U.S. Department of Energy
Hanford Site

November 13, 2020

20-ORP-0016

Ms. Stephanie N. Schleif, Acting Program Manager
Nuclear Waste Program
Washington State Department of Ecology
3100 Port of Benton Boulevard
Richland, Washington 99354

Dear Ms. Schleif:

TRANSMITTAL OF THE RIVER PROTECTION PROJECT "SYSTEM PLAN, REVISION 9"

The U.S. Department of Energy, Office of River Protection (ORP) hereby transmits to the Washington State Department of Ecology, the River Protection Project "System Plan, Revision 9" (Attachment), in fulfillment of the Hanford Federal Facility Agreement and Consent Order – Tri Party Agreement Milestone M-62-40 and extended due date of November 13, 2020.

If you have any questions, please contact me, or your staff may contact Kaylin W. Burnett, Mission Analysis and Planning Coordinator, Office of the Chief of Staff, ORP, on (509) 372-0622.

Sincerely,

Digitally signed by Thomas W. Fletcher
Date: 2020.11.13 09:27:12 -08'00'

Ben J. Harp
Deputy Manager
Office of River Protection

ORP:KWB

Attachment

cc w/attach:
Administrative Record
Environmental Portal

Attachment
20-ORP-0016

River Protection Project "System Plan, Revision 9"

(297 Pages Including Cover Sheet)

ORP-11242
Rev. 9

River Protection Project System Plan

Safely, Effectively, and Efficiently Treat Tank Waste and Close Hanford Tanks

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

River Protection Project System Plan

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Date Published:
October 2020

OFFICE OF RIVER PROTECTION
United States Department of Energy

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FOREWORD

The U.S. Department of Energy (DOE) is submitting Revision 9 of the *River Protection Project System Plan* (System Plan Rev. 9) to the Washington State Department of Ecology in accordance with Tri-Party Agreement Milestone M-062-40. System Plan Rev. 9 is a computer modeling analysis that evaluates a set of five technical scenarios and provides rough cost and schedule estimates for completing the River Protection Project mission at the Hanford Site.

The scenarios evaluated in System Plan Rev. 9 were developed collaboratively between DOE and the Washington State Department of Ecology. The baseline, although it represents a theoretically achievable solution, is based on a substantial assumption set. Since the last revision of the system plan, these assumptions have been refined to attempt to report more accurate results, although there are a number of key assumptions that are yet to be validated and could have substantial impact on the mission results.

Additionally, this revision is being provided during a time when DOE and the Washington State Department of Ecology are in mediated negotiations related to a serious risk notification for Waste Treatment and Immobilization Plant High-Level Waste and Pretreatment Facilities Consent Decree milestones. DOE has also begun work on an analysis of alternatives for high-level waste processing. The decisions that will result from these activities may substantially shift the direction of the mission and would be reported in future system plans.

For near-term planning, DOE continues to focus efforts to complete direct-feed low-activity waste objectives to meet the Consent Decree milestones established for the Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility. This includes the construction of the tank-side cesium removal system, enhancements to the Integrated Disposal Facility, and completion of the Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility.

DOE continues to work with stakeholders and regulators to find opportunities for schedule and budget efficiencies.

DISCLAIMER

Some of the activities described herein may be subject to and/or undergoing the analysis required by the *National Environmental Policy Act*, 42 USC 4321, et seq. These activities are included in this document for planning purposes. Decisions would be made following any necessary *National Environmental Policy Act* analysis.

TRADEMARK DISCLAIMER

OFFICE OF RIVER PROTECTION
RIVER PROTECTION PROJECT SYSTEM PLAN

SIGNATURES

Digitally signed by Thomas W. Fletcher
Date: 2020.11.13 09:28:15 -08'00'

B.J. Harp
Deputy Manager
U.S. Department of Energy
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ACKNOWLEDGMENTS

Many additional individuals contributed to or guided the development of the current version of the 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 and 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
6	October 2011	Reflects a Baseline Case, which provides the technical basis for the Performance Measurement Baseline, and nine additional scenarios jointly selected by the ORP and Ecology to meet the requirements of HFFACO Milestone M-062-40.	M.N. Wells
7	October 2014	Uses the Baseline Case originally presented in System Plan, Rev. 6, plus five additional scenarios selected and defined by Ecology only, to meet the requirements of HFFACO Milestone M-062-40D.	M.N. Wells
8	October 2017	Reflects a Baseline Case, which provides the technical basis for the Performance Measurement Baseline, and 10 additional scenarios, all of which 11 were jointly selected by the ORP and Ecology to meet the requirements of HFFACO Milestone M-062-40.	S.D. Reaksecker, S.N. Tilanus
9	October 2020	Presents an updated Baseline Case and four additional scenarios selected to meet the requirements of HFFACO Milestone M-062-40.	S.D. Reaksecker, A.J. Schubick

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of River Protection (ORP), manages the River Protection Project (RPP) at the Hanford Site. The ORP and RPP mission is to treat tank waste safely, efficiently, and effectively and close Hanford tanks. The RPP system plan, a deliverable for the *Hanford Federal Facility Agreement and Consent Order*[1] (also known as the Tri-Party Agreement [TPA]), describes the completion of the treatment mission and disposition of all tank waste managed by the ORP. This System Plan Rev. 9 analyzes the following different scenarios and sensitivities for achieving this objective:

- A baseline scenario representing ORP's current plans for completing the RPP
- Four alternative scenarios evaluating other plans for the RPP, three of which include full-mission direct-feed low-activity (DFLAW) and direct-feed high-level waste (DF-HLW) treatment
- Nine sensitivity scenarios evaluating the effect of modifying specific assumptions for the baseline and alternative scenarios.

The baseline scenario completes all single-shell tank (SST) retrievals by 2061 and completes all tank waste treatment by 2066 at a life-cycle cost of $107 billion unescalated and without contingency. Scenario 2 demonstrates that full-mission DF-HLW and DFLAW treatment has the potential to accelerate the mission. However, none of the alternative scenarios could improve upon or meet the baseline scenario schedule due to an assumption of lower treatment throughput versus the baseline scenario.

Background

The DOE's Hanford Site in southeastern Washington State has 56 megagallons (million gallons; Mgal) of chemical and radioactive waste stored in underground tanks—the result of more than four decades of plutonium production. The ORP is responsible for the retrieval, treatment, and disposal of this waste in a safe, efficient manner, reducing the threat posed to the Columbia River by Hanford's hazardous, radioactive tank waste. The RPP mission involves the following two efforts, which must be performed in parallel because the double-shell tanks (DST) do not currently have the capacity to hold all the waste stored in the SSTs:

- Retrieve and transfer waste from the SSTs into DSTs where it can be stored until it is treated
- Treat the tank waste, producing a stable waste form for permanent disposal.

The TPA became effective when it was signed by DOE, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency in 1989. This agreement includes legally enforceable milestones for regulatory compliance and environmental remediation. One of the TPA milestones, M-062-40, requires the ORP to prepare a system plan every 3 years with its own specific set of requirements.

Between 2007 and 2009, as a result of a lawsuit filed by the state of Washington, DOE and Ecology negotiated new and revised TPA milestones. Additional milestones were established in

[1] Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*, State of Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington, as amended.

a Consent Decree (Consent Decree, *State of Washington v. Dept. of Energy*, No. 08-5085-FVS) issued by the Eastern District of Washington Federal District Court. Various technical and safety issues, funding constraints, and other challenges arose that adversely affected DOE's ability to meet the milestones in the 2010 Consent Decree. Therefore, after litigation between the parties and prior to System Plan Rev. 8, the Consent Decree was amended in an Amended Consent Decree issued March 11, 2016, and in a Second Amended Consent Decree issued April 12, 2016. On October 12, 2018, the Third Amended Consent Decree was issued, which extended the dates associated with near-term milestones for tank waste retrievals of SSTs in the 241-A and 241-AX Tank Farms.[2]

Changes in mission strategies are being explored by ORP to address the continuing RPP mission challenges. Examples include treating waste as soon as 2022 by directly feeding low-activity waste (LAW) to the Waste Treatment and Immobilization Plant (WTP) LAW Vitrification Facility (i.e., DFLAW treatment) and advancements in technologies and glass formulation models.

Accomplishments and Updates

Significant progress has been made in the field since System Plan Rev. 8 was published in October 2017. The following highlights describe key field accomplishments since System Plan Rev. 8 (more information can be found in Section 4.0 of the main document):

- Tank C-105 reached the limits of both second and third retrieval technologies. The ORP-certified retrieval completion was submitted to Ecology in June 2018. In August 2018, ORP sent a letter notifying Ecology that DOE had completed the requirements of Consent Decree Milestone B-1. The C Tank Farm was prepared for turnover to Production Operations for surveillance and monitoring pending closure.
- Retrieval operations in Tank AX-102 were completed in January 2020 (with first and second technologies).
- Critical Decision-2/3 was approved for the schedule, scope, and cost baseline for the Tank-Side Cesium Removal (TSCR) Project and the associated waste feed delivery infrastructure. Subsequently, the ORP issued a letter approving the construction start of the TSCR system.
- Factory acceptance testing for a TSCR system was completed, successfully verifying the TSCR system's performance.
- Tank AP-106 was repurposed to act as the receiver for supernatant pretreated by the TSCR system.
- The WTP Balance of Facilities was transitioned from construction to startup after permanent power was supplied and all modifications to support the DFLAW configuration were completed.
- The final assembly of the first and second melters in the WTP LAW Vitrification Facility was completed.

[2] To aid readability of the document, the official designation of "241-" in tank and tank farm names will be omitted. Unless otherwise specified, tanks and tank farms are classified with "241-."

- Construction was completed for the WTP Analytical Laboratory, and the first team of chemists began setup.

In early 2019, slurry lines in the 242-A Evaporator failed pressure tests preventing further hot campaigns that are performed to concentrate waste in the tank farms. A project to replace the slurry transfer lines is currently underway, which is expected to be completed by June 2022.

On March 24, 2020, the Hanford Site moved to an essential mission-critical operations posture in recognition of increasing COVID-19 concerns. Potential schedule consequences due to the partial stop-work order are not assessed in this RPP system plan.

Purpose

This revision of the system plan is written to satisfy the requirements of TPA Milestone M-062-40D.[3] The system plan promotes mutual understanding between Ecology and DOE of the issues, risks, and uncertainties surrounding the RPP mission, with DOE and Ecology each having the right to select a minimum of three scenarios for evaluation. The system plan also lays the foundation for future TPA renegotiations, and TPA milestone renegotiations are required to occur following every other revision of the system plan in accordance with TPA Milestone M-062-45.

This revision includes five main scenarios—a new baseline and four alternatives—as well as nine sensitivity scenarios evaluating the effects of modifying specific assumptions. The scenarios are described in Table ES-1, and the scenario map in Figure ES-1 shows how each scenario is related in terms of input assumptions. Figure ES-2 depicts the general flowsheet for the Baseline Case and Scenario 5. The alternative scenarios, including full-mission DFLAW and DF-HLW treatment, are identified as either "treatment-favored" or "retrieval-favored," with the "retrieval-favored" scenarios receiving added new DSTs prior to the start of high-level waste (HLW) treatment for the purpose of expediting SST retrievals. Figure ES-3 illustrates the general flowsheet for Scenarios 2, 3, and 4.

Table ES-1. System Plan Revision 9, Scenarios with Objectives. (2 pages)

Scenario #	Scenario Name	Scenario Objective
Scenario 1	Baseline Case	The purpose of this scenario is to establish a system plan Baseline Case that reflects the best estimate of how the mission is thought to proceed given current conditions, constraints, and assumptions. The Baseline Case also assesses the ability to be compliant with the Consent Decree[a] and the TPA. The Baseline Case includes the following four sensitivity cases: • Scenario 1A – U Tank Farm Retrieved After A/AX Tank Farms • Scenario 1B – Reduced WTP TOE • Scenario 1C – Limited Simultaneous SST Retrievals • Scenario 1D – No Supplemental CH-TRU Waste Processing.

[3] The addition of the letter "D" after "M-062-40" is for administrative convenience for tracking milestones that have many sub-elements, referred to as "embedded milestones." The "D" is not an official designation.

Table ES-1. System Plan Revision 9, Scenarios with Objectives. (2 pages)

Scenario #	Scenario Name	Scenario Objective
Scenario 2	Treatment-Favored DFLAW and DF-HLW with Early Characterization in DSTs	The purpose of this scenario is to evaluate the life-cycle effects of replacing the WTP Pretreatment Facility with a new HFPF for pretreatment of waste destined for the WTP HLW Vitrification Facility, to include leaching and washing. Additionally, the TWCS capability is removed and, instead, existing DSTs are used for sampling and characterization of waste slurry. To support the pretreatment of all waste destined for LAW treatment, the capacity of TFPT is increased and a new LAW Feed Evaporator is added. Scenario 2 builds on Scenario 1B and includes the following three sensitivity cases: • Scenario 2A – Add New DSTs • Scenario 2B – Slower WTP Ramp-Up • Scenario 2C – Increased WTP TOE.
Scenario 3	Treatment-Favored DFLAW and DF-HLW with Independent HLW Sampling and Pretreatment Facility	The purpose of this scenario is to evaluate the life-cycle effects of replacing the TWCS capability and solids pretreatment function in the WTP Pretreatment Facility with a new HFPF. Although this scenario resembles Scenario 2, Scenario 3 differs in that sampling and characterization of slurry are performed in the HFPF instead of in the DSTs. Supernatant is pretreated through the DFLAW process with a TSCR system and later by a TFPT system. The capacity of the TFPT system is increased as needed to support both the WTP LAW Vitrification Facility and LAW supplemental treatment operations. The LAW Feed Evaporator is also added to support pretreating supernatant. Scenario 3 builds on Scenario 1B and includes one sensitivity case, Scenario 3A – Add New DSTs.
Scenario 4	Retrieval-Favored DFLAW and DF-HLW with Early Characterization in DSTs and Add New DSTs	The purpose of this scenario is to evaluate the life-cycle effects using existing DSTs for sampling and characterization and other equipment for pretreatment of waste destined for HLW melters, to include leaching, sampling, and washing, while adding new DSTs to favor SST retrievals. In this scenario, new DSTs are utilized to maintain SST retrievals consistent with the Baseline Case despite a slowdown in treatment throughput. Scenario 4 builds on Scenario 2 and includes one sensitivity case, Scenario 4A – Increased WTP TOE.
Scenario 5	Periodic DST Failures	The purpose of this scenario is to evaluate the life-cycle effects of a sequence of DST failures, one every 5 years with failure of the first tank in 2025 (tank sequence: AY-101, AZ-101, AZ-102, AN-107, AW-105). Scenario 5 is based on Scenario 1B.

[a] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

CH-TRU = contact-handled transuranic.
DF-HLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HFPF = High-Level Waste Feed Preparation Facility.
HLW = high-level waste.
LAW = low-activity waste.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TOE = total operating efficiency.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

Figure ES-1. System Plan Revision 9, Scenario Relationships.

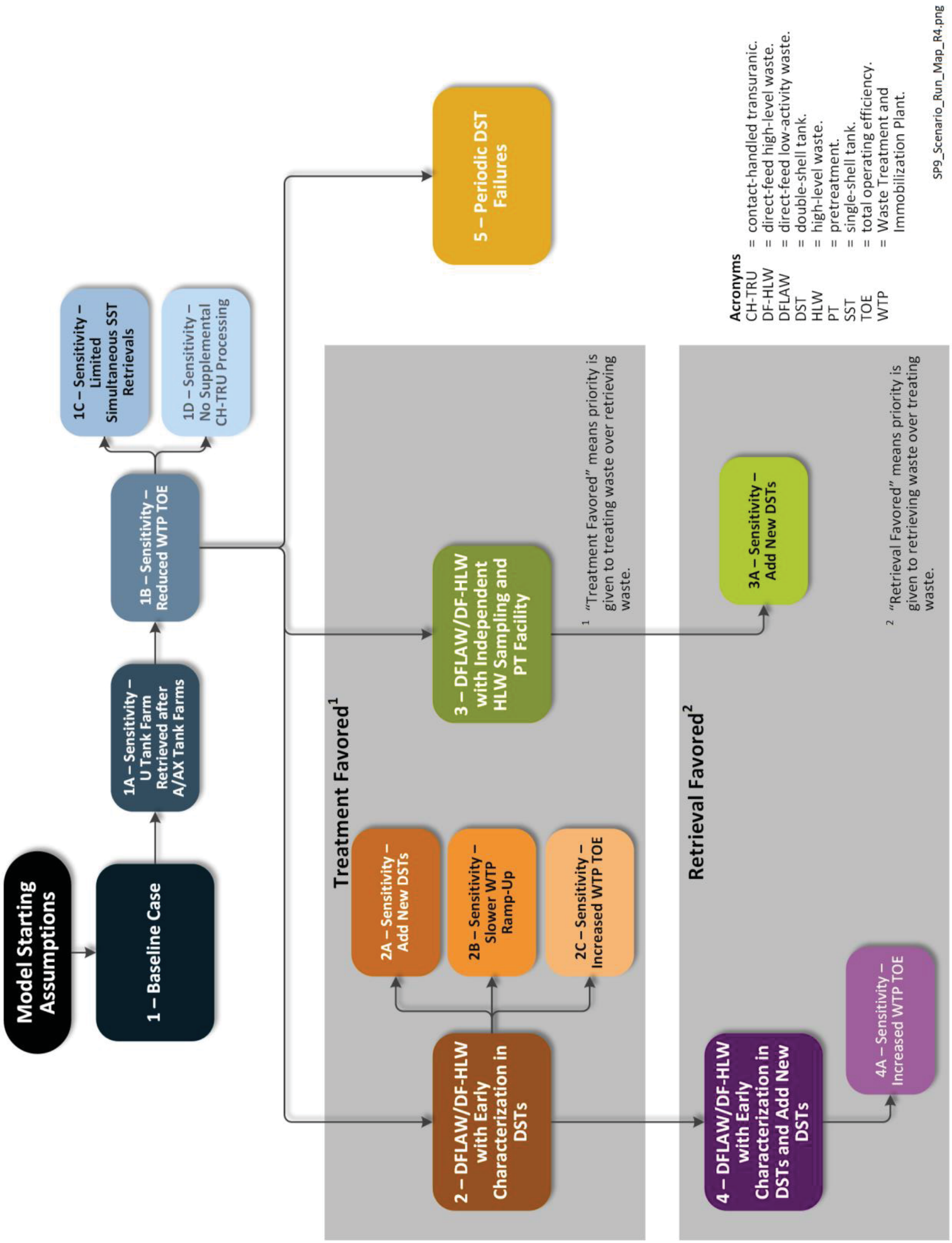


Figure ES-2. Simplified Flowsheet Representing Scenarios 1 and 5.

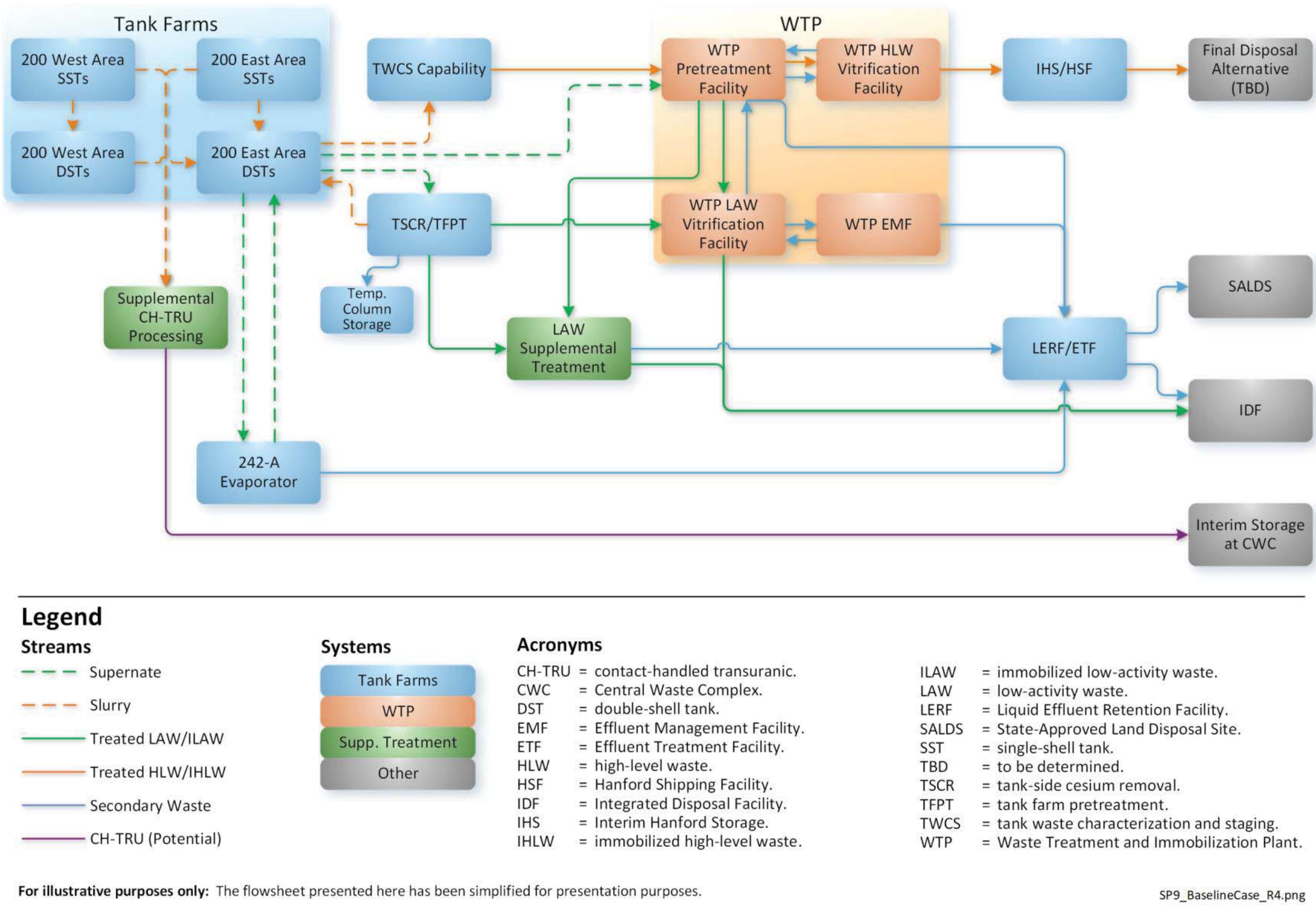
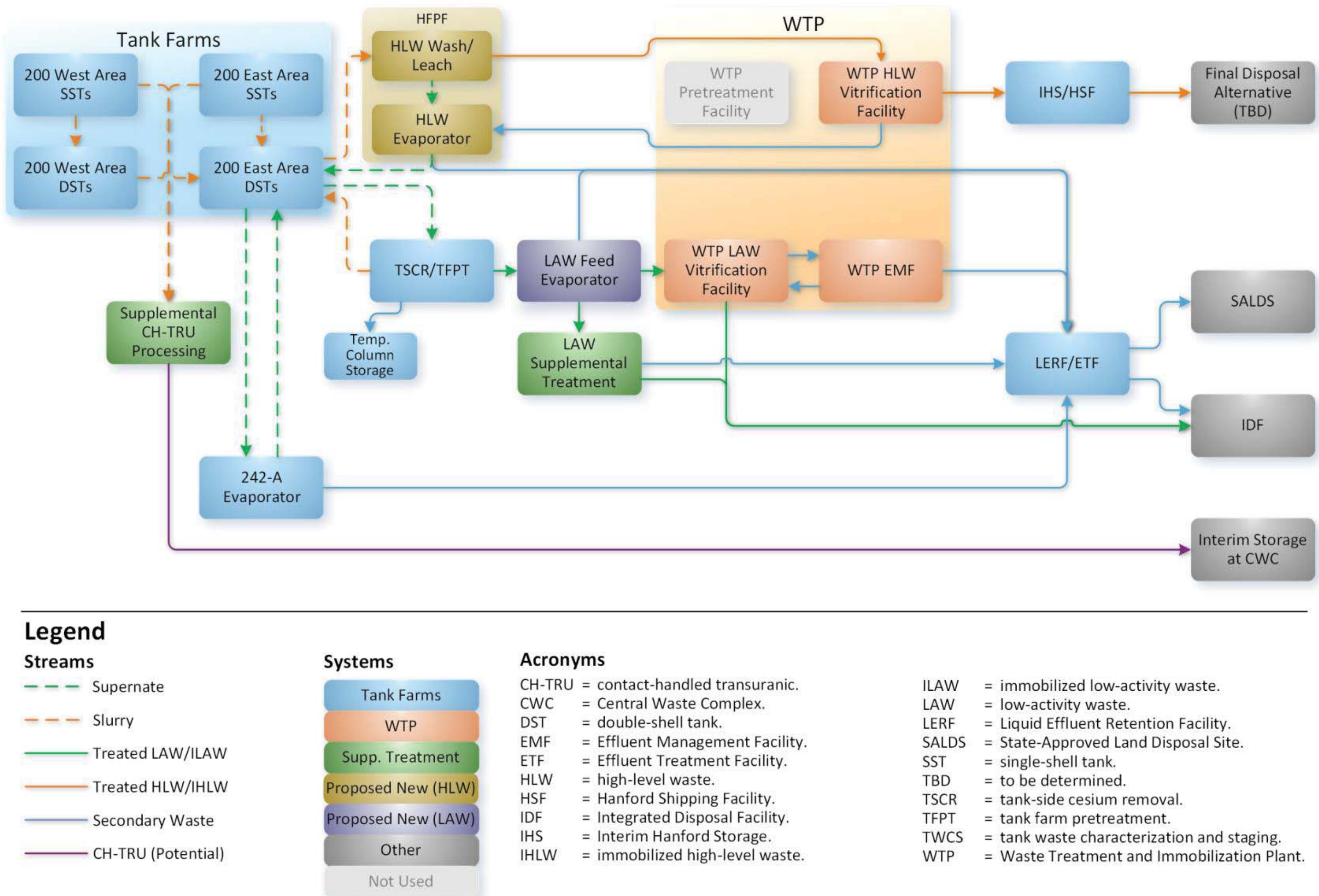


Figure ES-3. Simplified Flowsheet Representing Scenarios 2, 3, and 4.



For illustrative purposes only: The flowsheet presented here has been simplified for presentation purposes.

There have been several changes to the Baseline Case flowsheet and modeling approach from previous system plans. Table ES-2 presents a summary of the key changes to the planning bases for System Plan Rev. 9, versus the previous revision. The full Model Starting Assumptions for the Baseline Case are provided in Appendix A of the main system plan.

Table ES-2. Summary of Key Assumption Changes from System Plan Revision 8. (2 pages)

Starting Assumption #	System Plan Rev. 8 Assumption	System Plan Rev. 9 Assumption
A1.1.1.5	No minimum duration for DST heel retrievals.	Heel retrieval durations for DSTs are assumed to be 128 days per tank based on DST AY-102 retrieval.
A1.1.1.6	The 2013 LAW and HLW GFMs developed at the PNNL are used for all scenarios.	The 2016 LAW and HLW GFMs developed at the PNNL are used for all scenarios.
A1.1.1.8	Near-term operations, including retrievals in A and AX Tank Farms, are consistent with the Multi-Year Operating Plan (Rev. 5).	Updated near-term operations, including retrievals in A and AX Tank Farms, are consistent with the Multi-Year Operating Plan (Rev. 8).
A1.2.4.1	Unlimited 242-A Evaporator campaigns.	The 242-A Evaporator will be available for no more than six campaigns in any 365-day period.
A1.2.5	The Low-Activity Waste Pretreatment System is utilized for pretreatment of supernatant fed through DFLAW.	The TSCR (and later TFPT) process is utilized for pretreatment of DFLAW supernatant, coupled with interim storage of pretreated supernatant in DST AP-106.
A1.4.2.1	The treatment/packaging process for the potential CH-TRU waste starts on 01/01/2031.	The treatment/packaging process for the potential CH-TRU waste starts as budget and resource constraints allow. The start date will be determined by analyzing the cost profile to pinpoint the timeframe that results in the lowest increase in annual costs.
A1.2.3.21	Retrievals of SSTs are limited to two at a time per area (200 East and 200 West Areas) for the full mission.	Retrievals of SSTs are limited to one at a time per area (200 East and 200 West Areas), increasing to two simultaneous retrievals per area only when needed to maintain adequate feed to the WTP.
A1.2.3.22	There is a 2-week delay between completing an SST retrieval and beginning the next one.	There is a 2-month delay between completing an SST retrieval and beginning the next one.
A1.2.3.21	Unlimited simultaneous DST retrievals are allowed.	Retrievals of DSTs at the end of the mission are constrained by a limit of no more than four total simultaneous DST and SST retrievals and no more than two simultaneous DST retrievals per farm.
A1.5.1.8	Only secondary liquid effluent produced directly from operational facilities included in the RPP mission flowsheet are included in LERF volume projections.	The estimated effect of rainwater including leachate trucked to LERF from the IDF and MWTs, as well as direct contributions to the LERF volume from rainwater that falls on the LERF basins, are included in LERF volume projections.

Table ES-2. Summary of Key Assumption Changes from System Plan Revision 8. (2 pages)

Starting Assumption #	System Plan Rev. 8 Assumption	System Plan Rev. 9 Assumption
A1.6.2.9	Operations costs for the WTP are based on estimated hot commissioning costs for the WTP LAW Vitrification Facility.	Operations costs for the WTP are based on a new Independent Government Cost Estimate.

CH-TRU	=	contact-handled transuranic.	MWT	=	mixed-waste trench.
DFLAW	=	direct-feed low-activity waste.	PNNL	=	Pacific Northwest National Laboratory.
DST	=	double-shell tank.	RPP	=	River Protection Project.
GFM	=	glass formulation model.	SST	=	single-shell tank.
HLW	=	high-level waste.	TFPT	=	tank farm pretreatment.
IDF	=	Integrated Disposal Facility.	TSCR	=	tank-side cesium removal.
LAW	=	low-activity waste.	WTP	=	Waste Treatment and Immobilization Plant.
LERF	=	Liquid Effluent Retention Facility.			

A hierarchy of assumptions underpins the scope of each scenario. Table ES-3 summarizes the key assumptions that affect the modeling results for each scenario. Because several key assumptions implemented in Scenario 1B (sensitivity to Scenario 1 – Baseline Case) are carried over into the alternative scenarios, including the SST retrieval order and WTP total operating efficiency, Scenarios 2, 3, 4, and 5 are compared back to Scenario 1B instead of to Scenario 1. The Model Starting Assumptions modified for each alternative scenario are described in the respective scenario sections. Washington River Protection Solutions LLC modeled the cases using TOPSim modeling software and prepared this system plan on behalf of ORP.

Table ES-3. Key Scenario Inputs and Assumptions.

Input	System Plan Rev. 8 Baseline Scenario	System Plan Rev. 9 Scenarios					
		Scenario 1	Scenario 1B	Scenario 2	Scenario 3	Scenario 4	Scenario 5
DFLAW	2023 - 2033	2023 - 2033	2023 - 2033	Full Mission	Full Mission	Full Mission	2023 - 2033
DF-HLW[a]	No	No	No	Full Mission	Full Mission	Full Mission	No
WTP (and LAWST) TOE	70%	70%	50%	50%	50%	50%	50%
Next SST Farm Retrieved after A/AX Tank Farms	S/SX	S/SX	U	U	U	U	U
TSCR Startup	N/A	03/24/2023	03/24/2023	03/24/2023	03/24/2023	03/24/2023	03/24/2023
TFPT Startup	N/A	03/24/2028	03/24/2028	03/24/2028	03/24/2028	03/24/2028	03/24/2028
WTP LAW Vitrification Facility Startup	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023
TWCS Capability Startup	06/30/2032	06/30/2032	06/30/2032	N/A	N/A	N/A	6/30/2032
New HFPF Startup	N/A	N/A	N/A	06/30/2032	06/30/2032	06/30/2032	N/A
WTP Pretreatment Facility Startup	12/31/2033	12/31/2033	12/31/2033	N/A	N/A	N/A	12/31/2033
WTP HLW Vitrification Facility Startup	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033
TFPT Capacity Expansion	N/A	N/A	N/A	12/31/2034	12/31/2034	12/31/2034	N/A
New LAW Feed Evaporator Startup	N/A	N/A	N/A	12/31/2034	12/31/2034	12/31/2034	N/A
LAWST Startup	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034
Potential CH-TRU Waste Processing	01/01/2031	01/01/2040	01/01/2040	01/01/2040	01/01/2040	01/01/2040	01/01/2040
Other[b]				(1)		(2)	(3)

[a] DF-HLW is used herein to refer to delivering feed to the WTP HLW Vitrification Facility from a facility other than the WTP Pretreatment Facility.
[b] (1) – TWCS function performed in existing DSTs.
(2) – New DSTs added as needed to the 200 East and/or 200 West Area(s) starting 12/31/2030.
(3) – One additional leaking DST every 5 years from 2025 to 2045.

CH-TRU = contact-handled transuranic.
DF-HLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HFPF = High-Level Waste Feed Preparation Facility.
HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TOE = total operating efficiency.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

Results

Scenario 1 ("Baseline Case") shows the tank farms, together with the integrated WTP, a LAW supplemental treatment (LAWST) capability, and the potential contact-handled transuranic (CH-TRU) tank waste treatment process, could retrieve and treat the Hanford tank waste by 2066. However, this is contingent on receipt of adequate funding and successful resolution of key technical issues and uncertainties. The Baseline Case has an estimated, unescalated life-cycle cost of $107 billion without contingency ($192 billion escalated).[4] For each scenario in System Plan Rev. 9, performance against TPA and Consent Decree milestones was assessed, resultant quantities of immobilized waste products were calculated, and the life-cycle cost was estimated. Table ES-4 summarizes these findings for each scenario in the System Plan Rev. 9 versus the System Plan Rev. 8 baseline scenario.

The updated planning bases for System Plan Rev. 9 led to the following notable changes in Scenario 1 versus the System Plan Rev. 8 baseline scenario:

- The predicted completion of the "next nine" additional SST retrievals slipped 4 years to 2026 due to the tank-vapors-related Stop Work, the 242-A Evaporator slurry line replacement, and funding constraints.
- The additional constraints modeled for SST retrievals and 242-A Evaporator operations led to a 5-year delay in the completion of all SST retrievals to 2061.
- The slip in SST retrievals and additional constraints modeled for DST retrievals led to a 3-year delay in completing tank waste treatment to 2066.
- The introduction of the 2016 LAW and HLW glass formulation models reduced the mission-total glass container/canister quantities.
- The scheduled start date for potential CH-TRU waste treatment was shifted from 2031 to 2040, and therefore, the completion of potential CH-TRU waste treatment extended from 2036 to 2045. This was done to help level the mission cost profile. The number of CH-TRU waste drums increased due to an increase in the estimated waste inventory of the tanks containing potential CH-TRU waste.
- The inclusion of leachate trucked to the Liquid Effluent Retention Facility and rainwater in secondary liquid effluent volumes contributed to increasing the projected mission-total secondary liquid effluent volume by a net 50 Mgal. This amounts to a higher required annual secondary liquid effluent treatment capacity.
- Substantial cost savings could be achieved by grouting the supplemental LAW.
- Operating WTP with a single HLW melter would result in minimal schedule impacts.
- Treatment operations generate adequate space such that additional DSTs are not required to maintain retrieval commitments.
- Continued 242-A Evaporator operation is critical .

[4] Cost escalation is the change in the cost or price of goods or services over time, similar to the concept of inflation. Unescalated mission costs are presented in 2020 dollars, while escalated mission costs represent an estimate of the future costs and associated budgetary requirements.

Table ES-4. Comparison of Key Scenario Results.

	Metric	System Plan Rev. 8 Baseline Scenario	System Plan Rev. 9 Scenarios				
			Scenario 1	Scenario 1B	Scenario 2, 4[a]	Scenario 3	Scenario 5
Near-Term Regulatory	Complete Five Additional SST Retrievals (Third Amended Consent Decree Milestone B-3, 06/30/2021)	04/2019	07/2020	07/2020	07/2020	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Third Amended Consent Decree Milestone B-2, 09/30/2026)	05/2022	06/2026	06/2026	06/2026	06/2026	03/2027
	Complete Tank 241-A-103 Retrieval (TPA Milestone M-045-15, 09/30/2022)	11/2022	01/2027	04/2027	03/2027	03/2027	11/2027
Retrieval/ Storage	First Cross-Site Transfer	2025	2028	2028	2029	2028	2030
	Retrieve all SSTs (TPA Milestone M-045-70, 12/31/2040)	2056	2061	2065	2060	2066	2068
	Close all DSTs (TPA Milestone M-042-00A, 09/30/2052)	2067	2070	2079	2074	2077	2079
Treatment	Treat All Tank Waste (TPA Milestone M-062-00, 12/31/2047)	2063	2066	2076	2069	2076	2075
	Complete Potential CH-TRU Waste Packaging	2036	2045	2045	2045	2045	2045
	IHLW Glass Canisters	7,800	7,300	7,000	9,100	7,200	7,100
	Total ILAW Glass Containers	94,000	89,000	88,000	91,000	101,000	88,000
	WTP ILAW Glass Containers (% Total)	52,000 (55%)	52,000 (59%)	49,000 (56%)	29,000 (32%)	28,000 (28%)	49,000 (55%)
	LAWST ILAW Glass Containers (% Total)	42,000 (45%)	37,000 (41%)	39,000 (44%)	62,000 (68%)	72,000 (72%)	39,000 (45%)
	LAWST Glass Volume, yd^3	118,000	103,000	109,000	174,000	202,000	109,000
	LAWST Equivalent Grout Volume, yd^3	420,000	400,000	430,000	690,000	910,000	440,000
	Potential CH-TRU Tank Waste Drums	8,400	8,800	8,800	8,800	8,800	8,800
	Secondary Liquid Effluent Volume, gal	550M	600M	670M	770M	890M	670M
Cost	Unescalated Life-Cycle Cost (Escalated)[b]	$110B ($223B)	$107B ($192B)	$122B ($247B)	$112B ($208B)	$125B ($256B)	$122B ($247B)

[a] Scenario 2 met the Scenario 4 objective without requiring new DSTs, therefore Scenarios 2 and 4 represent the same scenario.
[b] Life-cycle cost includes $10B in sunk cost fiscal year 1997 through 2019 and LAWST (vitrification) but does not include WTP capital expenditure or contingency.

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TPA = Tri-Party Agreement.
WTP = Waste Treatment and Immobilization Plant.

As in the System Plan Rev. 8 baseline scenario, for most of the mission, the duration of the Baseline Case is driven by HLW pretreatment. Specifically, the WTP Pretreatment Facility does not pretreat HLW at a rate that is sufficient to allow the WTP HLW Vitrification Facility to operate at its capacity. As a result, HLW pretreatment is the rate-limiting step as the LAWST capability is sized as large as needed to keep pace with HLW processing. However, as opposed to System Plan Rev. 8, treatment is rate-limited at the end of the mission for the increased time required to retrieve the remaining waste from the DSTs. This is due to the new constraints limiting simultaneous and sequential SST and DST retrievals, extending DST retrieval durations, and capping the annual number of 242-A Evaporator campaigns (see Table ES-2 for more information.) These constraints extend the schedule for SST retrievals and require that DSTs can only be retrieved when resources become available following the completion of SST retrievals.

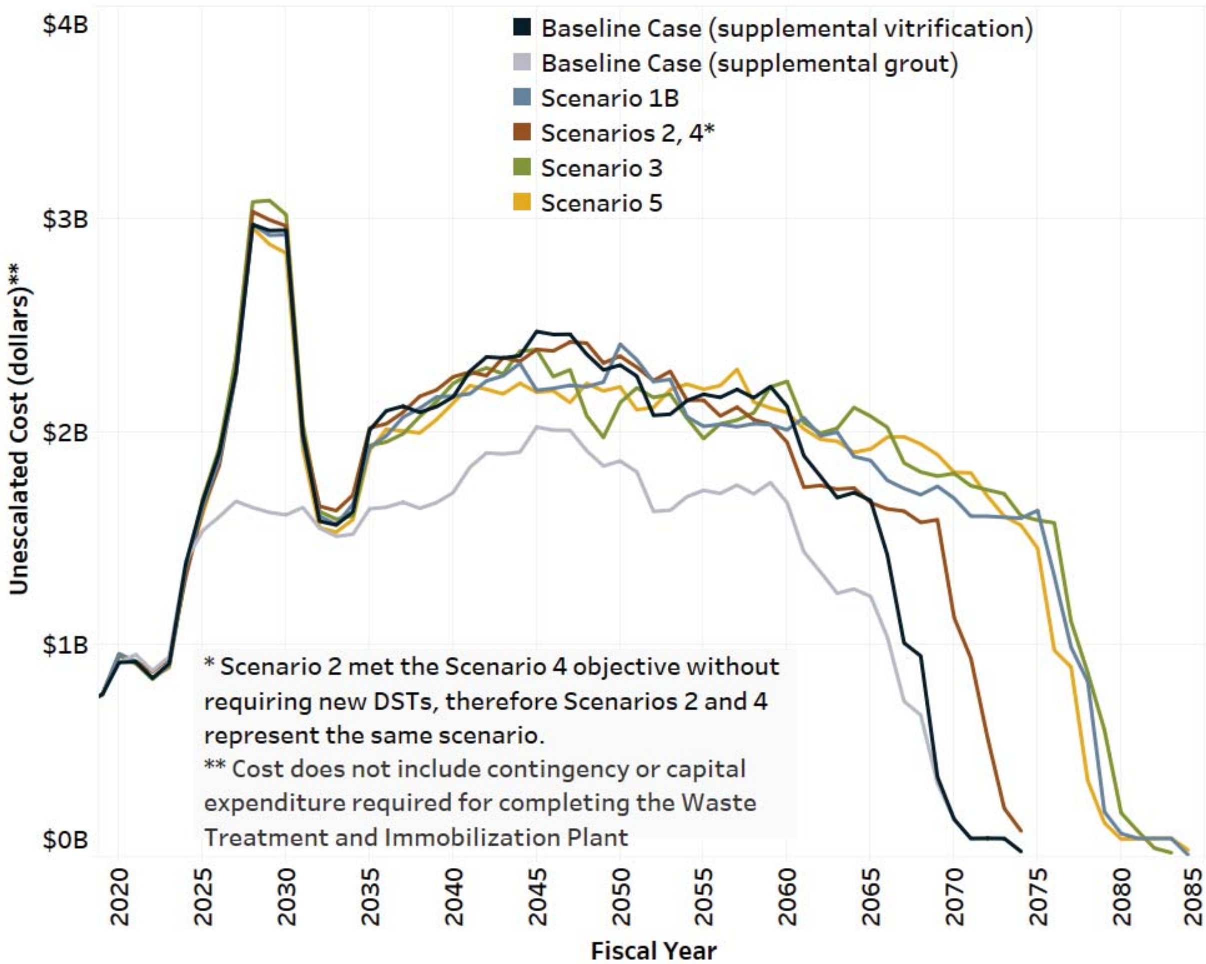
The alternative scenarios analyzed in System Plan Rev. 9 all assume a lower throughput for the WTP (and LAWST capability) equivalent to 50 percent total operating efficiency versus the 70 percent total operating efficiency throughput assumed for the Baseline Case. As a result, and because supplemental treatment capacity is not expanded for these scenarios versus the Baseline Case, none of the alternative scenarios are able to improve upon nor meet the Baseline Case treatment completion date. However, as demonstrated by Scenario 2, full-mission DF-HLW and DFLAW treatment has the potential to accelerate the mission compared to Scenario 1B.

The unescalated life-cycle cost profiles for the System Plan Rev. 9 scenarios are presented in Figure ES-4. For all scenarios evaluated in System Plan Rev. 9, there is a sharp increase in required funding above the current and historical funding levels starting in 2024. This occurs due to costs associated with the design and construction of the LAWST capability (costed as a vitrification facility) and other new facilities supporting waste treatment, as well as DFLAW operations. The annual cost increases steadily to $3 billion (unescalated) in fiscal year 2031 when major construction of these new capabilities is complete. The life-cycle cost does not include WTP construction costs. The costs for completing the WTP Pretreatment and HLW Vitrification Facilities, if included, would further exacerbate the issue of increased funding requirements through the early 2030s. Once the integrated WTP and the LAWST capability start in fiscal year 2034, the costs remain relatively constant at approximately $2 billion annually (unescalated) until the end of treatment. Because the annual operational costs tend to be stable across scenarios, the life-cycle cost correlates with the mission duration, and the lower-throughput, alternative scenarios consequentially have a higher life-cycle cost than the Baseline Case.

In System Plan Rev. 9, the LAWST capability is modeled as vitrification. However, grout is utilized at the Savanah River Site and is being considered as one of the technologies for immobilization of the Hanford LAW. If the LAWST capability is costed as a grout facility,[5] the life-cycle cost can be maintained at under $2 billion annually (unescalated) for the entire mission.

[5] Cost estimates for LAWST as grout are based on SRNL-RP-2018-00687, 2019, *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at Hanford Nuclear Reservation*, Rev. 0, Savannah River National Laboratory, Aiken, South Carolina.

Figure ES-4. Unescalated Life-Cycle Cost Profiles for System Plan Revision 9, Scenarios.



The key results for Scenario 1B and the alternative scenarios are summarized below.

SCENARIO 1B

In Scenario 1B, the reduction in treatment facility throughput made treatment capacity the sole driver for the mission duration. This increased the length of the mission for SST retrievals and treatment by 5 and 10 years, respectively, but the total quantity of immobilized waste products is similar to the Baseline Case.

SCENARIO 2

The Scenario 2 results show that this full-mission DFLAW and DF-HLW scenario accelerates the mission and reduces the life-cycle cost compared to Scenario 1B. This is achieved by replacing the solids pretreatment function of the WTP Pretreatment Facility with a higher throughput provided by the HLW Feed Preparation Facility (HFPF) thus removing the solids pretreatment bottleneck that exists in the baseline flowsheet. The HFPF is also a less complex and, therefore, likely less expensive facility compared to the WTP Pretreatment Facility. In Scenario 2, SST retrievals and tank waste treatment complete in 2060 and 2069 respectively, approximately 5 years earlier than Scenario 1B, while reducing life-cycle cost by $10 billion[6] (unescalated). The following are several other significant results realized from Scenario 2:

- Upon removal of the solids pretreatment limitation (which was due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step, as the capacity of LAWST is sized to match the Baseline Case.
- The reduction in the extent of solids pretreatment in the HFPF versus the WTP Pretreatment Facility (lower temperature caustic leaching, no oxidative leaching) leads to a 29 percent increase in immobilized HLW.
- The addition of two new evaporators (the HLW effluent management evaporator in the HFPF and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little effect on the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility resulting in a 15-percent increase in secondary liquid effluent produced.

SCENARIO 3

The Scenario 3 results show no significant acceleration of the overall RPP mission compared to Scenario 1B, despite eliminating the solids pretreatment bottleneck by replacing the solids pretreatment function of the WTP Pretreatment Facility with the HFPF, which has a higher throughput. The following are several other significant results realized from Scenario 3:

- Upon removal of the solids pre-treatment limitation (which was due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step, as the capacity of LAWST is sized to match the Baseline Case.
- A 50 percent increase in sodium hydroxide added to the HFPF to achieve similar leaching to Scenario 1B (but at a lower temperature) increases the immobilized LAW glass by 15 percent. This prevents Scenario 3 from improving the mission schedule against Scenario 1B because the mission is LAW-treatment driven in Scenario 3.
- As in Scenario 1B, constant constraints on DST space delayed SST retrievals, which also delayed feeding the WTP HLW Vitrification Facility.
- The addition of two new evaporators (the HLW effluent management evaporator and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little effect on the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility causing a 32-percent increase in secondary liquid effluent produced.

[6] Life-cycle cost does not include WTP construction costs, and thus the savings in life-cycle cost do not reflect the cost saved by not completing construction of the WTP Pretreatment Facility in Scenario 2.

SCENARIO 4

The objective of Scenario 4 was to add new DSTs to match the Baseline Case SST retrieval completion date of 2061 using the Scenario 2 flowsheet and planning bases. However, Scenario 2 satisfied the Scenario 4 success criteria without requiring new DSTs, completing SST retrievals in 2060. This demonstrates that increased (or expedited) treatment throughput is ultimately the best way to favor SST retrievals.

SCENARIO 5

The Scenario 5 results show that removing an additional five leaking DSTs from service results in a 3-year delay in the completion of all SST retrievals but does not affect other overall mission metrics. However, it did cause the “next nine” SST retrievals to slip 9 months, missing the milestone date in the Amended Consent Decree. Scenario 5 also demonstrates it is possible, from a tank space management perspective, to retrieve leaking DSTs at various points in the mission in less than 1 year, while still maintaining the required emergency pumping space.

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TERMS

Abbreviations, Acronyms, and Initialisms

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*
CH-TRU	contact-handled transuranic
CWC	Central Waste Complex
DF-HLW	direct-feed high-level waste
DFLAW	direct-feed low-activity waste
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EMF	Effluent Management Facility
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FY	fiscal year
GCALC	Gibbs Energy Minimization Calculator
GFM	glass formulation model
GMC	Glass Model Calculator
HEMF	High-Level Waste Effluent Management Facility
HFPF	High-Level Waste Feed Preparation Facility
HLW	high-level waste
HSF	Hanford Shipping Facility
ICD	interface control document
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHS	Interim Hanford Storage
ILAW	immobilized low-activity waste
IMUST	inactive miscellaneous underground storage tank
ISM	Integrated Solubility Model
IX	ion exchange
LAW	low-activity waste
LAWST	low-activity waste supplemental treatment
LCM	Lifecycle Cost Model
LERF	Liquid Effluent Retention Facility
LLW	low-level waste
MLLW	mixed low-level waste
NRC	U.S. Nuclear Regulatory Commission
ORP	U.S. Department of Energy, Office of River Protection
RCRA	*Resource Conservation and Recovery Act*
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision

RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SST	single-shell tank
TC & WM	Tank Closure and Waste Management (EIS) (DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*)
TEDF	Treated Effluent Disposal Facility
TFPT	tank farm pretreatment
TOC	Tank Operations Contract
TOE	total operating efficiency
TPA	Tri-Party Agreement
TRU	transuranic
TRUM	transuranic mixed
TWCS	tank waste characterization and staging
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant
WIR	waste incidental to reprocessing
WMA	waste management area
WOL	waste oxide loading
WRF	Waste Receiving Facility
WRPS	Washington River Protection Solutions LLC
WTP	Waste Treatment and Immobilization Plant
WVR	waste volume reduction

Units

°C	degrees Celsius
°F	degrees Fahrenheit
Ci	curie
ft	foot
ft^2	square foot
g	gram
gal	gallon
gpm	gallon per minute
kg	kilogram
kgal	kilogallon
L	liter
M	mega (million)
M	molar
MCi	megacurie
Mgal	megagallon
MT	metric ton
MTG	metric ton of glass
yd^3	cubic yard
wt%	weight percent

Definitions

As-retrieved. The volume of waste retrieved from a single-shell tank (SST), including the chemicals or motive fluids that are added in the process of removing and pumping the waste.

B Complex. The collective term for the 241-B, BX, and BY Tank Farms.

Buoyant displacement gas release event (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 can accumulate in a settled solids layer until the waste becomes hydro-dynamically 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 size of the tank headspace and capacity of the ventilation system. BDGREs are generally associated with tanks containing low-shear strength salt slurry.

Bottoms. The concentrated stream leaving an evaporator.

Closure. *Closure* is defined as the deactivation and stabilization of a radioactive waste facility intended for long-term confinement of waste (as per DOE M 435.1-1, *Radioactive Waste Management Manual*). *Final closure* of the operable units (tank farms) is 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, "Closure and Post-Closure."

Cross-site transfer. The Hanford waste tanks are located in two physically separated areas, the 200 East Area and 200 West Area, which are about 7 miles apart. The cross-site transfer system comprises the transfer pipelines and ancillary equipment used to transfer supernatant and slurry from the 200 West Area to the 200 East Area.

Disposal. Emplacement of waste in a way that ensures protection of workers, the public, and the environment with no intention of retrieval and that requires deliberate action to regain access to the waste (as per DOE M 435.1-1).

Emergency space. The 1.265 megagallons (Mgal) of empty waste storage space reserved in the double-shell tank (DST) system for use in the event of an emergency, such as a leak.

Entrained. Solid particulates suspended in a liquid due to mixing, pumping, or agitation.

Facility availability factor. Estimates of the total time to treat all tank wastes, with no reliability/availability/maintainability/inspectability failures applied, divided by the total time to treat all tank wastes, with all those failures applied.

Gas release event. Flammable gases, primarily hydrogen, are generated by tank waste. A gas release event occurs when flammable gases are released from the waste over an identifiable period of time at rates far exceeding that of gas generation (see also BDGRE).

Group A tanks. A tank, that because of its waste composition and quantities, has the potential for a spontaneous BDGRE and is conservatively estimated to contain enough flammable gas within the waste that if all the flammable gas were released into the tank headspace, the concentration would be a flammable mixture.

Hard heel. A large, solid mass or group of large solids not easily removed from the bottom of some large tanks.

High-level waste (HLW). The highly radioactive Hanford tank waste 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 concentration. But also, in the context of waste treatment, the fraction of the tank waste containing most of the radioactivity, which will be immobilized into glass and disposed of at an offsite repository. This waste includes the solids remaining after pretreatment, plus certain separated radionuclides.

Hot commissioning. The phase in which a facility first performs production runs using radioactive material.

Initial plant operations. A term associated with a milestone in the Amended Consent Decree (2016) and defined as "over a rolling period of at least 3 months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day, and low-activity waste glass at an average rate of at least 21 MTG/day."

Interim stabilized. A tank that contains less than 50 kgal of drainable interstitial liquid and less than 5 kgal of supernatant.

Integrated Waste Treatment and Immobilization Plant (WTP). The complete WTP (including the LAW Vitrification, HLW Vitrification, and Pretreatment Facilities, as well as the Analytical Laboratory and Balance of Facilities) operating together as currently envisioned starting in 2033 in the Baseline Case.

Ion exchange. A technology that uses a resin to remove radioactive cesium from liquid waste by exchanging sodium ions from the resin with cesium ions in the waste.

Limits of technology. The recovery rate of a retrieval technology for a tank that is, or has become, limited to such an extent that the retrieval duration is extended to the point at which continued operation of the retrieval technology is not practicable, including risk reduction, facilitating tank closures, costs, potential for exacerbating leaks, worker safety, and impact on the tank waste retrieval and treatment mission.

Low-activity waste (LAW). Waste that remains following the process of separating as much radioactivity as is practicable from HLW. When solidified, LAW may be disposed of as low-level waste (LLW).

Low-activity waste (LAW) feed. The liquid waste stream (supernatant plus a small amount of entrained solids) remaining after removal of key radionuclides, which is intended to be delivered to the WTP LAW Vitrification Facility or LAW supplemental treatment (LAWST) capability.

Low-activity waste supplemental treatment (LAWST). Proposed supplemental treatment process(es) that will complement the WTP LAW Vitrification Facility treatment capacity. The treatment technology is yet to be determined.

Low-level waste (LLW). Radioactive waste not classified as high-level radioactive waste, transuranic (TRU) waste, spent nuclear fuel, or byproduct material, as defined in Section 11e.(2) of the *Atomic Energy Act of 1954*.

Mixed Waste. This waste contains both radioactive and chemically hazardous components.

Mobile Arm Retrieval System (MARS). A robotic arm used to retrieve tank waste, which is designed to access all areas of a tank. (Additional details are provided in RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*.)

Retrieval. The process of removing, to the maximum extent practicable, all the waste from a given 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, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, a tank is officially in "retrieval status" if one of two conditions is met: (1) waste has been physically removed from the tank by retrieval operations, or (2) preparations for retrieval operations are directly responsible for rendering the leak or intrusion monitoring instrument "out-of-service."

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. Saltcake primarily comprises 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.

Scenario/case. A scenario/case is defined as a set of assumptions and/or success criteria intended to be used in the system planning process. Technical assumptions and/or success criteria are defined and used as input parameters for modeling or performing calculations. In the event that a case does not meet the success criteria or other stated objectives, the reasons will be identified and documented, as appropriate.

Sensitivity scenario/case. A sensitivity scenario/case is a secondary scenario/case (based on a primary scenario/case) in which limited model parameter(s) or sequences of events are altered to identify the effect of those changes on other system parameters. Examples include increasing or decreasing expected WTP melter capacities or changing a glass formulation model.

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 primarily comprises the hydroxides and oxyhydroxides of aluminum, iron, chromium, silicon, zirconium, and uranium, plus the majority of the insoluble radionuclides such as strontium-90 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 supernatant in a tank are mixed together. Slurries can be used to transfer solids by pumping the mixture through a pipeline.
- Slurry also refers to a waste produced at Hanford that results from concentrating supernatant 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 241-AN-103, 241-AN-104, 241-AN-105, and 241-AW-101).

Supernatant/supernate. Supernatant is technically the liquid floating above a settled solids layer. At Hanford, supernatant typically refers to any non-interstitial liquid in the tanks, even if no solids are present. Supernatant is similar to saltcake in composition and contains many of the soluble radionuclides such as cesium-137 and technetium-99.

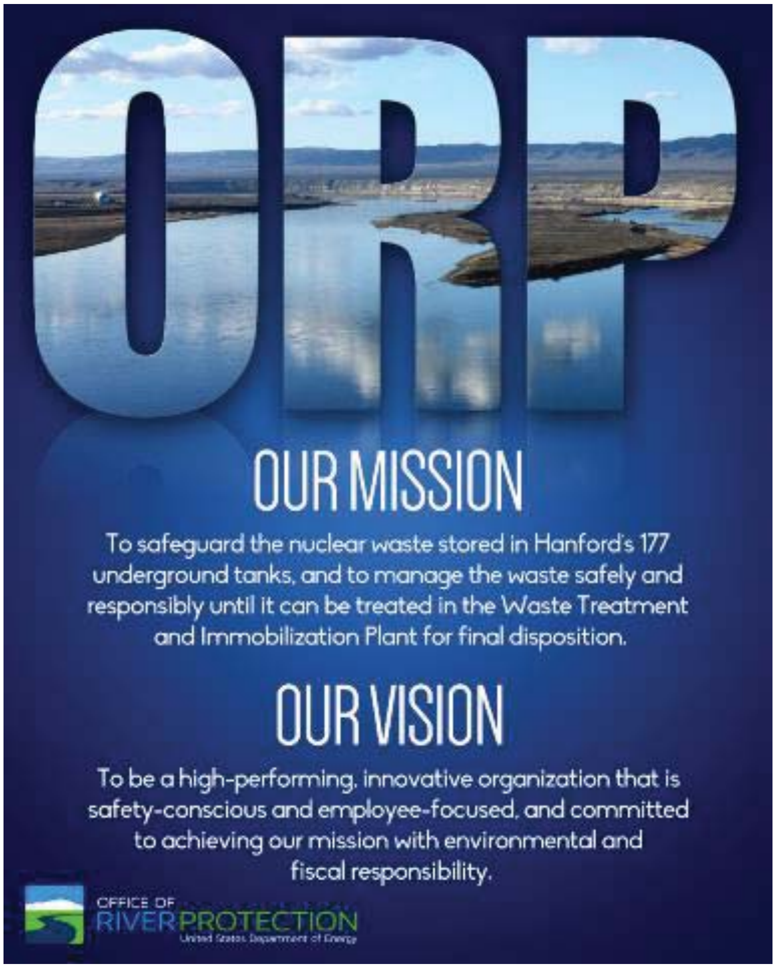
T Complex. The collective term for the 241-T, TX, and TY Tank Farms.

Tank waste treatment complex. This complex comprises the existing and future facilities, pipelines, and infrastructure needed for the storage, retrieval, and treatment of the Hanford tank waste.

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 operational research model, from operating data, or established as a goal. The TOE may be reported on a variety of bases, depending on the specific process, facility, or system.

Waste oxide loading (WOL). A measure of the quantity of pretreated waste that can be incorporated into a unit mass of glass.

Waste Receiving Facility (WRF). A future facility used to support the retrieval of waste involving slurry transfers from SSTs that are located too far away to be readily retrieved directly into a DST. The WRF, located near the SSTs, will accumulate and condition retrieved waste before transfer to a DST. (Note the WRF was once referred to as a “waste retrieval facility.”)



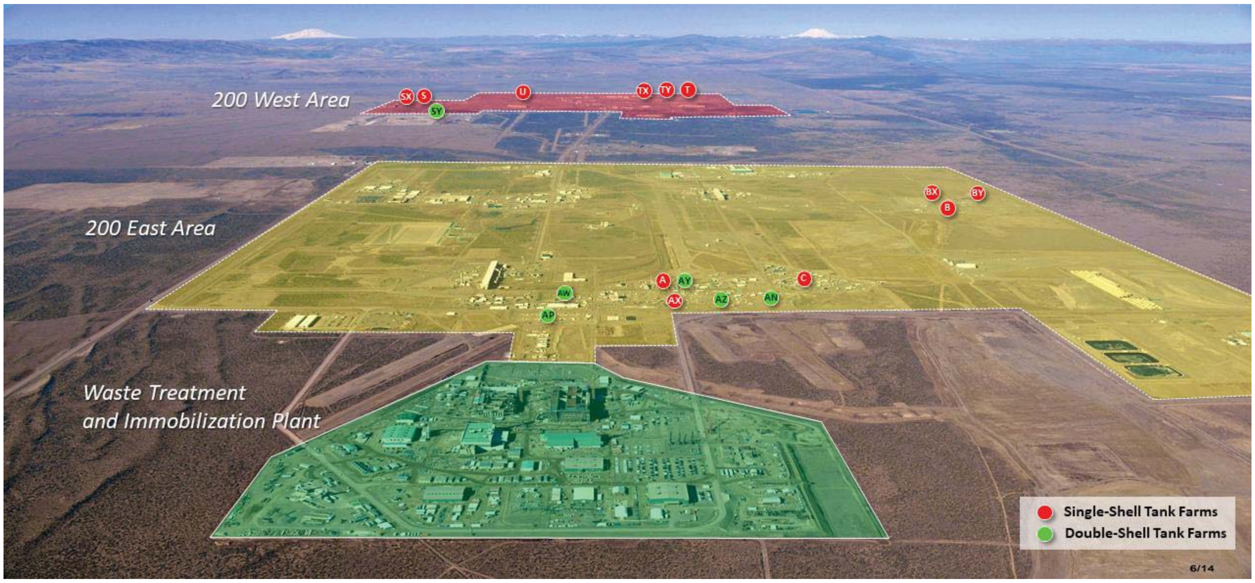
1.0 INTRODUCTION

The U.S. Department of Energy's (DOE) Hanford Site (see Figure 1-1) in southeastern Washington State has 56 megagallons (million gallons; Mgal) of chemical and radioactive waste stored in underground tanks – the result of more than four decades of plutonium production. The DOE Office of River Protection (ORP) is responsible for the retrieval, treatment, and disposal of this waste in a safe, efficient manner. The River Protection Project (RPP) mission involves the following two parallel efforts, both aimed at reducing the threat posed to the Columbia River by the Hanford hazardous, radioactive tank waste:

- Retrieve waste from the single-shell tanks (SST) into double-shell tanks (DST) where it can be stored until it is treated; and,
- Treat the tank waste, producing a stable waste form that can be permanently disposed of.

These efforts must be performed in parallel because the DST system does not currently have the capacity to hold all of the waste stored in the SSTs. Milestones for key components of the RPP mission have been established in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989) (also known as the Tri-Party Agreement [TPA]) between the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency, and DOE and in a Consent Decree,[7] as amended, issued by the U.S. District Court in the Eastern District of Washington. Amongst the milestones established in the Consent Decree, as amended, and the TPA are milestones for the "hot start" of the Waste Treatment and Immobilization Plant (WTP) and end dates for completing all remaining SST retrievals and waste treatment commitments. Changes in mission strategies to treat waste as soon as 2022 such as directly feeding low-activity waste (LAW) to the WTP LAW Vitrification Facility (i.e., direct-feed low-activity waste [DFLAW]), including advancements in technologies and glass formulation models (GFM), are examples of the efforts being engaged by ORP to mitigate the continuing RPP mission challenges.

Figure 1-1. General Layout of the Office of River Protection Tank Waste Treatment Complex.



The system plan provides the opportunity to explore alternative RPP mission strategies through computer simulation modeling and analysis. As discussed in more detail later in the document, the purpose of most of the scenarios is to assess the effects of various scenario-specific planning assumptions on the RPP mission. The DFLAW Program, the first phase of the planned, phased startup of the WTP, is included in the Baseline Case and is planned to operate for a period of 10 years beginning in December 2023 and completing in September 2033, at which time the WTP's Pretreatment and High-Level Waste (HLW) Vitrification Facilities are anticipated to be ready for operations. These new operating methods and systems, along with some potential alternative strategies, are analyzed further in this system plan.

