WTP Dynamic (G2) model are analyzed and used to assess the WTP design and operating plans.

The contents of this System Plan reflect the input of WRPS, BNI, ORP, and Ecology. WRPS had the overall lead in preparation of the System Plan – their personnel performed the mission modeling, developed more detailed tank farm planning assumptions, and integrated the Baseline Case with the SST Waste Retrieval Plan (RPP-PLAN-40145) and associated spreadsheet (SVF-1647, Rev. 3B), Integrated WFD Plan (RPP-40149), RMP (TFC-PLAN-39), Preliminary Decision Framework (RPP-46506), and the life-cycle PMB. In accordance with ORP direction, key features of the process flowsheet and modeling assumptions for the WTP and certain feed screening criteria all developed by BNI were adopted, as were the WTP facility status updates. A series of meetings were held with ORP and Ecology to solicit Ecology's general input. Meetings with WRPS and ORP were used to frame the scope and purpose of the System Plan and to establish the ORP-approved key assumptions and success criteria (see Appendix B).

1.9 SUCCESS CRITERIA

ORP recognizes the importance of incorporating regulatory milestones into long-term plans so that operating strategies can be developed and implemented to meet those commitments. However, the state of Washington filed suit alleging that DOE has violated certain *Hanford Federal Facility Agreement and Consent Order* (HFFACO) milestones for tank retrievals, the regulations underlying those milestones, and certain milestones for the WTP. A proposed Consent Decree (08-5085-FVS) and associated change package containing new milestone dates for Hanford tank waste cleanup has been drafted by the U.S. Department of Justice, transmitted to DOE and Ecology, and released for public comment. New milestones will be incorporated into the baseline and subsequent System Plans once the litigation is resolved. In the interim, the System Plan "success criteria" includes a limited number of near-term and long-term dates from the proposed consent decree milestones as proxies for approved milestones. The schedule-related "success criteria" used in the System Plan (Rev. 5), are as follows:

- Complete C Farm retrievals by September 30, 2014
- Initiate startup of retrieval from five additional (i.e., non-C Farm) tanks by December 31, 2017
- Complete closure of Waste Management Area C by June 30, 2019
- Complete retrieval from nine non-C Farm tanks by September 30, 2022[24]
- Retrieve all remaining SST farms by December 31, 2040
- Complete closure of all SST farms by January 31, 2043
- Complete pretreatment processing and vitrification of Hanford HLW and LAW waste tanks by December 31, 2047
- Complete closure of all DST farms by September 30, 2052.

The success criteria are used to determine how well each case meets its intended purpose. Although each case is intended to meet its success criteria, there is no guarantee that each criterion will be met. Changes to the timing of certain activities, assumed facility capacities, or other process variables might be needed to meet the success criteria. Additional information is provided in Appendix B, Assumption B2.0.

[24] Not including any tanks with waste packaged as TRU waste.

1.10 MISSION SCENARIOS

System Plan (Rev. 4) aligned the Baseline Case at that time with the then-draft near-term baseline and out-year planning estimate range (collectively, the life-cycle baseline) established by Baseline Change Request (BCR) RPP-09-002, *FY 2010 - FY 2013 TOC Near Term Baseline*. System Plan (Rev. 5) develops and continues the alignment of a single operating scenario, called the Baseline Case, with the evolving baseline. It is anticipated that a new BCR will be prepared to further align the baseline with results of this System Plan.

The System Plan includes two operating scenarios: the "Baseline Case" and "Sensitivity Case A." The two cases or operating scenarios are as follows:

- The **Baseline Case** is aligned with the current life-cycle baseline and forms the technical basis for both the near-term baseline and the out-year planning estimate range.
- **Sensitivity Case A** explores the impacts of eliminating supplemental TRU treatment of the potential TRU tank waste. Instead, this waste would be treated at the WTP and disposed along with the HLW. This is in anticipation of a potential future decision to dispose of this material as HLW rather than to dispose of this material at WIPP.

The results of evaluating the Baseline Case and Sensitivity Case A are summarized in Table 1-1.

Table 1-1. System Plan (Revision 5) Highlights. (2 pages)

Metric	Success Criteria	Baseline Case	Sensitivity Case A
Complete C Farm retrievals	9/30/2014	7/13/2013[a]	7/13/2013[a]
Start five additional SST retrievals	12/31/2017	2/9/2015	2/9/2015
Close Waste Management Area C	6/30/2019	6/28/2019	6/28/2019
Complete nine additional retrievals	9/30/2022	9/20/2017	9/20/2017
Complete all SST retrievals	12/31/2040	10/13/2039	7/6/2040
Close all SSTs	1/31/2043	9/29/2043[b]	≈ FY 2044
Treat all tank waste	12/31/2047	8/26/2045	11/14/2046
Close all DSTs	9/30/2052	9/15/2049	≈ FY 2051
Complete potential TRU tank waste packaging	–	6/26/2023	–
LAW glass mass (MTG)[c]	–	415,430	416,037
LAW glass packages	–	75,419	75,530
HLW glass mass (MTG)	–	33,654	37,994
HLW glass canisters	–	10,713	12,095
Lithium hydrotalcite by-product (MT)[d]	–	20,201	20,232
Potential TRU tank waste drums	–	7,491	0
Sodium reporting to LAW glass (MT)	–	53,058	53,338
LAW glass sodium oxide loading	–	17.2%[e]	17.3%[f]
HLW glass waste oxide loading	–	37.6%	34.8%

Notes to Table 1-1:

[a] These projected dates are contingent on the successful deployment of the MARS vacuum tool and incorporation of lessons learned during MARS-sluicing operations in Tank C-107. This tool is still under development and the actual retrieval durations and deployment logic may be different than currently assumed.

[b] Future work to improve the closure completion date will analyze the SST retrieval sequencing logic, retrieval infrastructure, and other applicable parameters to make better use of the available DST space near the end of the mission with the goal of meeting the success criteria.

[c] This is the total LAW glass projected from both the WTP LAW Vitrification Facility and the second (supplemental) LAW facility.

[d] This is the mass of only the by-product, not the final waste form for disposal.

[e] This is the mass weighted average sodium oxide loading from the WTP LAW Vitrification Facility (17.7%) and the second (supplemental) LAW facility (16.9%).

[f] This is the mass weighted average sodium oxide loading from the WTP LAW Vitrification Facility (17.5%) and the second (supplemental) LAW facility (17.1%).

DST	=	double-shell tank.	MT	=	metric ton.
FY	=	fiscal year.	MTG	=	metric tons of glass.
HLW	=	high-level waste.	SST	=	single-shell tank.
LAW	=	low-activity waste.	TRU	=	transuranic.
MARS	=	mobile arm retrieval system.	WTP	=	Waste Treatment and Immobilization Plant.

1.11 PATH FORWARD

ORP will continue to evaluate possible mission scenarios to accelerate the completion of SST retrievals, mitigate known risks, and optimize the overall mission using the systems engineering, project management, and risk management processes.

Additional system planning tools such as a tank farms operations research (OR) model will be used to analyze WFD requirements and provide input to WFD project needs. The HTWOS model will be refined to enhance its robustness, provide more flexibility, and stay aligned with the mission as it evolves.

A WFD OR model is being developed to provide insight into WFD system availability as a function of equipment reliability and maintainability (see Section 4.2.1).

A TOC cost model is being developed to more quickly evaluate the near-term and life-cycle cost impacts of proposed operational and flowsheet changes within the RPP system (see Section 4.3).

2.0 REGULATORY IMPACTS

Federal and state environmental regulations bind DOE decisions and underpin waste treatment and disposal facility designs.

DOE conducts its planning and activities in accordance with applicable state and federal laws, regulations, DOE Orders, Presidential Executive orders, and agreements with stakeholders and other government entities. An all-inclusive list of these legal drivers is not included in this document; however, the following specific regulations and Orders play key roles in determining the actions DOE can pursue.

2.1 NATIONAL ENVIRONMENTAL POLICY ACT

The *National Environmental Policy Act of 1969* (NEPA) is the legal driver to prepare an EIS. Federal law requires the completion of an EIS "(for) major Federal actions significantly affecting the quality of the human environment." An EIS must address: "…(i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, (v) and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented"(42 USC 4321). Three major NEPA documents that support the workscope currently being executed in the RPP system are discussed in the following subsections.

2.1.1 Tank Waste Remediation System, Final Environmental Impact Statement

In 1996, DOE and Ecology co-authored DOE/EIS-0189, *Final Environmental Impact Statement for the Tank Waste Remediation System, Hanford Site, Richland, Washington* (TWRS EIS). This EIS evaluated a range of reasonable alternatives to manage and dispose of radioactive, hazardous, and mixed wastes stored in the Hanford tanks. In 1997, DOE published the TWRS EIS Record of Decision (ROD). Three TWRS EIS supplemental analyses were subsequently published in 1997, 1998, and 2001.

2.1.2 Draft Tank Closure and Waste Management Environmental Impact Statement

DOE is currently preparing the Tank Closure and Waste Management (TC & WM) EIS (DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*).[25] This new EIS provides a comprehensive and integrated look at near-term waste management and tank waste cleanup actions at Hanford.

DOE recently released the draft *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site* for public review and comment. This new EIS provides a comprehensive and integrated look at near-term waste management and tank waste cleanup actions at Hanford.

[25] The Washington State Department of Ecology participates as a cooperating agency; as such, Ecology is responsible for reviewing the content of the Hanford EISs under authority of Washington's State Environmental Policy Act (RCW 43.21C) to ensure that it satisfies Washington State's requirements and supports its proposed action to issue permits under its hazardous waste program.

The TC & WM EIS will form the basis for making important decisions about Hanford's cleanup, including the following:

- Final closure of 149 SSTs that store radioactive and hazardous (i.e., mixed) waste
- Supplemental treatment processes for tank wastes
- Treatment of tank wastes
- Final decommissioning of the Fast Flux Test Facility (FFTF)
- Onsite disposal alternatives for low-level waste (LLW) and mixed LLW, both from Hanford and from some other DOE sites
- A cumulative analysis of environmental impacts, including impacts to groundwater.

Future decisions about tank waste treatment and tank closure at Hanford will be based on the analyses contained within the final TC & WM EIS. DOE is currently evaluating public comments; responses will be included in the final EIS. Upon issuance of the final EIS, and no sooner than 30 days thereafter, DOE may issue an ROD and publish it in the Federal Register.

Publication of the TC & WM EIS ROD is a prerequisite to several important Hanford cleanup and closure actions. It is needed to:

- Provide the NEPA basis for DOE to select an additional LAW treatment and immobilization approach to supplement WTP
- Begin waste incidental to reprocessing (WIR) evaluations and decisions (see Section 2.3.2)
- Support Ecology's issuance of permit(s) for tank treatment, disposal, and closure activities
- Support the WMA C performance assessment (PA)
- Support the Integrated Disposal Facility (IDF) PA
- Support closure of individual SSTs and WMA closures.

There are some significant differences in scope between the current TOC baseline and the alternatives evaluated in the TC & WM EIS, as highlighted in Table 2-1. While the EIS is being developed, the TOC baseline will proceed. Upon issuance of the ROD, which will identify DOE's preferred alternatives, any differences between the ROD and the TOC baseline will be evaluated and reconciled, as necessary, using the BCR process.

Table 2-1. Differences Between the Tank Operations Contract Baseline and the Tank Closure and Waste Management Environmental Impact Statement Scope. (2 pages)

Item	TOC Current Baseline	TC & WM EIS Scope
1	Storage: The existing 28 DSTs will be sufficient to support the RPP mission.	Storage: Additional DSTs could be built.
2	Storage: Two WRFs will be built and operated, one in B Complex, and one in T Complex.	Storage: Four WRFs could be built and operated.
3	Storage: A WFE may be deployed to support SST retrievals and supplement the evaporative capacity of the 242-A Evaporator.	Storage: No additional evaporation capacity is identified.
4	Retrieval: In accordance with the HFFACO, tank waste retrieval will be completed until 99% of waste has been removed from the tanks.	Retrieval: Retrieval to three different levels (90%, 99%, and 99.9%) is evaluated.
5	Treatment: Waste pretreatment and treatment processes include: • Lithium hydrotalcite process (ARF) • HLW/LAW separation • Vitrification.	Treatment: Additional treatment processes are considered, including: • Treatment of cesium and strontium capsules through the WTP • Bulk vitrification • Solid-liquid separations facility • Cast stone • Steam reforming • Replacement of WTP • ^{99}Tc removal • Sulfate removal.
6	Disposal: Secondary waste streams will be treated and disposed via the LERF/ETF. Primary treatment train includes: • Filtration • Ultraviolet light/oxidation • pH adjustment • Hydrogen peroxide decomposition • Degasification • Reverse osmosis and ion exchange. Secondary treatment train includes: • Evaporation • Thin-film drying • Packaging with subsequent staging of the packaged waste for subsequent disposal at IDF.	Disposal: Secondary waste treatment processes may include: • Grouted sulfate • Contaminated soil • Removal of some or all SSTs for treatment, repackaging and onsite storage pending disposition.
7	Closure: The PMB assumes landfill closure, but does not define all details for tanks, ancillary equipment, and contaminated soil. Assumptions associated with the baseline specifically state that updates to the baseline will be required, based on the EIS decision and final closure plans.	Closure: The TC & WM EIS[a] identifies several specific options for individual tanks, waste management areas and ancillary equipment, including: • Clean closure • Selective clean closure/landfill • Landfill closure • Modified RCRA Subtitle C barrier • Post-closure care.

Table 2-1. Differences Between the Tank Operations Contract Baseline and the Tank Closure and Waste Management Environmental Impact Statement Scope. (2 pages)

Item	TOC Current Baseline	TC & WM EIS Scope
8	Spent melter disposal: Spent LAW melters will be disposed onsite at the IDF. Spent HLW melters will be disposed onsite following a WIR determination.	Spent melter disposal: Spent LAW melters stored onsite. Spent HLW melters will be disposed offsite.
9	SST tank waste accelerated retrieval; currently under evaluation for possible implementation.	SST tank waste accelerated retrieval and staging – "Considered but not evaluated in detail."
10	Cesium and strontium capsules: Assumed to be dispositioned outside of the WTP and tank farm facilities by RL.	All options in the draft TC & WM EIS (except the "Do Nothing" option) assume that the contents of the cesium and strontium capsules will be treated at WTP.
11	Disposition of bulk sodium from FFTF: Falls outside the responsibility of ORP; RL has an HFFACO commitment to make a disposition decision in FY 2011.	Disposition of bulk sodium from FFTF: Evaluates the "Hanford Re-Use Option," in which the radioactive bulk sodium is recycled into the WTP process.[b]

[a] DOE/EIS-0391, 2009, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

[b] HNF-33211, 2007, *Hanford Site Sodium Disposition Evaluation Report*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

ARF = Aluminum Removal Facility.
DST = double-shell tank.
EIS = environmental impact statement.
EM = U.S. Department of Energy, Office of Environmental Management.
ETF = Effluent Treatment Facility.
FFTF = Fast Flux Test Facility.
FY = fiscal year.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
LERF = Liquid Effluent Retention Facility.
ORP = U.S. Department of Energy, Office of River Protection.
PMB = performance measurement baseline.
RCRA = Resource Conservation and Recovery Act.
RL = U.S. Department of Energy, Richland Operations Office.
RPP = River Protection Project.
SST = single-shell tank.
TC & WM = Tank Closure and Waste Management.
TOC = Tank Operations Contract.
WFE = wiped-film evaporator.
WIR = waste incidental to reprocessing.
WTP = Waste Treatment and Immobilization Plant.
WRF = waste retrieval facility.

2.1.3 Environmental Assessment for the 242-A Evaporator

In 2009 and 2010, DOE also prepared DOE/EA-1682, *Environmental Assessment (EA): Upgrades and Life Extension of the 242-A Evaporator, Hanford Site, Richland, Washington Conducted Under the American Recovery and Reinvestment Act of 2009.* A "Finding of No Significant Impact" was issued on February 3, 2010.

2.2 RCRA, CERCLA, AND HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER

The liquid and solid mixed (i.e., radioactive and hazardous) waste in Hanford's underground storage tanks includes hazardous wastes that are subject to the *Resource Conservation and Recovery Act of 1976* (RCRA) (42 USC 6901 et seq.). RCRA regulates hazardous waste from the point of generation through storage, treatment, and ultimate disposal. Many aspects of Hanford Site operations are governed by various RCRA permits. EPA's RCRA implementing regulations also include minimum technological requirements (e.g., secondary containment) that apply to management of hazardous wastes.

DSTs provide such secondary containment for wastes currently being stored at Hanford. Operation of the WTP, currently under construction, will ultimately allow ORP to remove waste from the SSTs that do not meet RCRA minimum technological (secondary containment) requirements. In the meantime, ORP has taken steps to significantly reduce the risk of waste potentially leaking to the environment. Under the Interim Stabilization Program, the pumpable supernate (liquid) waste from the SSTs was transferred to RCRA-compliant DSTs, although solidified saltcake and sludge wastes remain in those tanks. Also, seven SSTs have completed waste retrieval, three SSTs have been cleaned to the limits of current technology, and two tanks are currently in retrieval status (see Section 3.0, Figure 3-1, Table 3-2, Table 3-3, and Table 3-4).

Hanford is also subject to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) (42 USC 103 et seq.), also commonly known as "Superfund." CERCLA provides broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. During the 1950s and 1960s, as much as 1 Mgal of liquid radioactive waste is believed to have been released into the soil surrounding the tank farms. Some waste leaked out of SSTs; some waste was discharged deliberately via waste management practices in place at that time, which since have been changed. The extent of the environmental contamination at Hanford prompted the EPA to include four areas of the Hanford Site on its National Priorities List, making the Hanford Site subject to CERCLA's response action requirements (including removal and remedial actions) for hazardous substance releases or threatened releases.

DOE, EPA, and Ecology entered into the HFFACO (also known as the Tri-Party Agreement [TPA]) (Ecology et al. 1989), a legally enforceable comprehensive cleanup and compliance agreement, on May 15, 1989, to achieve compliance with RCRA treatment, storage, and disposal requirements for hazardous wastes and applicable corrective action provisions, and for CERCLA response action requirements. More specifically, the HFFACO:

- Defines and ranks RCRA and CERCLA cleanup commitments
- Establishes responsibilities
- Reflects a concerted goal of achieving full regulatory compliance and remediation, with enforceable milestones in an aggressive manner.

HFFACO milestones for specific cleanup activities are fundamental to long-range planning for ORP. Based on the proposed Consent Decree (08-5085-FVS) described in Section 1.9, ORP has selected as "success criteria" eight near-term and long-term dates from the proposed consent decree milestones (listed in Section 1.9) to be used as proxy HFFACO milestones for the

purposes of this System Plan. DOE anticipates that these proxies will be replaced with HFFACO milestones after the pending litigation is resolved.

2.3 DOE O 435.1 AND PREPARATIONS FOR FACILITY CLOSURE

The objective of DOE O 435.1, *Radioactive Waste Management*, is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. Specific and detailed requirements are further defined in the accompanying DOE M 435.1-1, *Radioactive Waste Management Manual*, and DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*.

2.3.1 Definition of High-Level Waste

DOE M 435.1-1 embraces the definition of HLW as presented in the *Nuclear Waste Policy Act of 1982* (NWPA) (42 USC 10101 et seq.), as amended, which was intended to provide DOE with a risk basis for determining when wastes were, or were not, HLW.[26]

This law defines "high-level radioactive waste" as the following:

> "(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and
> (B) other highly radioactive material that the [Nuclear Regulatory] Commission, consistent with existing law, determines by rule to require permanent isolation."

However, this definition is based on the manner in which the waste was generated, with no provision for the waste's actual characteristics.

2.3.2 Waste Incidental to Reprocessing

Not all of the wastes stored in Hanford's underground waste storage tanks meet the above definition of HLW set forth in the NWPA.

Some tank wastes could be separated from the reprocessing wastes and subsequently treated and disposed at significantly less cost than vitrification.

Given the very large mass of chemical waste in the Hanford tanks, DOE collaborated with the U.S. Nuclear Regulatory Commission (NRC) to identify approaches DOE could deploy to (1) identify reprocessing waste streams that are not HLW based on their innately low radionuclide concentrations (citation process), and to also (2) treat tank wastes, as appropriate, to concentrate radionuclides into a small volume of highly radioactive waste (i.e., the HLW stream) and a large volume of decontaminated chemical waste (LAW) that could be disposed of as LAW (evaluation process). Wastes found not to be HLW by either the citation or evaluation process are referred to as "wastes incidental to reprocessing" (WIR). The NRC and DOE developed three criteria (paraphrased below) that identify the evaluation process DOE could use to decontaminate tank wastes and ascertain the wastes would be then suitable for disposal as LLW.

[26] For purposes of consistency and conservatism, all wastes stored in Hanford's tank farms are managed as HLW; this simply means that these wastes are subject to the highest health and safety protocols.

Those criteria are:

1. Key radionuclides (i.e., those that are most significant to near-term or long-term human health and safety) must be removed to the maximum technical and economical extent practical.[27]
2. Waste must meet Title 10, *Code of Federal Regulations*, Part 61 (10 CFR 61), "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives."
3. Wastes must be solidified and the radionuclide concentrations within the solidified wastes must be within 10 CFR 61.55 Class C concentration limits.

The essence of these three criteria is that if the radionuclides are removed so that the wastes are no longer "highly radioactive," and if the decontaminated wastes then meet NRC regulatory requirements for disposal as a LLW, DOE can determine the waste to be LLW and manage it accordingly. The radionuclides that are removed are combined with the HLW and vitrified. [28]

DOE's approach to meeting these three WIR criteria formed the basis for the 1997 DOE/NRC provisional LAW agreement, "Classification of Hanford Low-Activity Tank Waste Fraction as Incidental" (Callan 1997), which was endorsed by the state of Washington. This agreement allows DOE to divide the tank waste into HLW and LAW fractions for separate treatment and disposal. This agreement thereby underpins the design of the WTP and was the basis for proceeding with facility design and construction. However, an official WIR waste determination (WD) by DOE in consultation with the NRC will be required prior to beginning disposal of immobilized low-activity waste (ILAW).

In addition, as described in Section 2.2, some residual waste, including hard-to-remove heels, the contaminated tank itself, and associated contaminated components, will remain after bulk waste retrieval is complete in accordance with the HFFACO (TPA). Additionally, these residuals may be stabilized and disposed in place if (1) the residual waste can be determined to be WIR pursuant to the DOE M 435.1-1 WD process, and (2) landfill closure for tanks is supported by the TC & WM EIS ROD. To support future SST farm closure operations, a WD is expected to be necessary for each of the seven SST WMAs.[29] Current estimates indicate that it may take 24-36 months to issue each WD. The scope of the WD for each WMA will be comprehensive, and will include tank residuals, pipeline residuals, and equipment abandoned in place.

Wastes that are retrieved from tanks will typically be filtered to remove insoluble materials, including ^{90}Sr and TRU isotopes, and then treated by ion exchange to remove cesium isotopes. Decontamination of waste heels in tanks occurs during the retrieval process, which both removes most of the wastes from the tanks and also washes the heel materials to remove much of the radioactivity. DOE analyses the wastes treated by either approach to ascertain that the second and third WIR criteria will be met (i.e., that the treated wastes can be safely disposed of as LLW). The second criterion, in particular, assures that the calculated doses to maximum

[27] This requirement later drove the selection of solid-liquid separation, removal of cesium using ion-exchange, and strontium/TRU removal processes for the WTP facility flowsheet.

[28] The Nuclear Waste Policy Act specifies geologic disposal for all spent nuclear fuel HLW.

[29] The seven WMAs include C, A/AX, B/BX/BY, S/SX, T, TX/TY, and U.

exposed individuals following disposal and to humans that inadvertently intrude into the disposal site would be no higher than is allowed by NRC regulations for LLW sites.

2.3.3 Performance Assessment for Waste Management Area C

DOE O 435.1 also requires the preparation of a PA to support decisions about closure activities at facilities with radioactive waste. A site-specific radiological PA includes calculations of potential doses to representative future members of the public and potential releases from the facility for a 1,000-year period after closure, to provide a reasonable expectation that the performance objectives defined by DOE are not exceeded as a result of operation and closure of the facility.

HHFACO Appendix I, Section 2.5 requires the development of a PA for the SST system and the development of a PA for each WMA. The PAs will address the post-closure, long-term risk to human health and the environment presented by residual waste, equipment, and contaminated soil. The PAs will address both radionuclides and hazardous chemicals, and incorporate all applicable requirements, including performance requirements defined by the *Hazardous Waste Management Act of 1976*, RCRA, *Clean Water Act of 1972* (33 USC 1251 et seq.), *Safe Drinking Water Act of 1974* (42 USC 300f et seq.), *Atomic Energy Act of 1954* (42 USC 2011 et seq.), and any other performance requirements that might be "applicable or relevant and appropriate requirements" under CERCLA. Successful closure of each WMA will require a systems approach to address all of these elements.

The first WMA to be closed will be WMA C. The HFFACO-proposed Consent Decree No. 08-5085-FVS (described in Section 1.9) includes Closure Milestone M-45-83, which calls for closure of WMA C in 2019. Facilities to be addressed in the closure of WMA C include 16 SSTs, a catch tank, seven diversion boxes, a vault containing four tanks, and about six miles of pipelines. In addition, WMA C corrective measures associated with existing soil and groundwater contamination must be performed. These corrective measures have been divided into two phases, which are being executed concurrently. The first phase includes the retrieval of waste from SSTs in C Farm and cleanout of the 244-CR vault (see Section 3.1.1.2 for additional details). The second phase of corrective measure investigations is underway in WMA C, per RPP-PLAN-39114, *Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C*, provided through HFFACO milestone M-45-60. This work involves characterization of past releases to the soil using borehole logging, soil sampling, and soil electrical resistivity evaluations. Characterization results are combined with historic information regarding releases and conceptualizations of contamination fate and transport are being developed. In addition, potential methods for soil remediation are being evaluated to support the development of a Phase 2 RCRA Facility Investigation/Corrective Measures Study for WMA C (HFFACO milestone M-45-61, due December 31, 2014 per the proposed change package). Additional investigations are planned for assessing and determining disposition of ancillary equipment within the tank farm through actual demonstrations and technical evaluations (M-45-80 and M-45-81 per the proposed change package).

Development of the WMA C PA document is underway via a series of technical exchanges with staff from DOE, NRC, Ecology, and EPA. Other participants include the Tank Operations Contractor (WRPS), the Oregon Department of Energy, several Tribal Nations, members of the Hanford Citizens Advisory Board, and other stakeholders. Technical discussions allow for the identification and clarification of specific technical questions related to: (1) conceptual models

and alternatives, (2) exposure scenarios, and (3) specific data and parameter values that will be needed to support development and implementation of the numerical model calculations used in the PA. The completed PA will support related WDs, RCRA closure plans, and CERCLA RODs, which will be needed to close some Hanford facilities. The initial planning session was conducted in February 2009. Seven working sessions have been held to-date; a total of 13 are planned, ending in January 2012.

2.4 DOCUMENTED SAFETY ANALYSIS

A hierarchy of government requirements exists to ensure the safety of workers, the public, and the environment as related to the operation of nuclear facilities. Title 10, *Code of Federal Regulations*, Part 830 (10 CFR 830), *Nuclear Safety Management*, Subpart B, "Safety Basis Requirements," governs the conduct of DOE contractors, DOE personnel, and other persons conducting activities that affect, or may affect, the safety of certain DOE nuclear facilities. To implement the requirements of 10 CFR 830, DOE created DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses.*

A documented safety analysis (DSA) is a comprehensive analysis of the potential causes of major accidents at a particular nuclear facility, and imposes controls to prevent those accidents from occurring. A DSA:

- Describes the facilities and equipment used for nuclear operations
- Identifies the operational activities necessary to perform the work
- Defines and evaluates the hazards associated with those facilities, equipment, and operations
- Establishes conditions, safe boundaries, and hazard controls for those hazards, and thereby
- Provides the basis for ensuring safe operations.

During 2009 and 2010, ORP updated RPP-13033, *Tank Farms Documented Safety Analysis*, and the associated HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*.

The 222-S Laboratory and the 242-A Evaporator each have their own DSA and technical safety requirements. The evaporator DSA and technical safety requirement revisions will be completed in 2011.

Per DOE-STD-1189-2008, *Integration of Safety into the Design Process*, the hazards presented by any new operation will need to be evaluated early in the project, and the design features and controls to address those hazards will be integrated into the design. Although there are mixer pumps currently installed in four DSTs (SY-101, AP-102, AN-107, and AZ-101), operation of these mixer pumps and operations to mix DSTs for delivery to the WTP or for purposes of mitigating the Group A tanks are not currently authorized in the tank farms DSA (RPP-13033). Operation of mixer pumps will require hazards evaluation, accident analysis, development of controls, and development of a DSA amendment to authorize their operation. Implementation of updated buoyant displacement gas release event (BDGRE) controls specific to sludge waste and any other new operations (e.g., supplemental treatment or pretreatment), will also be required to meet DOE-STD-1189-2008.

3.0 STATE OF THE RIVER PROTECTION PROJECT SYSTEM

Ongoing safe storage of waste and preparation for waste treatment and disposal require active management.

A fully integrated system of RPP waste storage, treatment, and disposal facilities is in varying stages of design, construction, operation, or future planning. In addition to the facilities highlighted in Figure 1-2, this section addresses waste retrieval from SSTs and DSTs, miscellaneous underground storage tanks (MUST), inactive miscellaneous underground storage tanks (IMUST),[30] waste transfer systems, the 242-A Evaporator, the Vadose Zone Integration Program, ARRA-funded projects, various supplemental treatment facilities, the WTP, and other interfacing facilities. Current events and recent accomplishments are also described in this section. Additional background information on these facilities is provided in Appendix C.

3.1 STORAGE

Many facilities are involved in the safe storage of waste at Hanford. These facilities include 149 SSTs, 28 DSTs, numerous IMUSTs, miles of waste transfer lines and supporting facilities, and the 242-A Evaporator. The Waste Encapsulation and Storage Facility (WESF), while not considered a component of the RPP system, may impact future RPP system operations, so it is included here for completeness. Likewise, while the Vadose Zone Integration Program is an integral part of ORP's strategy to reduce the threat from contaminants already present in the ground around the tank farms, that program does not bear on RPP processes directly. However, the lessons learned during this program may influence future remediation and closure options within the tank farms, and so the Vadose Zone Integration Program is also included for completeness.

All waste storage activities within the RPP system are located in either the 200 West or 200 East operating areas (see Figure 3-1 and Figure 3-2). Tank farm waste volumes are shown in Table 3-1. Note that total waste volumes fluctuate slightly due to the addition of water and chemicals during waste retrieval operations, the receipt of laboratory wastes, and operation of the 242-A Evaporator.

Table 3-1. Tank Farm Waste Volumes.

Tank Type	200 East Area	200 West Area	Totals
Single-shell tanks	10.4 Mgal	19.2 Mgal	29.6 Mgal
Double-shell tanks	23.6 Mgal	2.4 Mgal	26.0 Mgal
Totals	34.0 Mgal	21.6 Mgal	55.6 Mgal

Mgal = million gallons.

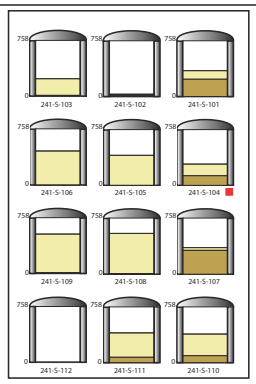
[30] MUSTs and IMUSTs are collectively referred to as IMUSTs in this plan (see Section 3.1.3 for more details).

200 West Tank Waste Contents

S-Tank Farm- 1950-51

12 @ 758 Kgal Tank Capacit y, Single-Shell

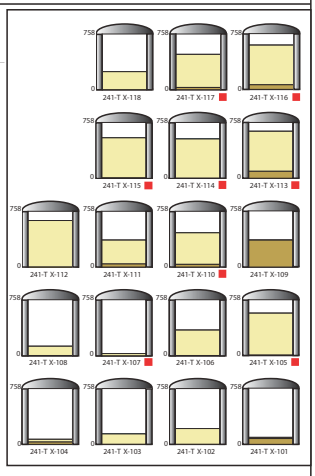
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-S-101	235	117	0
241-S-102	17	13	1
241-S-103	9	227	1
241-S-104 ■	132	156	0
241-S-105	2	404	0
241-S-106	0	455	0
241-S-107	320	38	0
241-S-108	5	545	0
241-S-109	13	520	0
241-S-110	96	293	0
241-S-111	76	325	0
241-S-112	2	0	0



TX-Tank Farm- 1947-48

18 @ 758 Kgal Tank Capacit y, Single-Shell

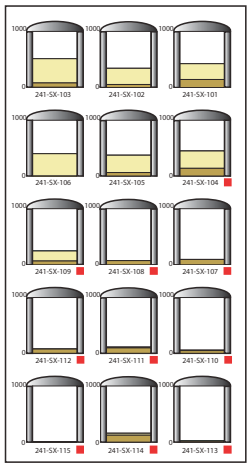
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-TX-101	74	17	0
241-TX-102	2	215	0
241-TX-103	0	145	0
241-TX-104	34	33	2
241-TX-105 ■	8	568	0
241-TX-106	5	343	0
241-TX-107 ■	0	30	0
241-TX-108	6	121	0
241-TX-109	363	0	0
241-TX-110 ■	37	430	0
241-TX-111	43	321	0
241-TX-112	0	634	0
241-TX-113 ■	93	545	0
241-TX-114 ■	4	528	0
241-TX-115 ■	8	545	0
241-TX-116 ■	66	533	0
241-TX-117 ■	29	451	0
241-TX-118	0	247	0



SX-Tank Farm- 1953-54

15 @ 1,000 Kgal Tank Capacit y, Single-Shell

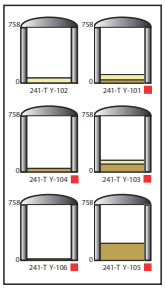
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-SX-101	144	276	0
241-SX-102	55	287	0
241-SX-103	78	431	0
241-SX-104 ■	136	310	0
241-SX-105	63	312	0
241-SX-106	0	396	0
241-SX-107 ■	94	0	0
241-SX-108 ■	74	0	0
241-SX-109 ■	66	175	0
241-SX-110 ■	49	7	0
241-SX-111 ■	97	18	0
241-SX-112 ■	75	0	0
241-SX-113 ■	19	0	0
241-SX-114 ■	126	29	0
241-SX-115 ■	4	0	0



TY-Tank Farm- 1951-52

6 @ 758 Kgal Tank Capacit y, Single-Shell

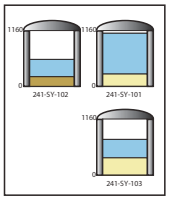
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-TY-101 ■	42	76	0
241-TY-102	0	69	0
241-TY-103 ■	103	51	0
241-TY-104 ■	43	0	1
241-TY-105 ■	231	0	0
241-TY-106 ■	16	0	0



SY-Tank Farm- 1977

3 @ 1,160 Kgal Tank Capacit y, Double-Shell

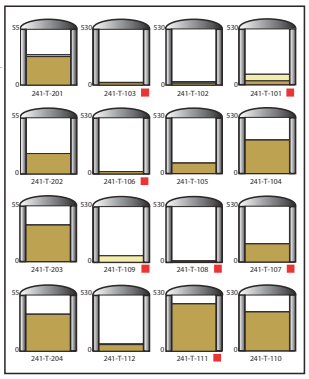
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-SY-101	0	255	851
241-SY-102	203	11	353
241-SY-103	0	357	380



T-Tank Farm- 1943-44

12 @ 530 Kgal Tank Capacit y, Single-Shell
4 @ 55 Kgal Tank Capacit y, Single-Shell

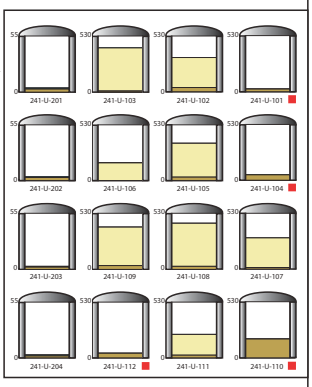
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-T-101 ■	37	62	0
241-T-102	19	0	13
241-T-103 ■	23	0	4
241-T-104	317	0	0
241-T-105	98	0	0
241-T-106 ■	22	0	0
241-T-107 ■	173	0	0
241-T-108 ■	5	11	0
241-T-109 ■	0	62	0
241-T-110	369	0	1
241-T-111 ■	447	0	0
241-T-112	60	0	7
241-T-201	28	0	2
241-T-202	20	0	0
241-T-203	36	0	0
241-T-204	36	0	0



U-Tank Farm- 1946-49

12 @ 530 Kgal Tank Capacit y, Single-Shell
4 @ 55 Kgal Tank Capacit y, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-U-101 ■	23	0	0
241-U-102	43	283	1
241-U-103	11	405	1
241-U-104 ■	54	0	0
241-U-105	32	321	0
241-U-106	0	168	2
241-U-107	15	279	0
241-U-108	29	405	0
241-U-109	35	366	0
241-U-110 ■	176	0	0
241-U-111	26	196	0
241-U-112 ■	45	0	1
241-U-201	3	0	1
241-U-202	3	0	1
241-U-203	2	0	1
241-U-204	2	0	1



LEGEND: Sludge, Saltcake, Supernatant, Available Space, Assumed/C onfirmed L eaker ■

Data Derived From Waste Tank Summar y Repo rt Dated 12/31/2009

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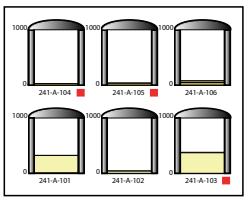
Figure 3-1. 200 West Tanks.

200 East Tank Waste Contents

A-Tank Farm- 1954-55

6 @ 1,000 Kgal Tank Capacity, Single- Shell

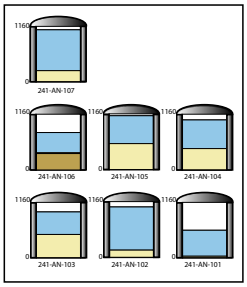
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-A-101	3	317	0
241-A-102	0	37	3
241-A-103 ■	2	372	4
241-A-104 ■	28	0	0
241-A-105 ■	37	0	0
241-A-106	50	29	0



AN-Tank Farm- 1981

7 @ 1,160 Kgal Tank Capacity, Double- Shell

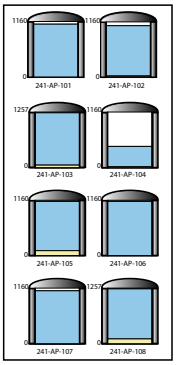
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AN-101	0	31	545
241-AN-102	0	154	895
241-AN-103	0	486	474
241-AN-104	0	443	605
241-AN-105	0	536	588
241-AN-106	338	17	427
241-AN-107	0	230	859



AP-Tank Farm-1986

6 @ 1,160 Kgal Tank Capacity, Double- Shell
2 @ 1,257 Kgal Tank Capacity, Double- Shell

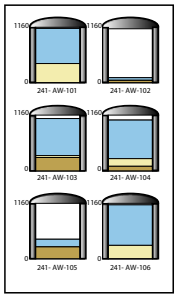
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AP-101	0	0	1112
241-AP-102	28	0	1053
241-AP-103	0	52	1185
241-AP-104	0	18	430
241-AP-105	0	105	1032
241-AP-106	0	0	1136
241-AP-107	0	0	1106
241-AP-108	0	112	1132



AW-Tank Farm-1980

6 @ 1,160 Kgal Tank Capacity, Double- Shell

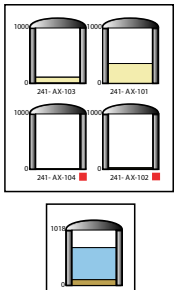
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AW-101	0	396	735
241-AW-102	49	0	56
241-AW-103	280	40	770
241-AW-104	97	157	809
241-AW-105	248	0	163
241-AW-106	0	281	848



AX-Tank Farm- 1965-66

4 @ 1,000 Kgal Tank Capacity, Single- Shell

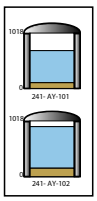
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AX-101	3	355	0
241-AX-102 ■	6	24	0
241-AX-103	8	99	0
241-AX-104 ■	7	0	0



AY-Tank Farm- 1971-76

2 @ 1,018 Kgal Tank Capacity, Double- Shell

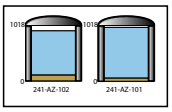
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AY-101	105	0	587
241-AY-102	151	0	766



AZ-Tank Farm- 1975-76

2 @ 1,018 Kgal Tank Capacity, Double- Shell

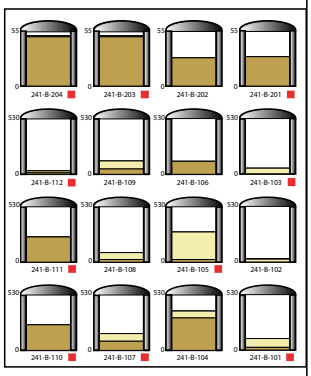
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AZ-101	52	0	933
241-AZ-102	105	0	815



B-Tank Farm- 1945-47

12 @ 530 Kgal Tank Capacity, Single- Shell
4 @ 55 Kgal Tank Capacity, Single- Shell

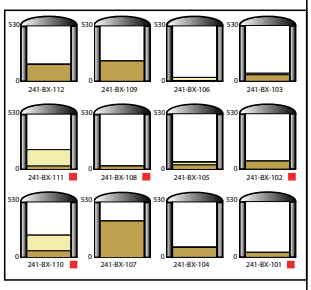
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-B-101 ■	28	81	0
241-B-102	0	28	4
241-B-103 ■	1	55	0
241-B-104	309	65	0
241-B-105 ■	28	262	0
241-B-106	122	0	1
241-B-107 ■	86	75	0
241-B-108	27	65	0
241-B-109	50	76	0
241-B-110 ■	244	0	1
241-B-111 ■	241	0	1
241-B-112 ■	15	17	3
241-B-201 ■	29	0	0
241-B-202	28	0	0
241-B-203 ■	49	0	1
241-B-204 ■	49	0	1



BX- Tank Farm- 1948-50

12 @ 530 Kgal Tank Capacity, Single- Shell

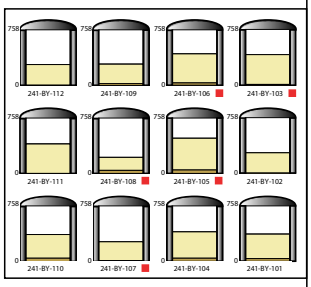
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BX-101 ■	48	0	0
241-BX-102 ■	79	0	0
241-BX-103	62	0	13
241-BX-104	97	0	3
241-BX-105	42	25	5
241-BX-106	10	28	0
241-BX-107	347	0	0
241-BX-108 ■	31	0	0
241-BX-109	193	0	0
241-BX-110 ■	65	37	1
241-BX-111 ■	32	156	0
241-BX-112	163	0	1



BY-Tank Farm- 1950-51

12 @ 758 Kgal Tank Capacity, Single- Shell

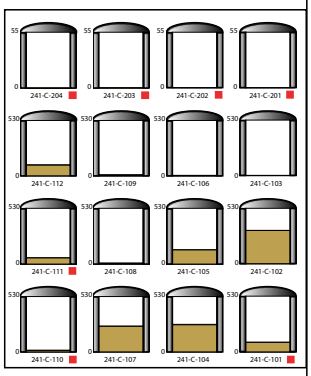
Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BY-101	37	333	0
241-BY-102	0	278	0
241-BY-103 ■	9	405	0
241-BY-104	46	359	0
241-BY-105 ■	48	433	0
241-BY-106 ■	32	398	0
241-BY-107 ■	15	256	0
241-BY-108 ■	40	182	0
241-BY-109	24	263	0
241-BY-110	43	323	0
241-BY-111	0	402	0
241-BY-112	2	284	0



C-Tank Farm- 1946-53

12 @ 530 Kgal Tank Capacity, Single- Shell
4 @ 55 Kgal Tank Capacity, Single- Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-C-101 ■	88	0	0
241-C-102	316	0	0
241-C-103	2	0	0
241-C-104	259	0	5
241-C-105	132	0	0
241-C-106	3	0	0
241-C-107	247	0	0
241-C-108	7	0	1
241-C-109	8	0	1
241-C-110 ■	17	0	0
241-C-111 ■	57	0	1
241-C-112	104	0	0
241-C-201 ■	0	0	0
241-C-202 ■	0	0	0
241-C-203 ■	0	0	0
241-C-204 ■	0	0	0



LEGEND: Sludge | Saltcake | Su pernatant | Available Space | Assumed/ Confirmed Leaker ■

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Figure 3-2. 200 East Tanks.

3.1.1 Single-Shell Tanks

Status: Existing (interim stabilized/retrievals in progress)

There are 149 SSTs on the Hanford Site constructed between 1943 and 1964; 66 SSTs are located in 200 East Area, and 83 SSTs are located in 200 West Area. The SSTs are used only for storage and have had nearly all free liquid removed as part of the Interim Stabilization Program. Although SST waste inventories today are primarily solidified sludges and crystallized salts with only incidental amounts of liquid, as many as 67 SSTs are assumed or confirmed to have leaked in the past.

To provide assurance that any future SST tank loss of integrity can be detected, Hanford has monitored SST integrity for years. Monitoring activities include dome deflection surveys, SST structural analysis of record (2002), photo and video archives of dome interiors, leak history archives, and a variety of surveillance methods, including liquid observation wells, drywell monitoring, material balances during retrieval, transfer route monitoring, waste surface level measurements, and leak detection during waste retrieval. In addition, tank farm personnel use a high-resolution resistivity leak detection and monitoring system, which was demonstrated on Tank S-102. Surface geophysical exploration technologies have been demonstrated in many of the SST farms; this method allows personnel to identify areas of higher conductivity in the soil but does not quantify leak volumes. Transfer routes are monitored for radioactivity, toxic vapor releases, and visual indications of a possible leak. A formal tank leak assessment process is also in place, using approved tank operating procedures.

Because the oldest SSTs are more than 60 years old, and knowing that completion of SST waste retrieval is still decades away, a new SST integrity program was developed in 2009 to identify those activities needed to extend the life of the tanks. An expert panel was convened and met twice in 2009 to address SST integrity concerns. From these two meetings, the panel identified 33 recommendations, documented in RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project*, for implementation of an enhanced SST integrity project (SSTIP). The panel focused on four key elements for the tank integrity project: (1) confirmation of tank structural integrity, (2) assessment of the likelihood of future tank liner degradation, (3) leak identification and prevention, and (4) mitigation of contaminant migration. In addition, the panel identified the key "top ten primary recommendations that form the foundation of a robust SSTIP."

The Baseline Case assumes that each SST will be interim closed in accordance with Appendix B, Assumption B3.2.1.2, sometime after retrieval of that tank is completed. Final closure of each SST and associated WMA is assumed to be completed within about five years after the last SST from that farm is retrieved. Closure will be conducted in accordance with applicable regulatory requirements.

3.1.1.1 Single-Shell Tank Waste Retrieval Process Fundamentals

Waste retrieval from SSTs requires a variety of techniques among tanks with different waste characteristics, design attributes, and operating histories. Multiple technologies may need to be deployed within a single tank to meet waste retrieval requirements.

Each SST waste retrieval process results in the transfer of waste from the SST to a receiver tank, which is typically a DST or a tank in a waste retrieval facility (WRF). Tank waste retrieved from the T Complex and B Complex tanks will first be collected in the T Complex and B Complex WRFs, respectively, before being transferred to DSTs in 200 East Area. Potential TRU waste currently stored in seven T Farm tanks and four B Farm tanks will be retrieved and sent directly to supplemental TRU treatment facilities.

The retrieved waste is transferred as slurry consisting primarily of dissolved salt or suspended solids. The concentration of SST waste in this slurry is a key parameter for measuring retrieval effectiveness. To facilitate the estimation of the volumes of retrieved waste and minimum retrieval durations, RPP-40545 assumes that each retrieval operation consists of the following three phases (or regions).

During the **bulk retrieval phase**, the waste slurry concentration is approximated as a constant value. The bulk retrieval phase begins at the start of retrieval and ends when the cumulative waste slurry concentration begins to show a definite decline as retrieval progresses. (Additional information on bulk retrieval is provided in Section 3.1.1.2.)

The **transition phase** begins when the bulk retrieval phase ends. In the transition phase, the waste slurry concentration steadily declines as the remaining waste volume in the tank is reduced. The transition phase ends when the waste slurry concentration is reduced to the point at which retrieval with the current equipment is no longer effective.

The **hard-to-remove heel** (HTRH) **phase** begins when transition ends. If HTRH retrieval is required, equipment is installed and HTRH removal begins. The waste slurry concentration during HTRH retrieval begins at a specified concentration and reduces steadily as remaining waste in the tank is reduced until the HTRH retrieval process is no longer effective. (Additional information on the HTRH process is provided in Section 3.1.1.3.)

For some retrieval processes, the transition region is assumed to end below the HFFACO residual waste volume limits. For these processes, retrieval is complete at the end of the transition phase, and no HTRH removal is required. For the remaining retrieval processes, the transition phase ends above the HFFACO residual waste volume limit and HRTH retrieval is required.

3.1.1.2 Waste Retrieval Methods for Single-Shell Tanks

A variety of waste retrieval techniques will be deployed in SSTs. The particular technique(s) used in a given tank will depend on the nature of the waste, tank integrity, tank design, the presence or absence of internal obstructions, and other factors. The SST Waste Retrieval Plan (RPP-PLAN-40145, Rev. 1) currently identifies the six methods for bulk waste retrieval, and SVF-1647 (Rev 3B) provides updated performance estimates.

Methods for bulk retrieval include the following:

- **Modified Sluicing with DST Supernate** will be used primarily to retrieve large quantities of sludge. It consists of spraying the supernate onto the SST waste surface to mobilize the waste into slurry, and then directing the slurry to the inlet of a pump. The pump then transfers the slurry to a DST, where the sludge settles out and the liquid is returned for reuse in SST retrievals. This minimizes the amount of water that would otherwise have to be added to the DST system, which would then take up additional DST space or require evaporation. The method is referred to as "modified sluicing" to differentiate it from sluicing methods used in the 1950s through the 1970s, where a significant volume of liquid was added to the SST near the outside of the tank to get the slurry circulating before being pumped out. Modified sluicing with supernate has been used through early 2010 for bulk waste retrieval in Tanks C-106, C-103, C-108, C-109, C-110, and C-104 (see Figure 3-3).

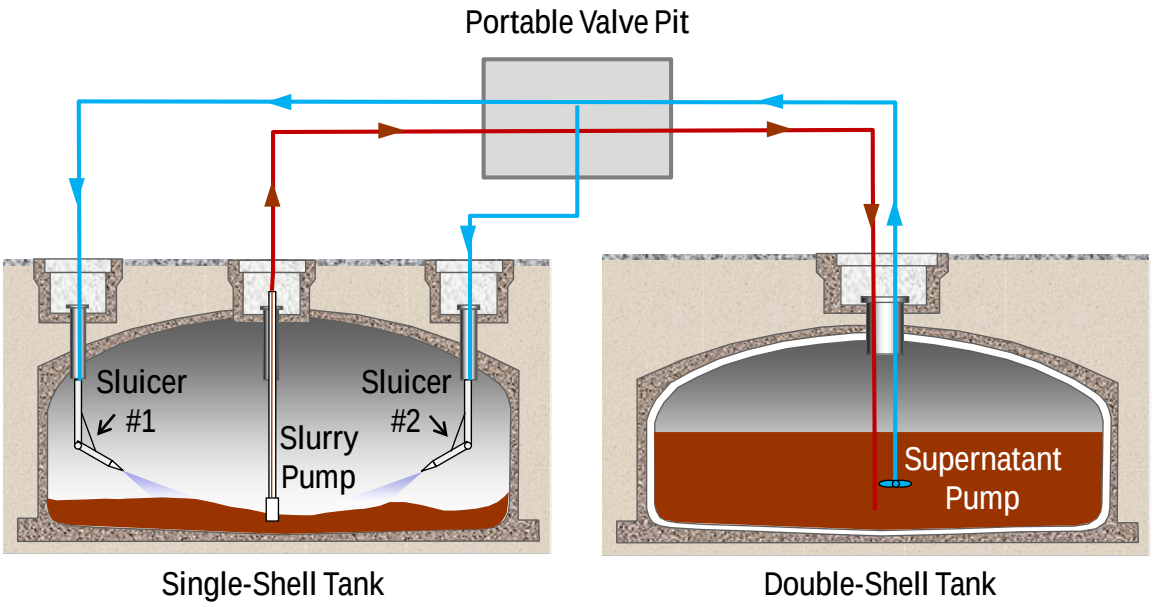


Figure 3-3. Modified Sluicing with Double-Shell Tank Supernate.

- As its name implies, **Modified Sluicing with Water** is similar to modified sluicing with DST supernate, but this method uses water instead of supernate as the motive medium. In tanks with large amounts of saltcake, water is used as the retrieval fluid to maximize dissolution rate of the saltcake, which decreases the retrieval time. In cases where there is only a small amount of sludge to be retrieved, this method provides the advantage that a DST pump, shielded transfer lines, and sluicing equipment will not be needed. Modified sluicing with water was used for part of the waste heel retrieval in Tank S-112.
- **Modified Sluicing for Saltcake Dissolution** is a form of modified sluicing with water. The main difference is that the solution may have a longer residence time in the SST than would occur when using supernate, to allow effective dissolution of the salt. Deployment of this method does not require the use of a DST pump and supernate transfer lines from a DST to the SST. Modified sluicing for saltcake dissolution was used for waste retrieval from Tanks S-112 and S-102, and for a limited test in Tank U-107.

- The **Mobile Arm Retrieval System** (MARS) is a transformational technology (described in Section 6.0) that was successfully tested at Hanford in 2009. The MARS unit consists of a telescoping arm that slides up and down a mast installed through a 42-in. riser in the center of a waste tank (Figure 3-4). The arm is capable of using elbow-joint movement to rotate a complete 360 degrees, and multi-axle wrist movement to reach around most in-tank obstacles. This allows the system to reach the furthest extremities of the tank walls and floor. Interchangeable tools mounted to the end of the arm will be used to break up the waste and channel it toward a central pump and backstop for removal (see related Item 3, Potential Mitigating Action i in Section 7.2, Table 7-2).

Figure 3-4. Mobile Arm Retrieval System Testing at Cold Test Facility.

Retrieval development has been projectized. Component testing of the arm and various end-effector tools was successfully completed in June 2009. Full-scale integrated testing followed, in which a prototypic **MARS-Sluicing (MARS-S)** unit was installed at the Hanford Cold Test Facility. There, the MARS sluicing unit was tested with three different waste simulants. The MARS sluicing unit successfully mobilized and "raked" the waste simulants toward the transfer pump for retrieval from the tank (Figure 3-5). Initial qualification testing was completed in September 2009. Design of the first deployable MARS-S unit is in progress.

In addition, a **MARS-Vacuum (MARS-V)** system is similar to the MARS-S system, but is intended for use in tanks that are known or suspected to have leaked in the past. Waste retrieval from those particular tanks will benefit from minimizing the volume of liquid that must be added to the tank.

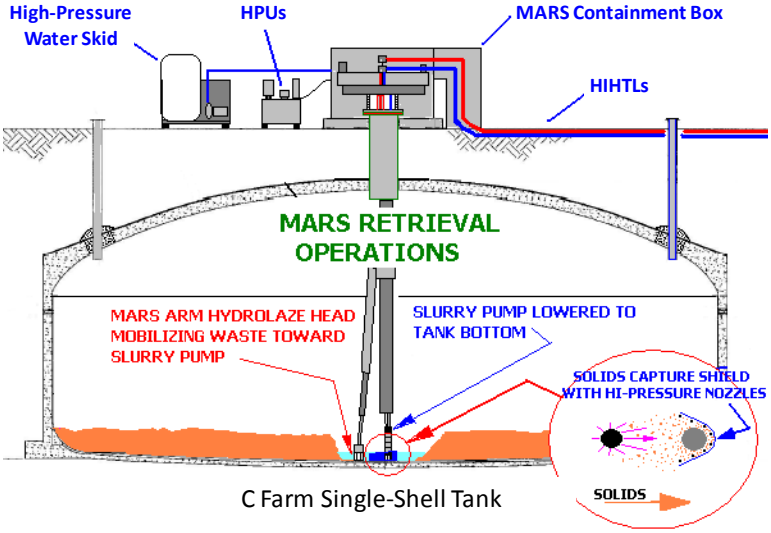


Figure 3-5. Mobile Arm Retrieval System Retrieval Operations.

The MARS-V head is designed to include the supernate/water sluicing nozzles, which mobilize the waste, and a suction nozzle, which then sucks up the slurried waste rather than directing it to a central pump. The waste slurry is collected in a small central tank mounted on the mast carriage inside the head space of the SST, from which it is transferred to a nearby DST. Prototype testing of a MARS-V system was conducted in FY 2009, with integrated testing planned in FY 2010.

- **Vacuum Retrieval** uses a mast arm capable of in-and-out, back-and-forth, and rotational motion. The arm is inserted through the tank's central riser and is used to vacuum up waste through a suction head covered by a protective screen. The vacuum head is equipped with low- and high-pressure water sprays; vacuum is provided by an aboveground skid equipped with vacuum blowers. The vacuum is drawn on a batch tank, mounted on a separate skid, which in turn pulls the vacuum on the mast. When the receiving batch tank is filled, the vacuum system is stopped and the batch tank pumped to the receiving DST. This method was used in Tanks C-201, C-202, C-203, and C-204 (see Figure 3-6).

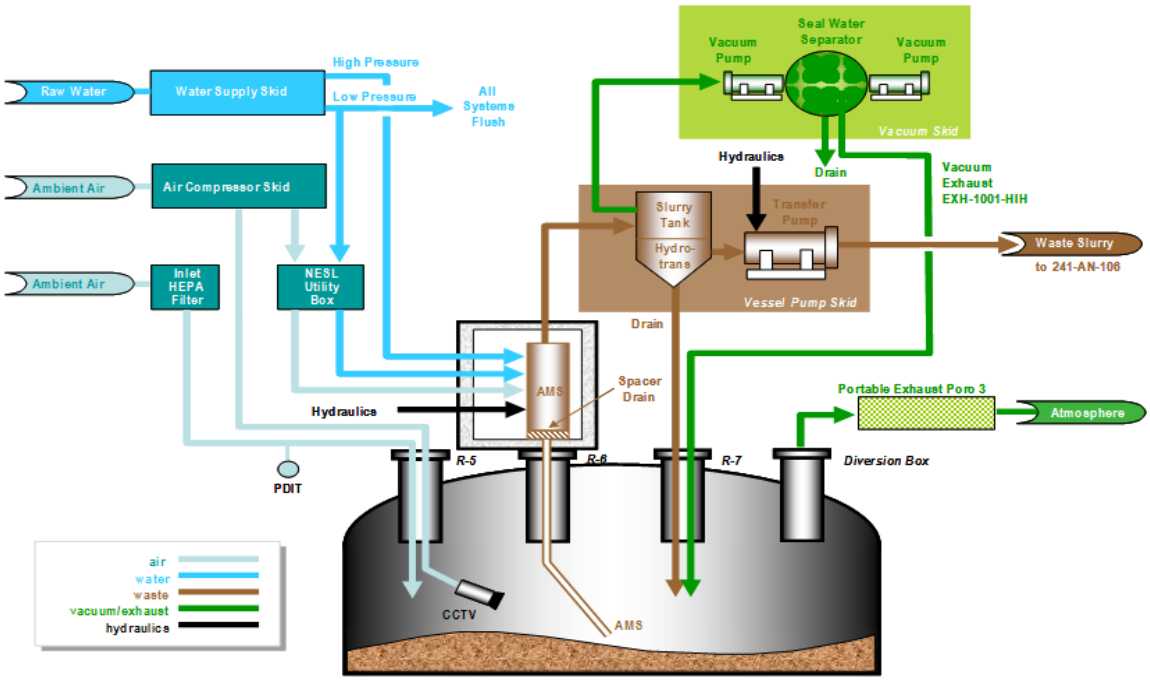


Figure 3-6. Vacuum Retrieval.

- A **Mobile Retrieval System (MRS)** combines a vacuum retrieval system with an **In-Tank Vehicle (ITV)** to push or spray waste toward the vacuum head inlet. The vehicle augments the retrieval capability of the vacuum because the reach radius of the vacuum head is only 20 ft around the center of a tank compared to the tank's 37.5-ft radius. This system uses a 400-gal batch tank, but the system is otherwise similar to vacuum retrieval. This method has not been deployed in any waste tanks to-date, but it has been tested extensively at the manufacturer's facility and at the Hanford Cold Test Facility, and it has been approved by Ecology for use in Tanks C-105 and C-101.

3.1.1.3 Hard-To-Remove Heel Processes

Hard-to-remove heels have been encountered in most tanks in which bulk retrieval has progressed near the tank bottom. Therefore, a hard-to-remove heel is conservatively assumed to be present in every tank. As with bulk retrieval, a variety of techniques may be necessary to retrieve the hard-to-remove heels. In some tanks, heel removal may be addressed by continuing to use the same technology as was used for bulk waste removal, albeit at a significantly less efficient rate (modified sluicing, vacuum retrieval). Other techniques (MARS, MRS) may prove to be more efficient. However, in some tanks, heel removal may necessitate other technologies, including the following:

- In-tank vehicle, similar to or the same as the vehicle that was used with the MRS.
- Chemical cleaning – Chemical treatments will be considered for use in conjunction with mechanical methods (e.g., MARS), because chemical processes will not be limited by in-tank obstructions or the accessible range of retrieval equipment. Two types of chemical cleaning are being explored:
  - High molarity caustic addition will metathesize sodium aluminate compounds (primarily gibbsite), followed by water addition to dissolve those solids and facilitate waste retrieval. This approach would apply to waste heels that consist largely of sodium aluminate compounds, and would facilitate the volume-based retrieval goals set forth by the HFFACO. The sodium from the caustic addition might increase the WTP LAW glass volume.
  - Oxalic acid cleaning was effective on the SRS tank heels and was used as part of Hanford's Tank C-106 retrieval. However, oxalic acid must be neutralized with caustic after use. The sodium from the caustic addition might also increase the WTP LAW glass volume. The potential buildup of oxalate in the WTP Pretreatment (PT) Facility is also an issue. A means to destroy the oxalic acid after it has performed its intended function needs to be investigated (see related Item 3, Potential Mitigating Action v, in Section 7.2, Table 7-2).

A high concentration caustic heel removal demonstration is planned as part of Tank C-108 retrieval in FY 2011. One or more oxalic acid cleaning demonstrations is planned as part of AX Farm retrieval in 2015-2016.

Additional information regarding retrieval of these tank wastes is provided in RPP-PLAN-40145.

3.1.1.4 Accelerated Single-Shell Tank Retrieval Initiative

In February 2010, WRPS proposed an initiative to address retrieval programmatic risks and to accelerate retrieval activities in the SST system. The initiative includes accelerated retrieval of the A and AX Farm tanks and six of the SX Farm tanks by 2017. Due to limited DST space available to accommodate these retrievals and the WTP operating schedule, a large bow-wave is reflected in the current System Plan that must be worked off in the 2030-2040 timeframe requiring up to a peak of 14 retrievals per year. By accelerating these retrievals, the bow-wave and associated programmatic risks might be significantly reduced. ORP agreed to move forward with accelerated A/AX Farm retrievals, and this work is currently underway. WRPS is further developing the regulatory approach and strategy for interim staging of tank waste.

3.1.1.5 Single-Shell Tank Waste Retrieval Progress To-Date

Waste retrieval from SSTs is in progress. Seven SSTs have been fully retrieved (see Table 3-2) and three SSTs have been retrieved to the limits of technology[31] (see Table 3-3). Waste retrieval activities in FY 2009-2010 have been focused on retrieving Tanks C-104 (see Table 3-4) and readying Tanks C-107 and C-111 for retrieval (see Table 3-5). Tank C-111 and five remaining C Farm tanks are scheduled to be retrieved next (see Table 3-5).

Tank S-102 retrieval was stopped prematurely in July 2007 due to an above-grade waste spill. As soon as the TOC demonstrates that this tank meets interim stabilization criteria, the mode of the tank will be changed from retrieval to storage. The System Plan assumes that the retrieval of Tank S-102 will be completed in FY 2021.

Table 3-2. Tanks Retrieved.

Tank	Retrieval completion date	*Waste Inventory Changes*[a]				Technology deployed
		Waste volume removed (gal)	Waste volume remaining (gal)[b]	Curies* removed (Ci)[c]	Curies* remaining (Ci)[d]	
C-106	12/31/2003	194,000	2,800	8,900,000	132,000	Modified sluicing and oxalic acid dissolution
C-203	3/24/2005	2,500	140	1,100	460	Vacuum retrieval
C-202	8/11/2005	1,300	150	2,600	960	Vacuum retrieval
C-201	3/23/2006	720	140	560	540	Vacuum retrieval
C-103	8/23/2006	69,000	2,500	2,700,000	19,700	Modified sluicing
C-204	12/11/2006	1,300	140	440	310	Vacuum retrieval
S-112	3/2/2007	612,000	2,400	608,000	130	Saltcake dissolution and modified sluicing
Totals:		**880,820**	**8,270**	**12,212,700**	**154,100**	

[a] Data reflects a variety of sources, including Best-Basis Inventory, retrieval progress reports, and process engineering estimates.
[b] Volumes downloaded from the Best-Basis Inventory on 7/27/2010.
[c] Decayed to 1/1/2004, except Tank C-106 which is decayed to 1/1/1998.
[d] Decayed to 1/1/2008.

[31] The Baseline Case and the PMB assume that additional retrieval will take place from these three tanks unless an official decision to do otherwise has been made.

Table 3-3. Tanks Retrieved to the Limits of Technology.

Tank	Retrieval start date	*Waste Inventory Changes*[a]				Technology deployed
		Waste volume removed to-date (gal)	Waste volume remaining (gal)[b]	Curies removed to-date (Ci)[c]	Curies remaining (Ci)[d]	
C-108	12/20/2006	59,000	6,800	148,000	13,400	Modified sluicing
C-109	6/19/2007	55,000	7,900	842,000	1,600[e]	Modified sluicing and FoldTrack mobile retrieval tool
C-110	9/22/2008	161,000	17,000	30,000	3,200	Modified sluicing
Totals:		**275,000**	**31,700**	**1,020,000**	**18,200**	

[a] Data reflect a variety of sources, including Best-Basis Inventory, retrieval progress reports, and process engineering estimates.
[b] Volumes downloaded from the Best-Basis Inventory on 7/27/2010, except as noted.
[c] Decayed to 1/1/2004.
[d] Activity based on Best-Basis Inventory data downloaded on 7/27/2010, decayed to 1/1/2008.
[e] These values are from before the use of the mobile retrieval tool.

Table 3-4. Tanks In Progress.

Tank	Retrieval start date	*Waste Inventory Changes*[a]				Technology to be deployed (bulk/heel method)
		Waste volume removed to-date (gal)	Waste volume remaining (gal)[b]	Curies removed to-date (Ci)[c]	Curies remaining (Ci)[c]	
S-102	12/16/2004	371,000	93,000[d,e]	N/A[f]	N/A[f]	Saltcake dissolution, high pressure mixer and modified sluicing
C-104	1/12/2010	195,000	64,000	745,000	299,000	Modified sluicing and chemical dissolution
Totals:		**566,000**	**157,000**	**N/A[f]**	**N/A[f]**	

[a] Data reflect a variety of sources, including Best-Basis Inventory, retrieval progress reports, and process engineering estimates.
[b] Waste volumes downloaded from Best-Basis Inventory on 7/27/2010.
[c] Activity based on Best-Basis Inventory data dated 7/27/2010 decayed to 1/1/2008.
[d] Obtained from WRPS-1000772 R1 (Sax 2010).
[e] Tank S-102 retrieval was stopped prematurely due to an above-grade waste spill.
[f] Best-Basis Inventory not yet updated to reflect new residual volume estimate in Tank S-102.

Table 3-5. Tanks Next In Line.

Tank	Scheduled started date	*Waste Inventory Changes*[a]				Technology to be deployed (bulk/heel method)
		Waste volume removed to-date (gal)	Waste volume remaining (gal)	Curies removed to-date (Ci)	Curies remaining (Ci)	
C-111	9/7/2010	–	57,000	–	1,680,000	Modified sluicing and chemical dissolution
C-107	5/1/2011	–	247,000	–	4,510,000	New riser, mobile arm retrieval vacuum system/none
C-112	10/1/2011	–	104,000	–	1,340,000	Modified sluicing and in-tank vehicle
C-102	11/1/2012	–	316,000	–	108,000	Modified sluicing and in-tank vehicle
C-101	6/1/2012	–	88,000	–	124,000	New riser, mobile arm retrieval vacuum system/none[b]
C-105	3/1/2013	–	132,000	–	939,000	New riser, mobile arm retrieval vacuum system/none[b]
Totals:		–	**944,000**	–	**8,701,000**	

[a] Data downloaded from Best-Basis Inventory on 7/27/2010; decay date is 1/1/2008.
[b] The regulator-approved retrieval technology for these tanks is currently the mobile retrieval system.

3.1.2 Double-Shell Tanks

Status: Operational

There are 28 DSTs on the Hanford Site; three in 200 West Area, and 25 in 200 East Area. All were constructed between 1968 and 1986, and no DSTs have ever leaked. Generally, the DSTs contain liquids and settled solids, either salts or sludge. The DSTs currently play an integral role within the RPP system, including:

- Supporting SST waste retrieval by receiving the retrieved SST waste
- Supporting 242-A Evaporator operations
- Being used to stage feed for delivery to ARF and the WTP.

As such, the DST Integrity Project implements controls and inspections to ensure that the DSTs and their ancillary equipment will be available for use through the end of the RPP mission. DST Integrity Project activities include the following:

- Conducting DST integrity assessments (e.g., ultrasonic and video examinations) and documenting results for use in subsequent inspections
- Conducting DST waste chemistry sampling and adjustments for corrosion mitigation
- Performing DST waste chemistry corrosion optimization studies to quantify the best waste chemistry parameters to minimize DST corrosion, while adding as few chemicals to the waste as possible
- Developing and installing in-tank corrosion probes for DSTs with new or revised corrosion control limits
- Performing DST structural analysis and studies for thermal, operating, and seismic loads
- Performing in-service testing needed to raise the operating levels of AP Farm tanks from 1.235 Mgal to 1.2465 Mgal (see Appendix B, Assumption B3.2.2.2)
- Conducting periodic testing, evaluation, and certification of DST support equipment (e.g., waste transfer lines, valve pits, etc.).

Effective and efficient management of the storage space available in the DSTs is essential to the success of the RPP mission. The theoretical total capacity of the 28 DSTs is 32.3 Mgal. Projections of how the DSTs are used over time are illustrated in Figure 5-6 (Section 5.4.2).

The majority of the space in the DSTs is used for waste storage. However, not all of the space is available for waste storage. Some headspace must be set aside to accommodate certain operating constraints:

- **Safety basis headspace** represents unfilled space in a DST containing waste that has an associated safety issue. For example, in Waste Group A Tanks AN-103, AN-104, AN-105, AW-101, and SY-103, the current waste conditions pose the potential for a spontaneous BDGRE involving flammable gas (RPP-13033). Therefore, no additional waste shall be transferred into those tanks.
- **DST emergency space**, in accordance with DOE M 435.1-1, represents 1.265 Mgal of available space that could be used to receive waste from another DST in the unlikely event that a DST would leak. The value for the emergency space allocation is based on

the maximum volume of waste that could be stored in an AP Farm DST (OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*). DOE has also requested that the tank farms provide the capability to receive up to the volume equivalent of one DST from the WTP on an emergency basis, to accommodate a potential emergency return of either LAW or HLW (Taylor 1999). The space to receive the WTP returns is counted as part of the emergency space allocation; the emergency space is not associated with a specific tank but is distributed throughout the DST system. Evaporator operational space and WTP feed headspace can be used to provide the DST emergency space if needed. When practical, one or two DSTs are designated to provide the bulk of the DST emergency space.

- **WTP feed headspace** represents the unfilled space in a DST containing waste specifically identified for delivery to the WTP as waste feed. Once the contents of these feed tanks have been sampled for WTP feed, they must be isolated from any transfers into the tank. The addition of more waste could corrupt the feed batch and provoke a schedule delay of at least 210 days (30 days to resample on top of the 180 days required by the interface control document). Currently, Tank AY-102 contains the hot commissioning feed for WTP. Other DSTs will be allocated into this category as waste is staged and sampled for delivery to WTP. Those tanks will be redeployed after delivery of waste from that tank has been completed.

There are other DST management issues associated with the waste itself. Solids and liquids must be carefully managed so as to avoid BDGRE and to avoid tank bumps (RPP-RPT-24887, *The Long-Term Management of Tank Waste at Hanford*). A BDGRE is the rapid release of gas that may be retained in a settled solids layer resulting in temporary creation of a flammable mixture in the headspace of the tank (RPP-7771, *Flammable Gas Safety Issue Resolution*). A tank bump is the rapid release of gas, mostly water vapor, causing the tank headspace to pressurize as a result of local superheated liquid vaporization (RPP-6213, *Hanford Waste Tank Bump Accident and Consequence Analysis*). The controls to prevent each of these events directly or indirectly limit the depth of the solids in the tank, the depth of the supernate, and/or the heat load from radioactive decay. This requires careful coordination with SST retrieval plans to allow effective use of the DSTs before waste treatment processes are online. However, given the need to maximize the use of available DST space, WRPS is currently reevaluating the analysis that led to the current restrictions on sludge and liquid levels in some tanks. It may be possible to relax some requirements on some tanks, without compromising safety, to regain some storage space. This System Plan assumes that current BDGRE controls can be relaxed for deep-sludge tanks. Additional information is provided in Appendix B, Assumption B3.2.2.6, and associated footnote.

Another consideration in operating the DSTs is managing waste containing high concentrations of phosphates. Wastes containing phosphates pose a high risk of solids precipitation and/or gelling during transfer, after evaporation and cooling, or during mixing with the waste in the receiver tank. This could (and has in the past) lead to formation of plugs in waste transfer lines or could cause significant difficulties during evaporator operations. It is asserted that a tank containing phosphate gel might retain flammable gases leading to a gas release event of a different mechanism than a BDGRE (RPP-23584, *Safety Evaluation of Waste Gel in the Tank Farms*). Because of these issues, controls for the transfer of phosphate wastes are provided by HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*.

These phosphate waste transfer controls are not currently explicitly modeled for life-cycle mission modeling purposes.

Two DSTs, Tanks AN-102 and AN-107, currently store waste that includes high concentrations of complexed strontium and TRU in the supernate. These two components must be precipitated out of solution prior to vitrification to avoid having those components report to LAW. Although the WTP PT Facility has the capability to do the precipitation step there, the current plan is to precipitate the strontium/TRU in-situ in the DST system. The precipitated strontium and TRU is incidentally blended with other HLW solids and will be vitrified at the WTP.

The Baseline Case assumes that closure of each DST and associated waste management area will be completed within about five years after all the Hanford tank waste has been treated. Closure will be conducted in accordance with applicable regulatory requirements.

3.1.3 Inactive/Miscellaneous Underground Storage Tanks

Status: Operational/Inactive

ORP is currently responsible for dozens of ancillary underground storage tanks known as MUSTs and IMUSTs. These smaller, auxiliary tanks supported SST tank operations. In the past, there was a regulatory distinction between the two: the IMUSTs were removed from service before RCRA permitting and therefore were not included in the RCRA operating permit for the tank farm facilities, while the MUSTs were permitted under either RCRA SST Part A or RCRA DST Part A. However, at Ecology's request, during a May 2010 revision to the RCRA SST Part A permit application, all inactive MUSTs were added to the SST Part A. All tanks will be closed under RCRA provisions in accordance with the HFFACO (Ecology et al. 1989).

The number of IMUSTs under ORP management changes over time as the status of waste sites and operable units is better understood and as memorandums of agreement between ORP and RL are adjusted. The Baseline Case assumed that ORP was responsible for 60 miscellaneous underground storage tanks (including 43 IMUSTs and 17 MUSTs). The list of these tanks, their waste volumes, and their status assumed by the Baseline Case is provided by HNF-EP-0182.

Efforts are underway to better integrate the IMUSTs into RPP waste retrieval planning, as documented in several recent reports:

- RPP-RPT-31148, *Composite Liquid Mitigation Report*, documents plans formulated by CH2M HILL personnel to mitigate the free liquids from 19 selected catch tanks and double-contained receiver tanks in A, AX, AZ, B, BX, S, TX, and U Farms.
- RPP-PLAN-41977, *Single-Shell Tank System Component Identification and Proposed Closure Strategy*, identifies a closure strategy for each IMUST in accordance with RCRA requirements and the HFFACO. In addition, this report identifies a path forward for determining the need for interim closure actions for 25 IMUSTs not already identified in RPP-RPT-31148. The path forward prioritizes sampling needs for the determination of interim closure actions at these 25 IMUSTs based on criteria that includes waste volume, uncertainty in waste volume, monitoring of tank and integrity, and release history.
- RPP-RPT-42231, *Summary of Twenty-Five Miscellaneous Tanks Associated with the Single-Shell Tank System*, was prepared as a supporting document to RPP-PLAN-41977 (described above), and summarizes MUST information available from historical data,

stabilization reports, and other sources for 25 specific MUSTs that were not assessed for interim closure in RPP-RPT-41977.

In addition, in support of upcoming retrieval and closure activities anticipated in C Farm and A Farm, WRPS is beginning planning activities to address two IMUSTs in those areas:

- Tank C-301 is a catch tank in C Farm. WRPS plans to submit a BCR to allow core sampling of this tank in FY 2011.
- Tank A-350 is a surface water collection tank in A Farm. WRPS is planning to replace a pump in this tank to allow the tank contents to be removed. Further closure actions are under consideration.

However, decisions regarding the retrieval of any remaining liquid or sludge from other MUSTs have not yet been made. Therefore, for the purposes of this System Plan, it was assumed that waste from the IMUSTs would be retrieved into the DST system and treated with the rest of the waste. The combined inventory of the IMUSTs is not well known and was estimated from an engineering study circa 1994 (WHC-SD-EN-ES-040, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site*). This should be acceptable for mission modeling purposes because the waste in the IMUSTs comprises only a small fraction of the total tank waste.

3.1.4 Waste Transfer Systems

Status: Operational

Most DSTs and those SSTs undergoing retrieval are equipped with transfer pumps. Eventually all tanks will be equipped with waste transfer pumps or an equivalent system to remove the waste to other tanks, to the WTP, or to a supplemental TRU treatment facility. The tank farms contain underground piping so the waste can be pumped between tanks, between tank farms, to and from the different facilities, and between the 200 East and 200 West Areas. These farms also contain other equipment such as valve pits that are used to route the waste. For safety and environmental protection, the pipelines have an encased pipe-in-pipe design with sensors to monitor for leaks. For retrieval of SSTs, aboveground hose-in-hose transfer line are used directly or in combination with existing transfer routes to permit more rapid deployment, reduce costs, and provide additional flexibility. The waste transfer system will require as of yet undetermined changes to accommodate the ARF (see Figure 3-7).

Upgrades to the current waste transfer system will be required before tanks can be retrieved and waste can be delivered to the WTP. These upgrades include installation or replacement of transfer pumps, installation of mixer pumps, replacement of some valves in the pits, and extension of some pipe encasements through the pit wall. RPP-40149, prepared in parallel with this revision of the System Plan, defines the upgrades and refines the approach for delivering feed to the WTP.

In the SY Farm, upgrades to the transfer lines have started. Eight of the original noncompliant transfer lines are being replaced. Because of this project work, the three SY Farm tanks are currently isolated from each other and from the 200 East Area DSTs. Transfers from the 222-S Laboratory facility (via the 219-S Waste Handling Facility) to Tanks SY-101 and SY-103 are still supported by compliant, dedicated transfer lines not impacted by the upgrade work. This work is scheduled to be completed by September 2011.

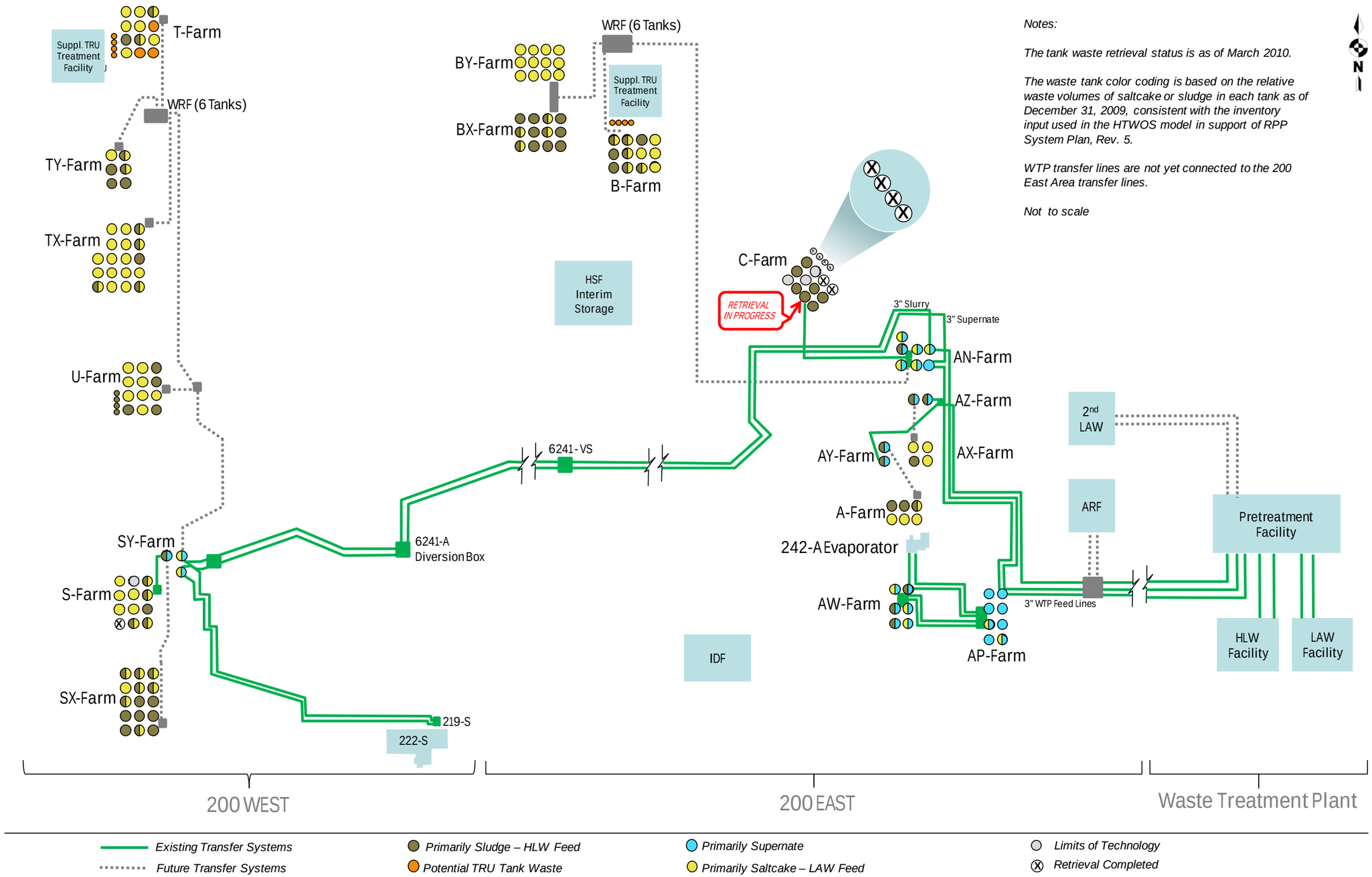


Figure 3-7. Hanford Tank Cleanup Status.

3.1.5 Waste Retrieval Facilities

Status: Proposed

The TOC baseline currently includes the design, construction, and operation of two WRFs: one in the 200 East Area near B Complex, and one in the 200 West Area near T Complex. These two waste complexes are geographically distant (several miles) from the nearest DST farms. As such, they require additional facilities to support timely and efficient SST waste retrievals. Each WRF would provide:

- Six 150,000-gal waste receipt tanks with pumps, transfer lines to the SSTs, and other ancillary equipment to allow recycle of supernate during waste retrieval, thereby minimizing the volume of waste generated by retrieval operations. The tanks would also provide space for the temporary storage of the retrieved waste, to decouple SST retrievals from the near-term limits of DST storage space.
- Waste transfer lines from the WRF to the DSTs and the pumping capacity needed to transfer the retrieved waste slurries at high solids loadings over the considerable distance to the nearest DST storage tanks, without exceeding the allowable pressure ratings for transfer system components.

The WRFs are included in the HTWOS model. Planning assumptions related to the WRFs are provided in Appendix B, Section B3.2.3.

The mission of the B Complex WRF potentially includes an enhanced WRF concept in which the basic WRF capabilities would be augmented to include mixing, blending, sampling, and filtration of retrieved waste to provide a more uniform feed to WTP (RPP-RPT-44860, *Mission Analysis Report Waste Feed Delivery Projects East Area Waste Retrieval Facility*). Sampling of the blended wastes at the WRF would support the certification of feed batches to WTP, in accordance with ICD-19 requirements. Further work on the enhanced WRF is on hold pending direction from ORP.

3.1.6 Evaporator

Status: Operational

The primary mission of the 242-A Evaporator (Figure 3-8) is to support tank farm waste storage by reducing dilute waste volume. Evaporator availability is essential to the success of the RPP mission to continue SST waste retrievals and to adjust the sodium levels to meet WTP feed requirements. The evaporator operates on a campaign basis, using the time between campaigns to implement facility upgrades as necessary. The 242-A Evaporator has a final status RCRA Part B permit.

Figure 3-8. 242-A Evaporator Facility.

Many facility upgrades have recently been completed or are planned to allow the continued use of the 242-A Evaporator to support the RPP mission. Some of these upgrades are ARRA-funded, and are identified in Section 3.1.9.

3.1.7 Waste Encapsulation and Storage Facility

Status: Operational

The WESF, adjacent to the west end of B Plant, was constructed in 1974 to encapsulate and store cesium and strontium that were separated from the Hanford Site's tank waste. Approximately one-third of the cesium and strontium contained in the original tank waste was previously removed and incorporated into capsules. The cesium waste is stored as a chloride salt in double-contained 316L stainless-steel capsules with maximum outer dimensions of 21 in. long by 3 in. in diameter. The strontium waste is stored as a fluoride salt in double-contained Hastelloy C-276 capsules, with maximum outer dimensions of 20.1 in. long by 2.625 in. in diameter. WESF provides for safe storage and monitoring of the capsules under water in pool cells. WESF is an interim status RCRA facility.

The current inventory at WESF consists of 1,335 cesium capsules and 601 strontium capsules. The capsules contain approximately 120 MCi of radioactivity,[32] including daughter products.

The management of WESF and the disposition of the cesium and strontium capsules is the responsibility of RL, which had planned on disposal of the capsules at the proposed Yucca Mountain nuclear waste repository. Recent national policy decisions have resulted in the termination of activities to construct a repository at Yucca Mountain and in the establishment of a Blue Ribbon Commission on America's Nuclear Future to consider alternative disposition of HLW and spent nuclear fuel inventories.

Additionally, DOE added cesium and strontium capsule storage to the scope of the TC & WM EIS (DOE/EIS-0391). The cesium and strontium capsule storage alternatives evaluated in the TC & WM EIS were constructed to address continued safe storage of the capsules in a manner that does not prejudice potential outcomes of future decisions on final disposition of the capsules. The alternatives for capsule storage range from maintaining the capsules in storage in underwater pools at WESF pending implementation of final disposition (No Action Alternative) to implementation and maintenance of dry capsule storage. The alternatives will maintain the capability for later direct disposal of the capsules at a final disposal site with applicable overpacking or future de-encapsulation and processing of capsule contents at the WTP to satisfy acceptance requirements at the final disposal site.

A decision as to the continuing viability of direct disposal will be made under HFFACO Milestone M-092-05 (circa 2017). This allows sufficient time for ORP to make the necessary changes to the WTP to receive and vitrify the contents of the capsules, and for RL to build a de-encapsulation and conditioning facility. Additional information about cesium/strontium capsule treatment and disposal is provided in Section 1.4.

[32] Note that the decay date for this activity is January 1, 2002.

The System Plan (Rev. 5) assumes that the capsules will not require processing at WTP (see Appendix B, Assumption B3.5.8.1). However, the current WTP contract provides for the ability to receive and vitrify the capsules contents as HLW, after appropriate conditioning, if processing of the capsules is determined to be required for final disposition. Therefore, WESF is not shown on the simplified process flow diagram nor is the treatment of the capsule contents modeled.

3.1.8 Vadose Zone Program

Status: Operational

The Vadose Zone Program is responsible for implementing the tank farm RCRA corrective action program through field characterization, laboratory analyses, technical analyses, risk assessment for past tank leaks, and installation of interim measures that will reduce the threat from contaminants until permanent solutions can be found. Results of vadose zone investigations and interim measures conducted during Phase 1 of tank farm vadose zone work are documented in DOE/ORP-2008-01, *RCRA Facility Investigations Report for Hanford Single-Shell Tank Waste Management Areas*. Vadose zone remediation is an important step to protect the Columbia River.

The first step in vadose zone remediation is achieving high-quality site characterization data. However, commercially available technologies are not always suitable for as-is deployment in the complex environment of the Hanford tank farms. For example, traditional soil characterization methods rely on drilling boreholes to obtain soil samples for laboratory analysis, but the complexity and expense of drilling in contaminated soil dictate the development of methods more suitable to the Hanford tank farm setting. Successful adaptation of existing technologies has led to recent advancements in soil characterization tools and groundwater monitoring and protection that will enable ORP to better understand, mitigate, and treat existing contamination plumes.

In FY 2009 and FY 2010, vadose zone program activities have focused on providing support for planned WMA C closure in 2019 (see Section 2.3.3), characterizing a number of areas for the placement of interim surface barriers, and several significant technology development and field implementation efforts.

3.1.8.1 Direct Push Boreholes and Sampling

Drilling traditional boreholes in contaminated soil is complex, expensive, generates waste, and may lead to the spread of contamination. To alleviate these problems, direct push characterization using a hydraulic hammer has been extensively employed for soil logging and sampling in the Hanford tank farms (Figure 3-9). The hydraulic hammer is mounted on a mobile, lightweight backhoe, making it more agile than truck-mounted units and thereby allowing it to be deployed in areas where traditional drilling equipment would not be feasible.

Figure 3-9. Hydraulic Hammer in C Farm.

The hammer has a specialized head that allows it to bore past rock and compacted soil. It drives a hollow pipe into the soil, either vertically or at an angle, to place instruments or retrieve soil samples from areas beneath tanks. This allows WRPS personnel to characterize some areas that were previously inaccessible.

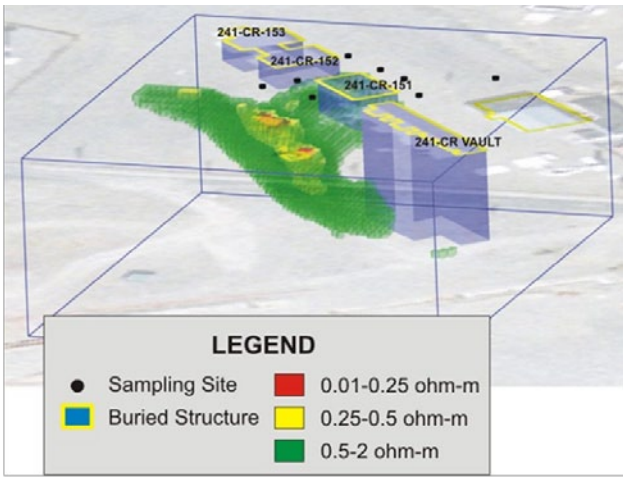


Figure 3-10. Subsurface Contamination Plume.

In FY 2009-2010, exploration of the C Farm has continued to support planning of the soil corrective measures that will be needed for closure of WMA C. Direct push characterization of SX Farm and the area between SX and S Farms was performed to evaluate potential sites for interim surface barriers. The hydraulic hammer unit was also deployed in conjunction with surface geophysical exploration (SGE) technology in C Farm to produce a 3-D image of a subsurface plume of contamination (Figure 3-10, see Section 3.1.8.2 for more details).

3.1.8.2 Surface Geophysical Exploration

In its natural state, the dry Hanford soil is quite electrically resistive. However, the addition of process wastes to soil decreases resistance. Measurement of soil resistivity through the soil can be used to identify areas where contamination may be present. This is a different application of the same science WRPS is using to monitor for releases during tank retrievals. SGE is so named because it does not require excavation or drilling of holes in the ground. Instead, it uses the electrical properties of the soil to map potential contamination plumes. Metal probes (electrodes) are inserted into the soil in a grid pattern in areas where a contaminant plume is suspected (Figure 3-11). The probes are connected to a central data collection system. Electric current is applied sequentially to all combinations of the probes, and the resistance of the soil between each pair of electrodes is measured. These data are analyzed by a geophysicist using computers, which then results in a visual image of the plume.

In the past, SGE results were limited to two-dimensional mapping of the plumes, which could show either the breadth of a plume, but not its depth, or the depth but not the breadth. Innovative use of existing well casings as additional electrodes, use of the hydraulic hammer (see Section 3.1.8.1) for placement of electrodes at almost any depth and location, and improved computational capabilities produced improved 3-D images of the plumes being investigated. These data will help to determine the most efficient and cost-effective placement of future sample locations, barriers, and treatment systems, as appropriate.

Figure 3-11. Metal Probes are Used During Surface Geophysical Exploration.

SGE, a combination of surface-deployed geophysical techniques, was applied in WMA TX-TY during FY 2008. In addition, in 2009, an application of SGE using drywells and adjacent groundwater monitoring wells was made in support of a proposed interim barrier in the SX Farm. The primary tool applied through SGE is pole-pole electrical resistivity; other tools include electromagnetic induction, magnetic gradiometry, and ground-penetrating radar.

These latter tools are used to help define the presence and distribution of buried infrastructure, so that those features may be taken into account during the analysis of resistivity data. All of the data collected by SGE must be geographically coordinated; to accomplish this, all data point locations are first defined, in three dimensions, by using survey-grade global positioning satellite instruments. The depth to which the resistivity measurements interrogate the subsurface is determined by the distance between electrode pairs (the further apart, the deeper the interrogation). Resistivity is an indirect measure of several subsurface phenomena (e.g., moisture distribution, saline contaminants, and soil texture). The more separated the electrode pairs, the lower the resolution of the analysis. Where an entire farm has been surveyed, ground-penetrating radar results are integrated with site drawings to produce a single map that need not be changed unless changes are made to the farm. Because these maps are geographically accurate and electronically maintained, they can be regenerated on the ground without needing to resurvey; thus adding to the efficiency of other tank farm operations activities.

3.1.8.3 Other Tools

Several other tools or techniques are being developed to support characterization of the vadose zone or management of surface water. These include:

- **In-Situ Beta Detection Tool.** This tool is currently being developed and tested at Idaho National Laboratory (INL) to determine if it could be deployed with the direct push unit to identify areas contaminated with ^{99}Tc, a beta-emitter, which is easily shielded by many materials. The probe would be deployed into a direct push probe hole just after a section of steel casing has been withdrawn, allowing the probe to be nearly in contact with the soil, with only a small air gap to attenuate the beta-particles from the ^{99}Tc.
- **Time-Domain Electromagnetics (TDEM).** This commercial technology is being adapted to detect plumes in the vadose zone. The TDEM method uses electrical pulses from an aboveground coil to generate a magnetic field in the earth, and then measures the decay response when that field is abruptly turned off. In areas where pipes have leaked, the response will be different than in areas where no leaks have occurred. Data from a proof-of-principle test above a known historic leak from a C Farm transfer line is being analyzed to determine if additional development of this technology is warranted.
- **Surface Water Management and Interim Surface Barriers**. Surface water infiltration could drive contaminants deeper into the vadose zone and into the water table. Therefore, it is important to minimize and control sources of surface water, including rain and snow runoff, surface flooding, and leaks from waterlines.
  - Berms, curbs, culverts, and gutters have been installed around all 12 SST farms to prevent the flow of surface water into the farms.
  - As many water lines as possible have been taken out of service and isolated. Those remaining have been leak-tested and repaired as necessary.

- Waterproof caps have been installed on 998 drywells.
- The T Farm interim surface barrier (TISB) (Figure 3-12) was installed to decrease infiltration of water into the area of contamination and thus decrease the potential for further contaminant migration, and to serve as a barrier demonstration project.
- An interim barrier is currently being constructed over all of TY Tank Farm (Figure 3-13), including an adjoining area contaminated by a past tank farm pipeline leak. The TY Farm barrier design incorporates lessons learned during the T Farm barrier construction and is expected to be completed in September 2010.
- Four additional barriers may be designed between 2011 and 2014, and installed between 2012 and 2015.

Figure 3-12. Interim Surface Barrier Installed at T Farm.

Figure 3-13. Artist's Concept of TY Farm Interim Barrier.

3.1.9 Recovery Act Projects

Passage of the ARRA, also referred to as the Recovery Act (RA), provided a unique opportunity to significantly reduce life-cycle costs by making near-term investments in core mission activities. ORP received $326 million to improve facilities that handle liquid waste. ARRA funds were allocated to support 30 subprojects in five categories, as summarized in Table 3-6.

As of June 1, 2010, all RA projects have been started, and many projects have already been completed.

Table 3-6. Recovery Act Projects.

RA-1 Tank Farm Infrastructure Upgrades	
AP/SY Ventilation	• AP/SY ventilation • SY Farm electrical upgrades • Valve funnel replacements • AP valve pit jumpers • AP level rise construction modifications • AZ Farm control system upgrade • Other tank/farm upgrades • DST upgrades / life extension • SST life extension • TY Farm interim barrier construction
RA-2 Other Infrastructure Upgrades	
Core Sampling System	• Wiped film evaporator • Core sampling system • MARS vacuum system • 135-ton, all-terrain crane and other support vehicles
RA-3 Facilities Upgrades	
222-S Laboratory Upgrades	• 242-A Evaporator upgrades / operation • 242-A Evaporator upgrades / life extension • 222-S Laboratory instrument upgrades • 222-S Laboratory life extension projects • 222-S Laboratory upgrades projects • Secondary waste form testing
RA-4 Waste Feed Infrastructure Upgrades	
Tank Waste Mixing Demos	• DST control systems update • AW/AN Farms exhauster D&D • AZ condensate line upgrade • AW cleanout box isolation and removal • Mixer pump design • Tank waste mixing demonstrations • AW Farm D&D (SHMS-GCS removal) • SY-102 D&D (SHMS-GCS removal)
RA-5 Waste Feed Transfer Lines Upgrades	
Transfer Line Upgrades	• Transfer line upgrades – SL-177/SN-277 and SL-180/SN-280 • Transfer line upgrades – SN-278/SN-279 and SN-285/SN-286.

D&D = deactivation and decommissioning.
DST = double-shell tank.
GCS = gas characterization system.
MARS = mobile arm retrieval system.
SHMS = standard hydrogen monitoring system.
SST = single-shell tank.

3.2 TREATMENT

3.2.1 Supplemental Transuranic Treatment Facility

Status: Early Design

Twenty tanks (17 SSTs and three DSTs) historically have been considered as containing waste that potentially may be TRU tank waste; reports by the Tank Operations Contractor are on file describing the origin of potential TRU tank wastes. Official identification of this tank waste as TRU will be performed by DOE after the TC & WM EIS ROD is issued. Waste identified as TRU could be retrieved, packaged, and shipped to WIPP located near Carlsbad, New Mexico, pending approval of a Class III change request to the WIPP RCRA Part B Permit. Potential TRU tank waste that is not so identified will be qualified as HLW and processed in the WTP.

The Baseline Case assumes that only eleven SSTs will be handled as TRU tank waste.

The potential TRU tank waste treatment and packaging process will use a modular approach. The facility will be first located at B Farm, the tank farm supplying the initial TRU tank waste feed, and then be relocated to T Farm, which supplies the remaining TRU tank waste feed. A single modular system, designed for relocation, has the advantage of cost-effectively maintaining a pristine TRU product, thus maintaining its TRU designation and meeting WIPP waste acceptance criteria. A single fixed system would require transfer of the SST TRU waste material through existing DSTs and cross-site piping, risking contamination with residual non-TRU waste material.

The potential TRU tank waste treatment system uses a high-vacuum, low temperature, rotary dryer to remove water from the retrieved sludge. The dried product, consisting of approximately 10 wt% water, 10 wt% sand, and 80 wt% waste solids is packaged in 55-gal drums. The low-dosage TRU waste product allows manual operation of the drum-filling equipment and movement of product drums without requiring remote manipulators. Condensate from the dryer is filtered and then discharged to the Liquid Effluent Retention Facility (LERF)/Effluent Treatment Facility (ETF) via a tank truck or reused to retrieve and transport additional TRU sludge. Off-gas is high-efficiency particulate air (HEPA) filtered and then discharged to the atmosphere.

Significant design of the potential TRU tank waste packaging system was completed, and several pieces of long-lead fabrication equipment were procured and fabricated. The project was placed in “standby” by DOE in 2005 to await final approval of the EIS. Reactivation of the project will initially involve generation of critical decision (CD) design packages in accordance with DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets*. Packaging system startup at B Farm is expected a little over five years after project reactivation.

The packaged potential TRU tank waste will be stored at the Central Waste Complex pending a determination of final disposition.

The technical and programmatic assumptions for the potential TRU tank waste treatment system are included in Appendix B, Section B3.4.3.

3.2.2 Waste Treatment and Immobilization Plant

Status: Design and Construction

The WTP (Figure 3-14) is currently being designed and built by BNI. There are five main facilities within the WTP project: the PT Facility, the HLW Vitrification Facility, the LAW Vitrification Facility, the dedicated Analytical Laboratory (Lab), and the balance of facilities (BOF), which includes supporting infrastructure systems such as air, water, electrical, power, fire protection, and others. More detailed planning assumptions are provided in Appendix B.

Figure 3-14. Hanford Waste Treatment and Immobilization Plant.

The WTP will generate secondary solid and liquid waste streams. The secondary solid waste (e.g., spent melters, spent ion-exchange resin, HEPA filters, carbon absorbers, silver mordenite columns) is assumed to be disposed of in the IDF (see Section 3.4.1). The secondary liquid waste is assumed to be treated at the ETF (see Section 3.2.5).

3.2.2.1 Pretreatment

The WTP PT Facility will receive both HLW feed and LAW feed from the tank farms. Specific pretreatment processes include concentration, ultrafiltration, caustic and oxidative leaching, and subsequent separation of the waste streams into a HLW fraction for treatment at the HLW Vitrification Facility, and a LAW fraction for treatment at the LAW Vitrification Facility. In addition, the WTP PT Facility also has the capability to precipitate complexed strontium and TRU elements to avoid having those constituents partition to LAW. However, these wastes would have to be segregated from other streams during pretreatment and the precipitate carefully blended in with pretreated HLW sludge, thus significantly reducing the WTP PT Facility throughput at that time. Therefore, current plans are to precipitate the strontium and TRU elements in the DST system prior to transferring the waste to WTP. For additional details, see Appendix B, Assumption B3.2.2.7.

As of the end of May 2010, the WTP PT Facility is approximately 51% complete. The near-term schedule forecast is as follows:

Complete PT Facility design:	February 18, 2015
Complete PT Facility construction:	November 13, 2015

The initial feed to the WTP for hot commissioning is already staged in Tank AY-102. Prior to delivery, the waste will be mixed and sampled. The solids will be allowed to settle and a portion of the supernate will be decanted and delivered to the WTP PT Facility as the initial feed for hot commissioning of the WTP PT Facility and LAW Vitrification Facility. The waste will be mixed to form a slurry, adding water if needed; a portion of this slurry will be delivered to the WTP PT Facility to complete commissioning of the WTP PT Facility and for hot commissioning of the HLW Vitrification Facility.

3.2.2.2 High-Level Waste

The WTP HLW Vitrification Facility will immobilize the HLW fraction of the waste in glass, which is poured into HLW stainless-steel canisters. Each 10-gauge, thin-walled, HLW canister will hold 3.14 MTG on average. The filled immobilized high-level waste (IHLW) canisters will be transferred to the Interim Hanford Storage Facility (IHSF) for interim storage, and then transported offsite to a planned geologic repository for disposal. As of May 2010, the HLW facility is approximately 52% complete. The near-term schedule forecast is as follows:

Complete HLW Vitrification Facility design:	June 19, 2015
Complete HLW Vitrification Facility construction:	May 26, 2016

3.2.2.3 Low-Activity Waste

The WTP LAW Vitrification Facility will immobilize the LAW fraction of the waste in glass, which is poured into LAW stainless-steel packages. Each LAW package will hold 5.51 MTG on average. The filled ILAW canisters are assumed to be transferred to the onsite IDF for disposal, consistent with final decisions to be reached in the TC & WM EIS ROD. As of May 2010, the LAW facility is approximately 70% complete. The near-term schedule forecast is as follows:

Complete LAW Vitrification Facility design:	September 18, 2008 (actual)
Complete LAW Vitrification Facility construction:	August 18, 2014

3.2.2.4 Analytical Laboratory

The WTP Lab and BOF facilities will provide operational support to the PT, HLW, and LAW facilities. As of the end of May 2010, the Lab Facility is approximately 51% complete. The near-term schedule forecast is as follows:

Complete Lab Facility design:	February 3, 2012
Complete Lab Facility construction:	August 27, 2013

3.2.2.5 Balance of Facilities

The WTP includes 20 support facilities, collectively referred to as the BOF, which provide various utilities and other functions to support the PT, HLW, and LAW facilities (for more detail, see Appendix C). As of the end of May 2010, the BOF is nearly 54% complete. The near-term schedule forecast is as follows:

Complete BOF design:	August 15, 2014
Complete BOF construction:	October 20, 2015

3.2.3 Aluminum Removal Facility

Status: Future Facility

Significant amounts of aluminum are present in the tank waste as a result of the addition of aluminum nitrate nonahydrate as a salting agent and for corrosion control during past separations and scrap recovery operations, and also from the dissolution of the aluminum cladding from reactor fuel rods. High quantities of aluminum lead to unnecessarily high quantities of HLW glass produced, thereby increasing overall program costs.

ORP added the ARF to the baseline in 2009 to mitigate the impacts on the waste treatment mission due to the expected need to add large quantities of sodium hydroxide to the waste to keep the aluminum in solution. It is anticipated that the need for the ARF may be avoided in future system plans as a consequence of ongoing refinements to the RPP mission in the areas of WTP pretreatment design and flowsheet, commonly referred to as the "WTP Equipment Option."

The ARF is assumed to be a standalone facility that uses a LiHT process to remove aluminum from the waste prior to delivery of the waste to the WTP PT Facility. In this facility, aluminum is first leached from sludge by the addition of sodium hydroxide. The majority of the liquid phase aluminum is then precipitated by adding lithium hydroxide to the waste to form LiHT ($Li_2CO_3 \cdot 4Al(OH)_3 \cdot 3H_2O$), which generates sodium hydroxide that can be recycled to caustic leaching. This process is used to (1) reduce the amount of sodium hydroxide that needs to be added to the waste to keep the aluminum in solution, and therefore, reduce the required capacity of the second LAW facility, and (2) reduce the demand placed on the WTP PT Facility by both eliminating the need to caustic leach the sludge in the PT Facility and by reducing the sodium additions. However, the WTP PT Facility is still assumed to caustic leach the sludge delivered to the facility before the ARF is operational.

The LiHT by-product is assumed to be decontaminated by water washing and is dried, drummed, and disposed at the IDF as a new secondary waste stream. It may be possible to use this by-product to offset a portion of the glass-forming chemicals added to the pretreated LAW in the WTP LAW Vitrification Facility and the second LAW facility, although this option was not further explored.

The technical and programmatic assumptions for the ARF are included in Appendix B, Section B3.4.1.

3.2.4 Second Low-Activity Waste Facility

Status: Future Facility

The Baseline Case assumes that the flowsheet for the second (supplemental) LAW vitrification facility is similar to the flowsheet for the LAW Vitrification Facility currently being constructed by the WTP project. Based on the assumptions used for the Baseline Case, the design capacity of the second LAW facility was selected as six 15 MTG/day melters (90 MTG/day total) yielding a net capacity of 63 MTG/day after application of a 70% total operating efficiency (see Section 5.5.4.1 for a discussion on how this capacity was selected). This capacity is three times the WTP LAW Vitrification Facility capacity. The new facility would be designed, constructed, and operated separately from the WTP LAW Vitrification Facility.

Note that additional pretreatment capacity in the form of the ARF is needed upstream of the WTP PT Facility to support the Baseline Case.

3.2.5 Liquid Effluent Retention Facility/Effluent Treatment Facility

Status: Operational

The LERF, shown in Figure 3-15, is designed to store 242-A Evaporator process condensate and other dilute liquid waste streams for treatment at the 200 East Area ETF.

The ETF provides for the collection, treatment, and storage of low-level mixed wastes and the disposal of treated wastes meeting applicable state and federal permit requirements.

The LERF/ETF has a final status RCRA Part B permit.

Figure 3-15. Liquid Effluent Retention Facility/Effluent Treatment Facility.

In addition to the waste streams already being collected, treated, and disposed at LERF/ETF, liquid effluent secondary wastes generated during waste treatment operations (WTP, supplemental LAW treatment, and supplemental treatment of potential TRU tank waste) will be sent to ETF for further treatment and disposal, either as liquids at the State Approved Land Disposal Site (SALDS) or as a solidified waste form at the IDF. An additional solidification treatment unit has been proposed for the ETF, which would produce a waste form for disposal at IDF. However, there are significant uncertainties (see Table 7-8, Item 33) associated with the projected characterization and predicted groundwater impacts of these secondary waste streams. Therefore, in 2008, ORP requested the DOE Office of Waste Processing (EM-21) to sponsor a workshop to develop a roadmap to outline the steps necessary to design the secondary waste form. Workshop participants included representatives from DOE, EPA, Ecology, NRC, Oregon Department of Energy private consultants, and technical experts from DOE national laboratories and academia. The participants focused on three areas: regulatory drivers, waste composition, and waste forms. Their efforts culminated in a roadmap of proposed actions (PNNL-18196, *Hanford Site Secondary Waste Roadmap*) necessary to address regulatory and performance requirements, waste composition, preliminary waste form screening, waste form development, process design and support, and validation. Successful implementation of the roadmap will lead

to the compliant, effective, timely, and low-cost disposal of secondary wastes. Work in this area is ongoing.

This System Plan assumes that the LERF and ETF will support the needs of the waste treatment mission. The technical and programmatic assumptions for the LERF and ETF are included in Appendix B, Assumption B3.5.1.

RL was previously responsible for the management of the LERF and ETF. However, these facilities are planned to be transitioned to ORP as part of the new contracting scheme for the Hanford Site. Under the TOC (DE-AC27-08RV14800), WRPS will assume responsibility for the LERF and ETF in FY 2015.

3.3 STORAGE ONSITE AND SHIPPING

3.3.1 Interim Hanford Storage Facility

Status: Future Facility

The mission of the IHSF is to (1) receive and temporarily store canisters of IHLW, and (2) eventually retrieve and transport those canisters to the Hanford Shipping Facility (HSF) in preparation for shipment to a planned national repository. Initially, the IHSF will provide storage for 2,000 canisters. Additional modules, each with a 2,000 canister capacity, can be built as needed to expand the facility up to its maximum capacity of 16,000 canisters. This expansion capability mitigates the risk caused by uncertainty regarding the availability of a national repository. The facility will be located in the 200 East Area. The technical and programmatic assumptions for the IHSF are included in Appendix B.

3.3.2 Hanford Shipping Facility

Status: Future Facility

The mission and capacity of the HSF is being reevaluated due to the likelihood that a planned offsite national repository may not be available to support the waste treatment mission. However, as it is currently envisioned, the HSF would receive, package, and stage the IHLW canisters from ORP, and the spent nuclear fuel multi-canister overpacks and spent fuel standard canisters from RL. The canisters and overpacks would be loaded into casks, and the loaded casks would be transported offsite to a national repository for permanent disposal. The HSF would have a 40-year design life. The facility would be specified to match the receiving capabilities of the IHSF. The HSF would be located in the 200 East Area, and built either as a standalone facility or as a module attached to the IHSF. The technical and programmatic assumptions for the HSF are included in Appendix B, Assumption B3.5.4.

3.3.3 Central Waste Complex

The Central Waste Complex (CWC) in the 200 West Area provides compliant interim storage for containerized LLW and mixed LLW pending onsite disposal, and solid TRU waste awaiting treatment and final disposal at WIPP. The CWC began waste management operations in August 1988 and is an interim status RCRA facility.

The CWC receives, stores, and distributes solid radioactive and non-radioactive waste in a safe and environmentally compliant manner. The CWC consists of an outdoor area, which is used to store large waste boxes, and multiple storage structures that provide interim storage for solid waste awaiting appropriate treatment and final disposal. The solid waste is received from both onsite and offsite generators. LLW, mixed LLW, and mixed TRU waste are all stored at the CWC.

The CWC is not modeled in HTWOS. It is assumed to provide, to the extent practical, permitted waste storage and characterization for the potential TRU tank waste that may be packaged by the supplemental TRU treatment system.

3.4 DISPOSAL ONSITE

3.4.1 Integrated Disposal Facility

Consistent with final decisions reached based on the analyses in the TC & WM EIS and documented in the ROD, the IDF would provide onsite disposal of ILAW[33] from WTP; mixed waste generated through waste operations; other LLW; alternative ILAW forms such as those generated from bulk vitrification (if implemented), the LiHT by-product from the ARF, or the ETF; and spent or failed LAW and HLW melters from the WTP. The Tank Operations Contractor will provide transport of spent or failed melters and ILAW packages from the WTP to the IDF. The initial phase of the IDF has been constructed; however, final decisions about using the IDF for ILAW disposal, or whether to construct an IDF in the 200 West Area, will not be made until the final TC & WM EIS has been issued and a ROD is published. The Hanford Facility RCRA permit will require modification, as it currently only addresses disposal of ILAW packages and roll-off boxes from bulk vitrification.

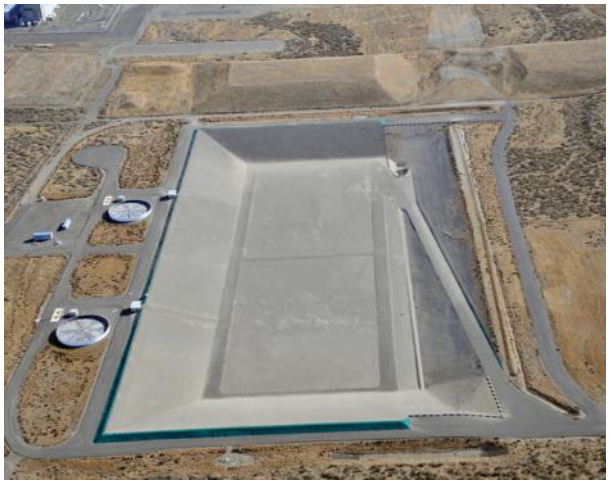


Figure 3-16. Integrated Disposal Facility.

The IDF (Figure 3-16) is located in the 200 East Area, southwest of the Plutonium-Uranium Extraction Plant (PUREX). The facility consists of a single landfill with two separate, expandable cells that would be used if and when the additional capacity is needed. One cell (Cell 1) is permitted as a RCRA Subtitle C landfill system and designed in accordance with Washington Dangerous Waste Regulations; this cell may receive dangerous and/or hazardous waste, specifically mixed LLW. This includes the ILAW from WTP and bulk vitrification, the spent or failed melters, and ETF secondary waste. The other cell (Cell 2) would not receive dangerous and/or hazardous waste; it would receive only LLW. Both cells include a double-liner system, leachate collection and removal systems, and a leak-detection system. Key issues and uncertainties associated with the IDF are included in Table 7-8. The technical and programmatic assumptions for the IDF are included in Appendix B.

[33] The ILAW is classified as mixed LLW until ORP gains approval from Ecology to delist this waste. At that time, it would no longer be dangerous waste.

3.4.2 State Approved Land Disposal Site

The SALDS is located north of the 200 West Area. Treated effluent from the ETF is transferred via pipeline to the SALDS where it is discharged to the ground (HNF-SD-ETF-ASA-001, *200 Area Effluent Treatment Facility Auditable Safety Analysis Report*).

The SALDS is not explicitly modeled in HTWOS, although the predicted volumetric demand on the SALDS from the ETF resulting from the retrieval and treatment of tank waste is calculated for the Baseline Case. The programmatic assumptions for the SALDS are included in Appendix B, Section B3.5.1.

3.4.3 Environmental Restoration Disposal Facility

ERDF is designed to serve as a waste isolation structure for radiologically and chemically contaminated bulk soil, demolition debris, and miscellaneous contaminated material from Hanford Site environmental remediation activities conducted under CERCLA authority. ERDF is authorized to operate through a CERCLA ROD issued by the EPA.

ERDF is located in the 600 Area, between the 200 East and 200 West Areas of the Hanford Site. Design requirements for ERDF were derived under the regulatory authority of CERCLA, as administered under the HFFACO. The ERDF is designed to RCRA minimum technology requirements and *Toxic Substances Control Act of 1976* (15 USC 2601 et seq.) specifications for chemical landfills.

ERDF operations began in July 1996. The facility is designed as a multi-cell burial trench that can be expanded over time to add more cells. Initially only two cells (Cells 1 and 2) were constructed. Four additional cells (Cells 3 – 6) have been constructed since operations began, and there are plans to build four more cells during the future operation of the facility. Additional cells beyond these ten may also be added in the future as needed. The trench layout is shown in Figure 3-17. ERDF is projected to receive up to 5,960,000 m^3 (7,800,000 yd^3) of waste when all ten cells have been built.

Figure 3-17. The Environmental Restoration Disposal Facility Trench Layout.

3.5 DISPOSAL OFFSITE

3.5.1 Potential Transuranic Tank Waste

The potential TRU tank waste will be stored at the CWC pending a determination of final disposition. At that time, the packaged waste can be either shipped offsite or treated (with additional conditioning) at the WTP and disposed as HLW.

3.5.2 Final High-Level Waste Disposal Alternative

The IHLW glass canisters were planned to be disposed at an offsite geologic repository, designed to isolate the IHLW from the environment for tens or hundreds of thousands of years.

This System Plan makes an enabling assumption that, on or before June 2022, a decision will be made to ship the IHLW glass canisters to an offsite geologic repository and that this repository will be ready to accept IHLW from Hanford beginning in FY 2029. However, until such a repository is ready for receipt of the IHLW canisters, the canisters will have to be stored and monitored on an interim basis at the IHSF. The IHSF will be designed to accommodate expansion in canister storage capabilities up to 16,000 canisters in case additional storage beyond 4,000 canisters is required.

3.6 222-S LABORATORY

The 222-S Laboratory is a full-service analytical facility located in 200 West Area that handles highly radioactive samples (Figure 3-18). Organic, inorganic, and radio-chemistry analyses are performed on a wide variety of air, liquid, soil, tank waste and biota samples. The laboratory provides support for a variety of essential tank farm activities, including tank-to-tank transfers, corrosion rate studies, and chemical testing to support tank corrosion inhibition, and input to the engineering specifications for each 242-A Evaporator campaign. The 222-S Laboratory also studies the physical and chemical characteristics of waste necessary to enable waste retrievals, provides data to support tank closure requirements, and supports the vadose zone program. In addition, 222-S Laboratory maintains the ability to analyze low-level and non-radioactive samples in support of developmental and industrial hygiene activities. A small business contractor (ATL) provides a service for routine analytical support at the laboratory.

Figure 3-18. 222-S Laboratory.

The 222-S Laboratory supports technology development for the RPP mission, including testing of proposed supplemental pretreatment and treatment processes using both simulants and actual tank waste, and verification of waste solid-liquid equilibria.

The 222-S Laboratory was constructed in 1950-51. The laboratory, supporting structures, and office space have been progressively enlarged and upgraded as the mission warranted. Currently, RA funding is being used to rebuild and upgrade the laboratory infrastructure, including securing new analytical equipment, replacing obsolete support facilities, modernizing the heating, ventilation, and air conditioning (HVAC) system, and other projects to extend the life of the facility in support of current mission needs. In the future, the 222-S Laboratory may provide support to WTP operations.

3.7 WASTE FEED INTERFACE

The most significant interface associated with the work described in this System Plan is the WTP feed delivery interface. Timely, efficient, and compliant delivery of waste feed from the tank farms to the WTP is the key interface component leading to success of the ORP mission.