ORP has set priorities to focus the tank waste cleanup work. The overarching priority for ORP and its contractors is always safety and the protection of workers, the public, and the environment, and this priority applies to all RPP work activities. With safety integrated throughout, and in order to achieve the milestones established by the court in the March 2016

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[7] Consent Decree, *State of Washington v. Dept. of Energy*, No. 08-5085-FVS (October 25, 2010), as amended by the Amended Consent Decree, No. 2:08-CV-5085 RMP (March 11, 2016), the Second Amended Consent Decree, No. 2:08-CV-5085-RMP (April 12, 2016), and the Third Amended Consent Decree, No. 2:08-CV-5085-RMP (October 12, 2018).

Amended Consent Decree and the October 2018 Third Amended Consent Decree, ORP has set the following five priorities (presented in no particular order):

- Complete construction and startup of the WTP LAW Vitrification Facility, Balance of Facilities (BOF), and Analytical Laboratory
- Complete the necessary construction of pretreatment facilities and tank farms' upgrades to initiate DFLAW operations
- Complete the infrastructure required to support DFLAW operations
- Continue tank waste retrievals
- Complete the WTP's HLW Vitrification and Pretreatment Facilities.

1.1 BACKGROUND

The RPP is comprised of a fully integrated system of waste storage, treatment, and disposal facilities at the Hanford Site, and the system is in varying stages of design, construction, operation, or future planning. These facilities are needed to complete the DOE RPP mission to safely manage, treat, and dispose of the nuclear waste stored in the Hanford tank farms. Many challenges must be met to achieve site cleanup and closure. DOE has two federal offices at Hanford: ORP, which is responsible for cleanup of Hanford Site tank waste, and the Richland Operations Office (RL), which is responsible for nuclear waste and facility cleanup and management of the Hanford Site. Each DOE office oversees separate contracts held by various government contractors.

The regulatory drivers affecting the work and decisions at Hanford are extensive, and include the following:

- *Atomic Energy Act of 1954*
- *Clean Water Act*
- *Code of Federal Regulations*
- *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA)
- Consent Decree, *State of Washington v. Dept. of Energy*, No. 08-5085-FVS (October 25, 2010), as amended by the Amended Consent Decree, No. 2:08-CV-5085-RMP (March 11, 2016), the Second Amended Consent Decree, No. 2:08-CV-5085-RMP (April 12, 2016), and the Third Amended Consent Decree, No. 2:08-CV-5085-RMP (October 12, 2018).
- DOE O 435.1, *Radioactive Waste Management* (including 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*)
- DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analyses*
- *Hanford Federal Facility Agreement and Consent Order* (also known as the TPA) (Ecology et al. 1989)

- *National Environmental Policy Act*
- *Nuclear Waste Policy Act*
- *Resource Conservation and Recovery Act* (RCRA)
- *Safe Drinking Water Act*
- *Washington Administrative Code*
- *Washington State Environmental Policy Act.*

Prior system plan documents discuss these regulatory drivers, most recently in Section 4.1 of ORP-11242 (Rev. 8). Changes or updates that have occurred since System Plan Rev. 8 are addressed in Section 4.0 of this document.

1.1.1 Understanding Hanford Waste

1.1.1.1 Low-Level Waste, Low-Activity Waste, and High-Level Waste

For purposes of consistency and conservatism, all wastes stored in the Hanford tank farms tanks are managed as HLW until otherwise classified. The definition of the term "high-level radioactive waste" is provided in the *Atomic Energy Act of 1954* and the *Nuclear Waste Policy Act*, and defined as:

> *(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.*

The DOE implements this definition by way of DOE O 435.1 and the associated DOE M 435.1-1. Given the mass of the chemical waste in tanks across the DOE complex, DOE collaborated with U.S. Nuclear Regulatory Commission (NRC) staff to identify approaches that DOE could use to classify waste streams according to their constituents. This process for waste incidental to reprocessing (WIR) is defined in DOE M 435.1-1 and must meet certain criteria. The waste streams:

- Must have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical
- Will be managed to meet safety requirements comparable to the performance objectives defined in 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives"
- Are to be managed, pursuant to DOE's authority under the *Atomic Energy Act of 1954*, as amended, and in accordance with the provisions of DOE M 435.1-1, Chapter IV, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste (LLW) as defined in 10 CFR 61.55, "Waste Classification," or will meet alternative requirements for waste classification and characterization as DOE may authorize.

Wastes that meet these criteria can be classified, under certain circumstances, as not being HLW and are referred to as LLW or LAW at Hanford. Once LAW has been immobilized and meets the land disposal restrictions criteria for solid wastes, the waste can be disposed of in a near-surface mixed low-level waste (MLLW) repository. The radionuclides that are removed are planned to be combined with the remaining HLW and vitrified, with the exception of spent cesium ion-exchange (CsIX) columns from tank-side cesium removal (TSCR), which do not yet have a defined treatment or disposal pathway.

Over the years, DOE personnel at the Hanford Site corresponded with the NRC regarding classification of the LAW fraction at Hanford. In 1997, the NRC concurred with DOE's approach to segregate waste by removing cesium and strontium; this was embodied in the 1997 NRC provisional LAW agreement, "Classification of Hanford Low-Activity Tank Waste Fraction" (Paperiello 1997). In this agreement, the NRC supported DOE's approach to divide tank waste into HLW and LAW fractions for separate treatment and disposal. This agreement thereby underpins the WTP design and was the basis for proceeding with facility design and construction. However, an official WIR determination by DOE, will be required prior to beginning processing of immobilized low-activity waste (ILAW) (synonymous with vitrified LAW).

1.1.1.2 Transuranic Waste

Another portion of the waste at the Hanford Site could potentially be classified as contact-handled transuranic (CH-TRU) waste. Eleven SSTs[8] have been evaluated as containing waste that could potentially be designated as CH-TRU[9] waste based on analytical reports identifying the origins of the waste in those tanks. In all cases, the wastes could be dispositioned as CH-TRU waste for the following reasons:

- The sludge in the tanks is not waste from reprocessing spent nuclear fuel and, therefore, is not within the *Nuclear Waste Policy Act* definition of HLW (see Section 1.1.1).
- The wastes contain alpha-emitting transuranic (TRU) radionuclides in concentrations defined as TRU waste in Public Law 102-579, *The Waste Isolation Pilot Plant Land Withdrawal Act*.

DOE has not taken formal steps to designate the waste as CH-TRU. However, DOE identified a preference to consider options for retrieving, treating, and disposing of the candidate CH-TRU waste evaluated in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC & WM environmental impact statement [EIS]), and further clarified this preference in a *Federal Register* notice issued March 11, 2013 (78 FR 15358, "DOE's Preferred Alternative for Certain Tanks Evaluated in the Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"). As stated in that notice, DOE prefers to retrieve, treat, package, characterize, and certify the wastes that are properly and legally classified as transuranic mixed (TRUM) waste for disposal at a yet-to-be-determined offsite TRU disposal facility. Initiating retrieval of tank waste for disposition as TRUM waste will be contingent on DOE obtaining the applicable and necessary permits, ensuring that the waste acceptance criteria (WAC) and all other applicable regulatory requirements are met, and making a determination that the waste is properly classified as TRUM waste. DOE did not decide to implement the

[8] Those SSTs include B-201, B-202, B-203, B-204, T-201, T-202, T-203, T-204, T-111, T-110, and T-104.
[9] As defined in Public Law 102-579, *The Waste Isolation Pilot Plant Land Withdrawal Act*, as amended by Public Law 104-201, (H.R. 3230, 104th Congress).

preferred, or any other, alternative associated with Hanford TRU waste in the TC & WM EIS record of decision (ROD) (78 FR 75913, "Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington: Record of Decision").

1.1.2 Long-Term Goals

The long-term RPP mission is to maintain the Hanford legacy tank waste safely and securely until the waste is immobilized and disposed of contained in long-term storage. In accordance with the TPA, some residual tank waste, including hard-to-remove heels, may remain in a tank after bulk waste retrieval is complete. The tank structure and associated equipment are also considered residual waste and will remain in the ground after the bulk of the waste is retrieved. These residuals may be stabilized and disposed of in place if the residual waste can be determined to be LLW pursuant to the DOE M 435.1-1 WIR process. Landfill closure for tanks is supported by the TC & WM EIS ROD.

Order DOE O 435.1 also requires the preparation of a performance assessment to support decisions about closure activities at facilities with radioactive waste. A site-specific radiological performance assessment 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, and provides a reasonable expectation that the performance objectives defined by DOE are not exceeded as a result of operation and closure of the facility.

The TPA's Appendix I explains the procedure for the "Single-Shell Tank System Waste Retrieval and Closure Process," and requires that each of the seven Hanford waste management areas (WMA)[10] undergo a thorough performance assessment. To support future SST farm closure operations, a waste determination is expected to be necessary for the SST WMAs. The scope of the waste determination for each WMA will be comprehensive and include tank residuals, pipeline residuals, and equipment abandoned in place.

Appendix I, Section 2.5, of the TPA requires the development of a performance assessment for the SST system and the development of a performance assessment for each WMA. The performance assessments will address the post-closure, long-term risk to human health and the environment presented by residual waste (containing both radionuclides and hazardous chemicals), equipment, and contaminated soil. Performance requirements are provided by the RCW 70.105, "Hazardous Waste Management;" RCRA; the *Safe Drinking Water Act*; the *Atomic Energy Act of 1954*; and any others that might be "applicable or relevant and appropriate requirements" under CERCLA. Successful closure of each WMA will require a systems approach to address these elements.

1.2 PURPOSE

The primary purpose of this document, referred to as "System Plan Rev. 9," is defined by the TPA and aligns with the Consent Decree.[11] As noted in TPA Milestone M-062-40, the system

[10] The seven WMAs include C, A/AX, B/BX/BY, S/SX, T, TX/TY, and U.
[11] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (E.D. WA October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

plan is to "[describe] the disposition of all tank waste managed by the ORP, including the retrieval of all tanks not addressed by the Consent Decrees in Washington v. DOE, Case No. 08-5085-FVS, and the completion of the treatment mission." A Baseline Case is established to satisfy this requirement. The ORP defined the Modeling Starting Assumptions (provided in Appendix A) from which the Baseline Case was developed for System Plan Rev. 9 (19-MIO-0024, "Contract No. DE-AC27-08RV-14800 – Washington River Protection Solutions LLC Transmits the River Protection Project 'System Plan, Rev. 9, Model Starting Assumptions' in Support of Contract Deliverable C.2.3.1.1-1," from W.E. Hader, U.S. Department of Energy, Richland, Washington, December 30, 2019). However, in addition to the Baseline Case, "DOE and Ecology each having the right to select a minimum of three scenarios," can conduct what-if options to assess the effects of various scenario-specific planning assumptions on the RPP mission. Sections 1.3 and 5.0 of this system plan discuss these scenarios in more detail.

The system plan process is also used to promote mutual understanding between Ecology and DOE of the issues, risks, and uncertainties surrounding the RPP mission and to lay the foundation for future TPA renegotiations. In accordance with TPA Milestone M-062-45, milestone renegotiations are required to occur following every other revision of the system plan.

1.3 SCOPE

The system plan scope is defined by the language of TPA Milestone M-062-40 and requires ORP to describe the disposition of the tank waste under its management (including tanks not addressed by the 2010 Consent Decree) and completion of the treatment mission. Facility decontamination and decommissioning and final disposition of immobilized high-level waste (IHLW) and TRU waste is outside the scope of the system plan. The tank farms project baseline also includes ORP technical support for the Tank Operations Contract (TOC) and the WTP Contract, WTP ramp-up and operations estimates, and decontamination and decommissioning of the WTP, but does not include scope for the design, construction, and startup of the WTP. The last approved baseline change proposal on work scope beyond the current TOC was 12 years ago (RPP-06-003, *Alignment of TFC Lifecycle Baseline*).[12] Much of the system plan Baseline Case is consistent with *Hanford Tank Waste Retrieval, Treatment, and Disposition Framework* (DOE 2013) and follows the Amended Consent Decree (2016). DOE intends to update the baseline at a future date. For the purposes of a TPA-compliant scenario in System Plan Rev. 9, "With no substantive changes since the last system plan, the results of the [System Plan Rev. 8] Scenario 6 compliant case are still valid and will not be repeated in revision 9" (19-MIO-0020, "Request for Concurrence on Selected Scenarios for the River Protection Project System Plan, Revision 9").

The language of TPA Milestone M-062-40 also requires that 1 year prior to issuing the system plan, DOE and Ecology are to select scenarios to be analyzed. For System Plan Rev. 9, this was accomplished and presented as a joint package (RPP-RPT-61707, *Selected Scenarios for the River Protection Project System Plan, Revision 9*) agreed to by 19-NWP-158, "Transmittal of Signed Concurrence for *Selected Scenarios for the River Protection Project System Plan, Revision 9*, RPP-RPT-61707, Rev. 0," followed by DOE's approval of the Model Starting Assumptions in December 2019 (19-MIO-0024).

[12] RPP-06-003 provides the project baseline summaries for ORP-0014 and HQ-HLW-0014X.

As per the TPA, the system plan is required to present the following minimum information for each scenario evaluated:

- A system description for each system utilized in the planning
- Planning bases for each case
- A description of key issues, assumptions, and vulnerabilities for each scenario evaluated, [including] a description of how such issues, assumptions, and vulnerabilities are addressed in the evaluation
- Sensitivities analysis of selected key assumptions
- Estimated schedule impacts of alternative cases relative to the baseline, including cost comparisons for a limited subset of scenarios that DOE and Ecology wish to analyze further
- Identification of new equipment, technology, or actions needed for the scenario (e.g., new evaporators or DSTs; new retrieval technologies; waste treatment enhancements; or mitigations such as sodium, sulfate, aluminum, and chrome mitigation measures)
- Identification of issues, techniques, or technologies that need to be further evaluated or addressed in order to accelerate tank retrievals and tank waste treatment.
- Effects on closure activities for each scenario.

The modeling tools and methodology used to define the scenarios are discussed in Section 2.0. Descriptions of the systems are provided in Section 3.0, and accomplishments and updates since System Plan Rev. 8 are discussed in Section 4.0. The key assumptions for each alternative scenario are documented in RPP-RPT-61707 and the Model Starting Assumptions are listed in Appendix A. Each scenario is described in Section 5.0. Section 6.0 compares key results across all scenarios. A discussion of key risks associated with the Baseline Case, along with contingency planning for the six risks identified in TPA Milestone M-062-40, are provided in Section 7.0.

Appendix B cross-references the TPA Milestone M-062-40 requirements in a manner that simplifies the requirements and displays how the system plan meets those requirements (Table B-1). Additional requirements related to tank waste treatment, supplemental treatment, tank waste retrieval, and contingency planning requirements established in the milestone are listed in the matrix.

The scenarios listed in Table 1-1, and several additional sensitivity cases, were defined by either DOE or Ecology. Key assumptions for Scenario 1 (Baseline Case) were established by ORP; however, they were reviewed jointly, and adjustments were made accordingly so this case could be altered for the additional scenarios. That is, the Baseline Case assumptions served as the foundation from which additional scenarios were developed. The remainder of the scenarios, defined by Ecology, were developed from Scenario 1B (a sensitivity to the Baseline Case) as it contained foundational assumptions from which Ecology adjusted for the remainder of the scenarios. The relationships of the scenarios are illustrated in Figure 1-2 the modeling process is described further in Section 2.0. The unique set of assumptions that distinguishes each additional scenario is included in its associated analysis in Section 5.0. A cost analysis was performed on every primary scenario (i.e., not sensitivity cases) and Scenario 1B, which was used as the basis for the remainder of the scenarios.

Table 1-1. System Plan Revision 9, Scenarios with Objectives.

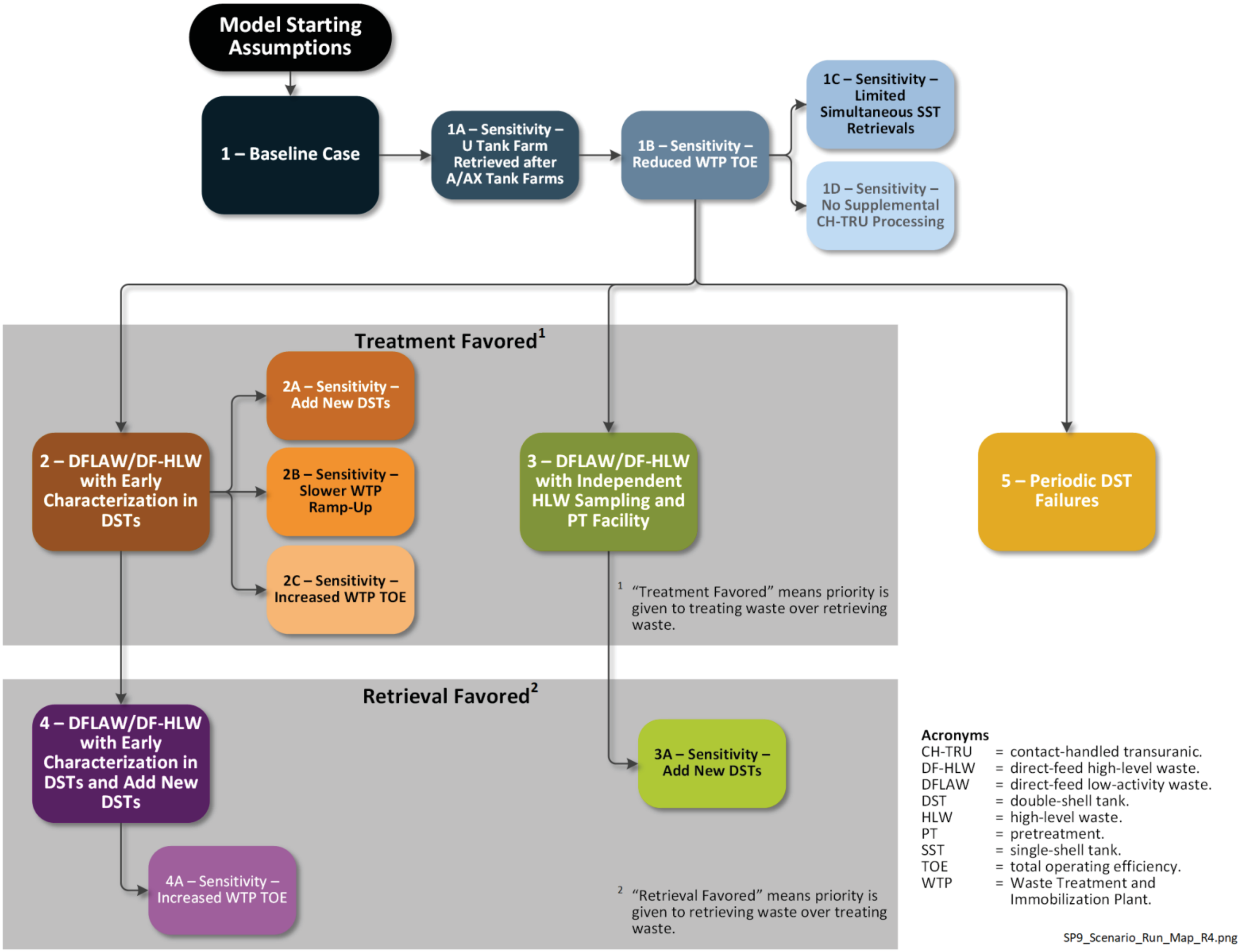
Scenario #	Scenario Name	Scenario Objective
Scenario 1[a]	Baseline Case	The purpose of this scenario is to establish a system plan Baseline Case that reflects the best estimate of how the mission is thought to proceed given current conditions, constraints, and assumptions. The Baseline Case also seeks to assess the ability to be compliant with the Consent Decree[b] and the TPA. The Baseline Case includes four sensitivity cases. • Scenario 1A – U Tank Farm Retrieved After A/AX Tank Farms • Scenario 1B – Reduced WTP TOE • Scenario 1C – Limited Simultaneous SST Retrievals • Scenario 1D – No Supplemental CH-TRU Waste Processing
Scenario 2[a]	Treatment-Favored DFLAW/DF-HLW with Early Characterization in DSTs	The purpose of this scenario is to evaluate the life-cycle effects of using existing DSTs for sampling and characterization and other equipment for pretreatment of waste destined for HLW melters, to include leaching, sampling, and washing. This scenario builds on Scenario 1B and includes three additional sensitivity cases. • Scenario 2A – Add New DSTs • Scenario 2B – Slower WTP Ramp-Up • Scenario 2C – Increased WTP TOE
Scenario 3[a]	Treatment-Favored DFLAW/DF-HLW with Independent HLW Sampling and Pretreatment Facility	The purpose of this scenario is to evaluate the life-cycle effects of using a new HLW feed preparation facility for sampling and characterization and pretreatment of waste destined for HLW melters, to include leaching, sampling, and washing. Scenario 3 builds on Scenario 1B and includes one sensitivity case: Scenario 3A – Add New DSTs.
Scenario 4[a]	Retrieval-Favored DFLAW/DF-HLW with Early Characterization in DSTs and Add New DSTs	The purpose of this scenario is to evaluate the life-cycle effects using existing DSTs for sampling and characterization and other equipment for pretreatment of waste destined for HLW melters, to include leaching, sampling, and washing, while adding new DSTs to favor SST retrievals. In this scenario, new DSTs are utilized to maintain SST retrievals consistent with the Baseline Case despite a slowdown in treatment throughput. Scenario 4 builds on Scenario 2 and includes one sensitivity case: Scenario 4A – Increased WTP TOE.
Scenario 5	Periodic DST Failures	The purpose of this scenario is to evaluate the life-cycle effects of a sequence of DST failures, one every 5 years with failure of the first tank in 2025 (sequence: AY-101, AZ-101, AZ-102, AN-107, AW-105). This scenario is based on Scenario 1B.

[a] Indicates that an additional sensitivity case(s), which includes a minor analysis of a variation to the primary case, has been selected.

[b] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (E.D. WA October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

CH-TRU = contact-handled transuranic.
DF-HLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HLW = high-level waste.
SST = single-shell tank.
TOE = total operating efficiency.
TPA = Tri-Party Agreement.

Figure 1-2. System Plan Revision 9, Scenario Relationship.



Additional items to note regarding this document include the following.

- The majority of the data is charted starting on October 1, 2018 as that is the first fiscal year (FY) for which transfers are modeled. The system plan contains all waste transfers required for the RPP mission, beginning in December 2018, consistent with RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to TOPSim*, and RPP-RPT-61975, *Near-Term Transfers for System Plan Revision 9*.
- The Model Starting Assumptions in Appendix A use the same units and precision as the source documents. This approach improves traceability and avoids unnecessary propagation of rounding errors. In the rest of the document, results are reported to precisions that are intended to reflect the random uncertainty of the modeling process. See Section 5.1.2.3 for more information. Examples include the reporting of calendar dates to the nearest year, life-cycle costs to the nearest $1 billion, and mission-total IHLW canisters to the nearest 100.

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2.0 PROCESS

Milestone M-062-40 states (in part):

> *Every three years… Ecology and DOE will each have the right to select a minimum of three scenarios that will be analyzed in the System Plan…*

2.1 METHODOLOGY

This system plan's focus was on shared learning and collaboration between ORP and Ecology. There was a focused effort to define and understand what ORP was planning in terms of managing and treating the waste stored in the tanks at Hanford. Once both sides had a solid understanding, scenario development began. Each organization brought scenarios to the combined working group to discuss and understand. Substantial energy was spent to not only understand the changes desired from the Baseline Case, but also to share knowledge of what outcomes might be expected based on the years of modeling and past system plans. Modeling then began ordered according to the basis for each scenario and sensitivity, starting with the Baseline Case. The DOE is responsible for providing the document and the balance of TPA-required information to Ecology (see Table B-1 in Appendix B).

For System Plan Rev. 9, ORP defined the Baseline Case (Scenario 1) from which Ecology then defined sensitivities to the Baseline Case and then additional alternative scenarios with and without sensitivities. The selected scenarios and the process by which the scenarios were defined were then described in a "Selected Scenarios Document," which was approved by both ORP and Ecology and forwarded to the Administrative Record to document completion of the first step in the milestone. As required by Milestone M-062-40, the scenarios were defined and approved before the due date of October 31, 2019. The process and scenarios were briefly described in RPP-RPT-61707, and approval of the scenarios is documented in 19-NWP-158.

The selected scenarios are listed in Sections 1.3 and 5.0. Each scenario is defined by a set of case-specific detailed assumptions that were converted into modeling requirements. Modeling reveals the effects of the assumptions for each case on the RPP mission duration, infrastructure needs, and costs. Detailed case-specific system descriptions, planning bases, and projected results, including cost and schedule results, risk, and opportunities are disclosed in each scenario discussion in Section 5.0.

The approach taken for modeling the System Plan Rev. 9 scenarios was not to constrain them by the TPA milestones for SST retrievals and waste treatment, but to provide best estimates of what could realistically be achieved given the input assumptions. The scenario results could then be used to inform negotiations of the TPA milestones.

Milestone M-062-40 requires that the scenarios include a comparison to a baseline (item #3 in Table B-1). The alternative scenarios are typically compared to the Baseline Case; however, in this revision, the alternative scenario results are compared against Scenario 1B as this is the scenario sensitivity from which the alternative scenarios for System Plan Rev. 9 were derived. The results of these comparisons are provided in each of their respective subsections in Section 5.0. Section 6.0 provides a comparison of all scenarios. The milestone also includes specific requirements related to tank waste treatment, supplemental treatment, tank waste retrieval, and contingency planning. Those discussions are located throughout the entire document, and specific systems and their functions are addressed in Section 3.0. Refer to Table B-1 for a matrix of required discussions and their location within this document.

Scenario 1, as the Baseline Case, incorporates optimizations and lessons learned from many previous studies and analyses. The strategy for modeling the alternative scenarios (2 through 5) was to minimize changes from Scenario 1B. This made each alternative scenario directly comparable to the baseline's sensitivity so that the consequence of each change could be quantified and understood. As a result, the alternative scenarios are not highly optimized, and there are opportunities for improvement, as addressed in the scenario-specific discussions in Section 5.0.

2.2 MODELING TOOLS

The modeling of scenarios is primarily performed using TOPSim, which was created using a commercial off-the-shelf modeling platform. TOPSim is described in further detail in Section 2.2.1 below. Several additional computer software tools are used in the process of modeling and analyzing system plan scenarios. The primary tools include the following:

- **TOPSim** – A software application developed using the Gensym® G2®[13] platform that simulates the Hanford tank farms and processing plant operations.
- **Glass formulation models (GFM) with Glass Model Calculator (GMC)** – A modeling tool that formulates the glass former blends during waste processing in the melter facilities, enabling TOPSim to model the projected waste glasses over a wide range of compositions and properties.
- **Integrated Solubility Model (ISM) with Gibbs Energy Minimization Calculator (GCALC)** – A modeling tool that calculates the solubility of waste constituents at multiple points in the flowsheet and over a wider range of conditions, which should more accurately reflect the conditions anticipated during waste processing and enable TOPSim to predict precipitation reactions and dissolutions.
- **Lifecycle Cost Model (LCM)** – A tool that electronically links the TOPSim output to schedule- and cost-processing software to generate life-cycle cost reports.

2.2.1 TOPSim

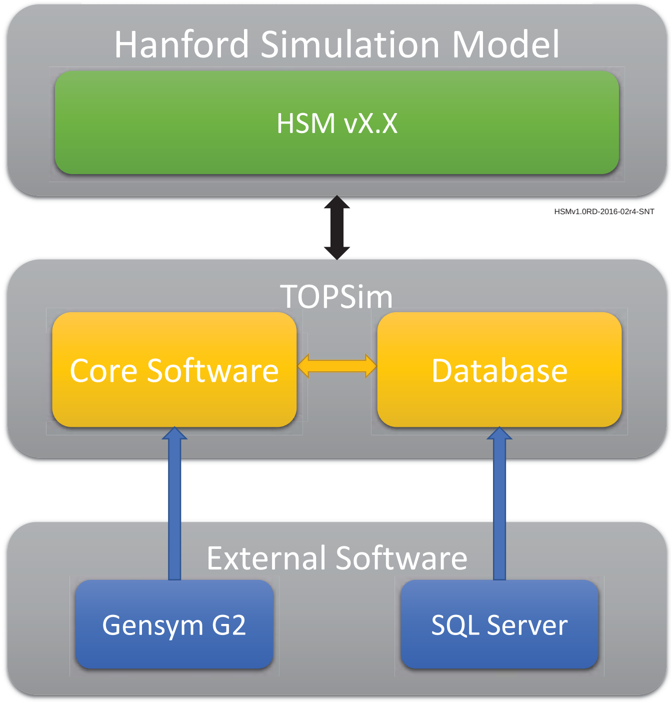
The TOPSim software application is used to host and simulate models of the Hanford tank farms and processing plant operations. TOPSim includes design elements that can be configured to model the physical plant, including tanks, process equipment, and transfer lines (defined in RPP-55533, *TOPSim Software Design Document*). The TOPSim environment also includes chemistry models to support calculations and tracking of chemical components through the

[13] Gensym®, G2®, and Gensym G2™ are either trademarks or registered trademarks of Ignite Technologies in the United States and/or other countries.

process. The application is designed to allow extensions of the model elements to incorporate cost, reliability, and other constraints.

TOPSim was developed using the Gensym® G2® platform. The fundamental operation of TOPSim involves the simulation environment paired with a model design and SQL database. The particular model design used in this case is referred to as the "Hanford Simulation Model" (Figure 2-1). The simulation software is coupled with the model and the operation of specific sub-processes, while the database provides a repository to store configuration data and the generated simulation data.

Figure 2-1. Relationship of the Hanford Simulation Model to TOPSim Software and Database.



The Hanford Simulation Model provides a simulation aligned to the latest technical information for use as a starting point for scenario modeling. The intent of aligning the default Hanford Simulation Model to the latest technical information is to improve the efficiency of configuring the model to create a requested scenario. A key part of this simulation environment is the ability to encode operations decision logic into the model. Incorporating decision logic into the simulation enables modeling of long-term, large-scale processes that require extensive decision logic in their execution.

TOPSim is a deterministic model; with a given configuration and set of inputs, TOPSim produces the same result every time. However, operations decision logic and operational processes are shared by multiple systems within the model, making results sensitive to small changes to logical components or inputs. Changes to inputs that are intended to affect activities later in the mission can affect the results of near-term activities, and vice-versa. Changes that occur early in the mission may have a compounding effect as time progresses, leading to more significant differences in the final results. Therefore, it is important to note that when comparing model scenarios with different inputs or configurations, results cannot be expected to be identical.

Further information on TOPSim and specific model requirements are provided in RPP-55533 and RPP-RPT-59470, *TOPSim V3.0 Model Requirements*.

2.2.2 Glass Formulation Models

Two GFMs were used in TOPSim for System Plan Rev. 9, one each for HLW glass and LAW glass. The 2016 models incorporate data from a wider variety of simulated waste glasses than were previously available. This enables the models to formulate projected WTP waste glasses with higher waste loading over a wider range of compositions and properties than was formerly possible. The 2009 and 2013 GFMs for HLW and the 2004 and 2013 GFMs for LAW glass, used in previous system plans, are still available GFMs in TOPSim, although the 2016 GFMs are currently the default. The 2016 (and 2013) GFMs were developed to be less conservative than the 2004 or 2009 GFMs. Descriptions of the two primary GFMs are provided below.

- The 2016 HLW GFM is a refinement of the "advanced" 2013 HLW GFM that incorporates more test data and makes computational improvements. (PNNL-25835, 20*16 Update of Hanford Glass Property Models and Constraints for Use in Estimating the Glass Mass to be Produced at Hanford by Implementing Current Enhanced Glass Formulation Efforts*)
- The 2016 LAW GFM is a refinement of the "advanced" 2013 LAW GFM that incorporates more test data and makes computational improvements. (PNNL-25835)

The 2016 GFMs were implemented in TOPSim using the GMC application (RPP-RPT-61155, *Glass Model Calculator [GMC]*). The GMC provides an estimate for the glass formers required to formulate each melter feed batch that minimizes glass mass while still achieving an acceptable glass composition. Due to the GFMs' nonlinear constraints and the need for computational efficiency and accuracy, a Sequential Least Squares Quadratic Programming solver is utilized by the GMC for this purpose. The acceptable glass composition is defined by the constraints imposed by the GFMs. For each batch formulation returned by the GMC, one or more of these constraints will be at their respective limit; these limiting constraints drive the quantity of glass produced and are, therefore, identified as "glass drivers."

Additional information on the GFMs is available in the following documents:

- PNNL-18501, *Glass Property Data and Models for Estimating High-Level Waste Glass Volume*
- PNNL-22631, *Glass Property Models and Constraints for Estimating the Glass to be Produced at Hanford by Implementing Current Advanced Glass Formulation Efforts*
- PNNL-25835, 20*16 Update of Hanford Glass Property Models and Constraints for Use in Estimating the Glass Mass to be Produced at Hanford by Implementing Current Enhanced Glass Formulation Efforts*
- RPP-RPT-61155, *Glass Model Calculator (GMC).*

2.2.3 Integrated Solubility Model with Gibbs Energy Minimization Calculator

The ISM is used to predict solubility of waste components in TOPSim. The ISM takes a graded approach to modeling solubility that involves assigning waste components to categories based on their effect on mission predictions (e.g., IHLW glass quantity) and their relative solubilities.

- Components that have intermediate solubility and high impact to mission outcomes are modeled using the Pitzer ion-interaction model (Pitzer 1972; Pitzer and Kim 1974) implemented in the GCALC application (RPP-PLAN-60042, *Software Management Plan for Grade D Custom Developed GCALC*).
- Strontium and boehmite, two components that have low solubility except under specific conditions, but a high impact on the mission outcomes, are modeled using equations.

- A kinetic equation model, provided in 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*, is used to predict the solubility of boehmite during caustic leaching in the WTP.
- Strontium solubility is predicted using the correlation recommended in RPP-21807, *Strontium-90 Liquid Concentration Solubility Correlation in the Hanford Tank Waste Operations Simulator*, which accounts for the effect of organic complexants on the solubility of strontium.

- Components that have a low effect on mission outcomes or are either highly soluble or highly insoluble are modeled using wash and leach factors if available from the Best-Basis Inventory. If wash and leach factors are not available, solubility is not modeled for these components.

The Best-Basis Inventory data is used as the TOPSim starting inventory. However, the Best-Basis Inventory is neither charge-balanced nor evaluated against the criteria established by the ISM prior to being entered into TOPSim. Therefore, dissolution and/or precipitation of components may occur the first time the ISM is applied to a DST. However, examining the effect of this implementation is beyond the scope of this document. For more information about the ISM implementation in TOPSim, refer to RPP-RPT-50703, *Development of a Thermodynamic Model for the Hanford Tank Waste Operations Simulator (HTWOS),* and RPP-RPT-58972, *ISM Simple Solubility Change Evaluation*.

2.2.4 Lifecycle Cost Model

The LCM schedule represents the unique dates and durations of activities projected by modeling results. Project activities are logically connected to allow the schedule to adjust as the TOPSim model results influence mission-related activities. The methodology used by the LCM does not include resource- or cost-leveling or allocation of schedule float. By aligning the start and end dates of activities directly to modeling results, and not constraints, the LCM produces zero-float schedules. This approach is useful in demonstrating the schedule fluctuations resulting from different technical assumptions; however, risk analysis and confirmation of resource and funds availability is required before using LCM schedules for anything other than comparative analysis.

Time phasing for all work to support tank farms activities is developed using Primavera® P6®[14] scheduling software, an industry standard project management tool. A separate P6® schedule is created for each system plan scenario. Depending on the TOPSim model results from each scenario, the schedule shortens or lengthens. Escalation[15] is then applied to the results of the P6® fiscal year time phasing. The escalation rate was provided by DOE and is assumed to be 2.4 percent per fiscal year for the duration of the mission. Escalation is compounded each fiscal year to simulate the changes in price for specific goods and services necessary to support Hanford tank waste processing.

The LCM uses the TOC performance measurement baseline as of October 2019 as the starting point for the current model run. The TOC performance measurement baseline includes the scope,

[14] Primavera® and P6® are either trademarks or registered trademarks of Oracle and/or its affiliates in the United States and/or other countries.
[15] Cost escalation is the change in the cost or price of goods or services over time, similar to the concept of inflation. Unescalated mission costs are presented in 2020 dollars, while escalated mission costs represent an estimate of the future costs and associated budgetary requirements.

schedule, and cost for the authorized baseline activities for the TOC period. An out-year planning estimate range schedule is used beyond the TOC period through the end of the RPP mission. Because some scenarios involve new facilities or system configurations that require additional work scope, some supplemental cost estimates were added. These estimates, time-phased with the schedule, are developed by estimators, project managers, or knowledgeable staff, and incorporated into an LCM schedule for the appropriate scenario using tank farms project work breakdown structure elements.

Estimates for future work scope (beyond the current TOC period) are typically rough-order-of-magnitude estimates that rely on information obtained from existing reports and studies, reference drawings, historical cost data (costs escalated to current year as applicable), scaling of baseline data, and estimator judgment.

Supplemental scenario-specific estimates are added for major scope additions, and the model can be modified to provide costs beyond the previous end-of-mission dates if a shift in the RPP mission schedule is required. No attempt is made to change or improve the estimating accuracy of activities in the TOC performance measurement baseline or to deviate from the existing set of estimating assumptions.

Additional information on the cost analysis in System Plan Rev. 9 and on the LCM is provided in RPP-RPT-62564, *System Plan, Revision 9, Lifecycle Cost Analysis*, and AEM-WRPS-2012-MDD-003, *Life-Cycle Cost Model (LCM) Design Document*, respectively.

3.0 SYSTEM DESCRIPTIONS

The RPP integrated system of waste storage, treatment, and disposal facilities is in varying stages of design, construction, operation, or future planning. This section describes waste retrieval from SSTs, the DSTs, inactive miscellaneous underground storage tanks (IMUST),[16] waste transfer systems, various treatment facilities, and other interfacing facilities. These systems and facilities makeup the flowsheet for Scenario 1 (Baseline Case). The section is divided into 3.1, Storage and Retrieval; 3.2, Testing; 3.3, Treatment; and 3.4, Disposal, and roughly follows the flow of waste throughout the process. The alternative scenarios include descriptions of how their individual flowsheets differ from the Baseline Case.

All Hanford tank wastes are stored in either the 200 West or 200 East Area. The tank farms' waste volumes are shown graphically in Figure 3-1 and Figure 3-2 (from HNF-EP-0182, *Waste Tank Summary Report for Month Ending April 30, 2020*, Rev. 388). Note that total waste volumes fluctuate slightly from additions of water and chemicals during waste retrieval operations, receipt of laboratory wastes, and operation of the 242-A Evaporator.

The waste in the 200 East and 200 West Areas' SSTs will be either retrieved into the DST system where it will be staged for immobilization at the WTP or directly retrieved to a potential onsite TRU waste treatment process. The packaged potential CH-TRU waste produced by this process would then be transported offsite for disposal. All other waste in the SSTs is retrieved into the DST system, and waste in the 200 West Area DSTs is transferred to the 200 East Area DSTs. Waste retrieved from the B and T Complexes are sent to their respective Waste Receiving Facility (WRF) and then to the DSTs. The 242-A Evaporator concentrates dilute waste retrieved from the SSTs thereby reducing the required DST storage space.

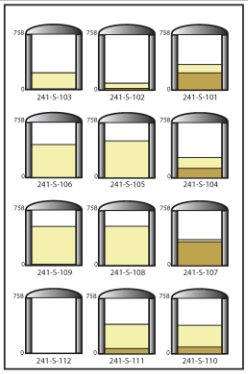
The majority of the Hanford tank waste will be immobilized by the WTP, which is being designed and built by Bechtel National, Inc. (BNI). Treatment is planned to begin with DFLAW in 2023, where supernatant is staged in DSTs and delivered to a tank-side pretreatment system (TSCR and/or tank farm pretreatment [TFPT]), where most of the cesium is removed using ion exchange (IX). The pretreated supernatant is sent to the WTP LAW Vitrification Facility and immobilized. The liquid effluent from the WTP LAW Vitrification Facility is sent to the WTP Effluent Management Facility (EMF) to be concentrated and recycled through the WTP LAW Vitrification Facility. A simplified, overall system flowsheet for the Baseline Case is presented in Figure 3-3.

[16] Note that in this plan, the miscellaneous underground storage tanks (MUSTs) and IMUSTs are collectively referred to as IMUSTs (described further in Section 3.1.3).

Figure 3-1. 200 West Area Tank Waste Contents.

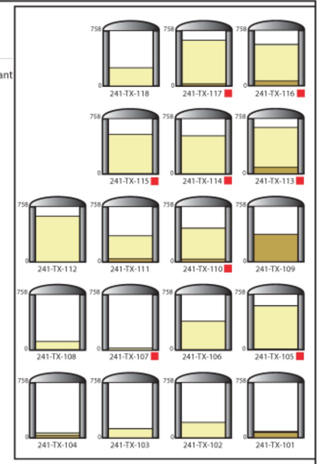
S-Tank Farm- Constructed 1950-1951
12 @ 758 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-S-101	235	115	0
241-S-102	22	69	2
241-S-103	9	220	1
241-S-104	132	149	0
241-S-105	2	506	0
241-S-106	0	451	0
241-S-107	328	30	0
241-S-108	5	536	0
241-S-109	13	520	0
241-S-110	91	296	0
241-S-111	72	329	0
241-S-112	2.5	0	0.1



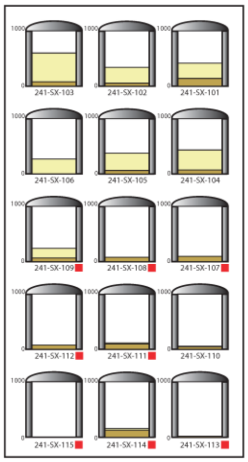
TX-Tank Farm- Constructed 1947-1948
18 @ 758 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-TX-101	73	14	0
241-TX-102	2	211	0
241-TX-103	0	126	2
241-TX-104	33	33	1
241-TX-105 ■	11	589	0
241-TX-106	5	386	0
241-TX-107 ■	0	27	0
241-TX-108	6	110	0
241-TX-109	375	0	0
241-TX-110 ■	37	425	0
241-TX-111	43	316	0
241-TX-112	0	627	0
241-TX-113 ■	88	546	0
241-TX-114 ■	4	518	0
241-TX-115 ■	8	536	0
241-TX-116 ■	66	499	0
241-TX-117 ■	29	597	0
241-TX-118	0	250	0



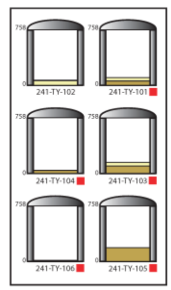
SX-Tank Farm- Constructed 1953-1955
15 @ 1,000 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-SX-101	141	275	0
241-SX-102	55	287	0
241-SX-103	80	519	0
241-SX-104	70	363	0
241-SX-105	63	313	0
241-SX-106	0	267	1
241-SX-107 ■	96	0	0
241-SX-108 ■	79	0	0
241-SX-109 ■	66	175	0
241-SX-110	49	9	0
241-SX-111 ■	97	20	0
241-SX-112 ■	77	0	0
241-SX-113 ■	19	0	0
241-SX-114 ■	127	31	0
241-SX-115 ■	4	0	0



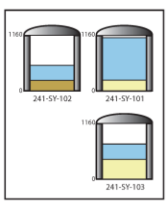
TY-Tank Farm- Constructed 1951-1952
6 @ 758 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-TY-101 ■	59	47	0
241-TY-102	0	61	9
241-TY-103 ■	101	51	0
241-TY-104 ■	41	0	1
241-TY-105 ■	187	0	0
241-TY-106 ■	13	0	0



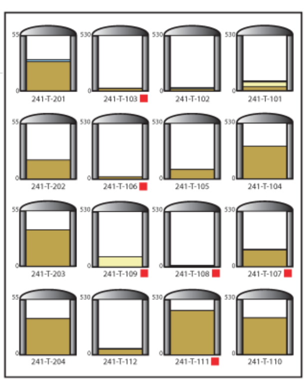
SY-Tank Farm- Constructed 1974-1976
3 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-SY-101	0	223	889
241-SY-102	220	0	314
241-SY-103	0	414	319



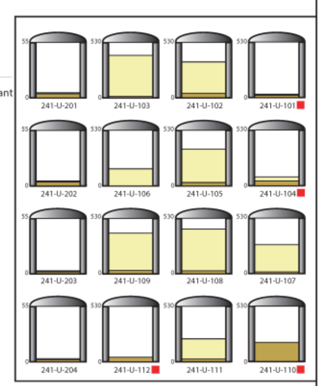
T-Tank Farm- Constructed 1943-1944
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-T-101	37	47	9
241-T-102	19	0	11
241-T-103 ■	23	0	3
241-T-104	310	0	0
241-T-105	92	0	0
241-T-106 ■	21	0	0
241-T-107 ■	160	0	7
241-T-108 ■	7	8	0
241-T-109 ■	0	98	0
241-T-110	351	0	2
241-T-111 ■	424	0	0
241-T-112	55	0	7
241-T-201	29	0	2
241-T-202	19	0	0
241-T-203	36	0	0
241-T-204	36	0	0



U-Tank Farm- Constructed 1943-1944
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-U-101 ■	21	0	10
241-U-102	43	299	2
241-U-103	13	392	1
241-U-104 ■	45	39	0
241-U-105	32	318	0
241-U-106	0	163	2
241-U-107	16	261	0
241-U-108	29	399	0
241-U-109	32	357	0
241-U-110 ■	183	0	0
241-U-111	26	193	0
241-U-112 ■	43	0	0
241-U-201	4	0	1
241-U-202	4	0	1
241-U-203	2	0	1
241-U-204	2	0	1



LEGEND: Sludge, Saltcake, Supernatant, Available Space, Assumed/Confirmed Leaker ■

Data Derived From Waste Tank Summary Report Dated 4/30/2020

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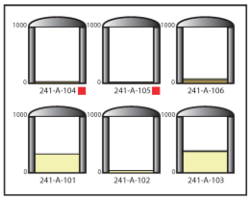
HNF-EP-0182, Rev. 388

Figure 3-2. 200 East Area Tank Waste Contents.

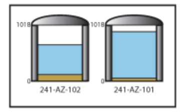
A-Tank Farm- Constructed 1953-1955
6 @ 1,000 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-A-101	3	329	1
241-A-102	0	38	2
241-A-103	2	376	12
241-A-104 ■	28	0	0
241-A-105 ■	20	0	0
241-A-106	50	29	0



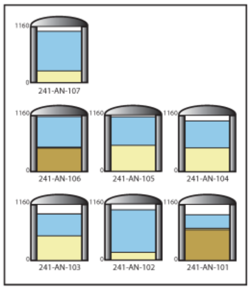
AZ-Tank Farm- Constructed 1970-1974
2 @ 1,018 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AZ-101	51	0	846
241-AZ-102	116	0	543



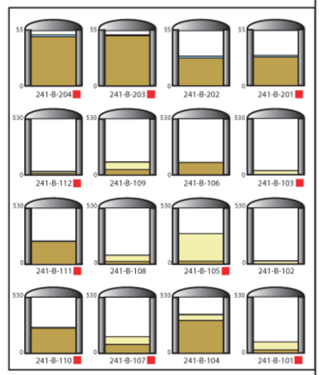
AN-Tank Farm- Constructed 1977-1980
7 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AN-101	635	30	281
241-AN-102	0	159	879
241-AN-103	0	510	453
241-AN-104	0	491	556
241-AN-105	0	536	585
241-AN-106	488	17	630
241-AN-107	0	240	819



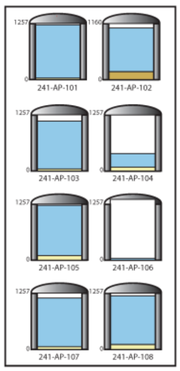
B-Tank Farm- Constructed 1943-1944
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-B-101 ■	30	75	0
241-B-102	0	27	4
241-B-103 ■	1	36	1
241-B-104	309	54	5
241-B-105 ■	28	261	0
241-B-106	116	0	1
241-B-107 ■	84	72	0
241-B-108	27	58	0
241-B-109	50	71	2
241-B-110 ■	237	0	7
241-B-111 ■	215	0	5
241-B-112 ■	14	17	3
241-B-201 ■	28	0	1.5
241-B-202	27	0	2
241-B-203 ■	49	0	1
241-B-204 ■	48	0	2



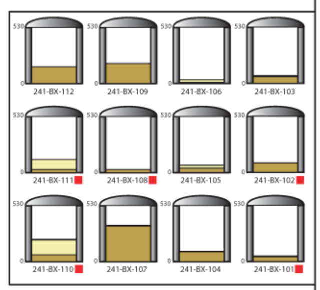
AP-Tank Farm- Constructed 1982-1986
1 @ 1,160 Kgal Tank Capacity, Double-Shell
7 @ 1,257 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AP-101	0	33	1192
241-AP-102	165	0	903
241-AP-103	0	48	1070
241-AP-104	0	88	304
241-AP-105	0	102	1126
241-AP-106	0	0	38
241-AP-107	0	63	1084
241-AP-108	0	111	1085



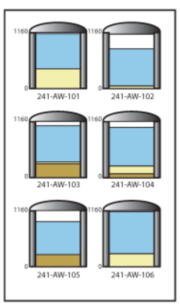
BX-Tank Farm- Constructed 1946-1947
12 @ 530 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BX-101 ■	43	0	9
241-BX-102 ■	89	0	0
241-BX-103	62	0	12
241-BX-104	93	0	4
241-BX-105	42	28	0
241-BX-106	10	26	0
241-BX-107	337	0	6
241-BX-108 ■	30	0	0
241-BX-109	189	0	0
241-BX-110 ■	65	141	6
241-BX-111 ■	30	94	0
241-BX-112	158	0	0



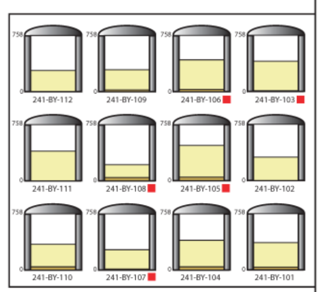
AW-Tank Farm- Constructed 1976-1980
6 @ 1,160 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AW-101	0	405	730
241-AW-102	0	53	769
241-AW-103	280	40	749
241-AW-104	81	157	797
241-AW-105	248	0	682
241-AW-106	0	266	872



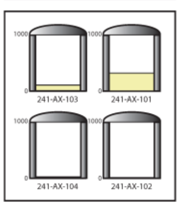
BY-Tank Farm- Constructed 1948-1949
12 @ 758 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-BY-101	37	329	0
241-BY-102	0	315	0
241-BY-103 ■	9	399	0
241-BY-104	43	358	0
241-BY-105 ■	48	429	0
241-BY-106 ■	30	399	0
241-BY-107 ■	16	258	0
241-BY-108 ■	44	172	0
241-BY-109	23	273	0
241-BY-110	44	304	0
241-BY-111	0	399	0
241-BY-112	2	284	0



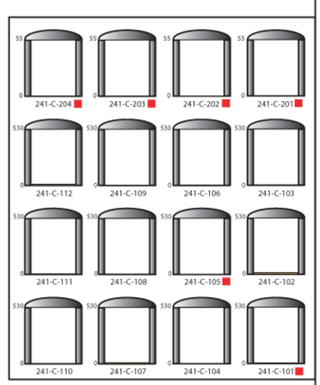
AX-Tank Farm- Constructed 1963-1965
4 @ 1,000 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AX-101	2	318	0
241-AX-102	6	7	0
241-AX-103	8	96	4
241-AX-104	5	0	18



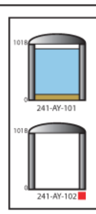
C-Tank Farm- Constructed 1943-1944
12 @ 530 Kgal Tank Capacity, Single-Shell
4 @ 55 Kgal Tank Capacity, Single-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-C-101 ■	5.5	0	0
241-C-102	15.5	0	0
241-C-103	2.3	0	0.2
241-C-104	1.9	0	0
241-C-105 ■	1.5	0	0
241-C-106	2.4	0	0
241-C-107	10	0	0
241-C-108	3.4	0	0
241-C-109	2	0	0
241-C-110	2.1	0	0
241-C-111	4.9	0	0
241-C-112	10	0	0
241-C-201 ■	0.1	0	0
241-C-202 ■	0.1	0	0
241-C-203 ■	0.1	0	0
241-C-204 ■	0.1	0	0



AY-Tank Farm- Constructed 1968-1970
2 @ 1,018 Kgal Tank Capacity, Double-Shell

Tank	Sludge (Kgal)	Saltcake (Kgal)	Supernatant (Kgal)
241-AY-101	105	0	826
241-AY-102 ■	8	0	3



LEGEND
Sludge | Saltcake | Supernatant | Available Space | Assumed/Confirmed Leaker ■ | Data Derived From Waste Tank Summary Report Dated 4/30/2020

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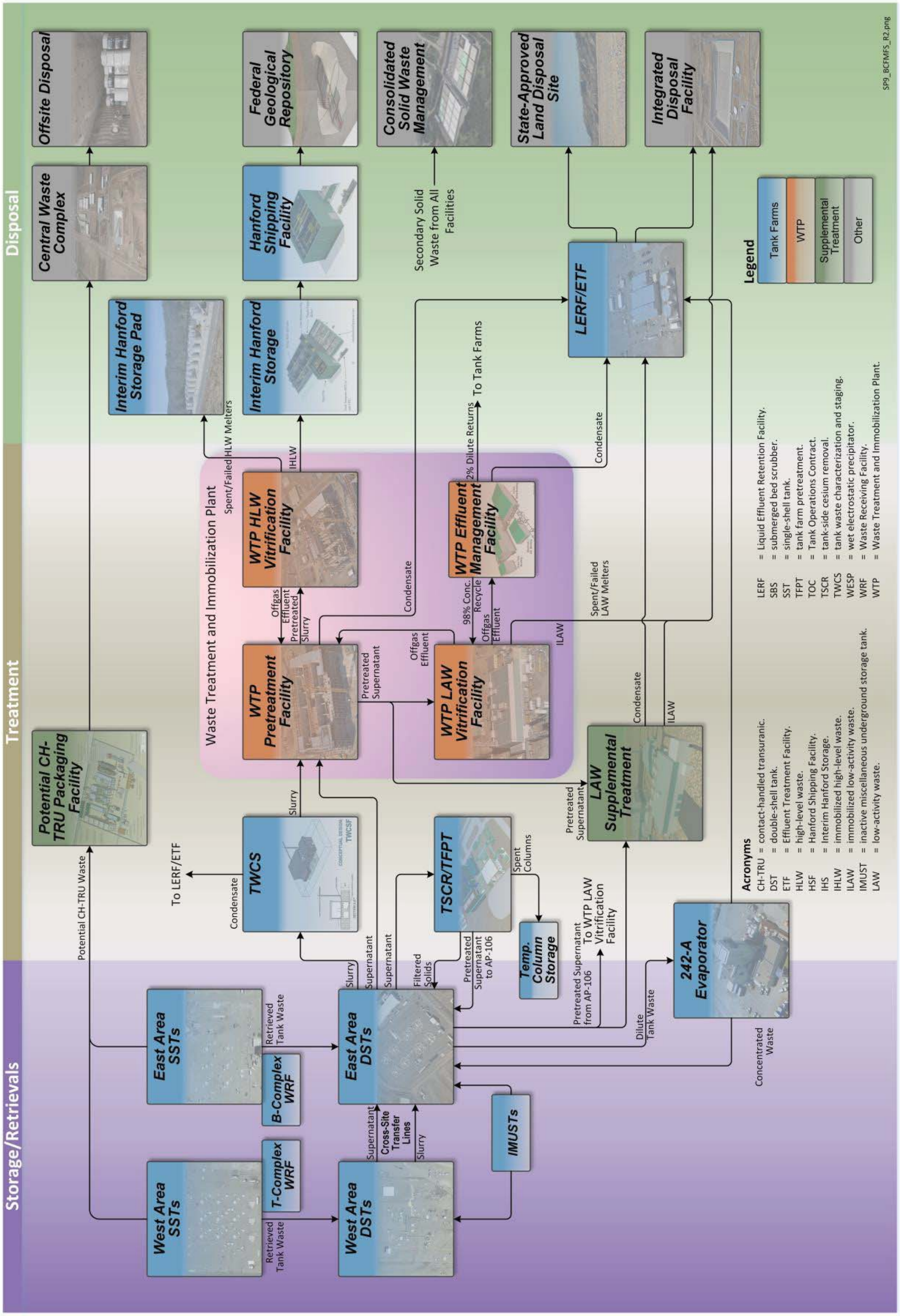


Figure 3-3. Simplified Baseline System Flowsheet.

After 10 years of DFLAW operations, the operation of TFPT will be temporarily suspended, the WTP EMF operations will be discontinued, and the WTP Pretreatment Facility and WTP HLW Vitrification Facility will begin hot operations. The WTP Pretreatment Facility receives both supernatant and slurry waste from the DSTs, with the slurry being staged and sampled in the intermediary tank waste characterization and staging (TWCS) capability. Within the WTP Pretreatment Facility, the waste slurry and supernatant are blended, and the solids are then filtered and pretreated via leaching and washing to reduce the amount of IHLW produced. The liquid permeate from the filter is pretreated via an IX process to remove most of the cesium, and the pretreated permeate is concentrated through evaporation. The cesium from the IX process is recombined with the pretreated slurry. The pretreated slurry from the WTP Pretreatment Facility is sent to the WTP HLW Vitrification Facility, and the pretreated supernatant is sent to either the LAW Vitrification Facility or, later, the LAW supplemental treatment (LAWST) capability. The liquid effluents from the WTP's HLW and LAW Vitrification Facilities are recycled through the WTP Pretreatment Facility. When the LAWST capability begins operations, the TFPT is restarted and provides an additional source of feed to that process.

The Liquid Effluent Retention Facility (LERF) receives process condensate and other dilute secondary liquid effluent waste streams from the 242-A Evaporator, WTP Pretreatment Facility, WTP LAW Vitrification Facility, WTP EMF, LAWST capability, supplemental potential CH-TRU waste treatment process, as well as contaminated groundwater (or leachate) from the Environmental Restoration and Disposal Facility (ERDF), the Integrated Disposal Facility (IDF), and others. Dilute waste sent to the LERF is treated at the Effluent Treatment Facility (ETF) and then disposed of, either as liquids at the State-Approved Land Disposal Site (SALDS) or as a solidified waste form at the ERDF and, later, the IDF. Immobilized waste from the WTP LAW Vitrification Facility and LAWST capability is also disposed of at the IDF. Immobilized waste from the WTP HLW Vitrification Facility is transported to the Interim Hanford Storage (IHS) facility, and then to a permanent, offsite disposal facility, when available. The majority of the secondary solid waste (e.g., spent LAW melters, spent IX resin) is also planned to be disposed of at the IDF. A disposal pathway for spent HLW melters and spent IX columns from the TSCR/TFPT systems has not yet been decided, although viable options have been identified.

In addition to the facilities shown in Figure 3-3, there are many additional facilities and programs in operation at Hanford that play an integral, but less substantial role in the safe storage, retrieval, and disposal of waste. Examples include the miles of waste transfer lines and supporting facilities, Waste Encapsulation and Storage Facility, and the Vadose Zone Integration Program.

Additional references for the systems and processes provided in the subsections below are listed at the end of each sub-section and available in Section 8.0.

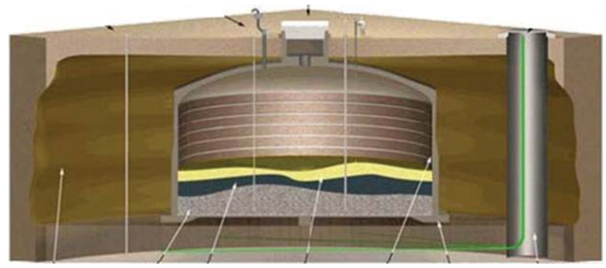
3.1 STORAGE AND RETRIEVAL

3.1.1 Single-Shell Tanks

Status: Existing (interim stabilization complete/retrievals in progress)

Current Responsibility: ORP TOC (Washington River Protection Solutions LLC [WRPS])

Figure 3-4. Simplified Depiction of a Single-Shell Tank.



Discussion: The 149 SSTs on the Hanford Site were constructed between 1943 and 1964 (see example tank in Figure 3-4). There are 66 SSTs located in the 200 East Area and 83 SSTs in the 200 West Area. Of those SSTs, 133 are 100-series tanks that have an available operating volume of 500 kgal to 1.0 Mgal. The remaining 16 tanks are 200-series tanks that have an available operating volume of 55 kgal. The majority of the SSTs contain wastes; however, nearly all of the drainable interstitial liquids have been removed to the criteria required by the SST Interim Stabilization Program.[17] The SST waste inventories consist primarily of sludge and crystallized salts, with only small amounts of free liquid. In total, the SSTs contain approximately 29 Mgal of waste. The SST system is not compliant with RCRA tank systems requirements (e.g., no secondary containment).

The waste remaining in the SSTs will be either retrieved into the DST system where it will be staged for treatment or directly retrieved to the CH-TRU waste treatment process (Section 3.3.1). Retrieval of waste from the SSTs requires the addition of retrieval water and dissolution chemicals, as needed, and the installation of retrieval equipment, such as sluicers. The process of retrieval to the DSTs also requires the utilization of WRFs for SSTs in B and T Complex (Section 3.1.4).

In accordance with TPA Interim Milestone M-045-91, a panel of nationally recognized technical experts was established in 2009 to review SST integrity. The panel identified the "top ten" recommendations that form the foundation for the SST Integrity Program. The integrity program has addressed many of the recommendations, and the results are discussed in RPP-PLAN-60765, *Single-Shell Tank Integrity Program Plan*. Since 2012, all SST video inspections have included evaluation of the tanks for water intrusions, which could lead to waste mobilization into the surrounding environment.

Additional information about the SSTs, including the basis for the amount of water required for a retrieval, dissolution chemical additions, and expected minimum retrieval durations, is provided in RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*. Note, however, that near-term operations, including retrievals in A and AX Tank Farms, are modeled consistent with the Multi-Year Operating Plan (WRPS-1903490, *"WRPS Multi-Year Operating Plan, Revision 8, FY 2020 – FY 2026*"). The Multi-Year Operating Plan does not include the third retrieval technologies identified in RPP-PLAN-40145 for the 241-A[18] and AX Tank Farms' retrievals.

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[17] The Interim Stabilization Program criteria allowed the following amounts to remain in a tank that was then deemed "interim stabilized" if these criteria were met: 50 kgal of drainable interstitial liquids, 5 kgal of supernatant; and less than 0.05 gpm if jet pumping was used.

[18] To aid readability of the document, the official designation of "241-" in tank and tank farm names will be omitted. Unless otherwise specified, tanks and tank farms are classified with "241-."

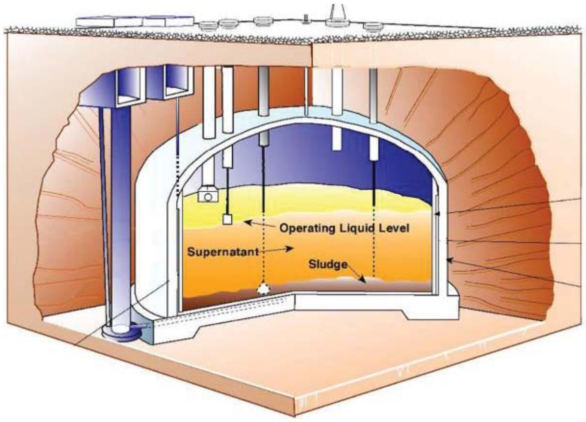
3.1.2 Double-Shell Tanks

Status: 27 DSTs operational, 1 DST confirmed leaker from primary tank

Current Responsibility: ORP TOC (WRPS)

Discussion: The DSTs differ from SSTs primarily by the secondary containment liner (Figure 3-5). There are 28 DSTs on the Hanford Site – 25 in the 200 East Area and three in the 200 West Area. All were constructed between 1968 and 1986. The DSTs contain liquids and settled solids, either salts or sludge. The DSTs currently play an integral role in completing the RPP mission, including the following:

Figure 3-5. Simplified Depiction of a Double-Shell Tank.



- Storing tank waste in accordance with their interim-RCRA status
- Supporting SST retrievals by receiving retrieved SST waste
- Supporting 242-A Evaporator operations (described in Section 3.1.5)
- Staging waste for DFLAW and receiving DFLAW secondary waste
- Staging feed for delivery to the WTP and receiving secondary waste from the WTP.