The details of the feed delivery interface are described in ICD-19 (24590-WTP-ICD-MG-01-019). ICD-19 describes both physical and administrative details of the feed delivery interface and includes a description of unresolved items (open issues) that are currently in the reconciliation process. Important aspects of this interface that are still in the reconciliation process include a definition of WTP waste acceptance data quality objectives and an evaluation of the ability of the baseline tank farms equipment to sufficiently mix, accurately sample, and consistently deliver the individual HLW feed batches.

4.0 MODELING TOOLS

Sophisticated computer models are employed to plan and evaluate operating scenarios within the RPP system.

WRPS and BNI use a variety of computer models to facilitate long-range planning efforts at Hanford. Each model has its own strengths and purpose. Five of these models are described in this section.

> The HTWOS model calculates the flow of events occurring during the storage, retrieval, supplemental treatment, pretreatment, and vitrification of Hanford tank wastes over the course of the entire RPP mission.

Two dynamic models are at the heart of flowsheet planning for the RPP System. WRPS uses the HTWOS model, a dynamic event-simulation model programmed using the G2[34] programming language, to track the waste as it moves through storage, retrieval, feed staging, and multiple treatment processes from the present day until the end of the RPP mission. The HTWOS model forecasts the outcomes of various proposed operating scenarios, including the quantities and composition of the primary and secondary waste streams, the timing of key process steps, life-cycle system mass balances, and mission end dates. BNI uses the WTP Dynamic (G2) model to evaluate WTP facility equipment utilization, unit operations and plant performance, and to support process and facility design decisions, integration with the tank farms, and other activities.

Two OR models are also planned or in use. WRPS is currently developing a WFD OR model using WITNESS[35] software, which will address equipment reliability, availability, and maintainability for the DSTs, the 242-A Evaporator, and the waste transfer systems leading to WTP. In addition, a simplified OR model of the WTP is being developed and will be integrated with the WFD OR model to allow evaluation of the effects of equipment failures on the combined WFD/WTP system. Results from this model will support operational planning.

A TOC cost model is also being developed. It will be incorporated within HTWOS and integrated with current project management data to analyze the impact of technical or programmatic changes on RPP budget profiles and projected life-cycle costs and schedules.

4.1 DYNAMIC MODELS

4.1.1 Hanford Tank Waste Operations Simulator Model

The HTWOS model is a dynamic flowsheet simulation and mass balance model developed for ORP using commercially available Gensym[36] Corporation G2 software. The HTWOS model is currently maintained and operated by the WRPS Mission Analysis and Strategic Planning organization. HTWOS is used to:

- Simulate the current planned RPP mission

[34] G2 is a registered trademark of Gensym Corporation, Austin, Texas.
[35] WITNESS is a registered trademark of Lanner Electronics, Inc. (in the United States).
[36] Gensym is a registered trademark of Gensym Corporation, Austin, Texas.

- Evaluate the impact of changes to the RPP mission
- Evaluate integrated sets of technical and programmatic assumptions for internal consistency
- Assist in generating tank-specific SST waste retrieval flowsheets
- Support planning for near-term transfers, evaporator operations, BCRs, and project development.

The overall configuration of the major systems actively modeled[37] in HTWOS for this System Plan is consistent with Figure 1-2 (Section 1.4), and includes:

- 149 SSTs
- Two WRFs
- 28 DSTs
- 242-A Evaporator
- Waste transfer and routing systems
- ARF
- WTP process facilities, including:
  - PT Facility
  - LAW Vitrification Facility
  - HLW Vitrification Facility
- Supplemental TRU treatment system
- Second LAW facility
- LERF/ETF.

The HTWOS model incorporates about 790 waste treatment vessels and operations, and unenumerated transfer and routing system segments. Model execution time for a single run is generally 3-5 hours. The initial waste inventory is established by the BBI, a compilation of tank waste data derived from historical process records and laboratory analysis. The BBI is updated quarterly and encompasses 25 chemical constituents and 46 radionuclides, plus numerous supplemental analytes. This data is compiled in TWINS, along with water wash and caustic leach factors; current data is loaded into HTWOS before starting each planning effort.

The HTWOS model calculates the flow of events occurring during the storage, retrieval, supplemental treatment, pretreatment, and vitrification of Hanford tank waste. The HTWOS generally models relevant physical constraints (e.g., connections between unit operations, volumes of vessels, flow rates of pumps, capacities, and efficiencies of the equipment) and approximates waste chemistry (e.g., phase equilibriums and reaction extents). Unit operations are based on process flowsheets and/or mass balances when available and include project schedules and net operating capacities. The HTWOS model also incorporates the programmatic constraints from current plans or strategies, including (but not limited to) capacity, volume, performance, dates of availability, outages, and commissioning. Some parameters may be modified by customer direction, emerging information, or simplifying assumptions.

[37] Modules for several other facilities and processes, including fractional crystallization, the full ETF flowsheet, a Demonstration Bulk Vitrification System, the Bulk Vitrification System, the East and West supplemental treatment plants, and an interim pretreatment facility have been used in the past, and could be reactivated if needed in the future.

Results from the model can be used to prepare flowsheets and mass balances for the entire mission or for parts of the mission. An overview of general input categories, case-specific input categories, and results categories is provided in Figure 4-1 (page 62). Of particular importance is the generation of the WTP feed vector, which describes the feed that the tank farm will be providing to WTP under the conditions modeled. The number of batches in a feed vector varies depending on the scenario being modeled, but generally is in the range of 300-400 batches for the overall mission. In general, each feed batch contains waste from several SSTs and DSTs. Feed vector details for each batch include the DST source (either the specific DST or the ARF) where the batch is staged immediately prior to transfer to WTP, the total waste volume, weight percent solids, waste feed composition data, leach factors, and other information. The feed vector can be used as input to the WTP Dynamic (G2) model. Additional information on the WTP Dynamic (G2) model is provided in Section 4.1.2.

WRPS recently completed a comprehensive upgrade of the HTWOS model to bring it into alignment with current technical and programmatic assumptions, and to make it easier to use and maintain.

From late 2009 and through 2010, WRPS personnel implemented significant upgrades to the HTWOS model. These upgrades improved (1) the alignment between the model and current tank farm operating plans, and (2) the alignment between the model and the WTP flowsheet. Many aspects of HTWOS were affected, including:

- SST waste retrieval plans modeled in HTWOS are now aligned with the guidelines, recommendations, and assumptions for SST retrieval planning described in RPP-PLAN-40145. These guidelines include the retrieval technologies, tank sequencing strategy, waste retrieval methods, as-retrieved waste volumes, and minimum retrieval durations.
- The 242-A Evaporator campaign logic has been modified to ensure that:
  - At least 500 kgal of dilute feed is available for each evaporator campaign
  - Sufficient DST space is available to accept the projected volume of concentrate produced by a full campaign
  - The concentrate produced will not exceed the 10 M sodium limit specified by the WTP contract, Specification 7, Section 7.2.2.1.
- The functional flow block diagram for the operation of the DSTs has been improved to better simulate many areas of DST operations:
  - The function or role of each DST will be defined by the capabilities of its installed equipment, in accordance with RPP-40149. In addition, each tank's availability for service will be determined by its construction schedule for equipment installation and for its current waste inventory.
  - HTWOS dynamically assigns allowable functions (such as dilute receivers or HLW feed staging) to DSTs based on installed equipment, established operating criteria, equipment capabilities, and evolving system demands.
  - The improvements in the operation of the DSTs have also increased the degree of sludge blending, both incidental and intentional, using only the existing tank space. This is expected to increase the waste oxide loading and reduce melter feed

variability, thereby reducing the total mass of glass predicted, which in turn shortens the waste treatment project duration and reduces life-cycle costs.

  - The new logic ensures that the required emergency space is maintained in the DSTs at all times. The previous version of HTWOS did not explicitly maintain the required emergency space. This resulted in over-allocation of the DST system with retrieved SST waste during a brief period in the System Plan (Rev. 4).
  - DSTs that currently store wastes containing complexant concentrates will be kept segregated so as to minimize the risk of creating additional TRU waste, which requires additional processing.

- A simplified model for the proposed ARF has been developed and incorporated into HTWOS, based on an evaluation of preliminary experimental results (Shuford 2010). This represents a significant planning improvement over the System Plan (Rev. 4), in which the impact of the ARF was calculated by Excel spreadsheets, not HTWOS, and without the benefit of experimental data.
- In HTWOS, the WTP flowsheet (equipment configuration, capacities, chemical reactions and extents, operating modes and logic, process splits and decontamination factors) used for mission modeling was updated to better reflect the planned WTP flowsheet, and to match naming conventions between the two models. Certain simplifications and changes from the WTP flowsheet were made, as discussed in Appendix B.
- The new 2009 GFM was implemented in HTWOS. A GFM is a collection of empirical property correlations and their associated limits and a set of model validity and solubility limits. Given a pretreated HLW feed, the GFM can predict the amount and composition of the resulting HLW glass. This information assists in predicting mission duration and long-term disposal requirements. The previous GFM in HTWOS was based mostly on 1996-era glass data (WHC-SD-WM-TI-768, *Tank Waste Remediation System Phase I High-Level Waste Feed Processability Assessment Report*, and PNNL-11790, *Liquidus Temperature Data for DWPF Glass*), with some relaxed constraints resulting from additional more recent research. Since 1996, significant amounts of glass property and solubility data have been collected, providing the opportunity to expand the range of the validity of the GFM. Also, a clearer understanding of the solubility of the HLW glass components left some of the older solubility constraints in need of updating. In late 2009, PNNL issued an updated GFM, PNNL-18501, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*, which incorporated these improvements. The new 2009 GFM was subsequently implemented in the HTWOS model. For the time being, the 1996 GFMs will be retained in HTWOS to facilitate sensitivity analyses.
- HTWOS includes two LAW GFMs—the DOE 2004 LAW GFM and the WTP baseline LAW model. The WTP baseline LAW GFM was updated in HTWOS to be consistent with the GFM used in 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions and Requirements Document*.

All of these improvements were subjected to a rigorous verification and validation effort to ensure that the HTWOS model would continue to perform as expected. Figure 4-1 summarizes the capabilities of the HTWOS model.

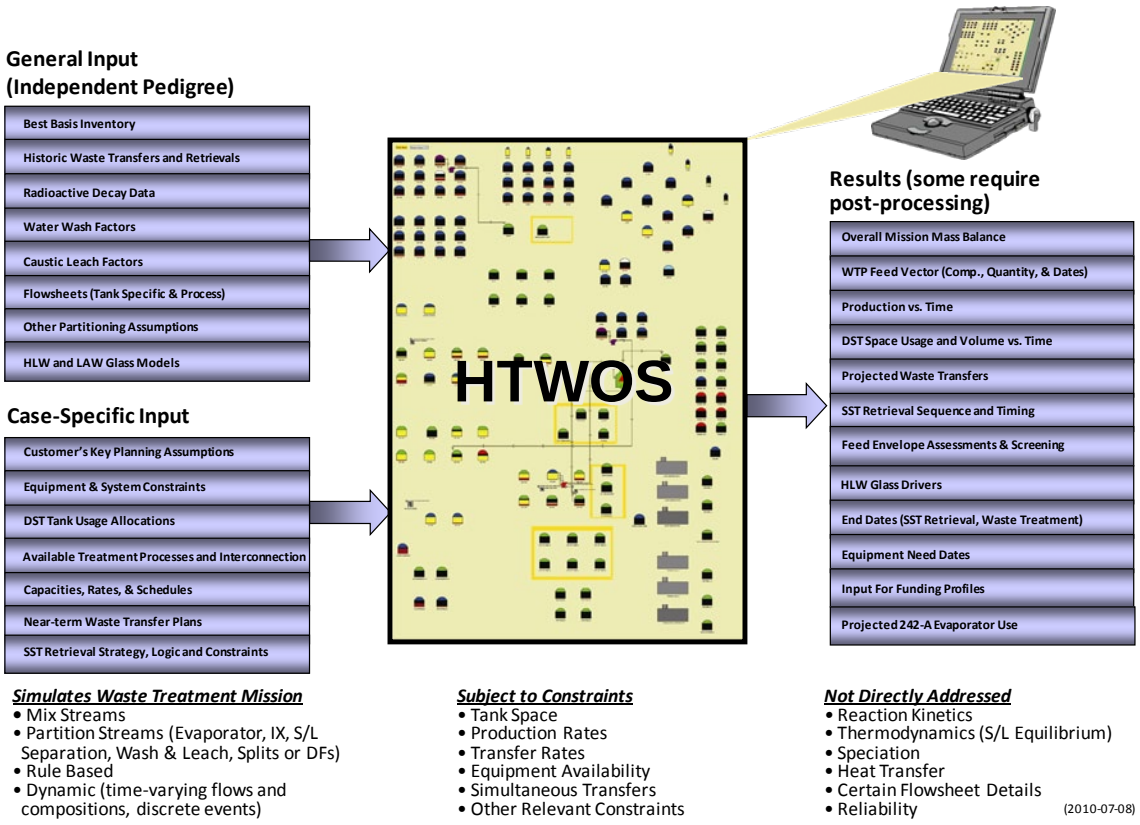


Figure 4-1. Hanford Tank Waste Operations Simulator.

As explained previously in Section 1.7, a detailed description of the key assumptions and success criteria used to develop this System Plan are provided in Appendix B. RPP-17152 documents how these assumptions were incorporated into the HTWOS model and provides more detailed modeling assumptions and descriptions of how the model works.

4.1.2 Waste Treatment and Immobilization Plant Dynamic (G2) Model

Like the HTWOS model, the WTP Dynamic model is based on Gensym Corporation G2 software. The WTP contractor, BNI, uses this model to:

- Evaluate WTP tank and equipment utilization, unit operation, and plant performance
- Predict reagent demand
- Support WTP process and facility design
- Support preoperational planning assessments
- Support technical integration with the tank farms regarding waste feed staging
- Support product and secondary waste acceptance activities.

In addition to the WTP feed vector from HTWOS, input to the WTP Dynamic model includes vessel volumes, pump flow rates, chemical reagents, sampling turnaround times, and appropriate research and technology data (e.g., filter flux data and melter off-gas data). Output data includes waste batch delivery predictions; volume history data, with plots for each vessel; sodium molarity and weight percent solids for each process vessel; cumulative mass transfer for every process stream; cumulative glass production; and waste loading and limiting constituents of

glasses. These data are interpreted to determine utilization rates for chemical reagents, process condensate and demineralized water, utilization of cesium ion-exchange resin, utilization of mineral glass formers, the volume and composition of pretreated LAW and LAW submerged bed scrubber recycle to the second (supplemental) LAW facility, and the volume and composition of waste water discharge.

Additional information about the WTP Dynamic G2 model is provided in the most current version (Rev. 10) of 24590-WTP-MDD-PR-01-002, *Dynamic (G2) Model Design Document*, and the underlying process flowsheet described in the most current version (Rev. 5) of 24590-WTP-RPT-PT-02-005.

4.2 OPERATIONS RESEARCH MODELS

4.2.1 Waste Feed Delivery Operations Research Model

WRPS personnel are currently developing a new WFD OR model, which will fill a unique niche in long-range planning efforts. The HTWOS model incorporates simplifying assumptions that (1) the WTP vitrification facilities will achieve an integrated 70% total operating efficiency, (2) the SST retrieval systems will each support the required total operating efficiency, and (3) that other systems can operate to support that rate. However, the WFD OR model will focus on uncertainties in tank farm operations such as random equipment failures, outages, and planned maintenance activities. In this way, the WFD OR model will be able to quantify the impact of equipment reliability, availability, maintainability, and inspectability to provide an accurate reflection of day-to-day tank farm operations and to provide a basis for improved operational planning.

The WFD OR model is being created using WITNESS, a commercial off-the-shelf process simulation software developed by the Lanner Group. The WFD system specifically includes the 28 DSTs, the 242-A Evaporator, and numerous waste transfer lines, pump pits, valve pits, jumpers and valves; in all, approximately 525 system components are represented. The availability data for the various systems and equipment has been derived from actual operating experience at Hanford, from similar experience at SRS, and from generic reliability databases when no indigenous source could be found.

Model development is proceeding in phases:

- **Phase 1**: The initial version of the WFD OR model, Phase 1, was developed to repeat the DST waste transfers as predicted by a simplified version of the HTWOS model run for the System Plan (Rev. 4) Unconstrained Case. By repeating the HTWOS sequence of events, the WFD OR model was able to incorporate most of the assumptions that form the basis for the HTWOS model run. This phase was completed in September 2009.
- **Phase 2**: In addition to modeling equipment failures, the Phase 2 OR model includes restoration times and then estimates the effects of failures on mission duration. Bottleneck analyses have been performed to identify those systems that contribute the most to mission delays. These systems are waste transfer pumps, waste transfer lines, and waste transfer jumpers. This information will be used to update WFD maintenance systems and potential designs to improve their reliability and availability. WITNESS is used to simulate equipment failures based on the reliability assumptions for each piece of equipment to estimate the impact on the WFD system. The reliability and restoration

data is a combination of Hanford-specific data, applicable SRS data, and generic data chosen by examination of Hanford operating experience. Phase 2 was completed in August 2010 (RPP-RPT-45827, *Phase 2 Waste Feed Delivery Operations Research [OR] Model Assessment Report*).

- **Phase 3**: This phase will begin to decouple the WFD OR model from strict reliance on the specific transfers projected by HTWOS and allow modeling of the response to failures of critical transfer equipment, taking advantage of the inherent flexibility of the DST system. Phase 3 will also model the WTP to the extent needed to evaluate the effects of equipment failures in one facility on other facilities. The Phase 3 effort is scheduled for completion by the end of FY 2011.

4.2.2 Waste Treatment and Immobilization Plant Operations Research Model

Bechtel maintains an OR model of the WTP as part of the WTP statement of work, as outlined in the WTP contract. Similar to the WRPS WFD OR model, the Bechtel WTP OR model also uses Lanner's WITNESS software. The Bechtel model simulates WTP operations, including PT, HLW, LAW and Analytical Lab, and the glass former facility, and is used to estimate the availability of these systems.

4.3 TANK OPERATIONS CONTRACT COST MODEL

A new cost model is being developed to help WRPS more quickly evaluate the near-term and life-cycle cost impacts of proposed operational and flowsheet changes within the RPP system.

Currently, two separate software programs are used jointly to project cost impacts: HTWOS, which defines the operating scenario by simulating field operations like waste transfers, retrievals, evaporator operations, and waste treatment processes; and Primavera Enterprise Project Portfolio Management[38] (P6), which tracks project resources, costs and schedules, including earned value metrics, milestones dates, work breakdown structure (WBS) summaries, and other project management tools. Each program serves its intended purpose well, but using them in tandem as currently configured to predict life-cycle cost impacts presents some concerns. For example, both models incorporate RPP-specific assumptions, but (1) there is no easy way to confirm that the assumptions in one model are fully consistent with the assumptions in the other model, (2) data sharing between these two programs must be done manually, and (3) the results are analyzed by individual subject matter experts rather than an automated system, which could be verified and validated. The length of time required for generation of scenario input and completion of HTWOS model runs and to iterate with P6 to generate a schedule with escalated costing data does not facilitate timely evaluation of life-cycle cost and schedule impacts.

Consideration was given to implement a new tool to address these concerns, but that option was rejected because of (1) the costs associated with purchasing a new tool; (2) the additional time required for personnel to become proficient at using the new tool; (3) the lack of existing resources, personnel, and equipment available to support the addition of a new tool; and (4) the additional complexities of managing the assumptions for yet another tool.

[38] Primavera Enterprise Project Portfolio Management is a registered trademark of Primavera Systems, Inc. (in the United States).

In June 2010, a contract was awarded to develop and deploy a life-cycle cost model (LCM) tool as a module within the HTWOS model that will integrate data used by both HTWOS and P6. Work will proceed in three defined tasks:

- Task 1 – Prepare an LCM tool deployment plan, define model design requirements in an issued model modification request, and initiate programming in 2010.
- Task 2 – Develop and implement the LCM, including verification and validation in 2011.
- Task 3 – Convert the HTWOS model into a high-level planning model with sensitivity analysis, optimization analysis and alternative capabilities, including verification and validation, in 2012.

5.0 CASE EVALUATION AND RESULTS

The detailed mission scenario for the Baseline Case provides the basis for planning and executing the RPP Mission in a way that strives to meet the success criteria.

The primary purpose of this section is to describe and evaluate the mission scenario based on the Baseline Case assumptions and serve as technical basis for future revisions of the PMB and detailed plans and strategies. After brief discussion of highlights and observations, the results for the Baseline Case are presented and organized according to the simplified process flow diagram in Figure 1-2 (Section 1.4) and the discussion in Section 3.0.

Section 5.9 includes an evaluation of the changes in the amount of HLW and LAW glass from System Plan (Rev. 4), and describes two HLW glass mass sensitivity studies. Section 5.10 provides the summary results for Sensitivity Case A.

Finally, this System Plan provides WTP feed vectors for both the Baseline Case and a no-ARF variant of the Baseline Case to facilitate more detailed analysis.

Unless explicitly stated otherwise, all results in Section 5.0 are specific to the Baseline Case.

5.1 METHODOLOGY

The detailed mission scenario for the Baseline Case was developed from a series of over fifty HTWOS model runs. HTWOS Version 5.0 was first updated with the technical and programmatic assumption provided in Appendix B, then a series of iterations and alignments were performed. These include:

- Iterating over the minimum SST retrieval durations to establish an initial requirement for SST retrieval performance[39]
- Iterating over the equipment and associated schedule for the DST upgrade projects (i.e., with the Integrated WFD Plan)
- Aligning with near-term operational planning (SST retrievals, evaporator operation, DST transfers)
- Establishing the capacity of the second LAW facility
- Establishing the “bootstrap transfers” needed to prepare and stage the initial HLW feed batches for delivery to the WTP

[39] The total operating efficiency (TOE) for each retrieval process was estimated based on experience and assumed future operating conditions. These estimated TOEs were low and inadequate to support future retrieval goals; using these original TOEs, all SSTs were projected to be retrieved by 2044 and all waste treated by 2049. The assumption was made that improvements would be made to operating conditions and procedures for all retrieval operations after C Farm such that the TOEs would be doubled. The results of this parametric study are documented in RPP-RPT-46711, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 5 Cases*. See the corresponding key issue and uncertainty in Table 7-2, Item 3, Potential Mitigating Action ii.

- "Debottlenecking" the system by:
  - Adjusting the use of the DSTs over time to balance the supply of HLW and LAW feed to the ARF and WTP, while backfilling the newly freed DST space with waste from SST retrievals
  - Determining the number of feed and product tanks and the volume of the recycle caustic tank in the ARF to avoid restricting delivery of feed to the WTP
  - Developing or implementing strategies for the metered blending of the high zirconium sludge in Tanks AW-103 and AW-105, blending of the enriched uranium in Tank C-104, mitigation of the Group A flammable gas tanks, and precipitating the strontium and TRU from the supernate currently in Tanks AN-102 and AN-107.

The verified model and the scenario resulting from the above series of runs became the final System Plan (Rev. 5) Baseline Case and was subsequently released as HTWOS Version 6.0 (RPP-17152).

A summary of the model run requests for the Baseline Case, Sensitivity Case A, and the no-ARF variant of the Baseline Case, along with the associated spreadsheets and other results, is provided in RPP-RPT-46711, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 5 Cases*, for traceability. These include reference to the corresponding WTP feed vectors, feed screening spreadsheets, and more detailed life-cycle mass balances.

5.2 HIGHLIGHTS

Table 1-1 (Section 1.10) summarizes and compares the key results from the Baseline Case with the success criteria. Figure 5-1 provides a simple mass balance for the Baseline Case. Section 5.10 provides the corresponding figure (Figure 5-17) for the Sensitivity Case A.

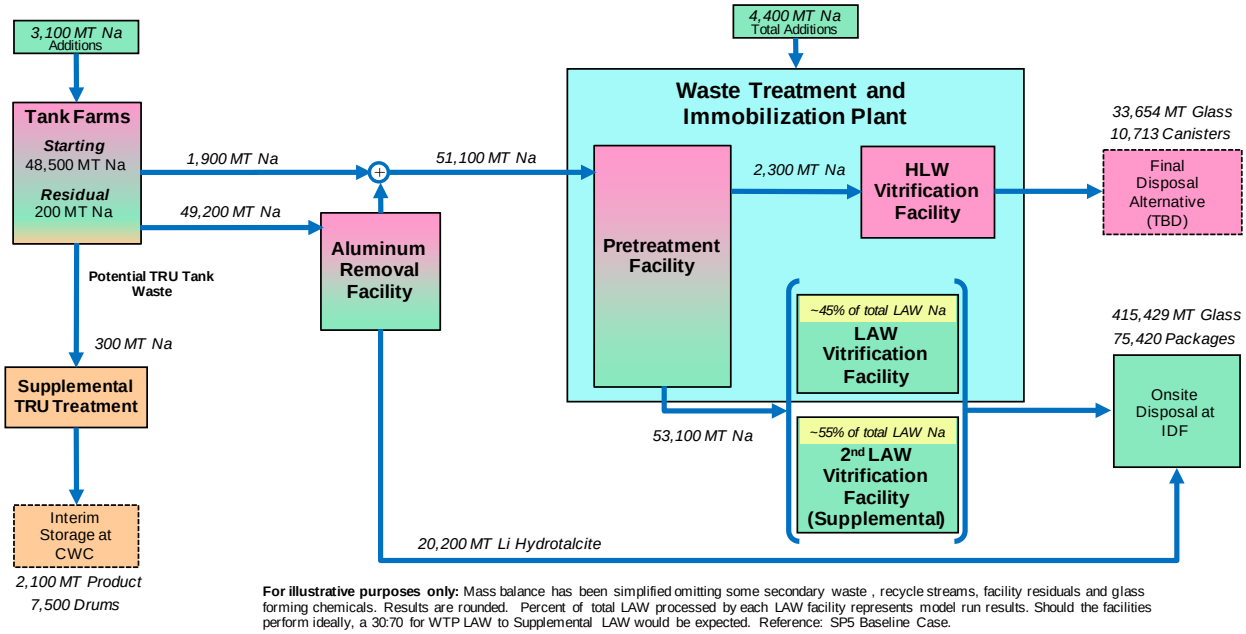


Figure 5-1. Simple Mass Balance for the Baseline Case.

5.3 OBSERVATIONS

Many of the assumptions for the Baseline Case are the same as those used in the Baseline Case in the System Plan (Rev. 4). The more notable changes from these assumptions are described below.

Programmatic Assumption Changes

- The schedule for the supplemental LAW vitrification facility was delayed one year.
- The schedule for the IHSF was delayed approximately one year.
- The schedule for DST and infrastructure upgrades and the specific equipment and functions planned for each DST were aligned with RPP-40149 (Rev. 1).

Technical Assumption Changes

- The model for the WTP was realigned to the WTP flowsheet and design as represented by 24590-WTP-MDD-PR-01-002 (Rev. 10) and 24590-WTP-RPT-PT-02-005 (Rev. 4), except when updated by other assumptions.
- The new HLW glass model (2009 GFM) was used to formulate HLW melter feed batches rather than the 1996 GFM.
- SST retrieval assumptions were updated.
- The assumed solids handling capabilities and limitations during routine operation of the DST system were updated and aligned with RPP-40149 (Rev. 1), including:
  - Supernate can be pumped down to within 12 in. of a settled solids layer or above the bottom of the tank
  - Slurry can be pumped down to within 36 in. of the bottom of the tank for DST to DST transfers
  - An enabling assumption[40] that the maximum settled solids level that can be effectively mobilized and well mixed using two mixer-pumps without incremental insertion capability is 70 in., with an allowance for mixing up to a nominal 76 in., will be assumed for the blending of Tank C-104 sludge
  - The minimum slurry level in DSTs actively delivering HLW feed to the WTP or ARF is 72 in. to ensure well-mixed feed.

Modeling Methodology Changes

- The Baseline Case, including the ARF, was explicitly modeled in HTWOS rather than approximated using spreadsheet calculations.
- The WTP LAW Vitrification Facility and the second LAW vitrification facility were modeled as separate facilities rather than a single facility with their combined capacity.

[40] This constraint is not explicitly modeled in HTWOS – it is implemented indirectly by controls on other parameters. Model results are reviewed for degree-of-compliance.

For most of the waste treatment mission, the duration the Baseline Case is driven by the HLW vitrification capacity, followed by the total LAW vitrification capacity and WTP pretreatment capacity.

In the early years, through 2025, the waste treatment mission is driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and the second LAW facility, which limits the amount of HLW that can be pretreated and prepared for vitrification. The effect is magnified in the years before the ARF comes online due to the amount of LAW waste generated during the pretreatment of HLW solids (see Section 5.5.2.1).

The management of DST space, up until all facilities have reached their full net capacities, is critical in maintaining progress with SST retrievals. After the retrieval of C Farm and the nine additional SSTs is completed, minimal DST space is available to support additional SST retrievals. If the Baseline Case plays out as projected, with the nine additional SST retrievals completed in FY 2017, there will be little or no DST tank space available to support SST retrievals from 2018 to 2022. A more detailed discussion of DST space management is provided in Section 5.4.2.1.

Sensitivity Case A exhibits similar behavior as the Baseline Case for both near-term and overall mission drivers. Sensitivity Case A also produces significantly more HLW glass (13%) than the Baseline Case due to the increased amount of tank waste processed through the WTP and consequently completes the treatment mission about 15 months later.

5.4 STORAGE

5.4.1 Single-Shell Tanks

The SSTs are projected to be retrieved by October 2039, with the C Farm retrievals being completed in July 2013.[41] Figure 5-2 shows the historical and projected SST retrieval progress as measured by the approximate volume of original waste remaining in the SSTs as a function of time. As discussed in Section 5.4.2.1, there is minimal DST space available to support SST retrievals between 2018 and 2022, and there is uncertainty in meeting the projected retrieval completion date for the nine additional SSTs (currently assumed to be from A and AX Farms).

Depending on the final WFD requirements (i.e., mixing requirements for feed characterization or mixing requirements for remobilization and blending of waste), DST space could be further constrained and jeopardize the timing of retrieval of the nine additional SSTs.

Figure 5-3 shows the number of retrievals that were completed or are projected to be completed during each fiscal year. The number of retrievals completed each fiscal year increases significantly after 2025, when all treatment facilities are on-line at their full capacity. It may be possible to reduce the peaks by carefully adjusting the detailed SST retrieval assumptions.

[41] These projected dates are contingent on the successful deployment of the MARS vacuum tool and incorporation of lessons learned during MARS-sluicing operations in Tank C-107. This tool is still under development and the actual retrieval durations and deployment logic may be different than currently assumed.

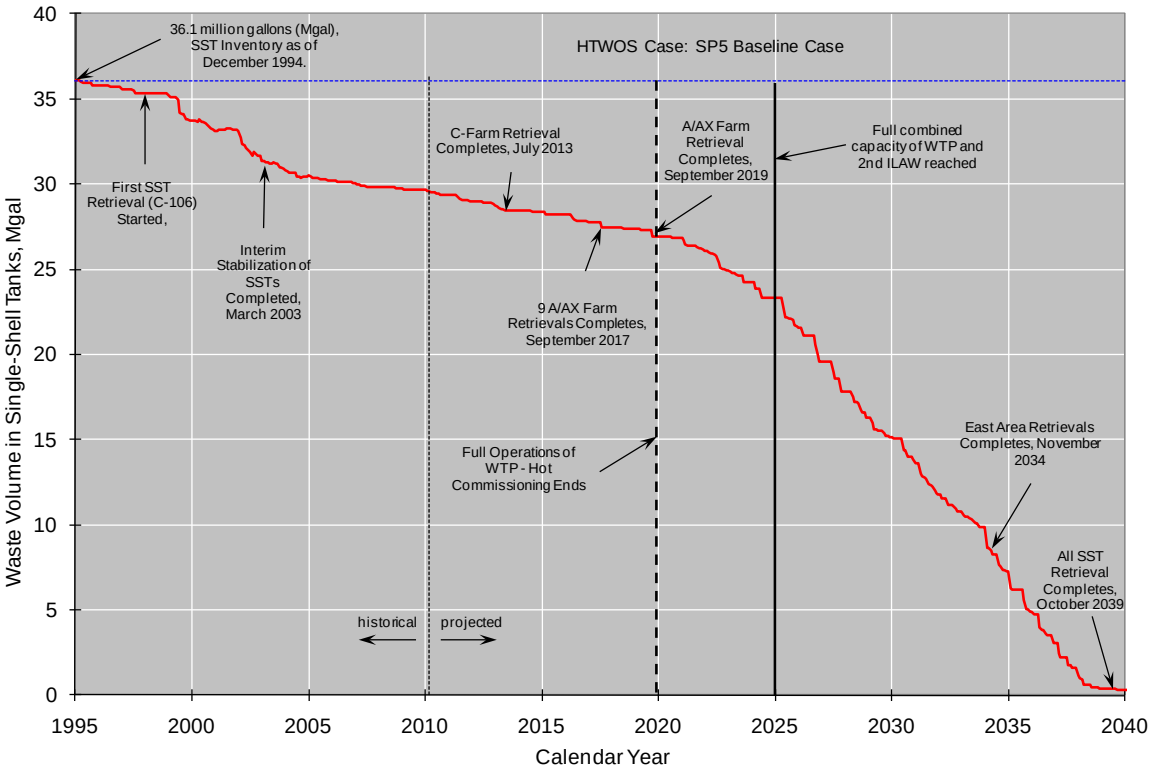


Figure 5-2. Overall Single-Shell Tank Retrieval Progress.

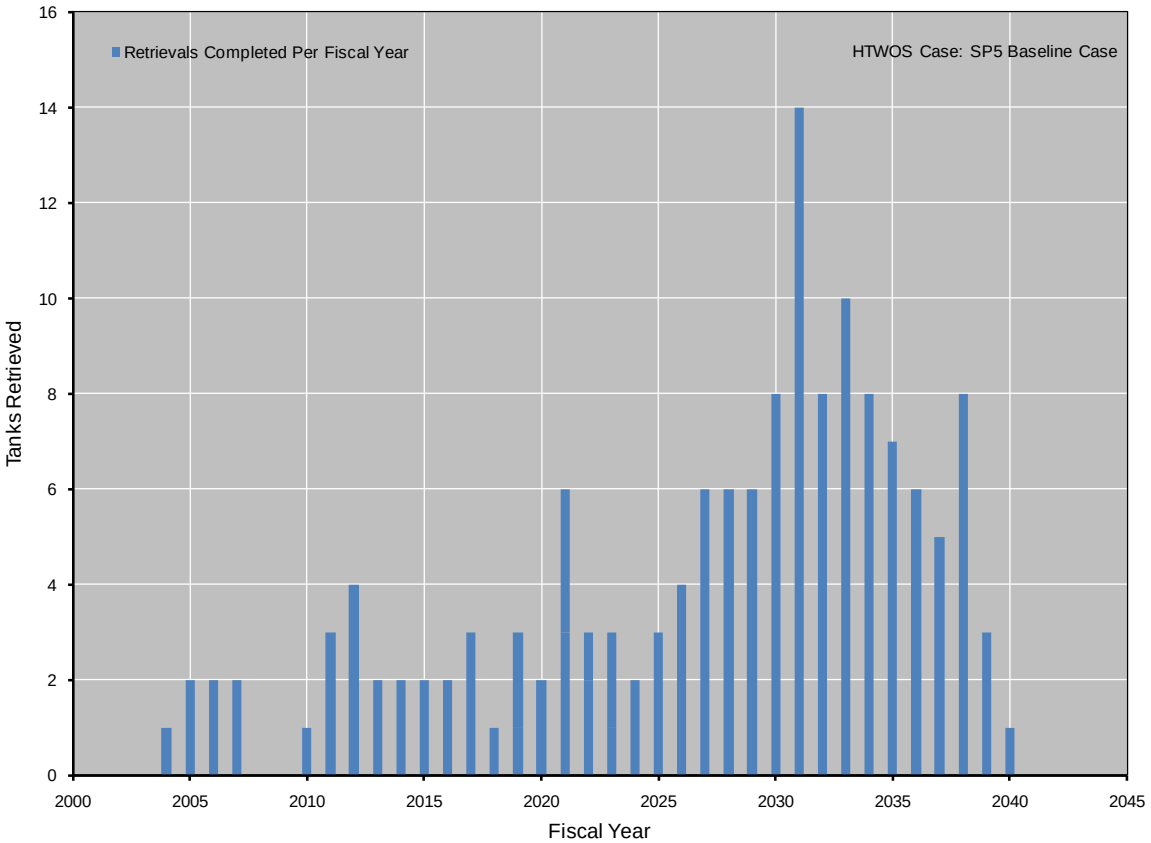


Figure 5-3. Single-Shell Tank Retrievals Completed Each Fiscal Year.

Figure 5-4 shows the general timing of the SST retrievals, grouped by tank farm. Most retrievals in a given farm are clustered together. This is a significant operational and logistical improvement over the System Plan (Rev. 3A) Reference Case in which retrievals from several individual farms were spread out in time over many years. However, a trade-off resulting from using this approach is a decrease in the amount of incidental blending of sludge, which results in an increase in the total projected mass of HLW glass as was seen in System Plan (Rev. 4). The updated WFD strategy (enhanced incidental and intentional blending) and updated WTP flowsheet used in System Plan (Rev. 5) appear to have offset this effect. Additional intentional blending scenarios using the farm-based retrieval approach may be examined in the future to attempt to further reduce the amount of HLW glass and the variability of HLW feed.

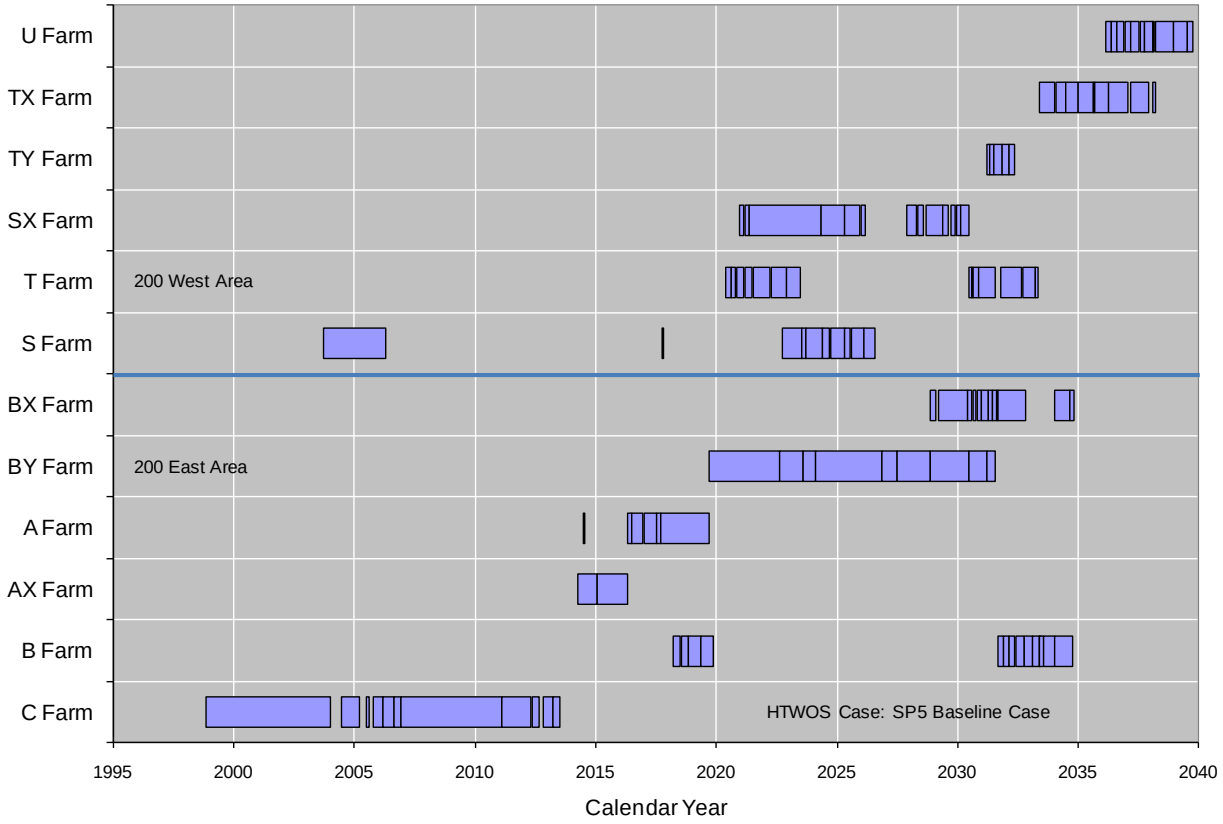


Figure 5-4. General Timing of Single-Shell Tanks Retrievals by Tank Farm.

Figure 5-5 shows the sequence and timing of each SST retrieval. The DST tank space is extremely limited for the retrievals enclosed in the two yellow ovals. The start of many of these retrievals would probably be delayed several years to avoid having the tanks and associated retrieval equipment sitting idle during periods of inadequate DST space. A more detailed discussion on DST space management is provided in Section 5.4.2.1.

Appendix D presents the sequence and timing for each SST retrieval along with projections of retrieval volumes and DST space impacts in tabular form.

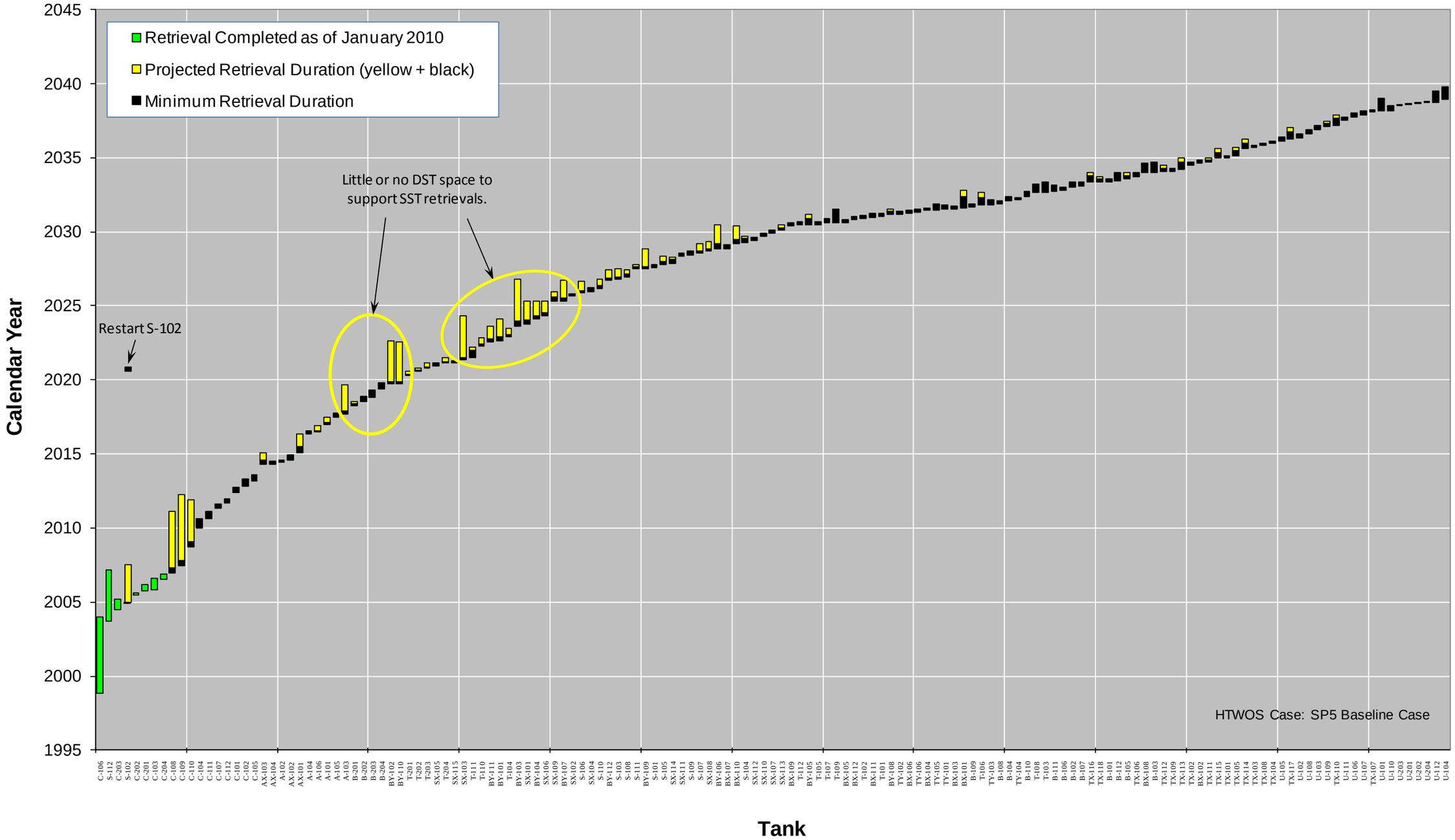


Figure 5-5. Single-Shell Tank Retrieval Sequence and Timing for the Baseline Case.

5.4.2 Double-Shell Tanks

This section includes discussion on both DST space management and on the use of the DSTs to support the RPP mission.

5.4.2.1 Double-Shell Tank Space Evaluation

Figure 5-6 shows the overall use of the DSTs for the overall waste treatment mission. It shows the total DST capacity,[42] the total volume of waste, the portion that was retrieved from the SSTs, and the various allocations of headspace for purposes other than waste storage (see Table 5-1). Space is extremely limited from 2015 to 2022, at which time the startup of the ARF frees up several million gallons of DST tank space as its feed and product tanks are filled. This beneficial side-effect may be less noticeable once the rate-limiting steps for processing in the ARF are understood and modeled. Tank space is made available to continue retrievals as the ARF begins operations and as the waste treatment system reaches full capacity in 2025.

Although there are between 1.5 and 3 Mgal of unallocated DST space available from 2015 to 2022, that space is not readily usable. The available space is distributed among several tanks and not always directly usable without a complicated series of waste transfers and evaporator staging operations. As the DST system nears capacity, it is increasingly difficult to conduct SST retrieval, evaporator, and feed staging operations.

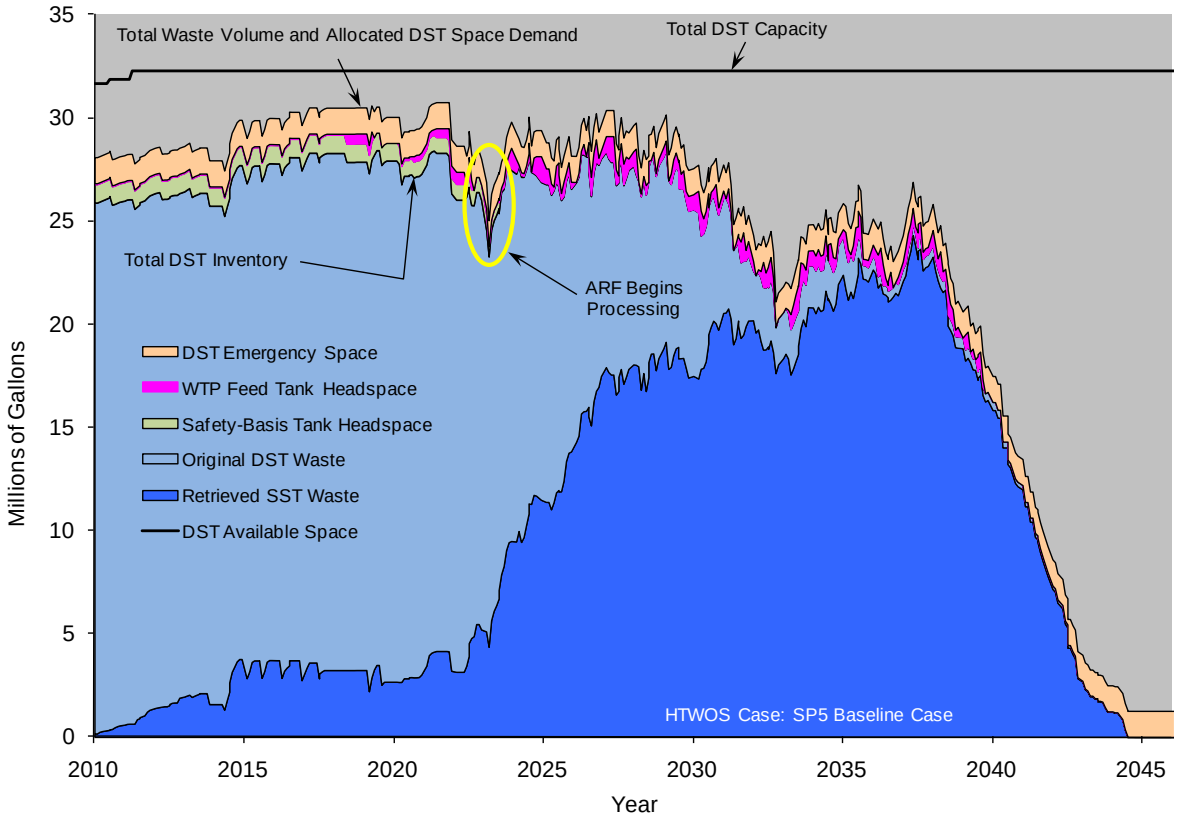


Figure 5-6. Use of the Double-Shell Tanks.

[42] The total DST capacity line reflects existing and planned increases in the maximum operating volume of the AP Farm DSTs.

Table 5-1. Double-Shell Tank Headspace Categories.

Category	Description
DST emergency space	1.265 Mgal of DST tank space that could be used to receive waste in the event of a leaking DST or emergency returns from the WTP (see Appendix B, Assumption B3.2.2.3).
WTP feed tank headspace	Space above waste specifically identified as an early WTP feed source or in tanks used to deliver feed to the WTP (or ARF) through the mission.
Safety-basis tank headspace	Space in tanks that cannot be used because of a safety issue associated with the waste. Currently, only the Group A tanks are in this category.

ARF = Aluminum Removal Facility.
DST = double-shell tank.
Mgal = million gallons.
WTP = Waste Treatment and Immobilization Plant.

After the retrieval of C Farm and the nine additional SSTs is completed, minimal DST space is available to support additional SST retrievals. If the Baseline Case plays out as projected, with the nine additional SST retrievals completed in FY 2017, there will be little or no DST tank space available to support SST retrievals from 2018 to 2022. Many SST retrievals are started during that period, only to sit idle until the WTP frees up enough tank space for them to continue (see Figure 5-5, inside the yellow circles—the yellow bars represent the portion of the total retrieval duration that is due to lack of tank space, and the black portion of the bar represents the minimum retrieval duration for that tank). During that period, the retrieval of the B Farm and T Farm 200-series tanks continues, since they are retrieved directly to the supplemental TRU packaging system and do not rely on DST tank space. To continue retrievals between 2018 and 2022, additional pathways for the early treatment of LAW, or additional storage space either as new DSTs or from a proposed feed characterization project, would need to be provided.

The DST space needed to adequately stage, sample, and blend solids for delivery to the WTP is still under evaluation. Once these WFD requirements are refined and modeled, the timing of the retrieval of nine additional SSTs may be impacted.

The management of DST space is one of the key issues and uncertainties. Factors that need to be considered include:

- BDGRE controls for sludge.
- The assumption that the evaporator can on average be run to reach a specific gravity (SpG) of 1.43 without precipitation of problematic quantities of solids or exceeding the evaporator's source term constraints.
- The allocation of a four-month period for sampling and analysis of waste in preparation for processing in the 242-A Evaporator may cause bottlenecks when retrieving dissolved saltcake. Alternative sampling and staging strategies should be considered.
- Uncertainties in the inventory and as-retrieved volumes of the SSTs retrieved before 2027.
- Potential delays in startup of WTP.
- Changes in mission configuration (early additional pretreatment and LAW treatment capacity, need for the ARF).

Because DST space is so limited, small perturbations or uncertainties in assumptions, plans, or actual field operations can cause large shifts in near-term plans as the available space approaches zero. This means that the retrieval of the nine additional SSTs by the projected early retrieval date of September 2017 or by the September 2022 success criteria, without running out of tank space, continues to be at risk. If this risk is realized, those retrievals might not complete until after 2025. Alternatives for the more effective use of DST space are being evaluated and will be incorporated into future mission scenarios. The proposed feed characterization project or an enhanced WRF might provide some transient relief of DST tank space demand.

The PMB assumes that improvements in DST space management will support the SST retrieval schedule projected for the Baseline Case. To that end, DST space management is considered one of the key issues and uncertainties and is addressed as a critical risk by the RMP (TFC-PLN-39). The key issues and uncertainties associated with DST space management and list of the potential mitigating actions are provided in Table 7-1.

5.4.2.2 Use of Double-Shell Tanks for the Baseline Case

The series of runs used to develop the Baseline Case (see Section 5.1) resulted in a DST utilization strategy, consistent with RPP-40149. A diagram showing the interaction between functions performed in each DST and the general flow of wastes from external sources through the DSTs to the ARF and WTP is presented in Figure 5-7. The solid red and blue lines indicate waste transfers of slurry and supernate, respectively. The dashed green lines indicate a dynamic reassignment of a DST from one function to another.

The DSTs are used in various major roles throughout the RPP mission. In general, the roles of each DST change over time. The dynamic assignment of the roles over time is the key challenge in optimizing the use of the DSTs to support the RPP mission. These roles or functions include (1) safely storing the existing DST waste, (2) receiving, storing, and transferring wastes from external sources such as the 222-S Laboratory and SST retrieval, (3) staging feed and receiving concentrated waste from the 242-A Evaporator, and (4) blending, staging, and delivering LAW and HLW waste to the WTP and ARF. There are also a couple of specialized functions dealing with the mitigation of the Group A tanks and the in-tank removal of strontium and TRU from the complexed concentrate waste.

For each of these DST functions, specific equipment requirements have been established for the types, quantity, and configuration of transfer and mixer pumps to effectively perform these functions. The DSTs are used in a manner consistent with the required equipment. The plan for the upgrading the equipment and infrastructure for the DSTs to successfully achieve the waste feed delivery objectives is provided in RPP-40149. Further details on the equipment installed in each DST and when the equipment was installed can be found in RPP-40149 and RPP-17152.

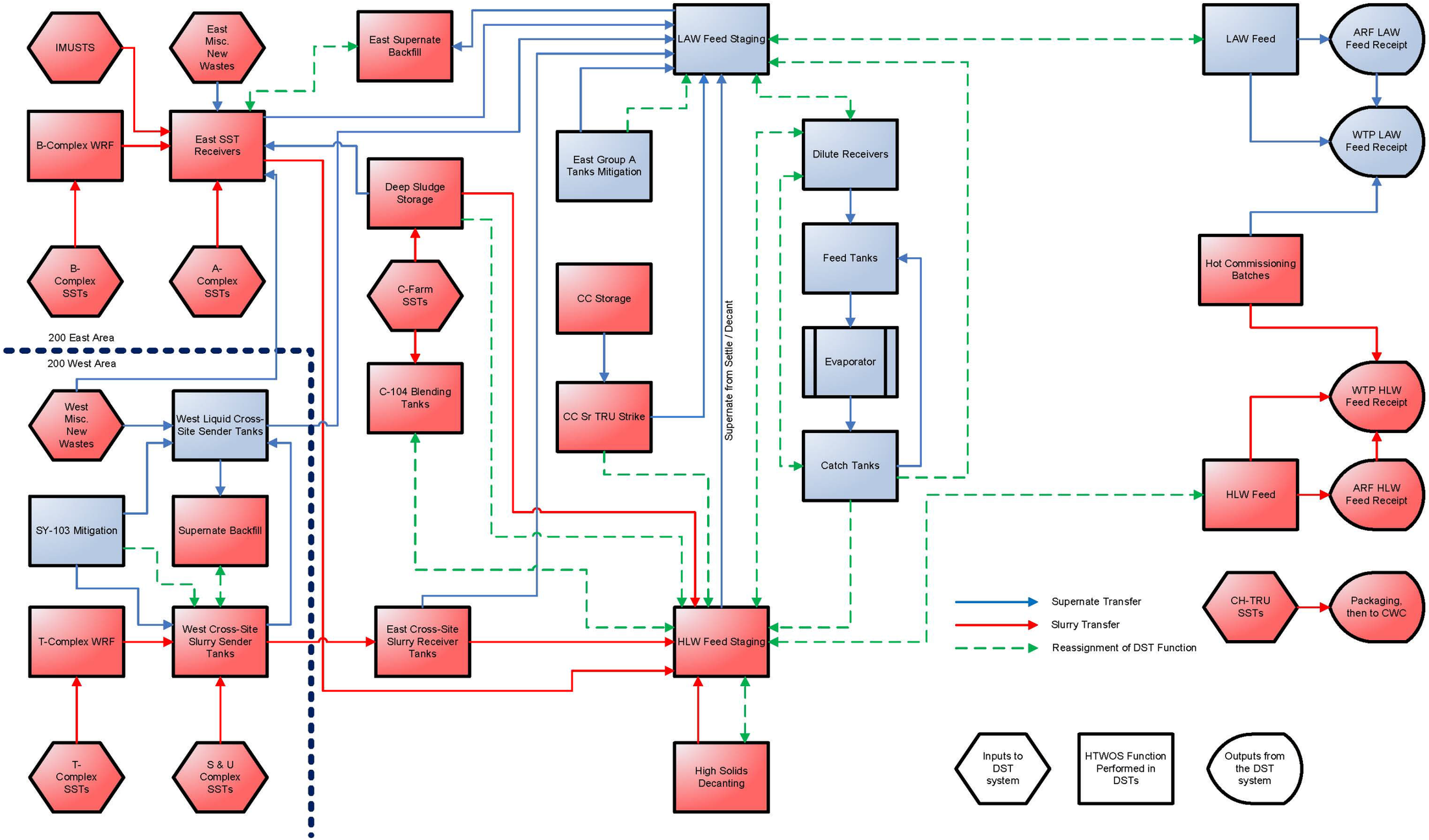


Figure 5-7. Use of Double-Shell Tanks to Support Single-Shell Tank Retrievals and Waste Feed Delivery.

A cursory review of the availability of staged feed for delivery to the WTP and the ARF was performed by inspecting the projected dwell time[43] for each batch of feed. Most of the feed batches are ready for delivery in advance of the projected need date. An analysis of the amount of staged feed ready for immediate delivery over time could be performed and the results used to help refine the utilization of the DSTs.

5.4.2.3 Early Feed Deliveries and Feed Staging Plan

The first four tanks of HLW feed projected to be delivered to the WTP or ARF are summarized in Table 5-2, along with a summary of the steps needed to prepare that feed. The subsequent HLW feed deliveries are available as part of the list of all projected DST transfers, as referenced in RPP-RPT-46711. The reuse of Tank AY-102 (after the hot commissioning feed is delivered) for the second tank of staged HLW feed is a result of giving support for SST retrievals higher priority than pre-staging early feed batches for the WTP. It may be prudent to stage the first several tanks of HLW feed early or to reserve a portion of the DST tank space to support initial feed staging and waste feed delivery operations rather than attempting to backfill all available space with retrieved SST waste. This would ensure that those first few tanks of HLW are ready to go regardless of how full the DST system becomes.

LAW feed batches, other than the hot commissioning feed, is fungible (i.e., readily interchangeable with other LAW feed), and therefore not highlighted in this document. The LAW feed deliveries are also available as part of the list of all projected DST transfers as referenced in RPP-RPT-46711.

A discussion of the projected LAW and HLW feed batches against WTP screening criteria is provided in Section 5.5.2.3.

[43] In this context, “dwell time” refers to the duration that waste staged for delivery to the WTP or ARF sits in a DST without any further transfers into or out of the DST. This time is used by the TOC to mix the waste if needed, obtain samples, and meet the schedule-related interface requirements for delivery.

Table 5-2. High-Level Waste Feed Staging Plan.