An established DST Integrity Program evaluates and maintains the structural integrity of the DSTs and ancillary equipment. The scope of the integrity program includes, among other things, both DST inspections (ultrasonic and video examinations) and waste sampling and chemistry adjustments for corrosion mitigation. In 2012, DST AY-102 was discovered to have a small amount of dry material at two locations in the tank annulus (the space between the primary and secondary walls). Subsequent laboratory analysis of the material confirmed that the material was dried waste. Inspections of DST AY-102 and ancillary equipment indicate that no waste has migrated to the surrounding soil. Additional dry material was discovered at a third location inside the annulus in 2014. The supernatant and sludge in DST AY-102 were then moved to Tanks AW-105 and AP-102 in FY 2016 and 2017, respectively, and DST AY-102 was taken out of service.

Effective and efficient management of the storage space available in the remaining 27 DSTs is essential to the success of the RPP mission. The total operating capacity of the 27 DSTs is 31 Mgal. Although the majority of the space in the DSTs is used for waste storage, not all of the space is available for that purpose. Some headspace (the space above the waste surface in the tank) must be set aside to accommodate certain operating constraints such as maintaining emergency space, staging feed to the WTP, and flammable gas hazard mitigation.

Closure of each DST and associated WMA will be completed within approximately 5 years after all Hanford tank waste has been treated. Closure will be conducted in accordance with applicable regulatory requirements.

Detailed information regarding the DSTs and TOC management of the tanks is provided in HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*, and OSD-T-151-00007, *Operating Specifications for the Double-Shell Storage Tanks*.

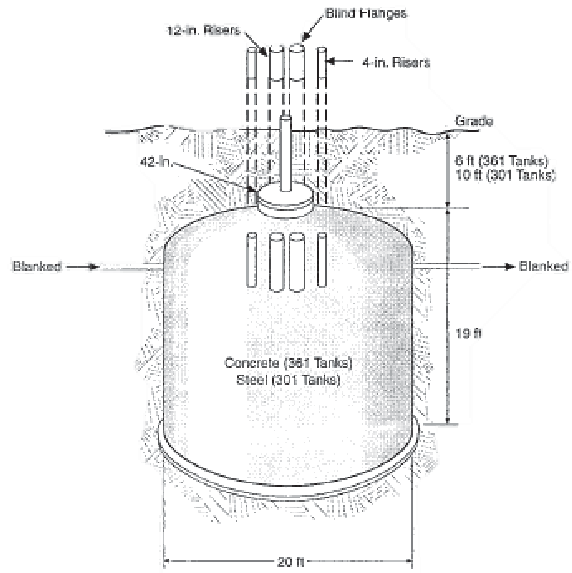
3.1.3 Inactive Miscellaneous Underground Storage Tanks

Status: Operational/Inactive

Current Responsibility: ORP TOC (WRPS) and RL (CH2M HILL Plateau Remediation Company)

Discussion: Additional minor waste sources exist at the Hanford Site in IMUSTs, dozens of which previously supported SST operations. This IMUST waste must be retrieved into the DST system, treated, and the IMUSTs closed under RCRA provisions in accordance with the TPA.

Figure 3-6. One of Many Types of Inactive Miscellaneous Underground Storage Tanks.



The number of IMUSTs (see example tank in Figure 3-6) under ORP management changes over time as the status of waste sites and operable units is better understood and as agreements between ORP and RL are adjusted. There are approximately 100 IMUSTs, including inactive and active tanks (HNF-EP-0182). Waste in some IMUSTs may be difficult to retrieve due to the lack of ready-access ports for retrieval equipment, unknown tank integrity conditions, and incomplete waste characterization data. Although the waste inventory in IMUSTs is small, the effort, resources, and time required for IMUST retrievals can be disproportionately large. Consequently, the retrieval and closure of IMUSTs have the potential to affect the RPP mission cost and duration.

Decisions regarding the retrieval of any remaining liquid or sludge from IMUSTs have not yet been made. For the purposes of this system plan, the waste from the IMUSTs is assumed to be retrieved into the DST system and treated with the rest of the waste. The combined inventory of the IMUSTs was estimated in RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to the Hanford Tank Waste Operation Simulator Model – 2012 Update*, Rev. 5 and email from H. J. Wacek to J. N. Strode "Operational Waste Volume Projection Assumptions for 1996." Additional details regarding retrieval of IMUSTs will be addressed in future system plans as those retrieval plans mature.

Efforts are underway to better integrate the IMUSTs into RPP waste retrieval planning. The following resources are available to understand the IMUSTs and their role in the RPP mission:

- RPP-PLAN-41977, *Single-Shell Tank System Component Identification and Proposed Closure Strategy*
- RPP-RPT-31148, *Composite Liquid Mitigation Report*
- RPP-RPT-42231, *Summary of Twenty-Five Miscellaneous Tanks Associated with the Single-Shell Tank System*

- RPP-RPT-58156, *Basis for Miscellaneous Underground Storage Tanks and Special Surveillance Facilities Waste Volumes Published in HNF-EP-0182 Revision 320 "Waste Tank Summary Report for Month Ending August 31, 2014"*
- WHC-SD-EN-ES-040, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site, Washington*.

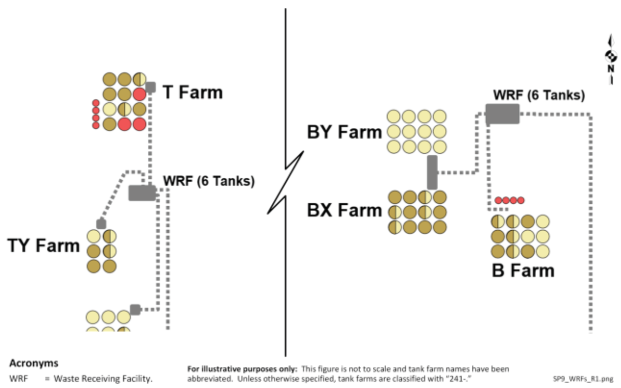
3.1.4 Waste Receiving Facilities

Status: Proposed

Current Responsibility: ORP TOC (WRPS)

Discussion: The SSTs in the B Complex (B, BX and BY Tank Farms) and T Complex (T, TX, and TY Tank Farms) require additional facilities to support retrieval of waste slurries due to the distance of these SSTs from the nearest DST farm. Waste from these locations will be retrieved into a WRF (Figure 3-7) before being transferred to the DST system as per RPP-PLAN-40145. The tank farms' baseline currently includes the design, construction, and operation of two aboveground WRFs, one in the 200 East Area near B Complex, and one in the 200 West Area near T Complex. Each WRF provides the following:

Figure 3-7. Sample Locations of Waste Receiving Facilities.



- Six 150,000-gal waste receipt tanks with pumps, transfer lines to the SSTs, and other ancillary equipment for recycling of supernatant during waste retrieval, thereby minimizing the volume of waste generated by retrieval operations.
- Space for the temporary storage of the retrieved waste, decoupling SST retrievals from the near-term limits of DST storage space.
- Transfer lines to connect the WRFs to the DST system.

Additional information on the WRFs is provided in RPP-RPT-44860, *Mission Analysis Report Waste Feed Delivery Projects East Area Waste Retrieval Facility*.

3.1.5 Cross-Site Transfer Lines

Status: Supernatant – inactive; slurry – not commissioned

Current Responsibility: ORP TOC (WRPS)

Discussion: Over half of the SSTs and three DSTs are located in the 200 West Area. With the exception of potential TRU waste, when retrieved from the 200 West Area, the waste will need to be transferred to the 200 East Area to be treated at the WTP. In the 1990s, a cross-site transfer system was built to replace lines that were plugged and unusable. Completed in 1998, the resulting replacement, consisting of separate supernatant and slurry transfer systems, provides a

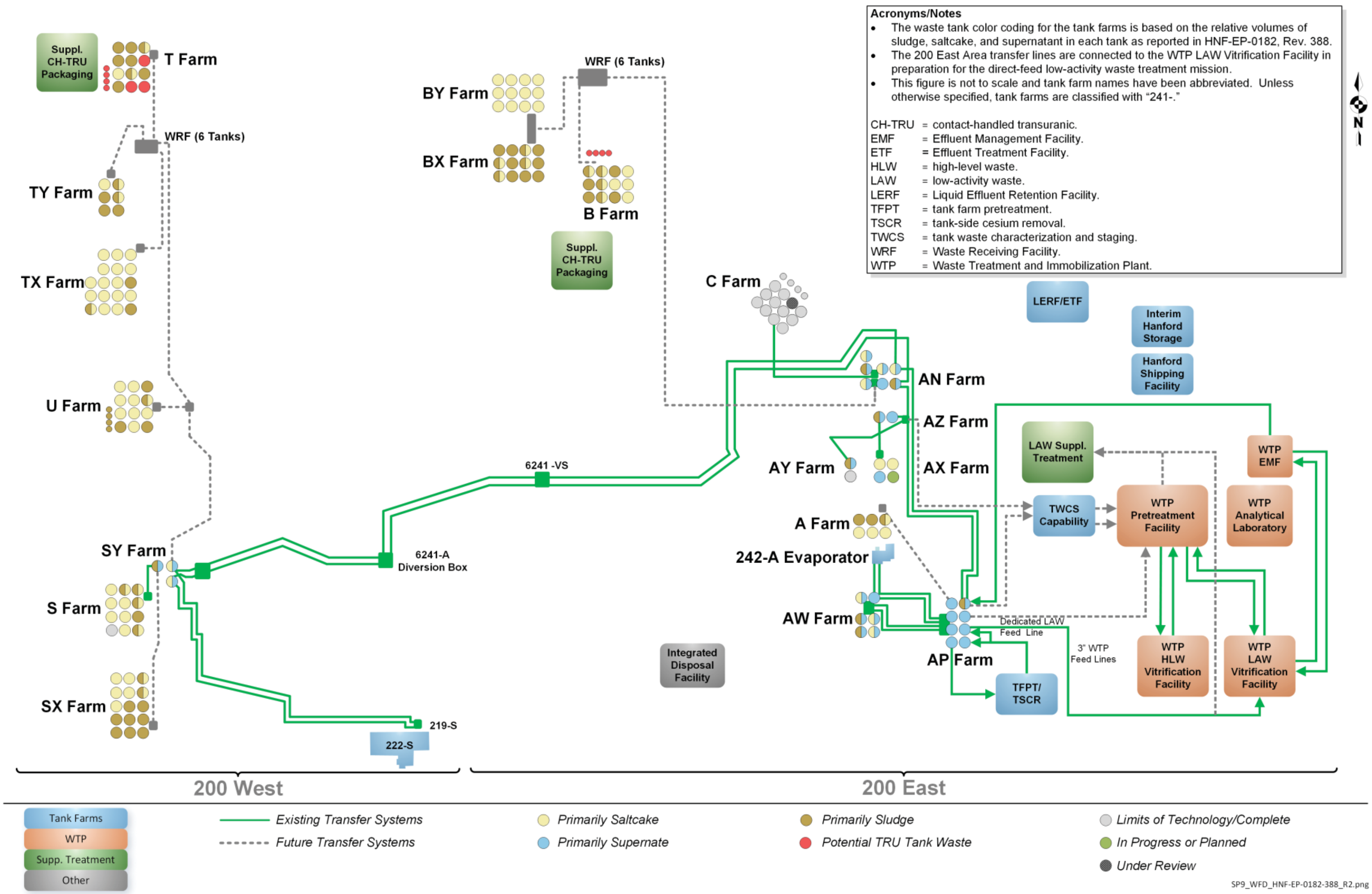
RCRA-compliant transfer system. A graphical representation of the cross-site transfer lines is provided in Figure 3-8. The cross-site transfer system consists of the following:

- Buried pipelines in the 600, 200 East, and 200 West Areas
- SY and AN Tank Farms
- Booster pumps, valving, and components at the 6241-A diversion box
- Valving and components at the 6241-VS vent station
- Monitoring and control hardware and software.

The cross-site transfer system consists of two parallel, pipe-in-pipe lines. The supernatant line extends from the SY-A valve pit in the 200 West Area to the AN-01A valve pit in the 200 East Area from which it can be routed to any 200 East Area DST. The slurry line extends from the SY-B valve pit in the 200 West Area directly into the DST AN-104 Riser 10 in the 200 East Area. An operational readiness review was done on the supernatant portion of the cross-site transfer system; however, the slurry line was never cleared for use. The slurry and supernatant transfer systems are not currently in service, and a project is in place to identify and implement the repairs and upgrades necessary for activation in the 2020s.

Additional information on the cross-site transfer system and its role in the RPP mission is provided in RPP-RPT-47572, *Cross-Site Slurry Line Evaluation Report*, and RPP-RPT-60825, *Reactivation of the Replacement Cross Site Transfer System – Supernatant Line SNL-3150*.

Figure 3-8. Simplified Representation of the Hanford Waste Feed Delivery System.



3.1.6 242-A Evaporator

Status: Operational

Current Responsibility: ORP TOC (WRPS)

Figure 3-9. 242-A Evaporator Facility.

Discussion: The primary mission of the 242-A Evaporator, located in the 200 East Area, north of the AW Tank Farm, and shown in Figure 3-9, is to support tank farms waste storage by reducing dilute waste volume. The 242-A Evaporator operates on a campaign basis, using the time between campaigns to perform maintenance and implement facility upgrades, as necessary.

The 242-A Evaporator began operating in 1977, and since then, the evaporator has boiled off more than 80 Mgal of water from Hanford waste. Space within the existing DSTs is limited; therefore, the 242-A Evaporator is critical to meeting SST retrieval milestones and continuing the cleanup mission. The 242-A Evaporator is also used to concentrate the waste to meet interface control document (ICD) feed requirements for the WTP. The 242-A Evaporator has a final status RCRA Part B permit.

The first step for each campaign is staging and sampling of the candidate waste feed in the DSTs to ensure that the material can be processed within the operating limits of the evaporator and transfer system as per HNF-SD-WM-OCD-015. Then, the waste feed is transferred from DST AW-102 to the 242-A Evaporator and heated to a boil using steam. Once the feed has been sufficiently concentrated, the concentrated feed (or “bottoms”) is pumped to DSTs in either the AP or AW Tank Farm. The offgas leaving the evaporator separator vessel passes through three condensers; the process condensate from the condensers is discharged to the LERF. Non-condensable vapors from the evaporator are filtered and discharged to the atmosphere via the vessel vent system. Steam condensate and the water used to cool the condensers are discharged to the 200 Area Treated Effluent Disposal Facility (TEDF). The current permitted capacity for the TEDF limits the 242-A Evaporator to approximately six campaigns of nominally 1 Mgal per year (*State Waste Discharge Permit Number ST0004502* [Ecology 2000]).

Usage of the 242-A Evaporator is currently limited by the condition of the transfer lines connecting it to DSTs. A project to replace these lines is anticipated to be completed in 2022.

3.2 TESTING

222-S Laboratory

Status: Operational

Current Responsibility: ORP Laboratory Analytical Services and Testing Contract (Wastren Advantage, Inc. for routine testing/analysis); ORP TOC (WRPS for infrastructure support, maintenance, and special analytical services)

Discussion: The 222-S Laboratory is a full-service analytical facility located in the 200 West Area (Figure 3-10) and is capable of handling highly radioactive samples. Organic- and inorganic-material and radiochemical analyses are performed on samples in a variety of sample

Figure 3-10. Aerial View of the 222-S Laboratory.

matrices. The laboratory provides support for a number of essential tank farms activities, including tank-to-tank transfers, tank closure, tank infrastructure maintenance, environmental monitoring, industrial hygiene, vadose zone management, and construction and demolition activities. The laboratory also provides process chemistry support for other operational facilities, such as 242-A Evaporator campaigns, ETF operations, and LERF management. In the future, the 222-S Laboratory will provide support to WTP operations (15-WSC-0067, *One System Decision Document No. 0007, Identification of the DFLAW Waste Feed Qualification Laboratory*).

The 222-S Laboratory services include physical and particle characteristics analyses of the tank waste necessary to enable waste retrievals, providing data to support tank closure requirements, and supporting the tank maintenance program. Investigative analysis and analytical support is provided for equipment materials failure forensics and durability studies of materials used in tank waste environments. The laboratory also supports technology development for the RPP mission, such as testing of proposed treatment and supplemental pretreatment processes using simulants and actual tank waste, verification of waste solid-liquid equilibria, and development of novel industrial hygiene testing methods for waste constituents of potential health concern.

The 222-S Laboratory develops and manages contracts with offsite laboratories providing analytical support for the RPP mission and for the treatment, storage, and disposal facilities servicing the ORP contractors. The facility is the staging and shipping point for most RPP samples and mixed waste leaving the site.

The 222-S Laboratory was constructed between 1950 and 1951. A plan is in place to ensure that the 222-S Laboratory will support mission needs through the completion of tank waste treatment (RPP-RPT-40632, *222-S Life Extension Strategic Management Plan*).

3.3 TREATMENT

3.3.1 Contact-Handled Transuranic Waste Packaging

Status: Early design

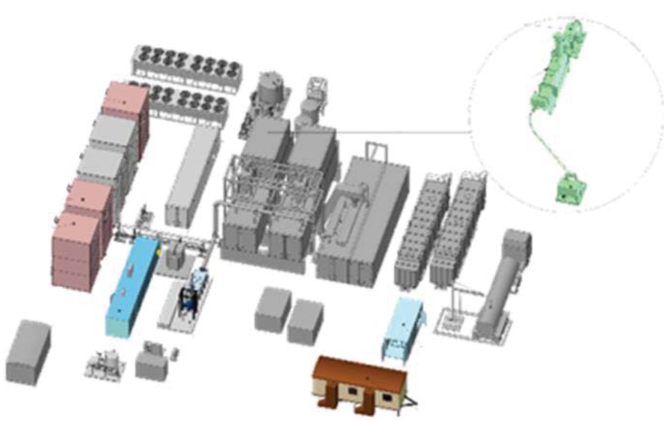
Current Responsibility: ORP TOC (WRPS)

Discussion: The Model Starting Assumptions for potential CH-TRU waste (provided in Section A1.4.2) indicate 11 SSTs will be handled as containing potential CH-TRU tank waste that would be treated at a supplemental TRU treatment facility (Figure 3-11), and then stored onsite at the Central Waste Complex (CWC) until final disposition has been determined.[19]

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

The potential CH-TRU tank waste treatment system design 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 CH-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 LERF/ETF via a tank truck or reused to retrieve and transport additional CH-TRU sludge. Offgas is directed through high-efficiency particulate air filters and then discharged to the atmosphere (RPP-21970, *CH-TRUM WPU&SE 11-Tank Material Balance*).

Figure 3-11. Sample Mobile Transuranic Processing Facility.



Significant design of a potential TRU tank waste packaging system was completed, and several pieces of long-lead fabrication equipment were procured, and some equipment was fabricated. The project was placed on "standby" by DOE in 2005 to await issuance of a ROD including the

[19] The treated potential CH-TRU tank waste could be disposed at WIPP near Carlsbad, New Mexico. To do so, DOE will need to submit a WIPP RCRA Part B Permit Class III permit modification request to the New Mexico Environment Department for approval. Waste that is approved via the permit modification request process for disposal at WIPP will be retrieved, dried, packaged, and certified to meet the WIPP RCRA permit and waste acceptance criteria prior to shipment to WIPP for disposal. However, if DOE elects not to seek permit modification request approval to dispose of this waste at WIPP, or if the permit modification request is denied, that waste could be blended with other Hanford sludge waste and processed in the WTP as HLW.

project. Reactivation of the project will initially involve generation of critical decision (CD) design packages in accordance with DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*. In FY 2014, limited funding was provided to support the resumption of project planning. A study was performed in FY 2015 that evaluated alternative project technologies to be used as input to a future down-selection process that may lead to significant rescoping of the project (RPP-56063, *Transuranic Tank Waste Project Technology Approach Planning*). In the meantime, using the pre-2015 flowsheet provides a basis for comparison between model results in System Plan Rev. 9. The timing of the restart of the potential CH-TRU waste project would likely be determined by the availability of capital funds. Waste packaging would start approximately 5 years after project reactivation.

Additional information related to the disposal of potential CH-TRU tank waste is provided in the following documents:

- Appendix E of DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*
- RPP-21970, *CH-TRUM WPU&SE 11-Tank Material Balance*
- RPP-56063, *Transuranic Tank Waste Project Technology Approach Planning*.

3.3.2 Tank-Side Cesium Removal / Tank Farm Pretreatment

Status: Construction

Current Responsibility: ORP TOC (WRPS)

Discussion: The TSCR system supports the DOE's strategy for DFLAW and will separate cesium and undissolved solids from tank waste, resulting in pretreated waste that will provide initial feed to the WTP LAW Vitrification facility. The TSCR system will be located adjacent to Hanford's AP Tank Farm on a 3,000-ft^2 site and will be comprised of three enclosures: a Process Enclosure, a Control Enclosure, and an Ancillary Enclosure containing supporting equipment and chemicals.

Waste will be staged in a DST, from which the waste will be transferred to the TSCR system. The waste will first pass through a pair of parallel filters to remove undissolved solids. From there, the filtered waste proceeds to a series of three IX columns where the cesium will be removed. The pretreated waste will then be passed through a delay tank and gamma detectors before leaving the system, after which it will be transferred into a second DST that will act as the feed tank for the WTP LAW Vitrification Facility. The solids removed by filtration will be returned to a DST and the spent IX columns will be transferred to an interim storage pad for eventual disposal.

The TSCR system may eventually be replaced by additional supplemental pretreatment capability to provide higher capacity pretreatment better matched to the capacity of the WTP LAW Vitrification Facility. As the specific design of the follow-up pretreatment system has not been determined, the term "tank-farms pretreatment" (TFPT) is being used to describe this additional pretreatment capability. The TSCR/TFPT system will also be a source of additional feed to LAWST (Section 3.3.9). An overview of this system can be seen in Figure 3-12 and Figure 3-13.

Figure 3-12. Overview of the Tank-Side Cesium Removal System.

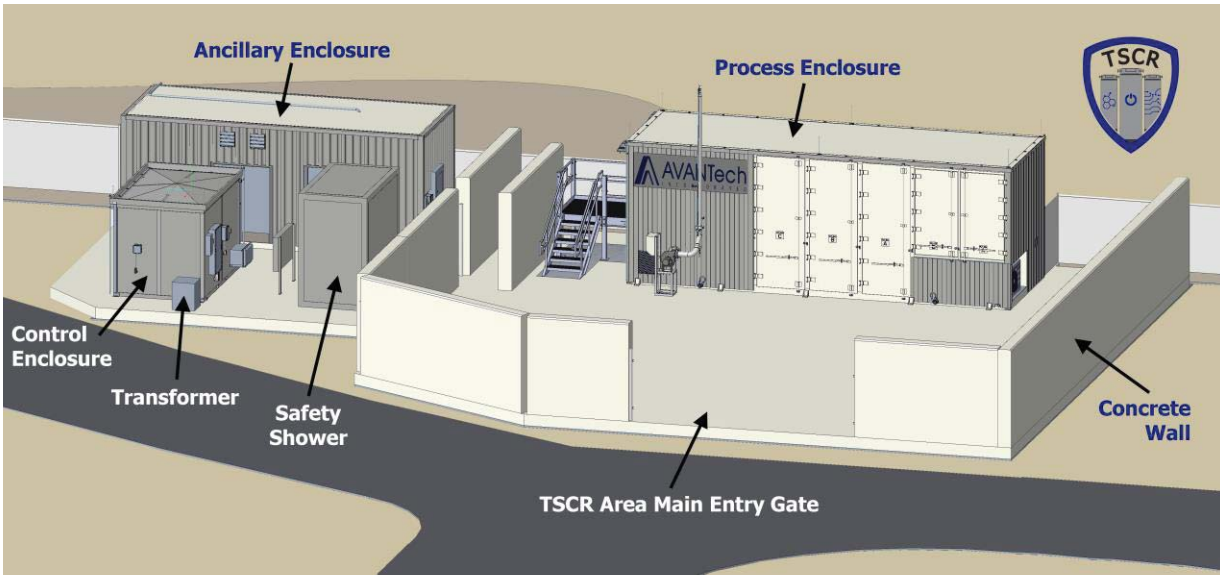
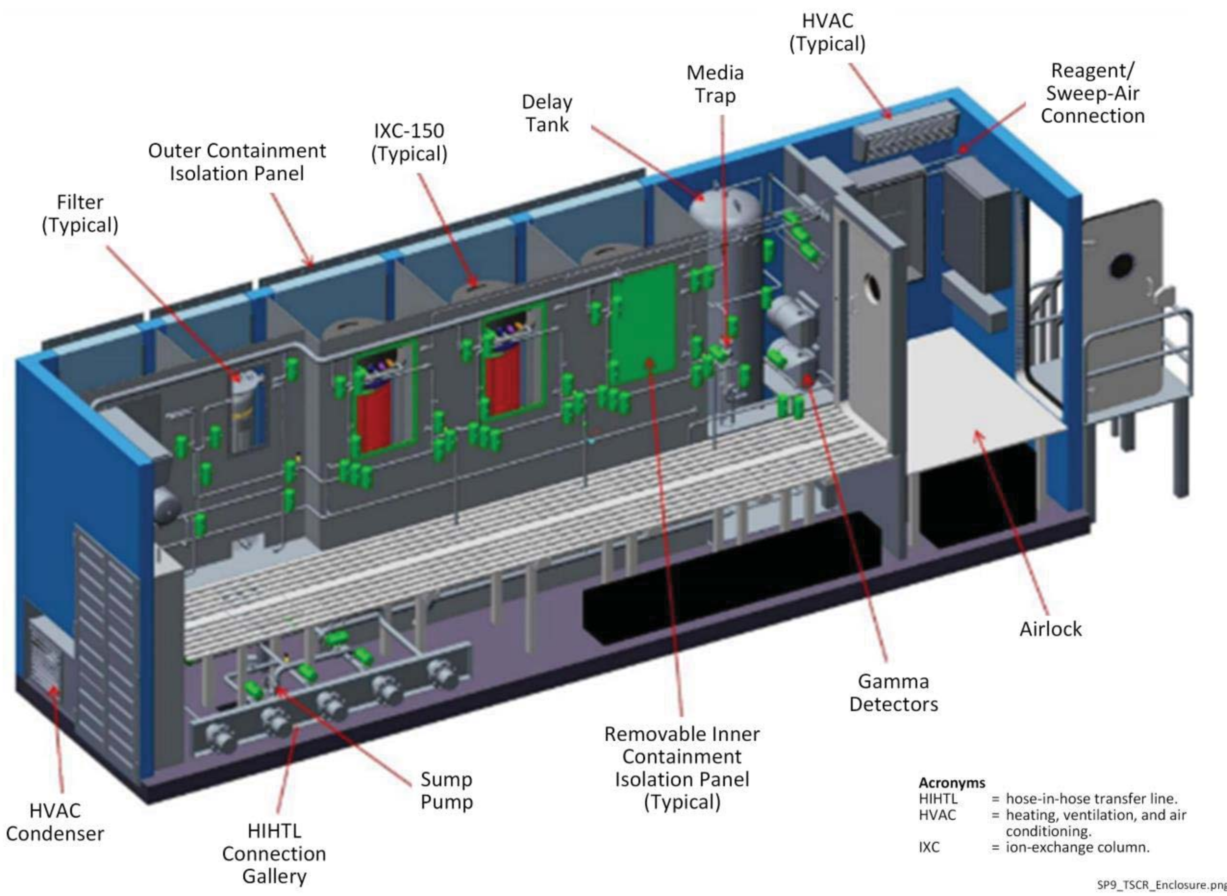


Figure 3-13. Overview of the Tank-Side Cesium Removal System's Process Enclosure.



3.3.3 Tank Waste Characterization and Staging

Status: Future facility

Current Responsibility: ORP TOC (WRPS)

Discussion: A TWCS capability would allow for waste batches to be conditioned, blended, and delivered to the WTP Pretreatment Facility to meet throughput requirements. The TWCS system, to be located in the 200 East Area, is envisioned to provide better slurry mixing, sampling, and feed staging than would otherwise be possible using DSTs. Current planning and assumptions are that the TWCS system will consist of six 500-kgal tanks and meet the functional requirements outlined in the justification. The TWCS tanks are envisioned to accept waste transfers from DSTs, condition the waste (including performing particle size reduction), keep waste slurries adequately suspended to allow representative sampling of the waste, make transfers to each other for blending, and transfer batches of ICD-19-compliant feed (24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed)* to the WTP Pretreatment Facility.

Few details are available for this capability. In September 2015, DOE formally approved the Justification for Mission Need, CD-0, for the TWCS capability to deliver HLW feed to the WTP (Whitney 2015); the design has not started.

Additional information is provided in the following documents:

- RPP-RPT-44860, *Mission Analysis Report Waste Feed Delivery Projects East Area Waste Retrieval Facility*
- RPP-RPT-45955, *East Area Waste Retrieval Facility Location and Tank Configuration Study*
- Whitney (2015), and associated attachments.

3.3.4 Waste Treatment and Immobilization Plant Pretreatment Facility

Status: Design and construction

Current Responsibility: ORP WTP Contract (BNI)

Figure 3-14. Waste Treatment and Immobilization Plant Pretreatment Facility.

Discussion: The WTP Pretreatment Facility (Figure 3-14) prepares waste for delivery to the WTP HLW and LAW Vitrification Facilities. Waste is received from the tank farms into the WTP Pretreatment Facility waste receipt vessels. Supernatant waste is transferred from the DSTs to the four feed-receipt process vessels inside the WTP Pretreatment Facility. A slurry containing both dissolved and undissolved solids is transferred from the TWCS tanks to the HLW feed receipt vessel.

The supernatant is blended with the slurry in the ultrafiltration system. The blended waste is filtered to separate the solids and liquids. The solids are caustic and oxidative leached (as necessary) and washed with additional filtration after each leaching or washing step. This results in the following two streams:

- Ultrafilter permeate, which is processed through IX to remove cesium, blended with the LAW vitrification offgas recycle, concentrated by evaporation, and then transferred to the WTP LAW Vitrification Facility
- Concentrated HLW solids slurry, which is blended with the cesium removed from the IX process before being transferred to the WTP HLW Vitrification Facility.

The WTP Pretreatment Facility waste feed evaporators process recycle streams from the WTP Pretreatment Facility and WTP HLW Vitrification Facility and blend the concentrate into the ultrafiltration feed. The feed evaporators are capable of concentrating dilute waste feed if needed; however, this feature is not used in the baseline flowsheet.

The WTP Pretreatment Facility has a plant wash and disposal system to collect recycle streams and flushes, a radioactive liquid disposal system to collect and store liquid effluents, a pretreatment vessel vent process system, an offgas treatment system, and a stack. Liquid effluents are either recycled back into the facility or sent to the LERF/ETF (see Section 3.3.10).

Additional information on the WTP Pretreatment Facility is provided in 24590-WTP-RPT-PT-02-005.

3.3.5 Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility

Status: Completing construction and turnover of systems to startup

Current Responsibility: ORP WTP Contract (BNI)

Discussion: The WTP LAW Vitrification Facility (Figure 3-15) consists of two melter systems operated in parallel. Each melter system has a dedicated set of feed preparation vessels, a joule-heated ceramic-lined melter, and a primary offgas treatment system. The facility also has a secondary offgas system shared by the two melter systems and vessel vents.

Figure 3-15. Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility.

Pretreated supernatant is received into one of two concentrate receipt vessels within the WTP LAW Vitrification Facility. The pretreated supernatant originates from the DSTs during the DFLAW mission and then from the WTP Pretreatment Facility after startup of the full, integrated WTP. During DFLAW, concentrate from the WTP EMF is also returned to the concentrate receipt vessels for blending with the supernatant feed. Batches of pretreated supernatant are transferred from these vessels to the melter feed preparation vessels, where the waste is blended with glass-forming chemicals. The slurry feed is then transferred to the melter feed vessels, where it is fed continuously to the LAW melters. Bubblers agitate the melter contents to increase the glass production rate. An airlift system pours the glass from the melter into stainless steel containers (Figure 3-16).

Each ILAW container will hold 5.51 metric tons of glass (MTG) on average, and each LAW melter is designed to operate at a capacity of 15 MTG/day of ILAW. The filled ILAW containers will be transferred to the onsite IDF for disposal, consistent with the DOE preferred alternative published in the TC & WM EIS ROD.

Figure 3-16. Example of an Immobilized Low-Activity Waste Glass Container.

3.3.6 Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility

Status: Design and construction

Current Responsibility: ORP WTP Contract (BNI)

Discussion: The WTP HLW Vitrification Facility (Figure 3-17) has two joule-heated ceramic-lined melters, each with its own dedicated feed train and primary offgas system. The two melters share a canister handling system and secondary effluent collection system.

Figure 3-17. Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility.

Figure 3-18. Example of an Immobilized High-Level Waste Glass Canister.

The WTP Pretreatment Facility transfers pretreated slurry to the melter feed preparation vessels, where the waste is blended with glass-forming chemicals. The slurry feed is transferred to the melter feed vessels, where it is fed continuously to the HLW melters. Bubblers agitate the melter contents to increase the glass production rate. An airlift system pours the glass from the melter into stainless steel canisters (Figure 3-18).

Each IHLW canister will hold 3.0 MTG on average, and each HLW melter is designed to support a capacity of 6 MTG/day with the original melters and up to 7.5 MTG/day with replacement melters. After filling, the canisters are decontaminated and transferred to the IHS facility (see Section 3.4.5), where the canisters will await to be transported offsite (through the Hanford Shipping Facility [HSF]) to a geologic repository for disposal.

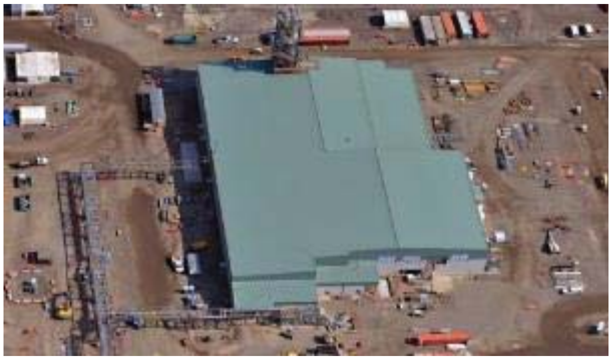
3.3.7 Waste Treatment and Immobilization Plant Analytical Laboratory

Status: Construction complete/preparing for operations

Current Responsibility: ORP WTP Contract (BNI)

Discussion: The WTP Analytical Laboratory, shown in Figure 3-19, will provide operational support to the WTP Pretreatment, HLW Vitrification, and LAW Vitrification Facilities. The laboratory will provide waste characterization data from samples collected at various stages of the treatment process to ensure that the waste complies with applicable requirements and the plants are operating effectively.

Figure 3-19. Waste Treatment and Immobilization Plant Analytical Laboratory.



3.3.8 Waste Treatment and Immobilization Plant Balance of Facilities

Status: Construction complete/systems entered startup and commissioning phases

Current Responsibility: ORP WTP Contract (BNI)

Discussion: The WTP BOF is made up of 14 buildings and 53 systems, plus interconnecting piping, electrical, and other utilities that provide support functions to the WTP's Pretreatment Facility, HLW Vitrification Facility, LAW Vitrification Facility, and Analytical Laboratory. The support functions include, but are not limited to effluent management, chilled water, compressed air, diesel generator, firewater distribution, steam, communications, and process control. (See Figure 3-20 for an example of one of the facilities.)

Figure 3-20. Waste Treatment and Immobilization Plant Balance of Facilities (Cooling Tower Facility).

In addition to utilities, the BOF includes the WTP EMF (Figure 3-21), which provides an alternate means of handling LAW vitrification offgas effluent during the DFLAW mission. The WTP EMF receives secondary effluents from the LAW offgas treatment system, transfer line flushes and drains, and radioactive effluents from the WTP Analytical Laboratory.

The effluents and flushes are collected in the EMF and blended together for evaporation, with the exception of the caustic scrubber effluent. The EMF concentrates the blended effluent to reduce the total volume, and the concentrate is then recycled through the LAW vitrification process. The caustic scrubber effluent is combined with the evaporator condensate and is sent to the LERF/ETF for disposal.

Figure 3-21. Waste Treatment and Immobilization Plant Effluent Management Facility.

Additional information on the WTP EMF is provided in 24590-BOF-3ZD-25-00001, *Effluent Management Facility (EMF) Design Description and System Design Descriptions (ACV,CIV,DEP,DVP)*. Additional information regarding the BOF is provided in 24590-BOF-3YD-50-00002, *Facility Description for the Balance of Facilities*.

3.3.9 Low-Activity Waste Supplemental Treatment

Status: Future facility

Current Responsibility: ORP TOC (WRPS)

Discussion: The WTP LAW Vitrification Facility was not intended to treat the entire inventory of Hanford liquid tank waste in the same period as the solid tank waste can be treated by the WTP HLW Vitrification Facility. Supplemental treatment was always envisioned to treat part of the liquid tank waste. Technologies that have been considered as potential supplemental treatment technologies include joule-heated melter vitrification (similar to WTP), grout, fluidized bed steam reforming, and bulk vitrification. The system plan is a tool that may be used to help define the future scope, technology, cost, and schedule of a LAWST method.

Although the TC & WM EIS evaluated information regarding supplemental treatment technologies, no decision was made in the associated ROD (78 FR 75913) because "DOE does not have a preferred alternative regarding supplemental treatment for LAW; DOE believes it is beneficial to study further the potential cost, safety, and environmental performance of supplemental treatment technologies. When DOE is ready to identify its preferred alternative regarding supplemental treatment for LAW, it will provide a notice of its preferred alternative in the *Federal Register*."

In the system plan, the LAWST capability is not assumed to consist of a particular treatment technology. Multiple technologies will be analyzed, and, based on the waste processed by LAWST, estimated amounts of various proposed immobilized waste forms (e.g., glass, grout) will be reported. For modeling purposes, the LAWST capability will be a vitrification process with the same design and GFMs as the WTP LAW Vitrification Facility. Waste product quantities will be specified in terms of immobilized glass and a grout waste form. In 2013, WRPS conducted screening tests of grout formulations over a range of LAW simulant compositions and waste loadings (RPP-RPT-55960, *Supplemental Immobilization of Hanford Low Activity Waste: Cast Stone Screening Tests*). The study concluded that acceptable grout formulations could be produced at all concentrations and mix ratios tested.

3.3.10 Liquid Effluent Retention Facility / Effluent Treatment Facility

Status: Operational

Current Responsibility: ORP TOC (WRPS)

Discussion: The LERF, shown in Figure 3-22, is designed to store low-activity, potentially hazardous, aqueous waste generated on the Hanford Site from a variety of remediation and waste management activities, such as 242-A Evaporator process condensate and other dilute liquid waste streams. The LERF consists of three lined and covered surface reservoirs that store the aqueous waste and then feed it to the ETF. The ETF consists of a series of wastewater process units that provide for the collection, treatment, and storage of low-level mixed wastes.

Figure 3-22. Liquid Effluent Retention Facility (right)/Effluent Treatment Facility (left).

The main treatment train includes process units that remove or destroy dangerous organic and radioactive constituents from the aqueous waste. The treated liquid effluent is directed to verification tanks, where the solution is sampled, analyzed, and verified to be below release limits. Once verified to be below permit limits, the waste is discharged under a state waste discharge permit and approved delisting petition to the SALDS located in the Hanford 600 Area. The treated effluent is discharged as a non-dangerous, delisted waste. Residue from these treatment processes is concentrated and dried into a powder in a secondary treatment train and disposed of in 55-gal drums at the ERDF. (A project upgrade to solidify residues is planned.) The LERF and ETF, co-located in the 200 East Area, have final-status RCRA Part B permits.

In addition to the waste streams already being collected and treated at the LERF/ETF, liquid effluent secondary wastes generated during waste treatment operations (WTP, LAWST, and supplemental treatment of potential TRU tank waste), will be sent to the ETF for treatment, and then disposed of either as liquids at SALDS or as a solidified waste form at the IDF. A new solidification treatment facility (i.e., waste solidification unit) was proposed for the ETF in the Secondary Liquid Waste Treatment Project conceptual design, which will solidify the liquid waste in a form that will be acceptable for disposal at the IDF. This system plan assumes that the

LERF and ETF will support the needs of the waste treatment mission, and, if not, the required modifications and/or supplemental facilities will be constructed.

Additional information regarding the LERF and the ETF is provided in RPP-RPT-61547, *ETF/TEDF/LERF Life Cycle Study*.

3.4 DISPOSAL

3.4.1 Central Waste Complex

Status: Operational

Current Responsibility: RL Plateau Remediation Contract (CH2M HILL Plateau Remediation Company)

Discussion: The CWC, located in the 200 West Area (see Figure 3-23), began waste management operations in August 1988 and is an interim status RCRA facility. The CWC provides interim compliant storage for solid radioactive and nonradioactive waste from onsite and offsite sources, including LLW, MLLW, solid TRU waste, and CERCLA cleanup activities. The complex consists of multiple buildings and outdoor storage areas categorized into operating or management groups. With approximately 300,000 ft^2 of space, the CWC provides interim storage until appropriate treatment and/or final disposal can be performed.

The CWC generates, stores, overpacks, and transfers/ships dangerous and/or mixed waste in a safe and environmentally compliant manner. The CWC must meet the requirements of WAC 173-303, "Dangerous Waste Regulations," Section 300, "General Waste Analysis." Waste entering the CWC is packaged in containers according to the U.S. Department of Transportation regulations, or onsite requirements, depending on the disposal pathway. All waste currently received at the CWC must be land disposal restriction-compliant, and TRU waste, for acceptance, must meet the requirements of HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*.

Figure 3-23. Aerial View of the Central Waste Complex.

The HNF-EP-0063 requirements allow the CWC to accept TRU and TRUM wastes in a Waste Isolation Pilot Plant (WIPP)-certifiable form, with no identifiable disposition path, only with case-by-case approval from RL. The CWC is assumed to provide, to the extent practical, permitted waste storage and characterization for potential TRU tank waste that is packaged by a supplemental CH-TRU tank waste treatment system.

Additional information regarding the CWC is provided in HNF-EP-0063.

3.4.2 State-Approved Land Disposal Site

Status: Operational

Current Responsibility: ORP TOC (WRPS)

Discussion: The SALDS, shown in Figure 3-24, is located in the 600 Area. Secondary liquid effluents requiring permanent disposal are sampled, monitored, and discharged to the ground. Liquid effluents not requiring treatment (nonradioactive, non-dangerous liquid effluents) are discharged to the TEDF. Contaminated liquid effluents are first treated at the ETF and transferred via pipeline to the SALDS, where the effluent is discharged as non-dangerous, delisted waste, permitted under *State Waste Discharge Permit Number ST0004500* (Ecology 2014).

Figure 3-24. State-Approved Land Disposal Site in the 600 Area.

Additional information on SALDS is provided in the following documents:

- DOE/RL-2005-10, *Application for Renewal of State Waste Discharge Permit ST 4500 for the 200 Area Effluent Treatment Facility*
- Ecology wastewater discharge permitting website, http://www.ecy.wa.gov/programs/nwp/permitting/WWD/
- RPP-RPT-56516, *One System River Protection Project Mission Analysis Report*
- *State Waste Discharge Permit Number ST0004500* (Ecology 2014)
- *State Waste Discharge Permit Number ST0004502* (Ecology 2000).

3.4.3 Integrated Disposal Facility

Status: Construction complete and in pre-active mode

Current Responsibility: RL Plateau Remediation Contract (CH2M HILL Plateau Remediation Company)

Discussion: In the TC & WM EIS ROD (78 FR 75913), DOE announced a decision to operate the IDF (Figure 3-25) located in the 200 East Area, and also construct and operate the River Protection Project Disposal Facility in the 200 Area for disposal of tank closure waste, as needed. The IDF, discussed in this section, provides onsite disposal of LLW and MLLW from the following:

- Tank waste treatment operations
- Waste generated from WTP and ETF operations

Figure 3-25. Integrated Disposal Facility.

- Onsite non-CERCLA sources
- Fast Flux Test Facility decommissioning waste
- Onsite waste management waste.

Currently, the dangerous waste permit for IDF only allows for the following MLLW:

- IDF operational waste
- ILAW in glass form from the WTP LAW Vitrification Facility.

Disposing of any other MLLW will require a permit modification to be approved by Ecology.

The IDF will be operated as an LLW/MLLW disposal facility and used for permanent disposal of ILAW glass.[20] The facility consists of a single landfill with two separate disposal areas called cells. The landfill is designed to be expanded to a total capacity of six cells as additional disposal space is needed. The first phase of the IDF construction was completed in April 2006. One cell is permitted as a RCRA Subtitle C landfill system and designed in accordance with Washington dangerous waste regulations (WAC 173-303). This cell may receive dangerous and/or hazardous waste, specifically MLLW, including the ILAW glass from the WTP LAW Vitrification Facility.

The other cell is specifically excluded from the dangerous waste permit and was previously planned to receive only LLW, not MLLW. With the planned permit modification, both cells will be able to receive MLLW and support disposal of the waste streams consistent with the TC & WM EIS ROD and the DFLAW mission. Both cells include a double-liner system, leachate collection and removal systems, and a leak detection system. The engineered surface barrier has not yet been designed. The preconceptual design is currently a modified RCRA Subtitle C-compliant barrier. The closure cap design will be finalized consistent with site-wide landfill closure cap planning for land-based disposal units. The planned date for the IDF to be operational depends on the schedule for the WTP.

3.4.4 Consolidated Waste Management Facility

Status: Pending

Current Responsibility: ORP TOC (WRPS)

Discussion: TPA Milestone M-047-00 requires work necessary to provide facilities for management of secondary waste from the WTP to be completed by the date that WTP achieves initial plant operations. Most waste streams generated by the WTP will require treatment (i.e., encapsulation, decontamination, void space filling, and some size reduction) prior to final disposal in order to meet the WAC for the eventual disposal site. The Consolidated Waste Management Facility is anticipated to support WTP operations by storing and processing radioactive solid waste created during production of IHLW and ILAW glass canisters prior to permanent disposal in the IDF, another Hanford facility, or offsite.

The option selected to meet these waste storage requirements during the DFLAW mission includes constructing new low-cost, permitted, 90-day waste storage pad(s) for the staging of WTP waste, while using the CWC, an existing, permitted treatment, storage, and disposal facility, for the small amount of waste that might require extended staging. This option can be implemented without affecting the DFLAW critical-path activities. Exceptions to the Hanford Site solid WAC (HNF-EP-0063) can be handled on a case-by-case basis for transferring waste to

[20] Disposal of ILAW glass in the IDF is predicated on approval of a WIR determination per DOE O 435.1-1.

CWC for longer staging times (15-WSC-0020, "One System Decision Document 0003, Consolidated Solid Waste Management Approach").

The approach of using low-cost storage pads with CWC as a backup may also offer a viable template for the full implementation of the Consolidated Waste Management Facility required to support initial plant operations of the integrated WTP. However, a decision has not yet been made.

3.4.5 Interim Hanford Storage

Status: Planned future facility

Current Responsibility: ORP TOC (WRPS)

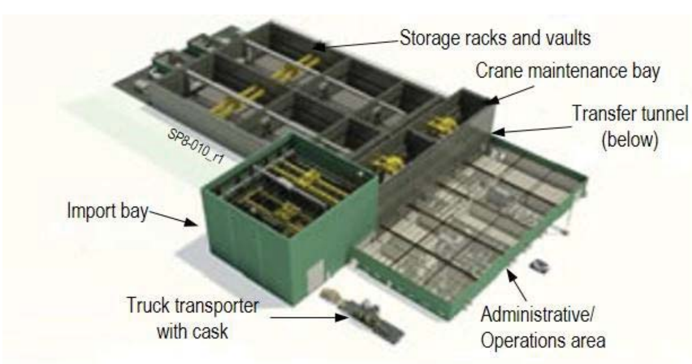
Discussion: The current process flowsheet, depicted in Figure 3-3, requires temporary storage of IHLW canisters prior to them being transferred to the HSF (Section 3.4.6) for shipment to a final offsite disposal location because the WTP HLW Vitrification Facility Export Cave Room has only 46 storage rack slots. Without adequate temporary storage for IHLW canisters, HLW processing could be delayed or shutdown.

The IHS facility, shown in Figure 3-26, will provide safe, economic, and environmentally sound receipt, handling, and storage of the first 4,000 IHLW canisters after the startup of WTP HLW Vitrification Facility operations. Subsequent IHLW canisters are assumed to be shipped to an offsite geological repository (if available) as they are produced. In the TC & WM EIS ROD, DOE indicated that enough IHLW interim storage modules should be constructed to store all IHLW generated by WTP treatment (78 FR 75913). At this time, the IHS facility is expandable in 2,000-canister increments, up to a total of 16,000 canisters, and includes a future offsite shipping module referred to as the HSF (RPP-PLAN-48151, *Interim Hanford Storage Project Execution Plan*).

According to RPP-PLAN-48151, IHS Project T3W14 is currently at CD-0, having completed conceptual design in this project definition phase and a demonstrated mission need. An approved alternative selection and cost range are needed for the project to achieve CD-1. Alternative selections have been evaluated, with the recommendation for an open rack configuration (RPP-RPT-50488, *Project T3W14 Interim Hanford Storage [IHS] Alternative Decision Document*). The open rack storage option uses standard handling technologies based on established and proven mechanical handling machinery. The IHS facility is also designed with a compact footprint, a simple configuration with redundancies, and ventilation to accommodate a range of possible heat loads.

Additional information on the IHS facility is provided in RPP-RPT-52176, *Interim Hanford Storage Conceptual Design Report*.

Figure 3-26. Conceptual Interim Hanford Storage Isometric.



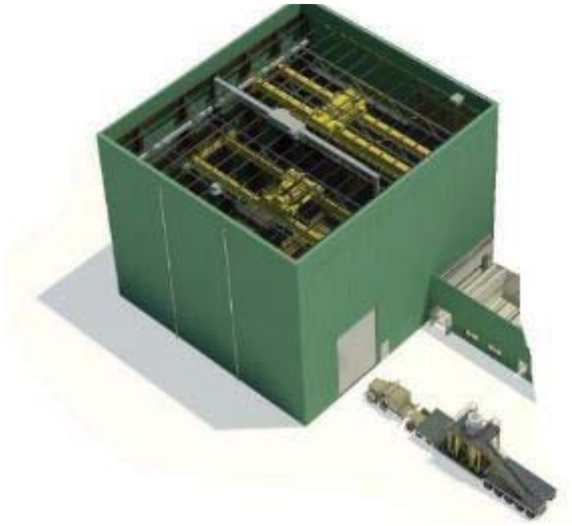
3.4.6 Hanford Shipping Facility

Status: Potential future facility

Current Responsibility: ORP TOC (WRPS)

Discussion: The current flowsheet identifies the HSF, shown in Figure 3-27, as the means of receiving, packaging, and loading the IHLW canisters from the IHS facility for transport to an offsite repository. In 2009, the near-term focus for HLW disposal shifted from shipping to onsite storage due to the uncertainty of an available repository (WRPS-0900637, "Contract number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Reaffirmation of Mission Need for Hanford Shipping Facility").

Figure 3-27. Conceptual Hanford Shipping Facility.



As currently envisioned, the HSF will receive, package, and stage the IHLW canisters from the WTP HLW Vitrification Facility (managed by ORP) and the spent nuclear fuel multi-canister overpacks and standard canisters (managed by RL). With disposal of IHLW managed by the DOE Office of Civilian Radioactive Waste Management, the canisters and overpacks will be packaged into casks in accordance with that office's procedures. The casks will be loaded onto transport vehicles for offsite shipment at a minimum rate of 600 per year (DE-AC27-08RV14800, *Tank Operations Contract*, Section C.2.3.3)

The HSF will be located in the 200 East Area and, as a result of the shift in focus to storage, will likely be built as part of the IHS facility (RPP-34544, *Cost Benefit Analysis for Immobilized High-Level Waste Storage*). Assumptions regarding HSF availability are provided in Section A1.5.4.

Additional information on the HSF is provided in RPP-RPT-52176.

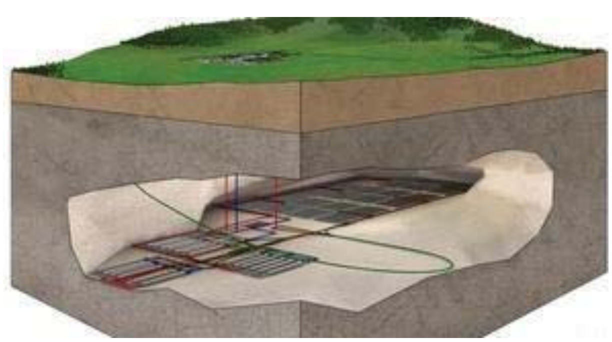
3.4.7 Federal Geological Repository

Status: Pending decisions

Current Responsibility: Other contractor

Discussion: As shown in Figure 3-3, the current flowsheet routes IHLW canisters from the WTP HLW Vitrification Facility to the IHS facility for temporary storage until the canisters are shipped via the HSF to a federal offsite repository. A deep geological repository, illustrated in Figure 3-28, is defined by the NRC as "an excavated, underground facility that is designed, constructed, and operated for safe and secure permanent disposal of high-level radioactive waste." Until the final

Figure 3-28. Deep Geological Repository Example.



disposal site has been determined, Hanford's IHLW canisters will be stored at the Hanford IHS facility.

Additional information is provided in DOE/EIS-0250F-S1D, *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, and the *Nuclear Waste Policy Act*, as amended.

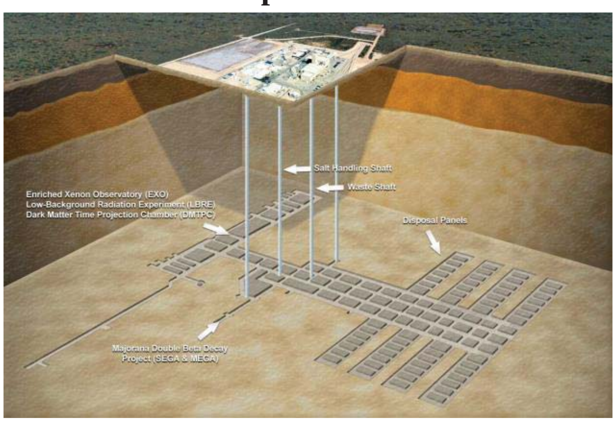
3.4.8 Defense-Related Transuranic Waste Disposal

Status: Operational

Current Responsibility: Other contractor

Discussion: The current process flowsheet, depicted in Figure 3-3, assumes that CH-TRU waste produced by the potential CH-TRU tank waste treatment and packaging process will be disposed of at a national, defense-related-TRU repository. The WIPP, near Carslbad, New Mexico, is the nation's only deep geologic repository that provides permanent underground disposal for defense-related CH-TRU and remote-handled TRU wastes. The underground repository, illustrated in Figure 3-29, is carved out of a 2,000-ft-thick underground salt bed that formed 250 million years ago.

Figure 3-29. Example Transuranic Waste Disposal Site.



Potential TRU waste is disposed of 2,150 ft underground in rooms mined from the salt bed. The salt bed is easily mined, impermeable, geologically stable, and free of fresh flowing water. The salt bed acts as a viscous fluid, gradually sealing any cracks or openings, allowing the salt to naturally encapsulate and contain the waste placed within it.

Potential TRU waste must undergo a certification process before it can be shipped to WIPP. The certification process ensures that the waste meets the WIPP WAC and that the waste can be safely disposed of at the facility. There is no current TRU waste certification program at Hanford; however, waste certification was previously performed at the Waste Receiving and Packaging Facility, adjacent to the CWC. Most packaged TRU waste awaiting certification is stored at the CWC. The CWC WAC require that TRU waste be packaged in a WIPP-compliant form before the waste can be accepted for storage.

Additional information is provided in DOE/WIPP-02-3122, *Transuranic WAC for the Waste Isolation Pilot Plant*, and *Waste Isolation Pilot Plant, Hazardous Waste Permit*.

4.0 KEY ACCOMPLISHMENTS AND UPDATES SINCE SYSTEM PLAN REVISION 8

Many updates, upgrades, and improvements have been made to facilities and in the field since System Plan Rev. 8 was published in October 2017. Ongoing field activities are vital in furthering the RPP mission. These field accomplishments are completed not only to fulfill regulatory obligations, but also to prepare for DFLAW as well as longer-term preparations for future retrieval and treatment activities. Listing the full breadth of accomplishments would not serve the length of this document due to the vast number of activities completed. The following subsections provide key accomplishments and RPP system updates from May 2017 through May 2020.

4.1 KEY ACCOMPLISHMENTS

4.1.1 Tank Operations Contract Contractor

The following highlights describe key accomplishments and updates for the TOC contractor (DE-AC27-08RV14800) since System Plan Rev. 8.

- Tank C-105 reached the limits of both second and third retrieval technologies. The ORP certified retrieval completion was submitted to Ecology in June 2018. In August 2018, ORP sent a letter notifying Ecology that DOE had completed the requirements of Consent Decree Milestone B-1. The Retrieval Data Report for Tank C-105 was submitted to Ecology in June 2019, completing TPA Milestone M-45-86D. (18-TF-0044, "The U.S. Department of Energy Office of River Protection Submits the Retrieval Completion Certification Report for Tank 241-C-105;" RPP-RPT-60717, *Retrieval Completion Certification Report for Tank 241-C-105*; 19-TPD-0011, "Contract No. DE-AC27-08RV14900 – The U.S. Department of Energy Office of River Protection Submits the Retrieval Data Report for Tank 241-C-105;" RPP-RPT-61449, *Retrieval Data Report for Single-Shell Tank 241-C-105*)

- Recent calculations performed confirmed the residual waste volume in Tank C-106 is 316.66 ft^3, meeting the TPA Appendix H retrieval goal defined in M-045-00 of 360 ft^3. (20-ECD-0016, "U.S. Department of Energy Rescinds 'Request for Waiver to Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for Single-Shell Tank 241-C-106,' 18-ECD-0055 Dated August 15, 2018")

- The maintenance and surveillance footprint for C Tank Farm was reduced which mitigates the potential effects of equipment degradation on the environment by dispositioning in-farm equipment. C Tank Farm was prepared for turnover to Production Operations for surveillance and monitoring pending closure.

- Retrieval operations in Tank AX-102 were completed in January 2020 (with first and second technologies) following the removal of old equipment and installation of retrieval equipment. (RPP-RPT-62066, *Single-Shell Tank 241-AX-102 Retrieval Completion Report*)

- Approximately 20 pieces of old equipment were removed from the remaining tanks in the AX Tank Farm and new retrieval equipment was installed in preparation for continued and future retrieval operation activities.

- After removal of old equipment from tanks in the A Tank Farm, a new exhauster and ventilation system was designed, fabricated, and installed.
- The procurement and installation of 18 new or replacement pieces of analytical equipment were completed in the 222-S Laboratory. The installation of four additional instruments is planned to be completed by the end of FY 2020.
- More than a dozen infrastructure upgrades and operations and maintenance activities were completed to support life extension of the 222-S Laboratory.
- Forty-three SST visual inspections, 12 DST ultrasonic testing examinations, and 29 DST air slot/annulus visual inspections were performed.
- Tank farms upgrade projects in A and AX Tank Farms were completed including pump installations, power/electrical upgrades, flow instrumentation installations, etc.
- Waste sampling activities were performed in 27 DSTs.
- The inventory at the LERF was reduced by approximately 6 Mgal.
- Two LERF basin covers were replaced.
- In support of upcoming DFLAW operations, several of many ongoing ETF upgrade projects (air compressor installation, peroxide destruction decomposer vessel removal and installation, verification tank #1 repairs, and three leachate pumping system upgrades) were completed.
- The TSCR design and fabrication contract was awarded, followed by the submittal to and approval by ORP of the safety design strategy for the TSCR demonstration.
- The test reports for TSCR support testing were submitted to ORP following completion of the testing plan for the TSCR technology to be used.
- The RCRA permit for the TSCR project was completed and submitted to ORP.
- CD-2/3 was approved for the schedule, scope, and cost baseline for TSCR and the waste feed delivery infrastructure. Subsequently, ORP issued a letter approving the start of TSCR construction.
- TSCR factory acceptance testing was completed successfully verifying TSCR system performance.
- In preparation for DFLAW activities, Tank AP-106 was repurposed to prepare the tank as the clarified waste receiver for treated TSCR waste.
- The first three engineered pallets that will be used to transport containers of glassified waste as part of the ILAW transporter system passed inspection.

4.1.2 Waste Treatment and Immobilization Plant Contractor

The following highlights describe key accomplishments and updates for the WTP contractor (DE-AC27-01RV14136, *Design Construction and Commissioning of the Waste Treatment and*

Immobilization Plant) since System Plan Rev. 8. (WRPS-2001154, "RE: Information Request for RPP System Plan")

- The WTP's BOF was transitioned from construction to startup after permanent power was supplied and all modifications to support the DFLAW configuration were completed.
- The final assembly of the first and second melters in the WTP LAW Vitrification Facility was completed.
- The initial documented safety analysis and technical safety requirements for the WTP LAW Vitrification Facility were approved by DOE.
- The following items were completed for the WTP Analytical Laboratory: permanent power was supplied, all systems were turned over from construction to startup for testing, the first analytical equipment was delivered, and the first team of chemists began setup.
- Construction and vessel installations were started at the WTP EMF, and all process vessels were installed.
- Permanent power was delivered to the WTP LAW Vitrification Facility followed by full operations of the WTP LAW Vitrification Facility control room.
- The last of the eight technical issues for the WTP Pretreatment Facility was resolved by DOE.
- The contract to provide engineered stainless-steel containers to hold vitrified waste for safe, long-term storage, and a spare melter for the WTP LAW Vitrification Facility was awarded. This is in preparation for the DFLAW program to begin by the end of 2023. (WRPS-2001873, "RE: Information Request for RPP System Plan")
- The milestone for the WTP Analytical Laboratory startup component and system testing was completed.

4.2 UPDATES

As a result of an agreement between DOE and the State of Washington, and in conjunction with the resolution of litigation pertaining to tank vapors, on October 12, 2018, the courts issued the Third Amended Consent Decree, extending the following milestone dates:

- Milestone B-2 for retrieval of all nine of the aforementioned tanks was extended from March 31, 2024 to September 30, 2026.
- Milestone B-3 for retrieval of at least five of the specified tanks was extended from December 31, 2020 to June 30, 2021.

In early 2019, slurry lines in the 242-A Evaporator failed pressure tests preventing further hot campaigns that are performed to concentrate waste in the tank farms. A project to replace the slurry transfer lines is currently underway and expected to be completed by June 2022.

On March 24, 2020, the Hanford Site moved to an essential mission-critical operations posture in recognition of the increasing COVID-19 concerns. Potential schedule consequences due to the partial stop work order are not assessed in this system plan.

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5.0 SCENARIOS

Two of the primary purposes of System Plan Rev. 9 are to provide a possible baseline for executing the RPP mission and to explore alternative operating scenarios in support of the TPA. Scenario 1 – Baseline Case uses the Model Starting Assumptions included in Appendix A. The purpose of the scenarios is to assess the effects of various scenario-specific planning assumptions on the RPP mission.

The following sections include the analyses for the scenarios and sensitivities evaluated, which are summarized in Table 5-1. The data are presented with a series of graphs and tables. Detailed schedule graphics representing the cost basis for each scenario are provided in Appendix C. Additional data is also available in RPP-RPT-62561, *TOPSim Model Data Package for the River Protection Project System Plan, Revision 9, Scenarios*.

Table 5-1. List of Scenarios and Sensitivities for System Plan Revision 9.

Scenario #	Scenario Name
Scenario 1	Baseline Case
Scenario 1A	Baseline Case Sensitivity – U Tank Farm Retrieved after A/AX Tank Farms
Scenario 1B	Baseline Case Sensitivity – Reduced WTP TOE
Scenario 1C	Baseline Case Sensitivity – Limited Simultaneous SST Retrievals
Scenario 1D	Baseline Case Sensitivity – No Supplemental CH-TRU Processing
Scenario 2	Treatment-Favored DFLAW and DF-HLW with Early Characterization in DSTs
Scenario 2A	Scenario 2 Sensitivity – Add New DSTs
Scenario 2B	Scenario 2 Sensitivity – Slower WTP Ramp-Up
Scenario 2C	Scenario 2 Sensitivity – Increased WTP TOE
Scenario 3	Treatment-Favored DFLAW and DF-HLW with Independent HLW Sampling and Pretreatment Facility
Scenario 3A	Scenario 3 Sensitivity – Retrieval-Favored DFLAW and DF-HLW with Independent HLW Sampling and Pretreatment Facility and Add New DSTs
Scenario 4	Retrieval-Favored DFLAW and DF-HLW with Early Characterization in DSTs and Add New DSTs
Scenario 4A	Scenario 4 Sensitivity – Increased WTP TOE
Scenario 5	Periodic DST Failures

CH-TRU = contact-handled transuranic.
DF-HLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HLW = high-level waste.
SST = single-shell tank.
TOE = total operating efficiency.
WTP = Waste Treatment and Immobilization Plant.