Order[a]	Feed Tank[b]	HLW Deliveries		Preparation Steps[c]				
				Transfers				
		Start Date	Volume (kgal)	From	To	Start Date	Volume (kgal)	Type
1	AY-102 hot commis-sioning	5/15/2018	156	Mix-Sample-Wait (ready for delivery 4/6/2018[d])				
		5/27/2018	156					
		4/5/2019	156	AY-102	WTP[e]	5/1/2018	123	Supernate
2	AY-102	1/28/2020	156	AW-103	AY-102	4/12/2019	139	Slurry
		9/10/2020	156	AZ-101	AY-102	4/18/2019	360	Slurry
		5/22/2021	156	AP-105	AY-102	4/25/2019	174	Supernate
		11/26/2021	156	Mix-Sample-Wait (ready for delivery 11/22/2019)				
		5/19/2022	156					
3	AZ-101	7/20/2022	379[f]	Complete Retrieval of Tank C-102				
				AZ-101	AW-102	7/13/2013	508	Supernate
				AP-107	AZ-101	7/17/2013	669	Supernate
		7/29/2022	206[g]	AZ-101	AY-102	4/18/2019	360	Slurry
				AZ-101	AZ-102	9/28/2019	254	Slurry
				AW-103	AZ-101	10/10/2019	139	Slurry
		8/5/2022	206[g]	AN-106	AZ-101	10/16/2019	189	Slurry
				AW-106	AZ-101	10/22/2019	293	Supernate
				Mix-Sample-Wait (Ready for Delivery 2/21/2020)				
4	AZ-102	8/7/2022	163	Complete retrieval of Tanks A-101 and A-103				
		8/16/2022	163	AW-103	AZ-102	9/23/2019	139	Slurry
		8/24/2022	163	AZ-101	AZ-102	9/28/2019	254	Slurry
		8/31/2022	163	AP-105	AZ-102	10/5/2019	299	Supernate
				Mix-Sample-Wait (ready for delivery 2/3/2020)				

[a] This is the order of delivery of the staged waste.

[b] This is the tank in which this specific batch group of the HLW feed is staged.

[c] These are the steps to prepare a specific batch group of HLW feed.

[d] The hot commissioning feed is already staged in Tank AY-102. This is the earliest date on which the hot commissioning feed would be ready for delivery given that the upgraded equipment will be operational on 9/8/2017.

[e] A key step in preparing HLW hot commissioning feed is delivery of the LAW hot commissioning feed to the WTP.

[f] This delivery was inadvertently modeled as being delivered to the ARF's LAW feed receipt system and will be corrected in future model runs.

[g] The first time the two ARF HLW feed receipt tanks are filled, they can receive a slightly larger volume due to lack of a preexisting tank heel.

5.4.3 Other Hanford Facilities and Inactive/Miscellaneous Underground Storage Tanks

The IMUSTs are projected[44] to be retrieved into the DST system between October 2019 and October 2028, with a total volume of approximately 440,000 gal of dilute supernate and sludge. The disposition of the waste in the IMUSTs has not been determined, the composition of the waste is incomplete and uncertain, and the schedule for retrieval of the IMUSTs might require adjustment to accommodate DST space limitations.

Approximately 740,000 gal of dilute waste from the 222-S Laboratory, terminal cleanout of PUREX, and deactivation of T Plant were projected to be received into the DST system between July 2010 and the end of the treatment mission.

5.4.4 Waste Transfer Systems

Numerous transfers occur between DSTs to support evaporator operations, to support staging of feed for WTP, and to receive transfers from retrieved SSTs. The Baseline Case predicts that approximately 1,400 transfers will occur among DSTs over the course of the RPP mission. As shown on Figure 5-8, the transfer system needs to support an average of approximately 11 transfers per year (5 Mgal per year) before the WTP starts, increasing to an average of about 73 transfers[45] per year (35 Mgal per year) after the WTP and second LAW facility reach full capacity.

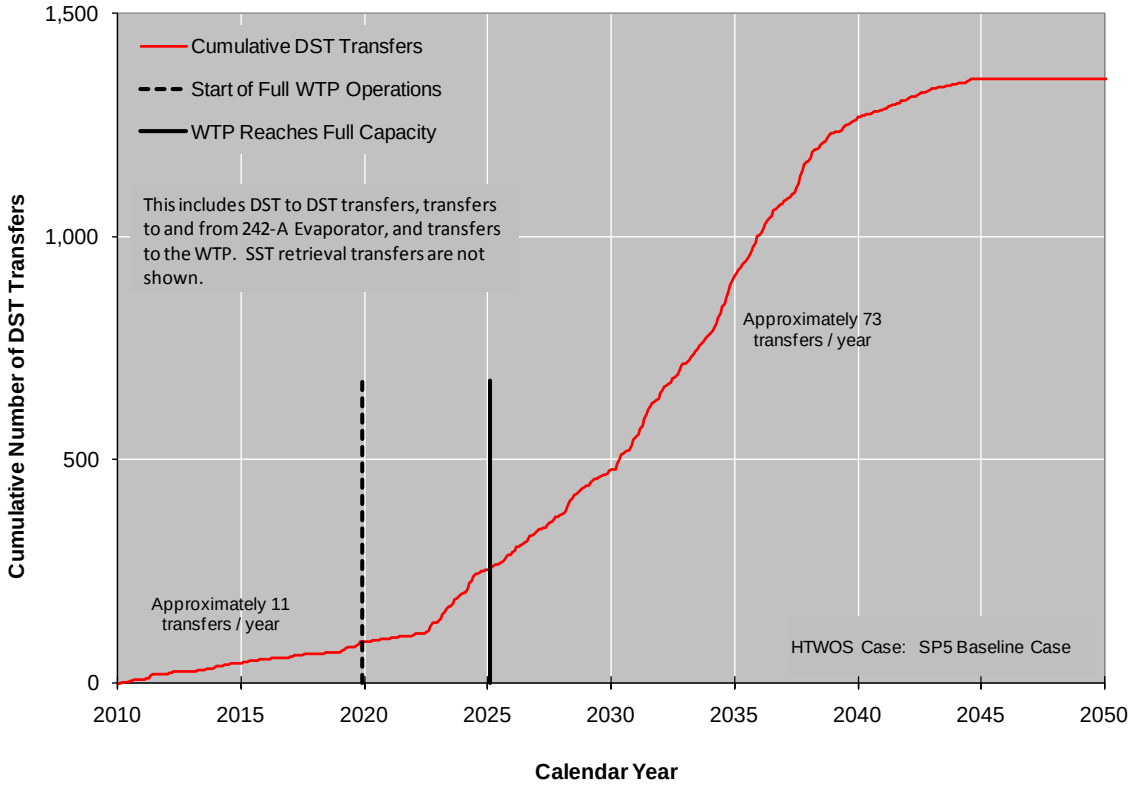


Figure 5-8. Projected Double-Shell Tank Transfer Demand.

[44] The starting assumption (see B3.5.10.4 in Appendix B) was between 2020 and 2030, or sooner if practical.

[45] System Plan (Rev. 4) projected an average of 59 transfers per year after the WTP and second LAW facility reach full capacity; the 73 transfers per year projected for System Plan (Rev. 5) is a 24% increase. This increase is due to the additional transfers needed to implement the improved management of solids in the DST system as compared to Rev. 4.

The transfer system must be sufficiently robust to support this average demand, including the year-to-year variability plus the transfers directly supporting SST retrievals. A number of transfer system upgrade projects are planned; details regarding the DST transfer system approach are available in the Integrated WFD Plan (RPP-40149), which has been developed concurrently with and reflected in this revision of the System Plan.

5.4.5 Evaporator

Figure 5-9 shows the projected demand on the 242-A Evaporator over the waste treatment mission. The 242-A Evaporator is expected to process about 84 Mgal of waste, reducing the stored volume by about 44 Mgal for the mission duration. The projected evaporator demand is used as a starting point for establishing the baseline operational plans after consideration and integration with WFD upgrade plans, planned 242-A Evaporator facility upgrade outages, ongoing field work, current transfer system status, and the need to support the early SST retrievals. This adjusted planning basis is shown in Table 5-3 and will be the basis for the near-term evaporator campaigns in a future update to the PMB.

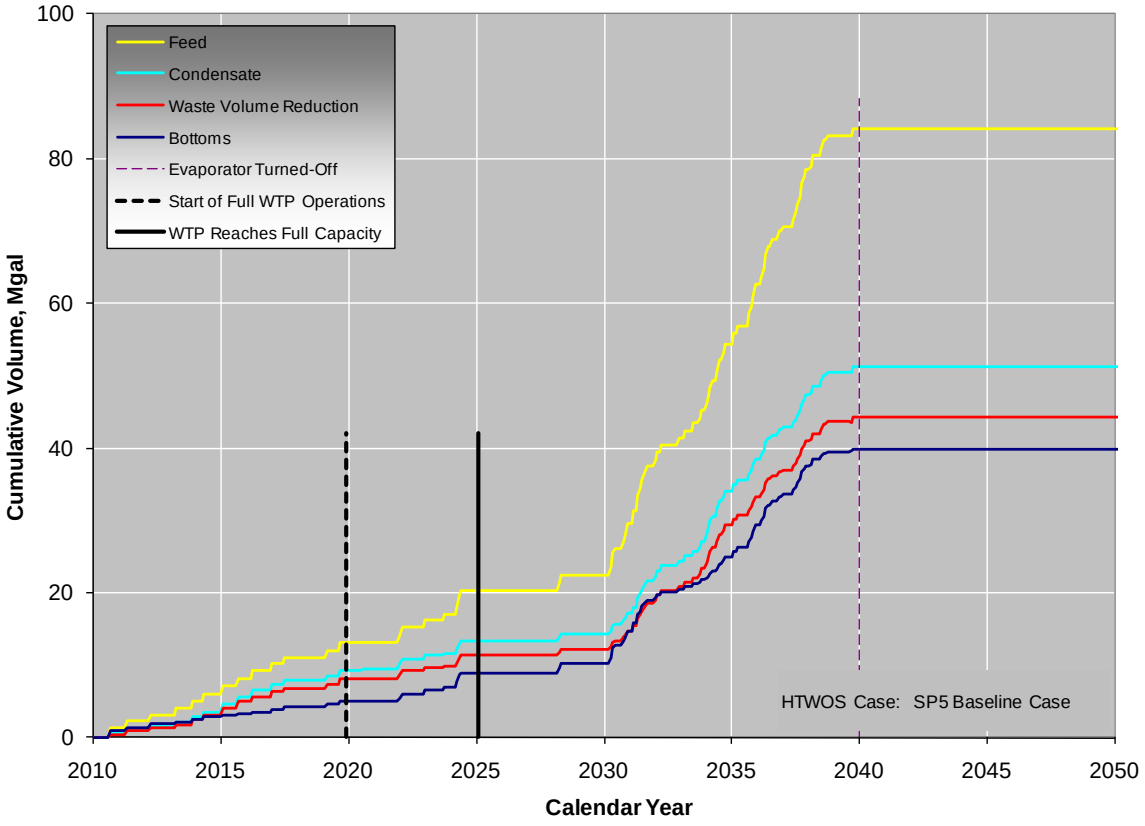


Figure 5-9. Projected Operation of the 242-A Evaporator for the Mission Duration.

Table 5-3. Plans for Double-Shell Tank Transfers and 242-A Evaporator Campaigns.

Fiscal Year	HTWOS Projection[a]	
	DST Transfers	242-A Campaigns
2010	11	2
2011	12	2
2012	5	1
2013	6	1
2014	13	2
2015	7	2
2016	5	1
2017	8	2
2018	5	0[b]
2019	17	2

Notes: No cross-site transfers are planned during FY 2010 through FY 2017. The next cross-site transfer is projected to occur in October 2017.

[a] This projection includes adjusting the System Plan (Rev. 5) Baseline Case results to reflect FY 2010 activity prior to the March 2010 date for demarcation between historical and projected activities.

[b] No cold run performed because of a lack of space in Tank AW-102, the dedicated evaporator feed tank. It is assumed that a cold run will take place in 2018 since there appears to be sufficient DST tank space to make room in Tank AW-102.

DST = double-shell tank.
FY = fiscal year.
HTWOS = Hanford Tank Waste Operations Simulator.

5.4.6 Waste Encapsulation and Storage Facility

As discussed in Sections 1.4 and 3.1.7, the cesium and strontium capsules are assumed to be dispositioned by RL and are not addressed by the Baseline Case nor included in the PMB.

5.4.7 Vadose Zone Program

The vadose zone program (see Section 3.1.8) is not modeled by HTWOS. However, the PMB does include cost and scope for this program in the TOC baseline.

5.5 TREATMENT

5.5.1 Supplemental Transuranic Treatment Facility

In the Baseline Case, processing of the potential TRU tank waste is projected to begin in April 2018 and will treat a maximum of 8,040 gal of slurry per day from retrieved potential TRU waste tanks. The Baseline Case indicates that processing this waste will produce 7,491 drums of packaged waste that will be stored at the CWC (see Section 5.6.3). Processing is projected to finish in June 2023.

See Section 5.10 for a discussion of Sensitivity Case A.

5.5.2 Waste Treatment and Immobilization Plant

This section presents the production metrics for the WTP for the Baseline Case and discusses the mission duration drivers. The WTP was assumed to begin hot commissioning on May 1, 2018, and begin full operations on December 2, 2019. The HLW Vitrification Facility is assumed to reach full capacity by February 6, 2025, when second generation HLW melters are assumed to be operational; the LAW Vitrification Facility by January 1, 2022. Waste treatment is projected to be completed in 2045 for the Baseline Case. Detailed programmatic and technical assumptions for the WTP are provided in Appendix B, Section B3.3.

5.5.2.1 Glass Production

Figure 5-10 compares the projected HLW glass production for the Baseline Case against the net capacity assumption. Figure 5-11 does likewise for the projected combined (WTP LAW + second LAW) LAW glass production; Figure 5-12 and Figure 5-13 do so for the individual LAW facilities.

The WTP LAW Vitrification Facility is projected to treat about 45% of the pretreated LAW from the WTP PT Facility, while the second LAW facility is projected to treat about 55%. The combined LAW glass production was selected to allow for the potential acceleration of the treatment end date (see Figure 5-10) that would be gained by fully using the available HLW treatment capacity. See Sections 5.5.4 and 5.5.4.1 for a discussion on how these facilities were sized and how the projected use of each facility may change.

For the Baseline Case, the HLW glass production was limiting during most of the waste treatment mission. However, in the early years, through 2025, the waste treatment mission is driven by the total LAW vitrification capacity from both the WTP LAW Vitrification Facility and the second LAW facility. The limited LAW vitrification capacity in those early years limits the amount of HLW that can be pretreated and prepared for vitrification. The effect is magnified in the years before the ARF comes online due to the amount of LAW waste generated during the pretreatment of HLW solids—HLW production is severely limited. Once the ARF come online, part of the pretreatment (caustic leaching) of the HLW waste is done in the ARF, and the reduced quantities of LAW thus generated are better handled by the WTP pretreatment system, allowing the HLW to be further processed with less restriction.

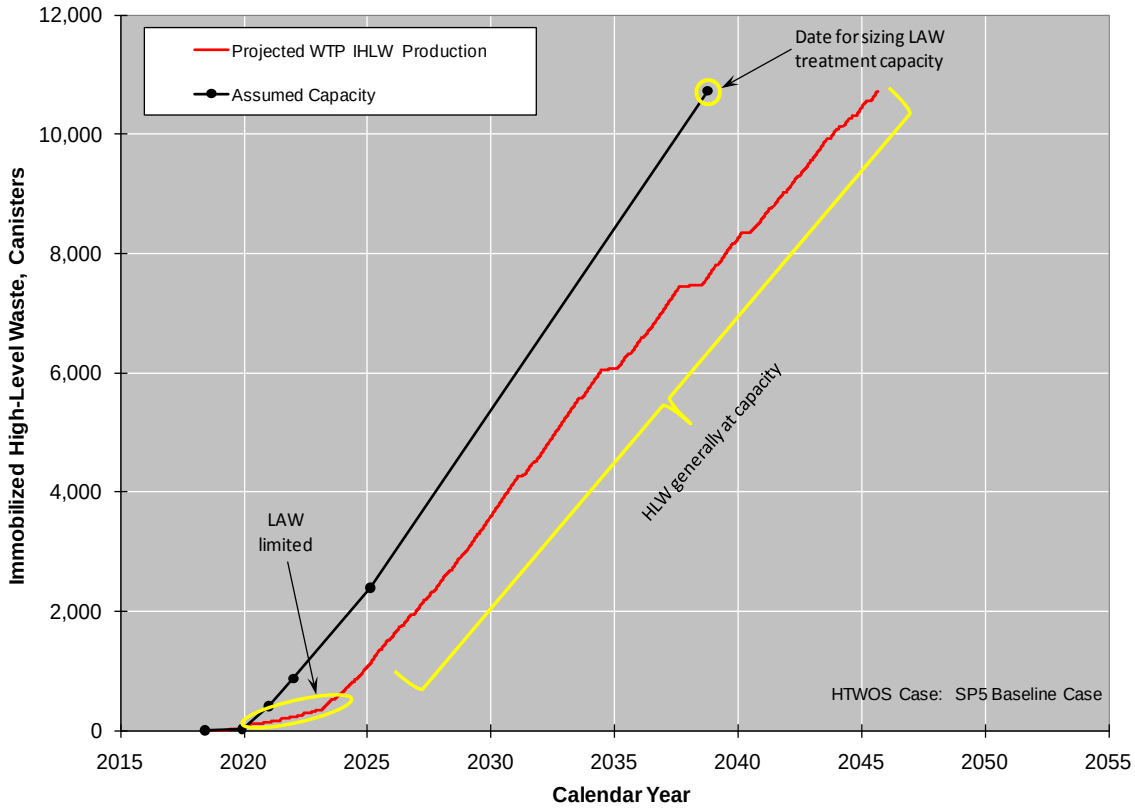


Figure 5-10. Projected High-Level Waste Glass Production.

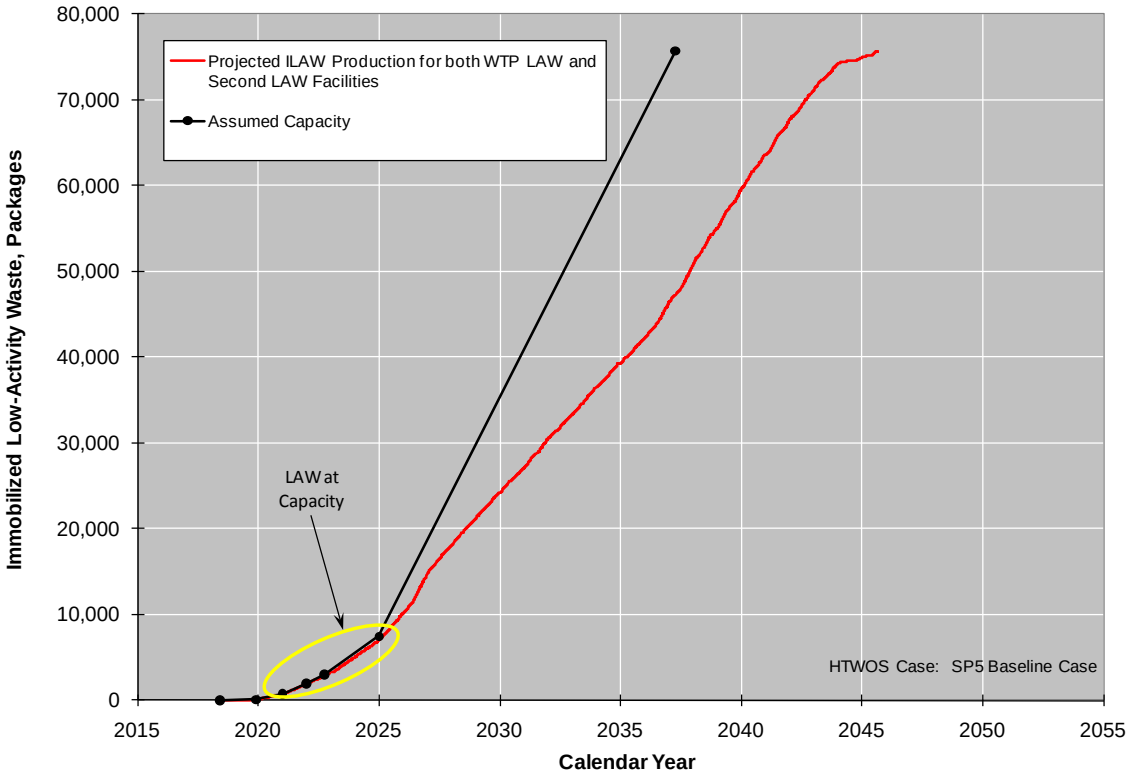


Figure 5-11. Projected Combined Low-Activity Waste Glass Production.

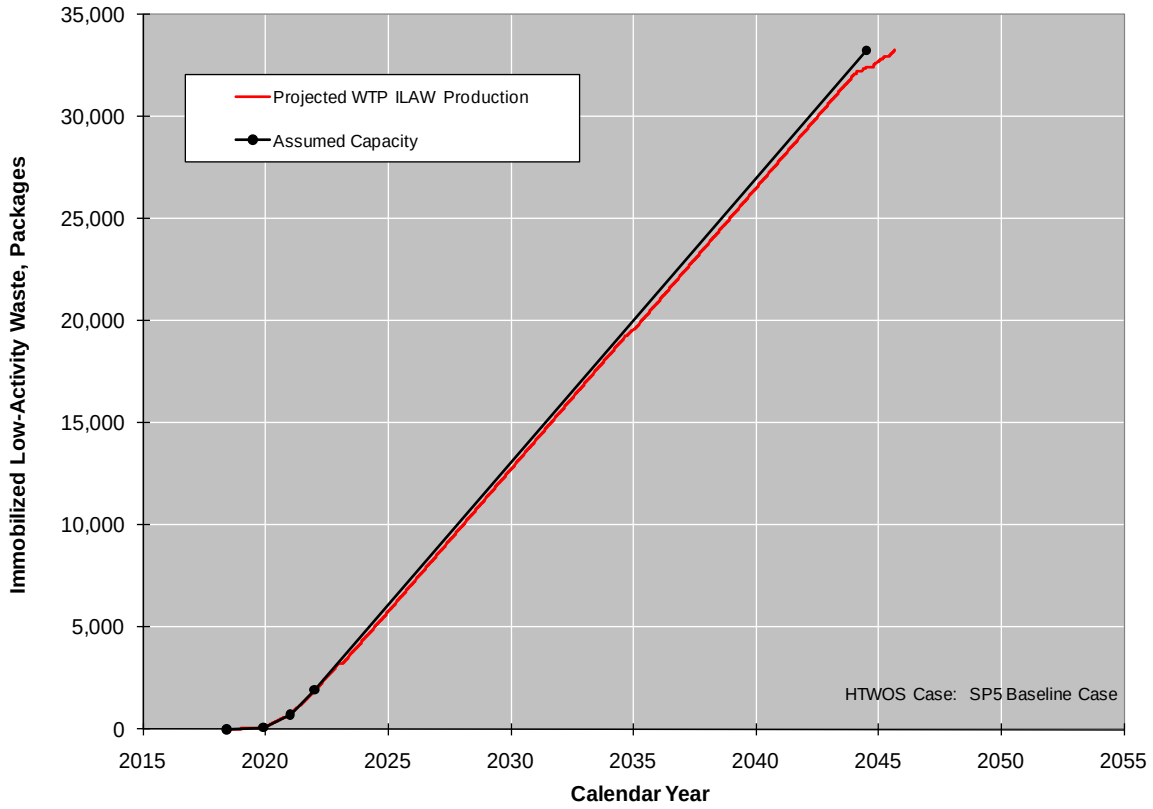


Figure 5-12. Projected WTP Low-Activity Waste Glass Production.

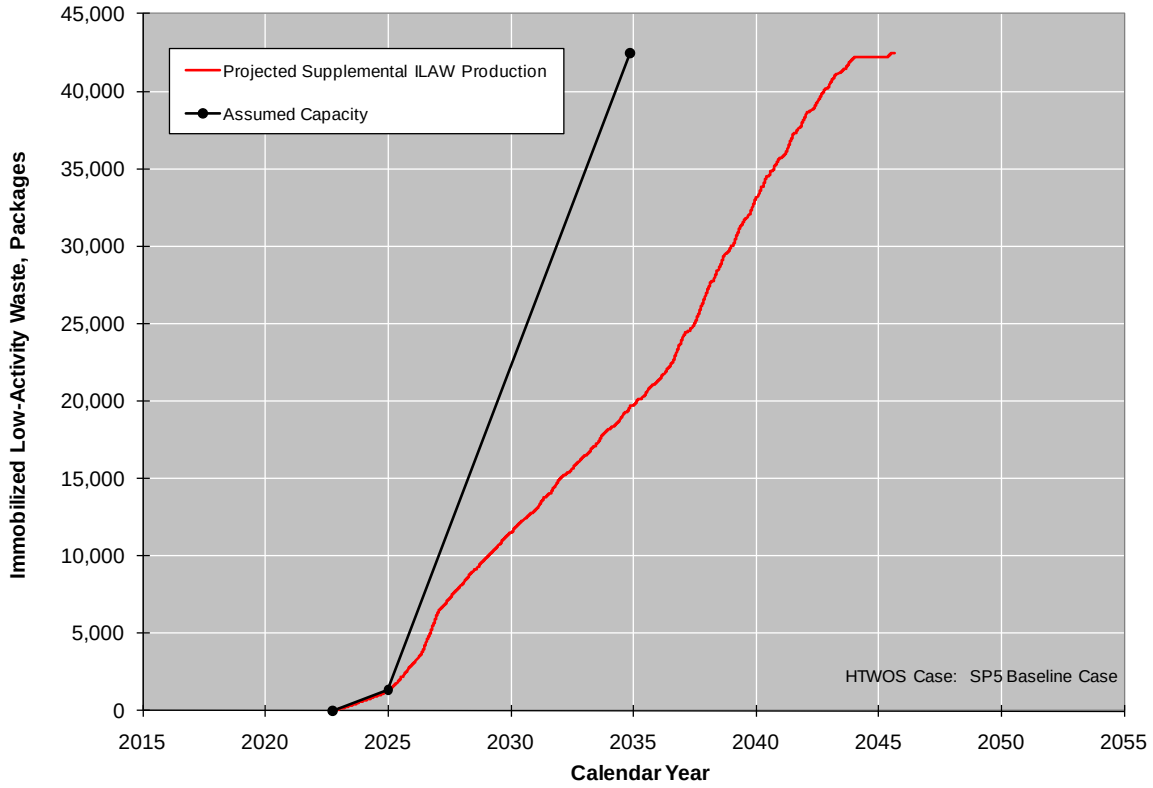


Figure 5-13. Projected Second Low-Activity Waste Facility Glass Production.

5.5.2.2 Pretreatment Capacity

The WTP contract requires that the pretreatment process has a treatment (net) capacity to produce 2,620 MT waste[46] sodium/year and to process 860 MT of as-delivered solids per year. The Baseline Case, as modeled, achieved 2,335 MT waste sodium/year and 725 MT as-delivered solids per year; both within the contractual requirements for the WTP.

The required pretreated capacity to finish treating waste in 2039 (the earliest date consistent with keeping HLW treatment as the sole mission duration driver) was 3,904 MT waste sodium/year and 887 MT/year as-delivered solids. These capacities exceed the contract minimums for the WTP, which implies that the demand on the WTP PT Facility will need to be reduced to make significant reductions in mission duration. The ability of the WTP to support these higher capacities was not evaluated.

The key issues and uncertainties associated with WTP capacity are listed in Table 7-5, along with potential mitigating actions.

5.5.2.3 Feed Vector and Feed Screening

The Baseline Case was rerun[47] for the sole purpose of recording the feed vector for batches of LAW and HLW feed projected to be delivered to the WTP. The projected feed batches were screened against the criteria in Specification 7, Specification 8, criticality safety limits (CSL), and hydrogen generation rate (HGR). The results of these screenings are documented in four spreadsheets:

- SVF-1923, "WTP_Spec_7_MMR-10-032-JHF-2-GKA-5.4-8.4r0-2010-07-14-at-23-55-05.xlsm"
- SVF-1924, "WTP_Spec_8_MMR-10-032-JHF-2-GKA-5.4-8.4r0-2010-07-14-at-23-55-05.xlsm"
- SVF-1934, "WTP_HGR_Limits_MMR-10-032-JHF-2-GKA-5.4-8.4r0-2010-07-14-at-23-55-05.xlsm"
- SVF-1935, "WTP_CSL_MMR-10-032-JHF-2-GKA-5.4-8.4r0-2010-07-14-at-23-55-05.xlsm."

The screenings results for the Baseline Case include the following:

- The delivered sodium concentration is within the upper and lower limits for all batches of HLW and LAW projected to be delivered to the WTP. This degree of sodium control results from the detailed modeling assumptions for the ARF and is not an indication of the capabilities of the DST system.
- The delivered wt% solids for LAW are below the maximum 3.8 wt% limit in all cases; the delivered HLW is at or below the 200 g/liter maximum limit in all cases. This degree of solid control results from the detailed modeling assumptions for the ARF and is not an indication of the capabilities of the DST system.
- All batches to WTP are within the volume limits.

[46] In this context, waste sodium is defined in the WTP contract to include sodium in the delivered LAW feed, the soluble sodium in delivered HLW feed, sodium added to wash and leach the solids, and sodium added to maintain the chemical stability of the ultrafiltration permeate.

[47] The feed vector was recorded by HTWOS run "MMR-10-045-6.01-8.4r0-2010-08-27-at-19-12-39."

- Several batches do not meet some criteria for the component composition limits in Specifications 7 and 8 (in Tables TS-7.1, 7.2, 8.1, 8.2, 8.3, and 8.4 of the contract DE-AC27-01RV14136). This is consistent with previous HTWOS modeling and System Plan runs. The implication of the out-of-specification batches will continue to be assessed and will provide insight for refining future plans, using the integrated project team process when appropriate.
- All of the batches meet the criticality limits except for two batches, which only slightly exceeded the CSL limit (maximum of 2% above the limit). This is likely due to the limitations of the solid-liquid partitioning assumptions used in HTWOS for the tank farms.
- All HLW batches meet the HGR limit.

A run of a variant[48] of the Baseline Case was performed at the request of the WTP design and construction contractor (Bechtel National, Inc.) to record projected feed to the WTP with the ARF removed from the system. Although a detailed evaluation and interpretation of the results of this run is outside the scope of this version of the System Plan, it is important to note that the total number LAW glass packages increased by 40%, the duration of the treatment mission increased by five years, and that there was more variability in the modeled solids concentration and sodium concentration in the delivered feed.

5.5.2.4 High-Level Waste Glass Drivers

The Baseline Case assumed that HLW glass would be formulated using the 2009 HLW GFM (PNNL-18501) per Assumption B3.3.3.7 (Appendix B). The primary glass drivers and the corresponding amount of glass limited by each are SO_3 (28.0%), Bi_2O_3 (3.9%), $T_{1\%}$-spinel (23.8%), and the nepheline discriminator (41.1%). Combined, those four constraints determine about 97% of the glass mass.

The average waste oxide loading (WOL) for the Baseline Case is about 38%, though as Figure 5-14 shows, the WOL varies over time based on the composition of the incoming waste and the constraints that are driving a particular batch.

The enhanced blending that was implemented in the Baseline Case, along with the new GFM, eliminated many of the single component solubility limited batches seen in the System Plan (Rev. 4) Baseline Case. While the WOL versus time profile is highly variable, there are only four major dips in which the WOL drops more than 10% below the average. Those time periods are described below:

- Three of the major dips in WOL are from Na_2O limited batches in the time periods 2034-2035, early 2038 to late 2038, and a brief part of 2040. The flat spots on the HLW glass production plot (Figure 5-10) shows that those periods correspond to when glass production stagnates and very few canisters are produced. These kinds of melter outages or decreased production periods are due to less than optimal HLW feed deliveries to the WTP. During those time periods, the HLW melter feed is primarily concentrated LAW

[48] The no-ARF variant of the Baseline Case and associated feed vector was recorded by HTWOS run "MMR-10-046-6.0-8.4r0-2010-08-30-at-18-52-37."

solids and recycles from pretreatment, which are high in sodium, resulting in the observed low WOLs in the HLW glass.

- In the period between 2036 and 2037, when the WOL drops to 22%, the HLW glass is limited by SO_3. SO_3 limited glass often has a lower than average WOL and has been the subject of recent research and development (R&D) testing. Section 5.11 describes a sensitivity analysis that was performed to analyze the effect of improving the HLW WOL by altering the SO_3 solubility limit (among others).

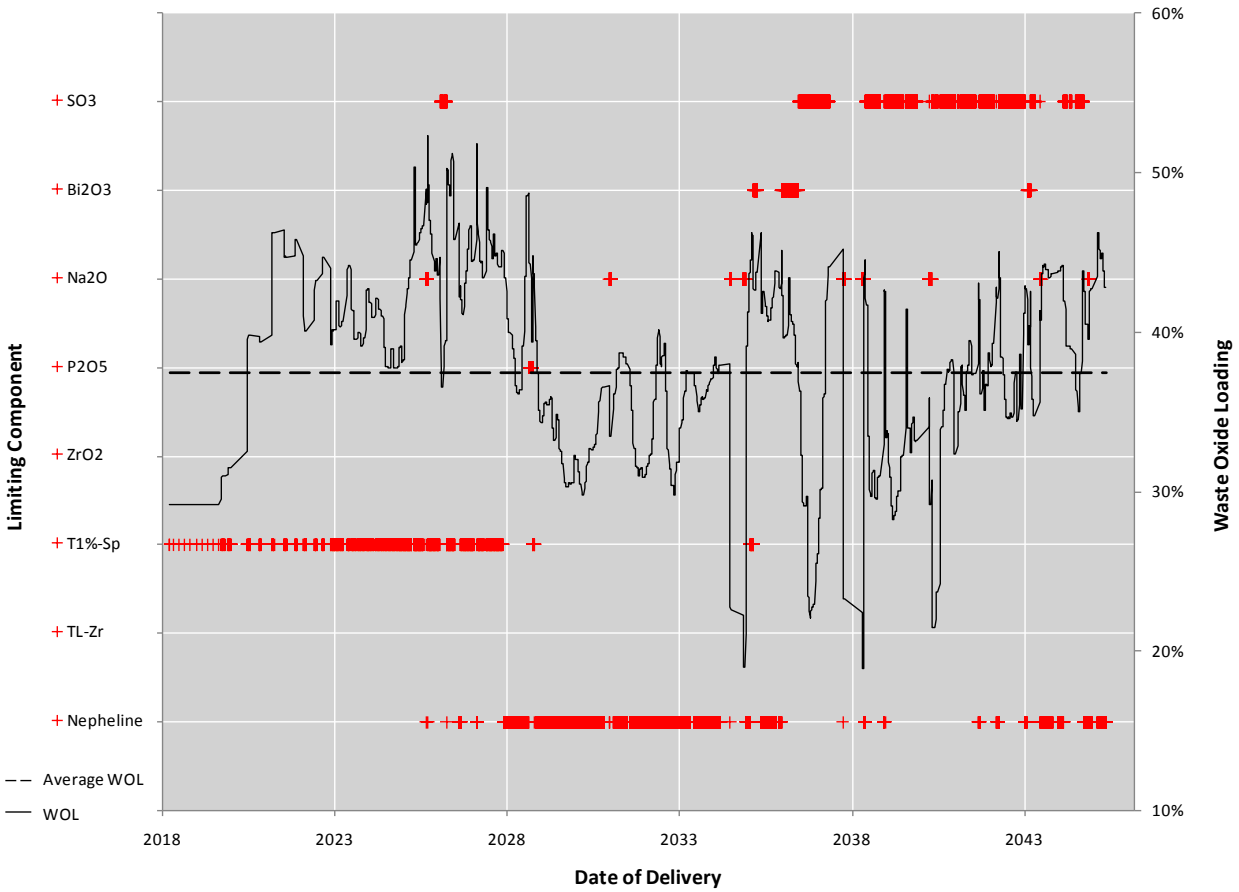


Figure 5-14. High-Level Waste Glass Drivers and Waste Oxide Loading versus Time for the Baseline Case.

5.5.2.5 High-Level Waste Blending

A global measure of the effectiveness of the blending of the sludge delivered to the WTP is how the projected glass mass compares to two hypothetical benchmarks—the total-blend and the no-blend. One such measure is called the percent-of-span, which is the percent of the way the projected glass mass falls between the total-blend and the no-blend glass mass. The Baseline Case achieved about a 15.6% percent-of-span through improvements in both incidental and intentional blending of solids and improved post-leach wash efficacy in the WTP PT Facility. For comparison, the percent-of-span achieved by the System Plan (Rev. 4) Initial Planning Case was about 69%, and was assumed to be 50% for the System Plan (Rev. 4) Baseline Case.

For the Baseline Case, two intentional blending approaches were implemented in the DSTs to improve HLW WOL.

High zirconium batches were found to limit HLW glass loading for the System Plan (Rev. 4) Baseline Case. For System Plan (Rev. 5) Baseline Case, an intentional blending strategy was used to meter small portions of high zirconium batches from Tanks AW-103 and AW-105 into multiple HLW feed batches. This blending strategy made use of existing DST space without extending overall retrieval durations. The high zirconium waste was split into eight equal batches (on a solids basis) and transferred into a DST each time a DST was assigned to stage feed HLW to the WTP.

System Plan (Rev. 5) also took advantage of enhanced incidental blending as a result of significantly increased heels in the DSTs providing HLW feed to the ARF and WTP, and by explicitly modeling heels in the WTP vessels. The presence of heels in the DSTs and in WTP vessels allowed batches of waste to blend as they moved through the Waste Treatment Complex.

Because the intentional blending strategies were implemented in tandem with the changes for enhanced incidental blending, the degree to which each change impacted HLW glass mass cannot be readily estimated. Review of the HLW glass drivers (see Section 5.5.2.4) showed that ZrO_2 and zircon liquidus temperature are no longer glass drivers, indicating that the high zirconium waste was blended adequately. As explained in Section 5.9.2, about a 6% decrease in IHLW canisters can be attributed to better blending and feed staging strategies.

A strategy for the blending of the high-fissile uranium retrieved from Tank C-104 and currently stored in Tank AN-101 was implemented. This strategy is described in RPP-RPT-43828, *Enhanced Use of AN Farm for C Farm Single Shell Tank Retrieval*. The blending strategy is rather complex given that the waste from Tank C-104 is already stored with low-fissile uranium blendstock; however, the resulting solids level (242-in. assuming no dissolution) in Tank AN-101 requires that this tank be retrieved layer-by-layer using incremental insertion of mixer pumps. Current assumptions allow approximately 70 in. of waste to be retrieved without incremental insertion, and the Tank C-104 waste occupied over 94 in. before SST retrieval. Using the blending strategy, the high-fissile uranium waste will be diluted with the low-fissile uranium and staged for delivery to the WTP in a series of DSTs, each containing slightly more than 70 in. of solids.

5.5.3 Aluminum Removal Facility

The ARF is assumed to begin operating on July 19, 2022. From that date forward, all feed to the WTP PT Facility will first be processed through the ARF. The ARF is projected to process about 95 Mgal of waste throughout the mission, producing about 20,000 MT of dried LiHT product and 400 Mgal of secondary liquid waste (excess water from process condensate that is routed to the LERF/ETF for treatment). The ARF is projected to complete operation on August 1, 2045.

The ARF is a standalone facility, meaning that all necessary unit operations (excluding those provided by the LERF/ETF and IDF) are contained within the facility. This includes feed staging tanks to receive waste from the tank farms, units for solid/liquid separation and filtration, evaporators, dryers, and lag storage product tanks for sampling and delivery of feed to the WTP.

The total operating volumes of the feed and product tanks in the ARF are about 2 Mgal and 4 Mgal, respectively. The number and size of feed and product tanks contained within the facility were chosen such that the ARF does not drive the mission duration and to interface smoothly with the HLW and LAW feed tanks in the WTP. There are two HLW and four LAW feed tanks to stage waste from the DSTs prior to processing in the ARF; and five LAW and eight HLW product tanks to stage the treated waste after processing prior to transferring to the WTP.

The ARF provides two very important benefits incidental to its aluminum removal role. First and foremost, the ARF, as modeled, provides explicit control of the sodium and solids concentrations in the LAW and HLW feed being delivered to the WTP. Second, there is a sharp drop in the projected DST volume (see Figure 5-6) as the ARF's internal feed and product tanks are filled with waste, freeing up more space to support continued SST retrievals and feed staging activities.

The LiHT process performed within the ARF is accomplished through the addition of a 10 wt% LiOH aqueous solution added in 25% excess of stoichiometric amounts and removes in excess of 80% of the total amount of leached aluminum in the waste.

The LiHT process supplies enough caustic for leaching virtually all of the waste throughout the mission. A small amount of NaOH (23 kg of 19 M NaOH) needs to be added when the ARF begins initial operation until there is sufficient caustic generated to recycle. The peak volume of caustic stored in the recycle tank is about 19,000 gal, with a minimum volume of around 2,000 gal.

The technical and programmatic assumptions associated with the ARF are provided in Appendix B, Section B3.4.1.

5.5.4 Second Low-Activity Waste Facility

The second LAW facility is assumed to begin production on October 1, 2022, and reach full net capacity on January 1, 2025.

The glass production for the second LAW facility is discussed in Section 5.5.2.1. For the Baseline Case, the second LAW facility treated about 55% of the pretreated LAW from the WTP PT Facility. Based on the relative assumed treatment capacity of the WTP LAW Vitrification Facility and the second LAW facility and their respective ramp-up schedules, the second LAW facility would need to treat about 70% of the pretreated LAW if waste treatment is to be completed in 2039 (the earliest date consistent with keeping HLW treatment as the sole mission duration driver).

5.5.4.1 Low-Activity Waste Vitrification Capacity

Assumptions B3.4.2.2 and B3.4.2.6 (Appendix B) for the Baseline Case require the capacity of the second LAW facility "to have the same technical assumptions as the WTP LAW Vitrification Facility," and that the capacity "be selected with the goal that the combined LAW vitrification capacity will be large enough as to not drive the mission duration, but no smaller than the WTP LAW vitrification facility." Therefore, the difference between the combined capacity and the WTP LAW Vitrification Facility capacity is the required supplemental capacity assumed to be provided by the second LAW facility. After calculating the required capacity for the second

LAW facility, the capacity was rounded up the next "whole" melter capacity according the assumptions for the WTP LAW vitrification facility.

Using that approach, the required combined LAW vitrification capacity (WTP LAW + second LAW facility) was estimated to be about 75 MTG/day; therefore, the required net capacity of the second LAW facility is about 54 MTG/day. Rounding up to the next "whole" melter capacity brings the required capacity to 63 MTG/day (six melters).

This approach of balancing the LAW and HLW capacities may lead to oversizing the second LAW facility unless the projected HLW glass production drives the mission duration. It may be prudent to allow the second LAW facility or the total pretreatment capacity (WTP pretreatment plus any assumed supplemental pretreatment capacity) to limit production during portions of the mission. In any case, the sizing of the second LAW facility will likely be iterative and involve multiple trade-offs and appropriate consideration of uncertainties in underlying assumptions and evolving configuration of the Waste Treatment Complex.

5.5.5 Liquid Effluent Retention Facility/Effluent Treatment Facility

In the Baseline Case, approximately 626 Mgal of radioactive dangerous liquid effluent (secondary waste from the WTP, the second LAW facility, 242-A Evaporator, the ARF, and supplemental TRU treatment system) is projected to be treated by the ETF over the duration of the treatment mission. The large increase relative to System Plan (Rev 4) is because the liquid effluent steam from the ARF was not estimated for the SP4 Baseline Case.

5.6 STORAGE ONSITE AND SHIPPING

5.6.1 Interim Hanford Storage Facility

The first module of the IHSF is planned to begin operations on November 21, 2018. Although this is after the start of WTP hot commissioning, the IHSF is not expected to begin receiving canisters from the WTP until January 7, 2020, due to the use of the WTP-provided storage for cooling and buffer capacity (see Figure 5-15).

If the decision is made to build the HSF and ship the canisters pending a final disposal alternative, the IHSF is assumed to operate about 1,000 canisters below the maximum storage capacity. The IHSF is projected to reach that operating target, 3,000 canisters, in December 2028. If the HSF is delayed and shipping cannot begin once the IHSF reaches the operating target, additional modules will be added to meet the storage requirements as outlined in Assumption B3.5.3.2 (Appendix B) and depicted in Figure 5-15.

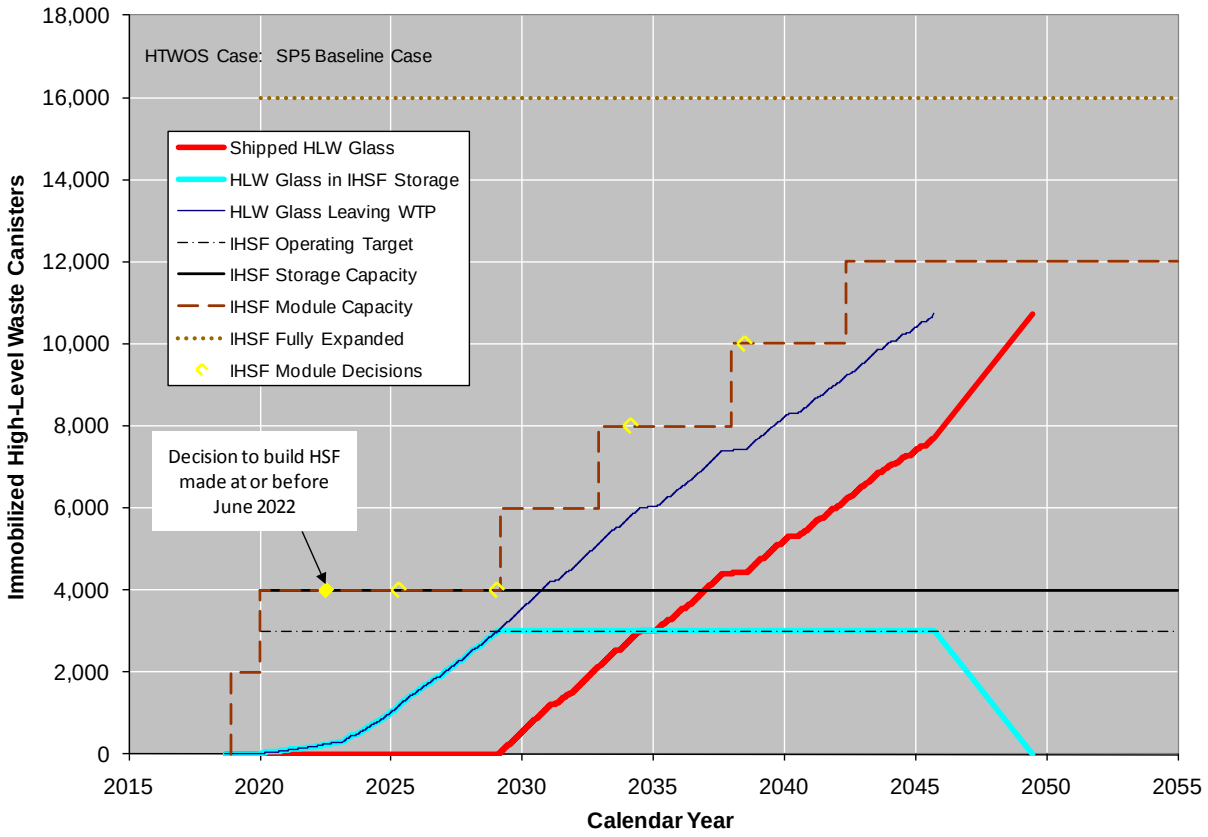


Figure 5-15. Interim High-Level Waste Storage and Shipping Projections for Baseline Case.

5.6.2 Hanford Shipping Facility

Pending a determination of the final disposal alternative, the enabling assumption is that in June 2022, a decision will be made to construct the HSF and begin shipping canisters to an offsite final disposal alternative (see Appendix B, Assumption B3.5.4.1). In that context, once the IHSF reaches its target operating capacity, the HSF will begin shipping IHLW canisters to the final disposal alternative. It is projected that the HSF will begin shipping operations in December 2028 and operate continually until all of the canisters have been shipped to the final disposal alternative, projected to be in June 2049 (see Figure 5-15).

5.6.3 Central Waste Complex

The CWC is assumed to store the 7,941 packaged potential TRU tank waste drums, generated between April 2018 and June 2023, until their final disposition has been determined (see Appendix B, Assumption B3.5.2.2).

5.7 DISPOSAL ONSITE

5.7.1 Integrated Disposal Facility

The IDF is projected to receive 75,420 packages of LAW glass, 41 spent LAW melters (11 from the WTP LAW Vitrification Facility and 30 from the second LAW facility), 11 spent HLW melters, 20,201 MT of dried LiHT product[49] from the ARF, and other solid waste over the duration of the mission.

5.7.2 State Approved Land Disposal Site

In the Baseline Case, approximately 626 Mgal of treated effluent from the ETF is projected to be disposed at the SALDS over the duration of the treatment mission.

5.8 DISPOSAL OFFSITE

5.8.1 Potential Transuranic Tank Waste

About 7,491 drums of packaged potential TRU waste are projected to be stored at the CWC pending determination of final disposition. If the final disposition of these packages is shipment offsite, then based on the projected retrieval and packaging schedule for this waste, the shipments could start no earlier than April 2018 and finish no earlier than June 2023.

5.8.2 Final High-Level Waste Disposal Alternative

Shipment of the projected 10,713 HLW canisters to a planned, offsite geologic repository is discussed in Sections 5.6.1 and 5.6.2 (see also Section 3.5.2).

5.9 GLASS MASS COMPARISON

5.9.1 Change in Projected Low-Activity Waste Glass Mass

The LAW glass mass for the Baseline Case was about the same as the Baseline Case from System Plan (Rev. 4). The slight decrease of approximately 7% was due to several interrelated causes:

- Updates to the partitioning assumptions for the LAW melter
- Improved sludge washing efficiencies in the ultrafiltration system as modeled
- Increases in incidental blending throughout the Waste Treatment Complex.

The updated partitioning assumptions for the LAW melter, particularly SO_4^-, reduced the amount of problematic (again, notably SO_4^-) in the off-gas recycle stream, reducing the required mass of glass-forming minerals, and therefore reducing the total mass of LAW glass. The improved sludge washing efficiency in the ultrafiltration system caused an increase in the amount of feed oxides to the LAW melters; however, this was more than offset by the combined effect from the changes to the partitioning assumptions and the improvement in blending.

[49] Not including the mass of any additives required to solidify this by-product per Assumption B3.4.1.7 (Appendix B).

The projected number of LAW packages for the Baseline Case has decreased only 0.5% (from 75,810 to 75,419 packages) relative to the System Plan (Rev. 4) Baseline Case. The number of packages remained about the same even with the reduction in total glass mass due to a 7% reduction in the fill mass of glass in each package from changes in both filled volume and glass density. System Plan (Rev. 4) packages were assumed to hold 5.92 MTG, while System Plan (Rev. 5) packages were assumed to hold 5.51 MTG (see Assumptions B3.3.4.5, B3.3.4.6, and B3.3.4.7 in Appendix B for details).

5.9.2 Change in Projected High-Level Waste Glass Mass

The projected mass of HLW glass for the Baseline Case has decreased by about 22% relative to the System Plan (Rev. 4) Baseline Case. The primary reasons for this overall decrease in glass mass are shown in Figure 5-16; all percentages are relative to the System Plan (Rev. 4) Baseline Case.

The projected number of HLW glass canisters for the Baseline Case has decreased by about 24% (from 14,111 to 10,713 canisters) relative to the System Plan (Rev. 4) Baseline Case. This additional 2% reduction in canister count beyond the glass mass reduction is due to a change in the canister fill assumption from the 3/8-in. wall canister holding 3.04 MTG/canister for System Plan (Rev. 4) to a thin-walled 10-gauge nominal canister holding 3.14 MTG/canister for the System Plan (Rev. 5) Baseline Case, plus small changes in the assumed glass density (see Assumptions B3.3.3.4, B3.3.3.5, and B3.3.3.6 in Appendix B for more details).

The three reasons for the reduced glass mass shown in Figure 5-16 are discussed below:

- **Realignment with WTP Flowsheet.** Better sludge wash efficiency in the WTP pretreatment process separates the LAW and HLW streams more effectively, reducing the mass of soluble constituents accompanying liquids to be routed to the WTP HLW Vitrification Facility. This, along with updated melter partitioning assumptions, accounts for about an 11% reduction in HLW glass mass.
- **Blending Improvements.** Enhanced blending in both the DSTs and the WTP, and a new WFD strategy, led to a 6% decrease in canisters (see Section 5.5.2.5 for a discussion of specific blending improvements).
- **New Glass Formulation Model.** A 5% decrease in glass mass was achieved through the implementation of the new 2009 GFM. The 2009 HLW GFM (PNNL-18501) makes use of the latest HLW R&D test data to expand the regions of model validity and to provide revised composition constraints. The new model allows the HLW WOL to approach 38%, an effective 22.5% increase over the 31% achieved for the System Plan (Rev. 4) Baseline Case. This improvement is sensitive to other process assumptions; a previous sensitivity study (RPP-RPT-42649, *High-Level Waste Glass Formulation Model Sensitivity Study, 2009 Glass Formulation Model versus 1996 Glass Formulation Model*) using System Plan (Rev. 4) assumptions did not see this improvement.

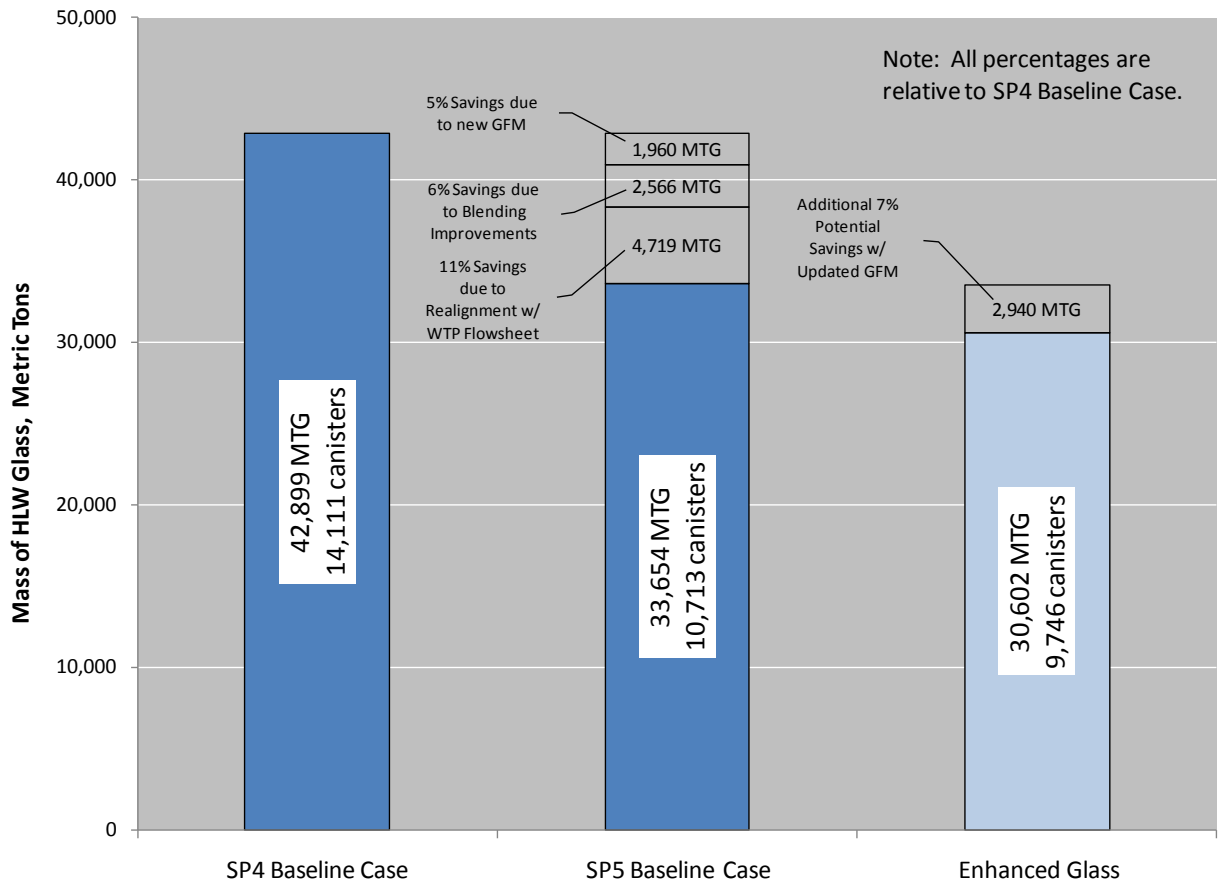


Figure 5-16. High-Level Waste Glass Change Analysis.

The WOL for HLW glass achieved for the Baseline Case was higher than from System Plan (Rev. 4) due to the updated GFM and improved blending, which allowed more waste to be loaded into the HLW glass. The WOL did not increase by the same amount that the total glass mass decreased, because the mass of pretreated HLW feed, on a waste oxides basis, was reduced from System Plan (Rev. 4). The HLW waste oxide mass reduction resulted from improvements in the modeled sludge wash efficiency, which more effectively separated the liquid and solid streams in pretreatment, causing fewer accompanying dissolved solids to be routed to the HLW melters. The decrease in pretreated HLW waste oxides decreased the final mass of HLW glass beyond the improvements in WOL because there were fewer waste oxides to load into the glass.

5.10 SENSITIVITY CASE A

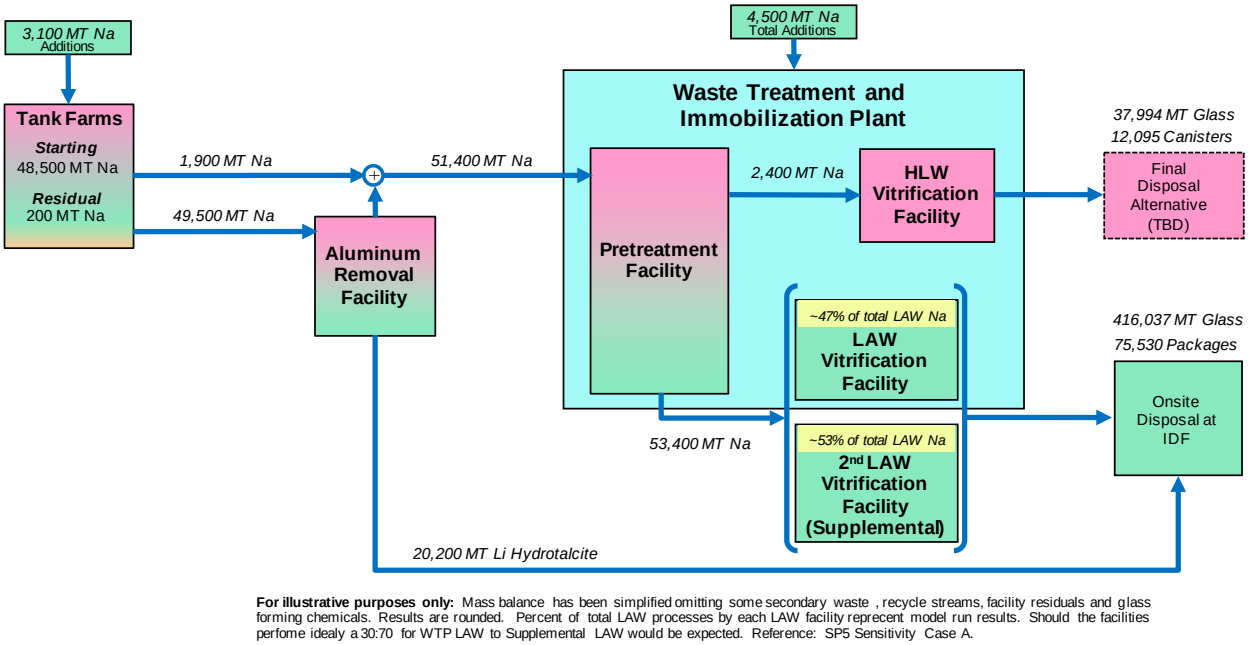
As discussed in Section 1.10, Sensitivity Case A[50] explores the impacts of eliminating supplemental TRU treatment of the potential TRU tank waste, thus treating this waste at the WTP and disposing of it along with the HLW. This is in anticipation of a potential future decision to dispose of this material as HLW rather than to dispose of this material at WIPP.

[50] Sensitivity Case A corresponds to HTWOS run MMR-10-036-6.0-8.4r0-2010-07-20-at-18-31-05.

HTWOS (Version 6), corresponding to the System Plan (Rev. 5) Baseline Case, was modified so that all potential TRU tank waste was no longer processed through the supplemental TRU treatment and packaging system. This waste was instead retrieved into the DST system, allowed to blend incidentally with other sludge, processed in the ARF, and delivered to the WTP for treatment.

Table 1-1 summarizes the key results of Sensitivity Case A and compares those results to both the Baseline Case and the success criteria. Sensitivity Case A exhibits similar behavior as the Baseline Case for both the near-term and overall mission drivers, including the demand on tank space. Sensitivity Case A also produces significantly more HLW glass (13%) than the Baseline Case due to the increased amount of tank waste processed through the WTP, and consequently completes the treatment mission about 15 months later.

Figure 5-17 provides the simple mass balance for Sensitivity Case A. See Figure 5-1 for the mass balance for the Baseline Case.



For illustrative purposes only: Mass balance has been simplified omitting some secondary waste , recycle streams, facility residuals and glass forming chemicals. Results are rounded. Percent of total LAW processes by each LAW facility reprecent model run results. Should the facilities perfome idealy a 30:70 for WTP LAW to Supplemental LAW would be expected. Reference: SP5 Sensitivity Case A.

Figure 5-17. Simple Mass Balance for Sensitivity Case A.

5.11 HIGH-LEVEL WASTE GLASS MASS SENSITIVITY STUDIES

Two HLW glass mass sensitivity studies were performed to explore (1) the potential benefits of further enhancements to the 2009 GFM, and (2) the ranges of impacts of various degrees of pretreatment, blending, and disposition of potential TRU tank waste. These sensitivity studies are discussed in the following two subsections.

5.11.1 Enhanced Glass Formulation Study

Further revisions to the 2009 GFM are recommended based on a recent evaluation performed by WRPS and PNNL (PNNL-19372, *Glass Composition Constraint Recommendations for Use in Life-Cycle Mission Modeling*). WRPS personnel identified the existing glass property and component-composition constraints that are most influential on the estimated HLW glass mass,

and PNNL researchers assessed the feasibility of revising those limits. PNNL-19372 recommends relaxed values for the phosphate, bismuth oxide, and sulfate solubility limits, and augments the nepheline discriminator with a new constraint, optical basicity, for purposes of life-cycle mission modeling. All of these constraints are the subject of ongoing research and have a high potential of being revised in the next update of the GFM. The above revisions to the model were recommended only for evaluating the impacts of glass formulation enhancements while R&D is underway.

A sensitivity analysis was performed to assess the impacts on the HLW glass mass of adopting the enhanced HLW GFM recommended by PNNL-19372. For this analysis, the HLW melter feed vector from the System Plan (Rev. 5) Baseline Case was used in an Excel version of the 2009 HLW GFM, with the updates recommended by PNNL-19372. The mass of HLW projected by the enhanced model was 30,602 MTG or 9,746 canisters, about 9% less than the System Plan (Rev. 5) Baseline Case, or about 7% less than the Revision 4 Baseline Case. The combined effects of the changes in glass drivers resulted in an average WOL of 41% for the sensitivity case. This analysis shows promising results for the impact of future glass formulation enhancements.

The glass drivers from the above sensitivity analysis were compared to those from the Baseline Case. The three primary glass drivers for the Baseline Case, SO_3, T1%-spinel, and the nepheline discriminator, remained the primary drivers for the sensitivity case. Relaxing the SO_3 limit allowed higher WOLs in batches limited by sulfate, and for the sensitivity case, SO_3 limited 18% of the batches versus the 28% for the Baseline Case. Similarly, relaxing the P_2O_5 and Bi_2O_3 limits resulted in eliminating them as glass drivers and increasing the average WOL. Revisions to the nepheline discriminator allowed glass formulations with higher aluminum concentrations. Waste loadings were improved by the increased aluminum loading constraints, but the Al_2O_3 solubility limit became a binding constraint, limiting 19% of the batches (versus 0% for the Baseline Case). To get more benefit from the revised nepheline discriminator – optical basicity constraint, more glass testing will have to be performed to allow the upper limit for Al_2O_3 concentration to be increased.

5.11.2 Blending Studies

A series of related sensitivity studies were performed using the total-blend/no-blend tool in the HTWOS model. This tool calculates two hypothetical benchmarks—the total-blend (representing the HLW glass that would be made if all DSTs and SSTs were perfectly blended together before feeding the WTP) and the no-blend (representing the glass that would result from feeding each SST and DST to the WTP individually, with no blending). A global measure of the effectiveness of sludge blending in the DSTs is the percent-of-span, which is the percent of the way the projected glass mass fall between the two hypothetical benchmarks. A lower value for the percent-of-span represents a projected glass mass closer to the total blend, and indicates better blending. The total-blend/no-blend tool also shows the glass mass sensitivity to various degrees of pretreatment and TRU disposition. Figure 5-18 shows the results of the total-blend/ no-blend sensitivity studies performed using this tool.

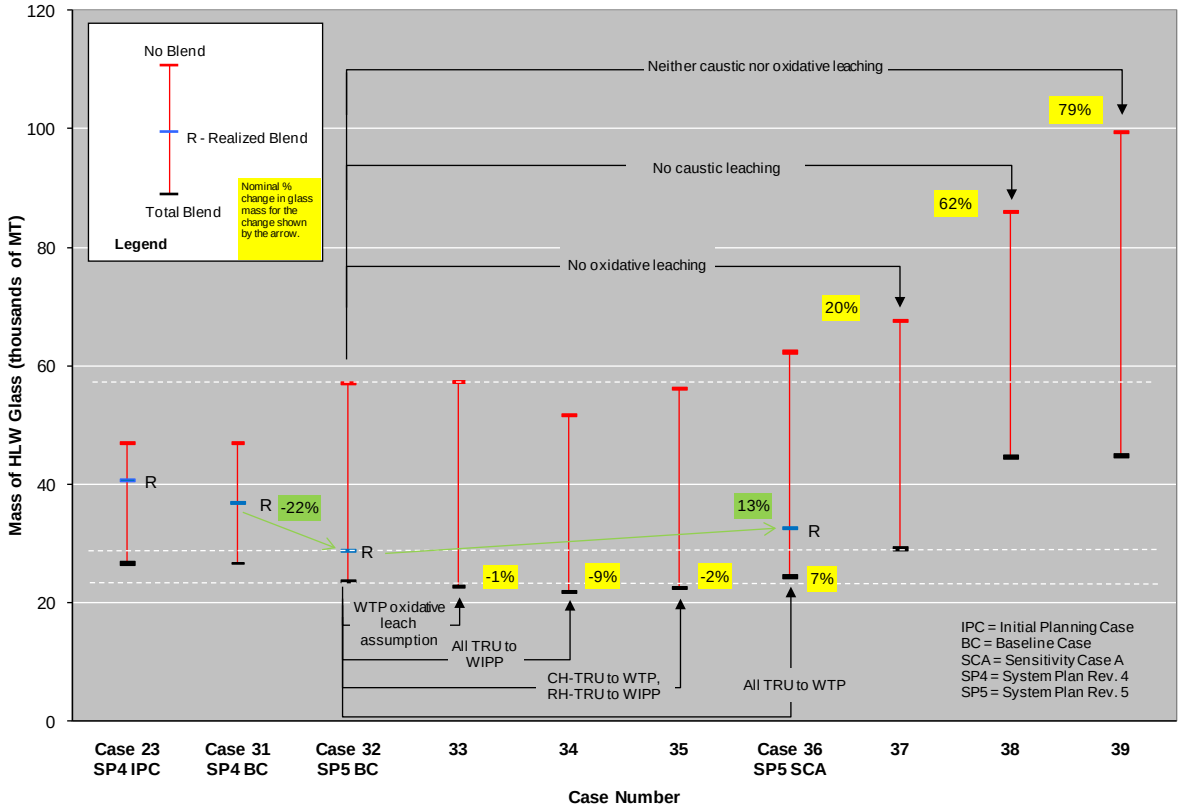


Figure 5-18. High-Level Waste Glass Mass Ranges for Total-Blend/No-Blend.

Case 32, the System Plan (Rev. 5) Baseline Case, shows the newest estimate for the total-blend, no-blend, and realized blend totals. The total-blend/no-blend span increased when the new 2009 GFM was implemented, indicating more significant glass mass sensitivity to variations in feed delivery strategies than was seen using the 1996 GFM. The realized blend total for the Baseline Case (Case 32) is 15.6% of the span, resulting from improvements in both incidental and intentional blending and improved post-leach wash efficacy in the WTP PT Facility. The 33,654 MTG realized blend total for System Plan (Rev. 5) is 22% less than the realized blend for the System Plan (Rev. 4) Baseline Case. An explanation of the blending strategies that contributed to this decrease in glass mass is provided in Section 5.5.2.5 (see Section 5.9.2 for a discussion of the impact of other changes).

Cases 33, 37, 38, and 39 show the glass mass sensitivity to various pretreatment assumptions. Case 33 applies all of the same assumptions as Case 32, except the oxidative leach is set to WTP's baseline assumption. As the figure shows, the change in oxidative leach assumption has negligible impact on total glass mass calculations. Cases 37-39, though, show the dramatic effects of completely eliminating certain pretreatment steps. Completely eliminating oxidative leaching would result in a nominal 20% increase in glass mass; eliminating caustic leaching would result in a 62% increase; and eliminating both would result in a 79% increase.

Cases 34-36 show the glass mass sensitivity to TRU disposition. Case 36 shows an overall 7% nominal increase in glass mass predictions resulting from all TRU being treated in the WTP based purely on the total-blend/no-blend analysis. The realized blend for Case 36 projected a 13% increase in glass mass (see Section 5.10).

6.0 TECHNOLOGY DEVELOPMENT

Significant new technology development has already been completed to begin addressing the unique challenges of cleaning up the legacy radioactive wastes at Hanford. However, to complete the U.S. Department of Energy's mission to protect the Columbia River, additional technology development is necessary.

The Technology Development Program objective is to assist WRPS and ORP in successfully completing the RPP mission by identifying technology gaps and potential solutions. In the past year, ORP and WRPS have continued to pursue technology development initiatives in support of the RPP mission. These initiatives support a wide array of needs, from mission completion and timely milestone achievement to cost and risk reduction. These and other initiatives are described in detail in the Technology Development Roadmap (RPP-PLAN-43988). A selection of the various technologies described in RPP-PLAN-43988 are highlighted and summarized in Table 6-1.

Technology development initiatives are integrated with risk management. Some initiatives described in this section are credited as "potential mitigating actions" for specific risks identified in Section 7.0, "Key Issues and Uncertainties."

ORP and WRPS are pursuing several transformational technologies. A transformational technology is an innovative approach potentially able to significantly reduce life-cycle costs, schedule, or technical risks. Of the 17 technology initiatives described herein, eight are transformational, including:

- Mobile arm retrieval system
- Wiped-film evaporators
- Glass formulation improvements
- Second generation melters
- Lithium hydrotalcite process
- At-tank filtration using rotary microfilters
- Small column ion-exchange systems
- Fluidized bed steam reforming.

Table 6-1. Technology Development Overview for the River Protection Project System.

Functional Area	Technology	Technology Description	Potential Application
Tank farms	Mobile arm retrieval system*	A device that allows different types of retrieval tools to be deployed throughout the tank.	Useful for retrieval of waste from SSTs. Two versions of MARS are under development: one uses a sluicing head and one uses a vacuum system.
	Increasing tank working capacity	Development of a modified cone penetrometer measurement tool for measurement of in-tank sludge properties.	Support change to BDGRE model for sludge tanks, thereby increasing usable storage space in DSTs.
	Enhanced chemical cleaning	Consider chemical treatments to assist with tank retrievals. May include high molarity caustic addition followed by water addition, or oxalic acid cleaning subsequently neutralized with caustic.	Sluicing hard heel materials has limits and potential in-tank obstructions can limit the range and effectiveness of retrieval equipment. Chemical treatment could improve overall retrieval efficiency.
	Waste feed delivery mixing and certification sampling	Develop and demonstrate the ability to adequately mix waste in DSTs to meet WTP waste acceptance requirements. Includes computer modeling and testing of tank mixing.	Validates DST mixing assumptions, supports sludge management, and supports development of a WTP feed strategy to ensure quality feed is consistently provided to WTP.
	Wiped-film evaporator*	Modular, transportable at-tank system to concentrate various waste supernate streams.	Provide additional process capacity to evaporate SST waste, DST waste, and secondary waste; provide back-up for the existing 242-A Evaporator facility.
	Tank integrity tools and methods	Adaptation of ultrasound probes, in-tank corrosion probes, chemical sensors, non-destructive examination methods.	Support long-term use of SSTs.
	Tank closure methodology	Development and testing of various grout formulations for closure operations.	Encapsulate waste tank residual heels and prevent subsidence of closed waste tank structures and other ancillary equipment, assuming future landfill closure of waste management areas.
WTP	Glass formulation improvement*	Optimize glass formulations for LAW and HLW facilities. May include improvements to borosilicate glasses and investigation of phosphate glasses.	Increase waste loading and overall throughput, which would reduce cost and schedule to complete waste treatment at WTP.
	Second generation melters*	Improve joule-heated ceramic melter technology and continue to develop cold crucible induction heated melters.	Increase glass production rates to reduce cost and schedule to complete waste treatment at WTP; may also reduce the size of the planned second LAW facility.
Supplemental treatment	LiHT process*	Further development of the LiHT process, which could be used to remove excess alumina from the tank waste and yield, as a by-product, recyclable sodium hydroxide that could be used for subsequent sludge dissolutions.	The LiHT process could be used at the ARF. Reducing the amount of aluminum in the waste before treatment at the WTP PT Facility is expected to reduce the amount of NaOH that would be needed to keep the aluminum in solution and eliminate the need to caustic leach the sludge, thereby improving facility throughput and reducing long-term costs and schedule. Sodium management also reduces the size of the second LAW facility.
	At-tank rotary microfilters*	Rotary microfilters could be used to remove solids from the waste streams.	Rotary microfilters could be deployed inside or near waste tanks to supplement the WTP PT Facility. Allows filtered supernate to be routed directly to the cesium ion-exchange process.
	Small-column ion exchange*	Small-column ion-exchange units could be used to remove cesium from the waste stream.	Implementation could reduce the demand on the WTP PT Facility and increase throughput.
	Fluidized bed steam reforming*	Fluidized bed steam reforming uses a reforming technology in the form of a superheated steam-driven fluidized particle bed, and could be used to treat the LAW waste stream.	This technology could be deployed to provide all or part of the waste treatment function currently allocated to the second LAW facility. This process produces a dry granular material, which is an insoluble mineral that must be macroencapsulated to meet Hanford IDF disposal standards.
	Electrochemical caustic recovery	Separates sodium ions from supernate and reacts those ions with water to yield a recyclable caustic stream.	Possible method for aluminum and sodium management. The recyclable caustic waste stream could be used to support caustic leaching processes in the WTP PT Facility.
	Continuous sludge leaching	Dissolves sodium aluminate in a heated reactor, then passes it through a cross-flow filter to generate a solids-free supernate.	Could be deployed in conjunction with either the LiHT process and/or the electrochemical caustic recovery processes. Supports WTP waste acceptance criteria for feed to the WTP PT Facility.
	Aluminum solubility	Ongoing studies of aluminum solubility under typical WTP and tank farm operating conditions.	May result in needing to add less sodium, thereby reducing the amount of LAW to be treated.
Interfacing facilities	Technetium management	Identify and formulate a waste form that safely immobilizes ^{99}Tc, a long-lived radionuclide that is highly mobile if released to the environment. Technologies under consideration include (1) improvement in technetium retention in glass, and (2) goethite precipitation from the off-gas condensate.	New technologies could improve on current plans to stabilize the LERF/ETF solids in a solidified waste form for disposal at the IDF, which may not be sufficient to isolate ^{99}Tc from the environment.

*Transformational technology

ARF = Aluminum Removal Facility.
BDGRE = buoyant displacement gas release event.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
IDF = Integrated Disposal Facility.
LAW = low-activity waste.
LERF = Liquid Effluent Retention Facility.
LiHT = lithium hydrotalcite.
MARS = mobile arm retrieval system.
PT = pretreatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

7.0 KEY ISSUES AND UNCERTAINTIES

Key issues and uncertainties highlight those areas that warrant particular attention.

The Baseline Case defined by Appendix B and presented in this System Plan includes a number of challenges that need to be successfully addressed to reach the desired performance for the mission. These challenges are summarized in this section along with potential mitigating actions and related details.

To more clearly communicate ORP's integrated approach to managing the risks and uncertainties associated with the RPP mission, this section has been restructured and expanded for this System Plan revision. Whereas the key issues and uncertainties previously were published as a single table, they now appear in a series of smaller tables. Each of the new tables aligns with, and is numbered similarly to, the critical risks identified in the RMP (TFC-PLN-39). For example, the RMP's Critical Risk TOC-01, "DST Space Management," aligns with Table 7-1 in Section 7.1, also entitled "DST Space Management." Subsequent tables are aligned and sections numbered accordingly. However, the RMP also addresses some critical risks that fall outside the scope of the System Plan, including TOC-09, "Work Stoppage;" TOC-10, "Skill Mix and Labor Shortfalls;" TOC-13, "Project Management Opportunities;" and TOC-14, "HAMTC Craft Realignment Provision Opportunity." Therefore, the specific risks associated with these sections are addressed exclusively in the RMP, and are intentionally omitted from the System Plan. Individual item numbers are for ease of reference only, and do not imply relative importance.

Within each table, the discussion of potential mitigating actions has been expanded to provide additional details, such as the TRL, the WBS level at which the work is being managed, or other information as appropriate and available.

Risks communicated in the RMP and the key issues and uncertainties tables herein are related strictly to workscope already included in the RPP baseline.

Information sources included Appendix B, TFC-PLN-39, the RPP risk database, and the HANDI–PERF Integrated Planning and Reporting System (IPARS) Control Module, which contains the WBS.

7.1 DOUBLE-SHELL TANK SPACE MANAGEMENT

Table 7-1. Double-Shell Tank Space Management. (2 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
1	The space available in the existing 28 DSTs will be sufficient to execute the RPP mission.	a. Small perturbations in assumptions or uncertainties affecting DST space management have a disproportionate effect on the early SST retrieval schedule as available DST space approaches zero.	i. Use SST retrieval experience and technology development to increase waste retrieval volumetric efficiencies.	
			ii. Continue waste management initiatives to increase usable storage space in existing DSTs. Per RPP-RPT-45825,[a] five options are recommended for further evaluation: • Raise the allowable waste limit in 9 tanks to provide up to 940 kgal of space • Concentrate the waste in 15 DSTs to 1.43 SpG to recover up to 3,500 kgal of space • Use four of six planned WRF tanks to create 600 kgal of space • Use DST space currently reserved as emergency space to make 1,265 kgal available • Implement a revised SST retrieval sequence giving priority to tanks containing sludge or less salt to reduce near-term impacts to DST space.	
			iii. Treat a portion of the tank waste, either by supplemental LAW treatment or by early startup of the WTP LAW Vitrification Facility.	The potential impact (good or bad) on DST space management will be considered as decisions are made on how to provide the needed supplemental treatment and pretreatment capabilities. See Table 7-8, Item 21
			iv. Take advantage of the storage space potentially provided by any new feed conditioning, blending, new or expanded WRFs, or other facilities.	The potential impact (good or bad) on DST space management will be considered as decisions are made with respect to new or expanded facilities.
			v. The allocation of a four-month period for sampling and analysis of waste in preparation for processing through the 242-A Evaporator may cause bottlenecks when retrieving dissolved saltcake. Alternative sampling and staging strategies should be considered.	
			vi. Retrieval and staging of waste from multiple SSTs into fewer, sound SSTs determined to be fit-for-use could partially decouple SST retrievals from DST space availability limitations.[b]	WBS 5.3.1 includes funding in FY 2010 to develop a SST fit-for-use regulatory strategy for ORP.
		b. The fill capacity of some DSTs is currently restricted to levels less than design capacity as a safety measure to address concerns related to possible BDGRE. If safety could be verified, the current limits on DST fill capacity could be modified, thereby increasing available DST storage space, as is assumed by this System Plan.	vii. Continue to resolve technical issues associated with sludge accumulation in DSTs. viii. TD 1.2: A cone penetrometer tool will allow data to be collected that could quantify the degree of conservatism in BDGRE models and provide the basis for more accurate modeling.	RPP-PLAN-30112 (2006)[c] identified the activities and decisions necessary to safely accumulate solids in DSTs in light of BDGRE concerns. Additional work followed, including publication of RPP-RPT-26836 (2010),[d] which proposed new criteria for predicting BDGRE behavior in tanks containing high shear strength waste. Work is ongoing. TRL-5: A prototype cone penetrometer measurement tool was tested in FY 2009. Design changes based on testing and procurement of the final assembly will be initiated in FY 2010. Based on the C Farm retrieval schedule, deployment is planned in Tank AN-106 in FY 2012.

Table 7-1. Double-Shell Tank Space Management. (2 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
2	The 242-A Evaporator will continue to operate as needed to minimize the volume of liquid waste generated during SST retrievals, and to adjust sodium levels to meet WTP feed requirements. (See Table 7-12, Item 41 for additional 242-A Evaporator assumptions.)	a. Failure of the 242-A Evaporator system would be a single-point failure that could interrupt planned SST retrieval schedules and/or waste feed delivery schedules to WTP.	i. Perform life-extension upgrades to ensure long-term viability of 242-A Evaporator. Periodically reevaluate the upgrade needs. Perform Independent Qualified Registered Professional Engineer multidiscipline reviews as needed.	WBS 5.3.1 includes annual funding for evaporator process engineering support. A combination of operating funds and RA project funds has been allocated to implement a variety of facility upgrades.
			ii. TD 1.3: WFE technology would provide a transportable system for evaporation of SST waste, DST waste, secondary waste, and TRU mixed waste, thus reducing the volume of waste requiring storage and eliminating the current total dependence on the 242-A Evaporator.	TRL-3: Development of a WFE has been projectized to further mature the technology. RA project funding has been allocated in FY 2009-2011, with additional funding in WBS 5.3.11 for FY 2012-2013. Workscope includes technology development activities necessary to demonstrate a TRL of 6. Full-scale operation is planned in 2016.
			iii. TD 1.4: The Waste Reduction Technology Demonstration project will use an agitated thin-film evaporator to test the evaporation of both simulants and actual waste. Test results will provide useful data and support field implementation of the WFE.	TRL-3: The procurement process will begin in FY 2010, with testing in FY 2011.

[a] RPP-RPT-45825, 2010, *Tank Space Alternatives Analysis Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[b] In 2002, in support of Hanford Federal Facility Agreement and Consent Order milestone M-23-24, the Tank Operating Contractor conducted an assessment of SST system integrity. The resulting report, RPP-10435, *Single-Shell Tank System Integrity Assessment Report*, concluded that "... the reinforced-concrete tank structures have an adequate collapse margin, justifying continued safe storage of the interim-stabilized waste. However, given the tank leak history and current condition of the tank liners, long-term leak integrity, for the liquids remaining in the tanks, cannot be proven for any of the SSTs..." Based on those conclusions, in a subsequent letter to Ecology (Rasmussen 2002, 02-OMD-036), ORP declared "...these tanks and ancillary systems should be considered unfit for use." The technical and regulatory hurdles that would have to be overcome to reverse this decision should not be under-estimated. Based on a preliminary evaluation of these potential options in RPP-RPT-25589, *Evaluation of Alternatives to Support Temporary Waste Staging Needs*, and the recommendations of RPP-RPT-45921, *Single-Shell Tank Integrity Expert Panel Report*, ORP is further exploring the cost, benefits, and risks of staging waste in SSTs.

[c] RPP-PLAN-30112, 2006, *Plan to Resolve Technical Issues Associated with Sludge Accumulation in Double-Shell Tanks*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

[d] RPP-RPT-26836, 2010, *Gas Retention and Release for Hanford Site High Shear Strength Waste*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

BDGRE = buoyant displacement gas release event.
DST = double-shell tank.
FY = fiscal year.
LAW = low-activity waste.
ORP = Office of River Protection.
RA = Recovery Act.
RPP = River Protection Project.
SST = single-shell tank.
TD = technology development.
TRL = Technology Readiness Level.
TRU = transuranic.
WBS = work breakdown structure.
WFE = wiped-film evaporator.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

7.2 SINGLE-SHELL TANK RETRIEVAL

Table 7-2. Single-Shell Tank Retrieval. (2 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
3	SST bulk waste retrieval methods (including modified sluicing with supernate or water, modified sluicing with water only, vacuum retrieval, a mobile retrieval system, and/or alternative processes) will meet RPP expectations for waste retrieval rates to provide feed on demand to WTP. SST heel removal technologies will be able to meet retrieval (tank residual) requirements. The System Plan (Rev. 5) Baseline Case requires that the TOE for retrievals from SSTs other than C Farm will be twice the currently estimated TOEs.	a. SST retrieval rates will be achieved based on assumed retrieval technologies and performance (including learning curves and demonstrated pumping rates); retrieval sequences, simultaneous retrieval constraints resulting from infrastructure or operational considerations, available DST space; supplemental treatment (packaging) of potential TRU tank waste; providing a balanced feed to the WTP (with priority given to feeding the more limiting facility); providing for incidental blending; and implementing designated intentional blends. However, based on retrieval system experience, waste in some tanks will be difficult to retrieve. Use of multiple technologies may be required in a single tank to meet retrieval (tank residual) requirements. The retrieval technologies may not be as efficient or effective as assumed. "Special case" SSTs and SSTs assumed to have leaked may present additional retrieval challenges. In addition to the four primary bulk waste retrieval methods already identified (i.e., modified sluicing with DST supernate, modified sluicing with water, vacuum retrieval, and a mobile retrieval system), alternative methods for bulk waste retrieval may be required. b. Certain tanks may require use of chemical dissolution for the removal of heels. Use of large quantities of sodium hydroxide, oxalic acid, or other chemicals for heel removal may increase the mass of LAW glass or adversely impact the WTP flowsheet. c. If the overall required retrieval rates cannot be met with improvements in the TOEs and associated retrieval durations, then other alternatives may need to be explored (e.g., increasing the number of simultaneous retrievals).	i. Develop, test, and deploy new SST retrieval technologies as needed. TD 2.1: The MARS technology consists of a telescoping arm that rotates a complete 360 degrees, enabling it to reach the furthest extremities of an SST. MARS with modified sluicing will be used for sound tanks, and MARS vacuum mode will be used for tanks that are assumed to have leaked in the past.	TRL-7: Sluicing version – Full-scale cold testing was performed in FY 2009. Test results prompted some design modifications, which are in progress. Deployment in Tank C-107 is scheduled in FY 2011. TRL-4: Vacuum version – Design activities are continuing in FY 2010. Deployment in Tank C-101 is scheduled in FY 2012.
			ii. Incorporate lessons learned into retrieval system plans, designs, and operations to meet the assumed TOEs and associated retrieval durations. Revise the SST Waste Retrieval Plan (RPP-PLAN-40145)[a] as appropriate.	Updated SST retrieval assumptions (assumed technology, TOEs and associated minimum retrieval durations, and as-retrieved waste volumes) used for the System Plan (Rev. 5) Baseline Case are provided by SVF-1647.[b] These will be used as a basis for establishing the initial performance requirements of future SST retrieval systems.
			iii. TD 1.1: Expand the existing SST Tank Integrity Program. Develop a suite of tools/methods and perform tests on SSTs to assess and demonstrate the integrity of the tanks for continued use, including SST use for waste staging.	An SST Integrity Program was initiated in FY 2009 with the assistance of an expert panel.
			iv. Revisit the designation of the SSTs that are assumed to have leaked, and if supported by evidence, revise those designations using the process described in TFC-ENG-CHEM-D-42.[c]	Leaks from tanks in A, AX, C and SX Farms have been reassessed using RPP-32681.[d] Adoption of results is pending the completion of formal tank leak assessments under TFC-ENG-CHEM-D-42.[c] Reports include RPP-ENV-33418,[e] RPP-ENV-37956,[f] and RPP-ENV-39658.[g]
			v. Support ORP in communications with regulators to determine if waste retrieval from a given tank meets regulatory requirements.	Ongoing.
			vi. Demonstrate the efficacy of both caustic and oxalic acid heel removals.	A high caustic concentration heel removal demonstration is planned for Tank C-108 in FY 2011. One (or more) oxalic acid cleaning demonstration(s) is planned as part of AX Farm retrieval around FY 2015–2016.
			vii. Evaluate the costs and benefits of implementing an oxalic acid destruction process.	SRS is currently developing enhanced chemical cleaning technology. This uses oxalic acid in conjunction with an oxalic acid destruction technology.
			viii. Evaluate the feasibility of reducing the peak number of SST retrievals completed per year.	This may be considered as part of a future revision to RPP-PLAN-40145.[a]

Table 7-2. Single-Shell Tank Retrieval. (2 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
3 cont.		d. Planned retrieval infrastructure may not be adequate to support the number of concurrent retrievals necessary to meet mission success criteria (i.e., WTP feed rates and HFFACO milestones).	ix. A variety of tank farm infrastructure upgrade projects are planned to support waste retrieval and waste feed delivery activities. Examples include (but are not limited to) removal of obsolete equipment and transfer lines, installation of mixer pumps, transfer pumps, instrumentation and transfer lines, and upgrades to tank ventilation and electrical systems.	Infrastructure upgrade projects are in various stages of planning and execution based on funding availability and anticipated need dates.
			x. Consider scheduling the removal of obsolete equipment, installation of new risers, refurbishment of pits, and similar work earlier to decouple preparatory scope from the actual installation of the upgrades.	
		e. Waste containing high concentrations of phosphates could result in transfer line plugging that would delay waste retrieval and/or evaporator operations.	xi. Engineering procedures and standards are in place to control the transfer of phosphate-bearing waste.	Operational controls are maintained through the Waste Compatibility Program.
			xii. Develop methods for locating plugs and unplugging the transfer lines.	Florida International University is currently testing two possible methods for removing line plugs.
4	The System Plan assumes that no waste will leak from SSTs or SST retrieval systems during retrieval to ensure that the maximum waste inventory is modeled through the WTP.	a. The potential exists for an SST to leak during retrieval operations. The discovery of a leak may require the implementation of response actions, including the potential use of a different retrieval technology, and might delay retrievals in nearby tanks.	i. Formulate detailed tank retrieval plans to retrieve adjacent sound tank(s) prior to retrieving suspect tank(s) to reduce the impact of a leak on nearby retrievals; include monitoring strategies to identify leaks if they should occur; and include response actions for tank leaks in the tank waste retrieval work plans and process control plans.	RPP-PLAN-40145[a] plans to retrieve adjacent sound tank(s) prior to retrieving suspect tanks(s).

[a] RPP-PLAN-40145, 2010, *Single-Shell Tank Waste Retrieval Plan*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[b] SVF-1647, 2010, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3B.xlsx'," Rev. 3B, Washington River Protection Solutions LLC, Richland, Washington.
[c] TFC-ENG-CHEM-D-42, 2009, *Tank Leak Assessment Process*, Rev. B-2, Washington River Protection Solutions, LLC, Richland, Washington.
[d] RPP-32681, 2007, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
[e] RPP-ENV-33418, 2008, *Hanford C-Farm Leak Assessment Report: 241-C-101, 241-C-110, 241-C-111, 242-C-105, and Unplanned Waste Releases*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
[f] RPP-ENV-37956, 2008, *Hanford A and AX-Farm Leak Assessments Report: 241-A-103, 241-A-104, 241-A-105, 241 AX-102, 241-AX-104 and Unplanned Waste Releases*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.
[g] RPP-ENV-39658, 2010, *Hanford SX-Farm Leak Assessments Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

DST = double-shell tank.
FY = fiscal year.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
LAW = low-activity waste.
MARS = mobile arm retrieval system.
ORP = Office of River Protection.
RPP = River Protection Project.
SRS = Savannah River Site.
SST = single-shell tank.
TD = technology development.
TOE = total operating efficiency.
TRL = Technology Readiness Level.
TRU = transuranic.
WTP = Waste Treatment and Immobilization Plant.

7.3 TANK/WASTE MANAGEMENT AREA CLOSURE - REGULATORY PROCESS

Table 7-3. Tank/Waste Management Area Closure Regulatory Process.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
5	ORP and Ecology will provide timely approval to support interim closure (tank isolation and filling with grout) of each SST after retrieval of that tank is complete.	a. Interim and final closure plans have not been fully developed. b. Closure activities are not modeled in HTWOS.	i. A closure integration plan is being developed to better define the strategy and approach to be used to close the tanks. The cost and schedule for interim and final closure activities will be reflected in the life-cycle baseline.	In 2009, WRPS provided ORP with RPP-PLAN-40761.[a] This document was provided as a released draft to facilitate future discussions with regulators.
	Timely approval will be provided to support waste management area closure after all tanks in that area have been interim closed.	c. Uncertainties regarding issuance of the draft TC & WM EIS and final ROD may impact development and implementation of closure plans.	ii. Continue to support finalization of the TC & WM EIS and release of the ROD.	Upon issuance of the TC & WM EIS ROD, the impacts of the ROD upon the RPP system will be assessed, and a BCR will be submitted to bring the baseline into alignment.
		d. Selection of closure activities and technologies through the regulatory process may be more costly and require more time than is planned in the baseline. Schedule delays could impact the ability to meet HFFACO closure milestones.	iii. Continue to develop information that supports closure initiatives.	Ongoing efforts in support of the Waste Management Area C performance assessment are discussed in Section 2.3.3 (see also Table 7-4).
		e. The ability of grout to successfully encapsulate and stabilize the residual tank waste is uncertain.	iv. Continue to develop and test grout formulations.	See Table 7-4, Item 6, Key Issue/Uncertainty b.

[a] RPP-PLAN-40761, 2009, *Integrated Single-Shell Tank Waste Management Area Closure Plan*, Rev. 0 DRAFT, Washington River Protection Solutions, LLC, Richland, Washington.

BCR = baseline change request.
Ecology = Washington State Department of Ecology.
EIS = environmental impact statement.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
HTWOS = Hanford Tank Waste Operations Simulator.
ORP = Office of River Protection.
ROD = record of decision.
RPP = River Protection Project.
SST = single-shell tank.
TC & WM = Tank Closure and Waste Management.
WRPS = Washington River Protection Solutions, LLC.

7.4 TANK/WASTE MANAGEMENT AREA CLOSURE - TECHNOLOGY

Table 7-4. Tank/Waste Management Area Closure – Technology.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
6	Sampling and analysis tools and methods to assess the quantity, composition, and radioactivity of residual tank waste will be developed. Interim tank closure technologies and waste management area closure technologies can be developed to meet as-yet-undetermined regulatory requirements.	a. Possible tools and methods for residual waste characterization are still under evaluation at this time. b. The ability of the grout to (1) sufficiently stabilize the waste heel, and (2) prevent subsidence of the tank has not yet been demonstrated.	i. Test technologies and techniques prior to field deployment. Ensure that lessons learned are gathered during testing and demonstrations and are incorporated into closure plans and the life-cycle baseline.	In 2009, WRPS released RPP-RPT-41550,[a] which documented the results of offsite cold testing of candidate grout formulations for tank closure. RPP-PLAN-43988[b] provides an overview of additional work planned.

[a] RPP-RPT-41550, 2009, *Closure Demonstration Grout Test Report*, Rev. 1A, Washington River Protection Solutions, LLC, Richland, Washington.
[b] RPP-PLAN-43988, 2010, *WRPS Technology Development Roadmap*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

WRPS = Washington River Protection Solutions, LLC.

7.5 WASTE TREATMENT AND IMMOBILIZATION PLANT

Table 7-5. Waste Treatment and Immobilization Plant. (3 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
7	WTP hot commissioning will start May 1, 2018, and end on December 1, 2019. Full WTP production operations will start December 2, 2019, and continue until the end of the treatment mission. The net LAW treatment rate during full operations will ramp to 21.0 MTG/day by January 1, 2022. The net HLW treatment rate during full operations will ramp to 5.25 MTG/day by February 6, 2025. The WTP PT Facility achieves its minimum contract capacity requirements. The WTP will operate at the above rates and according to its flowsheet and operating modes as reflected in: 24590-WTP-RPT-PT-02-005[a] and 24590-WTP-MDD-PR-01-002.[b]	a. The May 1, 2018 date for the start of hot commissioning only assumes the use of seven months of the 14-month contingency in the current WTP schedule. Experience at other sites indicates startup and readiness at complex facilities is uncertain. If the start of operations is delayed, or the capacity of the WTP is lower than projected, the duration of the treatment mission may increase. b. Depending on the current mission duration driver, more waste may have to be processed through supplemental treatment. c. The WTP PT Facility, LAW Vitrification Facility, or HLW Vitrification Facility may not achieve the assumed design or net treatment capacities. d. Supplemental treatment and pretreatment capacity beyond that provided by the WTP is needed to fully utilize the assumed LAW and HLW treatment capacity. The Baseline Case provides this capacity with the second LAW facility and the ARF.	i. Continue to identify WTP construction, start-up, and process throughput uncertainties and complete appropriate risk mitigation actions.	The recently formed WTP Operational Readiness organization includes personnel with knowledge and experience from both the TOC and WTP project.
			ii. Plan and execute the second (supplemental) LAW vitrification facility baseline scope of work.	WBS 5.4.1.8 – funded in FY 2011–2013.
			iii. Revisit programmatic assumptions, such as the amount and timing of supplemental treatment, if the projected mission duration exceeds the life of WTP or if the mission duration is otherwise unacceptable.	Analysis conducted as part of ongoing HTWOS modeling and system planning.
			iv. Continue to monitor WTP design capacities and predicted availabilities. Consider future improvements to WTP design, flowsheets, operating modes, and strategies.	The recently formed WTP Operational Readiness organization includes personnel with knowledge and experience from both the TOC and WTP project.
			v. Incorporate more accurate models of the WTP flowsheet and operating modes into future versions of the System Plan, via updates to HTWOS.	Ongoing. In FY 2010, significant upgrades were made to the HTWOS model to improve alignment with the WTP flowsheet (see Section 4.1.1). Additional upgrades will be implemented in the future as appropriate. WBS 5.3.1.2 is funded in FY 2010–2013.
			vi. Develop the LiHT process to TRL 3 by the end of FY 2010.	Laboratory testing conducted during FY 2010 provided useful information about the suitability of applying the LiHT process to Hanford wastes. Further development is on hold pending direction from DOE.
			vii. If the ARF is removed from the baseline, evaluate ways to reduce the demand on the WTP PT Facility so that HLW vitrification continues to drive the mission duration. This includes trading-off the mass of HLW glass against the mass of LAW glass, reducing variability in the projected WTP feed, refinements to the design and operating modes of the WTP, and providing supplemental pretreatment in the form of the ARF.	For System Plan (Rev. 5), the impact of the proposed ARF on the RPP System was modeled by HTWOS.
8	Startup and turnover of WTP facilities to the TOC will not be adversely impacted by inadequate staffing or documentation.	a. Organizational interfaces needed to enable facility turnovers are not yet in place. b. Operating documentation does not yet exist.	i. Create and maintain organizational interfaces to promote effective communication, planning, and issue resolution. ii. Considered turning over parts of the WTP to the TOC early, to allow for a phased transition.	The WTP Operational Readiness department was created in FY 2010 to facilitate interfaces between the two organizations and includes personnel with knowledge and experience from both the TOC and WTP project.

Table 7-5. Waste Treatment and Immobilization Plant. (3 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
9	The technical issues previously identified in several design oversight reviews, external reviews, and a comprehensive independent review either have been resolved or will be resolved without adverse impact to the assumed performance or schedule of WTP.	a. At this time, it is unlikely that the resolution of technical issues will have a negative impact on mission duration. If the aforementioned technical issues are not successfully resolved, the WTP may operate at less than its assumed design capacity, or its startup schedule could be delayed, either of which could increase the overall RPP mission duration.	i. Monitor resolution of the technical issues; provide support as appropriate.	Technical issues are being aggressively worked to bring timely closure and support the WTP construction schedule. Closure of critical issues is approved jointly by WTP and ORP through a technical steering group.
10	The composition, properties, and waste oxide loading of HLW glass will be estimated using the 2009 GFM documented in PNNL-18501.[c] For modeling purposes, the glass-forming chemicals are assumed to be provided as pure oxides rather than impure minerals. Projections of IHLW produced by the WTP are based on starting tank inventory, wash and leach factors, oxidative leach assumptions, and the assumed disposition of the TRU waste. In addition, the IHLW canister count is based on the newer 10-gauge (thin-walled) canisters.	a. HLW glass formulation assumptions have not been demonstrated for all Hanford waste compositions. Incorrect assumptions could impact expected waste loading per unit of glass, number of IHLW canisters, and mission duration.	i. Continue HLW glass development at the Vitreous State Laboratory (The Catholic University of America, Washington, D.C.) with DOE (EM-31) funding.	Work at Vitreous State Laboratory is ongoing. Higher alumina loadings have been demonstrated for some HLW glasses.
			ii Develop and implement in HTWOS a new GFM that reflects recent research at PNNL.	A new GFM was developed based on PNNL-18501[c] and implemented in HTWOS for System Plan (Rev. 5). Additional information on the model update is provided in Section . Additional information regarding HLW glass predictions is provided in Section 5.5.2.4.
		b. Projected number of IHLW canisters generated is uncertain. HLW glass mass is sensitive to the degree of blending (both incidental and intentional) achieved during the retrieval, storage and delivery of feed, to starting waste inventory, and to pretreatment assumptions.	iii. Continue to evaluate options for intentional blending, caustic and oxidative leaching, and improving the HLW glass formulations. Evaluate impacts that other assumption changes and operational constraints have on blending and the resulting HLW glass mass.	The waste blending scenario modeled in System Plan (Rev. 5) effectively reduces the impact of high zirconium concentration present in some tanks. RPP-RPT-42968[d] issued by WRPS.
		c. Given the current uncertainties associated with the location and waste acceptance criteria of the future federal repository, HLW product specifications are also uncertain.	iv. Sample, characterize, and test leaching performance of DSTs containing SST waste after early SST retrievals are complete to reduce uncertainty.	
		d. A single IHLW canister needs to be selected for use.	v. Select and promulgate either the original 3/8-inch wall or the newer 10-gauge wall canister for use in design, permitting, safety analysis, project definition, and system planning.	
11	Projections of WTP secondary wastes are not well defined.	a. Current modeling efforts are only capturing the secondary wastes directly related to the waste treatment process. These quantities have not been validated.	i. Need to quantify and validate projections of secondary waste streams.	
12	Composition of the LAW glass will be estimated using a glass recipe model similar to that described in Table B-2 of 24590-WTP-MRQ-PO-04-0065.[e] Sodium oxide loading of LAW glass from pretreated feed will be determined using the DOE model (D-03-DESIGN-004),[f] which maximizes the sodium oxide loading subject to constraints. Projections of ILAW produced by the WTP are based on starting tank inventory, wash and leach factors, oxidative leach assumptions, and the assumed disposition of the TRU waste.	a. Projected number of ILAW packages from the WTP is uncertain. LAW glass mass is very sensitive to the assumed caustic addition requirements (see Item 20, Table 7-8).	i. Continue development of improved glass formulation models for LAW vitrification taking into account recent glass formulation work to increase both the Na_2O and SO_3 loadings.	
		b. The IDF waste acceptance criteria for ILAW are not fully defined, and in their current state, may not be sufficient for ILAW disposal.	ii. Review and refine IDF waste acceptance criteria for ILAW.	

Notes to Table 7-5:

[a] 24590-WTP-RPT-PT-02-005, 2008, *Flowsheet Bases, Assumptions, and Requirements*, Rev. 4, Bechtel National, Inc., Richland, Washington.

[b] 24590-WTP-MDD-PR-01-002, 2009, *Dynamic (G2) Model Design Document*, Rev. 10, Bechtel National, Inc., Richland, Washington.

[c] PNNL-18501, 2009, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*, Pacific Northwest National Laboratory, Richland, Washington.

[d] RPP-RPT-42968, 2010, *River Protection Project Mission Analysis Waste Blending Study*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[e] 24590-WTP-MRQ-PO-04-0065, 2004, *Model Run Request, Supplemental LAW Data Collection*, Rev. 0, Bechtel National, Inc., Richland, Washington.

[f] D-03-DESIGN-004, 2003, *An Assessment of the Factors Affecting the Ability to Increase the Na_2O Loading in the Waste Treatment and Immobilization Plant (WTP) Low Activity Waste (LAW) Glass*, ORP WTP Engineering Division, U.S. Department of Energy, Office of River Protection, Richland, Washington.

ARF = Aluminum Removal Facility.
DOE = U.S. Department of Energy.
DST = double-shell tank.
FY = fiscal year.
GFM = glass formulation model.
HLW = high-level waste.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
LiHT = lithium hydrotalcite.
MTG = metric tons of glass.
ORP = Office of River Protection.
PNNL = Pacific Northwest National Laboratory.
PT = Pretreatment.
RPP = River Protection Project.
SST = single-shell tank.
TOC = Tank Operations Contract.
TRL = Technology Readiness Level.
TRU = transuranic.
WBS = work breakdown structure.
WRPS = Washington River Protection Solutions, LLC.
WTP = Waste Treatment and Immobilization Plant.

7.6 TANK CLOSURE/WASTE MANAGEMENT ENVIRONMENTAL IMPACT STATEMENT RECORD OF DECISION AND REGULATORY APPROVAL DELAY

Table 7-6. Tank Closure/Waste Management Environmental Impact Statement Record of Decision and Regulatory Approval Delay.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
13	Discrepancies between the current RPP baseline and the TC &WM EIS scope can be resolved via the baseline change request process after the EIS ROD has been issued.	a. The scope of work evaluated in the TC & WM EIS includes significant differences from the current RPP baseline (a detailed list is provided in Table 2-1). Implementation of the preferred alternative(s) identified in the ROD could significantly increase the cost or extend the schedule of the RPP program.	i. Discrepancies in scope between the draft TC & WM EIS and the current RPP baseline have been communicated to ORP. The HTWOS model could be used to evaluate the impacts of some changes, if requested by ORP.	DOE has full responsibility for the preparation of EISs and their associated ROD. WRPS will provide support as requested.
14	Timely approval will be received to (1) interim close individual waste tanks after they are emptied, and (2) close each tank farm after all tanks in that farm are interim closed.	a. Delays in completing the TC & WM EIS will impact progress in developing closure plans and initiating field closure activities. EIS alternatives and the ROD may not align with the baseline assumptions and not establish the needed standards to close tanks. Assumed closure technologies have been tested but not deployed.	See Item 5, Table 7-3.	See Item 5, Table 7-3.
15	Current HFFACO milestone completion dates are being renegotiated, and therefore will not be used as a planning basis.	a. Litigation between state and federal authorities over delinquent milestones and the ability to meet remaining milestones may impact establishment of HFFACO dates. New HFFACO milestone dates and commitments, if not consistent with the life-cycle baseline and associated uncertainties, would impact the baseline. Uncertainties regarding issuance of the draft TC & WM EIS and final ROD have the potential to impact new HFFACO milestone dates for retrieval and closure.	i. Continue to monitor and support ORP in renegotiation of HFFACO milestones and commitments. ii. Continue to work with Ecology to explain mission drivers and solicit input on baseline priorities.	Per the contract (DE-AC27-08RV14800),[a] WRPS has primary responsibility to interface with regulators.
16	The design, flowsheet, operating modes, and operating plans of all facilities or processes will drive the permit conditions, and the permits will be modified as the processes evolve.	a. Delays in permit changes could adversely impact the TOC or WTP schedule and cost baseline.	i. Maintain communications with agencies on permit applications to ensure that permit applications are complete and meet requirements.	
17	The Baseline Case implicitly assumes that the outcome of official WIR WDs will be consistent with the assumed disposition of the primary and secondary waste forms prior to disposal.	a. Emergent inconsistencies between planned primary/secondary waste dispositions versus WD outcomes would adversely impact waste disposal plans and schedules.	i. Schedule the WIR WDs early enough to remain off the critical path even if the outcome is different than currently assumed.	

[a] DE-AC27-08RV14800, *Tank Operations Contract*, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE = U.S. Department of Energy.
Ecology = Washington Department of Ecology.
EIS = environmental impact statement.
HFFACO = Hanford Federal Facility Agreement and Consent Order.
HTWOS = Hanford Tank Waste Operations Simulator.
ORP = Office of River Protection (DOE).
ROD = record of decision.
RPP = River Protection Project.
TC & WM = Tank Closure and Waste Management.
TOC = Tank Operations Contract.
WD = waste determination.
WIR = waste incidental to reprocessing.
WRPS = Washington River Protection Solutions, LLC.
WTP = Waste Treatment and Immobilization Plant.

7.7 222-S LABORATORY AVAILABILITY

Table 7-7. 222-S Laboratory Availability.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
18	Laboratory services required to support the RPP mission are available and provided in a timely manner.	a. 222-S Laboratory and associated support systems, such as core sampling trucks, are aging and prone to increased failure rates and increased maintenance attention.	i. Include any required life extension upgrades in the life-cycle baseline. Perform critical and routine maintenance on sampling systems and components to ensure readiness of these systems.	Various upgrade and facility life extension projects are in progress or are planned in the near future; some are funded through the baseline, and some are funded as RA projects. New mobile video vans were purchased recently to support SST retrievals, sampling, in-tank inspection, and leak checks.

RA = Recovery Act.
RPP = River Protection Project.
SST = single-shell tank.

7.8 INACCURATE MISSION DECISION

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
new	Execution of the RPP mission as planned will meet the success criteria.	a. This issue is essentially a roll-up of all the other key issues and uncertainties expressed throughout Section 7.0.	i. System planning activities will continue to integrate new information into baseline plans and actions.	Ongoing.
19	The ARF is assumed to start-up on July 19, 2022 and will condition all feed to the WTP PT Facility from that date on. The ARF is assumed to be a standalone facility that uses a process based on the LiHT process described in Shuford 2010[a] to caustic leach all of the solids in the delivered feed. In this context, standalone means that the facility contains all necessary unit operations and will not rely on the DST system, the 242-A Evaporator, or the WTP PT Facility for support, that all recycles are internal, and that it includes any needed lag-storage. (Note that this does not preclude the use of the LERF/ETF and IDF for handling secondary waste from the ARF.) The LiHT is assumed to be washed, dried, and drummed, and is further assumed to be suitable for disposal at the IDF as a new secondary waste stream.	a. The ARF is integral to the successful completion of the waste treatment mission as currently envisioned. The LiHT process has not been sufficiently developed to determine its efficacy or how to integrate it into the overall waste treatment complex flowsheet. The process may not be developed and implemented in a timely manner given the current level of technology immaturity, or may not be as effective as assumed.	i. The ARF and the LiHT process will be considered as part of supplemental treatment decisions (CD-0, CD-1, etc.) ii. Determine the acceptability of the LiHT by-product for disposal at IDF. The disposition may need to consider potential reuse as a portion of the LAW glass formers. iii. Refine the aluminum solubility correlations so that more accurate predictions of hydroxide needs can be made (see Item 22).	

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
20	The amount of caustic projected for caustic leaching is adequate to leach aluminum and keep aluminum soluble through cesium ion exchange. For modeling purposes, the solubility of aluminum in supernate present in the WTP PT Facility will be approximated using the correlation shown in Equation 4 from Reynolds and Adelmund (2007).[b] This aluminum solubility correlation will be used to determine the amount of sodium hydroxide added to the waste during pretreatment, with the goal of ensuring that all feed to the Cs ion-exchange system is not supersaturated with aluminum at 25°C.	a. The WTP baseline correlation shown in Equation 9 of Reynolds and Adelmund (2007)[b] is overly conservative and results in high estimates of required sodium additions. ORP has requested that Equation 4 be used to estimate nominal caustic additions until a better correlation is available. The potential consequences of this uncertainty depend on the efficacy of the ARF (see Item 19). If the ARF is not successful, then it is more important to accurately predict aluminum solubility.	i. Consider operating the PT Facility waste treatment processes at a higher temperature to help keep the aluminum in solution, thereby reducing the amount of sodium hydroxide that must be added.	ORP has directed BNI to incorporate the necessary design and operating mode changes into the WTP. WRPS is evaluating the impacts on the RPP mission.
			ii. Consider tailoring the degree of caustic leaching so that no more aluminum is removed from the HLW solids as is needed to produce an acceptable quantity of HLW glass.	BNI is exploring this in conjunction with Item 20, Potential Mitigation Action i. WRPS is evaluating impacts on the RPP mission.
			iii. Evaluate caustic recycle after pretreatment or other caustic management strategies.	
			iv. Develop refined LAW glass formulation models to increase sodium oxide loading and consider ways to increase total LAW treatment capacity. ORP has an ongoing effort to assess sodium use in the WTP. An approved sodium management plan and a recent assessment (A-09-AMWTP-RPPWTP-002[c]) may further refine this assumption. The use of referenced Equation 4 is appropriate until further revision or improvement is supported.	
			v. Provide additional LAW treatment capacity.	
			vi. Develop improved HLW glass formulation models that can accommodate higher alumina loadings. Increasing alumina waste loading in glass may reduce the number of batches or fraction of alumina that must be leached, which reduces NaOH added in processing.	
21	Supplemental LAW treatment capacity will be provided by a second LAW vitrification facility, located adjacent to the WTP. The second LAW facility will have the same technical assumptions as the WTP LAW Vitrification Facility and will complete hot commissioning on September 30, 2022, and begin full operations on October 1, 2022.	a. A formal decision is needed to determine (1) how the required supplemental LAW treatment capacity will be provided, (2) how condensate will be managed, (3) if supplemental pretreatment capacity is required, and (4) the additional scope and cost that will need to be included in the life-cycle baseline as a result. Also, the ARF is needed to support the assumed LAW treatment capacity and WTP pretreatment capacity.	i. A key element of the strategy for mitigating these issues is to accelerate the justification for mission need and technology down-select: • Complete a justification for mission need (CD-0) for supplemental treatment by 9/30/2010. • Complete a technology down-select (CD-1) by 9/30/2011. Evaluate a second LAW facility, steam reforming, bulk vitrification, and other technologies with a viable TRL 3 or higher.	Work in progress to submit the justification for mission need by 9/30/2010; approval is anticipated by 11/18/2010. A BCR is being prepared to accelerate the submittal of the technology down-select to 9/30/2011. It is anticipated that the ARF may be supplanted as a consequence of refinements to the WTP pretreatment design and flowsheet and the results of the technology down-select for supplemental LAW treatment.
			ii. Monitor technology development at other DOE sites for applicability to LAW pretreatment.	
			iii. Explore other options for reducing the amount of LAW that needs to be vitrified.	See Item 20, Potential Mitigating Actions i and ii.

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
22	The water wash factors in TWINS circa October 2008 will be used to partition waste into solid and liquid phases during retrieval and staging; strontium partitioning will be modeled in accordance with RPP-21807.[d] The feed vector will be reported on a fully water-washed basis. The caustic leach factors in TWINS circa October 2008 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids.	a. Uncertainties and biases in the water wash and caustic leach factors can significantly influence the canister counts and treatment end dates. Water wash factors and caustic leach factors are a zero order approximation to complex solid-liquid equilibrium; this is a known limitation of this methodology.	i. Continue to optimize the waste feed provided to the WTP. Undertake engineering optimization studies to evaluate solutions such as waste blending. Ensure waste storage/blending options are incorporated into the SST retrieval sequence and schedule, waste storage plans, and the WFD sequence and schedule. Update the HTWOS model runs as required.	RPP-RPT-46618[e] (Rev. 1) was issued 6/29/2010 by WRPS. RPP-RPT-42968[f] was issued by WRPS.
			ii. Develop composition-based solid/liquid solubility models to supplant water wash factors.	WRPS is currently developing solid-liquid phase equilibria models. Solubility models for major species are expected to be completed in FY 2011. Solubility models are being developed for those solid-phases that are major components in the waste and are expected to come reasonably close to equilibrium over the timeframe of waste processing. A first step was to compile all of the known mineralogical data of the waste, which was completed this year (RPP-RPT-46618[e])
			iii. Develop a composition or source-based speciation of aluminum to supplant the aluminum caustic leach factor.	An estimate of the solid-phase speciation of aluminum will be completed in FY 2010. This report will divide aluminum into three categories. One category is aluminum that is not expected to be able to be leached appreciably (primarily aluminosilicates). The second category is aluminum that is kinetically controlled and the amount removed depends on the leaching time and temperature (primarily boehmite). The third category is aluminum that is easy to leach (provided that sufficient NaOH is added) and is rapidly removed from the waste sludge. This category is primarily gibbsite, dawsonite, and a number of more minor species.
23	A formal WD will indicate that the potential TRU tank waste can be segregated from the high-level tank waste and subsequently treated, packaged, and disposed as TRU waste.	a. WDs cannot be completed until the TC & WM EIS ROD is issued. b. TRU waste determination is uncertain. Final criteria for potential TRU tank waste may be more stringent than current standards. Some potential TRU tank waste may not meet TRU waste dose limitations.	i. Develop bases for TRU waste classification. Pursue agreement with regulators and stakeholders. ii. Assess existing waste characterization data and if needed, obtain additional waste samples to support adequate characterization. iii. In the event that the waste is determined to be treated as HLW after packaging, implement contingency plans for treatment as HLW at the WTP.	
24	Waste treatment process and packaging capability will be developed to support potential TRU tank waste retrieval and handling.	a. Potential TRU tank waste packaging system equipment was developed and tested using simulated waste. Additional testing may be required on proposed systems to demonstrate that waste can be delivered to the TRU packaging facilities within specified waste characteristics and dose limits.	i. Develop and test waste processing technologies to support TRU tank waste retrieval and packaging, including ALARA considerations. Include workscope for testing in life-cycle baseline planning.	A draft flowsheet has been prepared (RPP-21970[g]).
25	The CWC permits can be modified as appropriate to accept the TRU waste.	a. CWC permit modification and approval is uncertain.	i. Support ORP and regulators as needed to secure permits modifications.	
26	If the WD for the potential TRU waste indicates that this waste is not TRU, and therefore not suitable for offsite disposal, it will be retrieved and comingled with other tank waste, and treated through the WTP facility.	a. Additional facilities may be required to condition the waste for processing through WTP.	i. Evaluate other options for disposition of this waste stream.	

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
27	The IDF will be operational on October 1, 2010, and will provide permanent disposal for the ILAW, other mixed LLW, and LLW, including LAW glass packages from the WTP; solid waste from the WTP, including spent LAW and HLW melters; the LiHT by-product from the ARF; and solid waste from the ETF from treating liquid effluent. The IDF can be expanded as needed to support the mission without interference from other users.	a. A final decision under the TC & WM EIS as documented in the ROD is required before IDF can be used for disposal. Delays to the TC & WM EIS ROD will delay the use of IDF for this purpose.	i. Evaluate schedule impacts upon issuance of the TC & WM EIS ROD.	
		b. Any upgrades or expansion of these facilities that are not covered under the current TC & WM EIS scope will need additional NEPA documentation to be prepared prior to implementing the upgrades.	ii. Evaluate scope impacts upon issuance of the TC & WM EIS ROD.	
		c. The performance of the IDF to safely dispose of the projected quantities, forms, and composition of primary and secondary waste from the treatment mission has not yet been demonstrated.	iii. Complete a performance assessment of the IDF to verify the ability to safely dispose of the projected primary and secondary waste forms. iv. Update the projections of primary and secondary waste to be disposed of in the IDF as underlying flowsheets and processes evolve. v. Evaluate options to reduce the projected volume of wastes to be disposed at IDF. Possibilities include: • Evaluate the disposition of the LiHT by-product. It may be possible to use this material to replace a portion of the glass-forming chemicals added to the pretreated LAW at the WTP PT Facility or the second LAW facility. • Upgrade the ETF to treat the projected liquid effluents.	
		d. The planned transportation system (fleet of 14 trainers) and emplacement strategy may not allow adequate time for cooling the ILAW packages before disposal in the IDF given the combined production rates of both the WTP LAW facility and the second LAW facility.	vi. Perform a timing study to see if the first layer of packages disposed in the IDF would be completed before the projected of maximum combined production rates would exceed the transport (including cooling) capability of the IDF. This would potentially allow the first layer to insulate the liner from the subsequent layers. vii. Include cooling capacity in the second LAW facility. viii. Explore the feasibility of a separate cooling area in which packages could be cooled, either on or off the trailers. ix. Explore the feasibility of starting the second layer before the first layer has been completed.	
28	One spent LAW melter is assumed to be replaced every 5/n years on average, where n is the total number of melters in operation, and will contain approximately 1,875 gal of glass. Spent LAW melters from both the WTP LAW Facility and the second LAW facility will be managed and disposed at the IDF as mixed LLW. One spent HLW melter is assumed to be replaced every 2.5 years on average, and will contain approximately 823 gal of glass. Spent HLW melters will be managed and disposed at the IDF as mixed LLW.	a. Melters are expendable; their replacement frequency is uncertain. Spent melter disposal pathways and associated potential issues are not fully defined.	i. Develop a spent melter disposal strategy and the associated planning.	
		b. Both the draft TC & WM EIS and the repository EIS evaluate disposal of spent HLW melters at the planned offsite geologic repository, not IDF.	ii. Upon issuance of the TC & WM EIS ROD, resolve the inconsistencies between the planning documents and the supporting NEPA documents.	