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5.1 SCENARIO 1 – BASELINE CASE

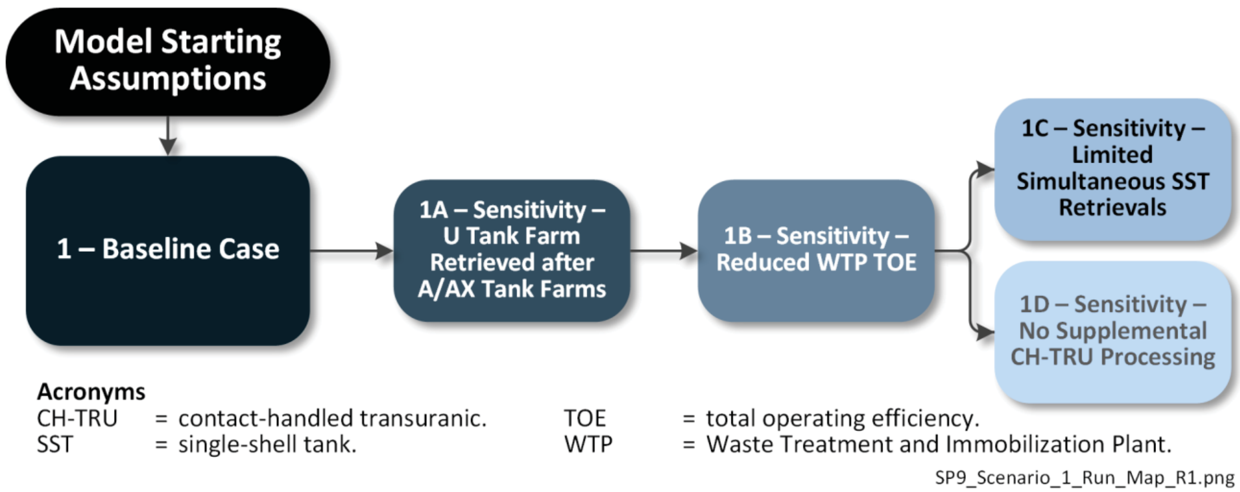
5.1.1 Objective and Planning Bases

The objectives of Scenario 1 – Baseline Case (hereafter referred to as "Baseline Case") is to (1) evaluate the RPP mission using current baseline plans and assumptions, (2) derive estimated retrieval and treatment completion dates using input dates from the Amended Consent Decree (2016), and (3) to assess the ability to comply with the Consent Decree[21] and the TPA. The four related sensitivity scenarios are listed below. Figure 5-1 shows the correlation between the primary scenario and its associated sensitivities.

- Scenario 1A – U Tank Farm Retrieved after A/AX Tank Farms
- Scenario 1B – Reduced WTP TOE
- Scenario 1C – Limited Simultaneous SST Retrievals
- Scenario 1D – No Supplemental CH-TRU Processing.

The planning bases for the Baseline Case are captured in the Model Starting Assumptions in Appendix A. The flowsheet for the Baseline Case is described in Section 3.0 and illustrated in Figure 3-3.

Figure 5-1. Baseline Case – Relationship to Sensitivity Scenarios.



[21] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (E.D. WA October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

5.1.2 Analysis

5.1.2.1 Key Results

The Baseline Case shows that the tank farms, together with the WTP, a LAWST capability, and the potential CH-TRU tank waste treatment process, could retrieve and treat the Hanford tank waste with an estimated life-cycle cost of $107 billion ($192 billion escalated), contingent on successful resolution of the key issues and uncertainties (see Section 7.0). The Baseline Case, which begins treating supernatant and slurry wastes in 2023 and 2033, respectively, projects that the Hanford SST retrievals would be completed by 2061 and all waste would be treated by 2066.

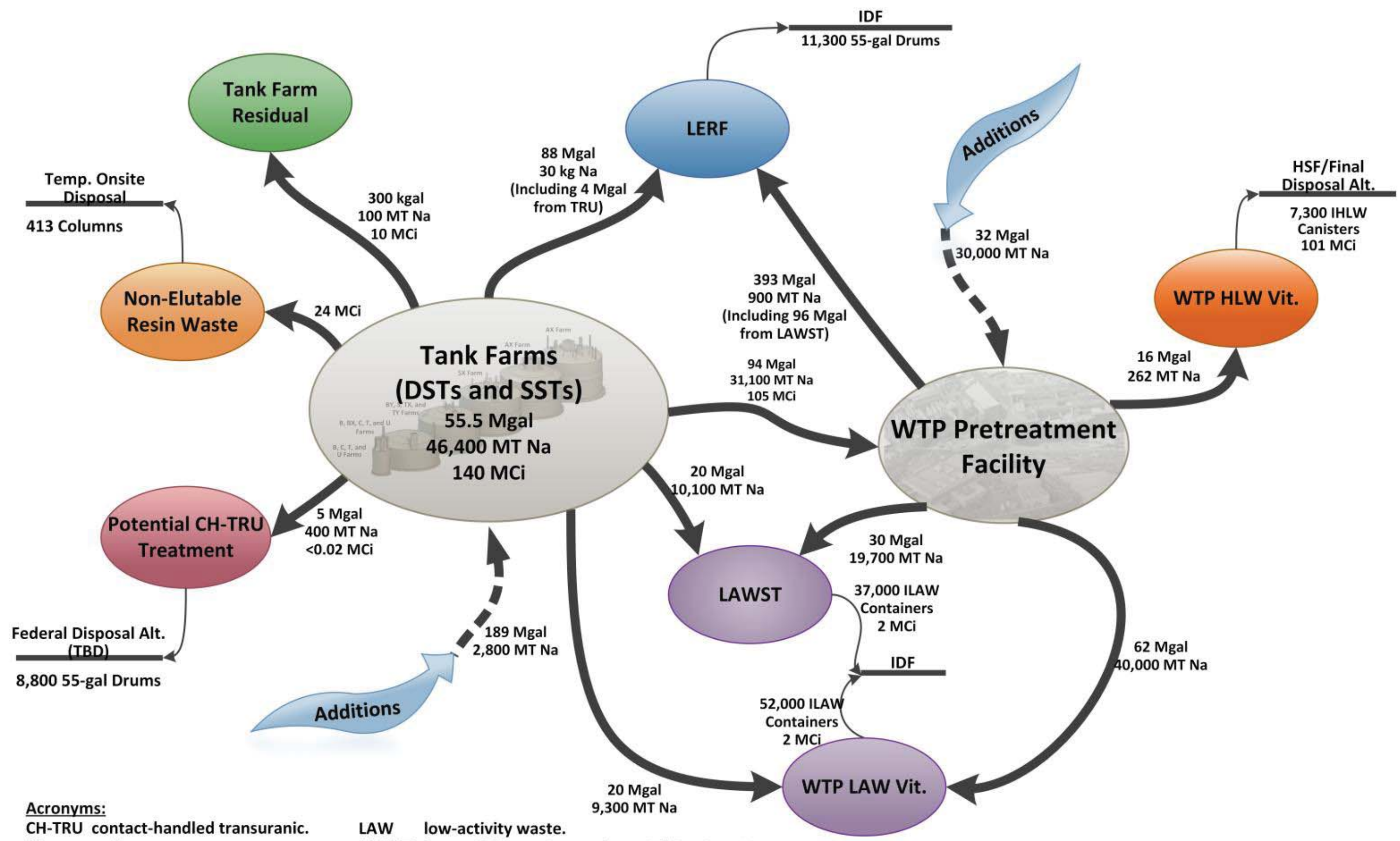
The near-term cost estimate through FY 2023 is approximately $900 million per year, and there is a sharp increase in required funding above the current and historical funding levels starting in 2024. This occurs because of the costs associated with the design and construction of the TWCS and LAWST capabilities (costed as a vitrification facility), as well as the cost of DFLAW operations. The annual cost increases steadily to $3 billion unescalated in FY 2031, when major construction of these new capabilities is complete. The life-cycle cost does not include WTP construction costs. The costs for completing the WTP Pretreatment Facility and the WTP HLW Vitrification Facility, if included, would further exacerbate the issue of increased funding requirements through the early 2030s. After the integrated WTP and the LAWST capability start in FY 2034 and 2035, respectively, the annual costs are relatively constant at approximately $2 billion unescalated until the end of treatment in 2066. If the LAWST capability is costed as a grout facility instead, the life-cycle cost can be maintained at under $2 billion unescalated annually for the entire mission.

Figure 5-2 shows the disposal pathways for over 56 Mgal of original tank waste consisting of over 46,000 MT of sodium and 140 MCi of radioactivity (back-decayed to January 1, 2020). Approximately 90 percent of the radioactivity is dispositioned within the 7,300 canisters of IHLW and the resin associated with the TFPT system. The bulk of the salts (waste and added sodium) are dispositioned within the 89,000 containers of ILAW.

The management of DST space, up until all treatment facilities have reached their full capacities, is critical in maintaining the progress of SST retrievals. The 242-A Evaporator is vital to the mission’s success by concentrating the dilute feed produced by SST retrievals and reducing the volume by nearly half, thereby creating space in the DST system for continued operations.

For most of the waste treatment mission, the duration of the Baseline Case is driven by HLW pretreatment. Specifically, the WTP Pretreatment Facility does not pretreat HLW at a rate that is sufficient to allow the WTP HLW Vitrification Facility to operate at its capacity. As a result, HLW pretreatment is the rate-limiting step, because the LAWST capability is sized as large as needed to keep pace with HLW processing.

Figure 5-2. Baseline Case – Summary of Waste Disposition.



Acronyms:

CH-TRU	contact-handled transuranic.	LAW	low-activity waste.
Ci	curie.	LAWST	low-activity waste supplemental treatment.
DST	double-shell tank.	LERF	Liquid Effluent Retention Facility.
g	gram.	M	million.
gal	gallon.	Mgal	million gallons.
HLW	high-level waste.	MT	metric ton.
HSF	Hanford Shipping Facility.	SST	single-shell tank.
IDF	Integrated Disposal Facility.	TRU	transuranic.
IHLW	immobilized high-level waste.	Vit.	Vitrification (Facility.)
ILAW	immobilized low-activity waste.	WTP	Hanford Tank Waste Treatment and Immobilization Plant.
k	kilo.		

NOTE: For illustration purposes only. The balance seen has been simplified and results have been rounded. All curie values are back-decayed to January 1, 2016

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5.1.2.2 Mission Schedule Results

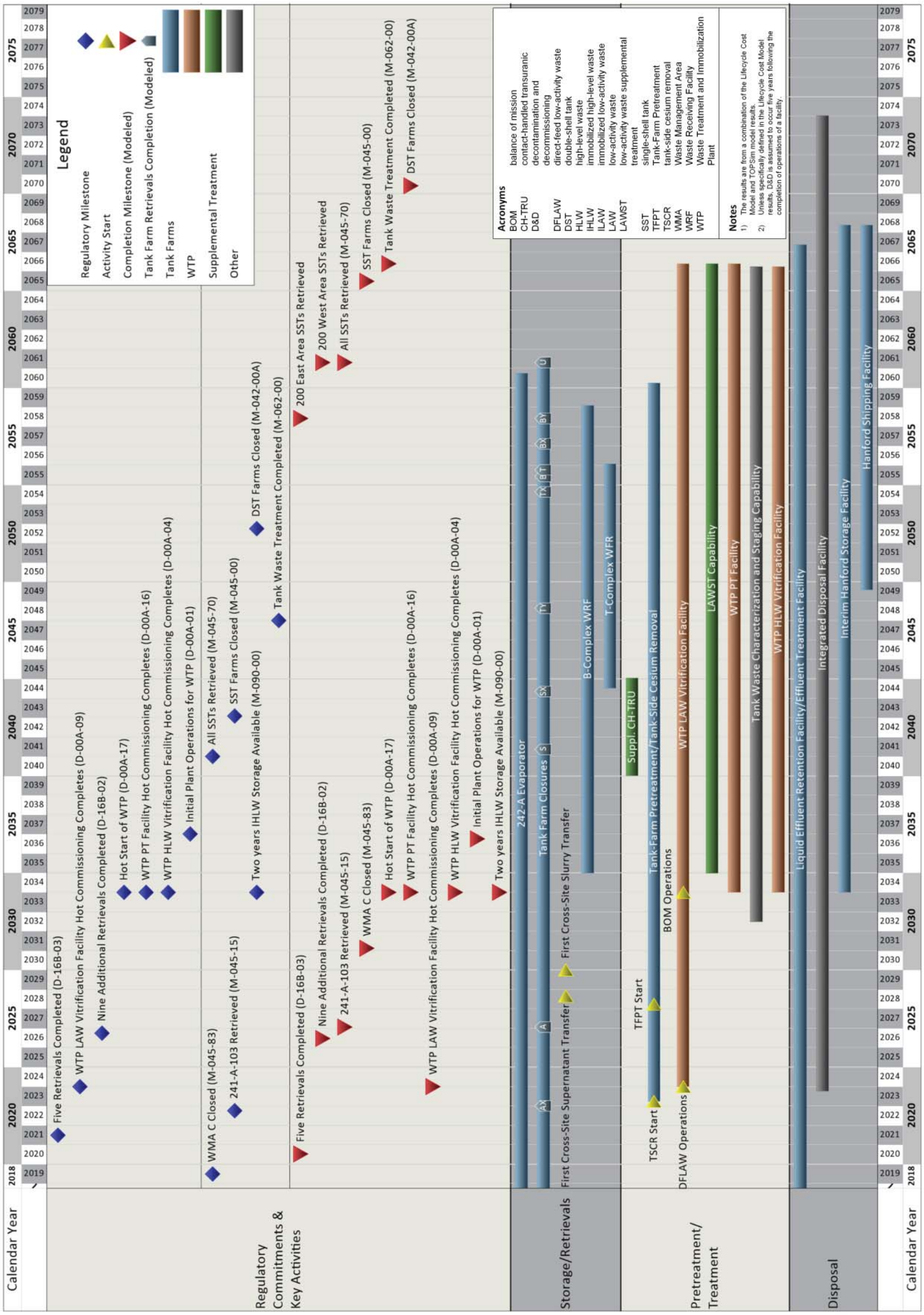
Given the current planning bases and assumptions, TOPSim projects that the WTP LAW Vitrification Facility will operate for 43 years, and the WTP Pretreatment and WTP HLW Vitrification Facilities will operate for 33 years. Table 5-2 lists the key mission activity dates for the Baseline Case, followed by Figure 5-3 that shows the projected operating schedule for SST retrievals and treatment systems.

Table 5-2. Baseline Case – Summary of Schedule Results.

	Key Mission Metric	Baseline Case
Regulatory	Complete Five Additional SST Retrievals (Existing Consent Decree 06/30/2021)	07/2020
	Complete Nine Additional SST Retrievals (Existing Consent Decree 09/30/2026)	06/2026
	Complete Tank 241-A-103 Retrieval (Existing TPA 09/30/2022)	01/2027
Storage/Retrieval	242-A Evaporator Operations	Present – 2060
	200 East Area WRF Operations	2034 – 2059
	200 West Area WRF Operations	2044 – 2056
	200 East Area SST Retrievals Complete	2058
	200 West Area SST Retrievals Complete	2061
	Cross-Site Transfer Line Activated (Supernatant)	2028
	Cross-Site Transfer Line Activated (Slurry)	2029
Pretreatment/Treatment	TSCR/TFPT Operations	2023 – 2060
	TWCS Capability Operations	2032 – 2066
	WTP Pretreatment Facility Operations	2033 – 2066
	WTP LAW Vitrification Facility Operations	2023 – 2066
	WTP HLW Vitrification Facility Operations	2033 – 2066
	LAWST Operations	2034 – 2066
	Potential CH-TRU Waste Packaging Facility Operations	2040 – 2045
	LERF/ETF Operations	Present – 2067
	Waste Treatment Complete	2066
Disposal	IDF Operations	2023 – 2074
	IHS Facility Operations	2033 – 2068
	HSF Offsite Shipping Operations	2049 – 2068
	All IHLW Shipped Offsite	2068

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
LERF = Liquid Effluent Retention Facility.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-3. Baseline Case – Modeled Operating Schedule of Major Facilities/Processes.



5.1.2.3 Uncertainty Analysis Results

The model results for the Baseline Case (such as mission end date, total containers/canisters, volume of feed, etc.) are presented as distinct values. However, TOPSim is a deterministic, discrete event-based simulation model, and has an intrinsic amount of variability associated with it. A minute change to a model input will result in bifurcations on decision points, a different sequence of transfers, etc. A series of model simulations/runs was completed to help quantify the random uncertainty associated with TOPSim. When evaluating the effect of changes to the flowsheet using TOPSim predictions, the intrinsic noise should be considered. In an attempt to evaluate the amount of uncertainty in the Baseline Case, many runs (100) were completed that changed the DST transfer rate by a small amount (140 $\pm$ 0.05 gpm).[22] The results of the uncertainty analysis (Table 5-3) indicate that, with the exception of the IHLW canisters, the Baseline Case slightly under-predicts durations and product quantities versus the mean run with the same input assumptions. This uncertainty analysis is meant to provide additional information on the interpretation of the various scenarios and sensitivities. For example, if a scenario finishes treating all tank waste in 2069 instead of 2066, it cannot be concluded with certainty that this is a significant change. The results of this uncertainty analysis are also used to determine the precision with which key results will be reported throughout this system plan.

Table 5-3. Baseline Case – Results of Uncertainty Analysis.

Metric	Baseline Case	Min.	Mean	Max.	Range
Complete SST Retrievals (year)	2061.3 (21st percentile)	2060.5	2061.7	2063.5	3.0 years
Treat All Tank Waste (year)	2066.3 (7th percentile)	2065.9	2067.0	2069.0	3.1 years
Total IHLW Glass Canisters	7,300 (90th percentile)	7,000	7,200	7,400	400 canisters
Total ILAW Glass Containers	88,900 (26th percentile)	88,400	89,100	89,600	1,200 containers

IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
SST = single-shell tank.

[22] It is demonstrated in WRPS-2003165, internal memorandum to L.M. Bergmann, S.D. Reaksecker, and A.J. Schubick from G.A. Hersi, "Analysis of TOPSim DST Pump Rates for System Plan Rev. 9," that changes to the DST pump rate of this magnitude are not significantly correlated with trends in the major mission metrics, and therefore such a change can be assumed to result in a true measure of random uncertainty.

5.1.2.4 Mission Flowsheet Results

The detailed mission flowsheet results for each system are presented in the following subsections.

5.1.2.4.1 Single-Shell Tank Retrievals

The SSTs are projected to be retrieved by 2061, with the retrievals of C Tank Farm declared complete in 2017 and retrievals in A/AX Tank Farms projected to complete in January 2027. Prior to 2045, SST retrievals are limited to one simultaneous retrieval per area, which better matches the treatment throughput and, therefore, DST space availability than two simultaneous retrievals per area used in previous system plans. As such, retrievals incur fewer delays waiting for DST space during this time. After several years of waste treatment (circa 2045), there is sufficient DST space to increase the number of concurrent SST retrievals to two per area. Figure 5-4 shows the historical and projected SST retrieval progress measured by the approximate volume of original waste remaining in the SSTs as a function of time. The rate of retrievals begins to increase after the cross-site slurry line becomes operational in 2030 and DFLAW treatment has been operational for 10 years. Once all WTP facilities and the LAWST capability begin operating by the end of 2034, the SST waste remaining decreases sharply as the rate of retrievals increases.

Figure 5-4. Baseline Case – Single-Shell Tank Retrieval Progress.

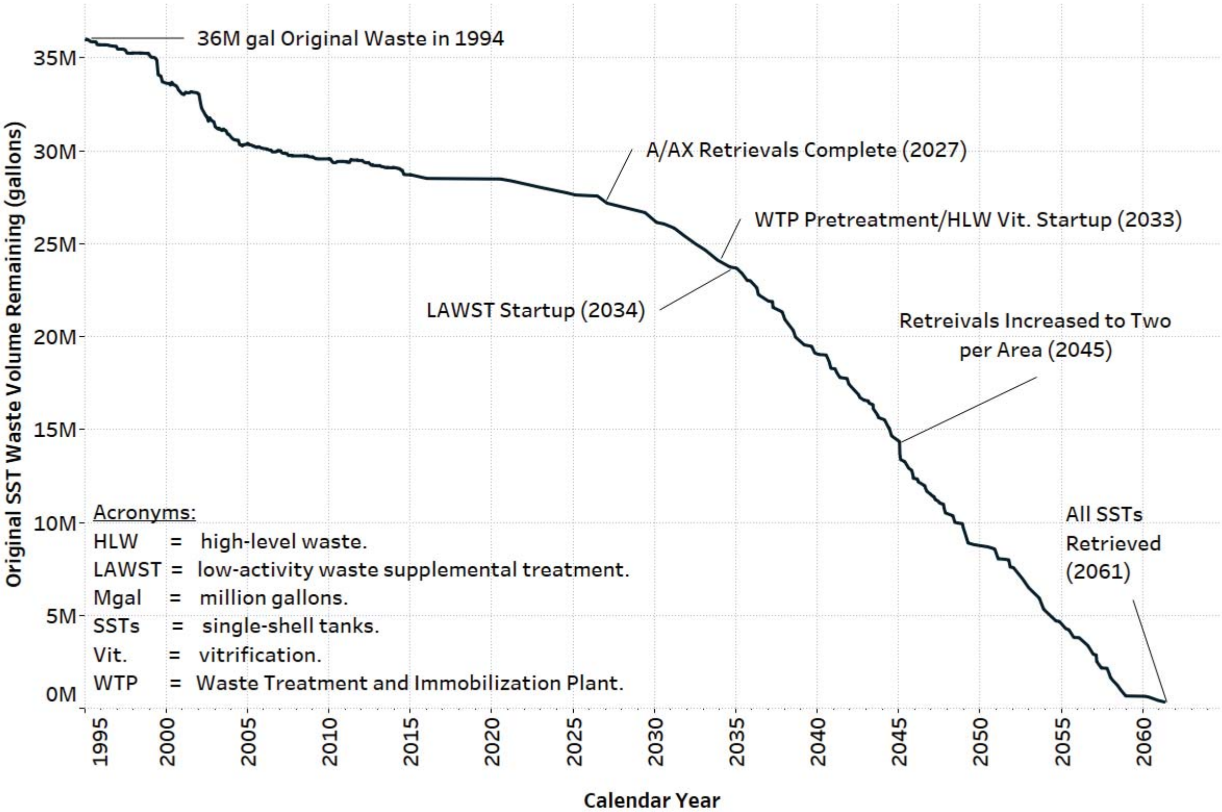
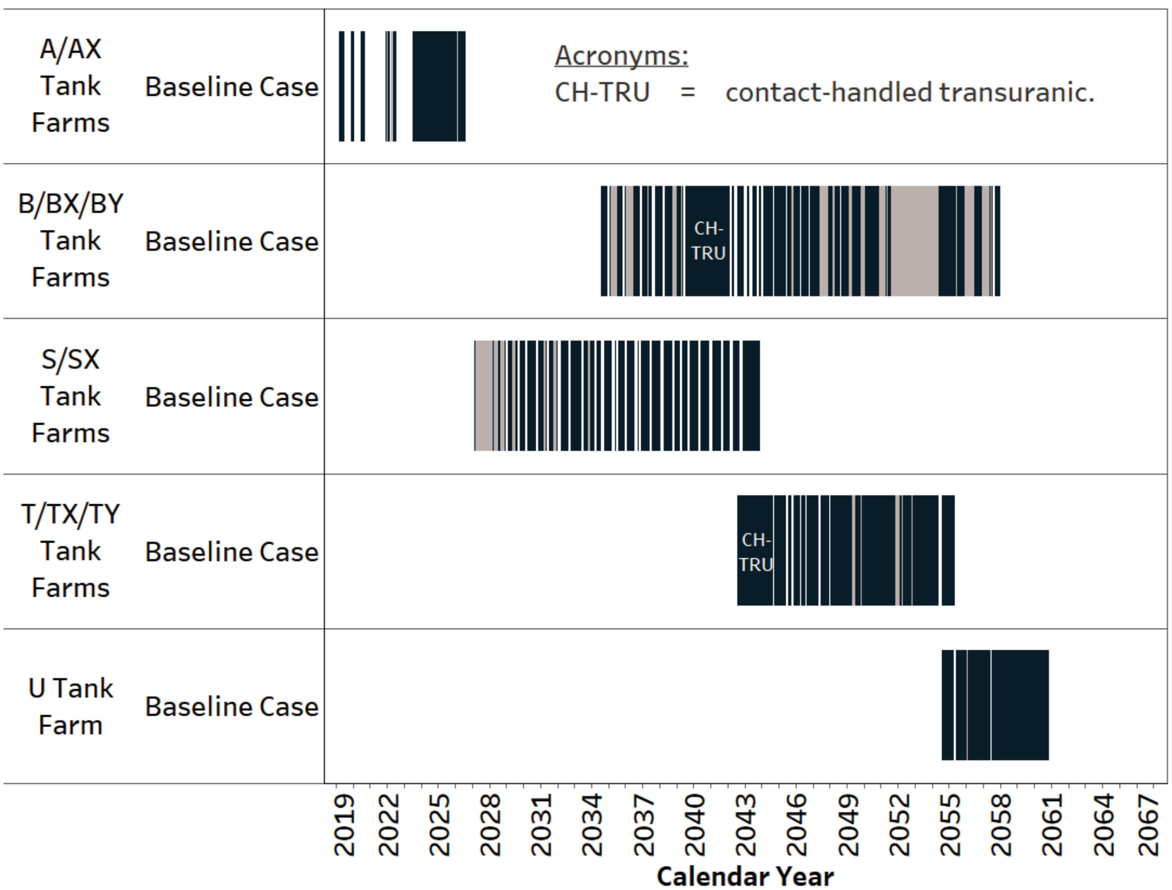


Figure 5-5 shows the sequence and timing of the SST retrievals during the RPP mission. The dark-colored bands indicate ongoing retrieval activity, the white spaces between the bars are the assumed setup time between retrievals (2 months), and the grey bands indicate delays in SST retrieval durations related to DST availability (the delays being the difference in the projected retrieval duration and the assumed retrieval duration). After the retrievals of A/AX Tank Farms are completed in 2027, retrievals in S/SX Tank Farms start; however, there is immediately a 1.5-year delay in S/SX Tank Farms' retrievals until Tank AN-104 (the cross-site slurry receiver DST) and Tank SY-103 are mitigated. Mitigation of Tanks AN-104 and SY-103 cannot be completed sooner due to the limited amount of available DST space. In 2045, the number of simultaneous retrievals per area is increased from one to two increasing the amount of dilute waste entering the DST system. The 242-A Evaporator remains restricted to six campaigns per year and is unable to concentrate the waste fast enough to prevent additional delays to SST retrievals (caused by a lack of available DST space).

Figure 5-5. Baseline Case – Single-Shell Tank Retrieval Schedule.



5.1.2.4.2 Double-Shell Tank Space Management

Figure 5-6 shows the utilization of DST space through the completion of the RPP mission. The figure shows the total capacity of the available DSTs combined, total volume of waste, and various allocations of DST headspace for purposes other than waste storage (Table 5-4). During the DFLAW period (2023 to 2033), the amount of space created by treatment is typically filled with the dissolved salt waste from Group A DST mitigations, along with SST retrievals from

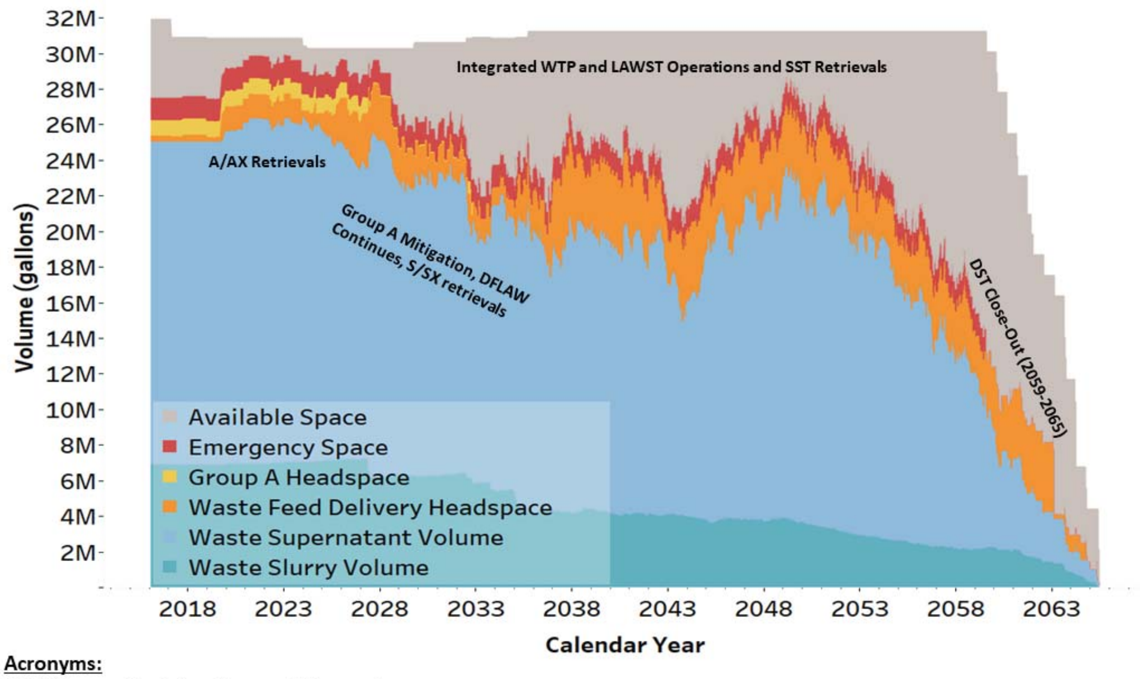
A/AX and S/SX Tank Farms. At the same time, the total DST waste volume averages very near the total DST capacity (leaving only 1 to 2 Mgal of available space). Once the TWCS capability starts in 2032, followed by the integrated WTP in late 2033 and the LAWST capability in late 2034, available DST space begins to increase, providing room to perform the following actions:

- Complete blending of high-fissile uranium waste in Tank AN-101 (originating from SST C-104) and blending of high-zirconium waste stored in Tanks AW-103 and AW-105
- Complete the complex concentrate strontium/TRU precipitation of the waste in Tanks AN-102 and AN-107
- Continue retrieving the remaining SSTs.

The decrease in available space beginning in 2045 is a result of additional incoming SST waste because the number of simultaneous retrievals per area is doubled. As the mission progresses beyond 2052, the available space increases as treatment continues and waste is concentrated in the 242-A Evaporator faster than waste is added (through SST retrievals). Between 2059 and 2065, the DSTs are sequentially closed as the remaining waste is treated.

Available DST space is often distributed among several tanks and is not always directly usable without a complicated series of waste transfers and evaporator staging operations. Some of the available DST space is located in the 200 West Area (SY Tank Farm), and other space is spread around the 200 East Area in tanks in the process of staging feed for the WTP. As the DST system nears capacity, the ability to conduct SST retrievals, 242-A Evaporator campaigns, and feed-staging operations becomes increasingly difficult.

Figure 5-6. Baseline Case – Double-Shell Tank Space Utilization.



Acronyms:

DFLAW = direct feed low-activity waste.
DST = double-shell tank.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

Table 5-4. Double-Shell Tank Headspace Categories.

Category	Description
DST Emergency Space	Tank space (1.265 Mgal in DSTs) that could be used to receive waste in the event of a leaking DST or emergency returns from the WTP (Appendix A, Assumption A1.2.2.3).
Waste Feed Delivery Headspace	Space above waste specifically identified as a WTP feed source or in tanks used to deliver feed to the WTP throughout the mission. This includes dedicated DFLAW space.
Group A Tank Headspace	Space associated with Group A tanks that cannot be used because of a safety issue associated with the waste.
Waste Supernatant Volume	The total DST liquid volume above the settled solids layer.
Waste Slurry Volume	The mixture of solids and interstitial liquid in the settled solids layer.
Available Space	The sum of the total waste volume and allocated headspaces for emergency, Group A, and waste feed delivery subtracted from the maximum DST volume.

DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-7 shows the source of the nearly 200 Mgal of inputs from the DST system and the destinations for those wastes over the mission. The positive volumes represent the original DST inventory (as of TOPSim's 2018 simulation start date) and inputs, and the negative volumes represent DST outputs. The majority of the DST additions to the initial 25 Mgal inventory are from SST retrievals (127 Mgal as-retrieved volume[23]). The second biggest contribution is water and chemical additions (49 Mgal) resulting from Group A mitigations, strontium/TRU mitigations, line flushes, solids dissolution, dilutions, DFLAW tank preparation (e.g., Tank AP-106 repurposing), and the DST closure activities. Outputs from the DSTs consist of feed to the various treatment facilities or from waste volume reduction (WVR) via evaporation.

Numerous transfers occur between DSTs to support (1) the staging of feed to the TSCR/TFPT systems and the WTP, (2) 242-A Evaporator operations, and (3) receipt of retrieved SST waste. There are approximately 1,900 DST transfers[24] predicted to occur over the course of the RPP mission. Figure 5-8 shows the projected DST transfer demand. Between 2020 and 2034, there is an average of 14 transfers per year. Beginning in 2027, after retrievals A/AX Tank Farms are completed and the DFLAW system continues to process the tank farm waste, DST space becomes available to start mitigating problematic tanks (i.e., Group-A, deep-sludge, high-zirconium, and Tank C-104 high-fissile wastes). These mitigation activities, which involve DST-to-DST transfers, increase as DFLAW treatment continues and the integrated WTP and the LAWST capability begin operating. The increase in mitigation activities causes a peak number of DST-to-DST transfers in 2035. From 2035 through 2058, the demand increases to an average of 62 transfers per year as the number of DST waste transfers increases because of increased transfers from the 200 East and 200 West Area WRFs and staging of supernatant and slurry for

[23] The original SST volume from the Best-Basis Inventory is 28.5 Mgal. Then retrieval water and chemicals are added to the SSTs such that the total as-retrieved volume from the SSTs is 127 Mgal.
[24] Transfers in this discussion include all DST-to-DST, DST-to-WTP Pretreatment, DST-to-TWCS, and WRF-to-DSTs. Non-discrete transfers, such as DST-to-TSCR/TFPT, DST-to-WTP LAW Vitrification, and 242-A Evaporator-associated transfers, are not included in these projections and are tabulated with their respective facility.

delivery to treatment facilities. In the last few years of the mission, DST activity decreases as SST retrievals are completed and DSTs are closed.

Figure 5-7. Baseline Case – Summary of Double-Shell Tanks Key Inputs and Outputs.

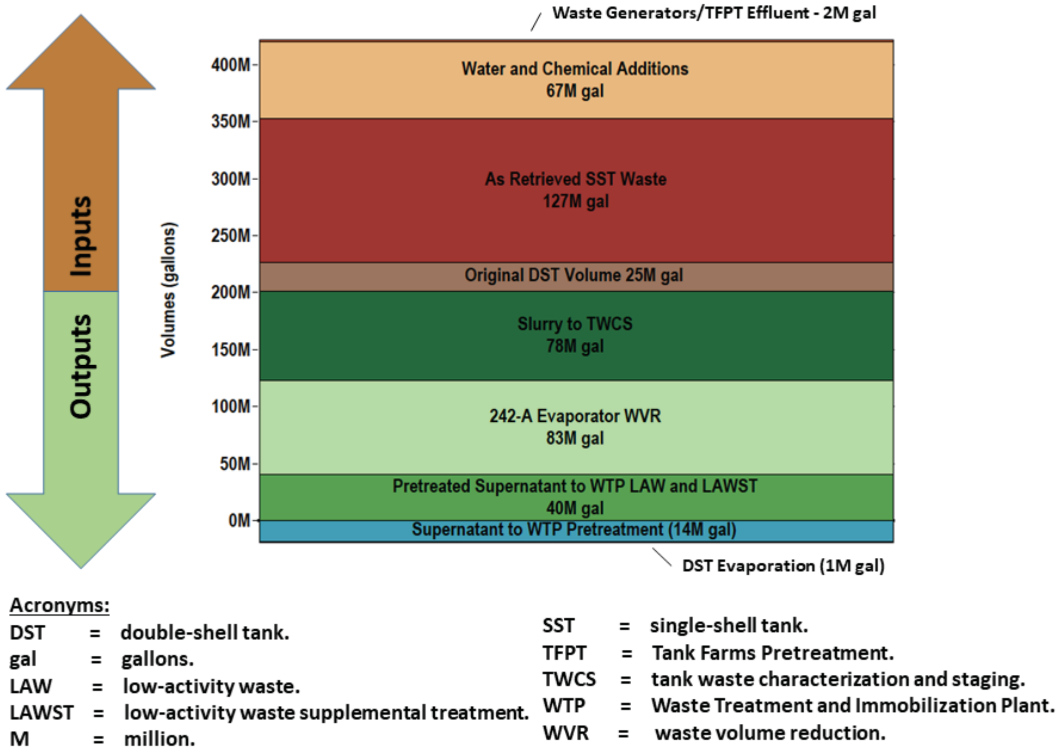
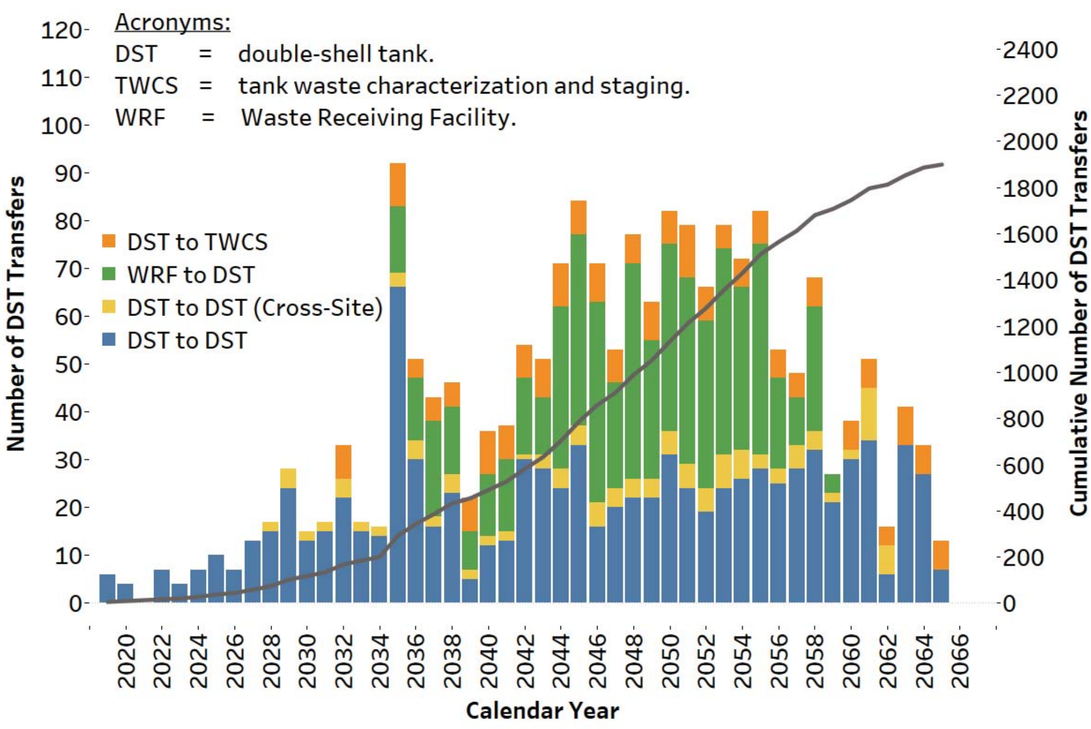


Figure 5-8. Baseline Case – Projected Double-Shell Tank Transfer Demand.



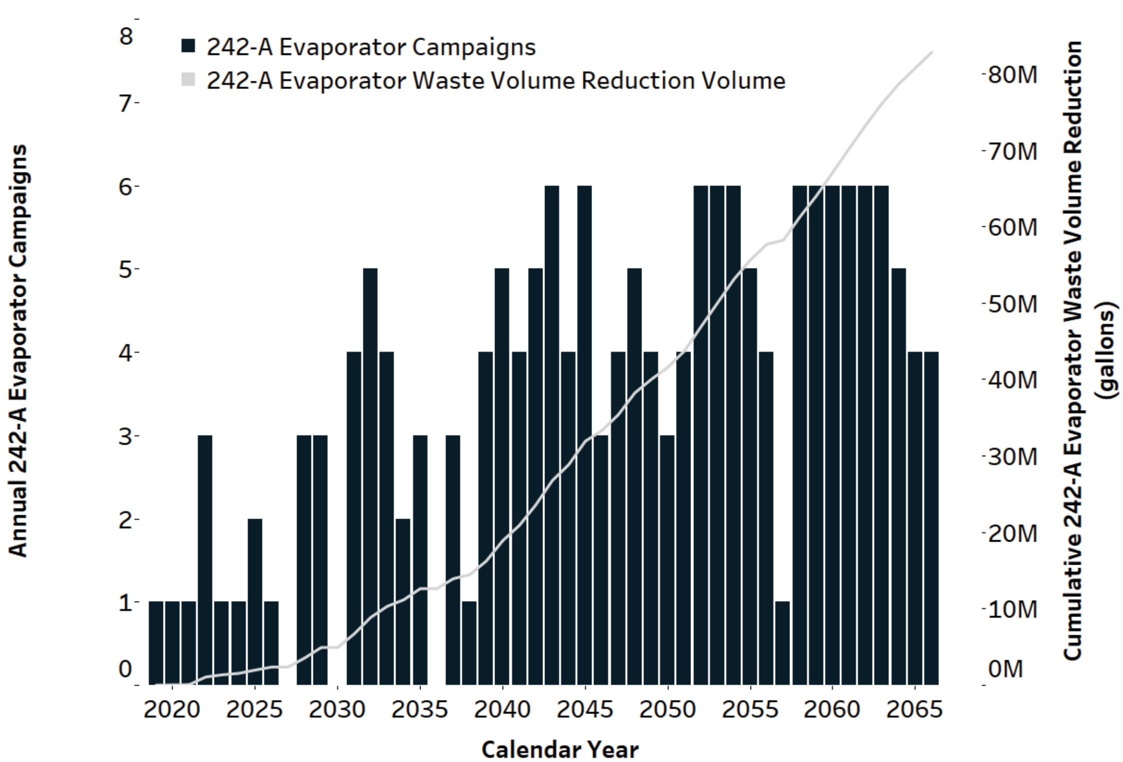
5.1.2.4.3 Waste Receiving Facilities

The B Complex WRF in the 200 East Area is projected to be used from 2035 to 2059 and the T Complex WRF in the 200 West Area from 2044 to 2056. The combined tanks in the B Complex WRF average 13 transfers per year and a total of 308 transfers to DSTs over the 24 years of operations. The combined tanks in the T Complex WRF average 25 transfers per year, with 332 transfers to DSTs occurring over the 12 years of operations. The T Complex WRF is operated for half as long as the B Complex WRF even though the volume received is approximately the same (approximately 39 Mgal). The T Complex retrievals have little wait time, indicating that DST space for the T Complex WRF is typically available. The B Complex retrievals are often restricted by competing DST activities in the 200 East Area and cross-site transfers, which are given priority to continue the progression of retrievals in the 200 West Area, further affecting 200 East Area retrievals.

5.1.2.4.4 242-A Evaporator

Figure 5-9 shows the projected demand on the 242-A Evaporator through the completion of the RPP mission. The 242-A Evaporator is expected to process about 123 Mgal of waste, reducing the stored volume by about 66 Mgal over the mission duration. There is an average of approximately four campaigns per year over the mission with the maximum campaigns per year restricted to six (Assumption A1.2.4.1). The 242-A Evaporator consistently operates at the maximum campaigns per year between 2048 and 2058 when the allowed number of simultaneous SST retrievals per area is increased. Waste from SST retrievals is generally very dilute (averaging with a density of 1.1 kg/L); concentration is necessary to reduce the effects on DST space.

Figure 5-9. Baseline Case – Projected Operation of the 242-A Evaporator.



5.1.2.4.5 Waste Treatment and Immobilization

This section presents the waste treatment and immobilization results for the Baseline Case. Table 5-5 summarizes the waste treatment facilities' operating durations and the amount of immobilized products for the potential CH-TRU waste, WTP ILAW and IHLW, and LAWST, both as a glass product and grouted product. The results of the specific treatments and immobilizations are provided in the following subsections.

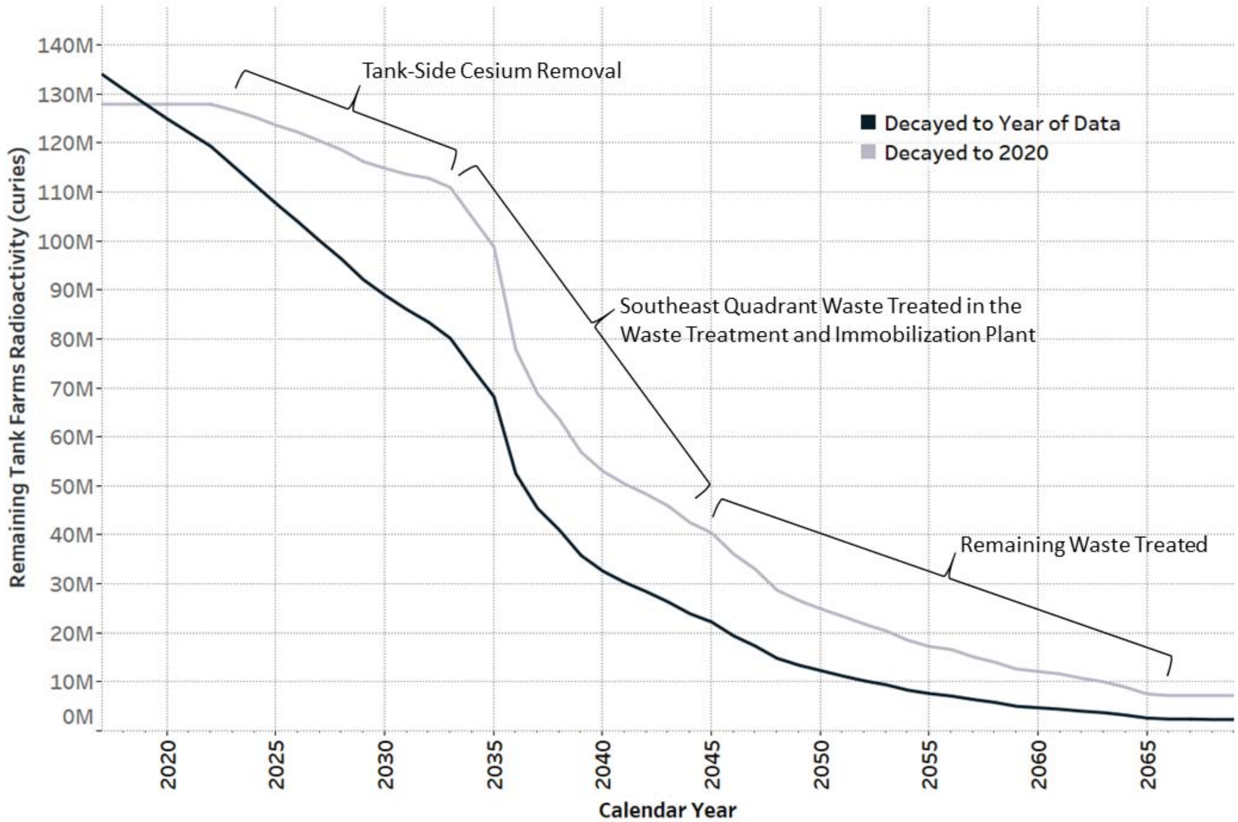
Table 5-5. Baseline Case – Waste Treatment Product Summary.

Treatment	Start Date	Completion Date	Immobilized Product Quantity	MT of Product	Waste Loading
Potential CH-TRU Waste	2040	2045	8,800 drums	2,300	80%
WTP IHLW	2033	2066	7,300 canisters	22,000	44%
WTP ILAW	2023	2066	52,000 containers	287,000	23% (Na_2O)
LAWST (as Vitrification)	2034	2066	37,000 containers (103,000 yd^3)	203,000	20% (Na_2O)
LAWST (as Grout)	2034	2066	399,000 yd^3	548,000	7% (Na_2O)
ETF Drums	Current	2065	11,300 drums	2,800	100% (powder)

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-10 shows the decrease in radioactivity in the tank farms' inventory as waste is delivered to the various waste treatment and immobilization facilities. The figure includes two profiles, one excluding and one including the decay of radionuclides over time. The relatively constant slope prior to the start of DFLAW treatment in 2023 in the line's profile including radioactive decay is due to radioactive decay only. There is a small increase in radioactivity removal after 2023 when, in addition to the decay, the TSCR/TFPT systems and DFLAW treatment are removing some of the radioactivity (mainly cesium-137). Once the WTP HLW Vitrification Facility begins operating in 2034, curie removal and treatment increases significantly, as the initial waste processed through the WTP is mainly from the southeast quadrant of the 200 East Area. Waste in the southeast quadrant of the 200 East Area, which includes the 200 East Area DSTs and SSTs in A/AX Tank Farms, contains 66 percent of the total radiological inventory in the tank farms. As the mission continues, the remaining waste is treated, and, by the end of treatment in 2066, there are approximately 2 MCi of residual waste remaining in the tank farms.

Figure 5-10. Baseline Case – Tank Farm Radioactivity.



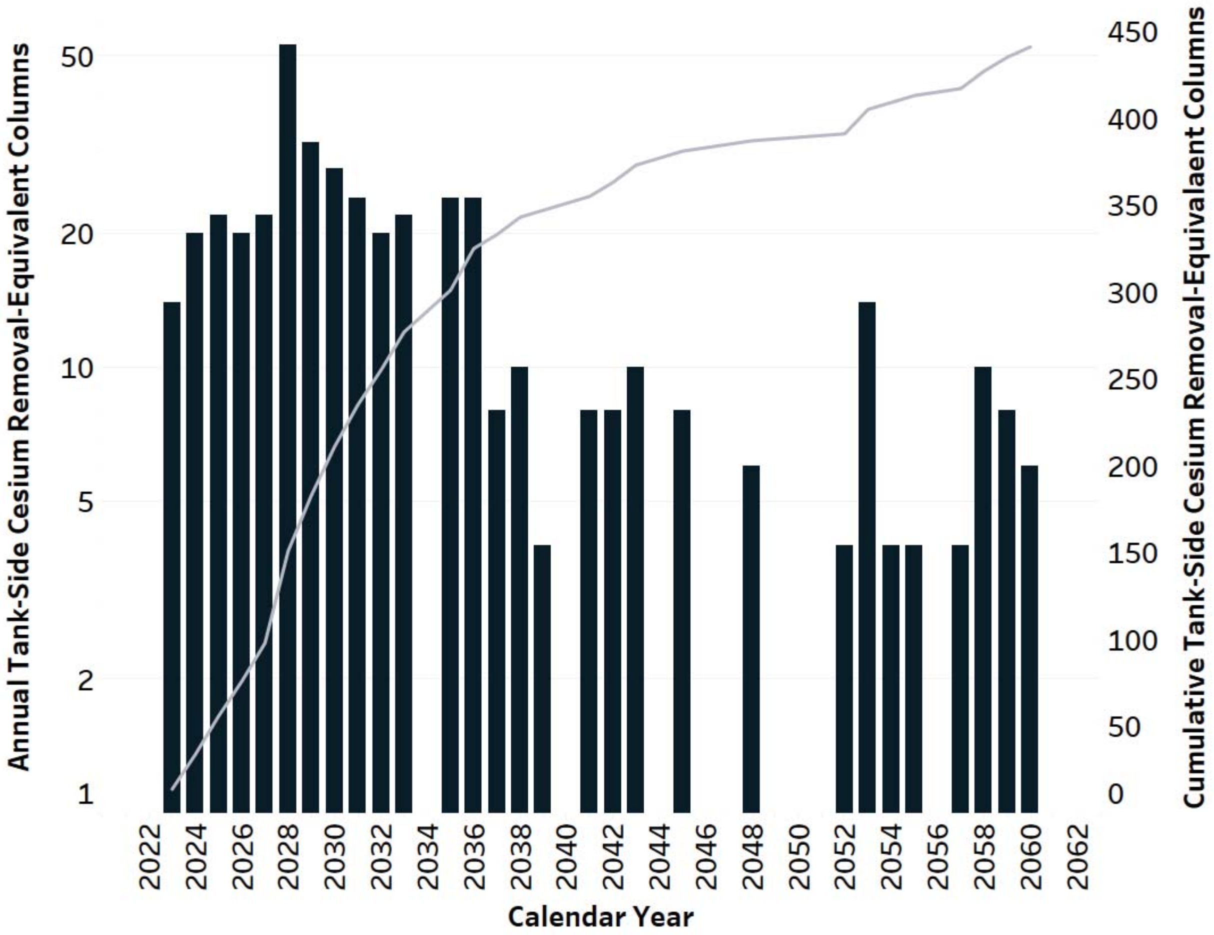
5.1.2.4.5.1 Direct-Feed Low-Activity Waste Pretreatment

Treatment using the DFLAW flowsheet operates for 10 years prior to the WTP Pretreatment Facility startup. During those 10 years, 20 Mgal of supernatant at a target concentration of 5.5M sodium is sent to the TSCR/TFPT systems, where the waste is pretreated and sent to the WTP LAW Vitrification Facility. During DFLAW operations, approximately 10,000 containers of ILAW are produced, which is approximately 11 percent of the total ILAW estimated for the mission. Roughly 9,300 MT (20 percent) of the original waste sodium is immobilized in the 55,000 MTG produced during the DFLAW period. The TSCR/TFPT systems deliver an average of 950 MT of sodium per year to the WTP LAW Vitrification Facility.

When DFLAW processing starts, the TSCR system operates at an instantaneous rate of 5 gpm. In 2028, the TFPT operations replace TSCR processing and the throughput increases to an instantaneous rate of approximately 10 gpm (the equivalent of two TSCR units, matched to the design throughput of the WTP LAW Vitrification Facility) and remains at this capacity for the remainder of the mission. After startup of the WTP Pretreatment Facility in 2033, which provides substantial additional LAW pretreatment capacity, the TFPT system transitions to providing supplemental feed to the LAWST capability.

During DFLAW treatment the TSCR/TFPT systems remove an average of 53,000 Ci per month of cesium-137 requiring an average of 21 IX column changes per year. Figure 5-11 shows the estimated number of TSCR-equivalent IX columns replaced each year. For the 10-year DFLAW period, the equivalent of 277 TSCR IX columns[25] is used, which accounts for more than half of the 441 total TSCR-equivalent IX columns over the mission. The annual IX column usage is higher during the DFLAW period since the supernatant treated during this time is mainly from the southeast quadrant of the 200 East Area (A/AX Tank Farms and DSTs), which contains 72 percent of the total waste cesium. Assuming a capacity of 150 IX columns per waste storage pad, two waste storage pads are required during the DFLAW period and three pads are needed for the mission. The cesium captured on the columns is assumed to be stored onsite and is not treated in the current flowsheet. Currently, no disposition pathway has been decided for these IX columns, though viable options have been identified.

Figure 5-11. Tank-Side Cesium Removal – Equivalent Ion-Exchange Column Replacements.



[25] A TSCR unit contains three IX columns—two columns are replaced each time the loading criteria is met, and three columns are removed if the entire TSCR unit is replaced. As an enabling assumption, it is assumed that TSCR unit replacements occur every 5 years, and the TFPT system is assumed to be the equivalent of two TSCR units (so when the TFPT system is replaced, it is counted as six equivalent-TSCR IX columns).

5.1.2.4.5.2 Waste Treatment and Immobilization Plant Pretreatment Facility

The WTP Pretreatment Facility, as modeled, processes an average of 1,800 MT waste sodium[26] and 1,000 MT as-delivered solids per year over the 33 years of operations. A total of 94 Mgal of feed containing 31,000 MT of sodium and 32,000 MT of solids is delivered from the tank farms to the WTP Pretreatment Facility. Most of the waste volume (80 Mgal) is delivered to the HLW feed receipt vessel containing an average of 9 wt% solids and a total of 25,000 MT of sodium. The remaining 14 Mgal and 6,000 MT of sodium is received into the LAW feed receipt vessels from the DST system.

After the waste is received into the feed receipt vessels, it is sent to the cross-flow ultrafiltration system, where 27,000 MT of sodium is added for leaching and to maintain the aluminum in solution. Leaching and washing dissolves solid species that limit the waste loading (e.g., aluminum, phosphorous, and chromium) in the IHLW thereby reducing the number of canisters produced. However, the large amount of sodium added for leaching increases the amount of ILAW. Cesium is removed from the supernatant stream in the cesium IX process, and then the cesium-rich stream is blended with the washed and leached solids. Sixteen Mgal of slurry containing most of the radionuclides and solids (11,000 MT of leached solids) are sent from the WTP Pretreatment Facility to the WTP HLW Vitrification Facility. Ninety-two Mgal of treated LAW containing 98 percent of the sodium is sent to the concentrate receipt vessels in the WTP LAW Vitrification Facility and to LAWST. Approximately 3,000 MT of additional sodium is added throughout the WTP Pretreatment Facility for neutralizations and filter cleaning.

Due to limitations in the WTP Pretreatment Facility design, specifically the cross-flow ultrafiltration process, HLW is not pretreated at a rate that is sufficient to allow the WTP HLW Vitrification Facility to operate at its capacity. As a result, pretreatment of the HLW drives the mission, because the LAWST capability is sized as large as needed to keep pace with HLW processing.

5.1.2.4.5.3 Low-Activity Waste Treatment

During DFLAW treatment (2023 to 2033), the feed to the WTP LAW Vitrification Facility melters is more dilute than if processed through the WTP Pretreatment Facility (an average of 5.5M sodium versus an average of 7.5M sodium). As a result, the melters cannot meet the theoretical capacity of 21 MTG/day, averaging only 17 MTG/day. This small deviation is caused by the processing rate estimated by the variable melter-rate equation that factors in the feed concentrations and power limitations of the melter (Assumptions A1.3.4.7 and A1.3.4.11). If the waste is dilute, more power is required to evaporate the water and the throughput of the melter becomes limited by the supply of electricity.

After DFLAW operations, when the WTP Pretreatment Facility feeds the WTP LAW Vitrification Facility, ILAW production meets the theoretical capacity of 21 MTG/day. Excess pretreated supernatant from the WTP Pretreatment Facility is sent to the LAWST capability. The WTP LAW Vitrification Facility produces 59 percent of the total ILAW, and 41 percent is produced by the LAWST capability.

[26] 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.

Assumption A1.4.1.5 requires that the LAWST capability "be selected with the goal that the combined LAW vitrification capacity will be large enough as to not drive the mission duration." Several scoping model runs were completed to determine the minimum number of whole melters that would meet this requirement. A four-melter operating capacity of 42 MTG/day (60 MTG/day × 70 percent availability) was found to be large enough to not extend the mission duration.

The Baseline Case assumes that ILAW will be formulated using the 2016 LAW GFM (PNNL-25835) as per Assumption A1.3.4.8. Table 5-6 lists the percentage of glass drivers for the WTP and LAWST ILAW. The loading rules are described in PNNL-25835. Figure 5-12 and Figure 5-13 graphically depict the major WTP ILAW and LAWST ILAW glass drivers over the mission. The average annual sodium oxide loading is 23 percent for WTP ILAW and 20 percent for LAWST ILAW. The waste oxide loading (WOL) in the WTP and LAWST ILAW is primarily driven by the alkali loading rule and the combined alkali and sulfur content rule. The LAWST capability (as vitrification) has more sulfur-limited glass because in the LAWST there is a greater amount of internally recyclable, sulfur-rich-offgas scrub solutions, while the WTP LAW Vitrification Facility recycles through the WTP Pretreatment Facility, which splits the outgoing stream between the WTP and the LAWST capability. This increase in recycling results in an increase of sulfur-related constraints limiting the glass WOL (the sulfur rule and a combined alkali plus sulfur rule). The increase in sulfur-constrained glass results in lower sodium and glass WOL in the LAWST capability ILAW.

Table 5-6. Baseline Case – Summary of Combined Immobilized Low-Activity Waste Glass Drivers and Waste Oxide Loading.

Key Glass Drivers and Waste Loadings		WTP LAW Vitrification Facility	LAWST
Glass Drivers	Alkali Loading Rule	58%	28%
	Alkali and Sulfur Content	31%	54%
	Sulfur Loading Rule	<1%	12%
	Other	~11%	~6%
Average Loading	Average Sodium Loading	23%	20%
	Average WOL	27%	24%

LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
WOL = waste oxide loading.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-12. Baseline Case – Immobilized Low-Activity Waste Glass Drivers (Waste Treatment and Immobilization Plant).

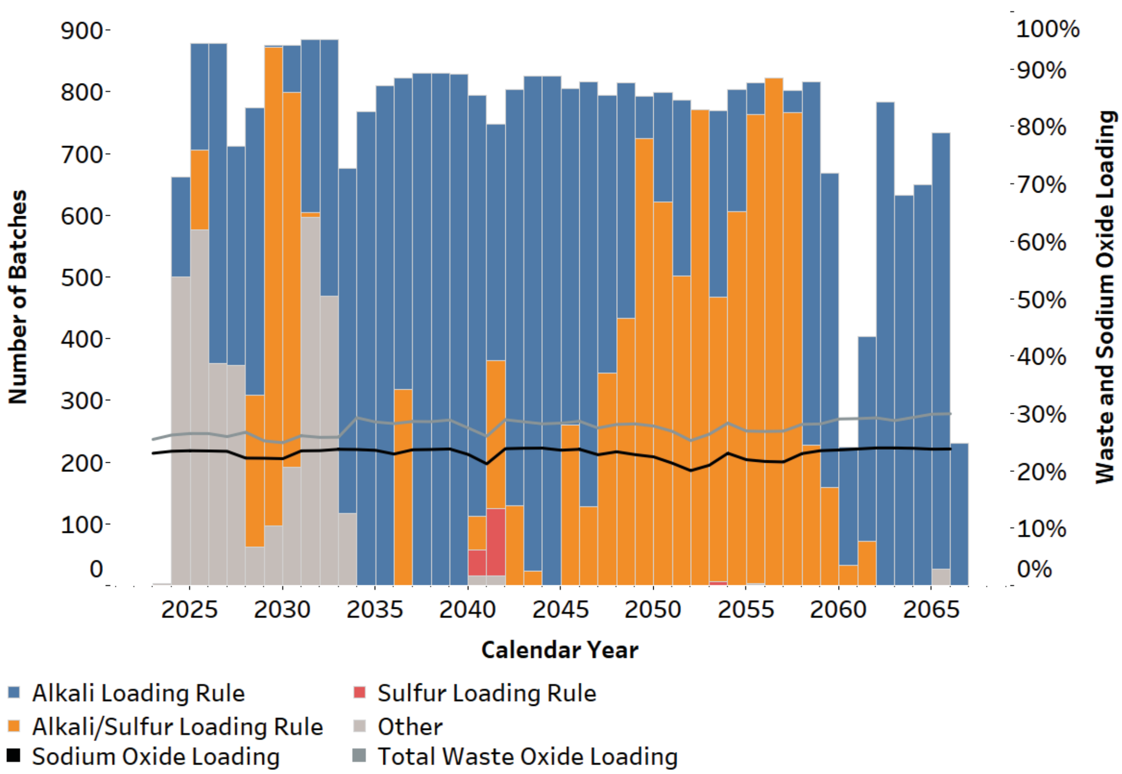
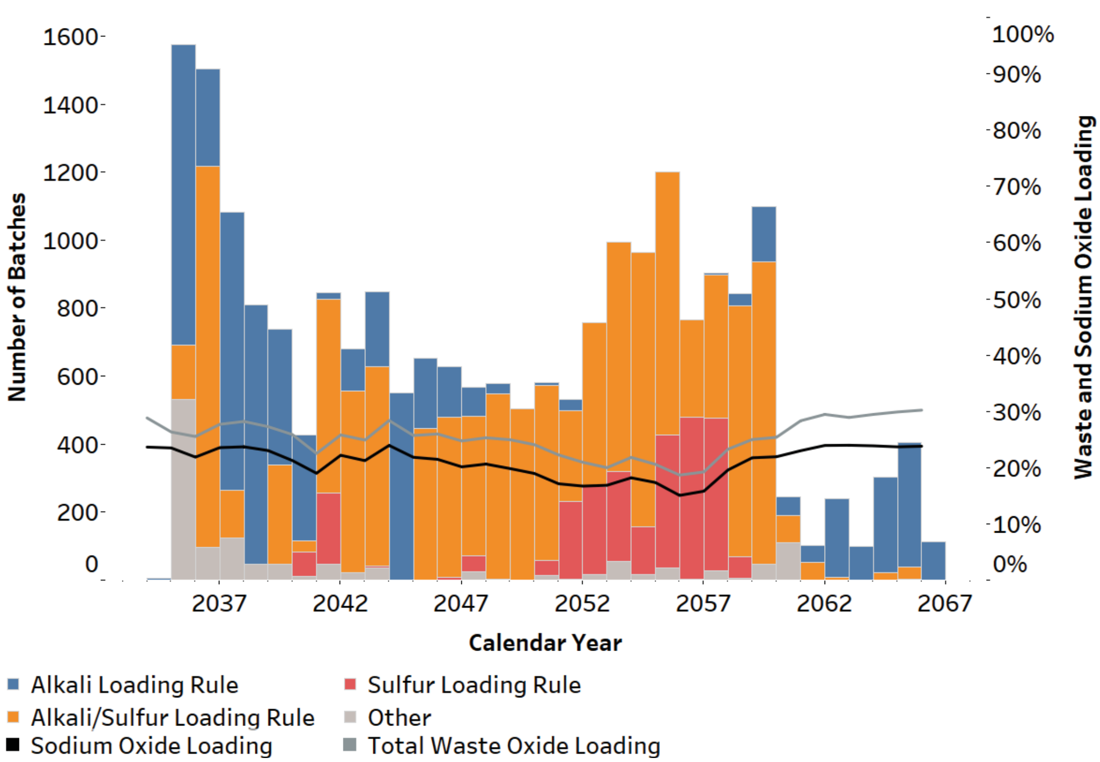


Figure 5-13. Baseline Case – Immobilized Low-Activity Waste Glass Drivers (Supplemental Treatment).