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
29	The final disposal alternative for the IHLW glass canisters is assumed to be at an unidentified offsite national repository.	a. The planned offsite national repository may experience delays. WTP may start producing glass before the repository is ready to accept the IHLW. Depending on production capability and timing, WTP could produce more IHLW than can be stored onsite awaiting opening of the repository, requiring the construction of additional interim storage.	i. Monitor planned offsite national repository developments. Continue to integrate the WTP and TOC schedules with projected startup and operating schedules for the repository. Evaluate impacts of repository delays on planned onsite interim storage on an annual basis.	
30	The IHSF will be operational on or before November 21, 2018, and provide interim storage for 2,000 IHLW canisters; storage for an additional 2,000 IHLW canisters will be operational by January 2, 2020. The average canister receipt and retrieval capability of the IHSF will each be 800 canisters per year, with a peak handling rate of three canisters per day	a. Design and construction of the HSF has not been planned in detail. b. This schedule requires that the WTP-provided storage for cooling and buffer capacity be fully used before transferring IHLW canisters to the IHSF.	i. The life-cycle baseline will include planning for the HSF consistent with the need dates.	
31	On or before June 2022, a decision will be made to either continue to build additional IHSF modules or to construct the HSF. For planning purposes, the outcome of this decision is assumed to be that the HSF will be constructed and HLW canisters are shipped to an offsite final disposal alternative. The canister shipping capability of the HSF is assumed to match the retrieval capability of the IHSF. If and when the HSF begins shipping, the first priority will be given to shipping newly created IHLW canisters beyond those stored at the IHSF and second priority is given to emptying the IHSF after HLW vitrification is finished. Shipping needs will be estimated with the IHSF operated at approximately 1,000 canisters less than capacity (i.e., operate at about 3,000 canisters) to decouple canister receipt from the WTP from shipping to a national repository.	a. Uncertainty in the timing and nature of the final disposal alternative may delay shipping.	i. Ensure the HSF is expandable in increments of 2,000 canisters up to a maximum of at least 16,000 canisters, to accommodate all projected IHLW canisters.	
32	The current strategy to comply with the OCRWM waste acceptance criteria is described in 24590-HLW-PL-RT-07-0001.[h] It is assumed that the strategy will be acceptable to OCRWM. It is further assumed that the WTP-prepared delisting petition for the IHLW is accepted by Ecology and the receiving state before shipping the waste to the planned offsite national repository.	a. There is a potential that the waste acceptance strategy will not be acceptable to OCRWM for the DOE/RW-0351[i] IHLW product requirements.	i. The waste compliance plan will be updated as the waste form qualification process evolves. It includes actions for ensuring that the strategy will meet waste form specifications and requirements.	

Table 7-8. Inaccurate Mission Decision. (7 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
33	The timing, capacities, and capability of the ETF, LERF, SALDS, and TEDF will be driven by the needs of the waste treatment mission and are assumed to be available when needed. If the treatment mission requires that changes be made to the ETF, LERF, SALDS, or TEDF or their operating plans, ORP is assumed to successfully drive the changes.	a. The current ETF is inadequate to treat the projected liquid secondary waste stream that will be generated by the WTP. Currently planned ETF upgrades may not be adequate to treat secondary waste streams for the waste treatment complex. Of particular importance is the ability to safely dispose of the ETF solid product in the IDF (especially the technetium and iodine) and compatibility of the waste with the ETF process (e.g., high fluoride concentrations). b. The projected disposition of technetium is uncertain due to the presence of recycle streams, and process splits based on limited test data. c. Any upgrades to these facilities that are not covered under the current TC & WM EIS scope will need additional NEPA documentation to be prepared prior to implementing the upgrades.	i. Plan and execute upgrades to the ETF facility to ensure that the ETF can handle the quantity and compositions of liquid secondary waste generated by the waste treatment complex.	WBS 5.3.10, the Secondary Liquid Waste Treatment Project, is funded in FY 2010-2013 to provide the needed secondary liquid waste treatment capability. This capability is scheduled to be ready for operation in FY 2018. RPP-RPT-43588[j] has been issued to support the justification of mission need for the handling and disposal of liquid effluents.
			ii. Implement alternative technologies for treatment of WTP recycle streams to reduce the demand on the ETF.	WBS 5.3.10, the Secondary Liquid Waste Treatment Project, will investigate technologies capable of treating the WTP secondary liquid waste, including the flexibility to treat WTP SBS recycle loop purge. A technology down-select process will define the project flowsheet for design and construction.
			iii. Increase the retention of technetium in LAW glass.	RA funding is being used to investigate methods of improving technetium in LAW glass at the Vitreous State Laboratory. An interim report was issued (RPP-RPT-45887[k]). A final report is to be issued in December 2010.
			iv. Develop improved waste forms for disposal of the solid waste generated from treating the secondary liquid waste.	RA funding is being used to investigate leachability of various waste forms that could be used by the Secondary Liquid Waste Treatment Project. The work is being done by PNNL. A screening test report was issued (PNNL-19505[l]). Final optimization reports will be issued by January 2011.
34	RL will dispose of WESF cesium and strontium capsules at an offsite national repository, independent of processing through the RPP system.	a. If direct disposal of WESF cesium and strontium capsules at a planned offsite national repository is not viable, vitrification at WTP could be required. Facility modifications would be required to retrieve the capsules from WESF, condition them for treatment through tank farm and/or WTP facilities, and introduce the conditioned cesium and strontium streams to the RPP system.	i. Monitor RL progress on direct disposal of WESF capsules at a planned offsite geologic repository. The WTP PT Facility can connect to a potential new facility designed to receive and treat the Hanford cesium and strontium capsules prior to incorporation into the HLW feed for immobilization in the HLW Vitrification Facility (See Section C.7(c)(2) of DE-AC27-01RV14136).[m]	
35	Key features of the WTP have been selected and will be modeled for purposes of mission planning and estimation of secondary waste streams.	a. A consequence of these simplifications is that the current version of the HTWOS model may not be able to identify potential bottlenecks in the WTP PT Facility or evaluate the projected capacity of the PT Facility.	i. Periodically update and align the HTWOS model with the essential features of the most current WTP process flowsheet.	**RESOLVED**. The HTWOS model has been aligned with an expanded list of key features to the current WTP process flowsheet (design and operating modes).
36	Waste from the retrieval of the IMUSTs will be transferred to the tank farms in a series of transfers between 2020 and 2030, or sooner, if practical. Waste inventory estimates for pumping of the IMUSTs, deactivation of other Hanford facilities, and operation of the 222-S Laboratory are provided in RPP-33715.[n]	a. The IMUSTs inventory is uncertain and incomplete. Specific operating plans are not in place to retrieve IMUSTs. The HTWOS only addresses the overall estimated volume of IMUST waste to be treated and feeds it into treatment from about 2020 through 2030. Final disposition of waste in the IMUSTs has not been determined.	i. Determine specific transfer dates as part of the life-cycle baseline development. ii. Continue to refine and update the IMUST inventory input to the HTWOS (RPP-33715[n]) and incorporate the results in the life-cycle baseline. Consider the feasibility and desirability of including the individual IMUST inventories in the BBI. iii. Determine disposition of waste in the IMUSTs and required closure conditions.	WRPS personnel are working to integrate IMUSTs into waste retrieval planning. Additional details are provided in Section 3.1.3.

Notes to Table 7-8:

[a] Shuford, D. H., 2010, "Aluminum Removal Facility Performance Assumptions for System Planning Purposes," (Interoffice Memorandum WRPS-1000230, Rev. 0, to T. W. Crawford, February 1), Washington River Protection Solutions, LLC, Richland, Washington.

[b] Reynolds and Adelmund, 2007, "Contract No. DE-AC27-01RV14136-Gibbsite Solubility Models. Supersedes CNN-137192" (Memorandum CCN-160514 to S. Saunders, Bechtel National, Inc., July 30), Bechtel National, Inc., Richland, Washington.

[c] A-09-AMWTP-RPPWTP-002, 2009, *Design Oversight Plan, Basis for Sodium Estimate*, Rev. 0, ORP WTP Engineering Division, U.S. Department of Energy, Office of River Protection, Richland, Washington.

[d] RPP-21807, 2004, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

[e] RPP-RPT-46618, 2010, *Hanford Waste Mineralogy Reference Report*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.

[f] RPP-RPT-42968, 2010, *River Protection Project Mission Analysis Waste Blending Study*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[g] RPP-21970, 2005, *CH-TRUM WPU&SE 11 Tank Material Balance*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

[h] 24590-HLW-PL-RT-07-0001, 2008, *IHLW Waste Form Compliance Plan for Hanford Tank Waste Treatment and Immobilization Plant*, Rev. 2, Bechtel National, Inc., Richland, Washington.

[i] DOE/RW-0351, 2008, *Waste Acceptance System Requirements Document*, Rev. 5, Office of Civilian Radioactive Waste Management, Washington, D.C.

[j] RPP-RPT-43588, 2009, *Secondary Waste/ETF Preliminary Pre-conceptual Engineering Study*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[k] RPP-RPT-45887, 2010, *Improved Technetium Retention in Hanford LAW Glass – Phase 1 Final Report*, Rev. 0, Washington River Protection Solutions, LLC, Richland, Washington.

[l] PNNL-19505, 2010, *Secondary Waste Form Screening Test Results – Cast Stone and Alkali Alumino-Silicate Geopolymer*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

[m] DE-AC27-01RV14136, *Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*, as amended through A164 (April 5, 2010), U.S. Department of Energy, Office of River Protection, Richland, Washington.

[n] RPP-33715, 2010, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operations Simulator Model – 2010 Update*, Rev. 3, Washington River Protection Solutions, LLC, Richland, Washington.

ALARA = as low as reasonably achievable.
ARF = Aluminum Removal Facility.
BBI = Best-Basis Inventory.
BCR = baseline change request.
BNI = Bechtel National, Inc.
CD = critical decision.
CWC = Central Waste Complex.
DOE = U.S. Department of Energy.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
EIS = environmental impact statement.
ETF = Effluent Treatment Facility.
FY = fiscal year.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
HTWOS = Hanford Tank Waste Operations Simulator.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHSF = Interim Hanford Storage Facility.
ILAW = immobilized low-activity waste.
IMUST = inactive miscellaneous underground storage tank.
LAW = low-activity waste.
LERF = Liquid Effluent Retention Facility.
LiHT = lithium hydrotalcite.
LLW = low-level waste.
NEPA = National Environmental Policy Act.
OCRWM = Office of Civilian Radioactive Waste Management.
ORP = Office of River Protection (DOE).
PNNL = Pacific Northwest National Laboratory.
PT = Pretreatment.
RA = Recovery Act.
RL = Richland Operations Office (DOE).
ROD = Record of Decision.
RPP = River Protection Project.
SALDS = State Approved Land Disposal Site.
SBS = submerged bed scrubber.
SST = single-shell tank.
TC & WM = Tank Closure and Waste Management.
TEDF = Treated Effluent Disposal Facility.
TOC = Tank Operations Contract.
TRL = Technology Readiness Level.
TRU = transuranic.
TWINS = Tank Waste Information Network System.
WBS = work breakdown structure.
WD = waste determination.
WESF = Waste Encapsulation and Storage Facility.
WFD = waste feed delivery.
WRPS = Washington River Protection Solutions.
WTP = Waste Treatment and Immobilization Plant.

7.9 WORK STOPPAGE

Table 7-9. Work Stoppage.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
The purpose of the River Protection Project System Plan is to provide a basis for alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans.				
Key issues and uncertainties associated with a potential work stoppage are outside the scope of the System Plan, and are more appropriately addressed in the Risk Management Plan (TFC-PLN-39[a]).				

[a] TFC-PLN-39, 2010, *Risk Management Plan*, Rev. F, Washington River Protection Solutions, LLC, Richland, Washington.

7.10 SKILL MIX AND LABOR SHORTFALLS

Table 7-10. Skill Mix and Labor Shortfalls.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
The purpose of the River Protection Project System Plan is to provide a basis for alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans. Key issues and uncertainties associated with skill mix and labor shortfalls are outside the scope of the System Plan, and are more appropriately addressed in the Risk Management Plan (TFC-PLN-39[a]).				

[a] TFC-PLN-39, 2010, *Risk Management Plan*, Rev. F, Washington River Protection Solutions, LLC, Richland, Washington.

7.11 BUDGET AND FUNDING UNCERTAINTY

Table 7-11. Budget and Funding Uncertainty.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
37	Fiscal year funding will be available to support the Baseline Case, including that funding required for risk mitigating actions.	a. Funding availability is uncertain and funding shortfalls have the potential to impact the life-cycle baseline.	i. Complete development of the life-cycle baseline. Align the life-cycle baseline cost and schedule estimates with FY-by-FY funding guidance. ii. Use formal baseline change control to address changes to funding needs and availability. iii Maintain adequate management reserve and contingency.	
38	The life-cycle cost of the RPP mission is accurately reflected by the PMB.	a. Evolving scope and requirements can increase costs. b. The annual operating cost of the WTP has not been fully validated c. The life-cycle cost and schedule for the RPP mission is uncertain.	i. Conduct annual updates of the RPP System Plan, the Risk Management Plan,[a] and the PMB.	The System Plan is being updated on an annual basis. The PMB is being aligned with the System Plan. The Risk Management Plan (TFC-PNL-39[a]) is being updated and will be released in parallel with this revision of the System Plan.
			i. Support independent oversight reviews.	In November 2009, an Independent Project Review team from DOE-HQ reviewed all aspects of the RPP baseline. At the completion of the review process, the team recommended that DOE-HQ approve the life-cycle PMB. The PMB was formally approved by DOE-HQ on June 18, 2010.
			iii. Develop an independent estimate of WTP operating costs, considering resources, essential materials and supplies, waste, maintenance, spare equipment, and documentation.	

[a] TFC-PLN-39, 2010, *Risk Management Plan*, Rev. F, Washington River Protection Solutions, LLC, Richland, Washington.

DOE-HQ = U.S. Department of Energy Headquarters.
FY = fiscal year.
PMB = performance measurement baseline.
RPP = River Protection Project.
WTP = Waste Treatment and Immobilization Plant.

7.12 TANK FARM SYSTEMS AND WASTE FEED DELIVERY

Table 7-12. Tank Farm Systems and Waste Feed Delivery. (3 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
39	The cross-site transfer system will be modified as needed to allow for the transfer of slurry into multiple DSTs to provide operational flexibility in management of waste and staging of feed to the WTP.	a. The existing cross-site transfer system slurry line has not been approved to operate and uncertainties exist due to the unknown condition of the existing line.	i. Continue to follow operating procedures for transfer piping systems to ensure piping longevity. Inspect slurry piping system and complete safety documents for slurry transfer using the existing system. In the life-cycle baseline, plan refurbishing of the piping as necessary to meet the requirements.	An evaluation of the cross-site slurry line for purposes of indentifying the work needed to activate the line is ongoing and scheduled for completion at the end of FY 2010.
			ii. Modify the cross-site transfer system to allow for the transfer of slurry into multiple DSTs.	The cross-site slurry line activate project is to be executed by CLIN 1 (WBS 5.1.4.1.7.4) beginning 8/2015 and ending 3/2018. Any reconfiguration of the slurry line to add the flexibility noted below would be completed as part of this CLIN 1 project.
40	The DSTs will remain fully operational for the nominal 40-year waste treatment mission duration.	a. The likelihood of a major failure of a tank or infrastructure component increases with time due to the age of the tank farm facilities. As-found tank, equipment, and facility conditions may lead to significant new scope.	i. TD 1.1: Develop a suite of tools/methods and perform tests on DSTs to assess and demonstrate the integrity of the tanks for continued use.	
			ii. Continue chemistry control programs.	
			iii. Plan and execute DST integrity, base operations field projects, and DST life extension workscope.	WBS 5.7.2.5
41	The 242-A Evaporator will continue to operate, as needed, through the life of the mission to support SST retrieval and to maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during scheduled maintenance outages.	a. Management of the water content of the tank waste is one of the keys to effective use of the DSTs. The likelihood of a major failure of a 242-A Evaporator component increases with time due to the age of the facility.	i. Execute 242-A Evaporator upgrades and maintain evaporator readiness to support mission needs. Evaluate evaporator replacement if necessary.	
		b. If there are periods greater than 11 months during which the 242-A Evaporator is not used to concentrate waste, a "cold run" of 82,000 gal of water will be performed to maintain personnel qualifications. A readiness review is required if the evaporator sits idle for more than 12 months.	ii. Establish the schedule of evaporator outages and availability during development of the life-cycle baseline.	
			iii. Revisit the need for cold runs to avoid readiness reviews—these take considerable effort and have a transient DST space impact.	
			iv. Consider the use of a near-tank, wiped-film evaporator in the case of a failure or extended outage of the 242-A Evaporator. Significant evaluation and planning needs to be done before this mitigation option could be implemented.	

Table 7-12. Tank Farm Systems and Waste Feed Delivery. (3 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
42	WFD (specifically, the staging of feed within the DSTs and delivery to the WTP) will support WTP treatment rates by providing sufficient HLW or LAW feed to keep the limiting facilities (WTP LAW vitrification and second LAW vitrification or HLW vitrification facilities) operating at or near assumed capacities.	a. WFD system rates and reliability have not been demonstrated. PNNL-17043[a] identified that the ability to effectively mix, sample, certify, and deliver consistent batches of HLW from the DSTs to the WTP as an issue.	i. Include technology development activities in the baseline to address mixer pump performance and feed sampling capabilities.	Tank waste mixing demonstrations and mixer pump design is funded in part by RA-4.
			ii. Include indexing or incremental insertion systems for the mixer pumps in deep sludge tanks.	The Integrated WFD Plan (RPP-40149[b]) specifies the DSTs that require indexing or incremental insertion systems and forms the basis for the associated upgrade projects.
			iii. Perform an external technical review of the Tank AZ-101 mixer pump test.	Completed (see PNNL-18327[c]).
			iv. Evaluate the proposed feed characterization project or an enhanced WRF.	
			v. Develop an OR model of the waste feed delivery system and evaluate its reliability, availability, and maintainability. Refine baseline plans as needed based on the results of the evaluation.	OR modeling is in progress (see Section 4.2.1). A review of the WFD maintenance system requirements is in progress and is scheduled for completion at the end of FY 2010. The review will provide a gap analysis between current practices/capabilities and required capability to meet WFD production rates.
		b. The allocation of specific DSTs and equipment upgrades to specific functions (e.g., HLW feed staging, LAW feed staging, evaporator bottom tank, etc.) has not been finalized.	vi. Evaluate the ability and robustness of the WFD system to supply feed on-demand. Revisit the need for a 180-day dwell time in accordance with ICD-19.[d]	
			vii. Both the near-term and long-term use of the DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to the WTP will be revisited as part of the integration between the Integrated WFD Plan (RPP-40149[b]) and SST Retrieval Plan (RPP-PLAN-40145[e]). Future revisions to the System Plan will incorporate specific WFD plans.	The initial alignment of the System Plan (Rev. 5) with the Integrated WFD Plan (RPP-40149[b]) has been completed. This will be revisited as the mission evolves.
			viii. Update the Integrated WFD Plan (RPP-40149[b]) to define the DST upgrades required to support WFD plans.	Plan updated and issued in parallel with System Plan (Rev. 5).
43	The WFD infrastructure upgrades will be coordinated with the overall tank farms priorities, including facility operations, SST retrievals, waste transfer plan, waste site closures, etc. The resulting plan will be optimized to the overall TOC mission.	a. Uncertainties exist regarding whether the planned WFD infrastructure upgrades are optimized to the overall TOC mission due to the size, complexity, and age of the facility and the continual changes in the treatment system configuration.	i. WFD infrastructure upgrades coordination and optimization will be planned in the life-cycle baseline.	

Table 7-12. Tank Farm Systems and Waste Feed Delivery. (3 pages)

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
44	Physical properties and composition of feed delivered to the WTP are assumed to be compatible with WTP design calculations and safety analyses. The WTP design basis makes assumptions that place feed constraints on rheology, particle size, particle density, particle hardness and abrasivity, criticality, hydrogen generation, and potentially other parameters. Internal WTP material flows and accumulations will be consistent with the WTP authorization basis.	a. Additional conditioning or processing schemes may be required because a portion of the WTP feed is projected to fall outside of these parameters or changes to current WTP requirements might be required.	i. Continue maintenance of the feed interface control document (ICD-19)[d] using existing interface management procedures. Consider implementing the recommendations of a recent assessment of proposed changes to ICD-19[d] to address these parameters (24590-WTP-ES-PET-01-001[f]).	
		b. A portion of the WTP feed is projected to fall outside of the feed envelopes documented in the WTP contract. Additionally, evolving waste feed delivery feed acceptance requirements are being revisited, and may impose new requirements on waste feed delivery. For example, better control of solids content may be required in delivered feed.	ii. Continue to screen feed projected to be delivered to the WTP to proactively identify potential issues for future inquiry and resolution. Identify and correct any assumption or modeling artifacts that may be driving these projections.	
			iii. Consider implementing facilities and strategies and/or facilities, such as an enhanced WRF to mix, sample, settle, decant, or otherwise improve preparation of feed for WTP.	
			iv. The integrated management process for ICD-19[d] will be used to address any feed not consistent with the assumption. New controls, if any, would be incorporated into the feed control list or interface requirements might need to be revised.	

[a] PNNL-17043, 2007, *Initial Investigation of Waste Feed Delivery Tank Mixing and Sampling Issues*, Pacific Northwest National Laboratory, Richland, Washington.
[b] RPP-40149, 2010, *Integrated Waste Feed Delivery Plan*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[c] PNNL-18327, 2009, *Estimate of the Distribution of Solids Within Mixed Hanford Double-Shell Tank AZ-101: Implications for AY-102*, Pacific Northwest National Laboratory, Richland, Washington.
[d] 24590-WTP-ICD-MG-01-019, 2008, *ICD 19 – Interface Control Document for Waste Feed*, Rev. 4, Bechtel National, Inc., Richland, Washington.
[e] RPP-PLAN-40145, 2010, *Single-Shell Tank Waste Retrieval Plan*, Rev. 1, Washington River Protection Solutions, LLC, Richland, Washington.
[f] 24590-WTP-ES-PET-01-001, 2008, *Technical and Risk Evaluation of Proposed ICD-19 Rev. 4*, Rev. 1, Bechtel National, Inc., Richland, Washington.

CLIN = contract line item number.
DST = double-shell tank.
FY = fiscal year.
HLW = high-level waste.
LAW = low-activity waste.
OR = operations research.
RA = Recovery Act.
SST = single-shell tank.
TD = technology development.
TOC = Tank Operations Contract.
WBS = work breakdown structure.
WFD = waste feed delivery.
WRF = waste retrieval facility.
WTP = Waste Treatment and Immobilization Plant.

7.13 PROJECT MANAGEMENT OPPORTUNITIES

Table 7-13. Project Management Opportunities.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
The purpose of the River Protection Project System Plan is to provide a basis for alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans. Key issues and uncertainties associated with project management opportunities are outside the scope of the System Plan, and are more appropriately addressed in the Risk Management Plan (TFC-PLN-39[a]).				

[a] TFC-PLN-39, 2010, *Risk Management Plan*, Rev. F, Washington River Protection Solutions, LLC, Richland, Washington.

7.14 HANFORD ATOMIC METAL TRADES COUNCIL CRAFT REALIGNMENT PROVISION OPPORTUNITY

Table 7-14. Hanford Atomic Metal Trades Council Craft Realignment Provision Opportunity.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
The purpose of the River Protection Project System Plan is to provide a basis for alignment of program costs, scope, and schedules from upper-tier contracts to individual facility operating plans. Key issues and uncertainties associated with Hanford Atomic Metal Trades Council Craft Realignment Provision Opportunity are outside the scope of the System Plan, and are more appropriately addressed in the Risk Management Plan (TFC-PLN-39[a]).				

[a] TFC-PLN-39, 2010, *Risk Management Plan*, Rev. F, Washington River Protection Solutions, LLC, Richland, Washington.

7.15 RECOVERY ACT

Table 7-15. Recovery Act.

Item	Assumption/Assertion	Key Issues and Uncertainties	Potential Mitigating Actions	Status/Comments
No River Protection Project key issues and uncertainties are identified in this area at this time.				

8.0 OPPORTUNITIES FOR IMPROVEMENT

A number of mission refinements will reduce risk to the RPP mission and increase confidence in planning and execution.

ORP will continue to follow a disciplined, systematic approach to guide the RPP to a successful conclusion. System Plan (Rev. 5) identifies three broad interrelated areas that represent opportunities for improving the RPP mission:

1. Ongoing management (identification, quantification, and mitigation) of RPP risks and opportunities will increase confidence in system planning and mission execution. Many of the technical and programmatic risks to the RPP may be reduced by implementing some of the potential mitigating actions described in Section 7.0. Successful implementation of certain actions is necessary to execute the Baseline Case as presented in this System Plan. Others represent opportunities to reduce programmatic risk, reduce life-cycle costs, or allow for earlier completion of the mission.

2. Continued use of the systems engineering process will refine the mission objectives, manage functions and requirements, and establish the bases for informed decision-making. With input from ORP, future revisions to the Preliminary Decision Framework (RPP-46506) will help communicate a structured hierarchy of decisions needed to establish key features of the RPP.

3. Expand the role of the System Plan to support collaboration with Ecology. The draft Consent Decree (08-5085-FVS) includes commitments for the joint development of certain future System Plans in conjunction with Ecology. In particular, the draft Consent Decree, Enclosure B, item SP-1 states (in part):

   "Submit a System Plan to Ecology describing the disposition of all tank waste managed by the Office of River Protection . . . The Plan will be updated and submitted to Ecology every three years to document any further optimization of retrieval and waste treatment capabilities to . . . complete such retrievals . . . (and) complete such treatment as quickly as is technically feasible . . ."

   "Starting October 31, 2010, and every three years thereafter, Ecology and DOE will each have the right to select a minimum of three scenarios that will be analyzed in the System Plan. Beginning October 31, 2011, and every three years thereafter, issue the System Plan."

   Although the Consent Decree is still draft at this time, ORP and Ecology have already had a series of meetings to establish the scenarios to be evaluated in the next revision of the System Plan (Rev. 6).

9.0 SUMMARY SCHEDULE

Figure 9-1, Figure 9-2, and Figure 9-3 summarize the schedule of major activities represented in this plan. The success criteria (selected draft consent decree dates) contained in the assumptions are shown on the schedule along with a projected date for completion of each criterion based on current modeling. Some key facility startup and ramp-up dates are also taken from the assumptions. The dates for waste retrieval, transfer, and treatment are based on the HTWOS model run. Dates for preparatory activities, including upgrades to tanks and tank farms, and closure activities for tank farms are based on the detailed schedule[51] with adjustments to reflect the retrieval and transfer dates derived from the model. Significant restrictions on DST usage that have modeling and scheduling implications are also shown for each tank with such restrictions.

Summary schedules are provided for the following:

- SST retrieval and closure (Figure 9-1)
- DST retrieval, waste feed delivery, and closure (Figure 9-2)
- Waste treatment (Figure 9-3).

[51] To develop the cost and schedule corresponding to the System Plan (Rev. 5) Baseline Case, a *copy* of the configuration-controlled schedule for the current PMB was updated to reflect the assumptions and results of the Baseline Case. The resulting detailed schedule was then summarized and presented in this section.

River Protection Project Mission Summary Schedule

Single Shell Tank Retrieval and Closure

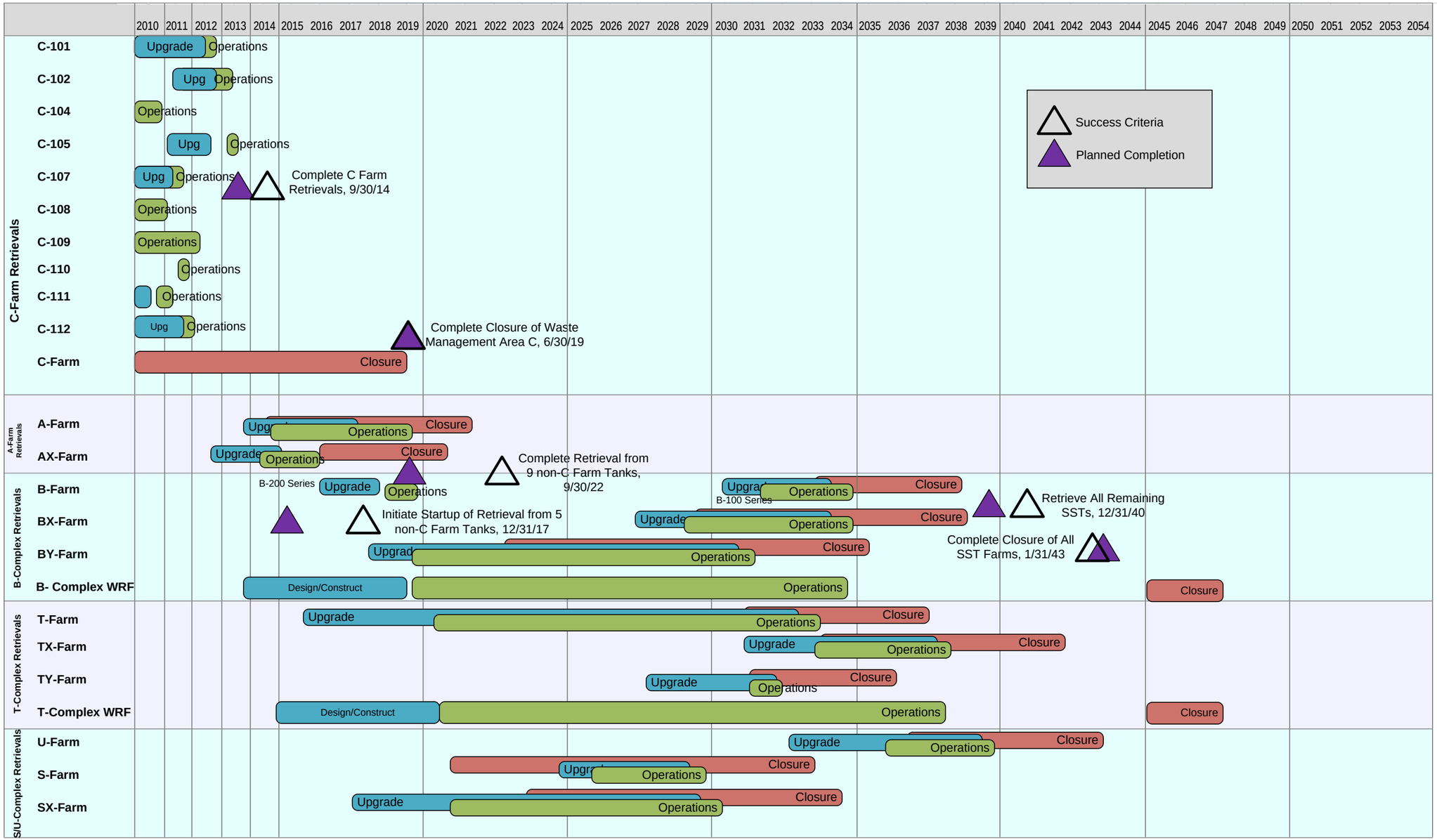


Figure 9-1. River Protection Project Mission Summary Schedule – Single-Shell Tank Retrieval and Closure.

River Protection Project Mission Summary Schedule

Double Shell Tank Retrieval, Waste Feed Delivery, and Closure

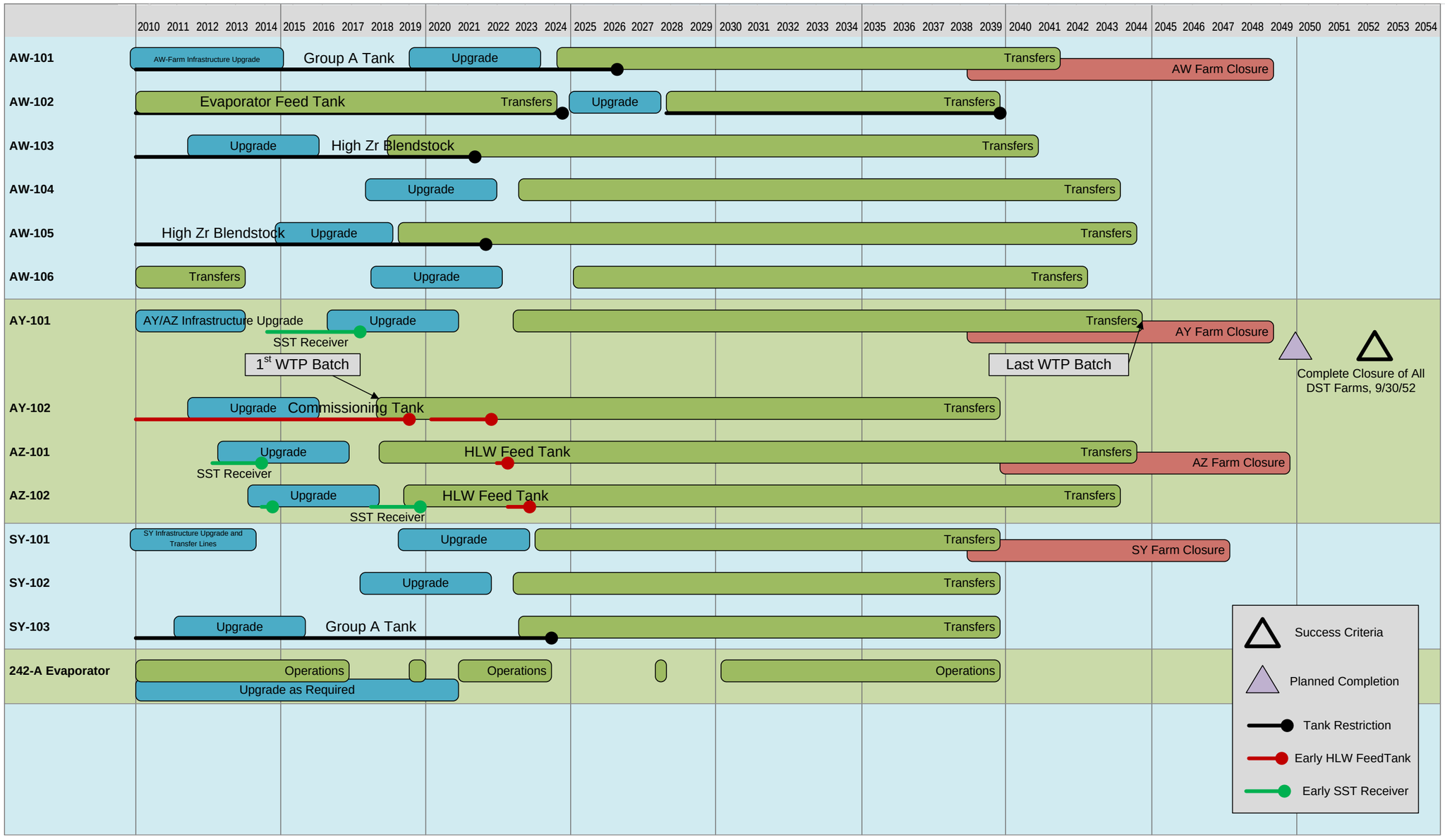


Figure 9-2. River Protection Project Mission Summary Schedule – Double-Shell Tank Retrieval, Waste Feed Delivery, and Closure. (page 1 of 2)

River Protection Project Mission Summary Schedule

Double Shell Tank Retrieval, Waste Feed Delivery, and Closure

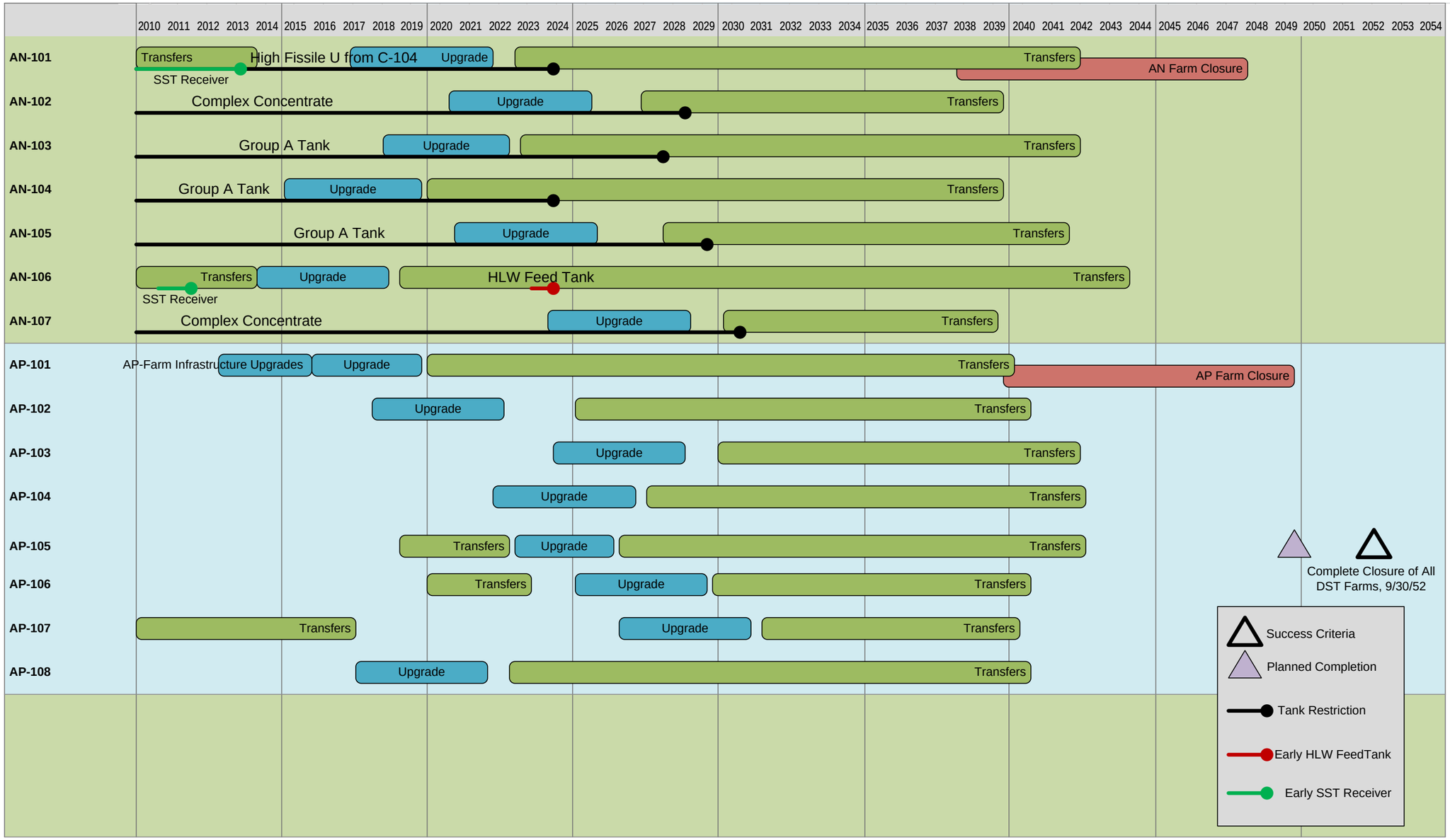


Figure 9-2. River Protection Project Mission Summary Schedule – Double-Shell Tank Retrieval, Waste Feed Delivery, and Closure. (page 2 of 2)

River Protection Project Mission Summary Schedule

Waste Treatment

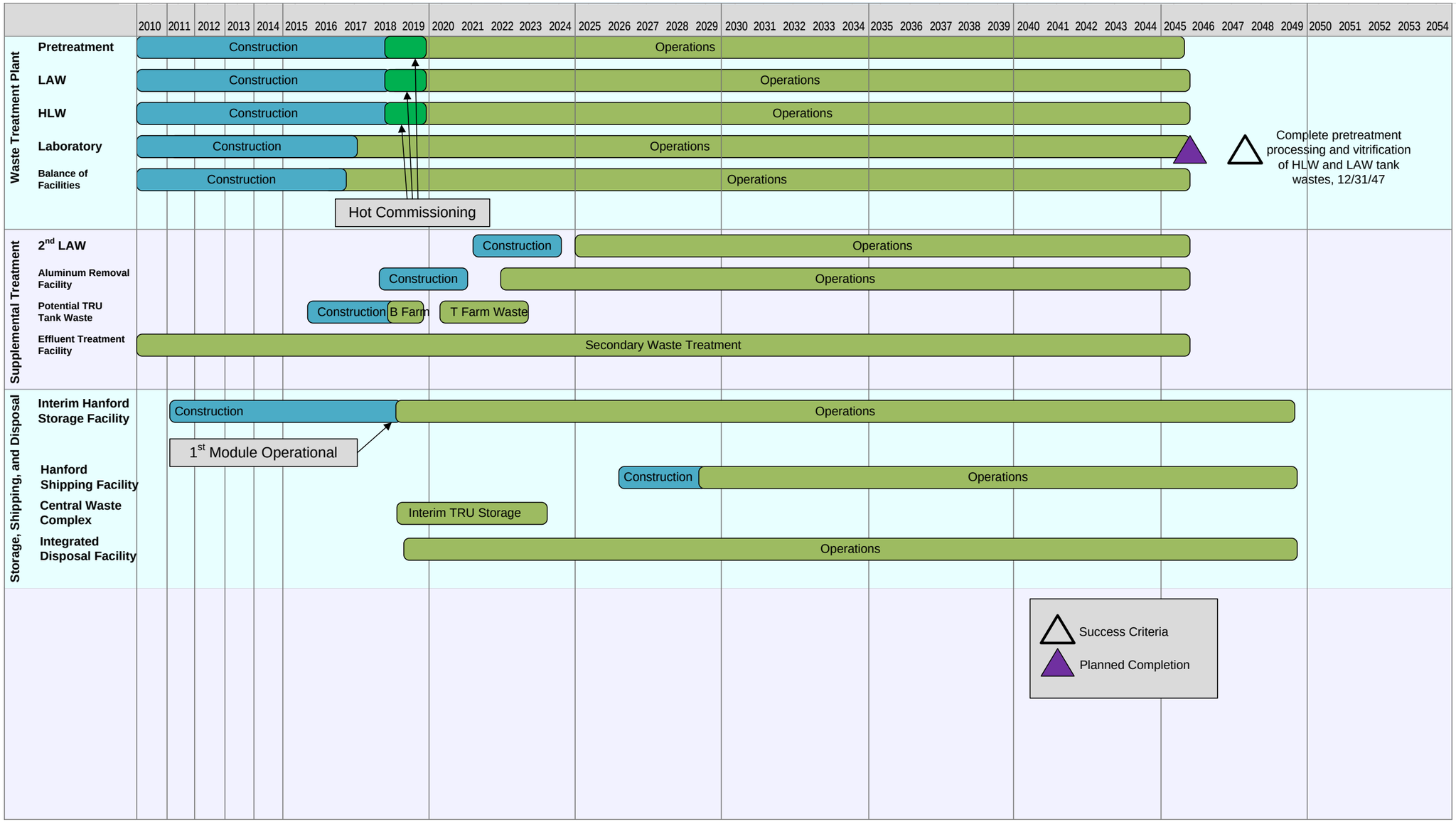


Figure 9-3. River Protection Project Mission Summary Schedule – Waste Treatment.

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33 USC 1251, et seq., *Clean Water Act of 1972*.

42 USC 103, et seq., *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.

42 USC 300f, et seq., *Safe Drinking Water Act of 1974*.

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APPENDIX A – GLOSSARY

Term or Abbreviation	Definition or Expansion
Assumed Leaker	The integrity classification of a waste storage tank for which surveillance data indicates a loss of liquid attributed to a breach of integrity in the past. No tanks are known to be leaking today.
Baseline Case	In System Plan (Rev. 5), the Baseline Case is a mission scenario that forms the technical basis for both the near-term baseline and the out-year planning estimate range.
Bulk Retrieval	The retrieval of waste down to any hard-to-remove heel encountered in the tank.
Buoyant-Displacement Gas Release Events (BDGRE)	Tank waste generates flammable gases through the radiolysis of water and organic compounds, thermolytic decomposition of organic compounds, and corrosion of the carbon steel tank walls. Under certain conditions, this gas may accumulate in a settled solids layer until the waste becomes hydrodynamically unstable (less dense waste near the bottom of the tank). A BDGRE is the rapid release of this gas, partially restoring hydrodynamic equilibrium. The release may result in the temporary creation of a flammable mixture in the headspace of the tank, depending on the size of the release relative to the capacity of the ventilation system.
Caustic Leach Factor	The fraction of an analyte in previously washed solids that will go into solution by caustic leaching. The term, caustic leach factor, as used in this System Plan, is technically a *differential* caustic leach factor.
Closure	"Closure" is defined as the deactivation and stabilization of a radioactive waste facility intended for long-term confinement of waste (per DOE M 435.1-1).[a] "Final closure" of the operable units (tank farms) shall be defined as regulatory approval of completion of closure actions and commencement of post-closure actions. For the purpose of this document, all units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610.[b]
Cross-Site Transfer	The Hanford waste tanks are located in two physically separated areas called "East Area" and "West Area," about 5 miles apart. The cross-site transfer system is a pair of transfer pipelines and ancillary equipment that is used to transfer supernate and slurry from the West Area to the East Area.
Disposal	Emplacement of waste in such a manner that ensures protection of the public, workers, and the environment with no intention of retrieval and that requires deliberate action to regain access to the waste (per DOE M 435.1-1).[a]
Enhanced Waste Retrieval Facility (WRF)	A proposed concept in which a WRF-like facility with augmented mixing, blending, sampling, and filtration systems would be used to prepare feed for delivery to the WTP. This concept could be implemented as an extension of the B Complex (East Area) WRF or a separate Feed Characterization Project. In any case, the enhanced WRF would most likely need to be located near in proximity to both the East Area double-shell tanks (DST) and the Waste Treatment and Immobilization Plant (WTP).
Feed Characterization Project	This facility is proposed to mitigate the risk of not being able to properly mix and sample high-level waste feed before delivery to the waste treatment plant. It might consist of about six 500-kgal tanks specially designed and equipped for slurry handling. The Feed Characterization Project is not included in the performance measurement baseline.

Term or Abbreviation	Definition or Expansion
Feed Vector	The "feed vector" is a list of the individual feed batches projected to be delivered to a facility (e.g., WPT) and includes the associated waste composition and caustic leach factors.
Hard-to-Remove Heel	A large solid mass or group of large solids not easily removed from the bottom of some large tanks.
High-Level Waste (HLW)	As used in this System Plan, the term HLW refers to the fraction of the tank waste containing most of the radioactivity that will be immobilized into glass and disposed at an offsite repository. This includes the solids remaining after pretreatment plus certain separated radionuclides.
High-Level Waste (HLW) Feed	This refers to the slurry stream (sludge plus supernate) that is delivered to the WTP Pretreatment Facility. Any solids remaining after pretreatment report to the WTP HLW Vitrification Facility along with separated radionuclides.
Incidental Blending	This refers to the blending that occurs during the retrieval, staging, storage, and delivery of feed without any special effort other than single-shell tank sequencing. It is sometimes called unavoidable blending.
Initial Planning Case	In System Plan (Rev. 4), the Initial Planning Case was a mission scenario consistent with older funding guidance for FY 2009 to 2018 (Anderson 2007a)[c] and 2019 (Anderson 2007b)[d] and assumed that after a near-term ramp up, future budget allocations would be essentially level.
Intentional Blending	Any blending that is specifically orchestrated and, therefore, requires additional effort. Examples of intentional blending include pairwise blending (blending two tanks at a time), metered blending (where small amounts of a problematic waste are blended into a number of successive feed batches), and the blending of different wastes first segregated according to limiting constituents.
Interim Stabilized	A tank that contains less than 50 kgal of drainable interstitial liquid and less than 5 kgal of supernatant. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow or saltwell screen inflow must also have been at or below 0.05 gpm before interim stabilization criteria are met.
Low-Activity Waste (LAW)	Waste that remains following the process of separating as much of the radioactivity as is practicable from HLW. When solidified, LAW may be disposed of as low-level waste in a near-surface facility.
Low-Activity Waste (LAW) Feed	This refers to the liquid stream (supernate plus a small amount of entrained solids) that is delivered to the WTP Pretreatment Facility. After removal of key radionuclides, this supernate and the supernate from the HLW feed report to the WTP LAW Vitrification Facility.
Low-Level Waste (LLW)	Radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act of 1954.
Mixed Waste	Waste containing both radioactive and chemically hazardous components.
No-Blend	The hypothetical case in which the waste from each individual tank is retrieved, pretreated, and the high-level waste fraction vitrified as a separate batch. No blending of waste between tanks is permitted.
Percent-of-Span	This is the percent of the way the projected glass mass falls between the total-blend and the no-blend glass mass. For example, 0% of span corresponds to the total blend, while 50% of span corresponds to halfway between the total-blend and no-blend.

Term or Abbreviation	Definition or Expansion
Realized-Blend	This refers to the actual blending that is predicted to occur during a specific mission scenario.
Retrieval	The process of removing, to the maximum extent practical, all the waste from a given underground storage tank. The retrieval process is selected specific to each tank and accounts for the waste type stored and the access and support systems available. In accordance with OSD-T-151-00031,[e] a tank is officially in "retrieval status" if one of two conditions is met: either waste has been physically removed from the tank by retrieval operations, or preparations for retrieval operations are directly responsible for rendering the leak or intrusion monitoring instrument "out of service."
Safety-Significant Structures, Systems and Components (SSC)	Structures, systems, or components that are not designated as safety-class SSCs but have a preventive or mitigative function that is a major contributor to defense-in-depth and/or worker safety as determined from safety analyses.
Saltcake	Saltcake is a mixture of crystalline sodium salts that originally precipitated when alkaline liquid waste from the various processing facilities was evaporated to reduce waste volume. Saltcakes are comprised primarily of the sodium salts of nitrate, nitrite, carbonate, phosphate, and sulfate. Concentrations of transition metals such as iron, manganese, and lanthanum and heavy metals (e.g., uranium and lead) are generally small. Saltcake typically contains a small amount of interstitial liquid. The bulk of the saltcake will dissolve if contacted with sufficient water.
Sludge	Sludge is a mixture of metal hydroxides and oxyhydroxides that originally precipitated when acid liquid waste from the various reprocessing facilities was made alkaline with sodium hydroxide. Sludge is comprised primary of the hydroxides and oxyhydroxides of aluminum, iron, chromium, silicon, zirconium, and uranium, plus the majority of the insoluble radionuclides such as ^{90}Sr and the plutonium isotopes. Sludge typically contains a significant amount of interstitial liquid (up to nominal 40 wt% water). Sludge is mostly insoluble in water; however, a significant amount of aluminum and chromium will dissolve if leached with sufficient quantities of sodium hydroxide.
Slurry	The term slurry is used in two different contexts: • Slurry is a mixture of solids, such as sludge or undissolved saltcake, suspended in a liquid. For example, a slurry results when the sludge and supernate in a tank is mixed together. Slurries can be used to transfer solids by pumping though a pipeline. • Slurry also refers to a waste produced at Hanford that results from evaporating supernate originally removed from tanks containing saltcake so that aluminum salts begin to precipitate in addition to the sodium salts. This material, called "double-shell slurry" or "double-shell slurry feed" is present in the DSTs (specifically Tanks AN-103, AN-104, AN-105, and AW-101). For simplicity, this System Plan will use the term "settled salts" or "salt cake" instead of slurry in this context.
Sound	The integrity classification of a waste storage tank for which surveillance date indicate no loss of liquid attributed to a breach of integrity.
Supernate	Supernate is technically the liquid floating above a settled solids layer. At Hanford, it is typically used to refer to any non-interstitial liquid in the tanks, even if no solids are present. Supernate is similar to saltcake in composition and contains many of the soluble radionuclides such as ^{137}Cs and ^{99}Tc.

Term or Abbreviation	Definition or Expansion
Tank Bump	A tank bump is a postulated event in which gases, primarily water vapor, are suddenly emitted from the waste causing the tank headspace to pressurize due to vaporization of locally superheated liquid.
Total-Blend	The "total-blend" represents the hypothetical case in which all of the waste is blended together, pretreated, and the HLW fraction vitrified as a single batch of uniform composition.
Total Operating Efficiency (TOE)	A measure of the net throughput of a process, facility, or system relative to its design capacity. This can either be estimated from an operations research model, from operating data, or established as a goal. TOEs may be reported on a variety of bases, depending on the specific process, facility, or system.
Transformational Technology	A transformational technology is an innovative approach potentially able to significantly reduce life-cycle costs, schedule, or technical risks.
Unreviewed Safety Question	A situation where: (1) the probability of the occurrence or the consequences of an accident or the malfunction of equipment important to safety previously evaluated in the documented safety analysis could be increased, (2) the possibility of an accident or malfunction of a different type than any evaluated previously in the documented safety analysis could be created, (3) a margin of safety could be reduced, or (4) the documented safety analysis may not be bounding or may be otherwise inadequate (10 CFR 830.3).[f]
Waste Oxide Loading (WOL)	A measure of the quantity of pretreated waste that can be incorporated into a unit mass of glass. The quantity of pretreated waste is on a non-volatile oxide basis, with all components in their most prevalent oxide form, plus any halogens.
Waste Retrieval Facility (WRF)	A future facility used to support the retrieval of waste involving slurry transfers from SSTs that are located too far to be readily retrieved directly into a DST. The WRF, located near the SSTs, would accumulate and condition retrieved waste before transfer to a DST.
Waste Treatment Complex	Comprises all of the existing and future facilities, pipelines, and infrastructure needed for the storage, retrieval, and treatment of the Hanford tank waste.
Water Wash Factor	The fraction of an analyte in a solid waste phase that dissolves on contact with water either during retrieval or subsequent processing.

[a] DOE M 435.1-1, 2007, *Radioactive Waste Management Manual*, Change 1, Office of Environmental Management, U.S. Department of Energy, Washington, D.C.

[b] WAC 173-303-610, "Closure and Post-Closure," *Washington Administrative Code*, as amended.

[c] Anderson, C. E., 2007a, "Guidance for Implementing Baseline Changes to Reflect Funding Targets for Fiscal Year 2008 through the Out-Years," (Memorandum for distribution, U.S. Department of Energy, Office of Environmental Management, June 25), U.S. Department of Energy, Washington, D.C.

[d] Anderson, C. E., 2007b, "Supplemental Guidance to June 25, 2007, Memorandum, "Guidance for Implementing Baseline Changes to Reflect Funding Targets for Fiscal Year (FY) 2008 through the Out-Years," (Memorandum for distribution, U.S. Department of Energy, Office of Environmental Management, August 15), U.S. Department of Energy, Washington, D.C.

[e] OSD-T-151-00007, 2007, *Operating Specifications for the Double-Shell Storage Tanks*, Rev. 1, CH2M HILL Hanford Group, Inc, Richland, Washington.

[f] 10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*.

APPENDIX B – KEY ASSUMPTIONS AND SUCCESS CRITERIA

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FIGURES

Figure B-1. River Protection Project Simplified Flow Diagram for the Baseline Case. B-5

TERMS

ARF	Aluminum Removal Facility
BBI	Best-Basis Inventory
BCR	baseline change request
BDGRE	buoyant displacement gas release events
BNI	Bechtel National, Inc.
BOF	balance of facilities
CD	Critical Decision
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CH-TRU	contact-handled transuranic
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ETF	Effluent Treatment Facility
FY	fiscal year
GFM	glass formulation model
HEME	high-efficiency mist eliminator
HGR	hydrogen generation rate
HIHTL	hose-in-hose transfer line
HLW	high-level waste
HSF	Hanford Shipping Facility (for HLW canisters)
HTWOS	Hanford Tank Waste Operations Simulator
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHSF	Interim Hanford Storage Facility (for HLW canisters)
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
LAW	low-activity waste
LERF	Liquid Effluent Retention Facility
LLW	low-level waste
PMB	performance measurement baseline
PT	pretreatment
PUREX	Plutonium-Uranium Extraction (Plant)

TERMS

PWD	plant wash disposal system
ORP	U.S. Department of Energy, Office of River Protection
RH-TRU	remote-handled transuranic
RL	U.S. Department of Energy, Richland Operations Office
RLD	radioactive liquid waste disposal system
ROD	Record of Decision
RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SBS	submerged bed scrubber
SST	single-shell tank
TEDF	Treated Effluent Disposal Facility
TOE	total operating efficiency
TRU	transuranic
TWINS	Tank Waste Information Network System
WESP	wet electrostatic precipitator
WIPP	Waste Isolation Pilot Plant
WRF	Waste Retrieval Facility
WRPS	Washington River Protection Solutions LLC
WTP	Waste Treatment and Immobilization Plant

B1.0 GENERAL INFORMATION

The key assumptions and success criteria document the approved[53] input for Hanford Tank Waste Operations Simulator (HTWOS) modeling and mission planning purposes as of June 2010. These assumptions and success criteria were developed after reviewing existing assumptions from the previous version of the River Protection Project (RPP) System Plan, the Waste Treatment and Immobilization Plant (WTP) contract (DE-AC27-01RV14136, *Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*), and recent HTWOS model runs. These assumptions and success criteria:

- Reflect the outcome of a series of meetings in December 2009 and January 2010 with the U.S. Department of Energy (DOE), including personnel from both Headquarters and the Office of River Protection (ORP), and incorporate ORP's verbal and e-mail guidance.
- Incorporate ORP's and DOE Headquarters' verbal comments on the draft assumptions.
- Reflect informal input from the Washington State Department of Ecology (Ecology) during three meetings[54] conducted with ORP and Washington River Protection Solutions LLC (WRPS) in December 2009 and January 2010.

This version of the System Plan evaluates two cases (i.e., mission scenarios) as requested by ORP, the Baseline Case and one sensitivity case called Sensitivity Case A. The assumptions apply to both cases unless explicitly stated otherwise.

The Baseline Case provides the basis for updating the existing[55] performance measurement baseline (PMB) with the current WTP flowsheet (24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*); RPP-40149, *Integrated Waste Feed Delivery Plan*; RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*; SVF-1647, "Single-Shell Tank Retrieval Assumptions for Mission Modeling, Filename 'SVF-1647 Rev 3B';" and the new high-level waste (HLW) glass formulation model (GFM) (PNNL-18501, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*). As such, it continues to include management of sodium via the Aluminum Removal Facility (ARF) and reduced HLW glass mass via enhanced blending in the double-shell tanks (DST). However, the potential contact-handled transuranic (CH-TRU) tank waste is assumed to be stored onsite until its final disposition is determined. A baseline change request (BCR) will be required to realign the PMB with the Baseline Case, with allowances for additional funding guidance and emerging plans and field conditions.

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[53] The original assumptions were approved by ORP (Charboneau, S. L., 2010a, "Contract No. DE-AC27-08RV14800 – Approval of the Annotated Outline and Appendix B – Key Assumptions and Success Criteria for River Protection Project (RPP) System Plan, Revision 5, in Support of Contract Deliverable C.2.3.1-1, River Protection Project System Plan"). Assumptions related to the Hanford Storage Facility were updated in June 2010 (Charboneau, S. L. 2010b, "Re: System Plan Rev. 5 – Concurrence Requested to Update Assumptions Based on Preliminary Run"). Additionally, a number of non-substantive updates and clarifications have been made.

[54] Meeting minutes from December 18, 2009, January 7, 2010, and January 14, 2010 (WRPS-1000164, WRPS-1000165, and WRPS-1000166, respectively), regarding RPP System Plan (Rev. 5).

[55] The current PMB is comprised of RPP-09-002, *FY 2010 - FY 2013 TOC Near Term Baseline*, as revised by subsequent BCRs.

Sensitivity Case A explores the impacts of eliminating supplemental CH-TRU waste treatment, thus treating the potential CH-TRU tank waste at the WTP and disposing of it along with the HLW. This is in anticipation of a potential future decision to dispose of this material as HLW rather than to dispose of this material at the Waste Isolation Pilot Plant (WIPP).

The implementation of this set of assumptions into the HTWOS model is described in detail in the RPP-17152, *Hanford Tank Waste Operations Simulator (HTWOS) Version 6.0 Model Design Document*, and associated data package (RPP-RPT-46711, *Hanford Tank Waste Operations Simulator Model Data Package for the River Protection Project System Plan Rev. 5 Cases*).

Caveats

A number of non-substantive changes to these key assumptions are expected during the preparation of the System Plan, the integration of the various cases with the other contract deliverables, and the alignment of the HTWOS model to current technical and programmatic assumptions. These changes will not require ORP review and approval apart from ORP's final review and approval of the RPP System Plan.

- The overall organization, format, and level of detail may be changed during the preparation of the System Plan.
- The wording of the assumptions, basis, and associated discussions may be clarified.
- Additional references may be provided or updated as needed.

B2.0 SUCCESS CRITERIA

Success criteria are metrics that will be used to evaluate how well each case meets its intended purpose and may include dates or other objectives; however, there is no guarantee that they will be met. Changes to the timing of certain activities, assumed facility capacities, or other process variables might be needed to meet the success criteria. If preliminary results indicate that the success criteria cannot be met using the approved assumptions, the reasons will be identified and discussed with ORP and agreement reached on how to proceed.

B2.1 BASELINE CASE

B2.1.1 The Baseline Case will be considered successful if it is consistent with the ORP-provided guidance dates for key mission activities identified in Assumption B2.1.2 and the ORP-provided funding guidance in Assumption B2.1.3. In the event that the guidance cannot reasonably be met within the degrees of freedom discussed in Assumption B2.1.4, the reasons will be identified.

B2.1.2 The Baseline Case will meet the following guidance dates:[56]

- Complete C Farm retrievals by September 30, 2014
- Initiate startup of retrieval from five additional (i.e., non-C Farm) tanks by December 31, 2017 [57]
- Complete closure of Waste Management Area C by June 30, 2019
- Complete retrieval from nine non-C Farm tanks by September 30, 2022
- Retrieve all remaining single-shell tanks (SST) by December 31, 2040
- Complete closure of all SST farms by January 31, 2043
- Complete pretreatment processing and vitrification of Hanford HLW and low-activity waste (LAW) tank wastes by December 31, 2047
- Complete closure of all DST farms by September 30, 2052.

B2.1.3 The Baseline Case will meet the ORP-provided funding targets (Basche 2010) for fiscal year (FY) 2010 through FY 2015. These targets are consistent with the most recent budget planning guidance and briefing materials. After FY 2015, a reasonable ramp-up may be assumed.

B2.1.4 The timing of activities in the Baseline Case may be shifted as needed to satisfy the guidance dates, even if this requires deviation from other programmatic assumptions, including deviating from the funding guidance.

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[56] These dates are an ORP-provided proxy for a subset of key potential future milestones that reflect draft provisions in the proposed Consent Decree and Tri-Party Agreement modifications for Hanford tank waste treatment as submitted for public comment beginning October 1, 2009 (08-5085-FVS, *Proposed Consent Decree No. 08-5058-FVS between the U.S. Department of Energy and the State of Washington*).

[57] Not including any tanks with waste that is packaged as transuranic waste.

B2.2 SENSITIVITY CASE A

The purpose of Sensitivity Case A is to explore the impacts of eliminating supplemental CH-TRU waste treatment, thus treating the potential CH-TRU tank waste at the WTP and disposing of it along with the HLW. As such, it is anticipated that the mission duration and number of HLW glass canisters may slightly increase relative to the Baseline Case along with a commensurate increase in life-cycle cost.

B2.2.1 The Sensitivity Case A will be considered successful if it is consistent with the ORP-provided guidance dates for key mission activities in Assumption B2.1.2 and the ORP-provided funding guidance in Assumption B2.1.3. In the event that the guidance dates or funding guidance are not met, the reasons will be identified.

B2.2.2 The timing of activities in the sensitivity case may be shifted as needed to approximate the cost profile in the PMB, even if this requires deviation from other programmatic assumptions.

B3.0 KEY ASSUMPTIONS

B3.1 WASTE TREATMENT COMPLEX

The overall configuration and process flow assumed for the Waste Treatment Complex is shown in Figure B-1 for the Baseline Case; the configuration for Sensitivity Case A is identical with the exception of the removal of the supplemental CH-TRU waste treatment system, Central Waste Complex, and associated streams.

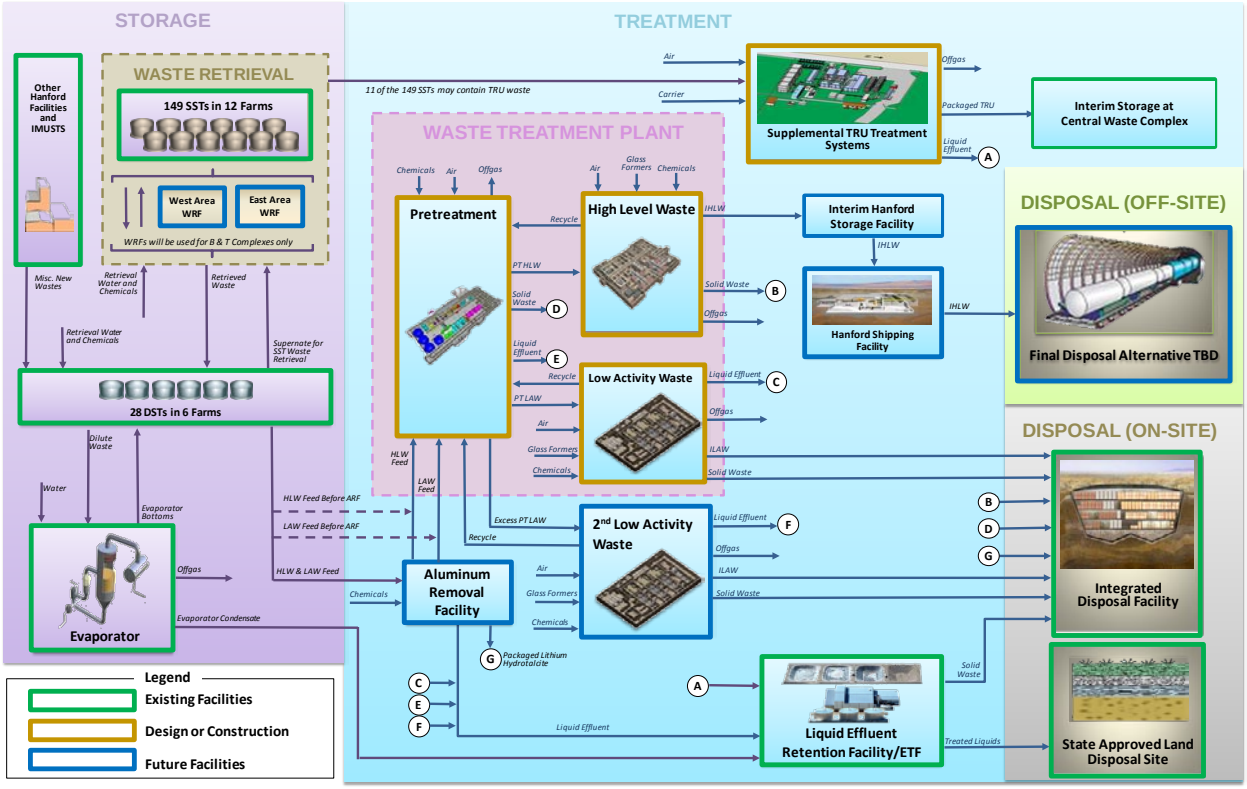

Figure B-1. River Protection Project Simplified Flow Diagram for the Baseline Case.

B3.2 TANK FARMS

B3.2.1 Single-Shell Tanks

B3.2.1.1 The integrity of the 149 SSTs is described in HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2009* (Rev. 261), with pending changes as agreed to with Ecology, ORP and the Tank Operations Contractor.

B3.2.1.2 It is assumed that timely approval will be received to support interim closure (tank isolation and filling with grout) of each SST sometime after retrieval of that tank is complete.[58]

B3.2.1.3 It is assumed that timely approval will be received to support full closure of each tank farm sometime after all tanks in that farm are interim closed.

B3.2.2 Double-Shell Tanks

B3.2.2.1 The integrity of the 28 DSTs is as described in HNF-EP-0182. It is assumed that the DSTs will remain fully operational for the duration of the waste treatment mission.

B3.2.2.2 The maximum modeled operating liquid levels for the DSTs are the "normal operating limits" provided in OSD-T-151-00007, *Operating Specifications for the Double Shell Storage Tanks*, with the exception that the maximum modeled operating level for all AP Farm tanks is increased to 454 in. (1.2465 Mgal).[59] The "normal operating limits" for Tanks AP-103 and AP-108 have already been increased to 454 in. It is assumed that the other AP Farm tanks will successfully pass the in-service leak testing required to use this increased operating level.

B3.2.2.3 The volume of DST space allocated for tank farm emergencies and emergency returns from the WTP is 1.265 Mgal (HNF-3484, *Double Shell Tank Emergency Pumping Guide*). This space may be distributed among multiple DSTs.

B3.2.2.4 No DST space will be reserved for non-emergency returns of pretreated LAW or liquid effluents to the DST system.

B3.2.2.5 Insoluble solids retrieved from SSTs are assumed to settle to approximately 40 wt% solids in the DSTs within 30 days, except for C Farm. Insoluble solids retrieved from C Farm are assumed to settle within two days to a solids-loading comparable to that in the source SST (see Section 4.3.5 of RPP-17152).

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[58] A draft closure integration plan (RPP-PLAN-40761, *Integrated Single-Shell Tank Waste Management Area Closure Plan*) has been prepared to better define the strategy and approach to be used to close the tanks. The cost and schedule for interim and final closure activities will be reflected in the PMB. Closure activities are not modeled in HTWOS.

[59] Note: At liquid levels above 426 in., the nominal 2,750 gal/in. of tank level begins to decrease, dropping to about 2,600 gal/in. at 454 in. The official spreadsheet tool for converting between liquid level and volume for both DSTs and SSTs is released under SVF-1770, "Tank Waste Volume Calculator.xlsx."

B3.2.2.6 The solids management strategy for the DSTs is to operate the DSTs so that they do not become Group A tanks (i.e., stay within acceptable buoyant displacement gas release event [BDGRE] criteria). For mission planning purposes, the following simplified proxy limits will be used:

- Existing BDGRE controls are assumed to apply to DSTs containing an accumulation of settled salts, including:
  - Restrictions on the use of currently existing Group A tanks will continue to be followed for those tanks until the waste has been retrieved.
  - Assumption B3.2.4.5 is assumed to prevent future accumulations of salts that might result in classifying a DST as Group A under existing BDGRE controls.
- The depth of settled sludge accumulated in each DST will be maintained less than 250 in.[60,61]

B3.2.2.7 The waste blending and segregation controls in the feed control list (HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, Table A-1) will be followed, with the following exceptions and clarifications:

- "Blend-off high-sulfate supernate" – The blending actions in this feed control were completed in June 2008 and documented in RPP-CALC-38051, *241-AZ-102 Supernate Transfers and Blending Confirmation*.
- "Blend off high ^{233}U solids" – It is assumed that the blending strategy described in Section 7.2.4 of RPP-RPT-43828, *Enhanced Use of AN Farm for C Farm Single Shell Tank Retrieval*, will successfully mitigate the uranium enrichment issues with Tank C-104 solids.[62]
- "Segregate Envelope C" – It is assumed that the strontium and transuranic (TRU) constituents will be removed from the Envelope C waste currently stored in Tanks AN-102 and AN-107 in the DST system rather than in the WTP, at which time segregation is no longer required.

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[60] RPP-PLAN-30112, *Plan to Resolve Technical Issues Associated with Sludge Accumulation in Double-Shell Tanks*, states that the current limits on preventing BDGREs are based on the behavior of settled salts and therefore are not applicable to accumulations of sludge. A review of open literature suggests that high-shear strength sludge may not retain gas in a way that would lead to BDGREs. A technical basis for relaxing BDGRE-related controls on sludge is being developed, with plans to implement a revision to the BDGRE-related controls in the safety basis by September 2012. It is assumed that this work is successful in relaxing BDGRE-related controls on the accumulation of sludge and supernate in DSTs. Unpublished scoping calculations suggest that the allowable sludge depth is expected to range between 160 and 400 in. depending on the actual physical properties of the settled sludge.

[61] DSTs containing more than about 70 in. of settled solids will require incremental insertion or lowering of mixer-pumps per Assumption B3.2.3.16. An allowance for mixing up to a nominal 76 in. without incremental insertion will be assumed for the blending of Tank C-104 sludge per Assumption B3.2.2.7.

[62] Since Tank AN-101 will contain nearly 250 in. of settled solids after retrieval of tanks C-104, C-111, C-112, C-101 and C-105, the waste will need to be retrieved layer-by-layer using incremental insertion of mixer pumps per RPP-40149. The intent is to fill two DSTs functioning as HLW staging tanks, each with half of Tank C-104 waste plus enough of the low-fissile blend stock to mitigate the uranium enrichment issue; the settled depth of the blended sludge in each of these two tanks is expected to be about 76 in. Note that the bulk of the sludge from the last two tanks to be retrieved into Tank AN-101 (currently assumed to be Tanks C-101 and C-105) would need to first be retrieved and transferred to other DSTs. The details are described in Section 7.2.4 of RPP-RPT-43828.

- "Segregate waste destined for TRU or low-level waste (LLW) packaging:"
  - Baseline Case: It is assumed that only the CH-TRU waste will be segregated. The remote-handled transuranic (RH-TRU) waste may be commingled with other tank waste.
  - Sensitivity Case A: All TRU tank waste may be commingled with other tank waste solids.
  - Both cases: The RH-TRU solids from Tanks AW-103 and AW-105 may be blended with other HLW solids to reduce the zirconium concentration if possible and beneficial.
- "Segregate low-cesium SST waste for non-WTP supplemental treatment" – No waste needs to be segregated as low cesium feed.

B3.2.2.8 Enhanced blending of sludge (increases in incidental blending and/or implementation of a small degree of intentional blending) will be used to reduce the projected mass of HLW glass to meet the success criteria for the completion date of waste treatment.

B3.2.3 Waste Retrieval and Transfers

B3.2.3.1 The next group of SSTs to be retrieved in the near-term will be the C Farm tanks.

B3.2.3.2 The goal for sequencing the retrieval of SST waste is to minimize the waste treatment mission duration[63] by attempting to provide sufficient HLW or LAW feed to keep the limiting facilities operating at or near assumed capacity and by maintaining as high an average waste oxide loading of the limiting facility product as reasonably achievable.

B3.2.3.3 The retrieval of the SSTs will be sequenced using a staggered, overlapping, farm-by-farm approach, described in RPP-PLAN-40145, that considers the following:

- Simultaneous retrieval constraints resulting from infrastructure or operational considerations
- Retrieval technologies and performance, including learning curves and anticipated difficulty in retrieval based on unique tank and waste conditions
- Available DST space
- Special handling for the CH-TRU waste (Baseline Case only)
- Providing a balanced feed to the WTP, with priority given to feeding the more limiting facility.

B3.2.3.4 Updated SST retrieval assumptions (assumed technology, minimum retrieval duration, and as-retrieved waste volumes) will be provided by SVF-1647.[64]

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[63] It is asserted that minimizing treatment mission duration significantly reduces the risk to human health and the environment. This input is consistent with discussions held with Ecology.

[64] The SST retrieval performance assumptions were updated by WRPS as part of the integration effort.

B3.2.3.5 Retrieval of waste from B Complex (B, BX and BY Farms), except that waste handled as CH-TRU waste (see Assumption B3.4.3.1), will be transferred to a tank in the B Complex Waste Retrieval Facility (WRF), with supernate routed back and forth from the WRF tank to the SST as required. Retrieved waste will be transferred from the WRF tank to DST storage via new double-encased hose-in-hose transfer lines (HIHTL) or stainless-steel lines (RPP-PLAN-40145).

B3.2.3.6 Retrieval of waste from T Complex (T, TX and TY Farms), except that waste handled as CH-TRU waste (see Assumptions B3.4.3.1 and B3.4.3.3), will be to a tank in the T Complex WRF, with supernate routed back and forth from the WRF tank to the SST as required. Retrieved waste will be transferred from the WRF tank to DST storage via new double-encased HIHTLs or stainless-steel lines (RPP-PLAN-40145).

B3.2.3.7 Each WRF will consist of six tanks, each tank with a 150,000-gal operating volume, along with all needed ancillary equipment per RPP-17152.

B3.2.3.8 The B Complex WRF will be available for operations on 7/2/2019; the T Complex WRF will be available for operations on June 30, 2020.[65]

B3.2.3.9 All SSTs (except those specifically retrieved into WRFs per Assumptions B3.2.3.5 and B3.2.3.6 or those handled as CH-TRU waste per Assumptions B3.4.3.1 and B3.4.3.3) will be retrieved directly into the DST system.

B3.2.3.10 During retrieval of waste from SSTs to the DST system, sodium hydroxide and sodium nitrite will be added as needed so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits given in Table 3-9 of HNF-SD-WM-OCD-015. Caustic additions for intra-DST transfers and for depletion of caustic over time are not modeled.

B3.2.3.11 All feed delivered to the WTP before the start-up of the ARF will be via the DST system; all feed delivered to the WTP after the start-up of the ARF will be via that facility.

B3.2.3.12 Allow 210 days[66] to sample the staged feed and verify compliance with permits and the safety authorization basis before delivery to the WTP, starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.

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[65] These dates are taken from the PMB and may be adjusted to meet success criteria.

[66] The 210-day dwell time comprises the 180 days required by ICD-19 (24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed*) with an additional 30 days allocated for the Tank Operations Contractor to mix and sample the staged waste.

B3.2.3.13 Allow 120 days[67] to sample the staged feed and verify compliance with permits and the safety authorization basis before delivery to the ARF, starting from when each staging tank (DST) is filled with feed, but no earlier than the availability of suitable mixing and sampling capability.

B3.2.3.14 The feed for LAW hot commissioning will be delivered by decanting a portion of the supernate from Tank AY-102 and transferring it to the WTP; the feed for HLW hot commissioning will be delivered by remobilizing the solids in Tank AY-102 with the remaining supernate and additional dilution water and then transferring them to the WTP.

B3.2.3.15 Subsequent deliveries of feed to the WTP will be timed and sequenced to balance the production of HLW glass and LAW glass.

B3.2.3.16 The use of the DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to the ARF and the WTP will be revisited as part of the integration with RPP-40149 and RPP-PLAN-40145. Key areas of alignment include (subject to change during the integration effort):

- Planned configuration of each DST.
- The maximum settled solids level that can be effectively mobilized and well-mixed using two mixer-pumps without incremental insertion capability is 70 in. An allowance for mixing up to a nominal 76 in. will be assumed for the blending of Tank C-104 sludge per Assumption B3.2.2.7.
- During normal operations, mixer-pumps will not be operated with less than 72 in. of waste in the tank for deliveries of HLW feed to ensure well-mixed feed.
- During normal operations, mixer-pumps will not be operated with less than 36 in. of waste in the tank for DST-to-DST transfers to prevent damage to the pumps.
- When used to stage HLW solids, the DSTs in AZ and AY Farms will each be limited to a maximum of nine complete fill-mix-empty cycles to avoid fatigue damage to in-tank components, not including final DST clean-out.[68]
- Key transfers needed to prepare the initial batches of feed for delivery to the WTP and to position the DST system to continue waste feed delivery operations (bootstrap transfers).

[67] The 120-day dwell time comprises an assumed 90 days to verify compliance with as-of-yet to be established permit conditions and authorization basis requirements with an additional 30 days allocated for the Tank Operations Contractor to mix and sample the staged waste.

[68] Leonard 2010, "RE: Mixer Pump Jet Forces on Internal Equipment in Aging Waste Tanks." This is an enabling assumption pending the outcome of the mixing demonstration program.

B3.2.3.17 All HLW batches delivered to the WTP should be between 52,834 and 158,503 gal before line flushes[69] whenever possible and contain between 10 and 200 gm of unwashed solids per liter of slurry.[70]

B3.2.3.18 The residual waste remaining in the SSTs and DSTs after retrieval is complete will be estimated as follows:

- The residual inventory in a 200-series SST will be Best-Basis Inventory (BBI) data for that SST where waste retrieval actions have already been completed, when that information is available, or will be estimated as 25 ft^3 of residual containing 83 wt% water washed solids with liquids at 5E-4 times the concentration of the bulk as-retrieved supernate.[71, 72, 73]
- The residual waste inventory in a 100-series SST will be BBI data for that SST where waste retrieval actions have already been completed, when that information is available, or will be estimated as 300 ft^3 of residual containing 83 wt% water-washed solids with liquids at 5E-4 times the concentration of the bulk as-retrieved supernate.[71, 72, 73]
- DSTs: 100 gal with composition of the last waste contained in the tank.[74]

B3.2.3.19 No waste is assumed to leak from the SSTs during retrieval.[75]

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[69] This operational consideration reduces the number of transfers needed to deliver staged HLW from a DST to the WTP. ICD-19 (24590-WTP-ICD-MG-01-019) allows transfers between 52,834 and 158,503 gal before line flushes. The System Plan will attempt to target a total delivered batch volume, including flushes, of at least 130,000 gal to facilitate more efficient WTP operations.

[70] The WTP contract (DE-AC27-01RV14136), Section C, Specification 8, Paragraph 8.2.2.1, establishes the range of acceptable solids concentration in the delivered HLW feed. The System Plan will attempt to target a nominal 8 wt% solid concentration to facilitate more efficient WTP operations.

[71] The residual volumes are conservatively assumed to be the maximum allowed by the Tri-Party Agreement (Ecology et al. 1996), adjusted downward for a nominal 20% estimating uncertainty (per RPP-37110, *Computer/ CAD Modeling System Test Results*), until better estimates can be developed. The residual volume estimate is not meant to define the limits of any particular retrieval technology nor replace the procedures established in Appendix H of the Tri-Party Agreement.

[72] The weight percent solids and liquid remaining in the residual is based on an informal review of post-retrieval waste volume estimates for Tanks C-103, C-106, S-112, C-201, C-202, C-203, and C-204 (Sasaki 2008).

[73] The reduction in liquid phase concentration relative to the pre-rinse composition is based on rinsing the 100-series residual with three rinses, each of 10,000 gal, and on rinsing the 200-series residual with three rinses, each of 833 gal. The pre-rinse composition is assumed to equal the bulk as-retrieved liquid phase composition. These are placeholder assumptions until better estimates are developed.

[74] The 100-gal DST residual volume is a placeholder assumption that has been used in the HTWOS model since 1997, and is not based on any evaluation of DST waste retrieval capability or end-of-mission flushing strategy. Use of this value is not meant to imply that the end-of-mission DST retrievals are efficient enough to leave this small of a residual.

[75] While performance assessments assume nominal leakage during retrieval operations, the System Plan assumes no leakage occurs to ensure that maximum waste inventory is modeled through the Waste Treatment Complex.

B3.2.4 Tank Farm Waste Evaporator (242-A)

B3.2.4.1 The 242-A Evaporator will be available, as needed, to support SST retrieval and to attempt to maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during scheduled maintenance outages.[76]

B3.2.4.2 If there are periods greater than 11 months during which the 242-A Evaporator is not used to concentrate waste, a "cold run" of 82,000 gal of water will be performed to maintain personnel qualifications and avoid the need for a full readiness review (RPP-17152, Section 5.3.4, "Evaporator Cold Runs"). A full readiness review will be assumed if the 242-A Evaporator sits idle for more than 12 months.

B3.2.4.3 A four-month period is allocated for the sampling and analysis of dilute feed staged in one or more DSTs, and for preparation of the process control plan before that feed can be run through the evaporator (RPP-17152, Section 5.3.3, "242-A Evaporator Feed Staging Dwell Time").[77] This assumes that the sampling and analysis effort is given high priority.

B3.2.4.4 When processing waste, the evaporator is assumed to run at the lesser of 40 gpm boil-off or 140 gpm feed (RPP-17152, Section 5.3.6, "242-A Maximum Evaporation Rate").[77]

B3.2.4.5 Dilute waste will be concentrated until it reaches a bulk concentration of 1.43 g/mL; feed will not be evaporated if it would achieve less than a 15% waste volume reduction at 1.43 g/mL or at 80% of the maximum product source term (RPP-17152, Section 5.3.2, "242-A Evaporator Feed Staging Requirement").[78]

B3.2.4.6 The composition of process condensate from the 242-A Evaporator and the releases from the condenser to the atmosphere will be estimated using the formulas, partition coefficients, and split factors given in RPP-17152, Section 5.2, "Model Description." The volume of process condensate will be 1.15 times the waste volume reduction to account for the vacuum system steam jets (RPP-17152, Section 5.3.7, "242-A Process Condensate Volume").

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[76] The schedule of evaporator outages and availability will be established by WRPS as part of the integration effort.

[77] These are estimates of recent 242-A Evaporator performance (Conner 2008).

[78] This density is expected to be the average density selected for future evaporator campaigns – it is not an inherent limitation of the evaporator. The feed for each evaporator campaign will be evaluated and a target density specific for that feed will be determined considering the ability of the transfer system to maintain solids in suspension and the DSTs ability to stay within BDGRE controls. In the future, a lower value may be used for waste containing high concentrations of phosphates. Precipitation of solids is not modeled.

B3.3 WASTE TREATMENT PLANT

The assumptions for the performance of the WTP used in this System Plan are consistent with the ORP assessment of the potential performance of the WTP after specific enhancements in design, flowsheet, or operating modes have been made.

B3.3.1 General

B3.3.1.1 The WTP will be operable for 40 years, from the start of hot commissioning through 2058.

B3.3.1.2 The balance of facilities (BOF), laboratory, and other support facilities are assumed to be capable of supporting the WTP. The WTP sampling and analysis times are assumed to support production.

B3.3.1.3 Hot commissioning will begin on May 1, 2018,[79] and end on December 1, 2019 (Babel 2008).

B3.3.1.4 Delivery of the first batch of LAW feed will begin on May 1, 2018.[80]

B3.3.1.5 Delivery of the first batch of HLW feed will begin on May 15, 2018.[81]

B3.3.1.6 Routine WTP operations will begin on December 2, 2019,[82] and continue until the end of the treatment mission.

B3.3.1.7 The WTP is assumed to not return any waste streams or wastewater back to the tank farms.

B3.3.1.8 The technical issues previously identified in several design oversight reviews, external reviews, and a comprehensive independent review either have been resolved or are assumed to be resolved without adverse impact to the assumed performance of or the schedule for the WTP.

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[79] The current WTP schedule has hot commissioning beginning in September 2017, with about 14 months of schedule contingency. The May 1, 2018 date assumes the use of about one-half of this contingency. The production goals for hot commissioning are addressed in Assumptions B3.3.3.2 and B3.3.4.3; detailed hot commissioning plans are not explicitly modeled.

[80] The date is set to match the start of hot commissioning (see Assumption B3.3.1.3).

[81] The date is set to allow receipt of the first batch of LAW feed before the delivery transfer of the first batch of HLW is started.

[82] One day after the end of the hot commissioning date specified in Babel 2008. There may be a contractor transition once hot commissioning has been completed, the effects of which are assumed to be reflected in various facility ramp-ups and not explicitly modeled.

B3.3.1.9 It is assumed that the delivered feed and internal WTP material flows and accumulations will be consistent with the WTP authorization basis.[83]

B3.3.1.10 The temperature of LAW feed delivered to the WTP is assumed to be less than 120°F; the temperature of HLW feed delivered to the WTP is assumed to be less than 150°F as an enabling assumption.[84]

B3.3.1.11 For the Baseline Case only, feed projected to be delivered to the WTP will be screened[85] against several sets of requirements to proactively identify potential issues for future resolution. These screenings are not directly suitable for safety basis or design decisions—they serve to identify areas of further inquiry. The criteria sets to be used are the following:

- Specification 7: LAW envelope definition from DE-AC27-01RV14136, Section C.[86]
- Specification 8: HLW envelope definition from DE-AC27-01RV14136, Section C.
- WTP hydrogen generation rate limits.[87]
- The criticality safety limits in Section 8.1 of 24590-WTP-CSER-ENS-08-0001, *Preliminary Criticality Safety Evaluation Report for the WTP*. This screening will be based on point estimates of the as-delivered feed; confidence limits and uncertainty will not be addressed.

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[83] This assumption is not necessarily true for all feed to the WTP. It is assumed that the integrated management process for ICD-19 (24590-WTP-ICD-MG-01-019), as described in 24590-WTP-PL-MG-01-001, *Interface Management Plan*, will be used to successfully address any feed not consistent with this assumption. New tank-specific controls, if any, would be incorporated into the feed control list. For example, the feed control list (HNF-SD-WM-OCD-015, Table A-1) already requires blending of the solids in Tank AZ-101 to reduce the hydrogen generation rate and blending of the solids in Tank C-104 to reduce the concentration of ^{233}U.

[84] Revision 4 of ICD-19 (24590-WTP-ICD-MG-01-019) currently states a limit of 120°F for LAW feed and 190°F for HLW feed. The integrated project team for ICD-19 has agreed to reduce the limit for HLW feed to 150°F (Pell 2009, "ICD-19 Team Meeting – Finalize Issues to be Included in Rev. 5"). When that change is formally approved and promulgated, the impacts on waste feed delivery systems and operations will need to be assessed.

[85] Based on previous feed screening, some delivered feed is expected to fall outside of the screening criteria and may require multiple iterations with ORP, Bechtel National, Inc. (BNI), and WRPS over several years to fully define an acceptable set of feed requirements.

[86] For batches delivered via the ARF, the permitted volume of batches delivered to the WTP LAW feed receipt tanks will be adjusted to match Assumption B3.4.1.5.

[87] The projected WTP feed will be screened against hydrogen generation rate (HGR) criteria to flag batches of feed that are potentially problematic and may require special consideration. This simplified screening will only be applied to the feed as projected to be delivered to the WTP feed receipt tanks. The HGR calculation will be performed using screening criteria, provided by BNI and approved by ORP, documented in RPP-39811, *Waste Treatment and Immobilization Plant Hydrogen Generation Rate Screening Criteria for System Modeling*. BNI has recommended the continued use of the existing screening criteria in RPP-39811, including the continued use of 120°F and 190°F as the LAW and HLW maximum operating temperature, until new HGR criteria are established (Eager 2010).

B3.3.1.12 Key features of the WTP that will be modeled for purposes of mission planning and estimation of secondary waste streams include the following:

- Pretreatment Facility
  - LAW feed receipt tanks (lumped)
  - HLW feed receipt tank
  - Front-end evaporators:
    - Recycle evaporator
    - Feed evaporator (modeled, but turned off per Assumption B3.3.1.13)
  - Two ultrafilter process trains (full cycle):
    - Caustic leach
    - Concentration
    - Oxidative leach (uses ORP-approved performance assumption)
    - Post-leach wash
  - Pretreated HLW lag storage tanks
  - Cesium ion-exchange:
    - Four-column carousel
    - Resin replacement, regeneration and acid recovery simplified
  - Back-end evaporator and pretreated LAW storage
  - Aluminum solubility modeled (but uses ORP-provided correlation)
  - Neither oxalate nor phosphate solubility modeled
- HLW Vitrification Facility
  - Both melter trains are lumped
  - Both off-gas treatment systems are lumped
  - HLW melter feed preparation (simplified; uses 2009 HLW GFM)
  - HLW melter
  - HLW canister (but use thin-wall canister)
  - HLW melter off-gas system
  - Recycle of HLW condensate (from submerged bed scrubber [SBS], wet electrostatic precipitator [WESP], and high-efficiency mist eliminator [HEME]), canister wash water and decontamination chemicals to the front end recycle evaporator via the plant wash disposal (PWD) system.
- LAW Vitrification Facility
  - Both melter trains are lumped
  - Both off-gas treatment systems are lumped
  - LAW melter feed preparation (simplified)
  - LAW melter
  - LAW container
  - LAW melter off-gas system
  - Recycle of both LAW SBS and WESP condensate to the back-end evaporator
  - Discharge of LAW caustic scrubber effluent and evaporator condensate to the Liquid Effluent Retention Facility (LERF)/Effluent Treatment Facility (ETF) via the radioactive liquid waste disposal system (RLD).

- General
  - Internal equipment and line flushed not modeled.
  - Facility and process vessel vents not modeled.
  - Sample hold times not modeled.
  - Aqueous and solid phase densities (use tank farm assumptions rather than WTP)
  - Total operating efficiency (TOE) includes downtime for major facility equipment change-out such as LAW and HLW melters.

B3.3.1.13 The basis for WTP flowsheet (equipment configuration, capacities, chemical reactions and extents, operating modes and logic, process splits and decontamination factors) used for mission modeling will be the 24590-WTP-MDD-PR-01-002, *Dynamic (G2) Model Design Document* (Rev. 10), with flowsheet and operating mode modifications as needed to implement the other assumptions in this System Plan. Additional details will be provided by 24590-WTP-RPT-PT-02-005.

B3.3.2 Pretreatment

B3.3.2.1 For planning purposes, the solids in each ultrafilter feed batch will be screened to determine if they will undergo caustic leaching.[88] The screening criteria are provided in Section 4.8.3 of 24590-WTP-MDD-PR-01-002 and are interpreted by MMR-09-025, *Pretreatment Alignment Part 2: Ultrafiltration*, and RPP-17152.

B3.3.2.2 When the WTP requests delivery of HLW feed, the HLW feed receipt tanks at the WTP will have sufficient space to receive 160,000 gal (600 m^3) of HLW feed from the ARF HLW product tanks (or the DST system before the ARF is available) without interruption.[89]

B3.3.2.3 When the WTP requests delivery of LAW feed, the LAW feed receipt tanks at the WTP will have sufficient space to receive a nominal 0.355[90] Mgal of feed from the ARF LAW product tanks (or 1 Mgal of feed from the DST system before the ARF is available) without interruption.

B3.3.2.4 The WTP Pretreatment (PT) Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to the second LAW vitrification facility as feed. This is downstream of the point to which LAW SBS/WESP condensate is recycled, so the feed to the second LAW vitrification facility will include a proportional fraction of recycled condensate from both LAW facilities.

B3.3.2.5 The extent of sludge dissolved by caustic leaching will be defined by the caustic leach factors associated with each delivered feed batch.

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[88] After the ARF begins operating, it is anticipated that no solids will require caustic leaching in the WTP since the solids will be caustic leached in the ARF before delivery to the WTP.

[89] These are operational considerations and may need to be adjusted depending on the design of the ARF. The intention is to match the size of the delivery from the ARF to a single WTP LAW or HLW feed receipt tank.

[90] The working volume of a single LAW feed receipt tank is about 0.355 Mgal per 24590-WTP-MDD-PR-01-002.

B3.3.2.6 An oxidative leach process that removes chromium from the HLW sludge will be implemented in the ultrafilter process system. Reaction stoichiometry and endpoint (5000 μg Cr/g dried solids) are described in RPP-15552, *Hanford Tank Waste Oxidative Leach Behavior Analysis*.[91]

B3.3.2.7 For modeling purposes, the solubility of aluminum in supernates present in the WTP PT Facility will be approximated using the correlation shown in Equation 4 from CCN 160514 (Reynolds and Adelmund 2007).[92] This aluminum solubility correlation will be used to determine the amount of sodium hydroxide added to the waste during pretreatment, with the goal of ensuring that feed to the cesium ion-exchange system is not supersaturated with aluminum at 25 ºC.

B3.3.2.8 The number of times the cesium ion-exchange resin is replaced will be tracked.

B3.3.2.9 The constituents that remain on the spent cesium ion-exchange resin are assumed to be negligible for system planning purposes and will not be modeled at this time.

B3.3.3 High-Level Waste Vitrification

B3.3.3.1 HLW vitrification at the WTP will begin on May 31, 2018.[93]

B3.3.3.2 During hot commissioning, the WTP will produce 84 MTG[94] of HLW glass.

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[91] Given that the oxidative leach process is currently being refined, the same oxidative leach endpoint from System Plan (Rev. 4) is being maintained for use in Rev. 5. The oxidative leach assumptions should be updated after the WTP flowsheet is revised to incorporate the refined process.

[92] The WTP baseline correlation in Equation 9 of the same reference is believed to provide overly conservative (biased high) estimates of required sodium additions. This is discussed in more detail in Reddick 2008. ORP has requested that Equation 4 be used instead of the WTP baseline as "a temporary estimate of nominal caustic additions until a better correlation is available." ORP has an ongoing effort to assess sodium use in the WTP. An approved sodium management plan and recent assessment (A-09-AMWTP-RPPWTP-002, *Design Oversight Report, Basis for Sodium Estimate*) may further refine this assumption. The use of the reference Equation 4 is appropriate until further revision/improvement is supported.

[93] This includes the hot commissioning period and reflects the modeled date on which the WTP HLW Vitrification Facility is changed from zero to the average hot commissioning rate. The 15-day lag after delivery of the HLW feed is an estimate of the time needed to characterize, pretreat, and transfer the pretreated waste to the LAW and HLW Vitrification Facilities; the actual date may vary (see Assumption B3.3.1.3 and associated Footnote 79).

[94] DE-AC27-01RV14136, Standard 5, (g)(4) and (g)(5), requires that 4.2 MTG/day of HLW glass be produced for 20 days. For modeling purposes, the average glass production rate during hot commissioning is set so that the contract goal (rounded up to the next whole canister) is just met by the end date for hot commissioning.

B3.3.3.3 After hot commissioning, the net WTP HLW vitrification capacity will be ramped as follows:

Starting On	Rate MTG/d
12/2/2019	3.0
1/1/2021	4.0
1/1/22	4.2[95]
2/6/2025	5.25

B3.3.3.4 The average bulk[96] density of immobilized high-level waste (IHLW) glass will be 2.66 Kg/L at 20°C; the average density of the molten glass will be 2.40 Kg/liter (24590-WTP-RPT-PT-02-005, Sections 4.2.3.6 and 4.2.3.2, respectively).

B3.3.3.5 On the average, each canister of IHLW will be filled to 41.692 ft^3 (1.1806 m^3).[97]

B3.3.3.6 Each canister of IHLW will contain 3.14 MT of HLW glass on the average.[98]

B3.3.3.7 The composition, properties, and waste oxide loading of HLW glass will be estimated[99] using the 2009 GFM documented in PNNL-18501. For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals.[100] For planning purposes, the allowable glass forming chemicals are: Al_2O_3, B_2O_3, Fe_2O_3, Li_2O, Na_2O, and SiO_2.[101]

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[95] DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the HLW Vitrification Facility will support a combined design capacity of 6 MTG/d with the original two melters and 7.5 MTG/d with two replacement melters, with a minimum integrated TOE of 70%.

[96] This is based on crucible density data and estimated volume percent void content per Section 4.2.3.6 of 24590-WTP-RPT-PT-02-005 and is consistent with Section 4.6 of 24590-WTP-MDD-PR-01-002.

[97] DE-AC27-01RV14136, Section C, Specification 1, Section 1.2.2.1.2, requires that on the average, the canisters will be filled to 95% of the volume of an empty canister; the corresponding glass volume for nominal canister dimensions is estimated by Appendix C of 24590-HLW-M0C-30-00003, *HLW Canister Weight and Volume Calculations*. This is also consistent with the estimate provided in 24590-HLW-M0-30-00001001, *HLW Test Canister Assembly*.

[98] This is based on filling a canister with 10-gauge thick walls (sometimes referred to as a "thin-walled" canister) to 95% fill (41.692 ft^3 or 1.1806 m^3) of glass with a bulk density of 2.66 kg/L per Assumptions B3.3.3.4 and B3.3.3.5.

[99] This model defines a constrained, non-linear programming problem, which is then solved in HTWOS by iterating over a linearized version of the model.

[100] A comparison of the 2009 GFM with the model used in previous System Plans is provided in RPP-RPT-42649, *High-Level Waste Glass Formulation Model Sensitivity Study, 2009 Glass Formulation Model versus 1996 Glass Formulation Model*.

[101] The HTWOS implementation of the 2009 GFM allows the user to specify which glass-forming chemicals may be used. In addition to the six stated above, the user can specify CaO, MgO, TiO_2, ZnO, and ZrO_2. However, for System Plan (Rev. 5), the allowable glass-forming chemicals are being aligned to those used by BNI per Gimpel 2009.

B3.3.3.8 One HLW melter is assumed to be replaced every 2.5 years on the average and contains approximately 823 gal of glass.[102] For purposes of this System Plan, spent HLW melters are assumed to be disposed of at the Integrated Disposal Facility (IDF) per Assumption B3.5.6.2 and Footnote 128, pending determination of their final disposition.

B3.3.4 Low-Activity Waste Vitrification

B3.3.4.1 LAW vitrification at the WTP will begin on May 31, 2018.[103]

B3.3.4.2 The WTP LAW Vitrification Facility will receive all of its feed from the WTP PT Facility.

B3.3.4.3 During hot commissioning, the WTP will produce 480 MTG[104] of LAW glass.

B3.3.4.4 After hot commissioning, the net WTP LAW vitrification capacity will be ramped as follows for all cases:

Starting On	Rate MTG/d
12/2/2019	9.0
1/1/2021	18.0
1/1/2022	21.0[105]

B3.3.4.5 The average bulk[106] density of immobilized low-activity waste (ILAW) glass will be 2.58 Kg/liter at 20°C; the average density of the molten glass will be 2.45 Kg/liter (24590-WTP-RPT-PT-02-005, Sections 3.2.3.2 and 3.2.3.7).

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[102] Replacement of spent melters is already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a 5-year minimum design life per 24590-HLW-3PS-AE00-T0001, *Engineering Specification for High Level Waste Melters*. The volume of glass in the melter is assumed to reflect the 25-in. heel remaining after the maximum pour and includes an allowance for increased volume due to corrosion of the refractory (CCN 102476 [Hall 2004]); other contributions to source term are neglected. No credit is taken for purging the melter with "cold" glass prior to removal from service.

[103] This includes the hot commissioning period and reflects the modeled date on which the LAW facility is changed from zero to the average hot commissioning rate. The 15-day lag after delivery of the HLW feed is an estimate of the time needed to characterize, pretreat, and transfer the pretreated waste to the LAW and HLW Vitrification Facilities; the actual date may vary. Also see Assumption B3.3.1.3 and associated Footnote 79.

[104] DE-AC27-01RV14136, Standard 5, (g)(4) and (g)(5), requires that 24 MTG/day of HLW glass be produced for 20 days. For modeling purposes, the average WTP glass production rate during hot commissioning is set so that the contract goal (rounded up to the next whole package) is just met by the end date for hot commissioning.

[105] Assumes two LAW melters, each 15 MTG/d design at a 0.7 TOE. DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the LAW Vitrification Facility will support a combined design capacity of 30 MTG/d using two melters, with a minimum integrated TOE of 70%.

[106] This is based on crucible density data and estimated volume percent void content per Section 3.2.3.7 of 24590-WTP-RPT-PT-02-005 and is consistent with Section 4.6 of 24590-WTP-MDD-RP-01-002.

B3.3.4.6 On the average, each package of ILAW will be filled to 564 gal (2.135 m^3).[107]

B3.3.4.7 Each package of ILAW will contain 5.51 MT of LAW glass on the average.[108]

B3.3.4.8 The total sodium loading of LAW glass from pretreated feed will be determined using the "DOE 2004" model (D-03-DESIGN-004, *An Assessment of the Factors Affecting the Ability to Increase the Na_2O Loading in the Waste Treatment and Immobilization Plant (WTP) Low Activity Waste (LAW) Glass*), which maximizes the sodium oxide loading in the LAW glass subject to the following constraints:[109]

$$[Na_2O] \leq 20 wt\%$$

$$[SO_3] \leq 0.8 wt\%$$

B3.3.4.9 The composition of the LAW glass will be estimated using a glass recipe model similar to that described in Table B-2 of 24590-WTP-MRQ-PO-04-0065, *Model Run Request, Supplemental LAW Data Collection*.

B3.3.4.10 One LAW melter is assumed to be replaced every 2.5 years on the average and contains approximately 1,875 gal of glass.[110] For purposes of this System Plan, spent melters will be managed and disposed of at the IDF as mixed LLW.

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[107] DE-AC27-01RV14136, Section C, Specification 2, Section 2.2.2.5, requires that the packages will be filled to at least 90% of the volume of an empty package; the corresponding volume is obtained from 24590-WTP-RPT-PT-02-005, Section 3.2.3.7.

[108] This is based on filling a package to 90% (2.135 m^3) of glass with a bulk density of 2.58 kg/L per Assumptions B3.3.4.5 and B3.3.4.6.

[109] LAW glass formulation work reviewed in D-03-DESIGN-004 suggests that the sodium loading projected by the DOE model can be achieved. To that end, DOE is continuing to fund LAW glass development at the Vitreous State Laboratory (The Catholic University of America, Washington, D.C.) to improve sodium oxide loadings beyond the WTP baseline model.

[110] Replacement of spent melters is already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001, *Engineering Specification for Low Activity Waste Melters*. The volume of glass in the melter does not include an allowance for increased volume due to corrosion of refractory and reflects the heel remaining after the maximum pour; other contributions to source term are neglected. No credit taken for purging melter with "cold" glass prior to removal from service.

B3.4 SUPPLEMENTAL TREATMENT

B3.4.1 Aluminum Removal Facility

B3.4.1.1 The ARF is assumed to startup on July 19, 2022, and will condition all feed to the WTP PT Facility from that date on.

B3.4.1.2 Feed is assumed to be sampled in the DSTs and qualified for delivery to the ARF LAW and HLW feed receipt tanks per Assumption B3.2.3.13. Samples from the ARF LAW and HLW product lag-storage tanks are used as feed qualification samples prior to delivery of the conditioned feed to the WTP per Assumption B3.4.1.3.

B3.4.1.3 Allow 190 days[111] to sample the staged product and verify compliance with permits and the safety authorization basis before delivery to the WTP, starting from when each product staging tank is filled with feed.

B3.4.1.4 The ARF is assumed to be a standalone facility that uses a process based on the lithium hydrotalcite process described in "Aluminum Removal Facility Performance Assumptions for System Planning Purposes" (Shuford 2010) to caustic leach all of the solids in the delivered feed. In this context, standalone means that the facility contains all necessary unit operations and will not rely on the DST system, the 242-A Evaporator, or the WTP PT Facility for support, that all recycles are internal, and that it includes any needed lag-storage. This doesn't preclude the use of the LERF/ETF and IDF for handling secondary waste from the ARF.

B3.4.1.5 The ARF will be modeled as a black-box, with the following attributes:

- There will be four LAW feed receipt tanks, two HLW feed receipt tanks, three LAW product staging tanks, and seven HLW product staging tanks; each set of tanks will be operated as a first-in first-out queue. Operating volumes will be selected to match the nominal WTP feed receipt tank operating volumes.[112]
- The extent of sludge dissolved by caustic leaching will be defined by the associated caustic leach factors. Excess OH^- from the lithium hydrotalcite precipitation reaction will be recycled to support the caustic leaching.
- Approximately 80% of the liquid phase aluminum (after sludge leaching) will be removed from the waste per the following reaction:[113]

$$2LiOH_{(AQ)} + Na_2CO_{3(AQ)} + 4NaAl(OH)_{4(AQ)} + 3H_2O \rightarrow$$
$$Li_2CO_3 \cdot 4Al(OH)_3 \cdot 3H2O_{(S)} + 6NaOH_{(AQ)}$$

[111] The 190-day dwell time comprises the 180 days required by ICD-19 (24590-WTP-ICD-MG-01-019) with 10 additional days allocated for the Tank Operations Contractor to mix and sample the staged waste.

[112] This is an estimate of the number and size of the lag storage tanks to ensure an adequate supply of feed to the ARF and WTP. These may be adjusted based on preliminary model runs.

[113] Shuford 2010. Adjustments for substitution of other anions that compete with the CO_3^- in the lithium precipitate may be made.

- The LiOH reagent will be added in 25% excess of stoichiometric amounts as a 10 wt% aqueous solution.[113]

B3.4.1.6 The capacity of the ARF is assumed to be selected so that it does not drive the mission duration.

B3.4.1.7 The lithium hydrotalcite is assumed to be washed, dried, solidified and drummed, and is further assumed to be suitable for disposal at the IDF as a new secondary waste stream. Contaminants will not be modeled nor will the mass of any additives required to solidify this by-product.[114]

B3.4.1.8 The supernate, containing the excess recovered hydroxide, is assumed to be delivered to the WTP LAW feed receipt tanks. The caustic leached sludge, along with a portion of the supernate, is assumed to be delivered to the WTP HLW feed receipt tank.

B3.4.1.9 Any excess condensate (all process water added in the ARF, plus a portion of the water in the feed) is assumed to be delivered to the LERF/ETF for treatment as a secondary waste. Contaminants will not be modeled.[115]

B3.4.2 Second LAW Vitrification Facility

B3.4.2.1 For purposes of this System Plan, supplemental LAW treatment capacity is assumed to be provided by a second LAW vitrification facility, located in 200 East Area adjacent to the WTP.[116]

B3.4.2.2 The second LAW vitrification facility is assumed to have the same technical assumptions as the WTP LAW Vitrification Facility.

B3.4.2.3 The second LAW vitrification facility will receive “excess” pretreated LAW from the WTP PT Facility per Assumption B3.3.2.4.

B3.4.2.4 Condensate from the SBS and WESP will be recycled via pipeline transfer through the back-end evaporator in the WTP PT Facility.

B3.4.2.5 Caustic scrubber effluent will be discharged to the LERF/ETF via the WTP pretreatment RLD system.

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[114] This is an enabling assumption that may be revised as the process matures. The lithium hydrotalcite by-product may also be considered for use as glass formers at the WTP LAW Vitrification Facility or the second LAW vitrification facility.

[115] This is an enabling assumption that may be revised as the process matures.

[116] This is a placeholder assumption pending a final decision circa 2015 as to how the needed LAW treatment capacity will be provided—by using a second LAW vitrification facility or by using bulk vitrification or another process in one or more supplemental treatment plants.

B3.4.2.6 The net capacity of the second LAW vitrification facility will be selected with the goal that the combined LAW vitrification capacity will be large enough so as to not drive the mission duration. The second LAW vitrification facility will complete hot commissioning on September 30, 2022 (hot commissioning will not be modeled) and begin routine operations on October 1, 2022. The facility will be ramped as follows:

Starting On	Rate MTG/d
10/1/2022	9.0
1/1/2025	Per Assumption B3.4.2.6

B3.4.2.7 One LAW melter is assumed to be replaced every P[117] years on the average and contains approximately 1,875 gal of glass.[118] Spent melters will be managed and disposed of at the IDF as mixed LLW.

B3.4.3 Supplemental Transuranic Sludge Treatment

B3.4.3.1 The supplemental CH-TRU waste treatment and packing process applies only to the Baseline Case; no waste will be handled as CH-TRU waste in Sensitivity Case A.

B3.4.3.2 The supplemental CH-TRU waste treatment and packaging process will be available on April 2, 2018[119] and will treat a maximum of 8,040 gal of CH-TRU slurry from retrieved CH-TRU tank waste per day.[120]

B3.4.3.3 The SSTs assumed to provide CH-TRU sludge are [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104, in the stated order except that the tank order within the [brackets] can be changed (RPP-21970, *CH-TRUM WPU&SE 11-Tank Material Balance*, Sections 3.0 and 5.0, Assumption 2).[121]

B3.4.3.4 The supplemental CH-TRU waste treatment and packaging system for CH-TRU waste will first be located near B Farm and then moved to T Farm. There will be a minimum 10-day outage between tanks and a minimum 180-day outage to move equipment between farms.

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[117] Each melter is assumed to have a 5-year design life and therefore the average replacement period, P, will be 5 years divided by the number of melters.

[118] Replacement of spent melters is already accounted for in the assumed net production capacity assumptions. Assumes two melters, each with a 5-year minimum design life per 24590-LAW-3PS-AE00-T0001. The volume of glass in the melter does not include an allowance for increased volume due to corrosion of the refractory and reflects the heel remaining after the maximum pour; other contributions to source term are neglected. No credit has been taken for purging melter with “cold” glass prior to removal from service.

[119] This is the date assumed by the life-cycle PMB.

[120] The assumed rate is based on 1:1 dilution of solids with water during retrieval and a 0.67 TOE per RPP-21970, Section 3.0.

[121] These are operational considerations. Order and timing may be adjusted to match the PMB.

B3.4.3.5 It is assumed that waste previously assumed to be RH-TRU[122] waste will be retrieved and treated at the WTP together with the HLW (Harp 2008).

B3.4.3.6 The process flowsheet for the CH-TRU sludge treatment is described in the material balance for the CH-TRU waste tanks and is assumed to use the "dry batch mode" (RPP-21970). For modeling purposes, the two dryers may be lumped into one continuous dryer of equivalent treatment capacity. Additional modeling details and simplifications are provided in Chapter 13 of RPP-17152.

B3.4.3.7 The dried waste product from the CH-TRU waste process is assumed to be packaged in 55-gal drums containing 620 lb_m product per drum (RPP-21970).

B3.4.3.8 Although not explicitly modeled, the CH-TRU waste drums are assumed to be stored onsite at the Central Waste Complex until their final disposition has been determined.

B3.4.3.9 Liquid effluent will either be transferred to the LERF via tank truck or recycled to the retrieval project. For planning purposes, it will be assumed that the liquid effluent is transferred only to LERF (no recycle) and will be modeled as a continuous pipeline transfer.

[122] The SSTs previously assumed to contain RH-TRU sludge are Tanks T-105, T-107, T-112, B-107, B-110, and B-111; the DSTs previously assumed to contain RH-TRU sludge are Tanks SY-102, AW-103, and AW-105.

B3.5 INTERFACING FACILITIES

B3.5.1 Liquid Effluents

B3.5.1.1 The capacities and capability of the ETF, LERF, State-Approved Land Disposal Site (SALDS), and 200 Area Treated Effluent Disposal Facility (TEDF) will be driven by the needs of the waste treatment mission and are assumed to be available when needed. If the treatment mission requires that changes be made to the ETF, LERF, SALDS, or TEDF or their operating plans, ORP is assumed to successfully drive the changes.

B3.5.1.2 The LERF consists of three basins, each with an operating volume of 7.8 Mgal (HNF-SD-WM-SAD-040, *Liquid Effluent Retention Facility Final Hazard Category Determination*), which are used to provide lag-storage of liquid effluent. For planning purposes, only two of the basins will be allocated to supporting the waste treatment mission; the third basin will be reserved for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) (42 USC 103 et seq.) effluents.

B3.5.1.3 The ETF will be modeled as a black-box. Overall partitioning of feed into solid waste and treated effluent will be approximated per HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*, Appendix A. Chemicals (e.g., those for bulking or stabilization of the solid waste form) will not be tracked.

B3.5.1.4 The SALDS will not be modeled; however, the demand on the SALDS from ETF will be estimated.

B3.5.1.5 The 200 Area TEDF[123] will not be modeled.

B3.5.2 Central Waste Complex

B3.5.2.1 The Central Waste Complex is assumed to support the needs of the waste treatment mission and is assumed to be available when needed. The demand on the Central Waste Complex will not be modeled.

B3.5.2.2 For the Baseline Case only, the packaged CH-TRU waste is assumed to be stored at the Central Waste Complex until the final disposition of the CH-TRU waste has been determined.

[123] The 200 Area TEDF treats and disposes of nonradioactive, non-dangerous liquid effluents such as 242-A and WTP evaporator condenser cooling water and WTP cooling tower blow-down.

B3.5.3 Interim Hanford Storage Facility

B3.5.3.1 The mission[124] of the Interim Hanford Storage Facility (IHSF) is to receive and temporarily store canisters of IHLW and eventually retrieve and transport those canisters to the Hanford Shipping Facility (HSF) in preparation for shipment to a potential national repository (RPP-23674, *Immobilized High-level Waste Interim Storage Facility System Specification*).

B3.5.3.2 The IHSF will be located in 200 East Area in the proximity of the WTP HLW Vitrification Facility and provide interim storage for a minimum of 4,000 IHLW canisters. The IHSF will be expandable in increments (modules) of 2,000 canisters up to a maximum of 16,000 canisters, if needed, to mitigate the risk from the availability of offsite geologic storage (RPP-23674).

B3.5.3.3 The need date for the IHSF will be the date on which the first radioactive HLW canister is produced. The baseline schedule (BCR RPP-10-107, "Interim Hanford Storage Facility Deferral") assumes:

- December 30, 2010: Critical Decision (CD)-0
- November 21, 2018: First 2,000 canister module operational
- January 2, 2020: Second 2,000 canister module operational
- Each additional module will be operational 1.5 years in advance of projected need date.
- A decision to construct each additional module will be made four years in advance of the projected operational need date.

B3.5.3.4 The 24 canisters of WTP-provided storage for cooling IHLW canisters and the 24 canisters of WTP-provided buffer capacity will be used before beginning to fill the IHSF.[125]

B3.5.3.5 The average canister receipt and retrieval capability of the IHSF will *each* be 800 canisters per year,[126] with a peak handling rate of three canisters per day (RPP-23674).

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[124] *Justification of Mission Need for an Interim Hanford Storage Facility, Non-Major System Acquisition Project*, December 2009, DRAFT.

[125] Cooling and buffer capacity obtained from 24590-HLW-3YD-HPH-00001, *System Description for HLW System HPH Canister Pour Handling*.

[126] This is about 25% above the average net production capacity required to support the assumed HLW glass production rate in Assumption B3.3.3.3.

B3.5.4 Hanford Shipping Facility

B3.5.4.1 It is assumed that on or before June 2022, a decision will be made to either continue to build additional IHSF modules or to construct the HSF. For planning purposes, the outcome of this decision is assumed to be that the HSF will be constructed and HLW canisters are shipped to an offsite final disposal alternative (see Assumption B3.5.5). However, the PMB will include scope for both potential outcomes to help mitigate the uncertainty.

B3.5.4.2 The HSF will be located in 200 East Area either as a standalone facility or a module attached to the IHSF. It will provide for shipping of HLW canisters to a potential national repository.

B3.5.4.3 The canister shipping capability of the HSF is assumed to match the retrieval capability of the IHSF in Assumption B3.5.3.5. If and when the HSF begins shipping, the first priority will be given to shipping newly created IHLW canisters beyond those stored at the IHSF and second priority is given to emptying the IHSF after HLW vitrification is finished. Shipping needs will be estimated with the IHSF operated at approximately 1,000 canisters less than capacity to decouple canister receipt from the WTP from shipping to a national repository.

B3.5.5 Final Disposal Alternative

B3.5.5.1 The final disposal alternative for HLW glass canisters is assumed to be at an unidentified offsite national repository.

B3.5.6 Integrated Disposal Facility

B3.5.6.1 The IDF will be operational on October 1, 2010[127] and will provide permanent disposal for the ILAW, other mixed LLW, and LLW.

B3.5.6.2 The IDF will receive LAW glass packages from the WTP; solid waste from the WTP, including spent LAW and HLW[128] melters; the lithium hydrotalcite by-product from the ARF; and solid waste from the ETF from treating liquid effluent. Only that portion of the primary and secondary waste streams directly related to treatment of the tank waste will be modeled.[129]

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[127] The stated date is the current baseline. However, an updated date will be established by DOE Richland Operations Office (RL), to support approved end uses of the IDF, pending the outcome of the Tank Closure and Waste Management Environmental Impact Statement (EIS) (DOE/EIS-0391). For planning purposes, it is assumed that ORP mission needs will drive this date. The PMB will be adjusted to match this date.

[128] The final disposition of the spent HLW melters has not yet been determined. The many alternatives in the draft EIS assume that these spent HLW melters will be packaged in an overpack and stored at the HLW Melter Interim Storage Facility until they can be removed for disposition and final disposal. For planning purposes, the final disposition of the spent HLW melters is assumed to be at the IDF to maintain consistency with the current PMB. Plans will be updated as needed after a Record of Decision (ROD) is published.

[129] For example, the inventory that is retained on a disposable filter will be modeled, but the mass, composition, and overall volume of the filter itself will not be tracked.

B3.5.6.3 For planning purposes, the IDF can be expanded as needed to support the mission without interference from other users.

B3.5.7 222-S Laboratory

B3.5.7.1 It is assumed that the laboratory services required to support waste characterization for Tank Operations Contract projects and operations are available and provided in a timely manner.

B3.5.7.2 Any required facility life-extension upgrades will be aligned with the PMB.

B3.5.7.1 The 222-S Laboratory is assumed to transfer 5 kgal/yr of waste (see Assumption B3.6.3) to the tank farms before the startup of the WTP and 10 kgal/yr thereafter.