Supplemental immobilization has always been envisioned to treat part of the LAW. In the Baseline Case, the LAWST capability is modeled as vitrification and the ILAW quantity is estimated. However, since grout is utilized at the Savanah River Site and is being considered as one of the technologies for immobilization of Hanford LAW, an estimate of the quantity of grouted product is also provided. The quantity of grout potentially produced from the 52 Mgal of feed to the LAWST process was estimated by assuming a constant water/dry mix ratio of 0.6 (mass ratio) (WRPS-1700663, "Recommended Assumptions for Waste Loading in Low-Activity Waste Grout for System Plan 8"). Using this assumption, if the waste sent to the LAWST capability is grouted, there will be approximately 398,600 yd^3 of grout (80.5 Mgal) with a 7 percent equivalent sodium oxide loading. This is compared to the 36,800 ILAW glass containers from the LAWST capability, which is equivalent to approximately 102,800 yd^3 of glass[27] (20.7 Mgal) with 20 percent sodium oxide loading. This volume of grout would require three of Savanah River Site's 32-Mgal-capacity slurry disposal units or 29 of their older 2.8-Mgal-capacity units. A discussion of the cost comparison of LAWST as a grout facility versus a vitrification facility is provided in Section 5.1.2.5.

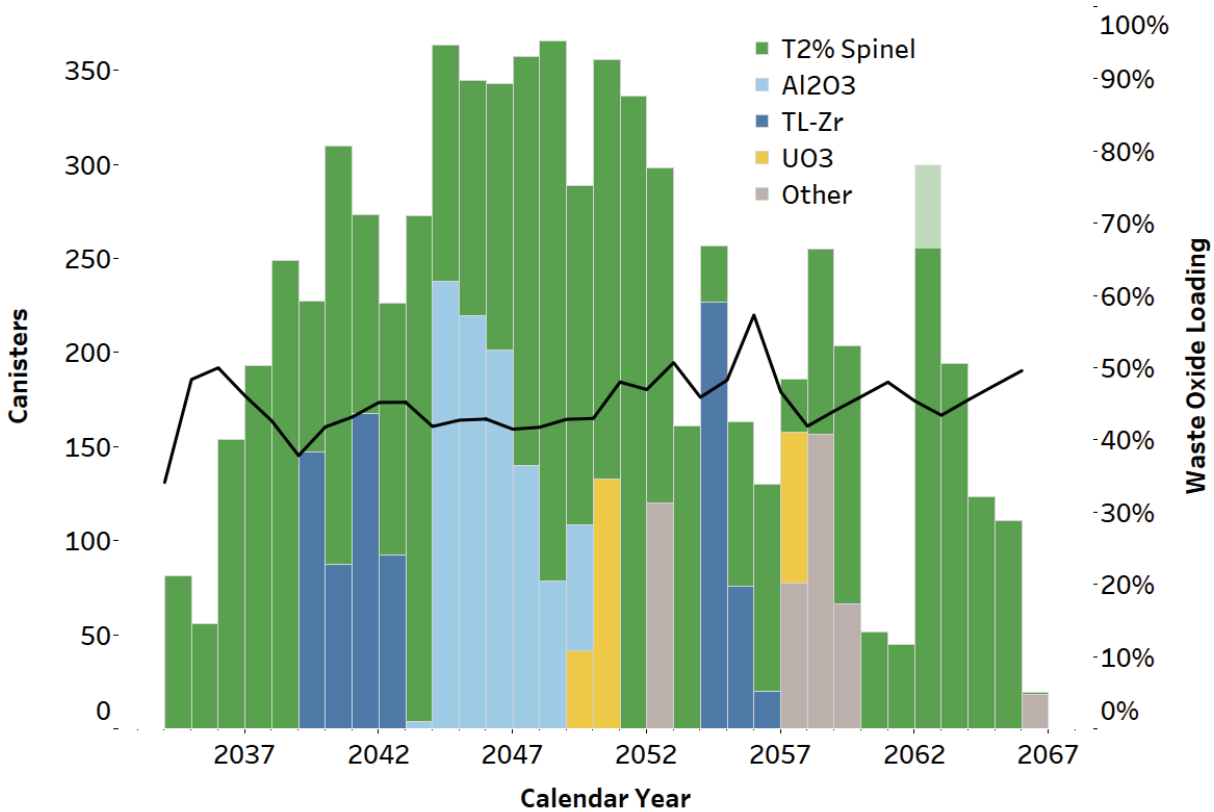
5.1.2.4.5.4 High-Level Waste Treatment

A total of 7,300 IHLW canisters are produced in the Baseline Case over the 33 years of production. Feed to the WTP HLW Vitrification Facility is steady and averages 2.0 MTG/day (steady-state value), which is less than the theoretical throughput of 4.2/5.25 MTG/day (first/second generation melters at 70 percent). The WTP HLW Vitrification Facility does not meet the theoretical capacity because the WTP Pretreatment Facility is rate limiting (Section 5.1.2.4.5.2).

The Baseline Case assumes that IHLW glass would be formulated using the 2016 HLW GFM (documented in PNNL-25835) as per Assumption A1.3.3.4. Figure 5-14 graphically depicts the major IHLW glass drivers over the mission. The primary glass drivers are T2%-spinel[28] (67 percent), aluminum oxide (11 percent), and liquidus temperature zirconium (10 percent). The average WOL is 44 percent, although, as shown in Figure 5-14, the WOL varies over time based on the composition of the incoming waste and the constraints that are driving a particular batch.

[27] The volume of the ILAW containers is 626 gal and, when filled to 90 percent, the containers hold 564 gal of ILAW per container, which is equivalent to 2.79 yd^3 of ILAW per container.
[28] "T2%-spinel" is the temperature at which 2 volume percent spinel crystals would be in equilibrium with the melt (with a maximum limit of 1742°F [950˚C]). Spinel crystals are typically composed of oxides from aluminum, iron, zinc, chromium, and manganese, and their formation is strongly correlated with aluminum content in the 2016 HLW GFMs.

Figure 5-14. Baseline Case – Immobilized High-Level Waste Glass Drivers.

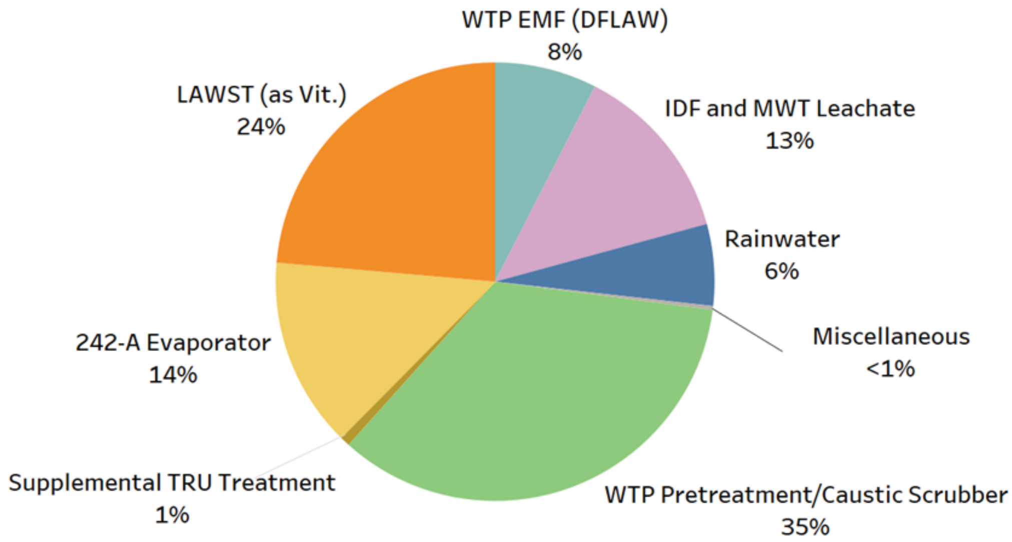


5.1.2.4.5.5 Secondary Liquid Effluent Treatment

Figure 5-15 shows the distribution of feed sources[29] to the LERF over the mission. Approximately 600 Mgal of radioactive liquid effluent is projected to be treated by the ETF over the duration of the treatment mission. Condensate from WTP operations (including the WTP EMF) and LAWST (as vitrification) evaporators and caustic scrubbers contribute nearly 67 percent of the total feed volume. The remaining feed to the LERF comes from the 242-A Evaporator condenser (14 percent), leachate from the mixed-waste burial trenches and IDF (13 percent), and rainwater (6 percent). The remaining volume is made up of condensate from the potential CH-TRU waste treatment process, aging waste tanks in the tank farms, and other miscellaneous sources.

[29] The totals to the LERF include non-modeled inputs from contaminated groundwater or leachate from the ERDF, mixed-waste trenches, the IDF, the K Basins, and annual rainwater. Annual volumes for these sources are based on WRPS-2001669, email April 30, 2020 from B. Angevine to A. Schubick "ETF Replacement Cost Estimates and Tanker Delivery Expectations."

Figure 5-15. Baseline Case – Distribution of Feed to the Liquid Effluent Retention Facility.

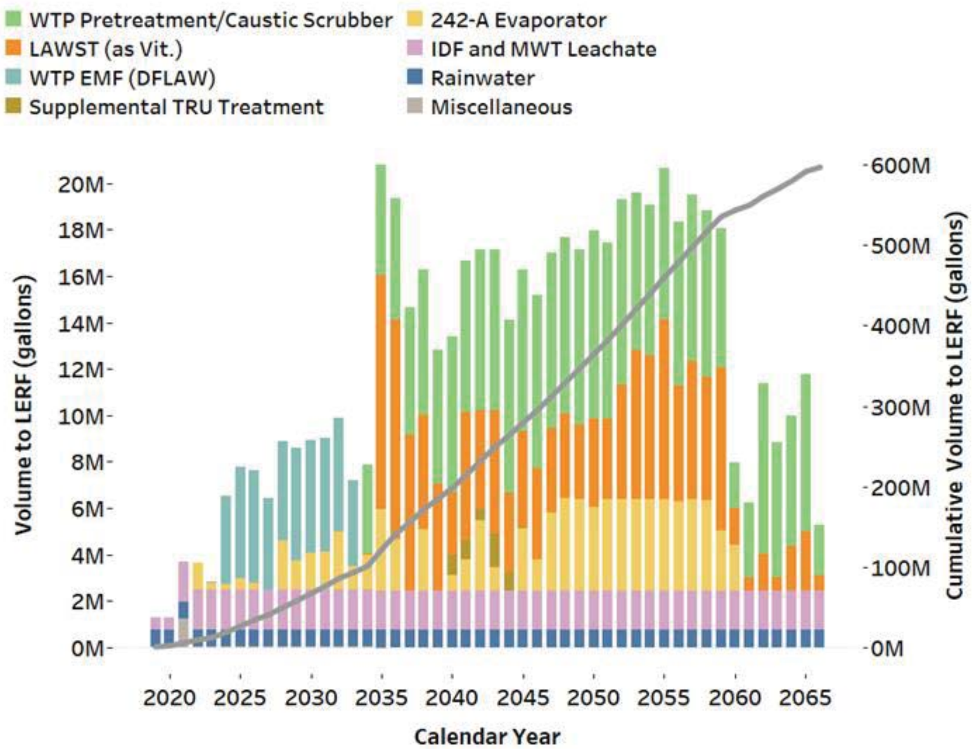


Acronyms:

DFLAW	=	direct-feed low-activity waste.	MWT	=	mixed waste trench.
EMF	=	Effluent Management Facility.	TRU	=	transuranic.
IDF	=	Integrated Disposal Facility.	Vit.	=	vitrification.
LAWST	=	low-activity waste supplemental treatment.	WTP	=	Waste Treatment and Immobilization Plant.

Figure 5-16 shows the estimated annual volume of secondary liquid effluent over the course of the mission. Prior to the start of DFLAW operations in 2023, the LERF is estimated to receive a maximum of 3.7 Mgal in a calendar year from the tank farms and 242-A Evaporator operations. Once DFLAW treatment begins, a significant volume increase is expected due to the addition of the WTP EMF effluent, which will require the ETF to process an additional 4.5 Mgal per year. When the integrated WTP begins operating in 2033, it is estimated to contribute an average of 6.4 Mgal per year, and a year later when LAWST begins operating, an additional 4.5 Mgal per year (average) is projected. From 2035 to 2060 the LERF/ETF must process an average of nearly 17 Mgal per year, which is considerably more than the 2.2 to 3.9 Mgal processed per calendar year since 2012 when WRPS began managing ETF operations.

Figure 5-16. Baseline Case – Annual Volume of Secondary Liquid Effluent.



Acronyms:

DFLAW	=	direct-feed low-activity waste.
EMF	=	Effluent Management Facility.
IDF	=	Integrated Disposal Facility.
LAWST	=	low-activity waste supplemental treatment.
LERF	=	Liquid Effluent Retention Facility.
MWT	=	mixed waste trench.
TRU	=	transuranic.
Vit.	=	vitrification.
WTP	=	Waste Treatment and Immobilization Plant.

5.1.2.4.5.6 Potential Contact-Handled Transuranic Treatment

The System Plan Rev. 9 Model Starting Assumptions (Section A1.4.2) indicate that 11 SSTs will be handled as CH-TRU tank waste. The potential CH-TRU waste, after classification, will be treated at a supplemental TRU waste treatment facility (Section 3.3.1), and then stored onsite at the CWC until final disposition. The treated potential CH-TRU tank waste could be disposed of at an approved federal geological repository (Section 3.4.7). However, if the DOE elects not to treat and dispose of this waste as such, it could be blended with other Hanford sludge waste and processed in the WTP as HLW.

A total of 5.4 Mgal of the potential CH-TRU tank waste is projected to be treated by the supplemental treatment process over 5 years[30] beginning in January 2040. The estimated 8,800 drums of packaged waste created by the supplemental process will be stored at the CWC pending certification and offsite shipment (Section 3.4.4).

Note: The number of drums increased by 400 compared to System Plan Rev. 8 due to an increase in the estimated waste inventory of the tanks containing potential TRU waste.

[30] The 5 years includes the assumed 6-month downtime when changing operations from the 200 East Area to the 200 West Area.

5.1.2.4.6 Waste Disposal

5.1.2.4.6.1 High-Level Waste Disposal

At least 4,000 IHLW canisters will be sent to the IHS Facility for interim storage. The IHS Facility will be expandable in increments of 2,000 canisters up to a maximum of 16,000 canisters, if needed (Assumption A1.5.3.2). The first module will be ready 3 months prior to the startup of HLW treatment in 2033, and the second 2,000-canister IHS module is projected to be available in June 2042, which is 1.5 years in advance of the projected need date of December 2043 (Assumption A1.5.3.6). It is assumed that the HSF will not be delayed; however, if it is delayed and shipping cannot begin, the IHS Facility will reach its maximum storage capacity of 4,000 canisters in 2049. In that case, additional modules will be added to meet the storage requirements, as outlined in Assumption A1.5.3.2. With the projected 7,300 canisters, there are two additional IHS expansion modules required to store all the canisters temporarily.

Pending a determination of the final disposal alternative, the enabling assumption is that in 2037, a decision will be made to construct the HSF and begin shipping IHLW canisters to an offsite final disposal alternative (Assumption A1.5.4.2). Based on the Baseline Case results, the HSF will begin shipping IHLW canisters to the final disposal alternative in 2049. The HSF is assumed to operate continually until all the canisters have been shipped to the final disposal alternative, which is projected to be in 2068. Shipment of the projected 7,300 IHLW canisters to a planned, offsite geological repository is discussed in Section 3.4.7.

In addition to the IHLW canisters, the WTP HLW Vitrification Facility is projected to generate 14 spent HLW melters during the mission. The final disposition of the spent HLW melters has not been determined.

5.1.2.4.6.2 Immobilized Low-Activity Waste Disposal

The ILAW containers and solid waste from the WTP LAW Vitrification Facility and LAWST (as vitrification) are disposed of onsite at the IDF. The IDF is projected to receive 89,000 packages of ILAW, 43 spent LAW melters (17 from the WTP LAW Vitrification Facility and 26 from the LAWST capability), and potentially solidified secondary waste from ETF processing and other solid waste over the duration of the LAW treatment mission (2023 to 2068).

5.1.2.4.6.3 Potential Contact-Handled Transuranic-Treated Waste Disposal

The CWC is assumed to store the 8,800 packaged potential CH-TRU waste drums generated between 2040 and 2045, until final disposition of the CH-TRU (Assumption A1.5.2.2).

5.1.2.4.6.4 Treated Secondary Liquid Effluent Disposal

An estimated 600 Mgal of treated effluent from the ETF is projected to be disposed of at the SALDS (Section 3.4.2) over the duration of the treatment mission (2019 to 2066). The solid waste from ETF processing may potentially be disposed of at the ERDF, as it is currently, or the IDF. A decision for the final treatment and disposal of the DFLAW ETF waste is pending.

However, if the WTP and LAWST secondary liquid effluent is dried and packaged as a powder, it may exceed the RCRA requirements for disposal as a packaged powder due to its concentration of certain heavy metals. The RCRA requirements can be satisfied by either macro-encapsulation or grouting of the powder, and it has been recommended to concentrate the WTP effluent to a brine in the ETF and, subsequently, stabilized offsite before being disposed of at the IDF (RPP-RPT-59124, *Offsite Treatment Onsite Integrated Disposal Facility Disposal for Secondary Waste from the Effluent Treatment Facility to Support Direct Feed Low Activity Waste Operations – Brine or Powder Alternative Evaluation*).

5.1.2.4.7 Closure

The estimated closure dates for the SSTs and DSTs are scheduled to reflect the baseline closure strategies and the individual retrieval dates projected by TOPSim. All SSTs are projected to be retrieved by 2061 and closed by 2065. After bulk retrieval of the last SST is completed, the critical path includes tank-specific, farm, and WMA closure activities. All DSTs are projected to be retrieved by 2065 and closed by 2070.

5.1.2.5 Life-Cycle Cost Results

Table 5-7 summarizes the projected near-term Baseline Case escalated costs through FY 2027, which total $10 billion. Figure 5-17 shows the life-cycle cost profile for the Baseline Case. The total unescalated life-cycle cost is $107 billion ($192 billion escalated). The near-term costs from FY 2020 to 2023 are from tank farm operations and the DFLAW Program, including construction completion of the TSCR system and related DST infrastructure upgrades. Beginning in FY 2024, there is a sharp increase in cost above current and historical funding levels required due to DFLAW operations costs (TSCR, WTP LAW Vitrification Facility, BOF, and Analytical Laboratory), as well as costs associated with the design and construction of the TWCS capability and LAWST (costed as a vitrification facility). There is a small dip from FY 2033 to 2034, when the LAWST capability has completed major construction, but has not started processing waste; however, when the integrated WTP and the LAWST capability start, the annual costs are relatively constant at approximately $2 billion (unescalated) until the end of treatment. Small dips and increases are a result of variations in annual SST retrievals and tank closures.

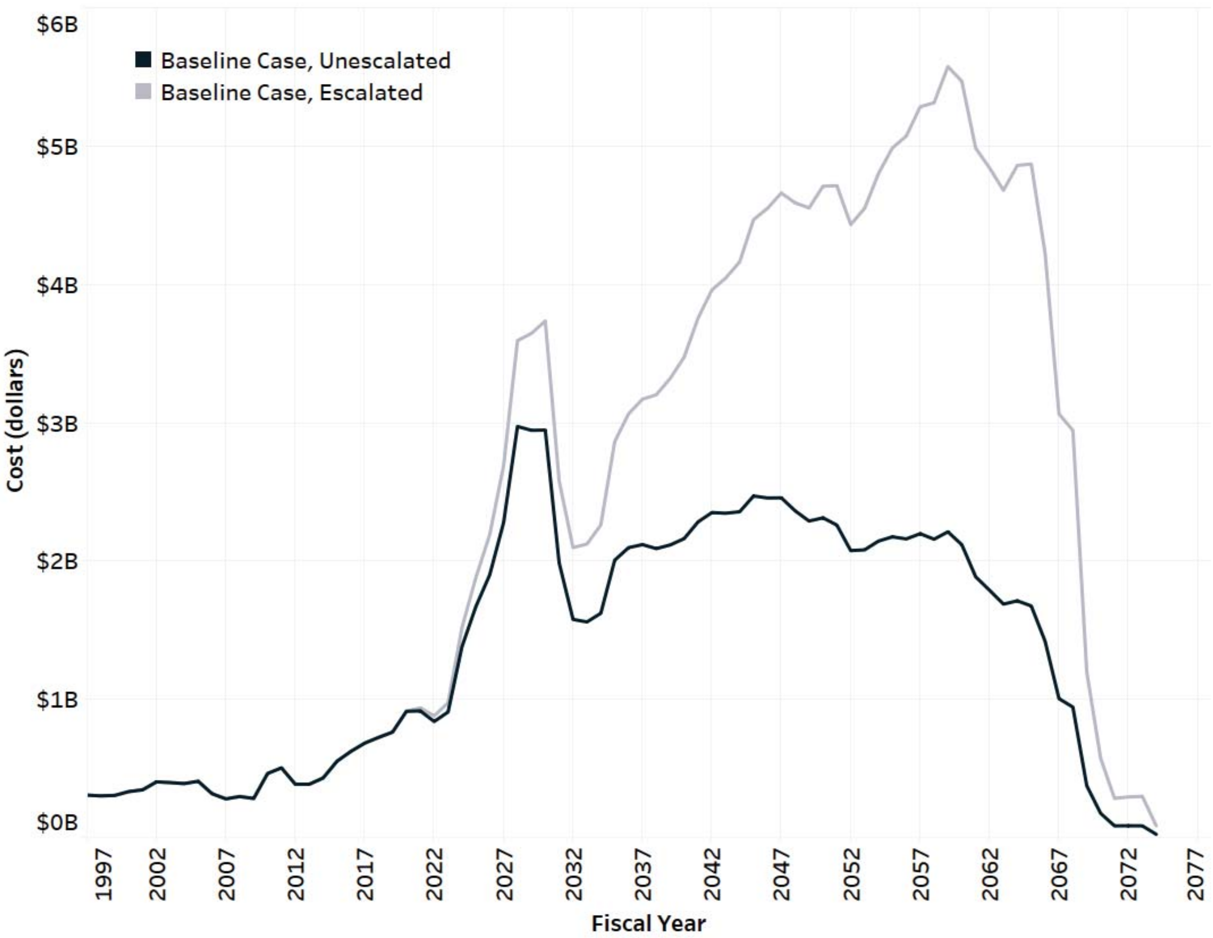
Note: Costs are reported without contingency. Construction and startup costs for the WTP including the WTP's Pretreatment Facility, HLW and LAW Vitrification Facilities; BOF; and Analytical Laboratory are not included in the System Plan Rev. 9 life-cycle cost, though operating costs of the aforementioned facilities are included. The cost of offsite transportation and disposal of IHLW canisters (or other potential waste forms such as TRU drums) is also not included.

Table 5-7. Baseline Case – Near-Term Cost Estimates (Unescalated).

Scenario	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	Total
Baseline Case ($M)	$918	$926	$874	$956	$1,377	$1,564	$1,639	$1,798	$10,053

FY = fiscal year.

Figure 5-17. Baseline Case – Life-Cycle Cost Profile.

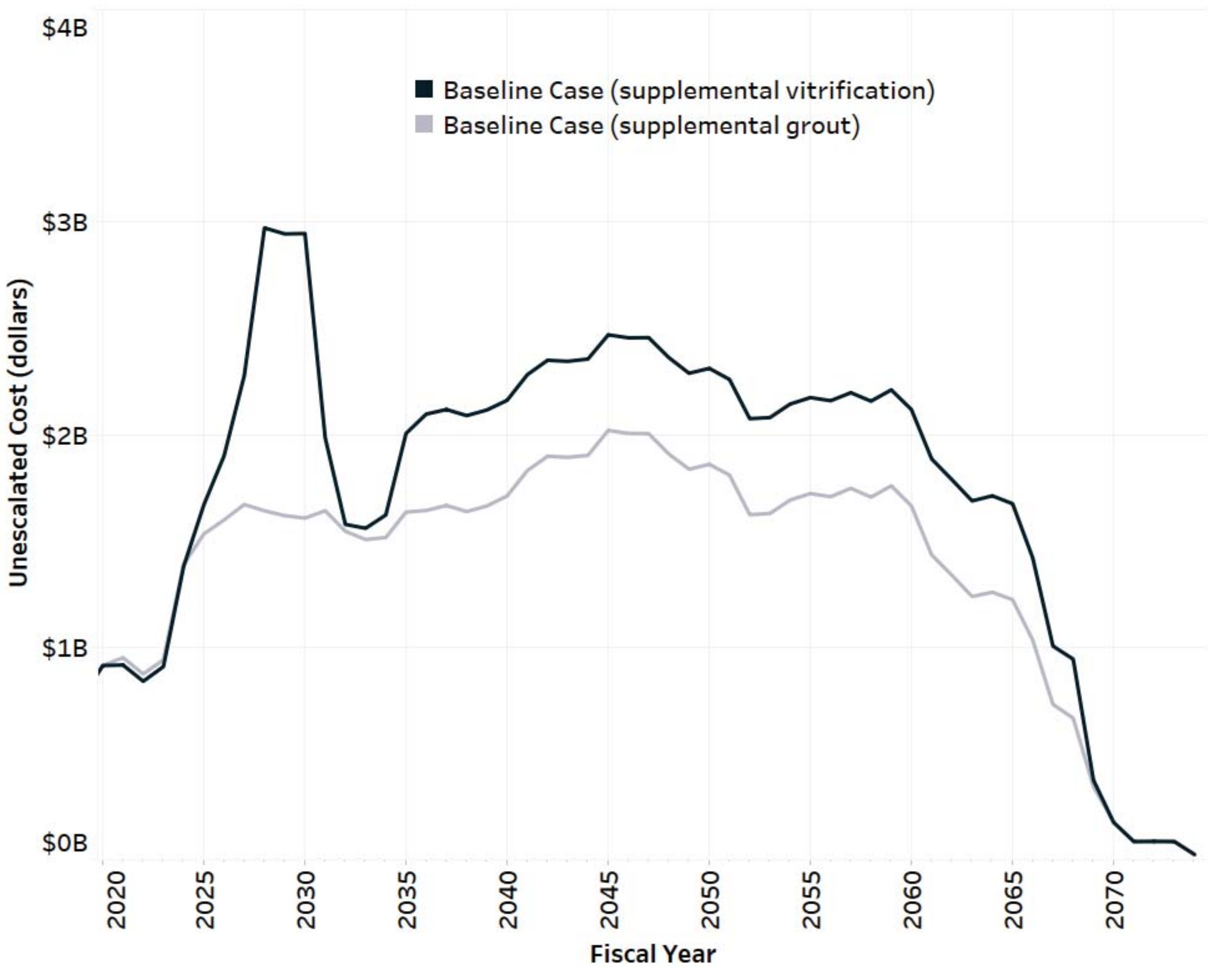


The life-cycle cost for the Baseline Case is also estimated assuming the LAWST capability is a grouting facility. Figure 5-18 shows the unescalated life-cycle cost comparison for the Baseline Case with the LAWST capability as vitrification versus grout. The life-cycle cost for the Baseline Case with LAWST as grout is $87 billion unescalated, versus the $107 billion unescalated estimated when LAWST is vitrification. This is driven by a reduction in the life-cycle costs for the LAWST capability from $21.3 billion to $2.1 billion.

- A grout LAWST capability is estimated to cost $583 million to construct compared to the $6 billion required to build the four-melter vitrification LAWST capability.
- The estimated annual operating cost of a grout LAWST capability is approximately $50 million per year compared to $475 million per year for the four-melter vitrification LAWST capability.

Cost estimates for LAWST as grout are based on SRNL-RP-2018-00687, *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at Hanford Nuclear Reservation*.

Figure 5-18. Baseline Case – Life-Cycle Unescalated Cost Profile for Low-Activity Waste Supplemental Treatment as Grout versus Vitrification.



5.1.3 Scenario 1A – Baseline Case Sensitivity – U Tank Farm Retrieved after A/AX Tank Farms

5.1.3.1 Objective and Planning Bases

The objective of sensitivity Scenario 1A is to determine the effect on the Baseline Case (specifically DFLAW feed) when U Tank Farm is retrieved after A/AX Tank Farms instead of after S/SX Tank Farms. Scenario 1A uses the same assumptions as the Baseline Case, except for the tank farm retrieval order.

5.1.3.2 Key Results and Analysis

The mission metrics for Scenario 1A are compared to the Baseline Case in Table 5-8. Because the changes in this scenario only involve a change in sequence of the SST retrievals, the operating schedule dates and total products are similar to the Baseline Case, with minor differences.

- SST retrievals completed 2 years earlier than the Baseline Case. [31]
- The T Complex WRF is not operational until 2049, 5 years after the operational date in the Baseline Case (which coincides with the start of the respective retrievals).

All other key metrics are similar, aligning within approximately 1 year of the Baseline Case.

Table 5-8. Scenario 1A Comparison – Key Metrics.

Metric	Baseline Case	Scenario 1A
SST Retrievals Complete	2061	2059
DST Retrievals Complete	2065	2065
Tank Waste Treatment Complete	2066	2065
IHLW Glass Canisters	7,300	7,000
Total ILAW Glass Containers	89,000	89,000
WTP ILAW Glass Containers (% Total)	52,000 (59%)	52,000 (58%)
LAWST ILAW Glass Containers (% Total)	37,000 (41%)	37,000 (42%)
LAWST Glass Volume, yd^3	103,000	103,000
LAWST Equivalent Grout Volume, yd^3	400,000	400,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,000	11,000

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-19 compares the SST retrieval sequence for Scenario 1A and the Baseline Case. The blue bands on the plots indicate when retrieval of the SST is occurring, the white spaces between the bars is the assumed setup time between retrievals, and the grey bands indicate delays in the SST retrievals due to inadequate DST space. The figure shows that retrieving U Tank Farm after the retrieval of tanks in the A/AX Tank Farms leads to less

[31] Although 2 years is within the typical aleatory uncertainty of the SST retrieval completion date in TOPSim, a completion date of 2059 is outside the range of uncertainty in the Baseline Case results, and thus is a significant (though still minor) result of this sensitivity (Section 5.1.2.3).

delay time overall than the Baseline Case. In this scenario, after retrievals in the A/AX Tank Farms are completed in 2027, two U Tank Farm tanks (Tanks U-202 and U-203) are initially retrieved without delays because these tanks have a relatively small retrieval volume (less than 113,000 gal combined). However, the next tank (Tank U-111) is delayed by a year while it waits for DST mitigations (Tanks AN-104 and SY-103) necessary to start the cross-site transfer line. In the Baseline Case, retrieval of Tank S-105 is started after those in A/AX Tank Farms and is then delayed by more than 18 months before there is adequate DST space to proceed. An advantage of this scenario is that the entire U Tank Farm is completed 5 years sooner than S/SX Tank Farms in the Baseline Case and with less effect to the timing of B Complex retrievals.

The cumulative delay for Scenario 1A is 78 percent less than the cumulative delay for the Baseline Case.[32] Less delay time enables retrieval completion of 200 East Area SSTs 6 years earlier and all SSTs 2 years earlier as compared to the Baseline Case.

Figure 5-19. Scenario 1A Comparison – Single-Shell Tank Retrievals.

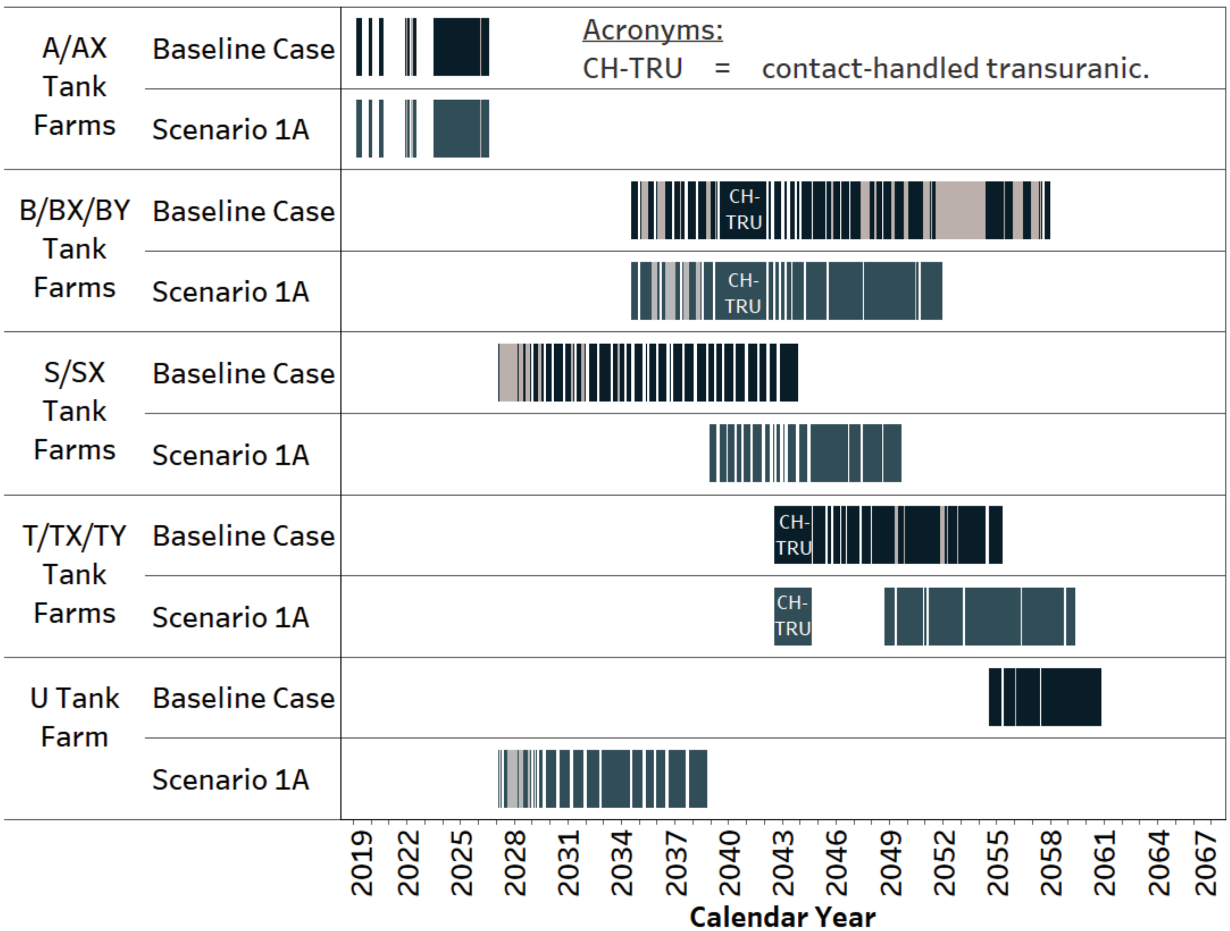


Table 5-9 compares the differences in retrieval metrics for Scenario 1A and the Baseline Case from mid-2027 (after A/AX Tank Farms' retrievals) to January 2034 (start of the WTP's Pretreatment and HLW Vitrification Facilities). During this period, more SSTs are fully retrieved

[32] The cumulative delay is the sum of all of the delays, and because multiple retrievals occur in parallel, this does not directly correlate to the total retrieval time.

in this scenario (10 in U Tank Farm) than in the Baseline Case (8 from S/SX Tank Farms). However, there is less volume of original SST waste retrieved from the tanks in the U Tank Farm compared to the eight tanks in the S/SX Tank Farms. The total radioactivity of the retrieved waste is approximately the same for both cases.

The approximate 20 Mgal of DFLAW feed to the WTP LAW Vitrification Facility for both the Baseline Case and Scenario 1A met all of the requirements in 24590-WTP-ICD-MG-01-030, *ICD 30 – Interface Control Document for Direct LAW Feed* (ICD-30), indicating that switching to early retrievals in U Tank Farm does not pose any negative consequences to the predicted DFLAW feed.

Table 5-9. Scenario 1A Comparison – Retrieved Waste Metrics from 2027 to 2034.

Metric	Baseline Case	Scenario 1A
Number of SSTs Completely Retrieved	8	10
Volume of Original Waste of SSTs Retrieved	2.7 Mgal	1.8 Mgal
Volume of Original Saltcake Removed	2.6 Mgal	1.7 Mgal
Volume of Original Sludge Removed	0.09 Mgal	0.1 Mgal
Volume of As-Retrieved Waste	12.7 Mgal	9.1 Mgal
Total Radioactivity of the Completely-Retrieved SSTs[a]	1.8 MCi	1.9 MCi

[a] Decay date of January 1, 2016, for comparison purposes only.
SST = single-shell tank.

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5.1.4 Scenario 1B – Baseline Case Sensitivity – Reduced Waste Treatment and Immobilization Plant Total Operating Efficiency

5.1.4.1 Objective and Planning Bases

The objective of sensitivity Scenario 1B is to determine the effect when the WTP integrated facility availability is reduced from 70 percent to 50 percent TOE. This scenario has the same assumptions as Scenario 1A, except that the WTP integrated TOE and LAWST TOE is reduced from 70 percent to 50 percent. The LAW, LAWST, and HLW capacities are reduced to 50 percent, and then the WTP Pretreatment Facility throughput is adjusted in order to achieve an overall WTP integrated TOE of 50 percent. A survey of nuclear waste treatment facilities (RPP-RPT-61717, *Updated Waste Treatment and Immobilization Plant Operating Efficiency Estimate*) found that 40 percent TOE was a typical value, so the 50 percent TOE used in Scenario 1B represents a potentially more realistic throughput compared to the 70 percent TOE in the WTP contract (DE-AC27-01RV14136). Table 5-10 identifies the assumptions from Appendix A that were modified from Scenario 1 to create Scenario 1B.

Table 5-10. Scenario 1B – Starting Assumptions Altered from Scenario 1.

Starting Assumption #	Scenario 1B Assumption
A1.2.3.4	U Tank Farm (instead of S/SX Tank Farms) will be the next SSTs retrieved after completion of retrievals in A/AX Tank Farms.
A1.3.1.3	The integrated facility availability of the WTP is assumed to be 50% instead of 70%.
A1.3.2.1	The net WTP HLW Vitrification Facility capacity will be ramped up as follows to reflect a TOE of 50% instead of 70%. **Starting** **Rate (MTG/Day)** 12/31/2033 1.8 12/31/2034 2.3 09/30/2036 3.0 12/31/2038 3.75
A1.3.4	The net WTP LAW Vitrification Facility capacity will be ramped up as follows to reflect a TOE of 50% instead of 70%. **Starting** **Rate (MTG/Day)** 12/31/2023 9.0 07/31/2024 11.0 07/31/2025 15.0
A1.4.1.5	The LAWST TOE will be 50% instead of 70%.
A1.4.1.5	The LAWST capability shall be sized with the same number of melters as the Baseline Case.

HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity supplemental treatment.
SST = single-shell tank.
TOE = total operating efficiency.
WTP = Waste Treatment and Immobilization Plant.

5.1.4.2 Analysis

5.1.4.2.1 Key Results and Metrics

The mission metrics for Scenario 1B are compared to the Baseline Case in Table 5-11. The reduction in treatment throughput made the mission fully treatment limited and increased the length of the mission by nearly 10 years. The total quantity of products is similar to the Baseline

Case; however, the key delays to the operating schedule dates are summarized below (as compared to the Baseline Case).

- All treatment facilities and DSTs operated approximately 10 years longer, including WTP LAW Vitrification Facility, WTP HLW Vitrification Facility, WTP Pretreatment Facility, TFPT, and LERF/ETF.
- The completion of all SST retrievals was 4 years longer than the Baseline Case and 6 years longer than Scenario 1A.

Table 5-11. Scenario 1B Comparison – Key Metrics.

Scenario	Baseline Case	Scenario 1B
SST Retrievals Complete	2061	2065
DST Retrievals Complete	2065	2075
Tank Waste Treatment Complete	2066	2076
IHLW Glass Canisters	7,300	7,000
Total ILAW Glass Containers	89,000	88,000
WTP ILAW Glass Containers (% Total)	52,000 (59%)	49,000 (56%)
LAWST ILAW Glass Containers (% Total)	37,000 (41%)	39,000 (44%)
LAWST Glass Volume, yd^3	103,000	109,000
LAWST Equivalent Grout Volume, yd^3	400,000	430,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids	11,000	11,000
Unescalated (Escalated) Life-Cycle Cost	$107B ($192B)	$122B ($247B)

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

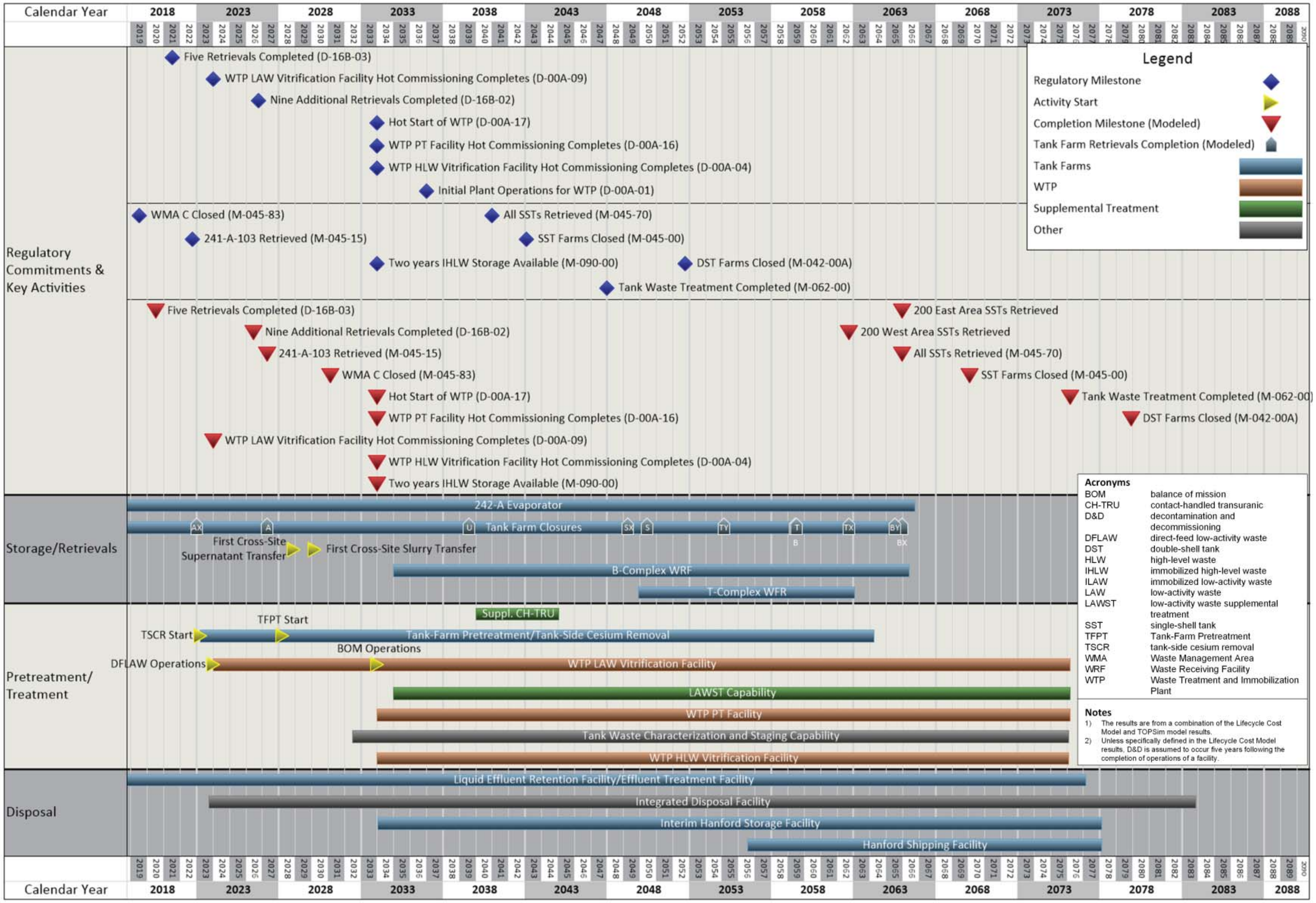
The longer mission creates an increase to the cost by $15 billion (unescalated) and $53 billion (escalated). There is an increased reliance on the 242-A Evaporator as it is operated 6 years longer and processes 24 percent more feed than the Baseline Case. Table 5-12 lists the key mission activity dates for Scenario 1B compared to the Baseline Case, followed by Figure 5-20 that shows the projected operating schedule for SST retrievals and treatment systems.

Table 5-12. Scenario 1B – Summary of Schedule Results.

	Key Mission Metric	Baseline Case	Scenario 1B
Regulatory	Complete Five Additional SST Retrievals (Existing Consent Decree 06/30/2021)	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Existing Consent Decree 09/30/2026)	06/2026	06/2026
	Complete Tank 241-A-103 Retrieval (Existing TPA 09/30/2022)	01/2027	04/2027
Storage/Retrieval	242-A Evaporator Operations	Present – 2060	Present – 2066
	200 East Area WRF Operations	2034 – 2059	2034 – 2065
	200 West Area WRF Operations	2044 – 2056	2049 – 2062
	200 East Area SST Retrievals Complete	2058	2065
	200 West Area SST Retrievals Complete	2061	2062
	Cross-Site Transfer Line Activated (Supernatant)	2028	2028
	Cross-Site Transfer Line Activated (Slurry)	2029	2030
Pretreatment/Treatment	TSCR/TFPT Operations	2023 – 2060	2023 – 2064
	TWCS Capability Operations	2032 – 2066	2032 – 2076
	WTP Pretreatment Facility Operations	2033 – 2066	2033 – 2076
	WTP LAW Vitrification Facility Operations	2023 – 2066	2023 – 2076
	WTP HLW Vitrification Facility Operations	2033 – 2066	2033 – 2076
	LAWST Operations	2034 – 2066	2034 – 2076
	Potential CH-TRU Waste Packaging Facility Operations	2040 – 2045	2040 – 2045
	LERF/ETF Operations	Present – 2067	Present – 2077
	Waste Treatment Complete	2066	2076
Disposal	IDF Operations	2023 – 2074	2023 – 2083
	IHS Facility Operations	2033 – 2068	2033 – 2078
	HSF Offsite Shipping Operations	2049 – 2068	2056 – 2078
	All IHLW Shipped Offsite	2068	2078

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
LERF = Liquid Effluent Retention Facility.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-20. Scenario 1B – Modeled Operating Schedule of Major Facilities/Processes.



5.1.4.2.2 Mission Flowsheet Results

To better understand the effect of the reduced treatment throughput on SST retrievals and DST space, Scenario 1B is compared to the Baseline Case and Scenario 1A (because Scenario 1B includes the changes to the retrieval sequence in Scenario 1A). The treatment rate at the 50 percent TOE reduces the speed that waste is removed from the DSTs resulting in less available space to receive SST retrieval waste. Figure 5-21 shows the SST retrieval progress for the Baseline Case, Scenario 1A, and Scenario 1B; Figure 5-22 shows the available DST space. Comparing the two figures (Figure 5-21 and Figure 5-22) illustrates the relationship between the DST space and the SST retrieval progress. The SST progress is nearly identical until about 2034 when the available DST space begins to be affected by the reduced treatment rate. Then in 2045, the retrieval progress deviates further when the number of allowable simultaneous retrievals is doubled. With the treatment rate reduced in Scenario 1B, the available DST space from 2045 to 2065 averages 5 Mgal compared with Scenarios 1 and 1A, which average twice the available DST space during the same period.

Figure 5-21. Scenario 1B Comparison – Single-Shell Tank Retrieval Progress.

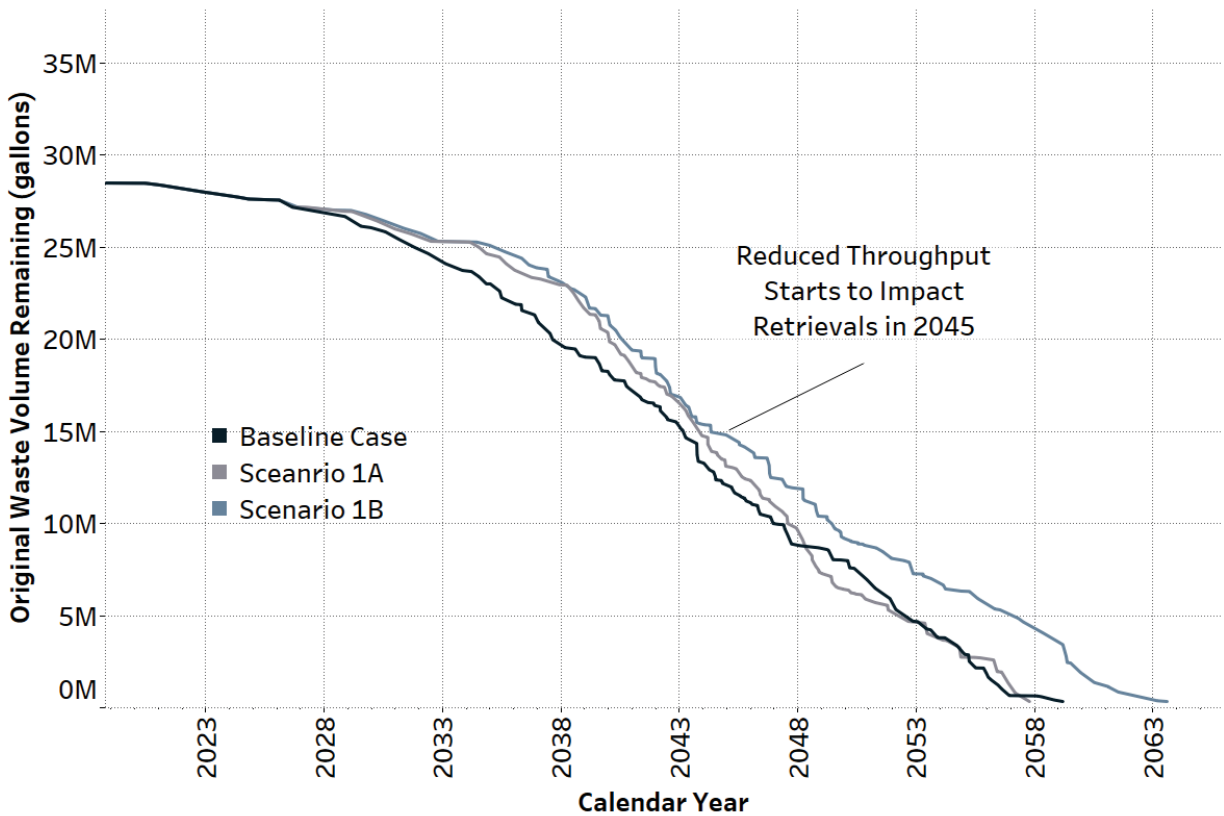


Figure 5-23 shows the projected demand on the 242-A Evaporator (campaigns and cumulative feed volume) through the completion of the evaporator's operations for Scenario 1B and the Baseline Case. With the reduced treatment throughput, the demand on the DST space is increased, resulting in an increase in evaporator operations, both in duration and volume. The 242-A Evaporator is expected to operate 6 years longer and to process 152 Mgal of dilute waste in Scenario 1B, 24 percent more than the Baseline Case (123 Mgal).

Figure 5-22. Scenario 1B – Double-Shell Tank Space Utilization.

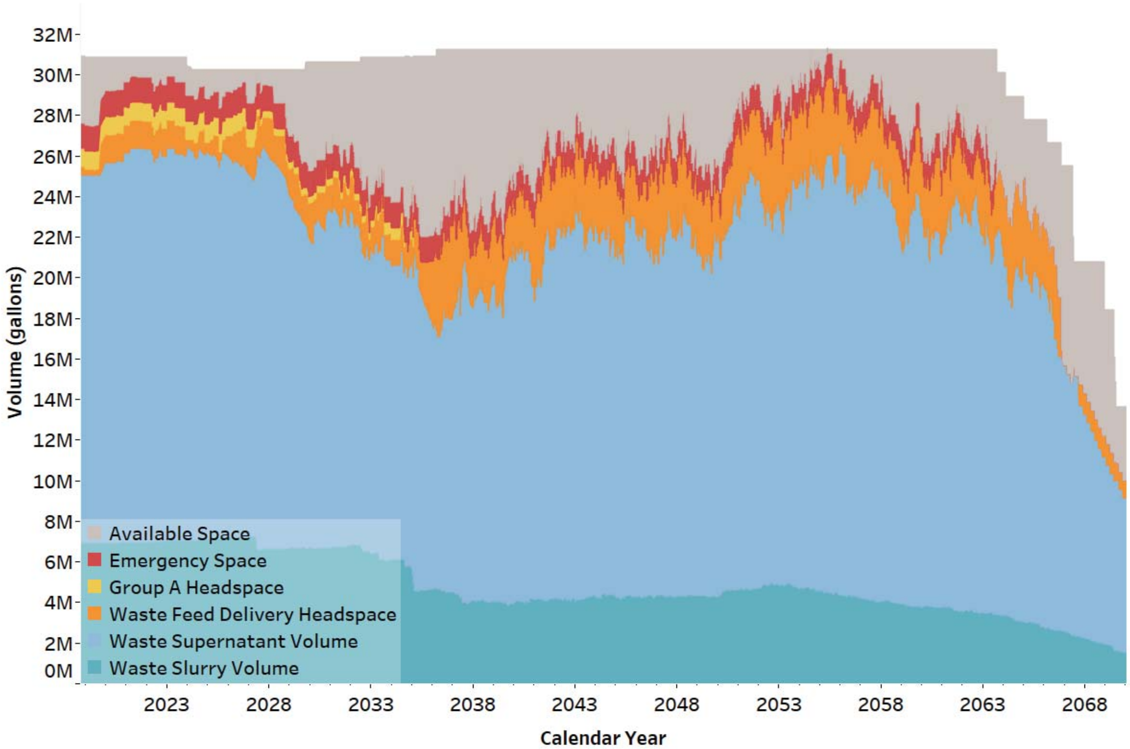
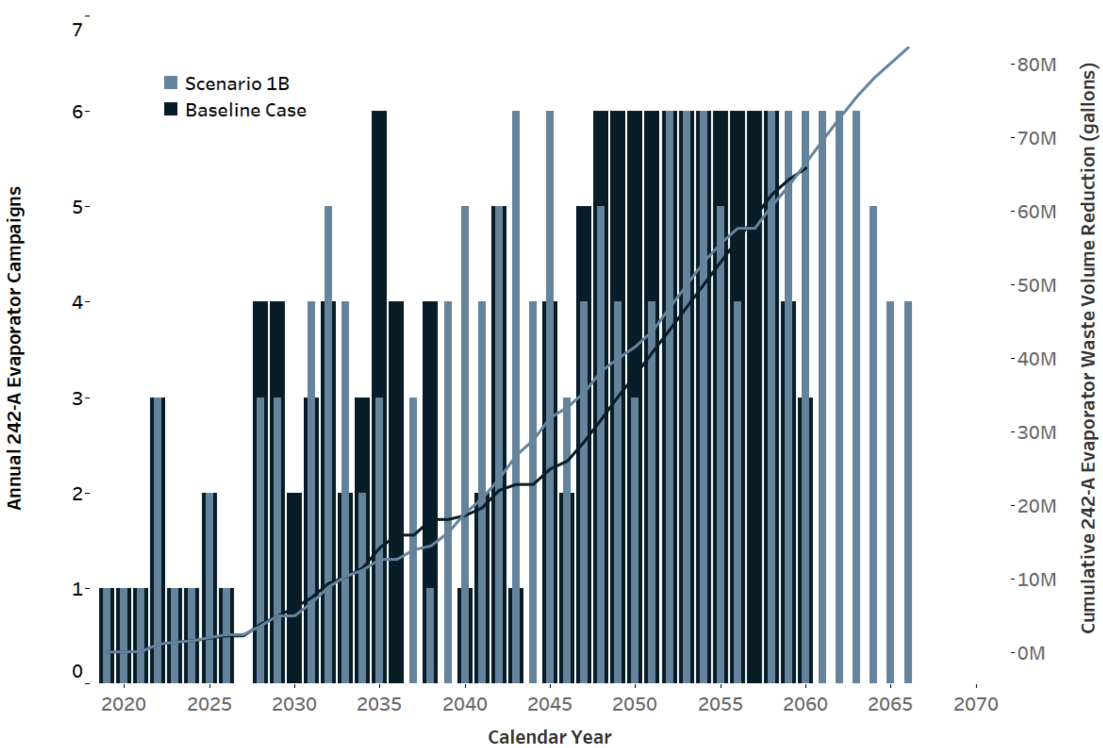


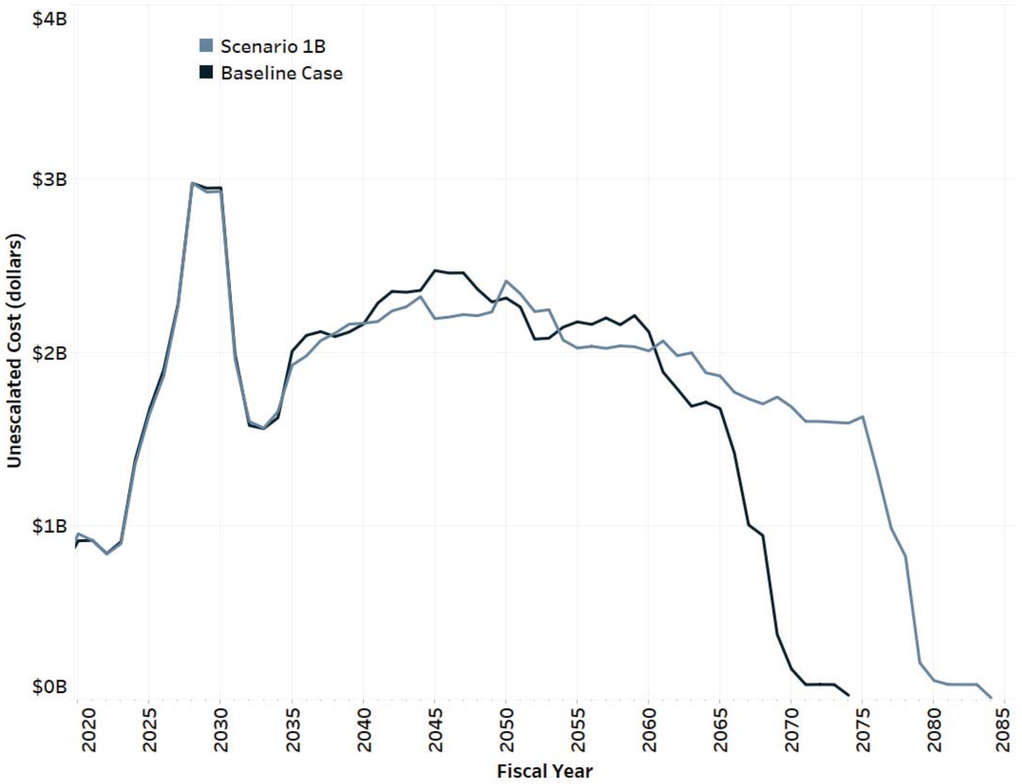
Figure 5-23. Scenario 1B Comparison – 242-A Evaporator Utilization.



5.1.4.2.3 Life-Cycle Cost Results

The life-cycle cost for Scenario 1B is $122 billion unescalated ($247 billion escalated). Figure 5-24 shows the cost profile comparison to the Baseline Case. The cost profile is similar to the Baseline Case, except the additional 10 years of operations increases the total cost by $15 billion unescalated ($56 billion escalated).

Figure 5-24. Scenario 1B Comparison – Unescalated Life-Cycle Cost Profile.



5.1.4.3 Risks

The risks associated with Scenario 1B are the same as the Baseline Case (see Section 7.1); however, the reduced TOE of 50 percent may be more achievable than the 70 percent assumed in the Baseline Case. The reduced throughput extends the mission by 10 years exacerbating the risks related to the aging infrastructure, tanks, and facilities.

5.1.4.4 Opportunities

By reducing the treatment throughput in Scenario 1B, the available DST space is reduced, increasing the delays to SST retrievals as compared to the Baseline Case. There is therefore an opportunity to optimize SST retrievals to promote level loading of retrievals over the course of the mission while maintaining feed to the WTP.

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5.1.5 Scenario 1C – Baseline Case Sensitivity – Limited Simultaneous Single-Shell Tank Retrievals

5.1.5.1 Objective and Planning Bases

The objective of Scenario 1C is to evaluate the effect of limiting SST retrievals to one at a time per area (200 East and 200 West Areas) and a maximum of two total simultaneous retrievals for the full mission.

This scenario has the same assumptions as Scenario 1B, except the following:

- The SST retrievals were limited to one retrieval at a time per area (200 East and 200 West Areas) for the full mission compared to two simultaneous retrievals per area after 2045 in the Baseline Case and Scenario 1B.
- The DST retrieval and closure activities are limited to one tank at a time per farm, compared to two per farm in the Baseline Case and Scenario 1B.
- The total DST and SST retrievals are limited to no more than two at a time, compared to four in the Baseline Case and Scenario 1B.

5.1.5.2 Key Results and Analysis

The mission metrics for Scenario 1C are compared to Scenario 1B in Table 5-13. The additional restrictions to SST and DST retrievals increase the length of the mission by 3 years compared to Scenario 1B (nearly 13 years compared to the Baseline Case). Restricting the SST retrievals to only one retrieval per area causes the mainly treatment-limited mission to become retrieval limited for a few years near the end of the mission. The total quantity of products is similar to Scenario 1B (and the Baseline Case); however, there are key delays to the operating schedule (as compared to Scenario 1B), which are summarized below.

- The completion of all SST retrievals is almost 8 years longer.
- 200 East Area SST retrievals are completed 4 years earlier and 200 West Area SST retrievals are extended by 11 years.
- The T Complex WRF startup is delayed by 4 years (corresponding to the start of T Complex retrievals).
- The reliance on the 242-A Evaporator is increased, as it was operated 7 years longer.
- All treatment facilities operate approximately 3 years longer, including the WTP LAW Vitrification Facility, WTP HLW Vitrification Facility, WTP Pretreatment Facility, TFPT, and LERF/ETF.

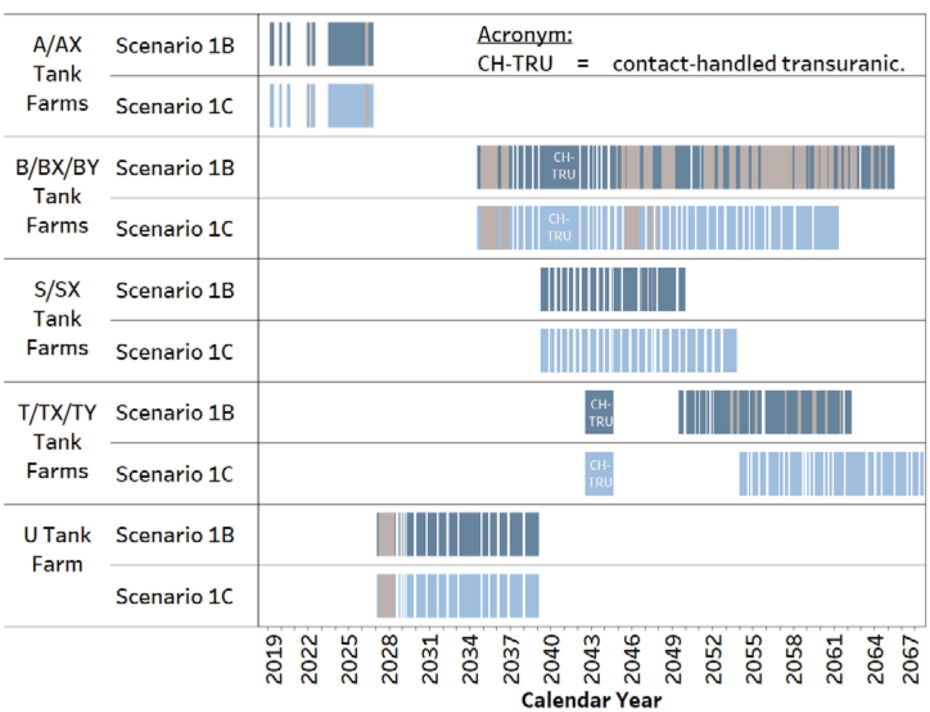
Table 5-13. Scenario 1C Comparison – Mission Metrics.