B3.5.8 Waste Encapsulation and Storage Facility

B3.5.8.1 Cesium and strontium capsules are assumed to be dispositioned outside of the WTP and tank farm facilities by the DOE Richland Operations Office (RL).[130]

B3.5.9 Waste Isolation Pilot Plant

B3.5.9.1 Permitting and operational requirements to accept Hanford CH-TRU tank waste at WIPP will not impact the schedule critical path, if it is determined that the final disposition of the packaged CH-TRU tank waste is disposal at WIPP.

B3.5.10 Other Hanford Site Facilities

B3.5.10.1 Sludge generated from the cleanup of the K Basins is assumed to be dispositioned outside of the WTP and tank farm facilities by RL.

B3.5.10.2 The Plutonium Uranium Extraction (PUREX) facility is assumed to transfer a one-time 15 kgal of waste circa 2025 (see Assumption B3.6.3) to the tank farms as part of its deactivation.

B3.5.10.3 The T Plant Facility is assumed to transfer a one-time 15 kgal of waste circa 2025 (see Assumption B3.6.3) to the tank farms as part of its deactivation. The transfer will include a flush equal to 22 vol% of the waste transferred.

B3.5.10.4 Waste from the retrieval of the inactive miscellaneous underground storage tanks (IMUST) (see Assumption B3.6.3) will be transferred to the tank farms in a series of transfers between 2020 and 2030,[131] or sooner if practical.

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[130] Pretreatment can connect to a potential new facility designed to receive and treat the Hanford cesium and strontium capsules prior to incorporation into the HLW feed for immobilization in the HLW Vitrification Facility, Section C.7(c)(2) of DE-AC27-01RV14136. All options in the draft EIS, except the "Do Nothing" alternative, assume that the contents of the cesium and strontium capsules are treated at the WTP. Therefore, this assumption may be revised when the disposition of the cesium and strontium capsules and their contents are formally established by the ROD and subsequent changes to the PMB.

B3.6 CROSS-CUTTING ASSUMPTIONS

B3.6.1 The decay date used for reporting all radionuclides is January 1, 2008, unless explicitly stated otherwise (RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operations Simulator Model - 2010 Update*).

B3.6.2 The starting tank inventory, as documented in RPP-33715, reflects the contents of the SSTs and DSTs as of January 1, 2010. This is called the "FY 2010" inventory and is based on the BBI downloaded from the Tank Waste Information Network System (TWINS) circa May 2010, with adjustments to reflect improvements in the estimation and reporting of bound hydroxide and bound oxygen. Adjustments will be made in the HTWOS model for historical transfers as needed and to account for chemicals added during cleanout of hard-to-remove heels from SST retrievals.

B3.6.3 Estimates of the inventory for the IMUSTs, the waste resulting from deactivation of other Hanford facilities, and operation of the 222-S Laboratory are provided in RPP-33715.

B3.6.4 The water wash factors[132] in TWINS circa May 2010 will be used to partition waste into solid and liquid phases during retrieval and staging; strontium partitioning will be modeled per RPP-21807, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*. The feed vector will be reported on a fully water-washed basis.

B3.6.5 The caustic leach factors in the TWINS circa May 2010 will be used as the basis for computing the caustic leach factors associated with each delivered batch of HLW solids.

B3.6.6 For modeling purposes, the approximations to waste chemistry in the tank farms are described in RPP-17152, Section 2.8.7, "Waste Chemistry and Mass Balances."

B3.6.7 Liquid density and specific gravity will be estimated using the correlations described in Section 2.5.1, "Liquid Specific Gravity," of RPP-17152.

B3.6.8 For modeling purposes, solid particulate density is assumed to be a constant 3 g/mL[133] per Section 2.4.2 "Volume of In-Process Streams," of RPP-17152.

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[131] The dates and timing of the transfers will be integrated with the PMB.

[132] Uncertainties and biases in the water-wash and caustic-leach factors can significantly influence the canister counts and treatment end dates. Water-wash factors and caustic-leach factors are a zero order approximation to complex solid-liquid equilibrium; this is a known limitation of this methodology.

[133] The value of this constant is being reevaluated and may be changed if warranted.

B3.6.9 The portion of total organic carbon due to oxalate will be tracked as oxalate rather than total organic carbon to avoid double-counting and will not be further speciated.[134] However, for modeling purposes, the remaining total organic carbon will be treated as oxalate once it enters the WTP to allow for reaction stoichiometry.

B3.6.10 The modeled composition of waste retrievals from SSTs will be homogeneous. The modeled composition of waste transferred from a DST will reflect the overall composition of the specific layers (e.g., supernate, dissolved salts, mobilized solids) being transferred.[135]

B3.6.11 The design, flowsheet, operating modes, and operating plans of all facilities or processes will drive the permit conditions, and the permits will be modified as the processes evolve.

B3.6.12 All cases are assumed to be consistent with and bounded by the outcome of the *National Environmental Policy Act of 1969* (42 USC 4321) process.

B3.6.13 All cases are assumed to be consistent with and bounded by the appropriate facility authorization basis.

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[134] Assumptions for speciating total organic carbon into its constituent organic compounds other than oxalate are not available. Therefore, the organic content of the various secondary waste streams will not be estimated.

[135] This is a simplifying assumption required for a tractable model.

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APPENDIX C – RIVER PROTECTION PROJECT SYSTEM DESCRIPTION

RIVER PROTECTION PROJECT SYSTEM DESCRIPTION

Hanford's River Protection Project (RPP) is comprised of nearly 200 interrelated waste storage, transfer, treatment, transportation, and disposal facilities. Some facilities date to the earliest days of the Hanford Site in 1944, others are new facilities under construction today, and some are still being planned, but all are essential to the continued protection of human health and safety and the environment. In this appendix, readers can familiarize themselves with the history and purpose of the principal facilities.

C.1 HANFORD SITE HISTORY

Construction of the Hanford Site first began in 1943 as part of the Manhattan Project. For decades, Hanford's nine nuclear reactors produced plutonium and other radioactive materials used primarily for national defense. Irradiated fuel from those reactors was transported to six separations facilities, also known as "canyons," for the complex process of isolating the desirable radionuclides from other reactor products. From 1944 to 1989, the separations processes yielded millions of gallons of highly radioactive and chemically hazardous waste, which was pumped through underground transfer lines and subsequently stored in 177 underground storage tanks. Although the reactors and separations facilities have long since ceased operations, the underground waste tanks and their contents remain.

C.2 WASTE FORMS IN UNDERGROUND STORAGE TANKS

The radioactive liquid wastes were transferred from the separations facilities as slurry, a liquid with entrained solids. Since the separations processes operated under acidic conditions, sodium hydroxide (NaOH, also known as caustic) was added to the waste streams prior to transfer to the underground storage tanks to inhibit corrosion. Over time, the radioactive solids settled to the bottom of the tanks, creating a layer known as sludge. The clarified liquid above, still radioactive, is known as supernate. To reduce the total quantity of waste to be stored, the supernate was periodically decanted and transferred out of waste tanks and evaporated (see Section C.8 for more details). The evaporation process separated the supernate into two fractions: the overheads, which were relatively clean and could be further treated and safely disposed, and the concentrated slurry, which still contained radionuclides and had to be returned to the underground waste storage tanks. After being processed through the evaporator, the concentrated slurry was returned to the storage tanks. There it cooled and began to form saltcake, a crystalline solid waste form. At one time, most tanks contained all three waste forms simultaneously (see photos of actual waste in Figure C-1.)

Figure C-1. Photos (left to right) of Radioactive Sludge, Salt, and Supernate Inside Hanford's Underground Waste Storage Tanks.

In addition, long-term storage at high temperatures contributed to the formation of a solid mass or group of large solids not easily removed called hard-to-remove heels in the bottoms of some tanks.

C.3 TANK FARMS

The underground waste storage tanks were built in groups of two to 18 each; each group is known as a "tank farm." The tank farms are located in the center of the Hanford Site, approximately 250 feet above the water table, and approximately 10 miles from the shore of the Columbia River. Seven tank farms (comprised of 86 tanks) are located in 200 West Area, and 11 tank farms (comprised of 91 tanks) are located about five miles away in 200 East Area. The tanks were built underground (constructed in a below-grade excavation and then backfilled; see Figure C-2) to take advantage of the natural radiation shielding provided by the earth. The 177 underground tanks represent two basic design types: single-shell tanks (SST) and double-shell tanks (DST), as described in the Sections C.3.1 and C.3.2.

Figure C-2. Waste Tanks Under Construction (circa 1945).

C.3.1 Single-Shell Tanks

There are 149 SSTs at Hanford, built from 1943 to 1964. The SSTs are underground, reinforced-concrete structures (i.e., a concrete tank with a concrete dome) with an interior carbon steel liner covering the concrete base and walls (see Figure C-3).

The SSTs have varying capacities. Of the 149 SSTs, 133 are large-capacity tanks with a 75-ft internal diameter (called "100-series" tanks) and 16 are smaller-capacity tanks (called "200-series" tanks) with a 20-ft internal diameter (see Figure C-4).

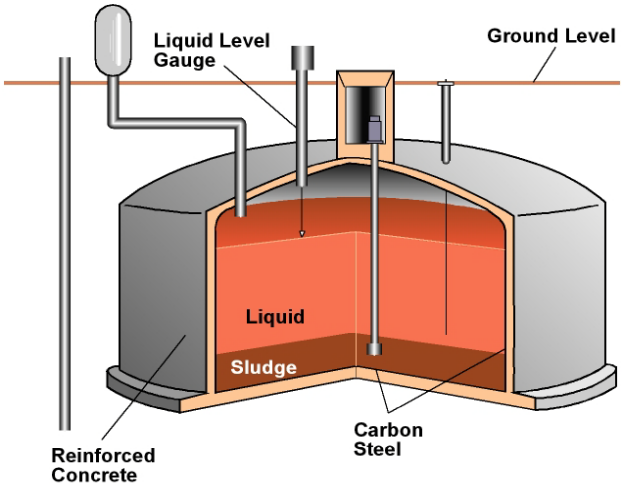

Figure C-3. Typical Single-Shell Tank.

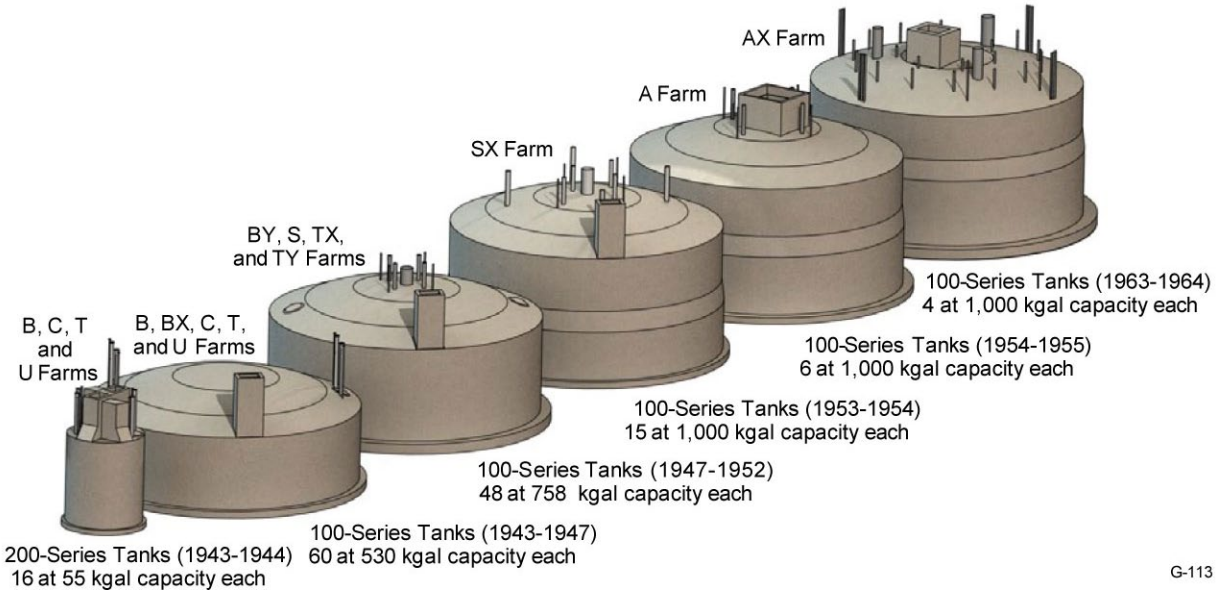

Figure C-4. Single-Shell Tank Size Comparison.

Since 1959, 67 SSTs are assumed to have leaked approximately 1 million gallons (Mgal) of liquid waste into the ground under the tanks. Some releases were accidental and occurred because of containment failures within the tanks. Other releases were the result of cascading the waste among a series of tanks to retain settled solids while releasing the clarified, but still contaminated, liquid wastes. This practice was considered acceptable at the time but was discontinued in 1958. To reduce the chance of further leakage, DOE made two important changes:

- As of November 1980, all of the SSTs were removed from active service as waste receivers; that is, no new waste could be added to any SST.
- Between 1979 and 2004, the SSTs were interim stabilized, meaning that the liquid portion of the wastes was transferred out of the SSTs and into safer DSTs. None of Hanford's 28 DSTs have ever leaked. The Interim Stabilization Program reduced the

liquid content of the SSTs to the greatest extent technically and economically feasible to minimize the risk associated with loss of tank integrity.

- An SST Integrity Program was implemented in 2009 (discussed further in Section 3.1.1 of the System Plan).

Although the total holding capacity of the SSTs is about 94 Mgal, as of January 2010 (the effective date of the starting tank inventory used in this analysis), the SSTs inventory had been reduced to approximately 30 Mgal and 85 MCi of radioactivity, primarily in the form of dried sludge solids or saltcake containing only small amounts of retained gases and interstitial liquids. In addition, as of July 2010, seven SSTs (C-103, C-106, C-201, C-202, C-203, C-204, and S-112) have been fully retrieved, three SSTs (C-108, C-109, and C-110) have been retrieved to the limits of current technology, and two SSTs (C-104 and S-102) are being retrieved. Tank S-102 retrieval was stopped prematurely due to an above-grade waste spill; restart is assumed in 2020. Additional retrievals are planned in the near future.

A variety of techniques will be used to remove the remaining wastes from the SSTs (see Section 3.1.1). The arrangements of tanks in the SST farms are provided in Figure C-5.

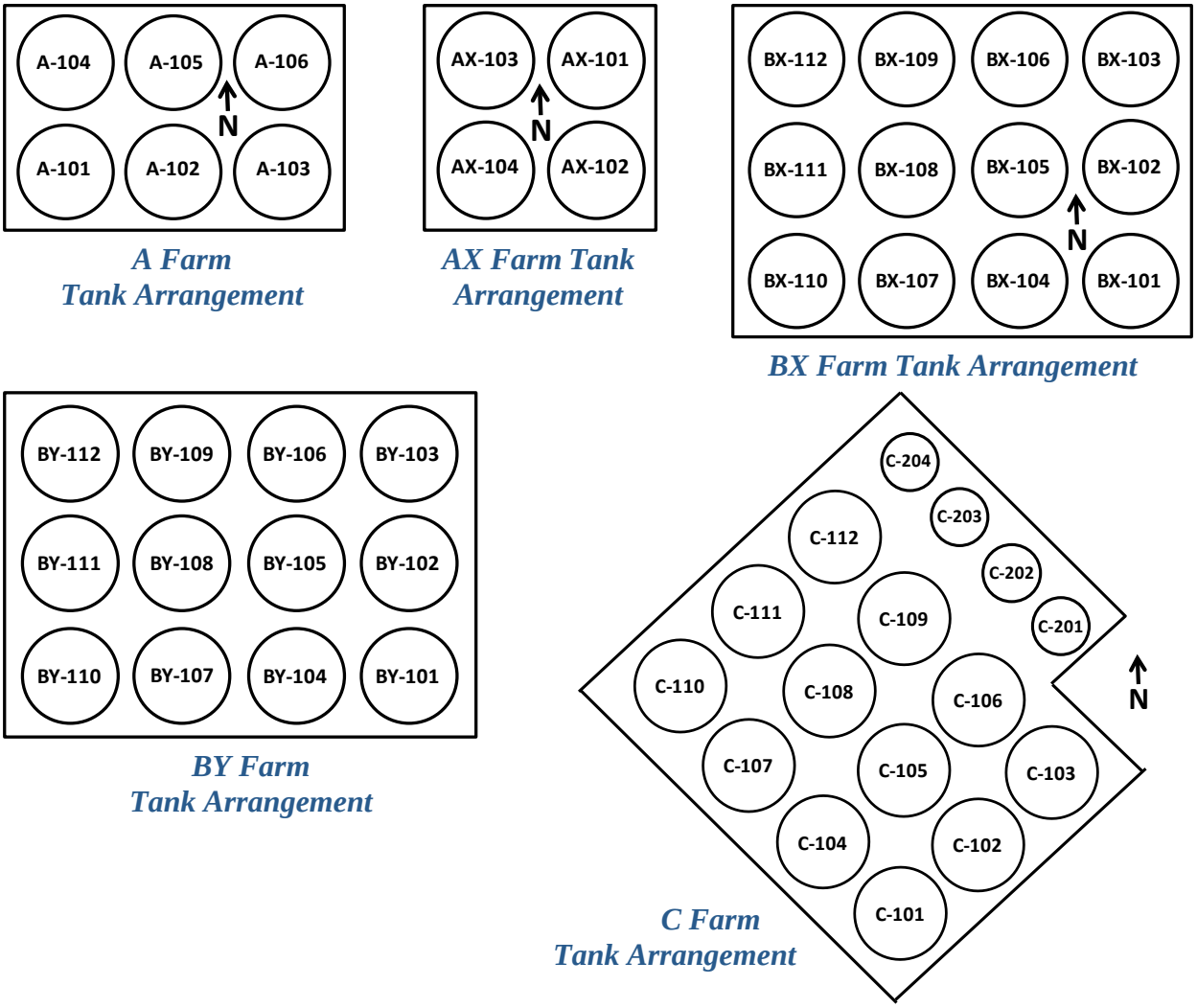

Figure C-5. Arrangement of Tanks in the Single-Shell Tank Farms. (page 1 of 2)

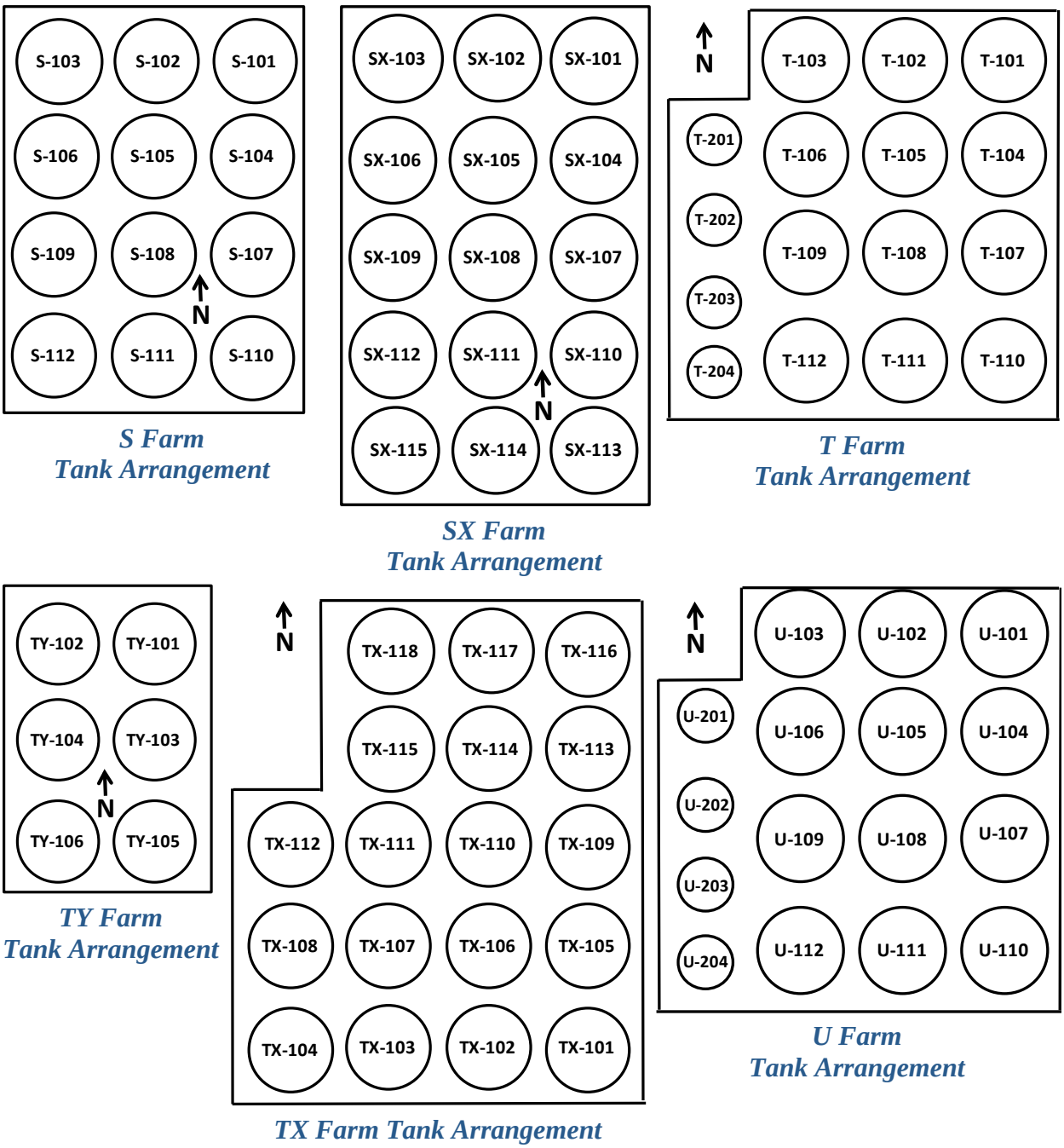

Figure C-5. Arrangement of Tanks in the Single-Shell Tank Farms. (page 2 of 2)

C.3.2 Double-Shell Tanks

Twenty-eight underground DSTs were built at Hanford between 1968 and 1986. The DSTs represent a significant improvement in waste storage safety because the reinforced concrete tank shell encloses not one, but *two* carbon steel liners, with leak detection systems (see Figure C-6). Three DSTs are located in 200 West Area, and the rest are in 200 East Area. The DSTs range in storage capacity from 1 Mgal to 1.25 Mgal. The arrangements of tanks in the DST farms are provided in Figure C-7.

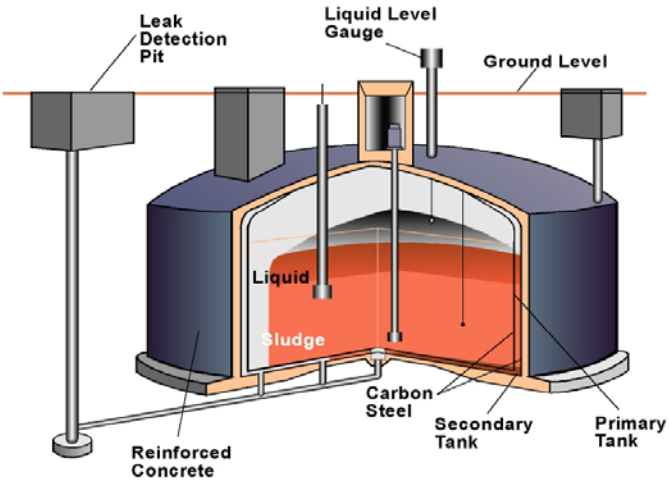

Figure C-6. Typical Double-Shell Tank.

The combined storage capacity of the DSTs is approximately 32 Mgal. As of January 2010 (the effective date of the starting tank inventory used in this analysis), the DSTs inventory was approximately 26 Mgal of mixed radioactive and hazardous waste and 95 MCi of radioactivity.

The current baseline assumes that all DSTs will remain in service without failure until the treatment mission has been completed and that no new DSTs will be built. While none of the DSTs have leaked, many are approaching their design lifetimes. The continued integrity of the DSTs is maintained by an ongoing DST Integrity Program, described in RPP-7574, *Double-Shell Integrity Program Plan*. This program consists of visual and ultrasonic inspections of the DSTs, corrosion monitoring probes installed in tanks of particular interest, well-defined waste chemistry limits, and structural analysis (RPP-RPT-24887, *The Long-Term Management of Tank Waste at Hanford*).

More information about current DST operations is provided in Section 3.1 of the System Plan.

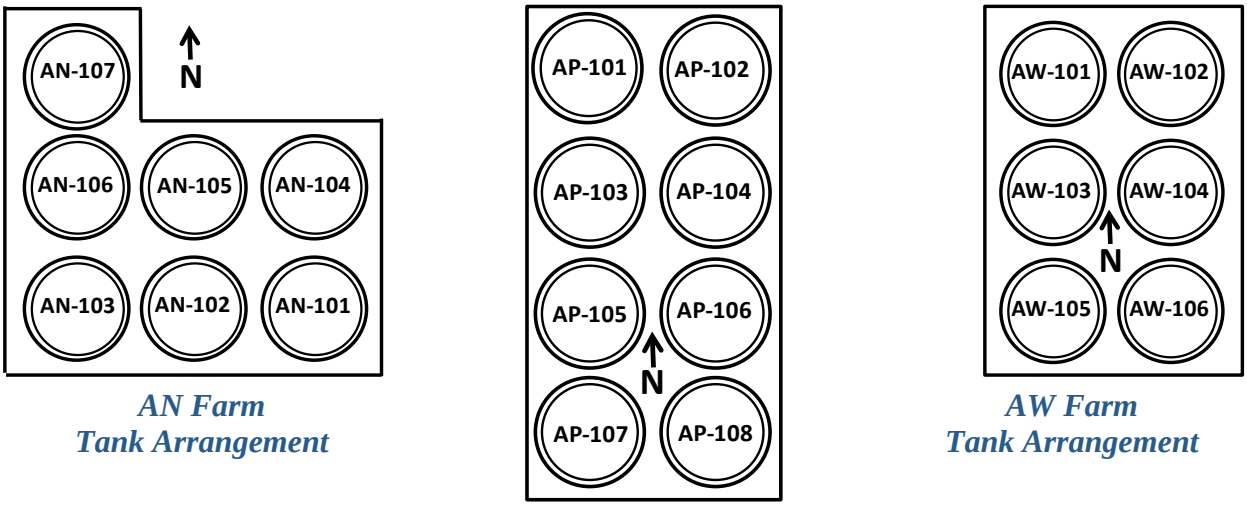

Figure C-7. Arrangement of Tanks in the Double-Shell Tank Farms. (page 1 of 2)

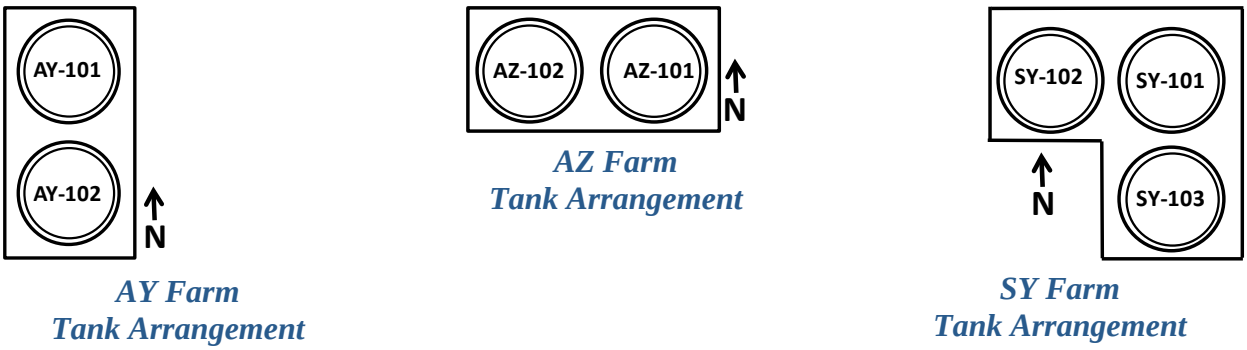

Figure C-7. Arrangement of Tanks in the Double-Shell Tank Farms. (page 2 of 2)

C.3.3 Inactive/Miscellaneous Underground Storage Tanks

Reserved for future use.

C.3.4 Waste Transfer Systems

Reserved for future use.

C.3.5 Tank Farm Simplified Maps and Historical Summaries

This section is reserved for future inclusion of simplified tank farm maps and tank farm histories as they relate to waste retrieval and waste treatment issues today.

C.4 FARM WASTE EVAPORATOR (242-A)

The 242-A Evaporator, located in the 200 East Area just north of the AW Farm, was constructed from 1974 through 1977, and began operating in 1977. The design life of the 242-A Evaporator as originally constructed was 10 years. Portions of the 242-A Evaporator were expanded and upgraded in 1983, and life-extension upgrades were made between 1989 and 1993 to extend its life through 2000. Since then, additional upgrades have either been made or are planned to extend the life of the 242-A Evaporator through 2019. Additional life extension upgrades are anticipated to allow the 242-A Evaporator to remain operational beyond 2019. The System Plan assumes that the 242-A Evaporator will be available as needed through completion of the RPP mission.

The purpose of the 242-A Evaporator is to reduce waste volume so that waste, primarily from retrieval of the SSTs, can be stored within the existing DST system. The process uses a conventional, forced circulation, vacuum evaporator operating at low pressure (approximately 60 torr) and low temperature [approximately 122°F (50°C)] to concentrate the waste and reduce its volume by removing some of the water.

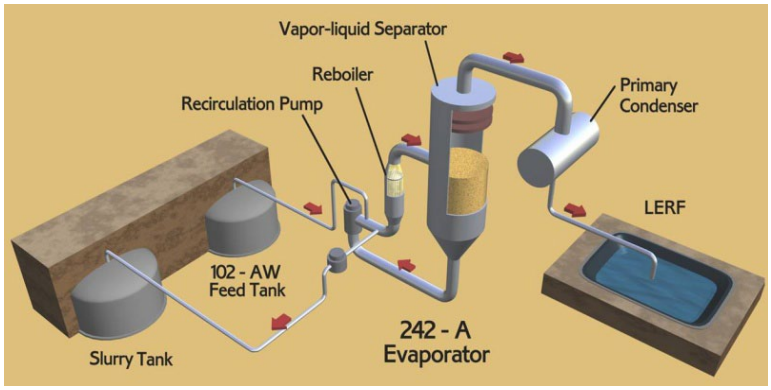

Figure C-8. 242-A Evaporator Flowsheet.

As shown in Figure C-8, the waste feed is pumped from feed Tank AW-102, through an underground encased transfer line to the 242-A Evaporator and subsequently into the recirculation loop. The waste feed passes through the tube of the reboiler and is heated with steam on the shell side. A portion of the water in the waste flashes in the main vessel, creating product slurry and water vapor. The slurry is transferred from the 242-A Evaporator through underground encased piping to other DSTs in the 200 East Area. Process off-gas and the water vapor are passed through one primary and two secondary condensers, creating process condensate and a gaseous effluent. Gaseous effluents are filtered and safely released to the environment from the vessel ventilation exhaust system. Process condensate is collected in the condensate collection tank and pumped directly to the Liquid Effluent Retention Facility (LERF) or is used in the process condensate recycle system. Cooling water from the process vapor condensers and the steam condensate stream is discharged to the 200 Area Treated Effluent Disposal Facility (TEDF) Pump Station 3 (HNF-14755, *Documented Safety Analysis for the 242-A Evaporator*).

C.5 WASTE TREATMENT AND IMMOBILIZATION PLANT

The Waste Treatment and Immobilization Plant (WTP) will pretreat the waste now stored in underground tanks at the Hanford Site and immobilize the waste by vitrification to borosilicate glass. The WTP consists of three individual waste treatment facilities [Pretreatment (PT), High-Level Waste (HLW) Vitrification, and Low-Activity Waste (LAW) Vitrification], a standalone analytical and radiochemical laboratory, and the balance of facilities (BOF). These facilities are described in the Sections C.5.1 through C.5.5. To process all the waste within the timeframe of the RPP mission, additional LAW vitrification capacity is required. The additional capacity is discussed in Section C.2.

C.5.1 Pretreatment

The WTP PT Facility separates waste feed from the tank farms into an HLW fraction and LAW fraction for subsequent treatment by either vitrification or a separate supplemental process. The WTP PT Facility consists of a series of process vessels in process cells and a hot cell. The PT Facility includes systems to support the following activities:

- Receive and store waste feed from the tank farm DST system
- Concentrate waste feed, recycle streams, and treated LAW product to facilitate WTP processing

- Precipitate strontium and transuranics (TRU) from selected waste for incorporation into HLW feed.[137] Mix appropriate amounts of HLW feed with LAW feed for use as feed to the ultrafilter process (UFP) system
- Use the UFP system to concentrate solids, caustic leach[138] and oxidative leach solids, and water wash solids
- Store pretreated HLW solids for HLW vitrification feed
- Transfer the remaining process stream to the LAW Vitrification Facility after removal of solids, strontium, TRU, and cesium
- Blend pretreated HLW feed with the separated cesium, strontium, and TRU material and then transfer it to the WTP HLW Vitrification Facility.

The WTP contract specifies that the PT Facility has a design capacity to treat 1,225 MT of as-delivered solids per year and produce pretreated supernate containing 3,740 MT of sodium per year. The respective treatment (net) capacity requirements are 860 MT/year and 2,620 MT/year, respectively.

The technical and programmatic assumptions for the PT Facility are included in Appendix B.

C.5.2 High-Level Waste Vitrification

The WTP HLW Vitrification Facility provides the final treatment for the HLW portion of the tank waste comprising the pretreated HLW feed (sludge) and the separated cesium, strontium, and TRU. The waste is blended with various glass-forming materials and is fed into two ceramic-lined, joule-heated melters where the mixture is processed into molten borosilicate glass. This glass contains and is called immobilized high-level waste (IHLW). The glass is poured into large canisters (24 in. [0.61 m] diameter x 177 in. [4.5 m] long), cooled, sealed, decontaminated, and staged for interim storage at the Hanford Shipping Facility (HSF) prior to final disposal at a planned offsite geologic repository.

The WTP HLW Vitrification Facility also provides temporary storage for up to 48 canisters of IHLW allocated equally between canister cooling and buffer capacity.

The WTP contract specifies that the HLW Vitrification Facility will support a combined design capacity of 6 MTG/day with the original two melters and 7.5 MTG/day with two replacement melters, with a minimum integrated total operating efficiency of 70%. At 100% total operating efficiency, the HLW Vitrification Facility with the replacement melters can produce up to 2.46 3/8-in. walled canisters per day (2.39 thin-walled canisters per day).

The technical and programmatic assumptions for the WTP HLW Vitrification Facility are included in Appendix B.

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[137] This capability is not used in this mission scenario since this is assumed to be performed in the tank farms for the waste currently in Tanks AN-102 and AN-107.

[138] The Baseline Case does not require caustic leach of solids in the WTP PT Facility after the Aluminum Removal Facility is operational.

C.5.3 Low-Activity Waste Vitrification

The WTP LAW Vitrification Facility provides the final treatment for the LAW portion of the tank waste comprising the pretreated LAW feed (supernate) and leachate from pretreatment of the HLW sludge after removal of the cesium, strontium, and TRU. The waste is blended with various glass-forming materials and is fed into two ceramic-lined, joule-heated melters where the mixture is processed into molten borosilicate glass. This glass contains and is called immobilized low-activity waste (ILAW). The glass is poured into large packages (48 in. [1.22 m] diameter by 90 in. [2.286 m] height), cooled, sealed, decontaminated, and staged for onsite disposal at the Integrated Disposal Facility (IDF).

The WTP contract specifies that the LAW Vitrification Facility will support a combined design capacity of 30 MTG/day using two melters, with a minimum integrated total operating efficiency of 70%. At 100% total operating efficiency, the LAW Vitrification Facility can produce up to 5.44 packages per day.

The technical and programmatic assumptions for the WTP LAW Vitrification Facility are included in Appendix B.

C.5.4 Waste Treatment and Immobilization Plant Analytical Laboratory

A standalone analytical and radiochemical laboratory will support efficient WTP operations and meet permitting, process control, authorization basis, and waste form qualification requirements. The laboratory will also support the investigation of operational anomalies or process upsets, process improvements, analytical methods optimization, and qualification of new instruments.

C.5.5 Balance of Facilities

The WTP includes 20 support facilities collectively referred to as the BOF, which consist of seven functional groups (D-05-DESIGN-019, *Review of Balance of Facilities [BOF] Equipment, System and Facility Preservation Lay-Up and Turnover*):

- Power group – two switch gear buildings and a diesel generator facility
- Steam group – a steam plant and a fuel oil facility
- Water group – cooling towers, water treatment facility, chiller/compressor facility, and firewater pump houses
- Air group – chiller/compressor facility
- Process support group – glass former storage facility, wet chemical storage facility, and anhydrous ammonia storage and supply facility
- Waste facility group – spent melter staging pad and the non-dangerous, nonradioactive effluent facility
- Miscellaneous support facility group – administration building, simulator facility, warehouse, and site infrastructure (e.g., roads, grading, lights, sanitary waste, storm drains, etc.).

The purpose of the BOF is to provide chemicals, services, utilities, and civil infrastructure for the process (PTF, HLW, LAW) and laboratory facilities. A complete list of the individual systems is

available in 24590-BOF-3YD-50-00002, *Facility Description for the Balance of Facilities (BOF), Preliminary Issue*. Chapter 2 of 24590-WTP-PSAR-ESH-01-002-05, *Preliminary Documented Safety Analysis to Support Construction Authorization; Balance of Facility Specific Information*, provides a description of the BOF facilities and their projected uses, configuration, and basic processes performed therein.

C.6 ALUMINUM REMOVAL FACILITY

Reserved for future use.

C.7 SECOND LOW-ACTIVITY WASTE FACILITY

Reserved for future use.

C.8 HANFORD SHIPPING FACILITY

Reserved for future use.

C.9 LIQUID EFFLUENT RETENTION FACILITY / EFFLUENT TREATMENT FACILITY

The LERF is designed to store 242-A Evaporator process condensate and other dilute liquid waste streams for treatment at the 200 East Area Effluent Treatment Facility (ETF). The LERF is located in 200 East Area, approximately 0.75 mile (1.2 km) north of the 242-A Evaporator. The LERF consists of three 7.8 Mgal basins, each equipped with primary and secondary liners, leachate detection, collection and removal systems, and a floating cover, capable of storing up to 23.4 Mgal of waste. The LERF also includes transfer piping and pumps connecting it to the 242-A Evaporator and the ETF.

The ETF is located in the northeast corner of 200 East Area, near the LERF, approximately 1 mile (1.6 km) north of the 242-A Evaporator. The ETF began operation in 1995 and has an operating design life of 30 years.

C.10 INTEGRATED DISPOSAL FACILITY

Reserved for future use.

C.11 STATE APPROVE LAND DISPOSAL SITE

Reserved for future use.

C.12 ENVIRONMENTAL RESTORATION DISPOSAL FACILITY

The Environmental Restoration Disposal Facility (ERDF) is designed to serve as a waste isolation structure for radiologically and chemically contaminated bulk soil, demolition debris, and miscellaneous contaminated material from Hanford Site environmental remediation activities conducted under *Comprehensive Environmental Response, Compensation, and*

Liability Act of 1980 (CERCLA) (42 USC 103, et seq.) authority. The ERDF is authorized to operate through a CERCLA Record of Decision (ROD) issued by the U. S. Environmental Protection Agency (EPA).

ERDF is located in the 600 Area, between the 200 East and 200 West Areas of the Hanford Site. Design requirements for ERDF were derived under the regulatory authority of CERCLA, as administered under the Hanford Federal Facility Agreement and Consent Order. The ERDF is designed to *Resource Conservation and Recovery Act of 1976* (42 USC 6901, et seq.) minimum technology requirements and *Toxic Substances Control Act of 1976* (15 USC 2601 et seq.) specifications for chemical landfills.

ERDF operations began in July 1996. The ERDF is designed as a multi-cell burial trench that can be expanded over time to add more cells. Initially only two cells (Cells 1 and 2) were constructed. Four additional cells (Cells 3 – 6) have been constructed since operations began, and there are plans to build four more cells during the future operation of the facility. Additional cells beyond these ten may also be added in the future as needed. The trench layout is shown in Figure C-9. ERDF is projected to receive up to 7.8 million yd^3 (5.96 million m^3) of waste when all ten cells have been built.

Figure C-9. The Environmental Restoration Disposal Facility Trench Layout.

C.13 CENTRAL WASTE COMPLEX

Reserved for future use.

C.14 WASTE ISOLATION PILOT PLANT

Reserved for future use.

C.15 PLANNED OFFSITE GEOLOGIC REPOSITORY

Reserved for future use.

C.16 REFERENCES

15 USC 2601, et seq., *Toxic Substances Control Act of 1976.*

42 USC 103, et seq., *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).*

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

24590-BOF-3YD-50-00002, 2010, *Facility Description for the Balance of Facilities (BOF), Preliminary Issue*, Rev. A, Bechtel National, Inc., Richland, Washington.

24590-WTP-PSAR-ESH-01-002-05, 2010, *Preliminary Documented Safety Analysis to Support Construction Authorization; Balance of Facility Specific Information*, Rev. 4g, Bechtel National, Inc., Richland, Washington.

D-05-DESIGN-019, 2006, *Review of Balance of Facilities (BOF) Equipment, System and Facility Preservation Lay-Up and Turnover*, Design Oversight Report, Office of River Protection, Richland, Washington.

HNF-14755, 2010, *Documented Safety Analysis for the 242-A Evaporator*, Rev. 2-D, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-7574, 2010, *Double-Shell Tank Integrity Program Plan*, Rev. 3, Washington River Protection Solutions, LLC, Richland, Washington.

RPP-RPT-24887, 2007, *The Long-Term Management of Tank Waste at Hanford*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

APPENDIX D – SINGLE-SHELL TANK RETRIEVAL SEQUENCE

SINGLE-SHELL TANK RETRIEVAL SEQUENCE

Table D-1 provides the overall sequence and schedule for retrieving waste from all of the single-shell tanks (SST) during the River Protection Project mission for the Baseline Case. The table includes a mix of historical and projected data—historical for those tanks for which retrievals have already been completed and for the start of tanks currently being retrieved; projected for all future retrievals and for the end of tanks currently being retrieved. The reference date for the transition from historical to projected retrievals in this table is March 2010 (see Section 1.7 of the System Plan). Adjustments may be made to the projected dates based on funding guidance or in response to emerging plans and field conditions as part of aligning the performance measurement baseline with the Baseline Case results.

The "Current Waste Volume" is the volume in each SST as of the reference date. The "Total Retrieved Waste Volume" is an estimate of the volume generated during the retrieval of the waste and represents the transient demand on double-shell tank (DST) space. The "DST Volume Impact Post-Evap" volume is an estimate of the volume after settling of retrieved solids and concentration of the supernatant layer to a liquid specific gravity of 1.43 in the 242-A Evaporator, and represents an estimate of the final demand on DST space for each retrieval; this estimate does not consider evaporator source term and operational constraints. Both the "Total Retrieved Waste Volume" and the "DST Volume Impact Post-Evap" reflect the portion of the retrievals projected to occur after the reference date. "Minimum Retrieval Duration" is set to zero for tanks which have already completed retrievals.

Table D-1. Single-Shell Tank Retrieval Sequence. (5 pages)

Tank	Retrieval Start Date[a,b]	Minimum Retrieval Duration (days)	Modeled or Actual Retrieval Duration[a] (days)	Modeled or Actual Retrieval End Date[a,b]	Current Waste Volume[a] (kgal)	Total Retrieved Waste Volume[a] (kgal)	DST Volume Impact Post-Evap[a] (kgal)
C-106	11/18/1998	0	1869	12/31/2003	3	0	0
S-112	9/26/2003	0	1253	3/2/2007	2	0	0
C-203	6/30/2004	0	267	3/24/2005	0.14	0	0
S-102	12/16/2004	21	5848	12/19/2020	187	131	144
C-202	6/30/2005	0	42	8/11/2005	0.15	0	0
C-201	10/25/2005	0	149	3/23/2006	0.14	0	0
C-103	11/6/2005	0	290	8/23/2006	3	0	0
C-204	7/23/2006	0	141	12/11/2006	0.14	0	0
C-108	12/20/2006	134	1515	2/12/2011	7	92	25
C-109	6/19/2007	134	1772	4/25/2012	8	101	28
C-110	9/22/2008	134	1177	12/13/2011	17	209	67
C-104	1/11/2010	216	216	8/14/2010	259	490	381
C-111	8/30/2010	158	158	2/3/2011	57	181	115
C-107	5/2/2011	87	87	7/28/2011	247	414	303
C-112	10/1/2011	96	96	1/5/2012	104	262	166
C-101	6/1/2012	101	101	9/10/2012	88	182	144

Table D-1. Single-Shell Tank Retrieval Sequence. (5 pages)

Tank	Retrieval Start Date[a,b]	Minimum Retrieval Duration (days)	Modeled or Actual Retrieval Duration[a] (days)	Modeled or Actual Retrieval End Date[a,b]	Current Waste Volume[a] (kgal)	Total Retrieved Waste Volume[a] (kgal)	DST Volume Impact Post-Evap[a] (kgal)
C-102	11/1/2012	157	157	4/6/2013	316	755	495
C-105	3/1/2013	134	134	7/13/2013	132	224	148
AX-103	4/20/2014	117	290	2/4/2015	106	1177	265
AX-104	4/21/2014	68	68	6/28/2014	7	294	14
A-102	7/3/2014	25	25	7/27/2014	40	309	92
AX-102	8/3/2014	102	102	11/14/2014	30	855	69
AX-101	2/9/2015	167	452	5/5/2016	357	2491	1036
A-104	5/10/2016	53	53	7/2/2016	28	184	60
A-106	7/7/2016	33	159	12/13/2016	79	328	169
A-101	12/31/2016	53	189	7/9/2017	320	1035	757
A-105	7/11/2017	71	71	9/20/2017	37	228	99
A-103	9/21/2017	66	727	9/18/2019	379	1429	783
B-201	4/2/2018	72	106	7/16/2018	29	225	35
B-202	7/26/2018	99	102	11/5/2018	29	218	35
B-203	11/15/2018	139	178	5/12/2019	50	379	58
B-204	5/22/2019	138	174	11/12/2019	49	371	58
BY-102	9/29/2019	56	1059	8/22/2022	278	1165	766
BY-110	9/29/2019	57	1033	7/27/2022	366	1060	855
T-201	5/10/2020	18	93	8/11/2020	30	197	35
T-202	8/21/2020	16	67	10/26/2020	20	143	24
T-203	11/5/2020	18	116	3/1/2021	36	247	43
SX-105	12/27/2020	57	70	3/6/2021	376	1033	900
T-204	3/11/2021	18	116	7/5/2021	36	247	43
SX-115	3/11/2021	25	60	5/10/2021	4	86	8
SX-103	5/15/2021	67	1098	5/17/2024	509	1326	1131
T-111	7/15/2021	192	263	4/4/2022	447	561	473
T-110	4/14/2022	67	227	11/27/2022	370	484	397
BY-111	8/1/2022	80	384	8/19/2023	402	1822	1102
BY-101	9/1/2022	94	546	2/28/2024	370	2067	1141
T-104	12/7/2022	62	201	6/26/2023	317	429	346
BY-103	8/27/2023	141	1173	11/11/2026	413	2276	1150
SX-101	10/11/2023	106	572	5/5/2025	418	2355	1384
BY-104	3/4/2024	62	432	5/9/2025	405	1174	1021
SX-106	5/22/2024	59	339	4/25/2025	397	1272	894
SX-109	5/10/2025	102	230	12/26/2025	241	1037	580
BY-107	5/11/2025	85	511	10/4/2026	272	1134	728
SX-102	9/24/2025	51	51	11/14/2025	341	908	771

Table D-1. Single-Shell Tank Retrieval Sequence. (5 pages)

Tank	Retrieval Start Date[a,b]	Minimum Retrieval Duration (days)	Modeled or Actual Retrieval Duration[a] (days)	Modeled or Actual Retrieval End Date[a,b]	Current Waste Volume[a] (kgal)	Total Retrieved Waste Volume[a] (kgal)	DST Volume Impact Post-Evap[a] (kgal)
S-106	11/19/2025	68	295	9/9/2026	455	1517	1130
SX-104	1/4/2026	60	72	3/17/2026	446	1056	919
S-110	3/22/2026	57	228	11/4/2026	389	1018	851
BY-112	10/11/2026	48	265	7/2/2027	286	943	801
S-103	11/9/2026	41	248	7/15/2027	237	699	543
S-108	12/18/2026	72	192	6/28/2027	550	1576	1315
S-111	7/4/2027	55	119	10/30/2027	401	1003	834
BY-109	7/7/2027	71	495	11/12/2028	287	1486	706
S-101	8/1/2027	50	81	10/21/2027	352	629	572
S-105	11/4/2027	59	193	5/15/2028	406	1354	1074
SX-114	11/20/2027	98	150	4/18/2028	155	380	265
SX-111	5/20/2028	81	81	8/9/2028	115	298	216
S-109	6/16/2028	71	86	9/10/2028	533	1580	1361
S-107	8/14/2028	54	221	3/23/2029	358	605	541
SX-108	9/21/2028	65	250	5/29/2029	74	197	191
BY-106	11/23/2028	121	579	6/24/2030	429	1706	1087
BX-107	11/23/2028	64	81	2/12/2029	347	484	418
BX-110	4/1/2029	88	438	6/13/2030	215	941	537
S-104	4/15/2029	102	157	9/19/2029	288	803	496
SX-112	6/3/2029	67	76	8/17/2029	75	219	138
SX-110	9/24/2029	60	77	12/9/2029	56	221	111
SX-107	12/16/2029	75	74	2/28/2030	94	216	157
SX-113	3/5/2030	35	111	6/24/2030	19	132	25
BX-109	6/17/2030	53	62	8/18/2030	193	323	290
T-112	6/30/2030	43	47	8/15/2030	67	171	81
BY-105	6/30/2030	151	262	3/18/2031	481	2226	1465
T-105	6/30/2030	46	50	8/19/2030	98	204	137
T-107	8/25/2030	90	99	12/2/2030	173	287	235
T-109	8/25/2030	302	332	7/23/2031	62	803	167
BX-105	8/26/2030	46	55	10/20/2030	72	285	168
BX-112	10/29/2030	50	65	1/2/2031	164	266	195
T-102	12/8/2030	39	44	1/20/2031	32	135	41
BX-111	1/7/2031	67	92	4/9/2031	188	701	437
T-101	1/26/2031	50	60	3/26/2031	99	358	185
BY-108	3/23/2031	77	125	7/26/2031	222	855	590
TY-102	3/31/2031	28	43	5/13/2031	69	421	186
BX-106	4/25/2031	48	52	6/17/2031	38	282	81

Table D-1. Single-Shell Tank Retrieval Sequence. (5 pages)

Tank	Retrieval Start Date[a,b]	Minimum Retrieval Duration (days)	Modeled or Actual Retrieval Duration[a] (days)	Modeled or Actual Retrieval End Date[a,b]	Current Waste Volume[a] (kgal)	Total Retrieved Waste Volume[a] (kgal)	DST Volume Impact Post-Evap[a] (kgal)
TY-106	5/18/2031	32	46	7/3/2031	16	129	27
BX-104	6/22/2031	46	50	8/11/2031	100	202	144
TY-105	7/8/2031	111	126	11/10/2031	231	373	315
TY-101	7/27/2031	69	89	10/24/2031	118	540	204
BX-103	8/3/2031	43	47	9/19/2031	75	177	118
BX-101	8/17/2031	284	447	11/7/2032	48	623	88
B-109	9/21/2031	55	75	12/4/2031	125	552	314
T-106	10/29/2031	198	313	9/6/2032	22	431	45
TY-103	11/16/2031	83	102	2/26/2032	155	606	265
B-108	12/7/2031	53	73	2/18/2032	92	543	234
B-104	2/22/2032	69	94	5/25/2032	374	694	581
TY-104	3/2/2032	43	74	5/15/2032	44	225	73
B-110	5/30/2032	116	131	10/7/2032	245	376	317
T-108	9/12/2032	186	194	3/25/2033	16	395	43
T-103	9/12/2032	230	244	5/14/2033	27	444	41
B-111	10/10/2032	115	124	2/11/2033	241	344	284
B-106	11/14/2032	48	62	1/15/2033	123	243	182
B-102	1/23/2033	94	119	5/22/2033	32	806	72
B-107	2/16/2033	83	108	6/4/2033	161	709	335
TX-116	5/22/2033	150	249	1/25/2034	598	2377	1680
TX-118	5/22/2033	72	129	9/27/2033	247	1623	610
B-101	6/2/2033	49	59	7/30/2033	109	396	225
B-112	6/12/2033	203	222	1/19/2034	35	446	72
B-105	8/7/2033	87	147	1/1/2034	290	1583	682
TX-106	10/7/2033	62	107	1/22/2034	348	1313	867
BX-108	1/8/2034	220	234	8/30/2034	31	508	76
B-103	1/22/2034	232	257	10/6/2034	56	733	126
TX-112	1/30/2034	83	161	7/9/2034	634	2142	1596
TX-109	1/30/2034	50	65	4/4/2034	363	478	458
TX-113	4/9/2034	177	279	1/12/2035	638	2724	1865
TX-102	7/19/2034	41	72	9/29/2034	217	796	529
BX-102	9/7/2034	55	64	11/10/2034	79	176	97
TX-111	10/9/2034	53	88	1/6/2035	365	1095	859
TX-115	1/14/2035	135	219	8/20/2035	553	2369	1450
TX-101	1/14/2035	26	31	2/14/2035	91	190	265
TX-105	2/22/2035	125	210	9/19/2035	576	2180	1474
TX-114	8/26/2035	139	233	4/14/2036	532	2498	1361

Table D-1. Single-Shell Tank Retrieval Sequence. (5 pages)

Tank	Retrieval Start Date[a,b]	Minimum Retrieval Duration (days)	Modeled or Actual Retrieval Duration[a] (days)	Modeled or Actual Retrieval End Date[a,b]	Current Waste Volume[a] (kgal)	Total Retrieved Waste Volume[a] (kgal)	DST Volume Impact Post-Evap[a] (kgal)
TX-103	9/24/2035	34	54	11/16/2035	145	588	361
TX-108	11/21/2035	30	47	1/6/2036	126	445	310
TX-104	1/16/2036	25	29	2/14/2036	69	194	192
U-105	2/24/2036	69	83	5/17/2036	353	1031	779
TX-117	4/20/2036	179	290	2/3/2037	480	3087	1339
U-102	5/27/2036	66	71	8/5/2036	327	922	763
U-108	8/19/2036	76	99	11/27/2036	434	1265	1013
U-103	12/13/2036	79	94	3/17/2037	417	1271	897
U-109	2/18/2037	82	137	7/5/2037	401	1456	909
TX-110	3/22/2037	166	257	12/4/2037	467	2537	1250
U-111	7/27/2037	58	63	9/28/2037	222	708	519
U-106	10/9/2037	74	114	1/31/2038	170	851	369
U-107	12/8/2037	82	95	3/12/2038	294	1357	781
TX-107	2/7/2038	27	37	3/16/2038	30	285	90
U-101	3/18/2038	272	284	12/28/2038	23	583	109
U-110	3/23/2038	90	123	7/23/2038	176	276	220
U-203	7/28/2038	15	15	8/11/2038	3	24	6
U-201	8/16/2038	15	15	8/30/2038	4	27	7
U-202	9/5/2038	15	15	9/19/2038	4	26	6
U-204	9/26/2038	14	14	10/9/2038	3	20	4
U-112	10/17/2038	251	265	7/8/2039	45	609	141
U-104	1/2/2039	270	284	10/13/2039	54	676	55

[a] The reference date for the transition from completed historical to projected retrievals (and hence the basis for the actual retrieval duration, current waste volume, total retrieved waste volume, and DST volume impact post-evaporator) in this table is March 2010. The reference date for all other SSTs, including Tank C-104, is January 2010—the effective date of the tank inventory used for this System Plan.

[b] These projected dates are contingent upon the successful deployment of the MARS vacuum tool and incorporation of lessons learned during MARS-sluicing operations in Tank C-107. This tool is still under development and the actual retrieval durations and deployment logic may be different than currently assumed.

DST = double-shell tank.
MARS = mobile arm retrieval system.
SST = single-shell tank.

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Bryan, Catherine					

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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
-------ORP:					
Alexander, Don					
Babel, Corbin					
Brockman, David					
Brunson, Gary					
Burandt, MaryBeth					
Charboneau, Stacy					
Diediker, Janet					
Dowell, Jonathan					
Fletcher, Tom					
Furlong, Pete					
Gamache, Lori					
Gilbert, R. A.					
Harp, B. J.					
Harrington, Chris					
Hoertkorn, T. R.					
Huffman, Lori					
Knutson, D. E.					
Koll, R.					
Kruger, A. A.					
Lober, R.					
Mauss, B. M.					
Noyes, D. L.					
Olds, Eric					
Olinger, S. J.					
Pfaff, Stephen H					
Reddick, Julie A					
Russell, Woody					
Scott, Walter B					
Shuen, Jian-Shun					
Stubblebine, Scott D					

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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
-------ORP (continued):					
Taylor, Hugh					
Taylor, William J					
Trenchard, Glyn					
Wicks, Jim					
-------PNNL:					
Fluegal, A					
Holton, Langton					
Hrma, Pavel					
Josephson, Gary					
Kim, DS					
Lumetta, Greg					
McCloy, JS					
Vienna, John					
-------Savannah River National Laboratory:					
Jantzen, Carol - carol.jantzen@srnl.doe.gov					
Peeler, David - david.peeler@srnl.doe.gov					
-------Savannah River Nuclear Solutions:					
Chew, David - david.chew@srs.gov					
Hill, Pete - peter.hill@srs.gov					
-------URS:					
Gay, Bill - wwgay@bechtel.com					
-------Washington Hanford Closure:					
Brosee, M. Neil					

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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
-------WRPS:					
Allen, G. K.					
Allen-Floyd, Julie					
Appel, John N					
Baide, Dan					
Banning, Dave L					
Barton, Blaine					
Basche, Amy D					
Brlsher, Jeremy					
Boomer, Kayle D					
Burrows, Christopher					
Carothers, Kelly					
Cato, Diane M					
Certa, Paul J					
Chamberlain, Blake					
Colosi, Kristin A					
Conner, John M					
Crawford, Thomas W					
Dunning, Abe					
Eberlein, Susan					
Empey, Peter A					
Eppler, Larry L					
Foster, James					
Gallaher, Ben					
Garrett, Richard					
Gregory, Rob					
Greenwell, Doug					
Haigh, Paul					
Hewitt, Bill					
Hill, Raymond (Phil)					
Ho, Quynh-Dao T					
Hohl, Ted					

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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
-------WRPS (continued):					
Holloway, Jerry N					
Jasper, Russell T					
Jo, Jaiduk					
Johnson, Gloria					
Kelly, Jim					
Kennedy, Doug					
Kennedy, Ed					
Kilgannon, Trevor					
Killoy, Steve					
Kirch, Nicholas W					
Kirkbride, Randy A					
Knight, Mark A					
Larsen, Doug					
Leonard, Mike					
Luke, Jeff					
Lund, Dennis					
Lytle, Randy					
May, Tom					
Meacham, Joe					
Meinert, Fiona					
Mendoza, Ruben					
Nguyen, Duc					
Place, Dave					
Powell, Bill					
Rasmussen, Juergen					
Ramsey, Wm Gene					
Reynolds, Jake					
Reynolds, Tammy					
Rieck, Curtis					
Ritari, Jake					
Robbins, Rebecca					

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Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
-------WRPS (continued):					
Rodgers, Matt					
Rueter, Ken					
Russell, Rose					
Rutland, Paul					
Sams, Terry					
Sasaki, Leela					
Saunders, Scott					
Sax, Scott					
Schofield, John					
Seniow, Kendra					
Shinabery, Jason					
Shuford, Dave					
Skwarek, Ray					
Smith, Kim					
Spencer, Chuck					
Squires, Rebekah					
Tedeschi, Rick					
Thompson, Leo					
Thein, Mike					
Turner, Mike					
Washenfelder, Dennis					
West, Elizha					
Wheeler, Martin					
Wojtasek, Rick					
Wooley, Ted					
Yarbrough, Riley					