Scenario	Scenario 1B	Scenario 1C
SST Retrievals Complete	2065	2073
DST Retrievals Complete	2075	2079
Tank Waste Treatment Complete	2076	2079
IHLW Glass Canisters	7,000	7,100
Total ILAW Glass Containers	88,000	88,000
WTP ILAW Glass Containers (% Total)	49,000 (56%)	49,000 (56%)
LAWST ILAW Glass Containers (% Total)	39,000 (44%)	39,000 (44%)
LAWST Glass Volume, yd^3	109,000	108,000
LAWST Equivalent Grout Volume, yd^3	430,000	430,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,000	11,000

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

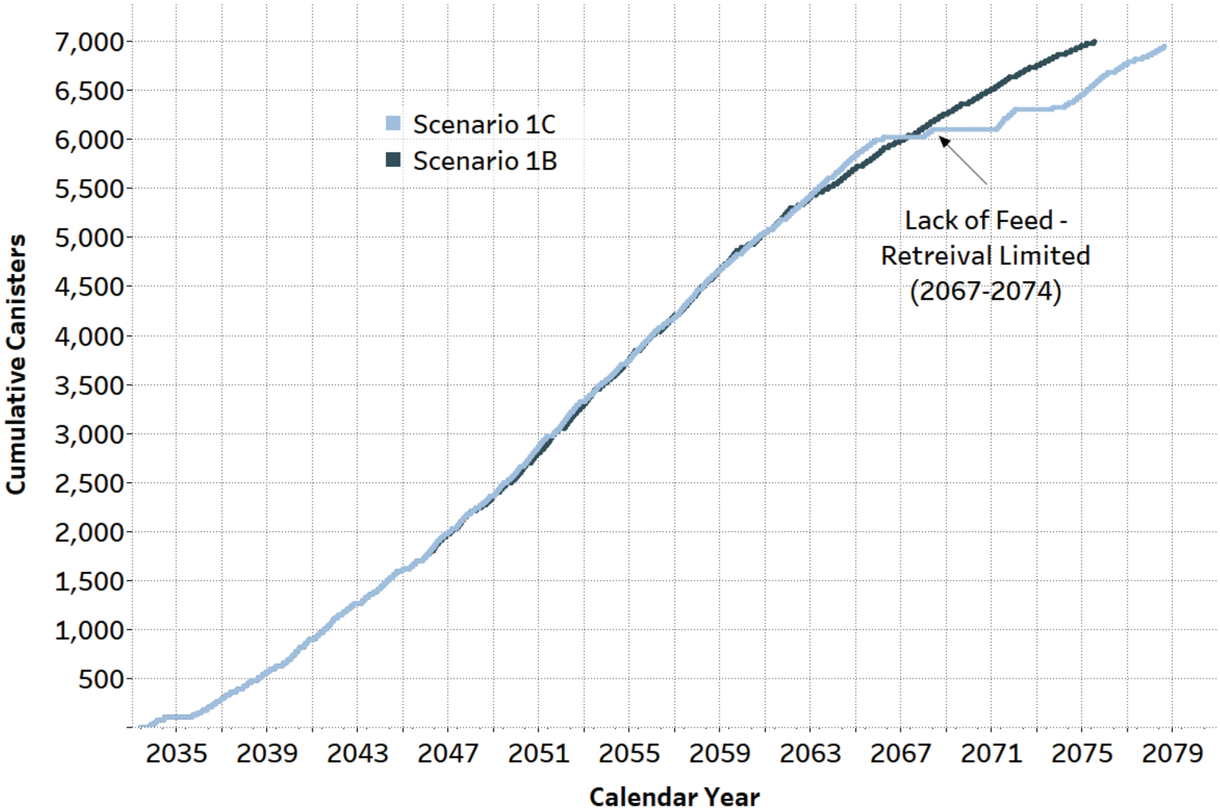
Figure 5-25 shows that there are fewer delays to the SST retrievals compared to Scenario 1B. The B Complex retrievals progress faster than Scenario 1B because, with fewer simultaneous retrievals, there is less competition for DST space, especially from the 200 West Area. There is a greater effect on retrievals in the 200 West Area in Scenario 1C because of 33 additional SSTs in 200 West Area versus 200 East Area and, therefore, more waste [75 percent by volume] and a longer total duration.

Figure 5-25. Scenario 1C Comparison – Single-Shell Tank Retrieval Schedule.



The WTP IHLW production plot is provided in Figure 5-26. The plot indicates that there is a lack of feed to the treatment facilities between 2067 and 2074, when the last few SSTs are being retrieved; however, at the end of the mission, during DST closures, the mission becomes treatment limited again.

Figure 5-26. Scenario 1C Comparison – Immobilized High-Level Waste Production.



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5.1.6 Scenario 1D – Baseline Case Sensitivity – No Supplemental Contact-Handled Transuranic Waste Processing

5.1.6.1 Objective and Planning Bases

The objective of Scenario 1D is to determine the effect of eliminating supplemental processing of the potential CH-TRU waste. This scenario starts with Scenario 1B but does not operate supplemental CH-TRU treatment; instead it retrieves the 11 CH-TRU tanks' waste (Section 3.3.1) into the DSTs via the WRFs.

5.1.6.2 Key Results and Analysis

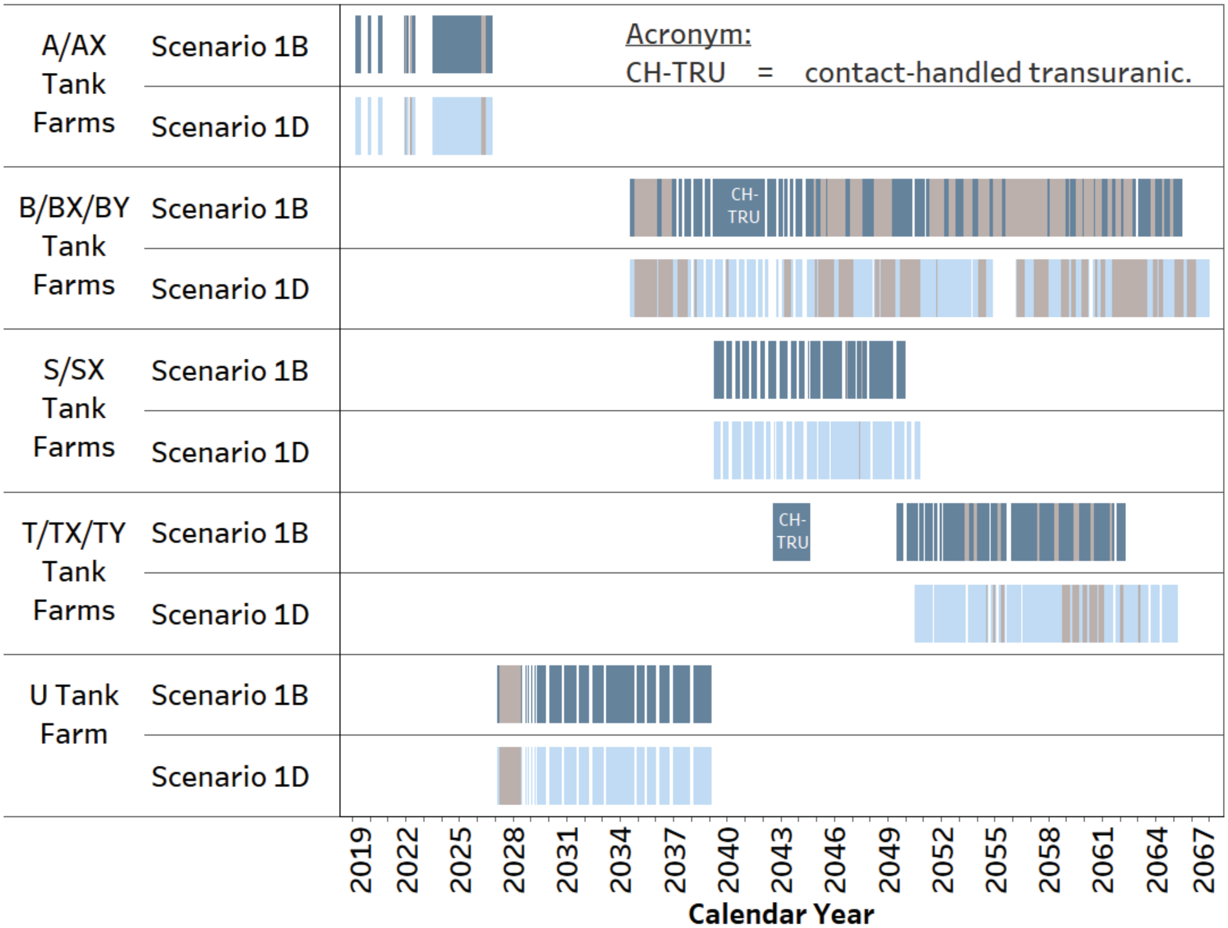
The mission metrics for Scenario 1D are compared to Scenario 1B in Table 5-14. The CH-TRU tanks consist of 5.4 Mgal of as-retrieved waste in 11 tanks (Section 3.3.1). Eliminating the supplemental CH-TRU treatment results in an extension of SST retrievals by 2 years and a 5 percent increase seen in IHLW. Although these results make sense, the differences fall within the random uncertainty of TOPSim modeling, and a difference is not demonstrated conclusively. The only significant difference for Scenario 1D versus Scenario 1B is the elimination of the 8,800 TRU packages produced in Scenario 1B. Figure 5-27 compares the SST retrieval schedules for Scenario 1B and Scenario 1D.

Table 5-14. Scenario 1D Comparison – Mission Metrics.

Scenario	Scenario 1B	Scenario 1D
SST Retrievals Complete	2065	2067
DST Retrievals Complete	2075	2075
Tank Waste Treatment Complete	2076	2076
IHLW Glass Canisters	7,000	7,400
Total ILAW Glass Containers	88,000	88,000
WTP ILAW Glass Containers (% Total)	49,000 (56%)	49,000 (56%)
LAWST ILAW Glass Containers (% Total)	39,000 (44%)	39,000 (44%)
LAWST Glass Volume, yd^3	109,000	109,000
LAWST Equivalent Grout Volume, yd^3	430,000	440,000
Potential CH-TRU Tank Waste Drums	8,800	0
ETF Solids Drums	11,000	11,000

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-27. Scenario 1D Comparison – Single-Shell Tank Retrieval Schedule.



5.2 SCENARIO 2 – TREATMENT-FAVORED DIRECT-FEED LOW-ACTIVITY WASTE AND DIRECT-FEED HIGH-LEVEL WASTE WITH EARLY CHARACTERIZATION IN DOUBLE-SHELL TANKS

5.2.1 Objective and Planning Bases

The purpose of this scenario is to evaluate the life-cycle effects of replacing the WTP Pretreatment Facility with a new High-Level Waste Feed Preparation Facility (HFPF) for pretreatment of waste destined for the WTP HLW Vitrification Facility, to include leaching and washing. Additionally, the TWCS capability is removed and, instead, existing DSTs are used for sampling and characterization of waste slurry. To support pretreatment of all waste destined for LAW treatment, the capacity of TFPT is increased and a new LAW Feed Evaporator is added. This scenario builds on Scenario 1B. Table 5-15 identifies the Model Starting Assumptions from Appendix A that were modified from Scenario 1B to create Scenario 2. Scenario 2 also includes the following three sensitivity scenarios:

- Scenario 2A – Add New DSTs (Section 5.2.6)
- Scenario 2B – Slower WTP Ramp-Up (Section 5.2.7)
- Scenario 2C – Increased WTP TOE (Section 5.2.8).

Table 5-15. Scenario 2 – Starting Assumptions Altered from Scenario 1B.

Starting Assumption #	Scenario 2 Assumption
A1.2.2.13	Additional DSTs are assigned as needed to support DFLAW treatment (including additional TSCR/TFPT feed and feed staging tanks).
A1.2.3.17, A1.2.6	All slurry feed to treatment is sampled in the existing DSTs. The TWCS capability is not included in this scenario.
A1.2.5.3	In order to limit re-precipitation of phosphate solids in the DSTs, supernatant as low as 2M sodium will be staged as feed to TFPT starting with the retrieval of B Complex SSTs in 2035.
A1.2.5.6	With the startup of LAWST in 2034, TFPT will increase in capacity beyond the 1.9-times-TSCR capacity from the starting capacity, as needed, to support pretreatment of all waste destined for LAW treatment.
A1.3.2	The WTP Pretreatment Facility is not included in this scenario. Instead, this scenario includes the following: • A new HFPF for pretreatment of waste destined for the WTP HLW Vitrification Facility, to include leaching and washing • An HEMF evaporator (included in the HFPF) for concentration of dilute effluents from solids washing and those produced at the WTP HLW Vitrification Facility • An expanded TFPT capacity, as well as a new LAW Feed Evaporator, to support pretreatment of all waste destined for LAW treatment.

DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HEMF = High-Level Waste Effluent Management Facility.
HFPF = High-Level Waste Feed Preparation Facility.
HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

5.2.2 Flowsheet Description

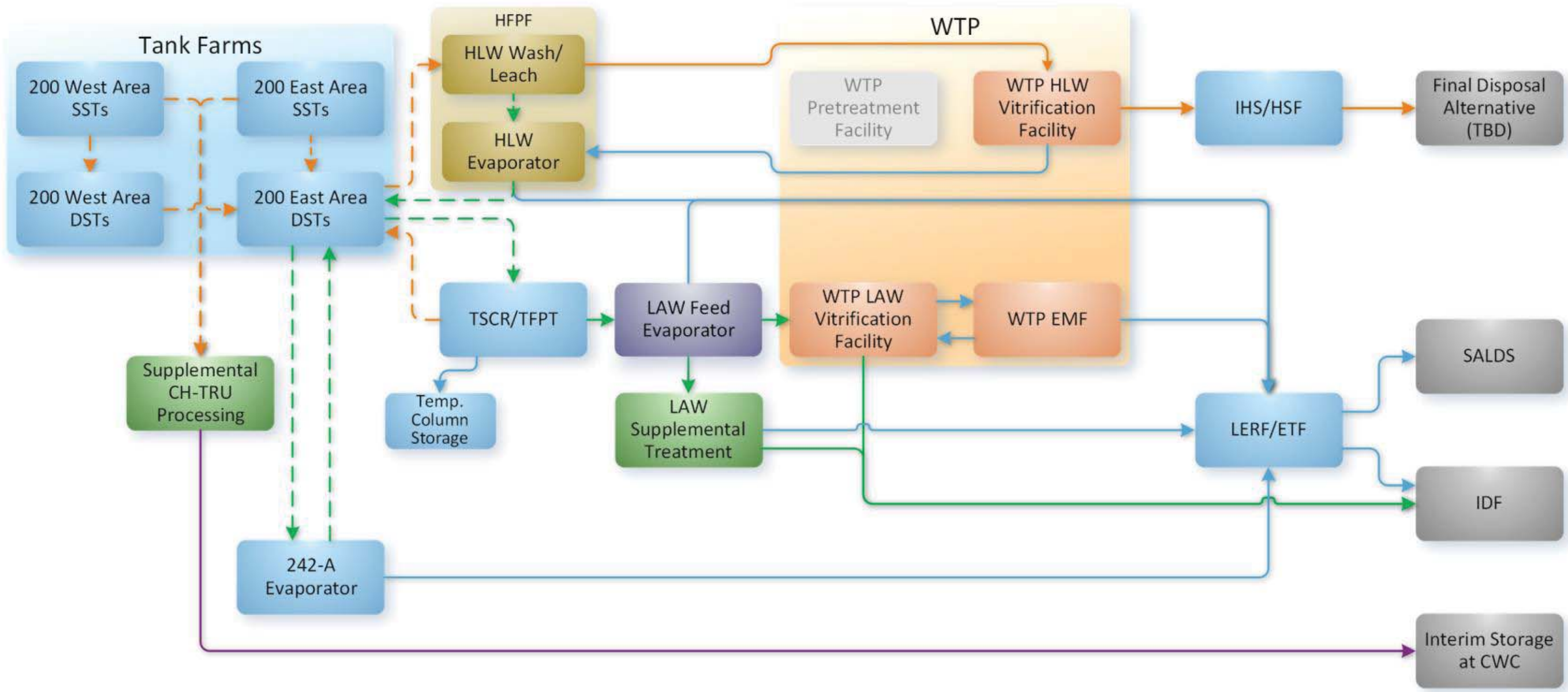
The simplified flowsheet for Scenario 2 is provided in Figure 5-28. The flowsheet differs from Scenario 1B in several ways. The WTP Pretreatment Facility and TWCS capability are no longer included in the flowsheet. The functionality of these facilities is replaced by the HFPF, two new evaporators (one in the High-Level Waste Effluent Management Facility [HEMF] and the LAW Feed Evaporator), additional TFPT capacity, and slurry sampling and characterization in the DSTs (Table 5-15).

All waste slurry destined for HLW treatment is sampled in the existing 200 East Area DSTs and subsequently pretreated in the HFPF prior to being delivered to the WTP HLW Vitrification Facility for treatment. The HFPF pretreatment process includes caustic leaching at 140°F (60°C) followed by washing to reduce the soluble salts in the feed, but does not include high-heat leaching to dissolve boehmite or oxidative leaching to dissolve chromium, as in the WTP Pretreatment Facility (where leaching is performed at 185°F [85°C]). The HFPF also receives the liquid effluent from the WTP HLW Vitrification Facility, which is combined with dilute decantate from the HLW pretreatment process and concentrated in the HEMF evaporator before being returned to the 200 East Area DSTs. The physical configuration of the HFPF is described in Section 5.2.2.1.

Through 2034, all supernatant waste destined for LAW treatment is pretreated with TSCR/TFPT, which is unchanged from the baseline DFLAW flowsheet. At the end of 2034, with the startup of the LAWST capability (with the same 4-melter-equivalent capacity as in Scenarios 1 and 1B), the following changes occur to this flowsheet to support treating the remaining liquid waste.

- The minimum sodium concentration of supernatant staged for TFPT is decreased to 2M to reduce re-precipitation of dissolved phosphate salts from B Complex retrievals, which are just beginning. Supernatant above this concentration is no longer concentrated using either the 242-A Evaporator or the HEMF evaporator.
- To concentrate the dilute pretreated feed, a new LAW Feed Evaporator comes online. The evaporator would be located between Tank AP-106 (the TFPT pretreated supernatant receipt tank) and the LAW treatment facilities (WTP LAW Vitrification Facility and LAWST). The physical configuration of the LAW Feed Evaporator and justification for reducing the concentration of the feed to TFPT to 2M sodium is described in Section 5.2.2.2.
- The TFPT is increased in capacity to support pretreating dilute feed to both the WTP LAW Vitrification Facility and LAWST capability.
- Additional DSTs are assigned as needed to support the increased capacity in TFPT. An additional TFPT feed tank is added to eliminate downtime while the feed tank is being refilled, and more TFPT feed staging tanks are added as needed. These roles are fulfilled by Tanks AP-107 and AP-105, respectively, in the baseline flowsheet.
- The secondary liquid effluent from the new HEMF evaporator and LAW Feed Evaporator is sent to the LERF.

Figure 5-28. Scenario 2 – Simplified Flowsheet.



Legend

Streams

- Supernate
- Slurry
- Treated LAW/ILAW
- Treated HLW/IHLW
- Secondary Waste
- CH-TRU (Potential)

Systems

- Tank Farms
- WTP
- Supp. Treatment
- Proposed New (HLW)
- Proposed New (LAW)
- Other
- Not Used

Acronyms

CH-TRU = contact-handled transuranic.
CWC = Central Waste Complex.
DST = double-shell tank.
EMF = Effluent Management Facility.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHS = Interim Hanford Storage.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
LERF = Liquid Effluent Retention Facility.
SALDS = State-Approved Land Disposal Site.
SST = single-shell tank.
TBD = to be determined.
TSCR = tank-side cesium removal.
TFPT = tank farm pretreatment.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

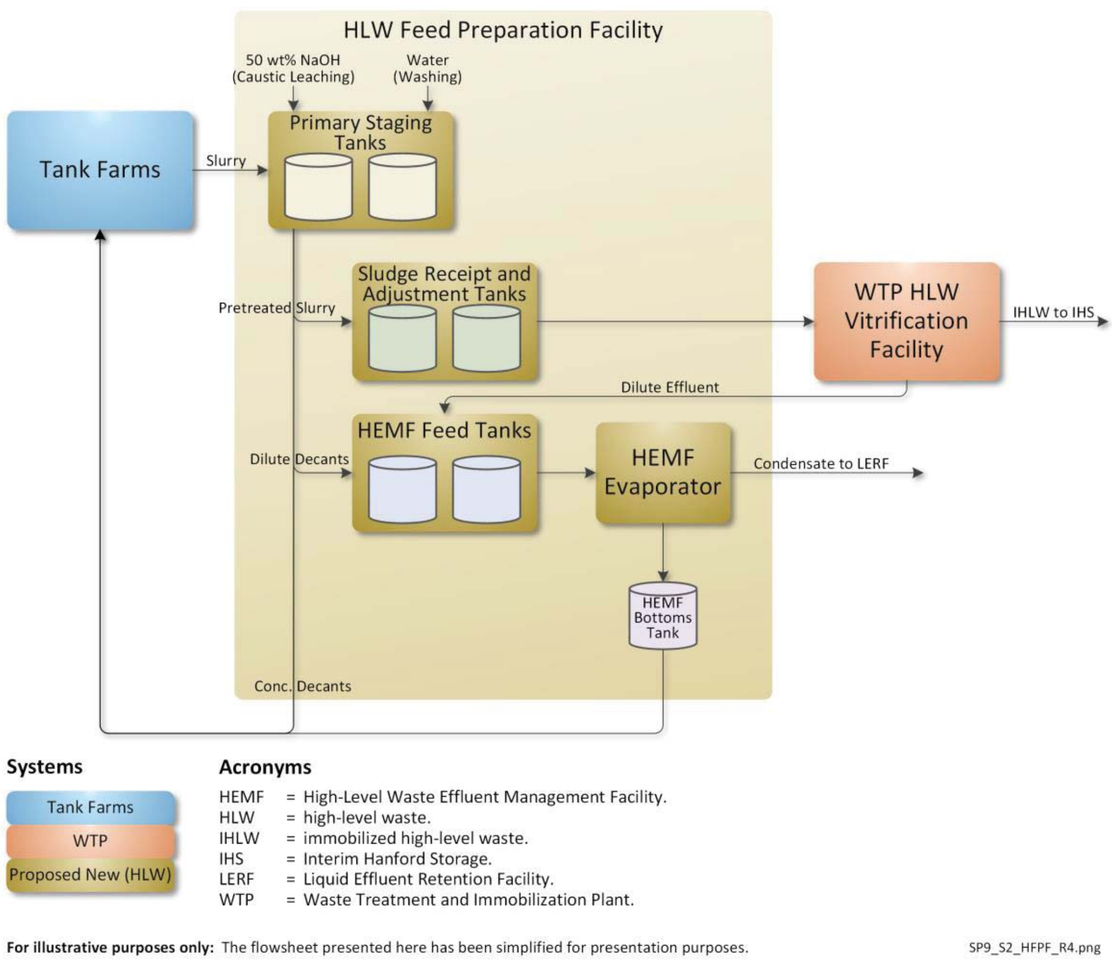
For illustrative purposes only: The flowsheet presented here has been simplified for presentation purposes.

SP9_Scenario_2_R4.png

5.2.2.1 High-Level Waste Feed Preparation Facility

A simplified flowsheet for the Scenario 2 HFPF is depicted in Figure 5-29. The feed preparation side of the HFPF is based on the process description and associated equipment sizing documented in RPP-CALC-53226, *Supporting Calculations for Development of Direct-Feed High-Level Waste Engineering Study*, and consists of two mixed 120-kgal primary staging tanks and two mixed 40-kgal sludge receipt and adjustment tanks. The primary staging tanks receive fully characterized slurry from the 200 East Area DSTs, decant the supernatant, add caustic soda, and heat to 140°F (60˚C) to leach aluminum, as needed to optimize glass loading. Then water is added and decanted several times to wash soluble salts from the remaining solids until the supernatant is below 1M sodium and the solids are concentrated to 15 wt%. The pretreated slurry is then transferred to the sludge receipt and adjustment tanks, where a final, confirmatory sample of the waste is pulled, and the feed is delivered to the WTP HLW Vitrification Facility. Decantate from the primary staging tanks is either returned to the 200 East Area DSTs if it is sufficiently concentrated to be fed to TFPT or transferred to the effluent management side of the HFPF to be concentrated. It is assumed that the solid/liquid separation is a settle-decant process and that some type of vessel heating will be employed to heat the waste for leaching (such as a steam jacket, external heat exchanger, or electric coils).

Figure 5-29. Scenario 2 – Simplified High-Level Waste Feed Preparation Facility Flowsheet.



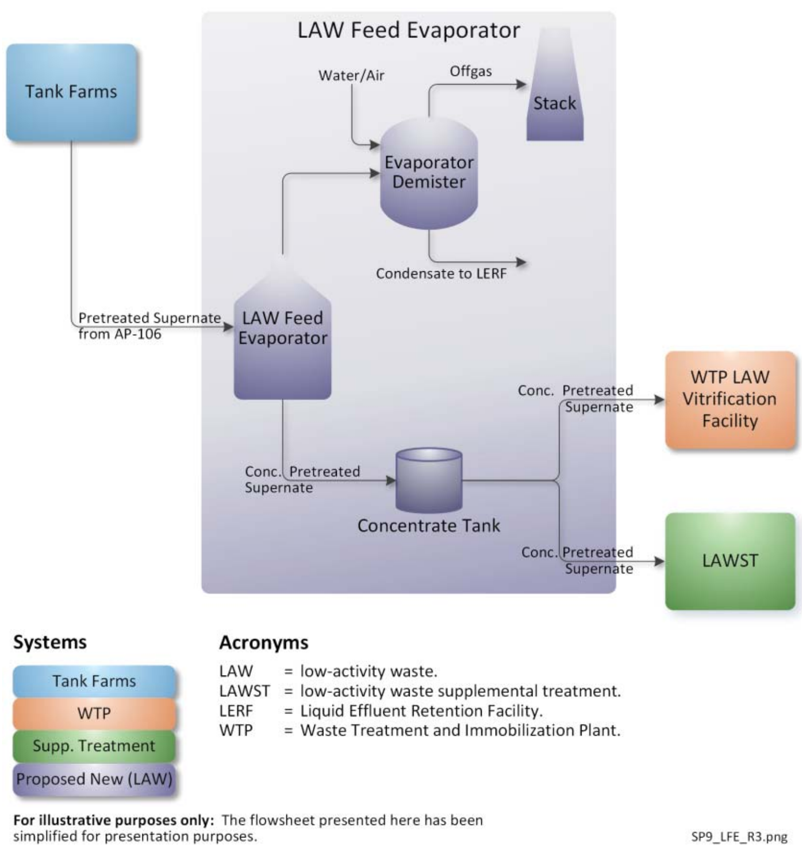
The effluent management portion of the HFPF is based on the process and equipment-sizing proposed in RPP-RPT-61957, *High-Level Waste Analysis of Alternatives Model Results Report*, and consists of two mixed 60-kgal feed tanks, the HEMF evaporator, and one mixed 250-kgal concentrate tank. The feed tanks receive dilute decantate from the feed preparation side of the HFPF and the neutralized liquid effluent from the WTP HLW Vitrification Facility and alternate between filling and feeding the HEMF evaporator. The HEMF evaporator, based on the waste feed evaporation process system's evaporator in the WTP Pretreatment Facility, concentrates feed to a density of 1.27 kg/L. Concentrate from the HEMF evaporator is routed to the concentrate tank, where it is chemically adjusted to meet the tank farm corrosion specification by additions of sodium nitrite and sodium hydroxide as necessary. When the concentrate tank is full, it is transferred to the 200 East Area DSTs. Recycling the concentrated HLW effluent to the melter feed was evaluated in System Plan Rev. 8 Scenario 3, which led to a significant decrease in waste loading and associated increase in required IHLW production and extension in mission duration.

5.2.2.2 Low-Activity Waste Feed Evaporator

The LAW Feed Evaporator is similar to the treated LAW evaporation process system's evaporator in the WTP Pretreatment Facility. The evaporator receives dilute, pretreated supernatant directly from DST AP-106 and concentrates it to a density of 1.33 kg/L. The concentrated, pretreated supernatant from the evaporator is routed to a mixed 103-kgal concentrate tank similar to the treated LAW concentrate storage process in the WTP Pretreatment Facility. From the concentrate tank, the feed is delivered to the concentrate receipt vessels in the WTP LAW Vitrification Facility, with excess feed delivered to the LAWST capability. A simplified flowsheet for the LAW Feed Evaporator is shown below in Figure 5-30.

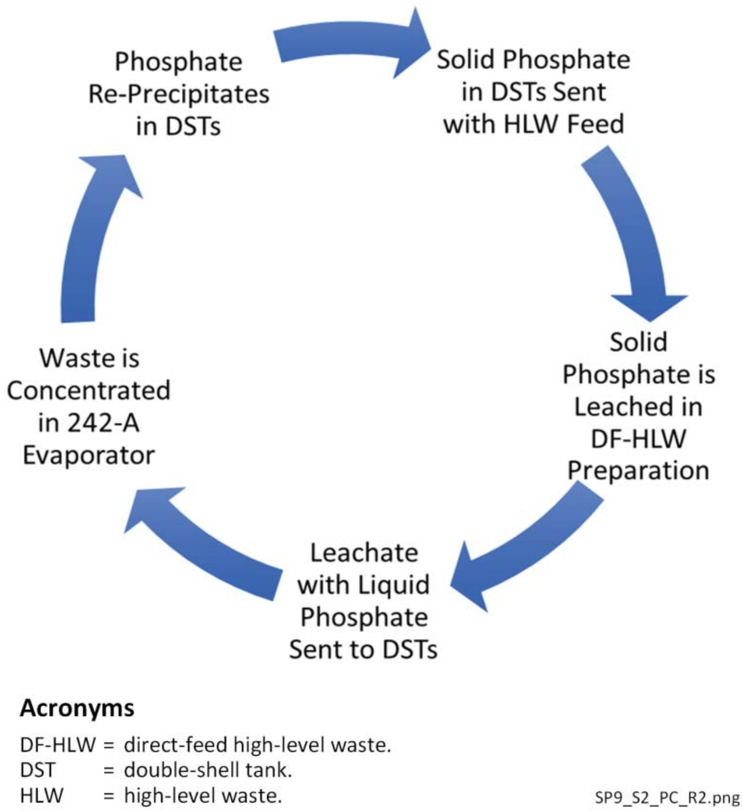
The requirement for the LAW Feed Evaporator is driven by retrieval of the high-phosphate waste in T and B Complexes starting in 2035. Retrieval of these SSTs increases the amount of phosphate in the DST supernatant. Concentration of this dilute supernatant using the 242-A Evaporator causes the phosphate to precipitate. Once it has precipitated, it is included

Figure 5-30. Scenario 2 – Simplified Low-Activity Waste Feed Evaporator Flowsheet.



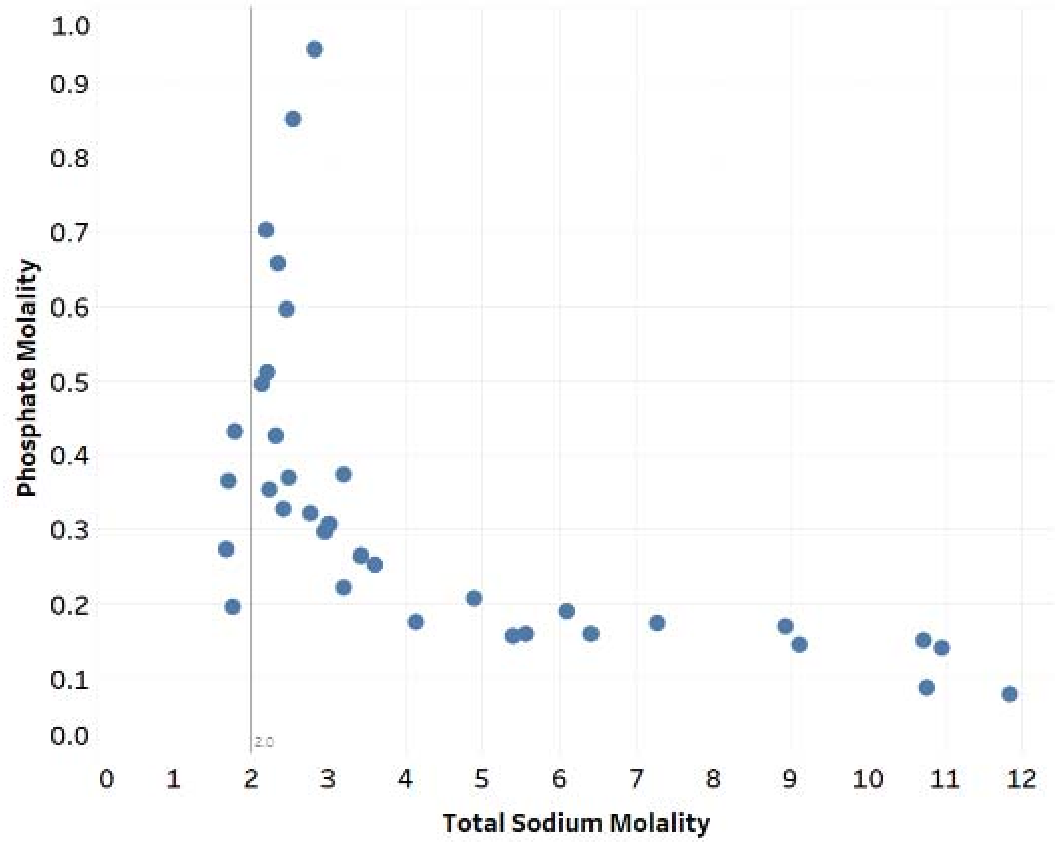
with the sludge solids delivered to the HFPF, where it is dissolved as a part of the pretreatment process and sent back to the tank farms as dilute waste. If this dilute waste is concentrated, it will again precipitate phosphate and will be sent to the HFPF again. This creates a positive feedback loop of increasing phosphate solids in the DSTs, as depicted in Figure 5-31. If this effect is allowed to continue unchecked, the loop continues and the feed to the WTP eventually slows to a trickle.

Figure 5-31. Phosphate Dissolution-Precipitation Cycle.



To break this feedback loop, the concentration of the supernatant feed to the TFPT system must be reduced to allow for the phosphate salts to be incorporated into the feed. Phosphate solubility drops off exponentially at approximately 2M total sodium. While phosphate solubility continues to decrease with increasing sodium concentration above 2M, the rate of decrease in solubility is more gradual. Figure 5-32 depicts the phosphate solubility at a range of sodium concentrations from the article "Salt Solubilities in Aqueous Solutions of $NaNO_3$, $NaNO_2$, NaCl, and NaOH: A Hofmeister-like Series for Understanding Alkaline Nuclear Waste" (Reynolds 2018). Therefore, reducing the minimum concentration of feed to TFPT to 2M sodium ensures the phosphate stays in solution so that it can be processed through the TFPT system and immobilized in the ILAW glass. Once the waste has been pretreated by the TFPT system, precipitation of the phosphate is less of a concern because the WTP LAW Vitrification Facility (and presumably the LAWST capability) has an allowance for solids. Thus, the LAW feed can be concentrated by the LAW Feed Evaporator to improve feed quality.

Figure 5-32. Solubility of Phosphate in Aqueous Solutions of Common Hanford Sodium Salts.



5.2.3 Analysis

5.2.3.1 Key Results and Metrics

The Scenario 2 results show that this full-mission DFLAW and direct-feed high-level waste (DF-HLW) scenario accelerates the mission and reduces the life-cycle cost compared to Scenario 1B. This is achieved by replacing the solids pretreatment function of the WTP Pretreatment Facility with a higher throughput HFPF, thus removing the solids pretreatment bottleneck that exists in the baseline flowsheet. The HFPF is also a less complex and, therefore, likely less expensive facility compared to the WTP Pretreatment Facility. In Scenario 2, SST retrievals and tank waste treatment are completed in 2060 and 2069, respectively, approximately 5 years earlier than Scenario 1B while reducing life-cycle cost by $10 billion unescalated. The mission metrics for Scenario 2 are compared to Scenario 1B in Table 5-16. The following are several other significant results realized from Scenario 2.

- Upon removal of the solids pretreatment limitation (which was due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step, as the capacity of LAWST is sized to match the Baseline Case.

- The reduction in the extent of solids pretreatment in the HFPF versus the WTP Pretreatment Facility (lower-temperature caustic leaching, no oxidative leaching) leads to a 29 percent increase in IHLW.
- The addition of two new evaporators (the HEMF evaporator and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little significance to the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility causing a 15-percent increase in secondary liquid effluent produced.

Table 5-16. Scenario 2 Comparison – Key Metrics.

Metric	Scenario 1B	Scenario 2
SST Retrievals Complete	2065	2060
DST Retrievals Complete	2075	2069
Tank Waste Treatment Complete	2076	2069
IHLW Glass Canisters	7,000	9,100
Total ILAW Glass Containers	88,000	91,000
WTP ILAW Glass Containers (% Total)	49,000 (56%)	29,000 (32%)
LAWST ILAW Glass Containers (% Total)	39,000 (44%)	62,000 (68%)
LAWST Glass Volume, yd^3	109,000	174,000
LAWST Equivalent Grout Volume, yd^3	430,000	690,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,400	11,800
Unescalated (Escalated) Life-Cycle Cost	$122B ($247B)	$112B ($208B)

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

5.2.3.2 Mission Schedule Results

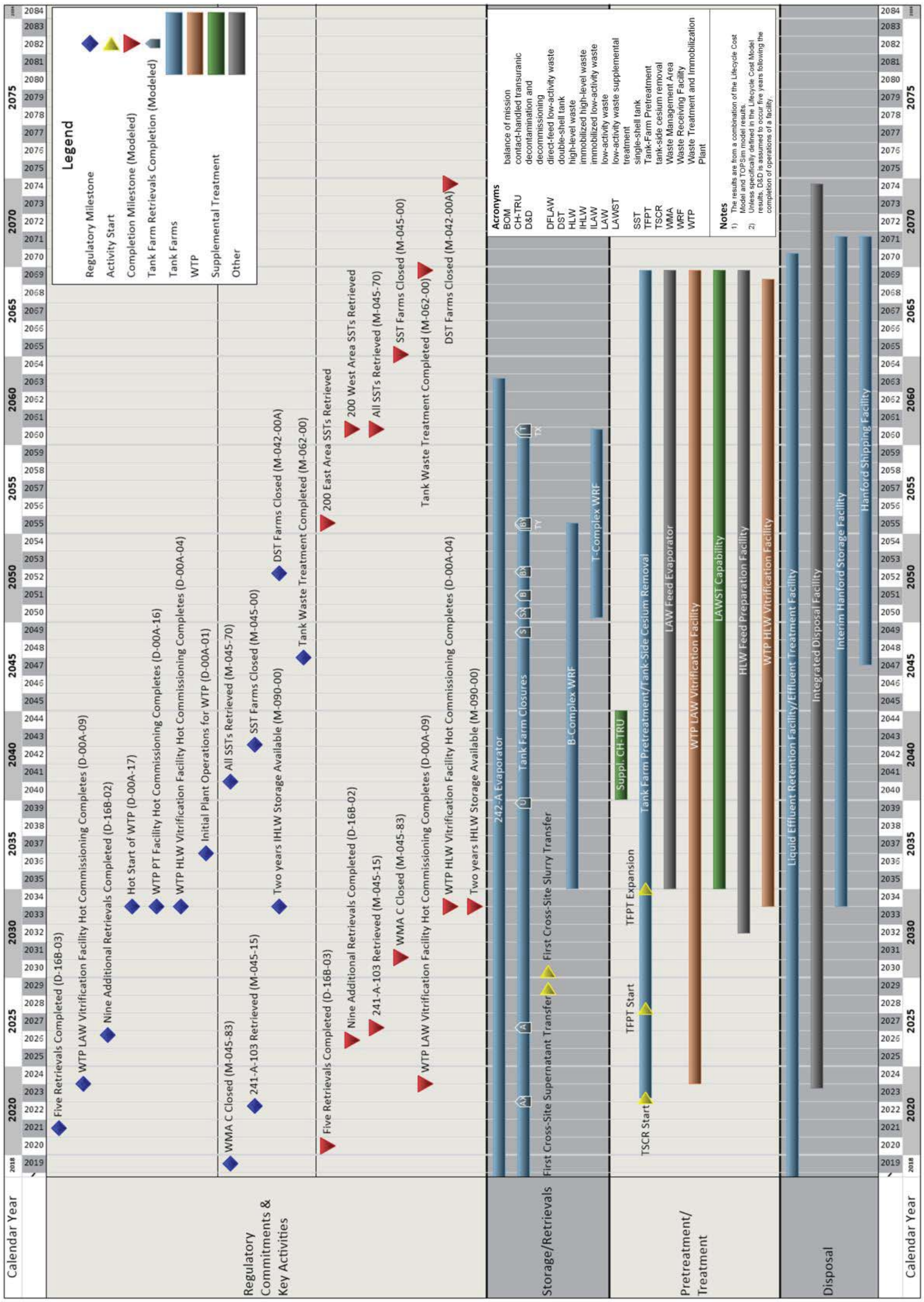
Table 5-17 lists the key mission activity dates for Scenario 1B, followed by Figure 5-33 that shows the projected operating schedule for the SST retrievals and treatment systems.

Table 5-17. Scenario 2 – Summary of Schedule Results.

	Key Mission Metric	Scenario 1B	Scenario 2
Near-Term Regulatory	Complete Five Additional SST Retrievals (Existing Consent Decree 06/30/2021)	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Existing Consent Decree 09/30/2026)	06/2026	06/2026
	Complete Tank 241-A-103 Retrieval (Existing TPA 09/30/2022)	04/2027	03/2027
Storage/Retrieval	242-A Evaporator Operations	Present – 2066	Present – 2063
	200 East Area WRF Operations	2034 – 2065	2034 – 2055
	200 West Area WRF Operations	2049 – 2062	2050 – 2060
	200 East Area SST Retrievals Complete	2065	2055
	200 West Area SST Retrievals Complete	2062	2060
	Cross-Site Transfer Line Activated (supernatant)	2028	2029
	Cross-Site Transfer Line Activated (slurry)	2030	2030
Pretreatment/Treatment	TSCR/TFPT Operations	2023 – 2063	2023 – 2069
	LAW Feed Evaporator Operations	N/A	2034 – 2069
	TWCS Capability Operations	2032 – 2076	N/A
	WTP Pretreatment Facility Operations	2033 – 2076	N/A
	HFPF Operations	N/A	2032 – 2069
	WTP LAW Vitrification Facility Operations	2023 – 2076	2023 – 2069
	WTP HLW Vitrification Facility Operations	2033 – 2076	2033 – 2069
	LAWST Capability Operations	2034 – 2076	2034 – 2069
	Potential CH-TRU Waste Packaging Facility Operations	2040 – 2045	2040 – 2045
	LERF/ETF Operations	Present – 2077	Present – 2070
	Tank Waste Treatment Complete	2076	2069
Disposal	IDF Operations	2023 – 2083	2023 – 2074
	IHS Facility Operations	2033 – 2078	2033 – 2071
	HSF Offsite Shipping Operations	2056 – 2078	2047 – 2071
	All IHLW Shipped Offsite	2078	2071

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
HFPF = High-Level Waste Pretreatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
LERF = Liquid Effluent Retention Facility.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-33. Scenario 2 – Operating Schedule for Major Facilities/Processes.



5.2.3.3 Mission Flowsheet Results

5.2.3.3.1 Tank Farms

The Scenario 2 DST space utilization over the mission is presented in Figure 5-34. DST space utilization is consistently moderately high because the mission for Scenario 2 is treatment limited (i.e., SST retrievals generally outpace waste treatment). The exception to this is an approximately 5-year period in the mid-2040's when SST retrievals are constrained by the limit of a single simultaneous retrieval per area and DST space has been increased after several years of LAWST operations. The number of simultaneous retrievals is increased to two per area in 2045.

Figure 5-34. Scenario 2 – Double-Shell Tank Space Utilization.

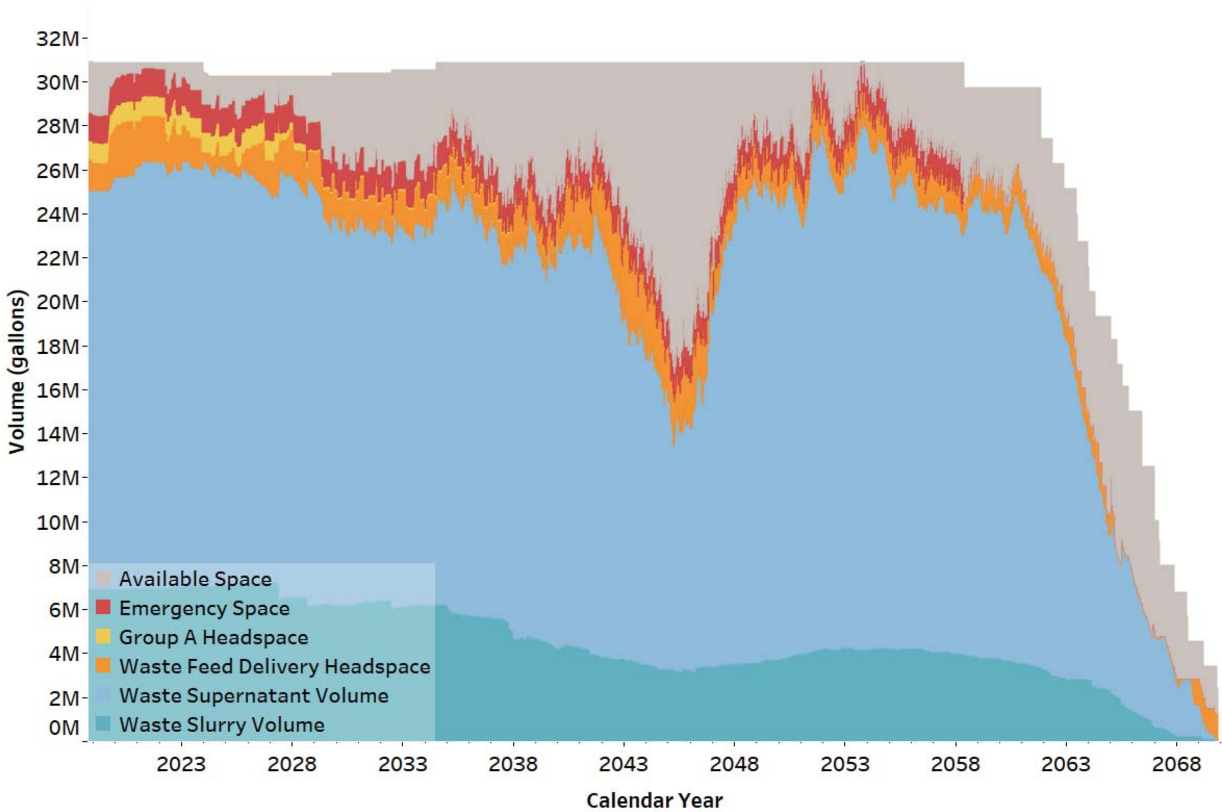
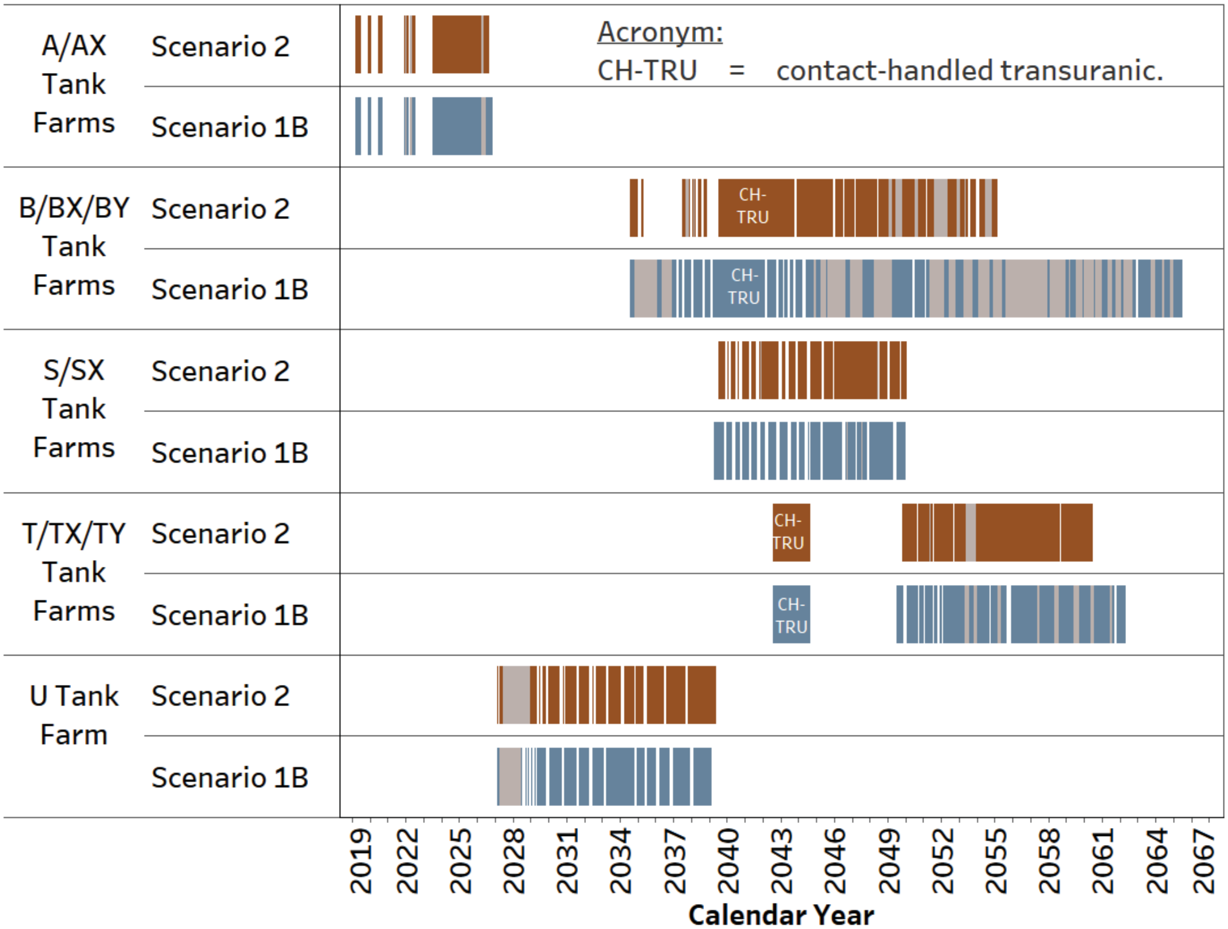


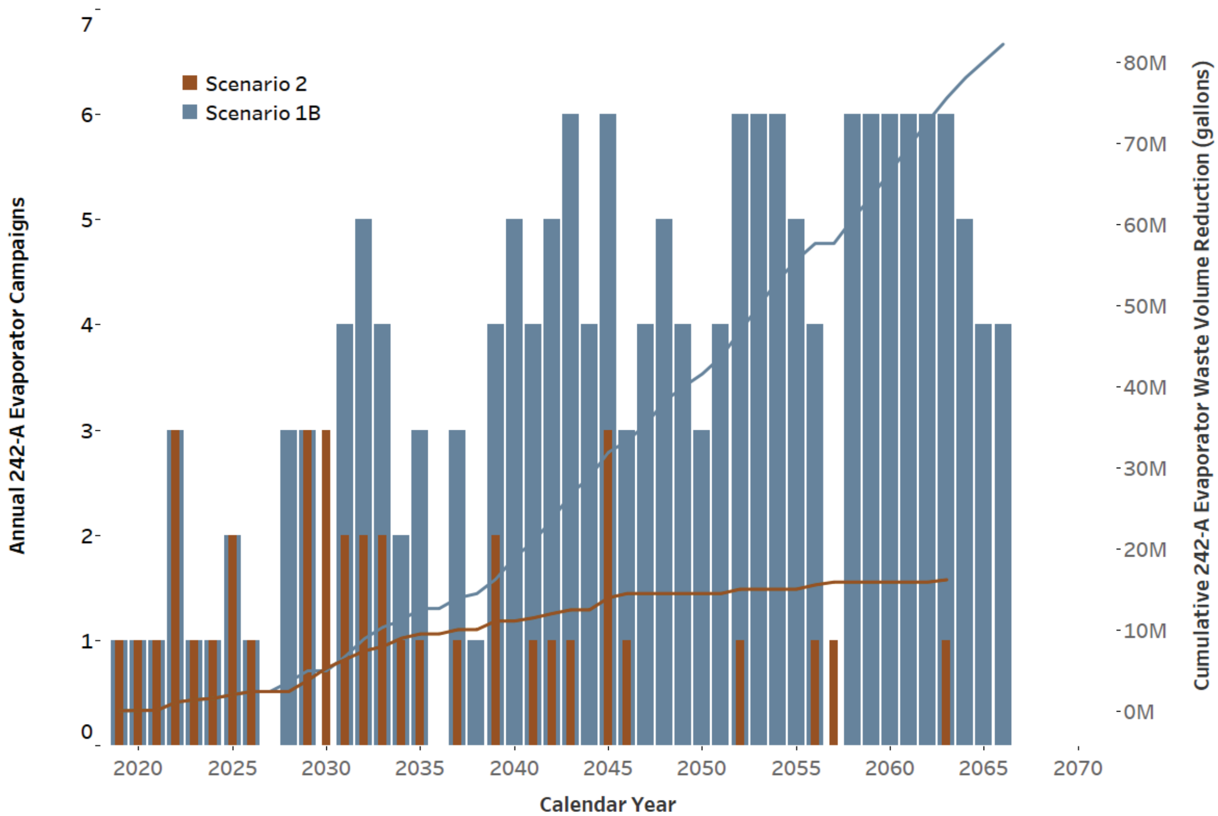
Figure 5-35 shows the sequence and timing of the SST retrievals during the RPP mission. The dark colored bands indicate ongoing retrieval activity, the white spaces between the bars are the assumed setup time between retrievals, and the grey bands indicate delays in the SST retrieval durations (i.e., the difference in the actual retrieval duration and the assumed retrieval duration) due to available DST space. The higher treatment throughput leads to higher DST space availability, and, therefore, fewer delays in retrievals versus Scenario 1B. Therefore, SST retrievals complete 5 years (2060) earlier in Scenario 2.

Figure 5-35. Scenario 2 Comparison – Single-Shell Tank Retrieval Schedule.



The annual and cumulative 242-A Evaporator utilization, in terms of campaigns and WVR for Scenario 2 as compared to Scenario 1B, is presented in Figure 5-36. The lower concentration target to reduce phosphate reprecipitation reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little influence to the mission. Much of this concentration is instead performed in the LAW Feed Evaporator following pretreatment in the TFPT system. Conversely, the number of DST-to-DST transfers increases (by 36 percent over Scenario 1B) because direct-feed operations increase the reliance upon aging DST infrastructure to simplify the requirements for new pretreatment facilities.

Figure 5-36. Scenario 2 Comparison – 242-A Evaporator Utilization.

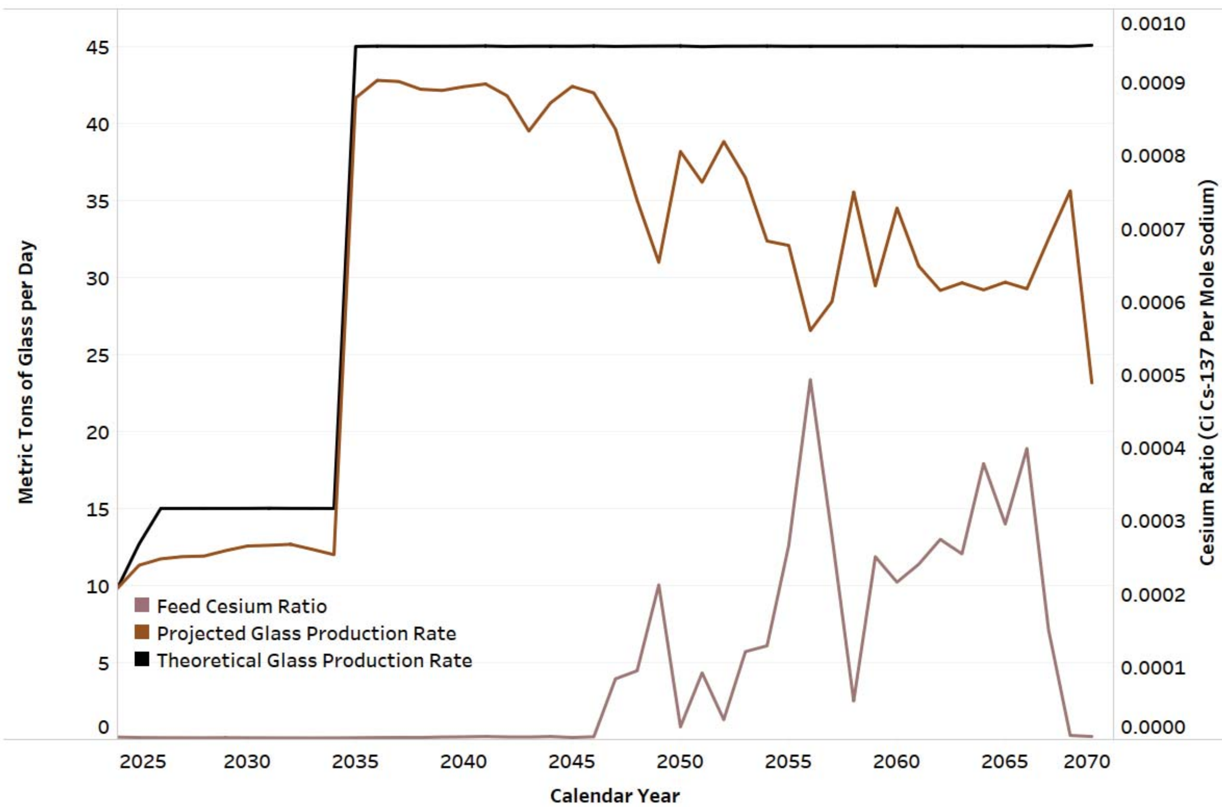


5.2.3.3.2 Low-Activity Waste Pretreatment and Treatment

Scenario 2 required a design throughput of 20 gpm for TFPT, equivalent to four TSCR in-parallel units, to support pretreating supernatant at a rate needed for the combined capacity of the WTP LAW Vitrification Facility and LAWST capability at 50 percent TOE. This capacity is predicated on avoiding feed stoppages by using two DSTs to feed TFPT. A maximum of five DSTs is used simultaneously for the dilution, sampling, and staging of supernatant feed to the TFPT capability. Overall, the TCSR and TFPT systems pretreat 240 Mgal of supernatant, which is reduced to 129 Mgal by the LAW Feed Evaporator prior to treatment. Pretreating this amount of supernatant through the TSCR and TFPT systems would generate a total of 751 TSCR-equivalent spent IX columns requiring five 150-column waste storage pads.

Figure 5-37 shows the ratio of cesium to sodium in the pretreated supernatant fed to the WTP LAW Vitrification Facility and the projected ILAW glass production for Scenario 2, both versus the theoretical production at 50 percent TOE for both the combined WTP LAW Vitrification Facility and LAWST. The overall ILAW production of 91,000 containers is similar to Scenario 1B, but with more production shifted to the LAWST capability to enable a similar amount of LAW to be treated with a shorter mission duration. Projected production closely mirrors the theoretical, except for when production is reduced by the dilute feed as per Assumption A1.3.4.11. This observation leads to the conclusion that the Scenario 2 mission duration is driven by LAW treatment. The problem of reduced melter rates becomes especially significant for the WTP LAW Vitrification Facility late in the mission as the feed becomes more dilute, which drops the cesium removal efficiency of the resin. As a result of this, the cesium concentration of the feed increases up to an order of magnitude above the ICD-30 treated LAW feed acceptance criteria (3.18×10^{-5} Ci cesium-137 per mole sodium) (24590-WTP-ICD-MG-01-030). The raised cesium concentration of the feed increases the cesium concentration of the LAW melter offgas condensate, limiting the ability of the WTP EMF to effectively remove water from the process without exceeding its cesium limit. For this reason, it may be desirable to provide separate feeds to the WTP LAW Vitrification Facility and the LAWST capability.

Figure 5-37. Scenario 2 – Combined Immobilized Low-Activity Waste Production Rate.



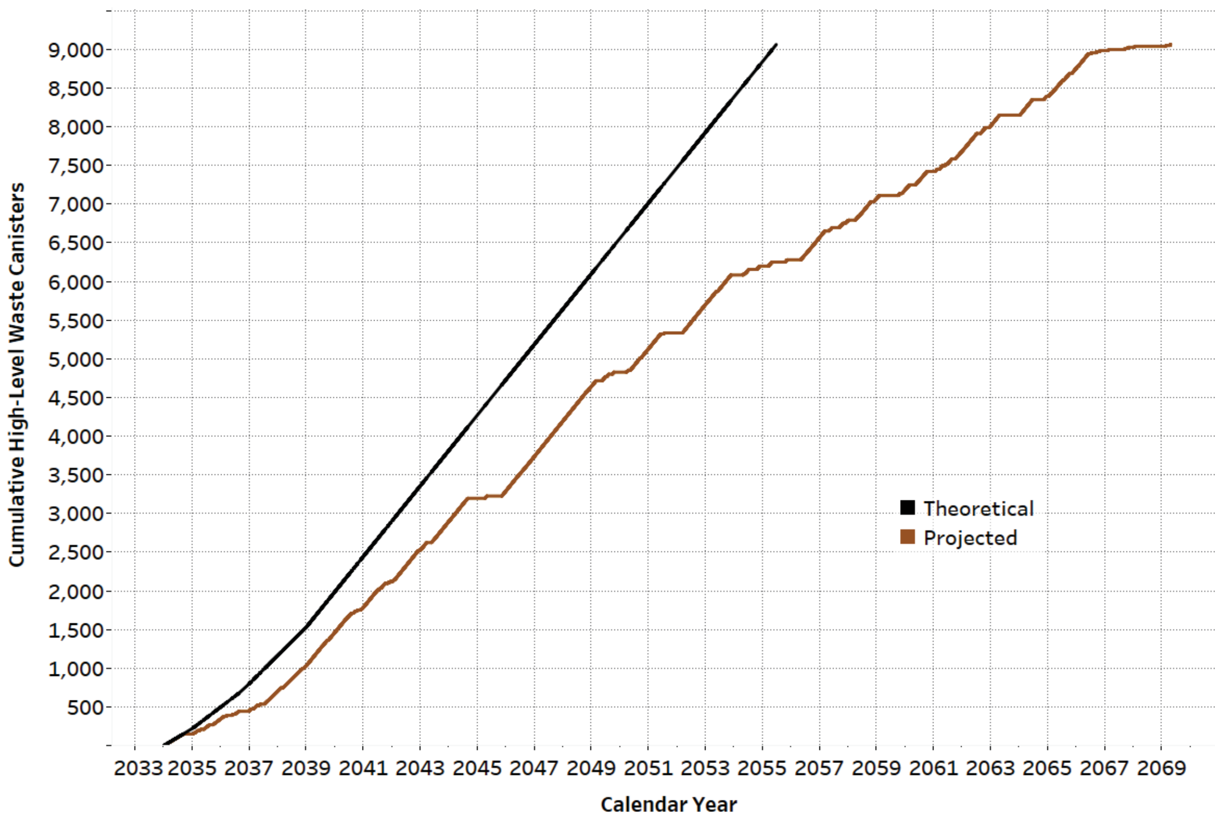
5.2.3.3.3 High-Level Waste Pretreatment and Treatment

Over 37 years of operations, the Scenario 2 HFPF processes 76 Mgal of slurry from the 200 East Area DSTs into 19 Mgal of feed to the WTP HLW Vitrification Facility and produces 136 Mgal of returns to the 200 East Area DSTs (includes 1.5 Mgal of chemicals added for corrosion control). This equates to 1.8 gal of effluent returned to the 200 East Area DSTs for every gallon of waste fed forward using the DF-HLW approach. This is owed to the HEMF evaporator, which processes 130 Mgal of dilute effluent to 15 Mgal of concentrate. Without the HEMF, this ratio would be 3.3 gal of effluent returned for every gallon forward, and the aging 242-A Evaporator would need to be relied upon for an additional 3 Mgal of annual WVR.

Figure 5-38 shows the projected IHLW glass production in Scenario 2 versus the theoretical production at 50 percent TOE for the WTP HLW Vitrification Facility. There are several extended periods during the mission when projected production mirrors the theoretical, and IHLW production increases from 7,000 canisters in Scenario 1B to 9,100 canisters in Scenario 2, despite operating 7 years less. This demonstrates the increase in HLW pretreatment throughput for the Scenario 2 HFPF versus the WTP Pretreatment Facility in Scenario 1B.

Even with this increased production, there are multiple flattened areas of the curve where LAW treatment and/or SST retrieval constraints limit IHLW production, especially later in the mission. When LAW treatment is insufficiently matched to HLW treatment, this allows the DSTs to fill, preventing continued operations of the HFPF and WTP HLW Vitrification Facility. Additionally, insufficient SST retrieval rates (which can by exacerbated by insufficient LAW treatment capacity) can lead to unavailability of sludge solids for use in making up batches of feed to the WTP HLW Vitrification Facility.

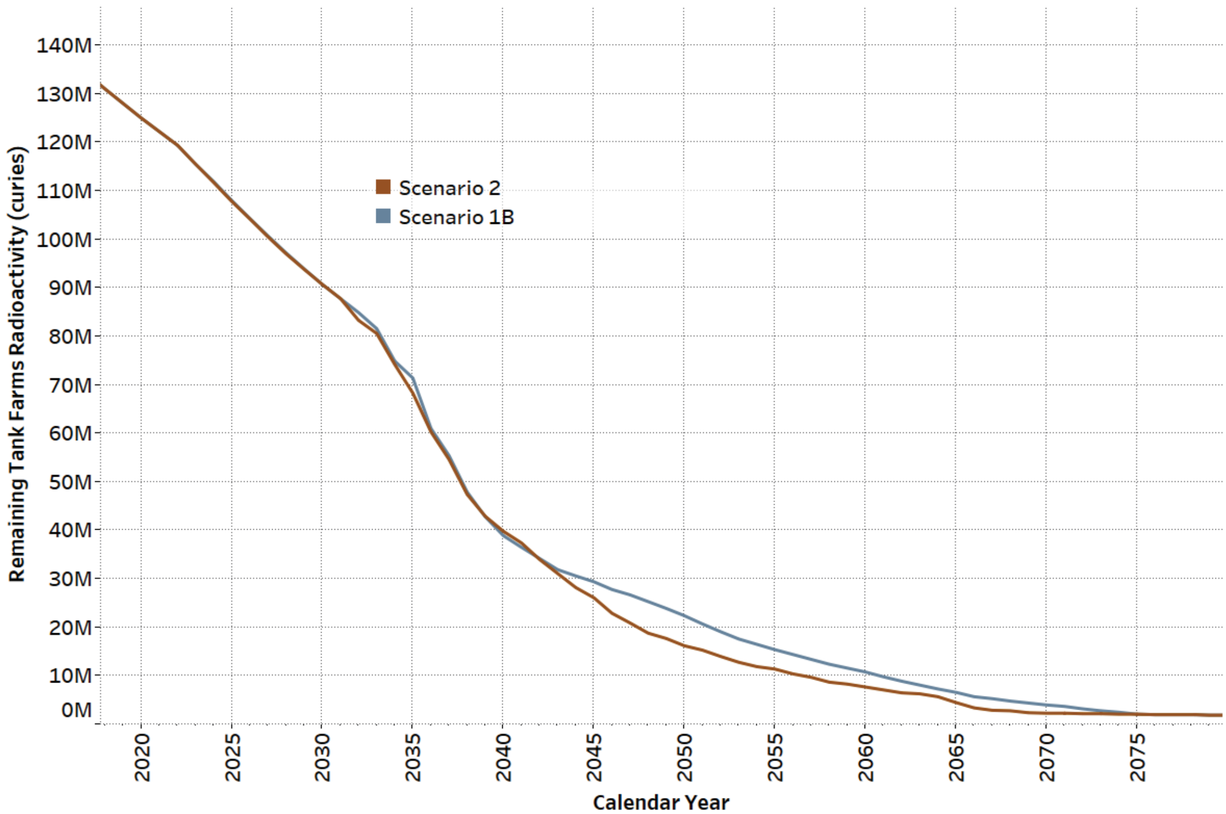
Figure 5-38. Scenario 2 – Immobilized High-Level Waste Production.



Further, as demonstrated by Figure 5-39, the discontinuous IHLW production caused by insufficient LAW treatment capacity prevents Scenario 2 from significantly improving the treatment rate achieved in Scenario 1B.

In Scenario 2, a "smart" leaching strategy is employed in the HFPF. Based on past modeling of DF-HLW with the 2016 GFMs, solids are caustic-leached in the HFPF if the projected composition of the feed exceeds 30 wt% aluminum oxide. There is also a minimum concentration of easily leached aluminum that must be present for leaching to be performed, ensuring the efficacy of caustic leaching for reducing aluminum concentration in the feed. During modeling of Scenario 2, modeling was performed with higher leaching thresholds. In general, less leaching, and therefore, lower additions of sodium hydroxide result in a lower required ILAW production. However, it was ultimately determined that this did not offer a significant benefit because the quantity of IHLW increases sharply with decreased leaching while the quantity of ILAW is reduced only gradually.

Figure 5-39. Scenario 2 Comparison – Remaining Tank Farms Radioactivity.



Glass drivers and waste loading for the Scenario 2 IHLW are presented in Figure 5-40 and compared to Scenario 1B in Table 5-6. Reducing the temperature of caustic leaching to 140°F (60°C) and eliminating oxidative leaching in the HFPF, as compared to the WTP Pretreatment Facility (which includes both oxidative leaching and caustic leaching at 185°F [85°C]), causes a 29 percent increase in the number of IHLW canisters produced versus Scenario 1B (Table 5-18). Glass loading for the majority of batches is limited by spinel temperature[33] (70 percent of glass) or by aluminum outright (18 percent of glass). The reduction in leaching temperature, combined with "smart" leaching, results in a 38 percent increase in the amount of aluminum fed to the HLW melter. Additionally, the lack of oxidative leaching results in a 340-percent increase in chromium fed to the HLW melter, limiting glass loading in 3 percent of glass.

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[33] "T2%-spinel" is the temperature at which 2 volume percent spinel crystals would be in equilibrium with the melt (with a maximum limit of 1742°F [950°C]). Spinel crystals are typically composed of oxides from aluminum, iron, zinc, chromium, and manganese, and their formation is strongly correlated with aluminum content in the 2016 HLW GFMs.

Figure 5-40. Scenario 2 – Immobilized High-Level Waste Glass Drivers.

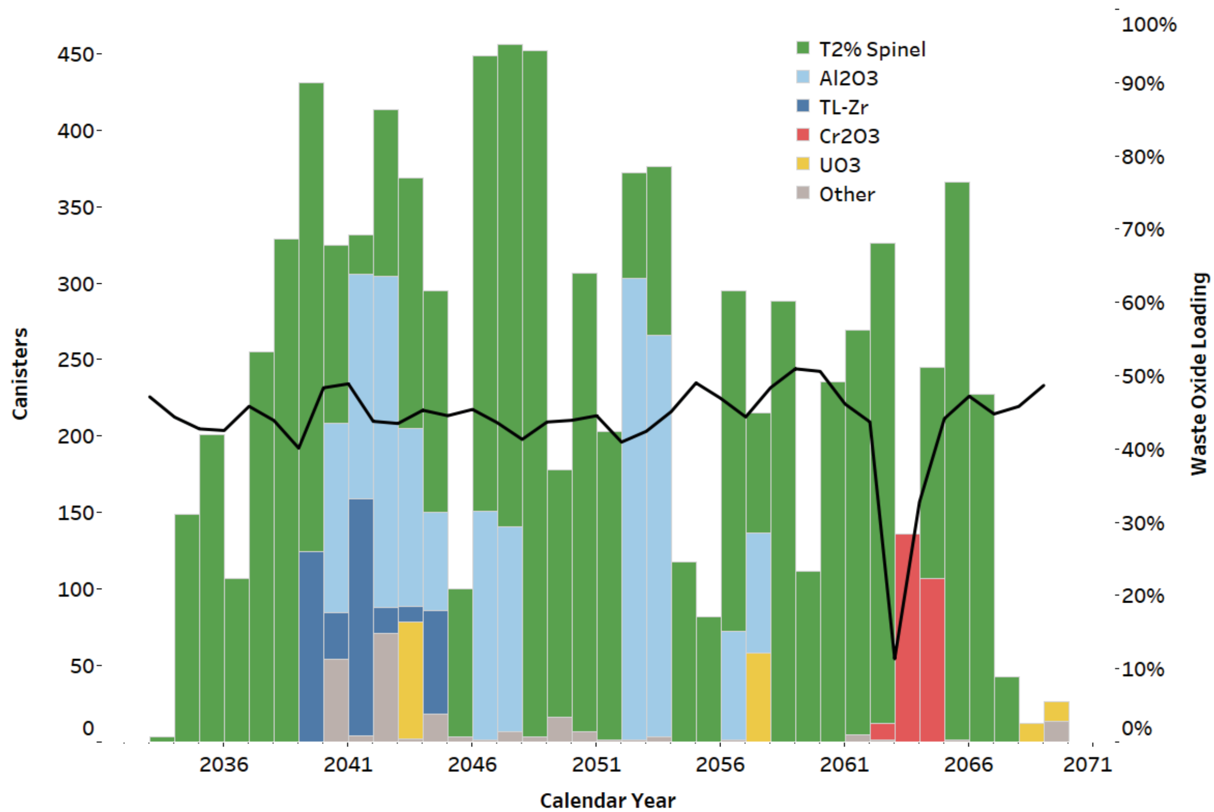


Table 5-18. Scenario 2 Comparison - Immobilized High-Level Waste Glass Drivers.

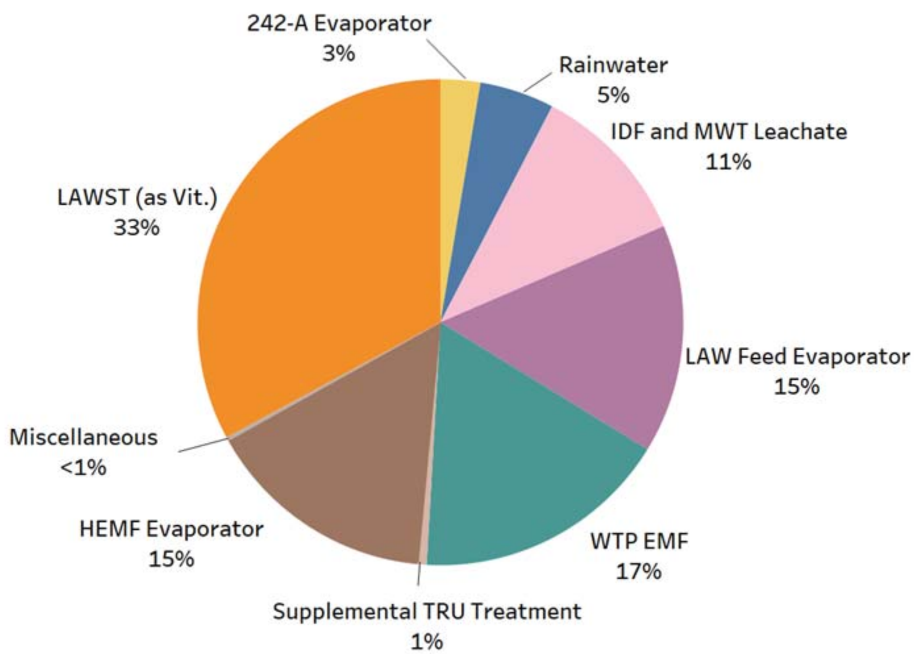
Key Glass Drivers and Waste Loadings		Scenario 1B	Scenario 2
Glass Drivers	T2% Spinel	73%	70%
	Al_2O_3	11%	18%
	TL-Zr	8%	4%
	UO_3	4%	2%
	Cr_2O_3	0%	3%
	Other	~4%	~3%
Average WOL		45%	44%

WOL = waste oxide loading.

5.2.3.3.4 Secondary Liquid Effluent Treatment

Figure 5-41 presents a breakdown of the secondary liquid effluent streams for Scenario 2 by source.[34] Overall, 771 Mgal of secondary liquid effluent is transferred to the LERF and treated in the ETF in Scenario 2—a 15-percent increase over the 673 Mgal in Scenario 1B—with demand peaking at 25 Mgal per year in the early 2040s. The WVR that previously occurred in the WTP Pretreatment Facility evaporators, as well as most of the 242-A Evaporator WVR, is shifted to the new LAW Feed Evaporator and HEMF evaporator in Scenario 2. The increase in secondary liquid effluent above Scenario 1B is attributable to additional water added to the Scenario 2 flowsheet. The amount of water added for solids washing increases from 19 to 127 Mgal due to using raw water for washing in the HFPF instead of recycled secondary liquid effluent as in the WTP Pretreatment Facility. Furthermore, the amount of water added for flushes associated with feed-delivery transfers increases from 8 to 28 Mgal as a result of longer distances between feed preparation and treatment facilities in this DFLAW/DF-HLW flowsheet. This water added for solids washing and for flushes is evaporated in the HEMF evaporator and sent to LERF.

Figure 5-41. Scenario 2 – Feed Sources to the Liquid Effluent Retention Facility.



Acronyms:

DFLAW	=	direct-feed low-activity waste.
EMF	=	Effluent Management Facility.
HEMF	=	High-Level Waste Effluent Management Facility.
IDF	=	Integrated Disposal Facility.
LAWST	=	low-activity waste supplemental treatment.
MWT	=	mixed waste trench.
TRU	=	transuranic.
Vit.	=	vitrification.
WTP	=	Waste Treatment and Immobilization Plant.

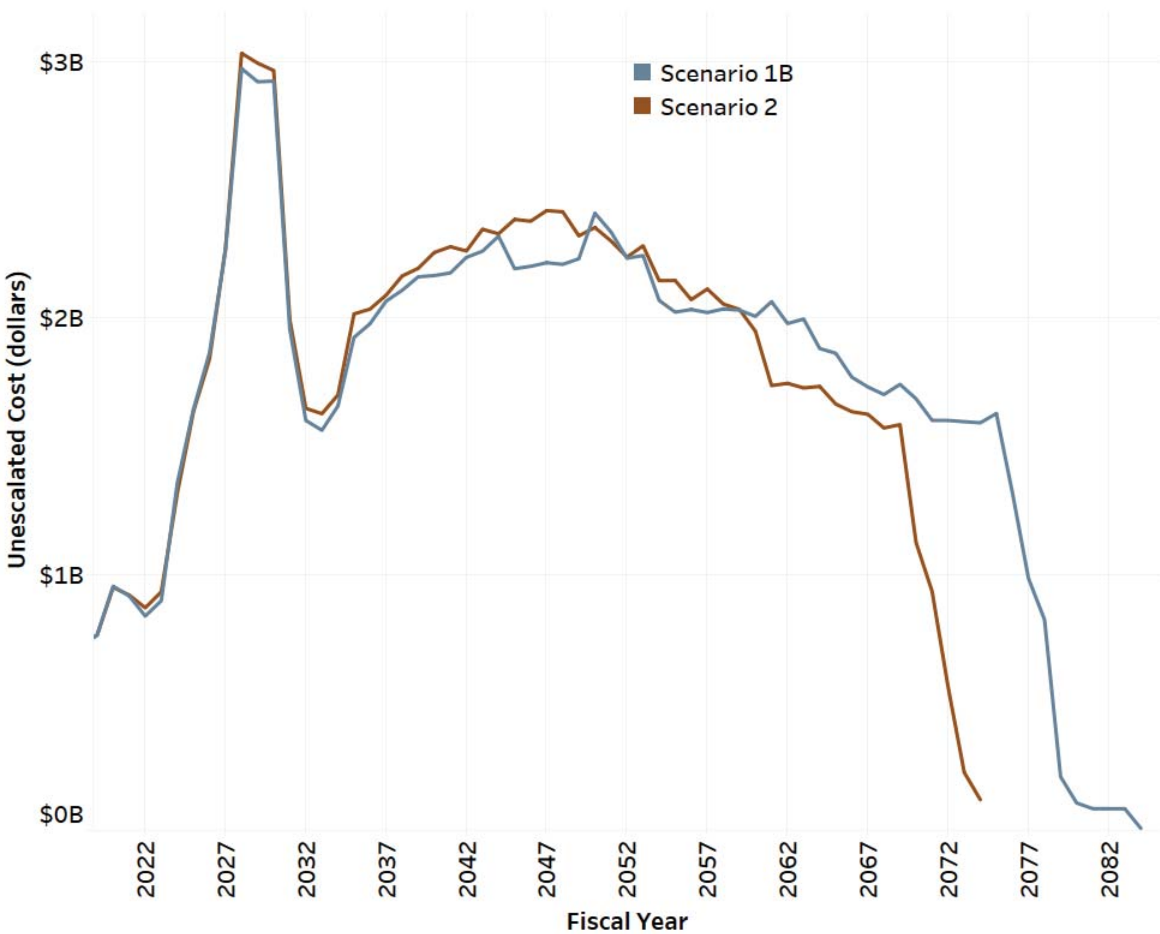
[34] The totals to LERF include only the sources shown and do not include potential inputs from contaminated groundwater or leachate from the ERDF, the IDF, or others.

5.2.3.4 Life-Cycle Cost Results

The annual unescalated life-cycle cost profile is presented in and compared to Scenario 1B in Figure 5-42. The cumulative life-cycle cost is $112 billion ($208 billion escalated), versus $122 billion ($247 billion escalated) for Scenario 1B. There is a $10-billion[35] cost savings realized from a 6-year-shorter mission duration; site operations cost approximately $2 billion annually after startup of the integrated WTP. However, while Scenario 2 may be more affordable than Scenario 1B, the proposed mission schedule still requires a sharp increase in funding above historical levels to construct the LAWST capability and other new facilities supporting waste treatment (e.g., the HFPF).

Although Scenario 2 added the new HFPF and LAW Feed Evaporator, as well as an expanded TFPT capacity, these costs are offset in the life-cycle profile by not constructing and operating the TWCS capability or operating the WTP Pretreatment Facility. The combined capital cost for the HFPF and LAW Feed Evaporator is $1.43 billion versus $1.04 billion for the TWCS capability.

Figure 5-42. Scenario 2 Comparison – Unescalated Life-Cycle Cost Profile.



[35] Life-cycle cost does not include WTP construction costs, and thus the savings in life-cycle cost do not reflect the cost saved by not completing construction of the WTP Pretreatment Facility in Scenario 2. The cost of offsite IHLW canister disposal is also not included.

5.2.4 Risks

Overall, the functions and throughputs of the various systems in the Scenario 2 flowsheet closely resemble those of the Baseline Case (Scenario 1) (see Section 7.1). However, there are a few new risks introduced, and a number of the Baseline Case's risks are significantly reduced (or enhanced) in Scenario 2. Scenario 2 reduces the Baseline Case's risks related to the cost and schedule of completing the WTP by replacing the WTP Pretreatment Facility with a collection of new, simpler, and less-expensive facilities (the HFPF, LAW Feed Evaporator, and expanded TFPT). However, because there are only preconceptual designs for the new facilities in Scenario 2, there is an enhanced risk of new technical issues, that could increase cost and schedule being identified. For example:

- Pipe routing changes required to support DF-HLW operations may complicate design of the WTP HLW Vitrification Facility
- Concentrated slurries must be pumped longer distances, which may lead to challenges in maintaining the solids in suspension during transfer
- Additional technologies, such as filtration, may be required for solids/liquids separation in the HFPF.

Additionally, as the mission flowsheet results show (Section 5.2.3.3), although Scenario 2 reduces the Baseline Case risks related to continued reliance on the aging 242-A Evaporator, there is more demand on aging DST transfer infrastructure (36 percent increase in DST transfers), as well as on the ETF for treatment of secondary liquid effluent (15 percent increase in secondary liquid effluent volume), and that risk is enhanced.

Scenario 2 reduces the Baseline Case risks related to treatment throughput. As in Scenario 1B, Scenario 2 assumes 50 percent TOE in the WTP LAW and HLW Vitrification Facilities and LAWST capability, a more achievable target versus the 70 percent assumed in the Baseline Case.

5.2.5 Opportunities

The flowsheet for the Baseline Case has a single, clear, rate-limiting step for treatment—pretreatment of solids in the WTP Pretreatment Facility. Scenario 2 capitalizes on this by eliminating this single bottleneck with the introduction of the higher-throughput HFPF. In Scenario 2 LAW treatment is the new rate-limiting step. This leads to a few potential opportunities.

- The tank waste treatment mission could be reduced in duration by increasing LAW throughput. This might be done through offsite treatment or by increasing the capacity for the LAWST capability but could be achieved by simply increasing the maximum cesium concentration in the WTP's LAW Vitrification Facility and EMF. However, due to the constraints on SST retrievals, the maximum benefit of this improvement would be an approximate 3-year acceleration in tank waste treatment completion (Section 5.2.8). Without any restrictions on LAW treatment throughput or SST retrievals, it may be possible to complete the mission as soon as 2055.
- The startup of the HFPF and the WTP HLW Vitrification Facility could be delayed significantly to promote level-loading of mission costs. Startup of HLW treatment could potentially be delayed up to 13 years to 2046 without affecting the overall mission

treatment schedule. This opportunity requires further modeling analysis and may require changes to planned strategies for managing the DST system and SST retrievals.

- The capacity of the HFPF and WTP HLW Vitrification Facility could be reduced to decrease the capital expenditure required for starting HLW treatment.
- Process condensate generated by the HEMF evaporator could be recycled within the HFPF for use in solids washing, partially mitigating the increase in secondary liquid effluent volume observed for Scenario 2.
- With the introduction of two new evaporators to the flowsheet (the HEMF evaporator and LAW Feed Evaporator), the 242-A Evaporator becomes redundant and could be shut down after 2035, lowering the life-cycle cost by nearly $800 million.

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5.2.6 Scenario 2A – Scenario 2 Sensitivity – Add New Double-Shell Tanks

5.2.6.1 Objective and Planning Bases

The purpose of Scenario 2A is to evaluate whether adding new DSTs to Scenario 2 improves the ability to maintain feed to the WTP. The assumptions are the same as those for Scenario 2, except that either four or eight new DSTs are added to the 200 East Area on December 31, 2030. The new DSTs are each assumed to have an operating volume of 1.25 Mgal and be equipped with a transfer pump and two mixer pumps.

5.2.6.2 Key Results and Analysis

Adding new DSTs (either four or eight) did not have a net effect on the ability to maintain feed to the WTP. The new DSTs improve HLW treatment continuity in the first several years of the DF-HLW mission by providing surge capacity for returns from HLW treatment. However, because the mission duration is driven by LAW treatment and not HLW treatment, the improved continuity is offset by less continuity of HLW treatment later in the mission. Retrievals of the SSTs and tank waste treatment ultimately complete at the same time as in Scenario 2.

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5.2.7 Scenario 2B – Scenario 2 Sensitivity – Slower Waste Treatment and Immobilization Plant Ramp-Up

5.2.7.1 Objective and Planning Bases

The purpose of the Scenario 2B sensitivity is to evaluate the effect to Scenario 2 of a slower WTP ramp-up. The assumptions are the same as for Scenario 2, except that the ramp-up periods for the WTP LAW and HLW Vitrification Facilities are increased from 32 and 34 months, respectively, to 10 years each. Additionally, 15 years pass (instead of 5) prior to the installation of second-generation melters in the WTP HLW Vitrification Facility. As in Scenario 2, the ramp-up is a linear ramp from half- to full-capacity, and no ramp-up is applied to the LAWST capability.

5.2.7.2 Key Results and Analysis

The results of the Scenario 2B sensitivity versus Scenario 2 are summarized in Table 5-19. Overall, the results are very similar between the two scenarios. There is a delay of approximately 2 years in SST retrieval completion, and less than 1 year in tank waste treatment completion. Although a delay in schedule given a slower ramp-up makes sense, these schedule differences fall within the random uncertainty of TOPSim modeling, and a delay cannot be demonstrated conclusively.

Table 5-19. Scenario 2B Comparison – Key Metrics.

Metric	Scenario 2	Scenario 2B
SST Retrievals Complete	2060	2062
DST Retrievals Complete	2069	2070
Tank Waste Treatment Complete	2069	2070
IHLW Glass Canisters	9,100	9,000
Total ILAW Glass Containers	91,000	91,000
WTP ILAW Glass Containers (% Total)	29,000 (32%)	27,000 (30%)
LAWST ILAW Glass Containers (% Total)	62,000 (68%)	64,000 (70%)
LAWST Glass Volume, yd^3	174,000	178,000
LAWST Equivalent Grout Volume, yd^3	690,000	720,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,800	11,800

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

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5.2.8 Scenario 2C – Scenario 2 Sensitivity – Increased Waste Treatment and Immobilization Plant Total Operating Efficiency

5.2.8.1 Objective and Planning Bases

The purpose of the Scenario 2C sensitivity is to determine the WTP throughput needed to achieve the Baseline Case tank waste treatment completion date of 2066 using the flowsheet from Scenario 2. The assumptions are the same as those for Scenario 2, except that the TOE of the WTP LAW and HLW Vitrification Facilities and LAWST capability are increased uniformly from 50 percent.

5.2.8.2 Key Results and Analysis

A throughput equal to 63 percent TOE in the treatment facilities (versus 70 percent in the Baseline Case) was required to achieve the same tank waste treatment completion date of 2066. Scenario 2C also required a design throughput of 25 gpm for TFPT, equivalent to five in-parallel TSCR units, to support pretreating supernatant at a rate equal to the combined capacity of the WTP LAW Vitrification Facility and LAWST capability at 63 percent TOE.

The benefits of increased throughput are lower than might be expected—26 percent increase in throughput for a 7 percent decrease in treatment duration. This is because, as Scenario 2 approaches the treatment schedule of the Baseline Case, SST and DST retrievals quickly become more limiting than treatment throughput. The results of the Scenario 2C sensitivity versus Scenario 2 are summarized in Table 5-20 and are consistent with Scenario 2 in every aspect except the treatment completion date.

Table 5-20. Scenario 2C Comparison – Key Metrics.

Metric	Scenario 2	Scenario 2C
SST Retrievals Complete	2060	2060
DST Retrievals Complete	2069	2066
Tank Waste Treatment Complete	2069	2066
IHLW Glass Canisters	9,100	8,900
Total ILAW Glass Containers	91,000	91,000
WTP ILAW Glass Containers (% Total)	29,000 (32%)	29,000 (32%)
LAWST ILAW Glass Containers (% Total)	62,000 (68%)	62,000 (68%)
LAWST Glass Volume, yd^3	174,000	174,000
LAWST Equivalent Grout Volume, yd^3	690,000	710,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,800	11,800

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

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5.3 SCENARIO 3 – TREATMENT-FAVORED DIRECT-FEED LOW-ACTIVITY WASTE AND DIRECT-FEED HIGH-LEVEL WASTE WITH INDEPENDENT HIGH-LEVEL WASTE SAMPLING AND PRETREATMENT FACILITY

5.3.1 Objective and Planning Bases

The objective of Scenario 3 is to evaluate the RPP mission with a new HFPF that replaces the TWCS capability and solids pretreatment function in the WTP Pretreatment Facility. Although this scenario resembles Scenario 2, Scenario 3 differs in that sampling and characterization of slurry are performed in the HFPF instead of in the DSTs. Supernatant is pretreated through the DFLAW process with a TSCR system and later by a TFPT system. The capacity of the TFPT system is increased as needed to support both the WTP LAW Vitrification Facility and LAWST operations. The LAW Feed Evaporator is also added to support pretreating supernatant. Because Scenario 3 uses Scenario 1B as its starting point, the throughput and resulting mission completion schedules of Scenario 3 are evaluated against Scenario 1B. The Scenario 3 assumptions that are different from the Scenario 1B assumptions are listed below in Table 5-21.

Scenario 3 also includes one sensitivity scenario, Scenario 3A – Add New DSTs, discussed in Section 5.3.6.

Table 5-21. Scenario 3 – Starting Assumptions Altered from Scenario 1B.

Starting Assumption #	Scenario 3 Assumption
A1.2.2.13	Additional DSTs are assigned as needed to support the DFLAW mission (including additional TSCR/TFPT feed and feed staging tanks).
A1.2.3.17, A1.2.6	All slurry feed to HLW treatment is sampled in the HFPF. The HFPF replaces the TWCS capability in this scenario.
A1.2.5.3	In order to limit re-precipitation of phosphate solids in the DSTs, supernatant as low as 2M sodium will be staged as feed to the TFPT systems starting with the retrieval of B Complex SSTs in 2035.
A1.2.5.6	With the startup of LAWST in 2034, TFPT capacity will be increased beyond the 1.9-times-TSCR capacity beginning in 2028, as needed, to support pretreatment of all waste destined for LAW treatment.
A1.3.2	The WTP Pretreatment Facility is not included in this scenario. Instead, this scenario includes the following: • A new HFPF for pretreatment, to include leaching and washing, of waste destined for the WTP HLW Vitrification Facility • An HEMF evaporator (included in the HFPF) for concentration of dilute effluents from the WTP HLW Vitrification Facility and solids washing • Expanded TFPT capacity, as well as a new LAW Feed Evaporator, to support pretreatment of all waste destined for LAW treatment.

DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HEMF = High-Level Waste Effluent Management Facility.
HFPF = High-Level Waste Feed Preparation Facility.
HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

5.3.2 Flowsheet Description

A simplified flowsheet for Scenario 3 is provided in Figure 5-43. The flowsheet differs from Scenario 1B in several ways. The WTP Pretreatment Facility and TWCS capability are no longer included in the flowsheet. The functionality of these facilities is replaced by the HFPF, two new evaporators (one in the HEMF and the LAW Feed Evaporator), and additional TFPT capacity (Table 5-21).

As in the flowsheet for the Baseline Case, supernatant is pretreated through the DFLAW process via a TSCR system, which is replaced by TFPT after 5 years. However, in Scenario 3, the TFPT throughput is expanded as needed at the same time as the LAWST capability starts to support feeding both the WTP LAW Vitrification Facility and the LAWST capability. Additional existing DSTs are also dedicated to preparing and feeding waste to the TFPT system as needed to support the increased DFLAW throughput. The LAW Feed Evaporator concentrates feed to both the WTP LAW Vitrification Facility and LAWST as described for Scenario 2 in Section 5.2.2.2.

In 2032, the HFPF, where solids pretreatment and effluent management occur, starts operating. The simplified HFPF flowsheet is shown in Figure 5-44. The feed preparation portion of the HFPF consists of four 250-kgal HLW feed preparation tanks and two 250-kgal HLW feed tanks. Slurries from the DSTs are sent to the HLW feed preparation tanks, where the waste is sampled, characterized, and pretreated. The waste is pretreated by settling and decanting to concentrate the slurry, adding caustic, heating to 140°F (60˚C) to leach aluminum for glass loading optimization, and finally by washing soluble salts from the remaining solids with water and decanting several times until the supernatant is below 1M sodium. The HLW feed preparation tanks send pretreated slurry to the HLW feed tanks, dilute decantate to the HEMF feed tanks, and concentrated decantate to the 200 East Area DSTs. The HLW feed tanks send the pretreated slurry feed to the WTP HLW Vitrification Facility. Dilute effluents from the WTP HLW Vitrification Facility are sent to the HEMF feed tanks.

The effluent management portion of the HFPF is based on the process and equipment sizing proposed in RPP-RPT-61957 and consist of two 60-kgal mixer feed tanks, the HEMF evaporator, and one 250-kgal mixer concentrate tank. The feed tanks receive dilute decantate from the feed preparation side of the HFPF and the neutralized liquid effluent from the WTP HLW Vitrification Facility, and alternate between filling and feeding the HEMF evaporator. The design of the HEMF evaporator is based on the waste feed evaporation process system evaporator in the WTP Pretreatment Facility and concentrates feed to a density of 1.27 kg/L. Concentrate from the HEMF evaporator is routed to the concentrate tank, where it is chemically adjusted to meet the tank farm corrosion specifications using additions of sodium nitrite and sodium hydroxide as necessary. When the concentrate tank is full, the waste is transferred to the 200 East Area DSTs. The secondary liquid effluent from the new HEMF evaporator and LAW Feed Evaporator is sent to the LERF.

Figure 5-43. Scenario 3 – Simplified Flowsheet.

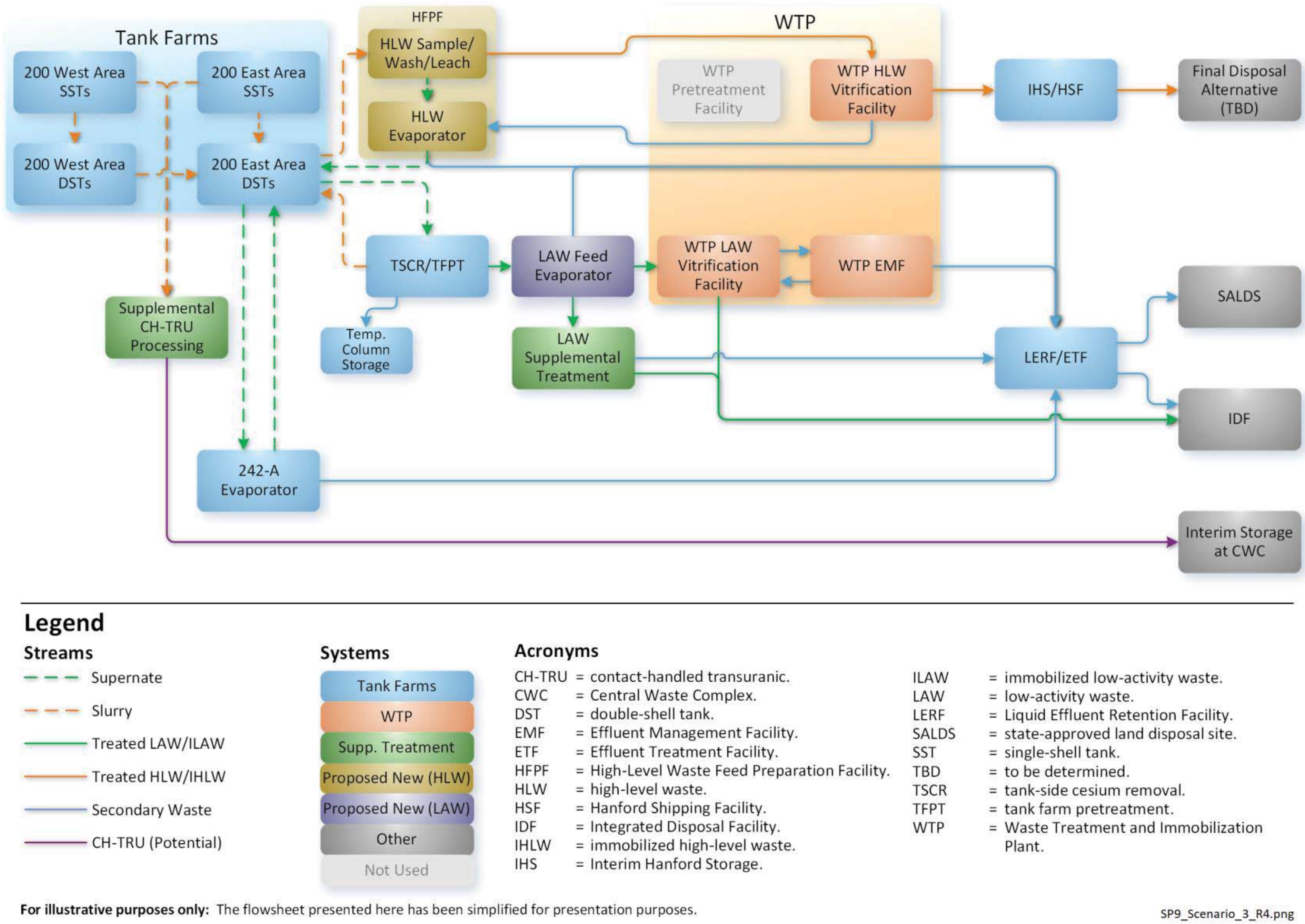
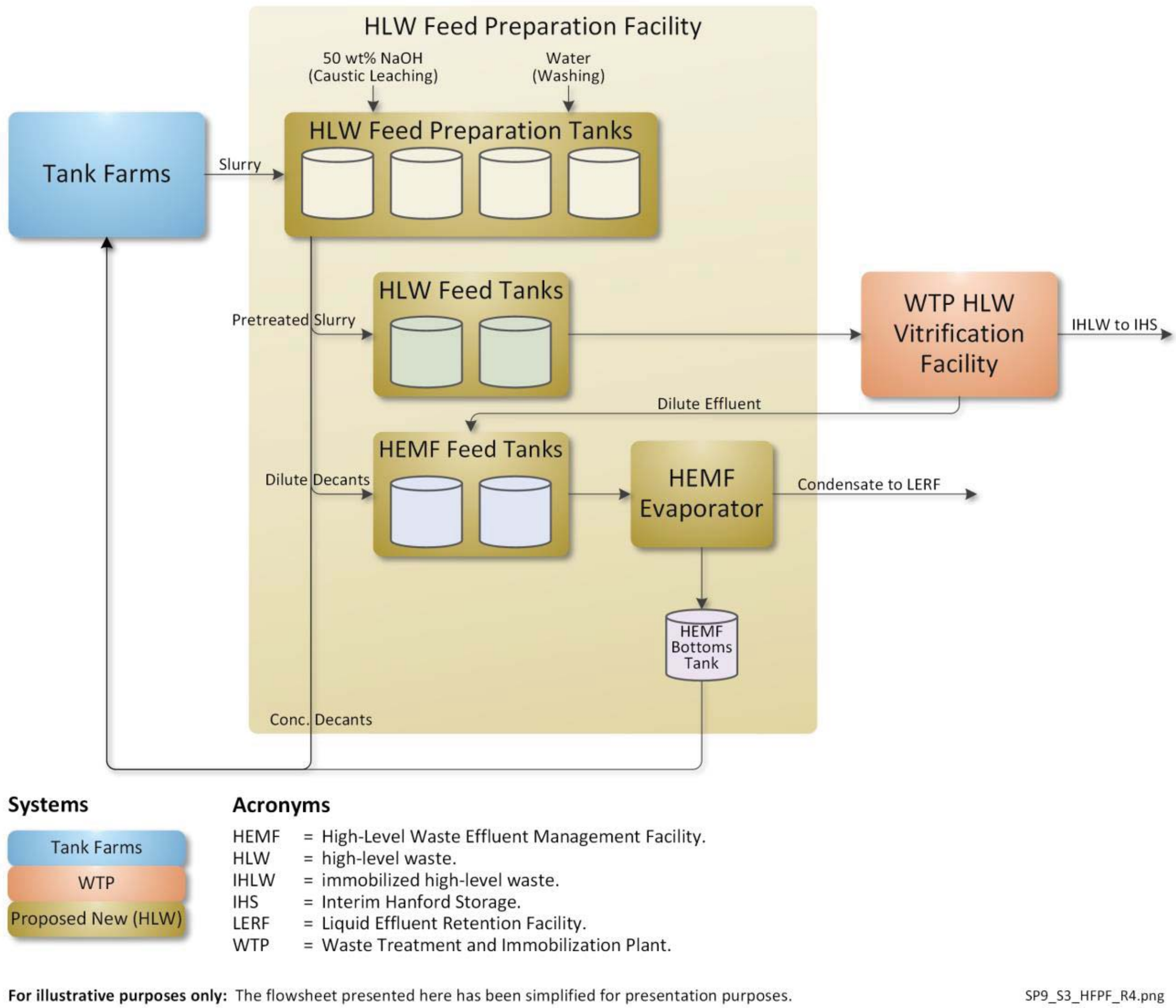


Figure 5-44. Scenario 3 – Simplified High-Level Waste Preparation Facility Flowsheet.



5.3.3 Analysis

5.3.3.1 Key Results and Metrics

The Scenario 3 results show no significant acceleration of the overall RPP mission compared to Scenario 1B, despite eliminating the solids pretreatment bottleneck by replacing the solids pretreatment function of the WTP Pretreatment Facility with the HFPF, which has a higher throughput. A comparison of the mission metrics for Scenario 3 and Scenario 1B is given in Table 5-22.

The following factors affect the Scenario 3 mission:

- Upon removing the solids pretreatment limitation (which is due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step because the capacity of the LAWST capability is sized to match the Baseline Case.

- A 50-percent increase in sodium hydroxide added to the HFPF to achieve similar leaching to Scenario 1B (but at a lower temperature) increases the ILAW glass by 15 percent. This prevents Scenario 3 from improving the mission schedule against Scenario 1B because the mission is driven by LAW treatment.
- As in Scenario 1B, constant constraints on DST space delay SST retrievals, which also delay feed to HLW vitrification.
- The addition of two new evaporators (the HEMF evaporator and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with few implications to the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility causing a 32-percent increase in secondary liquid effluent produced.

Table 5-22. Scenario 3 Comparison – Key Metrics.

Metric	Scenario 1B	Scenario 3
SST Retrievals Complete	2065	2066
DST Retrievals Complete	2075	2076
Tank Waste Treatment Complete	2076	2076
IHLW Glass Canisters	7,000	7,200
Total ILAW Glass Containers	88,000	101,000
WTP ILAW Glass Containers (% Total)	49,000 (56%)	28,000 (28%)
LAWST ILAW Glass Containers (% Total)	39,000 (44%)	72,000 (72%)
LAWST Glass Volume, yd^3	109,000	202,000
LAWST Equivalent Grout Volume, yd^3	430,000	910,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,000	12,000
Unescalated (Escalated) Life-Cycle Cost	$122B ($247B)	$125B ($255B)

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplement treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

5.3.3.2 Mission Schedule Results

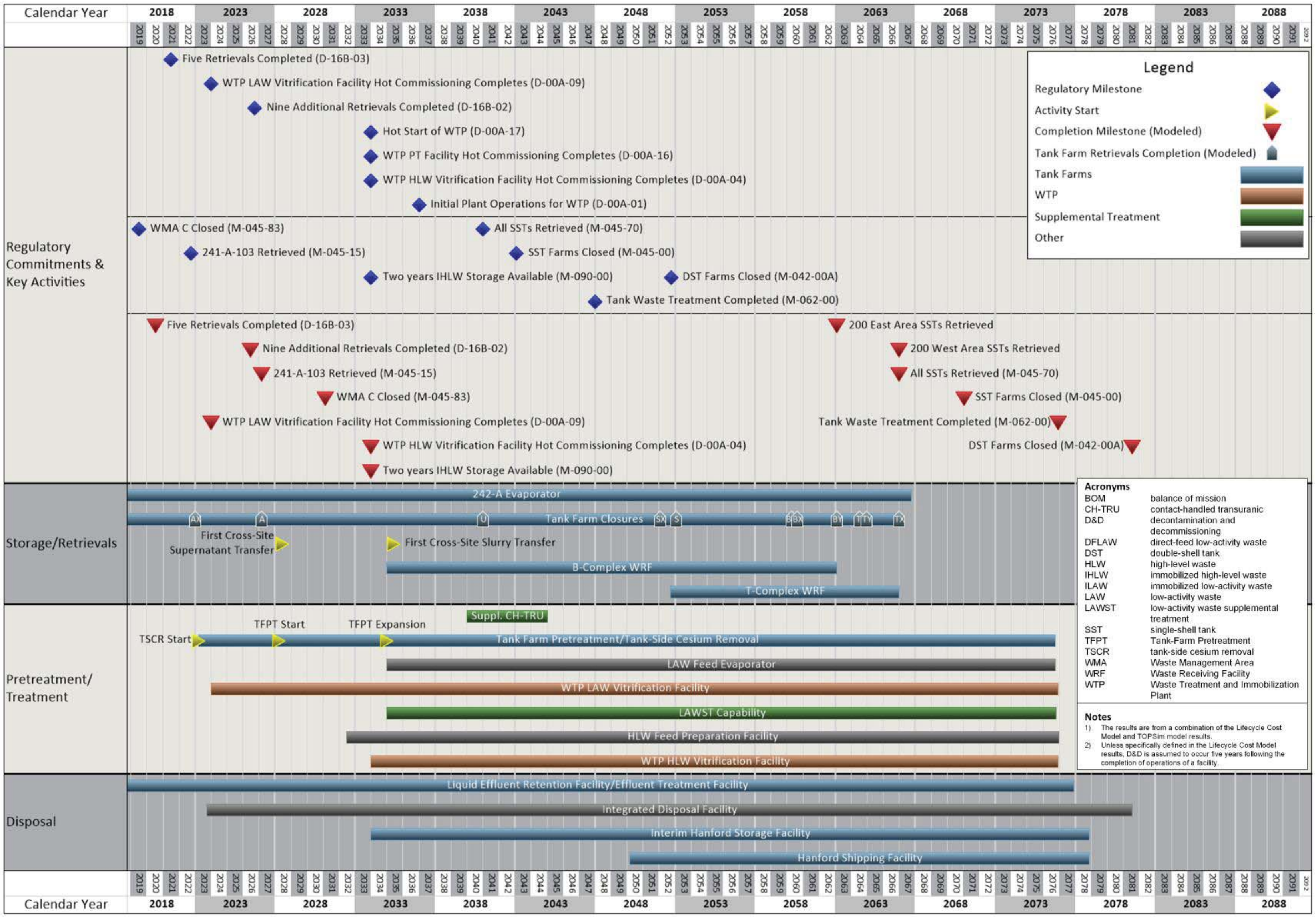
Table 5-23 lists the key mission activity dates for Scenario 3, followed by Figure 5-33 that shows the projected operating schedule for the SST retrievals and treatment systems.

Table 5-23. Scenario 3 – Summary of Schedule Results.

	Key Mission Metric	Scenario 1B	Scenario 3
Near-Term Regulatory	Complete Five Additional SST Retrievals (Existing Consent Decree 06/30/2021)	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Existing Consent Decree 09/30/2026)	06/2026	06/2026
	Complete Tank 241-A-103 Retrieval (Existing TPA 09/30/2022)	04/2027	03/2027
Storage/Retrieval	242-A Evaporator Operations	Present – 2066	Present – 2067
	200 East Area WRF Operations	2034 – 2065	2034 – 2063
	200 West Area WRF Operations	2050 – 2062	2052 – 2067
	200 East Area SST Retrievals Complete	2065	2063
	200 West Area SST Retrievals Complete	2062	2066
	Cross-Site Transfer Line Activated (Supernatant)	2028	2028
	Cross-Site Transfer Line Activated (Slurry)	2030	2035
Pretreatment/Treatment	TSCR/TFPT Operations	2023 – 2063	2023 – 2076
	LAW Feed Evaporator Operations	N/A	2034 – 2076
	TWCS Capability Operations	2032 – 2076	N/A
	WTP Pretreatment Facility Operations	2033 – 2076	N/A
	HFPF Operations	N/A	2033 – 2076
	WTP LAW Vitrification Facility Operations	2023 – 2076	2023 – 2076
	WTP HLW Vitrification Facility Operations	2033 – 2076	2033 – 2076
	LAWST Capability Operations	2034 – 2076	2034 – 2076
	Potential CH-TRU Waste Treatment Facility Operations	2040 – 2045	2040 – 2045
	LERF/ETF Operations	Present – 2077	Present – 2077
	Tank Waste Treatment Complete	2076	2076
Disposal	IDF Operations	2023 – 2083	2023 – 2081
	IHS Facility Operations	2033 – 2078	2033 – 2078
	HSF Offsite Shipping Operations	2056 – 2078	2050 – 2078
	All IHLW Shipped Offsite	2078	2078

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
HFPF = High-Level Waste Pretreatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
LERF = Liquid Effluent Retention Facility.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-45. Scenario 3 – Operating Schedule for Major Facilities/Processes.



5.3.3.3 Mission Flowsheet Results

5.3.3.3.1 Tank Farms

The SSTs are projected to be retrieved by 2066, within the anticipated 1-to-2-year range of random uncertainty associated with TOPSim when compared to the SST retrieval completion date for Scenario 1B (2065). Figure 5-46 shows the sequencing and timing of SST retrievals by complex for Scenarios 1B and 3. The colored bands indicate ongoing retrieval activity, the white spaces between the bars are the assumed delay between retrievals, and the grey bands indicate delays in the SST retrieval durations (i.e., the difference in the actual retrieval duration and the assumed retrieval duration) due to DST space availability. The retrieval sequences for both scenarios are virtually identical prior to the startup of the HFPF. However, the initial returns of effluent from the HFPF cause a delay to SST retrievals of approximately 2 years versus Scenario 1B. Scenario 3 requires effluent returns to be managed in the 200 East Area DSTs, whereas the WTP Pretreatment Facility does not return effluent to DSTs as part of normal operations. However, after 2039, Scenario 3 maintains a similar rate of retrievals as in Scenario 1B indicating that Scenario 3 retrievals are still just as limited by treatment.

Figure 5-46. Scenario 3 Comparison – Single-Shell Tank Retrieval Schedule.

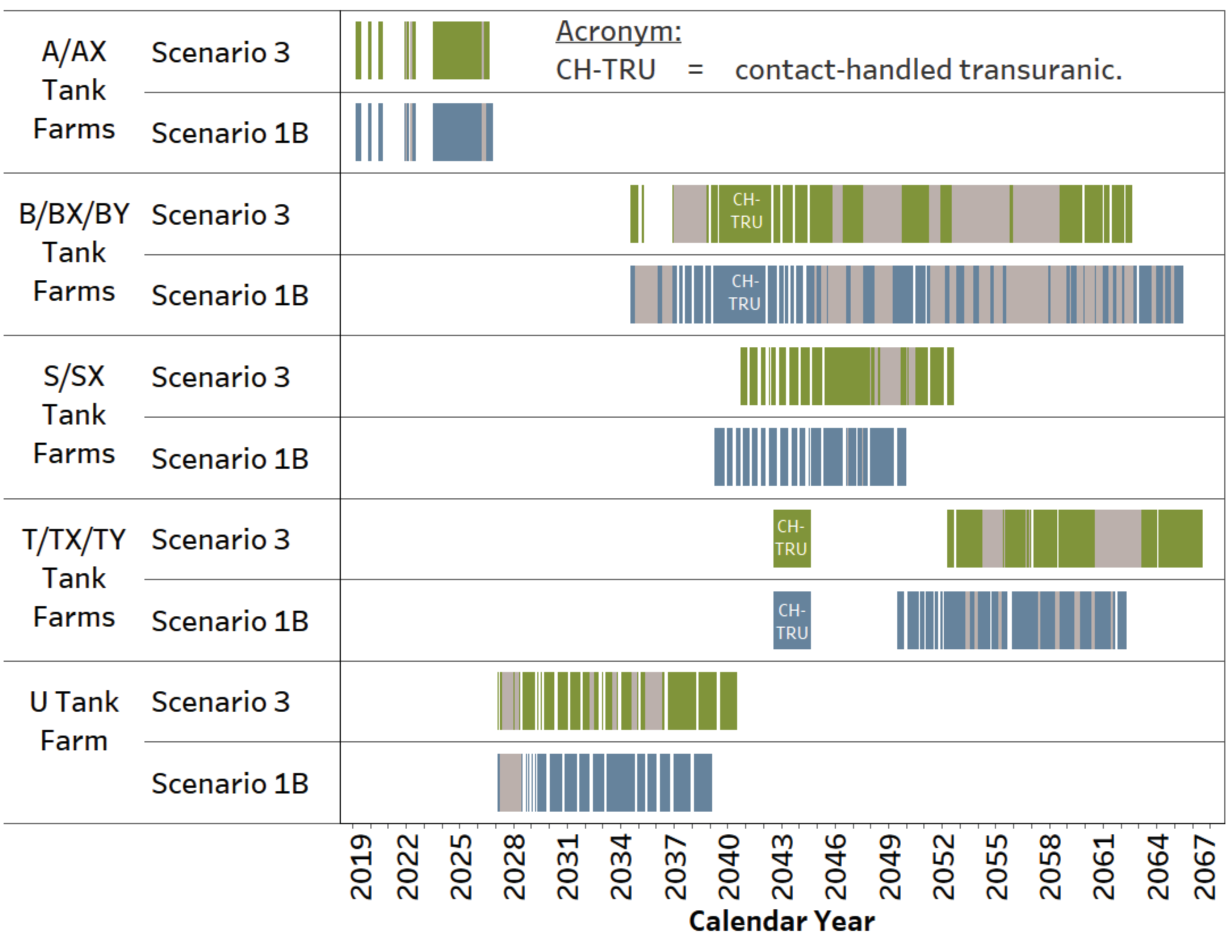


Figure 5-47 shows the DST space utilization through the completion of the mission for Scenario 3. Little DST space is created even after the startup of HLW treatment and LAWST, and the demand for DST space is consistently very high throughout the duration of the mission. Limited LAW treatment throughput reduces the available DST space, which is strained by managing the effluent returns from both the HFPF and SST retrievals.

Figure 5-47. Scenario 3 – Double-Shell Tank Space Utilization.

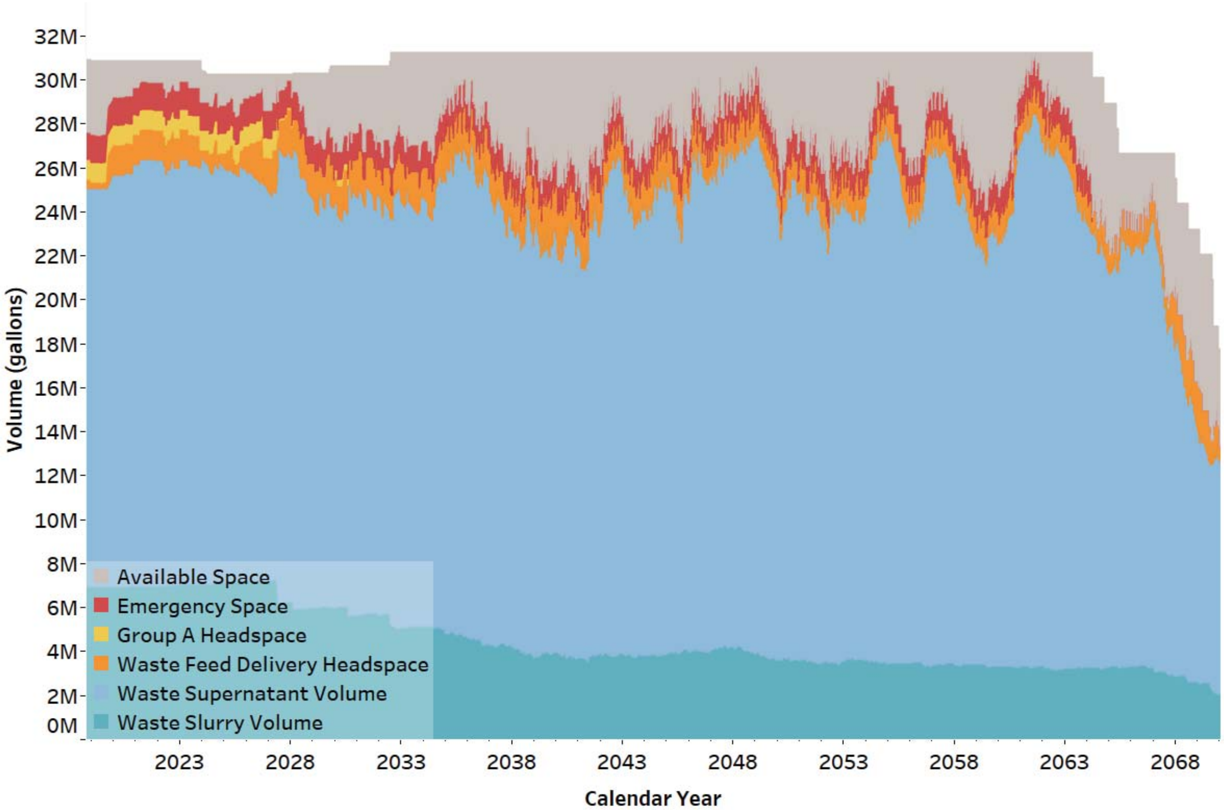


Table 5-24 compares the total volume of DST inputs (positive values) and outputs (negative values) throughout the mission for Scenario 1B and Scenario 3. At 42 percent and 37 percent of the total input volume, DF-HLW effluent returns and SST retrievals, respectively, present the greatest demand for DST space in Scenario 3. There is a significantly larger volume of supernatant fed to the WTP LAW Vitrification Facility and LAW Feed Evaporator for Scenario 3 in comparison to the combined volume fed to the WTP LAW Vitrification Facility, WTP Pretreatment Facility, and LAWST capability for Scenario 1B. This increase in volume is indicative of the high volume of returns from HFPF and the decreased utilization of the 242-A Evaporator in favor of the LAW Feed Evaporator.

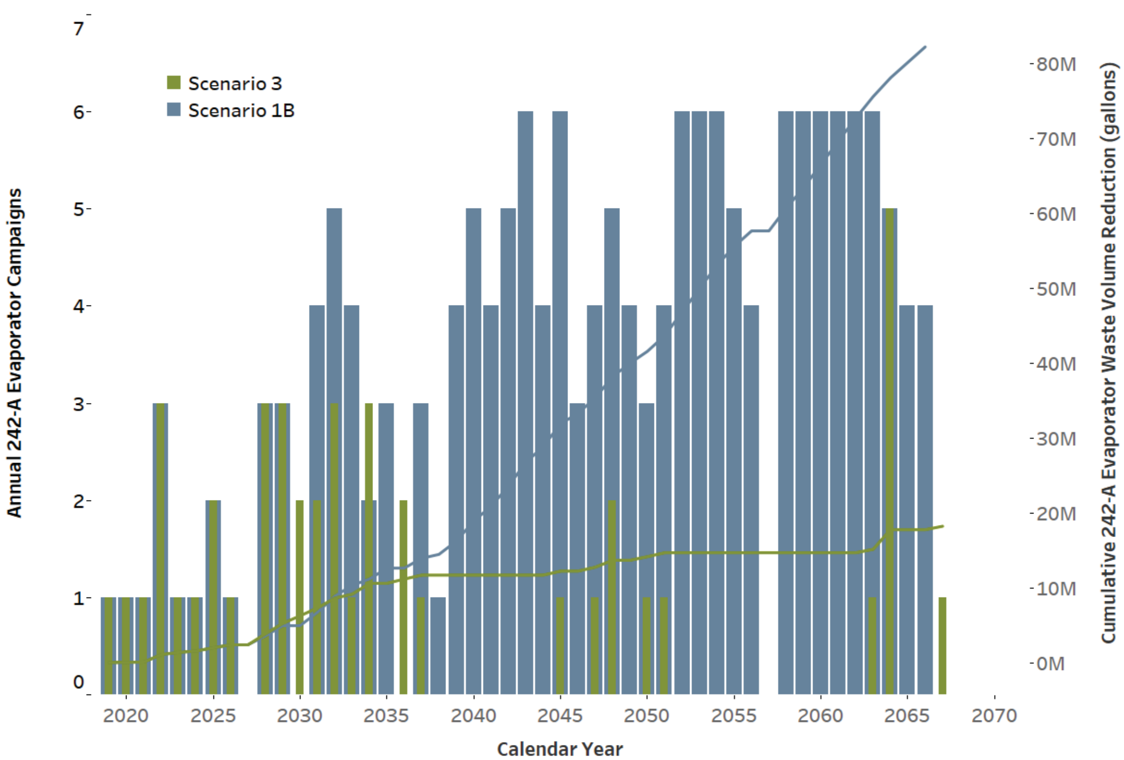
Table 5-24. Scenario 3 Comparison – Double-Shell Tank Input and Output Volume.

Source or Destination	Scenario 1B (Mgal)	Scenario 3 (Mgal)
Effluent Returns from HFPF	N/A	166
As-Retrieved SST Waste	127	127
Water and Chemical Additions	67	44
Miscellaneous Additions	1	3
Pretreated Supernatant to WTP LAW/LAWST/LAW Feed Evaporator	-40	-254
Slurry to TWCS (Scenario 1B) or HFPF (Scenario 3)	-78	-88
242-A Evaporator WVR	-83	-18
Supernatant to WTP Pretreatment Facility	-18	N/A
DST Evaporation	-1	-1

DST = double-shell tank.
HFPF = High-Level Waste Feed Preparation Facility.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.
WVR = waste volume reduction.

Comparison of the 242-A Evaporator usage for Scenario 3 versus Scenario 1B is shown in Figure 5-48. The addition of the HEMF evaporator and LAW Feed Evaporator, as well as targeting a lower sodium concentration in the DSTs to reduce phosphate reprecipitation, decreases reliance on the 242-A Evaporator. Starting in 2035, the majority of evaporation shifts to the HEMF evaporator and LAW Feed Evaporator to the point that further 242-A Evaporator operations after 2034 has a negligible effect to the overall mission.

Figure 5-48. Scenario 3 Comparison – 242-A Evaporator Utilization.



5.3.3.3.2 Low-Activity Waste Pretreatment and Treatment

Scenario 3 requires an expanded TFPT capability with a design throughput of 20 gpm, equivalent to four TSCR units, to support LAW vitrification and LAWST at 50 percent TOE. This capacity is based on avoiding feed stoppages by using two different DSTs to feed TFPT. A maximum of five DSTs is used simultaneously for the dilution, sampling, and staging of supernatant designated to feed the TFPT systems. Overall, the TSCR/TFPT systems pretreat 254 Mgal of supernatant, which is reduced to 145 Mgal by the LAW Feed Evaporator prior to treatment. Pretreating this amount of supernatant through the TSCR/TFPT systems generates a total of 801 TSCR-equivalent spent IX columns, which would require six 150-column waste storage pads.

Scenario 3 produces approximately 15 percent more total ILAW glass than Scenario 1B (93,000 versus 79,000 MT) due to 17 percent more sodium being sent to ILAW glass. The additional sodium is attributable to an increase in caustic solution added for solids leaching in the HFPF to 23.9 Mgal versus 15.6 Mgal added in the WTP Pretreatment Facility for Scenario 1B.

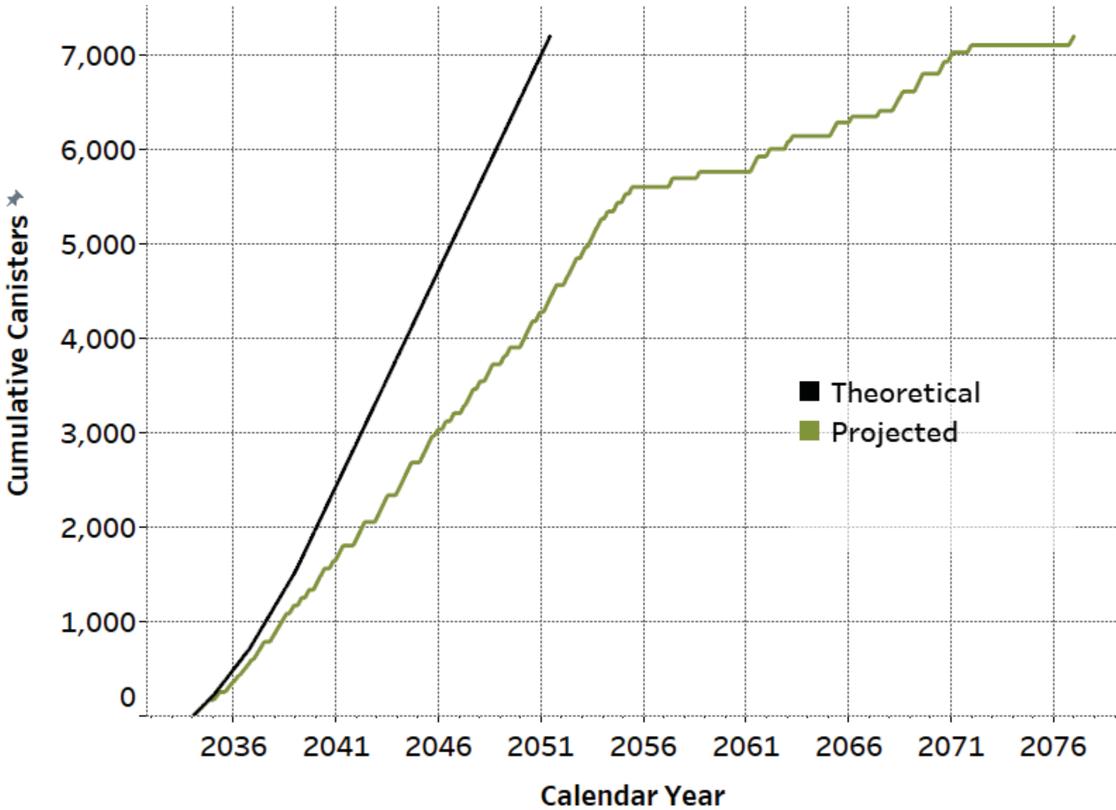
Along with an overall increase in the total ILAW containers in Scenario 3, there is a shift in the relative amount of ILAW produced by LAWST. For Scenario 3, 71 percent of the total ILAW was produced by LAWST versus 44 percent for Scenario 1B. This shift in ILAW production enables a higher amount of LAW to be treated over a similar mission duration and allows compensation for the decreased throughput for the WTP LAW Vitrification Facility after 2041 due to a reduced cesium-removal efficiency of the resin for dilute supernatant. Additional discussion of this issue can be found in Section 5.2.3.3.2.

5.3.3.3.3 High-Level Waste Pretreatment and Treatment

Over 43 years of operations, the HFPF processes 88 Mgal of slurry from the 200 East Area DSTs into 16 Mgal of feed to the WTP HLW Vitrification Facility and produces 166 Mgal of returns to the 200 East Area DSTs (includes 2.5 Mgal of chemicals added for corrosion control). This equates to 1.9 gal of effluent returned for every gallon fed via the DF-HLW approach because the HEMF evaporator processes 174 Mgal of dilute effluent to 24 Mgal of concentrate. Without the HEMF, this ratio would be 3.3 gal of effluent returned for every gallon fed via the DF-HLW approach that would require the aging 242-A Evaporator to produce an additional 3 Mgal of WVR annually. A total of only 1.5 Mgal of sodium nitrite is added to the HEMF returns to address corrosion mitigation; blending of the WTP HLW Vitrification Facility effluents with decantate from the HFPF feed preparation vessels is sufficient to meet the tank farms corrosion specifications.

Figure 5-49 shows the projected versus theoretical IHLW glass production for Scenario 3. The projected production line shows multiple extended periods where IHLW glass production either matches the theoretical production or is flattened due to a lack of available feed (particularly later in the mission). This demonstrates that the HFPF has adequate pretreatment throughput to feed the WTP HLW Vitrification Facility at the assumed rate. However, due to effluent returns from the HFPF and limited LAW treatment, the DSTs fill, preventing continued operation of the HFPF and WTP HLW Vitrification Facility. Additionally, an insufficient SST retrieval rate (which can be exacerbated by insufficient LAW treatment capacity) can lead to unavailability of sludge solids destined for the WTP HLW Vitrification Facility. Therefore, LAW treatment is the rate-limiting step that constrains HLW treatment.

Figure 5-49. Scenario 3 – Immobilized High-Level Waste Glass Production.



The two factors affecting caustic leaching efficacy for the HFPF for this scenario versus the WTP Pretreatment Facility in the baseline flowsheet are time and temperature. The leaching time is longer (120 versus 20 hours), and the leaching temperature is lower (140° versus 185°F [60° versus 85°C]) for Scenario 3. The increase in leaching time increases the amount of aluminum leached, while a lower temperature decreases the efficiency of leaching. For this scenario, longer leaching times are slightly more effective than the temperature difference and, consequently, slightly reduce the amount of IHLW glass produced. Additionally, the lack of oxidative leaching results in an increase in chromium fed to the HLW melter, limiting glass loading in 10 percent of all IHLW glass. The IHLW glass drivers are shown in Figure 5-50 and compared to Scenario 1B in Table 5-25.

Figure 5-50. Scenario 3 – Immobilized High-Level Waste Glass Drivers.

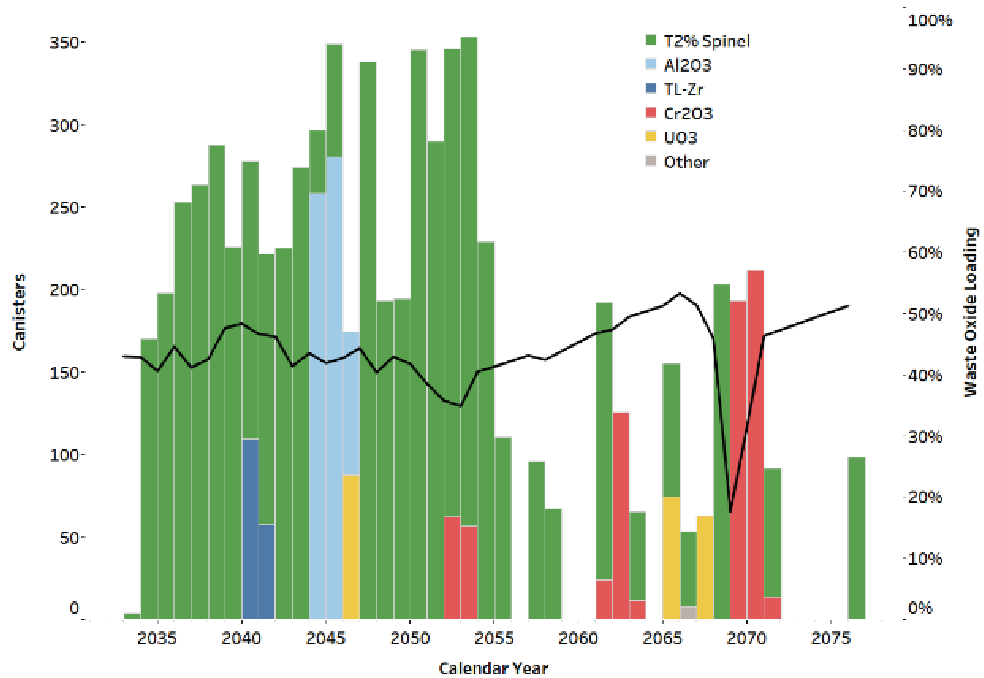


Table 5-25. Scenario 3 Comparison – Immobilized High-Level Waste Glass Drivers.

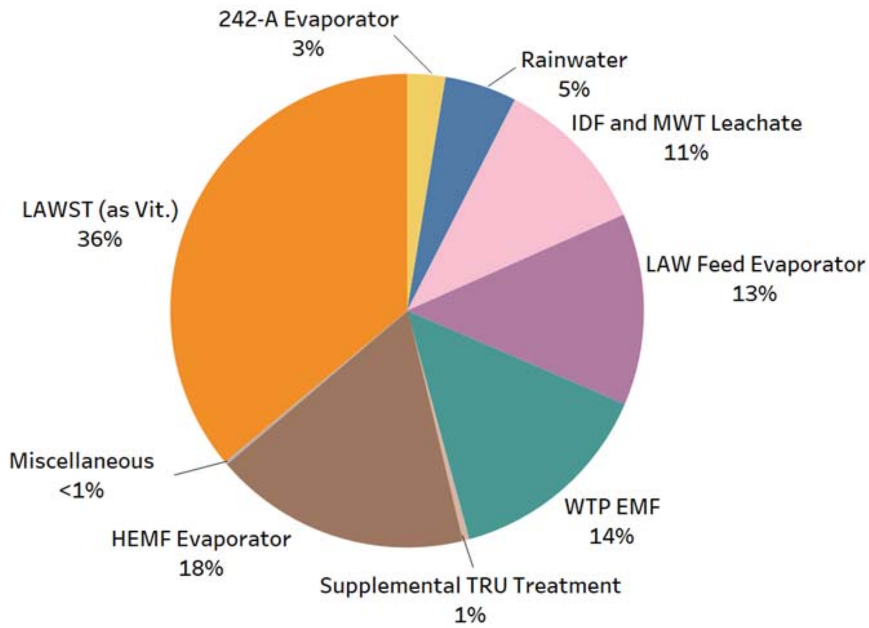
Key Glass Drivers and Waste Loadings	Scenario 1B	Scenario 3	
Glass Drivers	T2% Spinel	73%	76%
	Al_2O_3	11%	9%
	TL-Zr	8%	2%
	UO_3	4%	3%
	Cr_2O_3	0%	10%
	Other	~4%	0%
Average WOL	45%	42%	

WOL = waste oxide loading.

5.3.3.3.4 Secondary Liquid Effluent Treatment

The total secondary liquid effluent volume by source for Scenario 3 is shown in Figure 5-51 and compared to Scenario 1B in Table 5-26. Compared to Scenario 1B, the total volume of liquid effluent sent to LERF to be processed in the ETF increased by 215 Mgal. The HFPF uses raw water for washing instead of using recycled liquid effluent as in the WTP Pretreatment Facility causing increased water additions for solids washing. The longer distances between pretreatment and treatment facilities in this scenario also increase the effluent volume produced as more fluids are necessary to flush the longer pipes. This water added for solids washing and for flushes is evaporated in the HEMF evaporator and sent to LERF. The effluent produced by the LAWST capability is 320 Mgal, nearly double the amount produced in Scenario 1B. This is indicative of the increased reliance on the LAWST capability. Extending DFLAW processing for the full mission also increases the fraction of the effluent sourced from the WTP EMF.

Figure 5-51. Scenario 3 – Feed Sources to the Liquid Effluent Retention Facility.



Acronyms:

DFLAW	=	direct-feed low-activity waste.
EMF	=	Effluent Management Facility.
HEMF	=	High-Level Waste Effluent Management Facility.
IDF	=	Integrated Disposal Facility.
LAWST	=	low-activity waste supplemental treatment.
MWT	=	mixed waste trench.
TRU	=	transuranic.
Vit.	=	vitrification.
WTP	=	Waste Treatment and Immobilization Plant.

Table 5-26. Scenario 3 Comparison – Secondary Liquid Effluent Sources.

Secondary Liquid Effluent Source	Scenario 1B (% Total)	Scenario 3 (% Total)
LAWST (Evaporator and Caustic Scrubber)	168 Mgal (25%)	320 Mgal (36%)
WTP Pretreatment Facility Evaporators (and LAW Caustic Scrubber)	218 Mgal (32%)	N/A
HEMF Evaporator	N/A	155 Mgal (18%)
WTP EMF (and DFLAW Caustic Scrubber)	36 Mgal (5%)	127 Mgal (14%)
LAW Feed Evaporator	N/A	117 Mgal (13%)
IDF and MWT Leachate	96 Mgal (14%)	96 Mgal (11%)
Rainwater	44 Mgal (7%)	44 Mgal (5%)
242-A Evaporator	105 Mgal (16%)	23 Mgal (3%)
Potential CH-TRU Dryers	4 Mgal (1%)	4 Mgal (1%)
Miscellaneous	2 Mgal (<1%)	2 Mgal (<1%)
Total	**673 Mgal**	**888 Mgal**

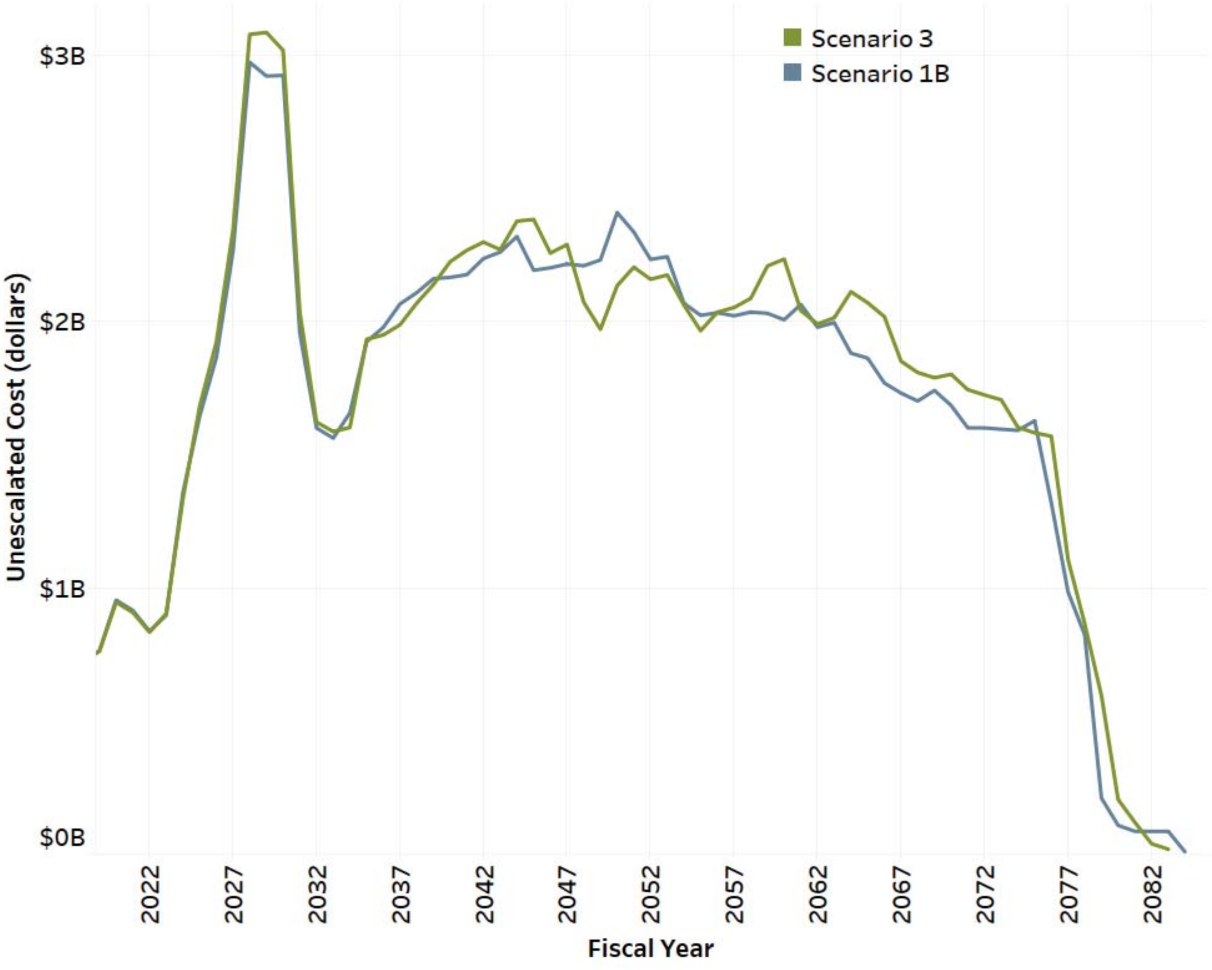
CH-TRU	=	contact-handled transuranic.
DFLAW	=	direct-feed low-activity waste.
EMF	=	Effluent Management Facility.
HEMF	=	High-Level Waste Effluent Management Facility.
IDF	=	Integrated Disposal Facility.
LAW	=	low-activity waste.
LAWST	=	low-activity waste supplemental treatment.
MWT	=	mixed-waste trench.
N/A	=	not applicable.
WTP	=	Waste Treatment and Immobilization Plant.

5.3.3.4 Life-Cycle Cost Results

Figure 5-52 presents a comparison of Scenarios 3's annual unescalated life-cycle cost profile to Scenario 1B. The cumulative life-cycle cost is $125 billion ($255 billion escalated), roughly the same as the $122 billion ($247 billion escalated) for Scenario 1B. The projected mission schedule for Scenario 3 also requires a sharp increase in funding above historical levels for capital expenses for the LAWST capability and the other new facilities supporting waste treatment (e.g., the HFPF).

Although Scenario 3 added the new HFPF and LAW Feed Evaporator, as well as the expanded TFPT capacity, these costs are offset in the life-cycle profile by not constructing and operating the TWCS capability or operating the WTP Pretreatment Facility. The combined capital cost for the HFPF and LAW Feed Evaporator is $1.64 billion versus $1.04 billion for the TWCS capability.

Figure 5-52. Scenario 3 Comparison – Unescalated Life-Cycle Cost Profile.



5.3.4 Risks

For Scenario 3, a few new risks are introduced, and a number of Baseline Case risks (Section 7.1) are significantly reduced, while others are enhanced. These risks are the same as those listed for Scenario 2 (Section 5.2.4). However, Scenario 3 offers one significant risk reduction over Scenario 2—sampling the HLW feed in the HLW feed preparation tanks within the HFPF reduces the usage of DSTs. Limiting the use of aging DSTs reduces the risk of DST failures.

5.3.5 Opportunities

The opportunities for Scenario 3 are the same as those for Scenario 2 (Section 5.2.5). However, in Scenario 3 there is an additional opportunity to reduce the caustic leaching in the HFPF to a level similar to that in Scenario 2. Because the Scenario 3 mission duration is driven by LAW treatment, adding less caustic for leaching could reduce the mission duration by 5 years or more, but this comes at the expense of a significant increase in IHLW canister production.

5.3.6 Scenario 3A – Scenario 3 Sensitivity – Add New Double-Shell Tanks

5.3.6.1 Objective and Planning Bases

The objective of Scenario 3A is to complete SST retrievals by the projected SST retrieval completion date of 2061 achieved in the Baseline Case by adding new DSTs as needed to achieve this goal. Scenario 3A is based on Scenario 3, and all assumptions for the Scenario 3 carry over. However, new DSTs are added in increments of four to the 200 East and/or 200 West Areas. During modeling, a varying number of DSTs were added to the 200 East and 200 West Areas to determine the fewest number of new DSTs necessary to meet the scenario's objective. Additional assumptions for the new DSTs include the following:

- All DSTs are added simultaneously on December 31, 2030.
- The maximum operating capacity of each additional DST is 1.25 Mgal.
- All new DSTs are equipped with a transfer pump and two mixer pumps.

5.3.6.2 Key Results and Analysis

The mission metrics for Scenario 3A are compared to Scenario 3 in Table 5-27. A total of 12 additional DSTs is required, eight in the 200 East Area and four in the 200 West Area. Single-shell tank retrievals complete approximately the same time as the Baseline Case (within the range of uncertainty) with the additional DST space mitigating SST retrieval delays observed in Scenario 3. Scenario 3A completes SST retrievals in 2059, 7 years earlier than Scenario 3; however, LAW treatment still drives the mission duration, and the product quantities and completion date for tank waste treatment are within the estimated random variability of the Scenario 3 results.

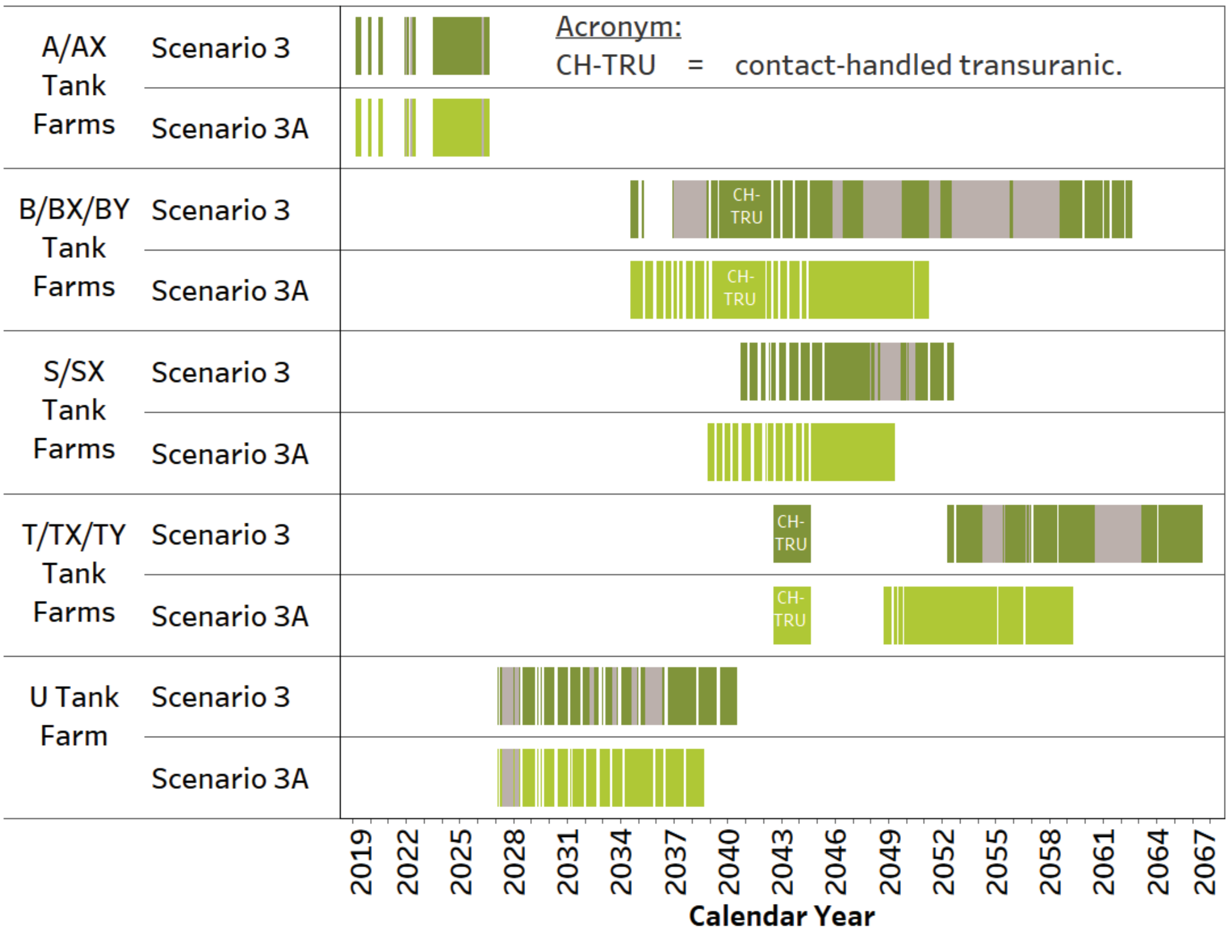
Table 5-27. Scenario 3A Comparison – Key Metrics.

Metric	Scenario 3	Scenario 3A
SST Retrievals Complete	2066	2059
DST Retrievals Complete	2076	2074
Tank Waste Treatment Complete	2076	2074
IHLW Glass Canisters	7,200	7,400
Total ILAW Glass Containers	101,000	101,000
WTP ILAW Glass Containers (% Total)	28,000 (28%)	32,000 (31%)
LAWST ILAW Glass Containers (% Total)	72,000 (72%)	69,000 (69%)
LAWST Glass Volume, yd^3	202,000	193,000
LAWST Equivalent Grout Volume, yd^3	910,000	830,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	12,000	12,000

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

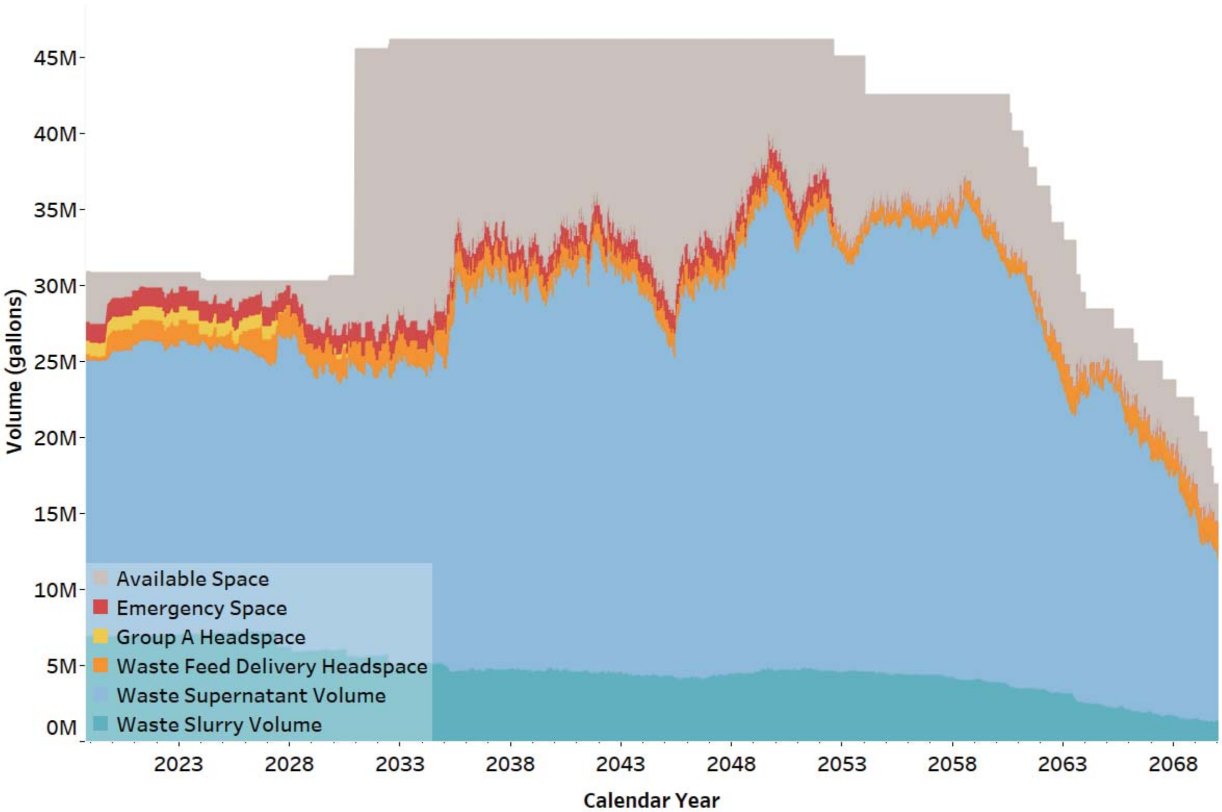
The sequencing and timing of SST retrievals in Scenario 3A as compared to Scenario 3 are presented in Figure 5-53 and show that the overall retrieval delays throughout the mission are nearly eliminated. The sole exception occurs in 2027 when retrievals are delayed in U Tank Farm to perform necessary Group A mitigation of Tanks AN-104 and SY-103 prior to operating the cross-site transfer lines. The additional 15 Mgal of DST space in Scenario 3A is sufficient to support two simultaneous SST retrievals per area starting in 2045 after which no retrieval delays are noted.

Figure 5-53. Scenario 3A Comparison – Single-Shell Tank Retrieval Schedule.



The DST space utilization plot presented in Figure 5-54 shows that the amount of available DST space is large for the duration of the mission. However, there is a decrease in available space beginning in 2047 as a result of doubling the number of simultaneous retrievals per area (from one to two) starting in 2045. The available DST space appears to be above that necessary to meet the objective of this scenario; however, the new DSTs are continually filled and emptied. Therefore, the abundance of available DST space is in appearance only. In order to significantly expedite retrievals, sufficient DST capacity is necessary to accommodate localized surges in DST space demand—at times in the mission, additional capacity is required in the 200 East Area, and at other times, in the 200 West Area. This, coupled with adding four new DSTs at a time (a total of 5 Mgal of space), leads to the appearance of excess DST space.

Figure 5-54. Scenario 3A – Double-Shell Tank Space Utilization.



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5.4 SCENARIO 4 – RETRIEVAL-FAVORED DIRECT-FEED LOW-ACTIVITY WASTE AND DIRECT-FEED HIGH-LEVEL WASTE WITH EARLY CHARACTERIZATION IN DOUBLE-SHELL TANKS AND ADD NEW DOUBLE-SHELL TANKS

5.4.1 Objective and Planning Bases

Scenario 4 evaluates the option of maintaining the SST retrieval schedule for the Baseline Case using the Scenario 2 flowsheet and adding new DSTs, as needed for this scenario. Scenario 4 builds on Scenario 2 and includes one sensitivity case, Scenario 4A – Increased WTP TOE, detailed in Section 5.4.4.

The only additional change to the Model Starting Assumptions (Appendix A) from Scenario 2 is that new DSTs are added starting December 31, 2030, as needed, in order to meet the Baseline Case SST retrieval completion year of 2061. The new DSTs are added in multiples of four to the 200 East and/or the 200 West Area and are each assumed to have an operating volume of 1.25 Mgal and be equipped with two mixer pumps.

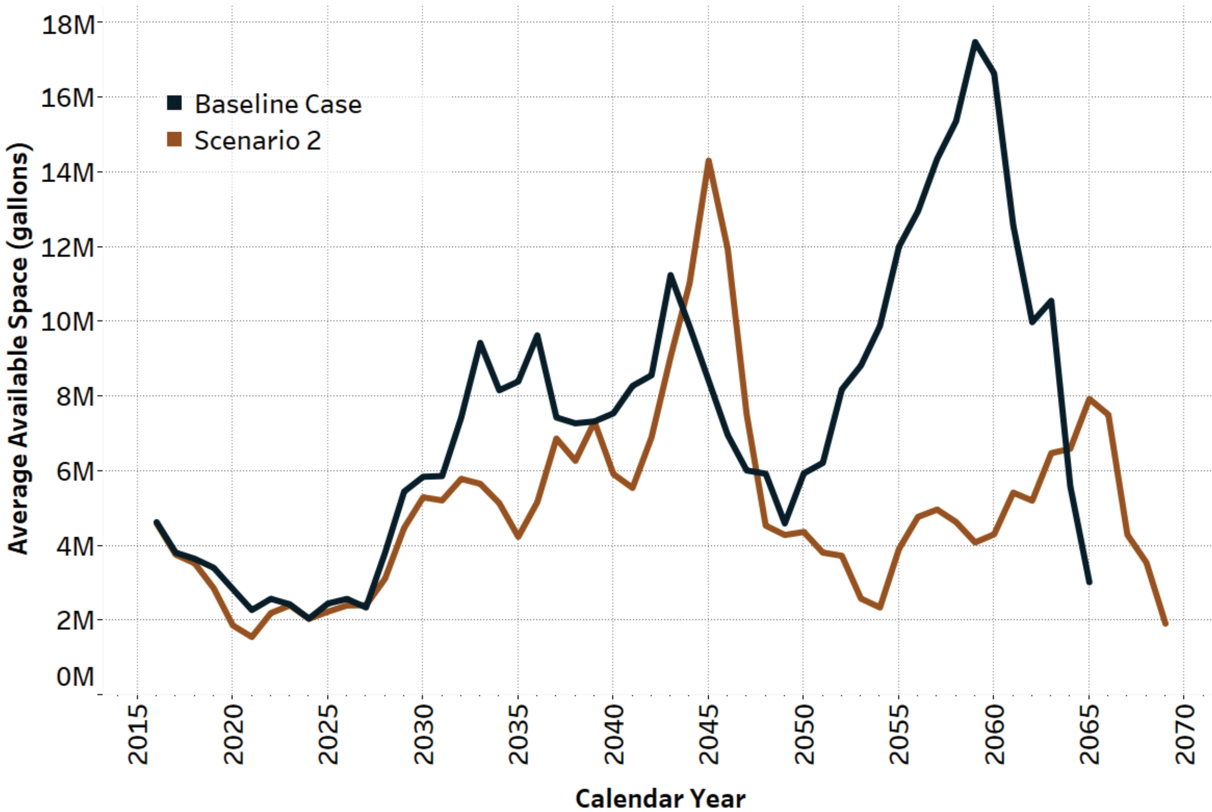
5.4.2 Analysis

When the modeling assumptions were established, it was expected that the Scenario 2 SST retrieval schedule would fail to achieve that of the Baseline Case. Scenario 4 was created to establish the location and number of new DSTs that would be needed. However, Scenario 2 modeling completes all SST retrievals on approximately the same date as the Baseline Case. Therefore, Scenario 4 is no longer needed.

The Baseline Case modeling projects an SST retrieval completion date in 2061 (Section 5.1.2), and Scenario 2 completes SST retrievals in 2060 without the addition of new DSTs (Section 5.2.3). The intention of adding new DSTs in Scenario 4 is to eliminate downtime barriers to SST retrievals caused by a lack of available DST space and to match the projected SST retrieval completion schedule of 2061 in the Baseline Case. Based on the 2060 SST retrieval completion year in Scenario 2, which uses the same flowsheet and modeling assumptions as Scenario 4, it is concluded that the Scenario 4 objective is accomplished without the need for new DSTs.

A comparative examination of available DST space between the Baseline Case and Scenario 2 is presented in Figure 5-55. As compared to the Baseline Case, the Scenario 2 profile shows the DSTs maintain adequate space as the SST retrievals progress to completion in 2060. The Scenario 2 profile indicates reduced space from approximately 2048 to 2054 compared to the Baseline Case modeled with the same assumption bases. This is caused by the simultaneous number of SST retrievals increasing from one to two per area after 2045. However, the space reduction does not adversely affect the overall SST retrieval rate.

Figure 5-55. Scenario 4 Comparison – Double-Shell Tank Available Space.



5.4.3 Risks and Opportunities

Because Scenario 2 meets the SST retrieval completion schedule projected for the Baseline Case, and, therefore, satisfies the Scenario 4 objectives, the risks and opportunities would be the same as Scenario 2. (See Section 5.2.4 and Section 5.2.5.)

5.4.4 Scenario 4A – Scenario 4 Sensitivity – Increased Waste Treatment and Immobilization Plant Total Operating Efficiency

5.4.4.1 Objective and Planning Bases

The Scenario 4A sensitivity case evaluates the necessary increase to the full-mission treatment TOE from 50 percent in order to finish treatment 7 years after the completion of SST retrievals. The significance of 7 years is that it is the duration between the milestones for completion of SST retrievals and completion of treatment in the current TPA. The modeling effort for Scenario 4A is built from Scenario 2 because Scenario 4 was not modeled, as discussed in Section 5.4.2. Table 5-28 identifies the Scenario 4 assumptions for Scenario 4A.

Table 5-28. Scenario 4A – Assumptions Altered from Scenario 4.

Starting Assumption #	Scenario 4A Assumption
A1.3.1.3	Increase full-mission WTP HLW Vitrification Facility average efficiency from 50 to 54% TOE to finish treatment 7 years after SST retrieval completion.
A1.3.1.3, A1.3.4.4	Increase full-mission WTP LAW Vitrification Facility average efficiency from 50 to 54% TOE to finish treatment 7 years after SST retrieval completion.
A1.3.1.3	Increase LAWST average efficiency from 50 to 54% TOE to finish treatment 7 years after SST retrieval completion.

HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TOE = total operating efficiency.
WTP = Waste Treatment and Immobilization Plant.

5.4.4.2 Key Results and Analysis

The treatment mission completes 9 years after the completion of SST retrievals in Scenario 2. Scenario 4A modeling projects an SST retrieval completion by 2060. A TOE of 54 percent for the WTP vitrification facilities and the LAWST capability is required to complete the treatment mission in Scenario 4A in 2067, 7 years after completion of SST retrievals. As compared to Scenario 2, an additional 4 percent increase in TOE is required. Scenario 4A requires a TFPT throughput design of 25 gpm to support pretreating supernatant at a rate matching the combined capacity of the WTP LAW Vitrification Facility and LAWST capability at 54 percent TOE, equivalent to five TSCR units operating in parallel. The mission metrics for Scenario 4A are compared to Scenario 2 in Table 5-29.

Table 5-29. Scenario 4A Comparison – Key Metrics. (2 pages)

Metric	Scenario 2	Scenario 4A
SST Retrievals Complete	2060	2060
DST Retrievals Complete	2069	2067
Tank Waste Treatment Complete	2069	2067
IHLW Glass Canisters	9,100	9,000
Total ILAW Glass Containers	91,000	91,000
WTP ILAW Glass Containers (% Total)	29,000 (32%)	30,000 (33%)
LAWST ILAW Glass Containers (% Total)	62,000 (68%)	61,000 (67%)

Table 5-29. Scenario 4A Comparison – Key Metrics. (2 pages)

Metric	Scenario 2	Scenario 4A
LAWST Glass Volume, yd^3	174,000	170,000
LAWST Equivalent Grout Volume, yd^3	690,000	690,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,800	11,800

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

5.5 SCENARIO 5 – PERIODIC DOUBLE-SHELL TANK FAILURES

5.5.1 Objective and Planning Bases

The objective of Scenario 5 is to analyze the effect of a sequence of DST failures on the RPP mission. Scenario 5 builds on Scenario 1B and evaluates the life-cycle consequences associated with the mitigation of a sequence of five DST failures occurring once every 5 years from 2025 to 2045. The sequence of failed DSTs was selected by Ecology based on the tanks identified to have the highest risk in previous tank integrity reports. This scenario assumes the quickest feasible timeline for retrieving the failed DSTs in order to assess a worst-case effect on DST space, and, therefore, SST retrievals and waste feed delivery. Table 5-30 identifies the starting assumptions that were modified from Scenario 1B for Scenario 5.

Table 5-30. Scenario 5 – Assumptions Altered from Scenario 1B.

Starting Assumption #	Scenario 5 Assumption
A1.2.2.1	Starting in 2025, and every 5 years thereafter, a DST shall be declared leaking (in the following order): 1. AY-101 (2025) 2. AZ-101 (2030) 3. AZ-102 (2035) 4. AN-107 (2040) 5. AW-105 (2045).
N/A	When a DST is declared leaking, pumping shall begin within 120 days. For this to be feasible, the required equipment to retrieve the DSTs (transfer pump if not already installed, annulus pump, sluicers, etc.) must be procured and fabricated in advance of the DST being declared a leaker. 1. Following the leak declaration, the tank is retrieved as per the baseline assumptions for the fieldwork associated with a DST retrieval (typically performed at the end of the mission). 2. Retrieve the bulk waste to the extent possible with the equipment already installed in the DST. 3. Install retrieval equipment in the DST (e.g., sluicers)—30 days. 4. Retrieve the waste heel from the DST (operate sluicers)—128 days as per Assumption A1.1.1.5. 5. Perform a final, triple rinse of the DST using water.
N/A	In addition to allowing use of the allotted emergency pumping space for retrieving the leaking DST, preference shall be given to mitigate leaking tanks over maintaining SST retrievals and feed to the treatment facilities.
N/A	Once a leaking DST is mitigated, it shall be removed from service for the balance of the mission.

DST = double-shell tank. SST = single-shell tank.

5.5.2 Flowsheet Description

The flowsheet for this scenario is the same as Scenarios 1 and 1B (Section 5.1). As in Scenario 1B, a WTP TOE of 50 percent is utilized for this scenario.

5.5.3 Analysis

5.5.3.1 Key Results and Metrics

The Scenario 5 results show that removing an additional five DSTs from service prior to 2045 does not significantly affect the overall mission metrics with the exception of a 3-year delay in the completion of all SST retrievals. However, it did cause the "next nine" SST retrievals to slip 9 months, missing the milestone date in the Third Amended Consent Decree. The retrieval of the five additional failed DSTs earlier in the mission means five fewer DSTs need to be retrieved after SST retrievals complete, offsetting the effect of the delay to SST retrievals. Therefore, the completion of tank waste treatment was not delayed.

Scenario 5 also demonstrates it is possible, from a tank space management perspective, to retrieve leaking DSTs at various points in the mission in approximately 1 year or less while still maintaining the required emergency pumping space. Waste feed delivery to the various treatment facilities is also unaffected. The mission metrics for Scenario 5 are compared to Scenario 1B in Table 5-31.

Table 5-31. Scenario 5 Comparison – Key Metrics.

Metric	Scenario 1B	Scenario 5
SST Retrievals Complete	2065	2068
DST Retrievals Complete	2075	2074
Tank Waste Treatment Complete	2076	2075
IHLW Glass Canisters	7,000	7,100
Total ILAW Glass Containers	88,000	88,000
WTP ILAW Glass Containers (% Total)	49,000 (56%)	49,000 (55%)
LAWST ILAW Glass Containers (% Total)	39,000 (44%)	29,000 (45%)
LAWST Glass Volume, yd^3	109,000	109,000
LAWST Equivalent Grout Volume, yd^3	430,000	440,000
Potential CH-TRU Tank Waste Drums	8,800	8,800
ETF Solids Drums	11,000	11,000
Unescalated (Escalated) Life-Cycle Cost	$122B ($247B)	$122B ($247B)

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
ETF = Effluent Treatment Facility.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
WTP = Waste Treatment and Immobilization Plant.

5.5.3.2 Mission Schedule Results

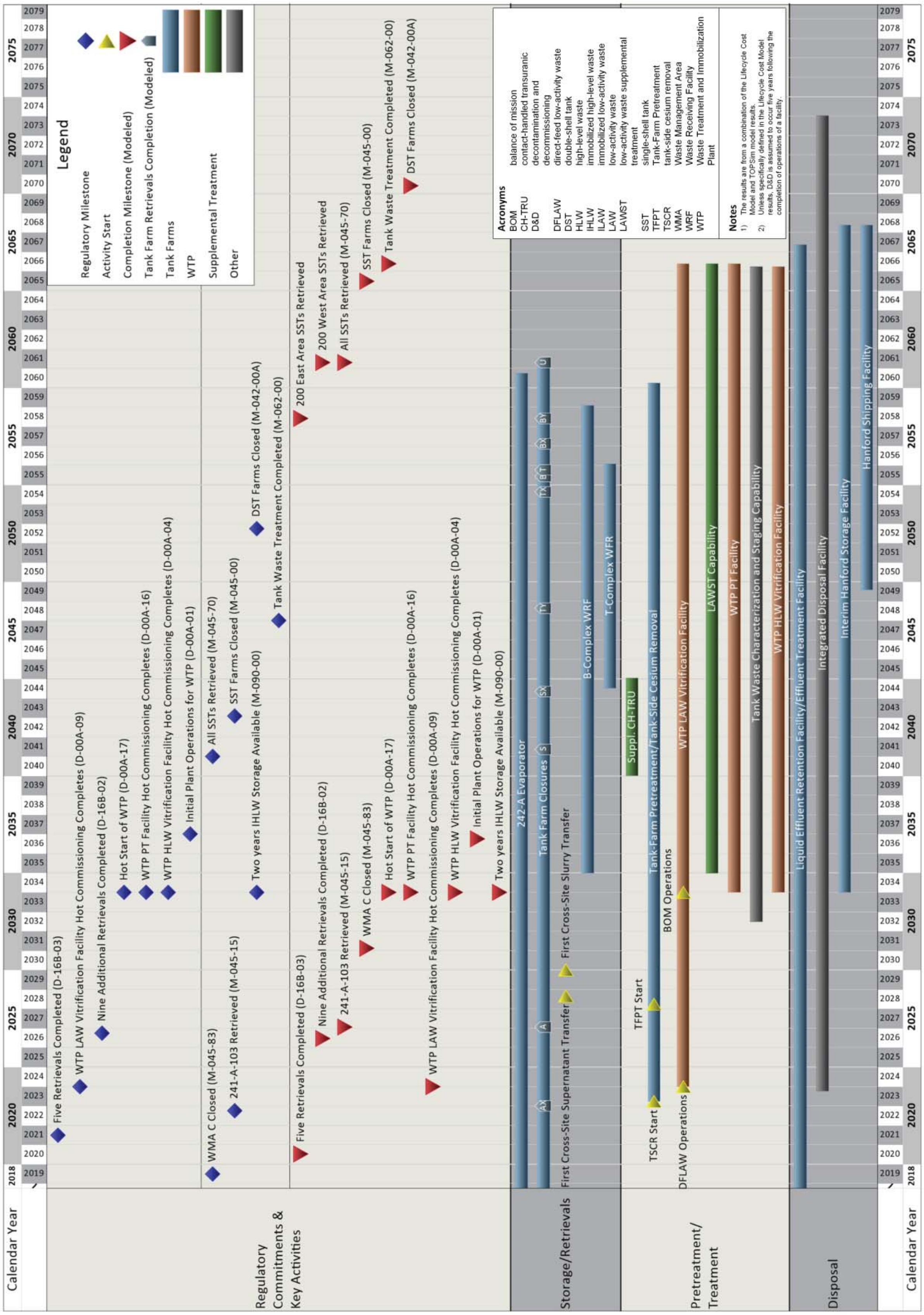
The mission schedule for Scenario 5, compared with Scenario 1B, is presented in Table 5-32, and the key schedule results are depicted in Figure 5-56.

Table 5-32. Scenario 5 – Summary of Schedule Results.

	Key Mission Metric	Scenario 1B	Scenario 5
Near-Term Regulatory	Complete Five Additional SST Retrievals (Existing Consent Decree 06/30/2021)	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Existing Consent Decree 09/30/2026)	06/2026	03/2027
	Complete Tank 241-A-103 Retrieval (Existing TPA 09/30/2022)	04/2027	11/2027
Storage/Retrieval	242-A Evaporator Operations	Present – 2066	Present – 2069
	200 East Area WRF Operations	2034 – 2065	2034 – 2069
	200 West Area WRF Operations	2049 – 2062	2052 – 2065
	200 East Area SST Retrievals Complete	2065	2068
	200 West Area SST Retrievals Complete	2062	2065
	Cross-Site Transfer Line Activated (Supernatant)	2028	2030
	Cross-Site Transfer Line Activated (Slurry)	2030	2030
Pretreatment/Treatment	TSCR/TFPT Operations	2023 – 2063	2023 – 2068
	TWCS Capability Operations	2032 – 2076	2032 – 2075
	WTP Pretreatment Facility Operations	2033 – 2076	2033 – 2075
	WTP LAW Vitrification Facility Operations	2023 – 2076	2023 – 2075
	WTP HLW Vitrification Facility Operations	2033 – 2076	2033 – 2075
	LAWST Capability Operations	2034 – 2076	2034 – 2075
	Potential CH-TRU Waste Treatment Facility Operations	2040 – 2045	2040 – 2045
	LERF/ETF Operations	Present – 2077	Present – 2076
	Tank Waste Treatment Complete	2076	2075
Disposal	IDF Operations	2023 – 2083	2023 – 2084
	IHS Facility Operations	2033 – 2078	2033 – 2077
	HSF Offsite Shipping Operations	2056 – 2078	2055 – 2077
	All IHLW Shipped Offsite	2078	2077

CH-TRU = contact-handled transuranic.
ETF = Effluent Treatment Facility.
HLW = high-level waste.
HSF = Hanford Shipping Facility.
IDF = Integrated Disposal Facility.
IHLW = immobilized high-level waste.
IHS = Interim Hanford Storage.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
LERF = Liquid Effluent Retention Facility.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TPA = Tri-Party Agreement.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WRF = Waste Receiving Facility.
WTP = Waste Treatment and Immobilization Plant.

Figure 5-56. Scenario 5 – Modeled Operating Schedule of Key Facilities/Processes.

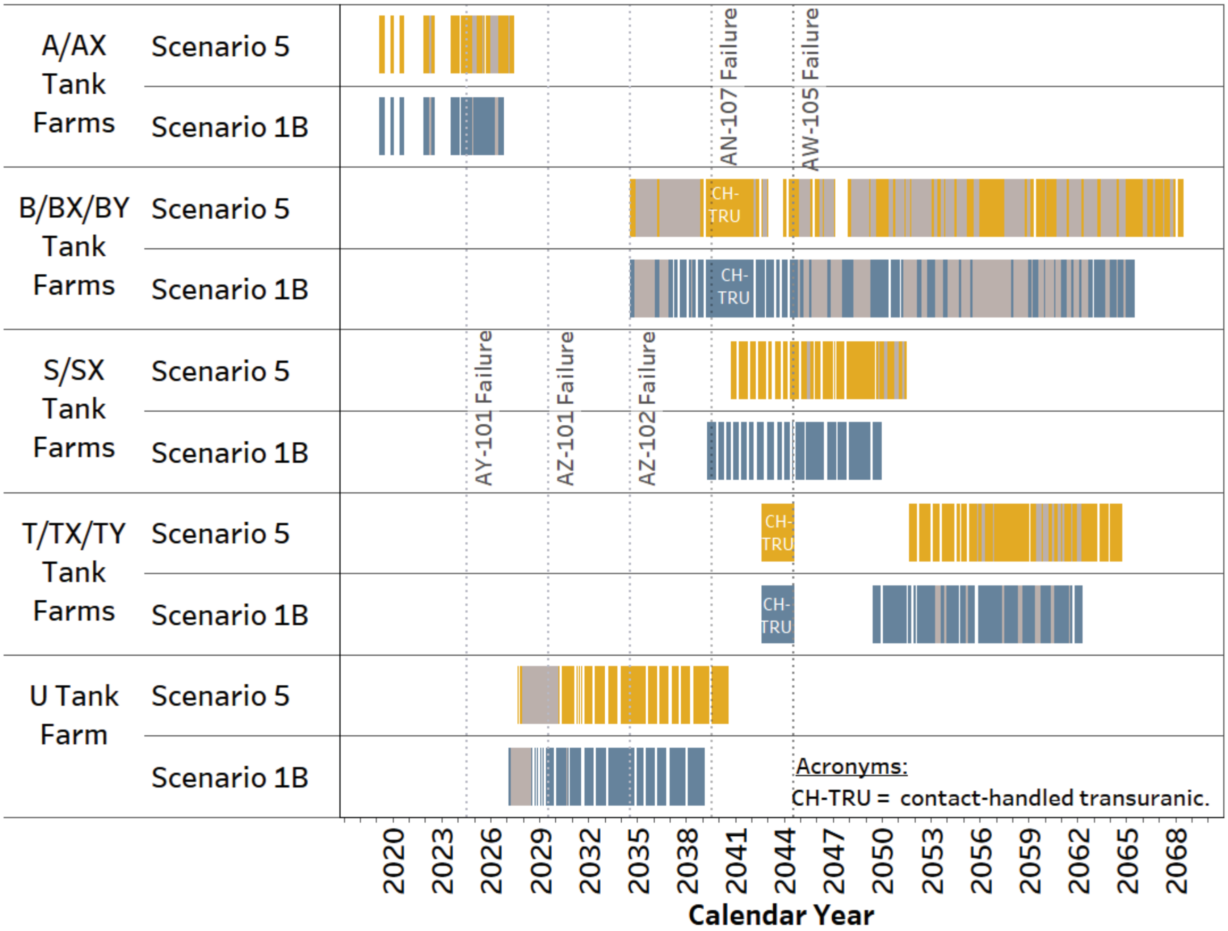


5.5.3.3 Mission Flowsheet Results

Figure 5-57 shows SST retrieval progress by farm groups for Scenario 5 with a direct comparison to Scenario 1B. The dark colored bands indicate ongoing retrieval activity, the white spaces between the bars are the assumed setup time between retrievals, and the grey bands indicate delays in the SST retrieval durations (i.e., the difference in the actual retrieval duration and the assumed retrieval duration) due to available DST space.

Following the retrieval and mitigation of Tank AY-101 in 2025, there is a 7-month delay in retrievals in A Tank Farm due to the reduced space in the DST system. This delay causes Scenario 5 to fail to meet Milestone B-2 of the Third Amended Consent Decree (retrieve nine SSTs in A/AX Tank Farms by September 30, 2026), which completed March 31, 2027. The identified leak and mitigation of Tank AZ-101 in 2030 caused a 1-year delay to retrievals in the U Tank Farm. The identified leak and mitigation of Tank AZ-102 in 2035 also caused a 1-year delay to retrievals in B Tank Farm. These delays resulted in a cumulative 3-year slip in the completion of SST retrievals.

Figure 5-57. Scenario 5 Comparison – Single-Shell Tank Retrieval Schedule.



Available DST space is limited early in the mission as a direct result of the leaking DST mitigations. As the mission progresses, DST space becomes less constrained as the WTP and the LAWST capability become operational. However, as shown in Figure 5-58, leaking DST mitigations were completed without utilization of emergency space. Although the emergency space was available to retrieve the leaking DSTs if needed, there was sufficient space available in the DST system so that mitigations were able to complete without impinging on the emergency space. Ultimately, all the DSTs are retrieved by 2074, 1 year earlier than Scenario 1B.

Figure 5-58. Scenario 5 – Double-Shell Tank Space Utilization.

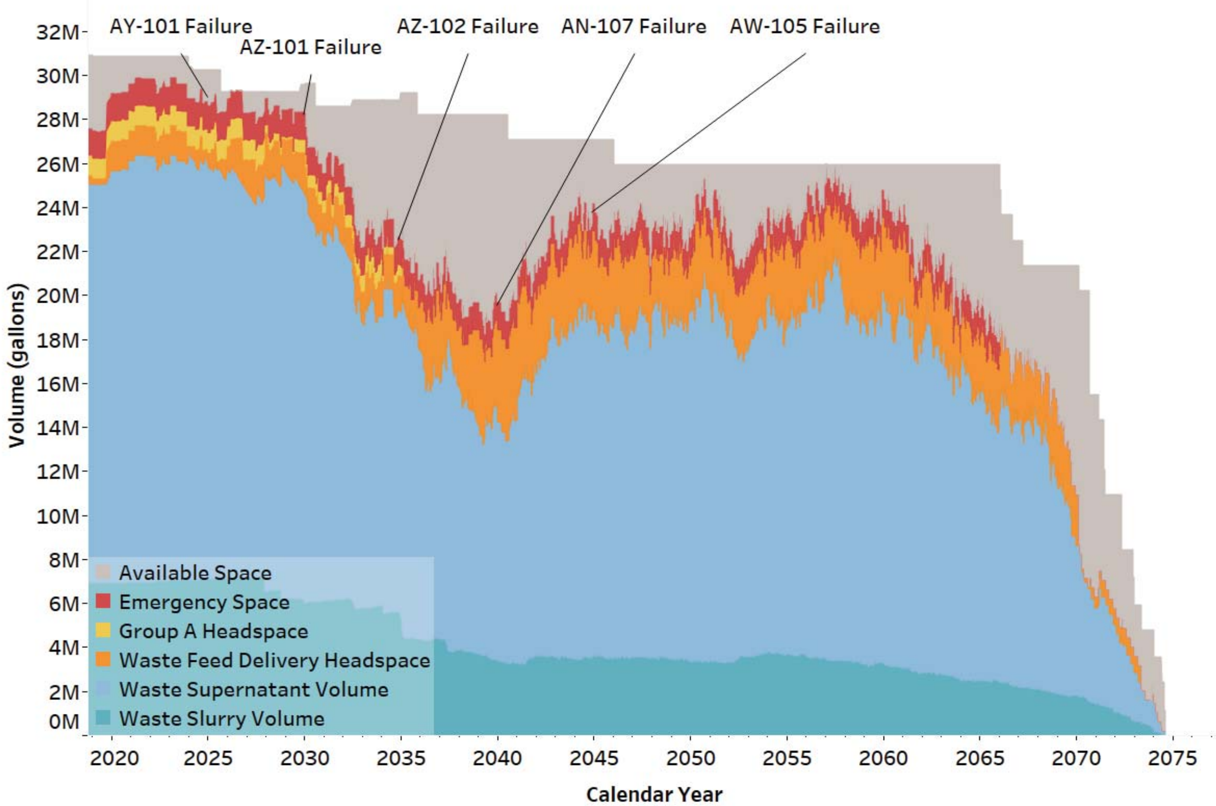
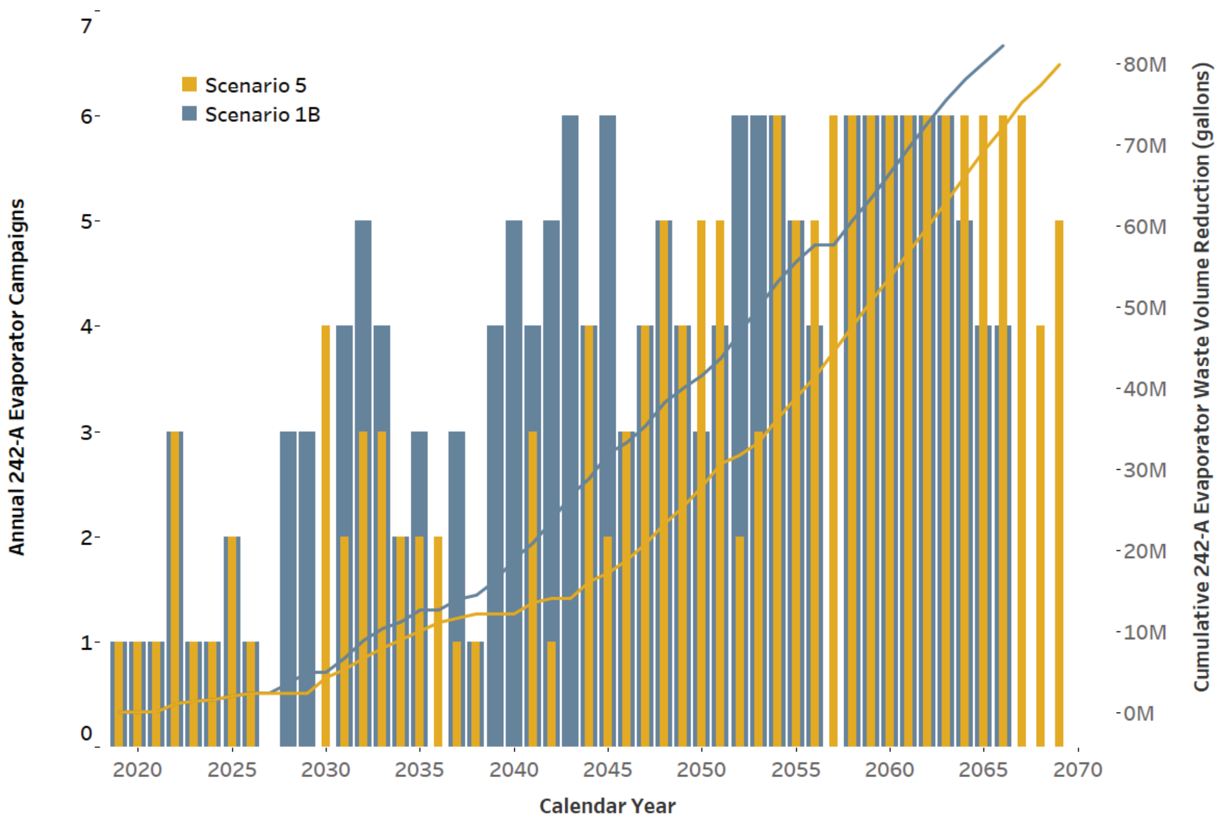


Figure 5-59 depicts the utilization of the 242-A Evaporator. Retrieving the leaking DSTs reduces the available DST space, postponing SST retrievals and resulting in a delayed demand for the 242-A Evaporator.

Figure 5-59. Scenario 5 Comparison – 242-A Evaporator Utilization.

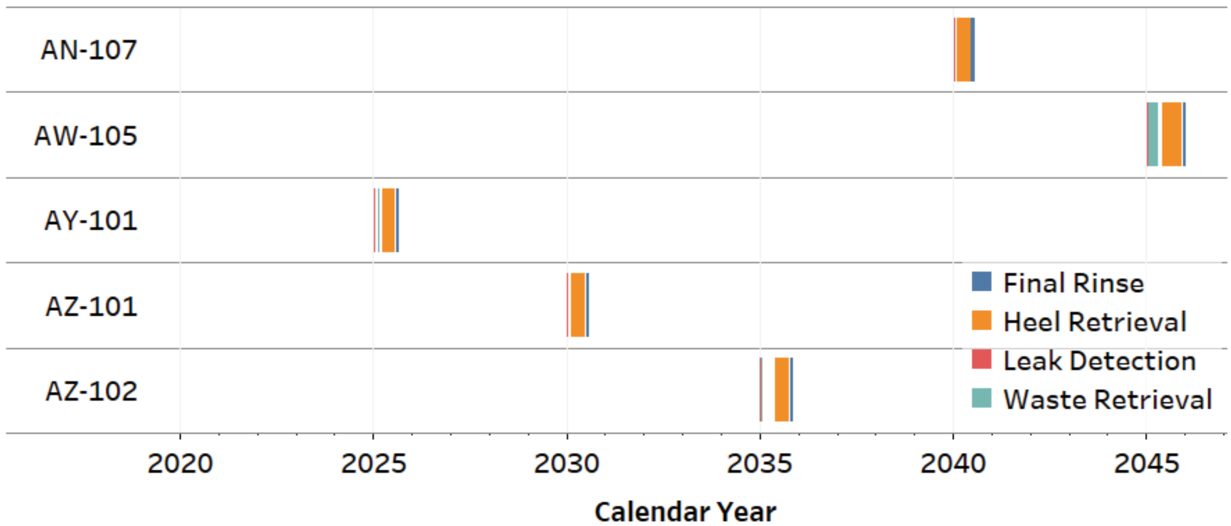


5.5.3.3.1 Double-Shell Tank Leak Mitigations

All leaking DSTs are retrieved and removed from service in approximately 1 year or less after leak detection without affecting throughput to treatment facilities and without utilizing DST emergency space. However, for several of the leak mitigations, the limited amount of DST space delays SST retrievals. For example, Milestone B-2 in the Third Amended Consent Decree was not met after mitigating the leak in Tank AY-101.

Figure 5-60 depicts the DST mitigation timeline for each leaking DST and the colors in each band correspond to a key step in the mitigation strategy: leak detection (red), waste retrieval (green), heel retrieval (orange), and final rinse (blue). As Tank AY-101 starts to leak in 2025 and subsequent DSTs fail in 5-year increments until 2045, DST space demand is at a premium early in the mission during DFLAW operations and DST space restrictions become less constrained once the integrated WTP and the LAWST capability begin operating.

Figure 5-60. Scenario 5 – Overall Timeline for Retrieval of Leaking Double-Shell Tanks.



5.5.3.3.1.1 Tank AY-101 Leak Mitigation

When Tank AY-101 is declared a leaker in 2025, retrievals in A Tank Farm are ongoing and DFLAW has been operating for approximately a year. Additionally, there is approximately 2 Mgal of available DST space as SSTs in A Tank Farm are being retrieved and feed is being prepared and delivered to the TSCR system during DFLAW operations.

The mitigation strategy is initiated immediately after leak detection so that the pumping of waste out of the tank occurs within 120 days of leak detection. The first step in retrieving the waste from Tank AY-101 involves transferring supernatant into Tank AZ-102, which is completed within a month of leak detection. In order to initiate the supernatant transfer, retrievals in A Tank Farm are delayed by approximately 7 months, and, as a result, fail to meet Milestone B-2 in the Third Amended Consent Decree. After the supernatant is retrieved, the remaining solids from Tank AY-101 are retrieved into Tank AZ-102, which requires approximately 4 months. Before removing the leaking tank from service, a triple water rinse is performed within a month after heel retrieval. Overall, approximately 9 months are required to mitigate and remove Tank AY-101 from service.

5.5.3.3.1.2 Tank AZ-101 Leak Mitigation

When Tank AZ-101 is declared a leaker in 2030, there is approximately 2 Mgal of available DST space. Additionally, the integrated WTP facilities and LAWST have not yet started operating. To mitigate Tank AZ-101 after the leak is detected, the supernatant and solids in the tank are transferred to DSTs containing sludge designated as future feed for the TWCS capability.

The supernatant's cesium-137 concentration is four times greater than the TSCR shielding design source term complicating leak mitigation (RPP-SPEC-61910, *Specification for the Tank-Side Cesium Removal Demonstration Project [Project TD101]*). Mixing the waste with potential DFLAW feed must be avoided when selecting receiver tanks. Additionally, the restriction in available DST space during this period results in SST retrievals in U Tank Farm being delayed by approximately a year. The retrieval delay provides adequate space in the DSTs so that waste is retrieved from Tank AZ-101 to DSTs for future delivery to TWCS-compatible tanks. The mitigation and removal from service of Tank AZ-101 required approximately 8 months to complete.

5.5.3.3.1.3 Tank AZ-102 Leak Mitigation

When Tank AZ-102 is declared a leaker in 2035, the integrated WTP and the LAWST capability have recently started operating, which increases the available DST space to approximately 7 Mgal. However, the solids in Tank AZ-102 must be retrieved to DSTs that have mixer pumps capable of delivering the slurry from Tank AZ-102 to the TWCS capability so that future feed delivery to the TWCS capability is not affected. Once the preferred DSTs are available as waste transfer destinations, removing the waste down to the heel completed in approximately 4 months. Overall, Tank AZ-102 requires approximately 1 year to mitigate and remove from service.

5.5.3.3.1.4 Tank AN-107 Leak Mitigation

When Tank AN-107 is declared a leaker in 2040, the tank is relatively empty. Immediately after being declared a leaker, sluicers are installed to retrieve the remaining heel. After installation, the contents are quickly retrieved as there is nearly 10 Mgal of space available in the DST system (from waste treatment at the WTP and the LAWST capability).

A potential concern with mitigating a leak in Tank AN-107 is the "complexed concentrate" supernatant in the tank. Complexed concentrate is so named because it contains high concentrations of radioactive strontium and transuranic isotopes that have been solubilized (or complexed) by organic chemicals found in this waste. Prior to mixing the complexed concentrate with other waste, the strontium and transuranic isotopes are precipitated from the supernatant via chemical additions in order to meet WTP's ICD-19 WAC (24590-WTP-ICD-MG-01-019). This could potentially pose a significant obstacle to retrieving Tank AN-107 if it developed a leak. Fortunately, in this scenario's timeline, this complication is avoided as the complexed concentrate is mitigated in 2037 in order to generate feed for the WTP (3 years before Tank AN-107 was declared a leaker in 2040). The mitigation and removal from service of Tank AN-107 requires approximately 8 months to complete.

5.5.3.3.1.5 Tank AW-105 Leak Mitigation

In 2045 Tank AW-105 is declared a leaker at the same time as the number of simultaneous SST retrievals is increased from one retrieval per area to two in order to maintain adequate feed to the WTP. At this time, Tank AW-105 is full of feed that is ready for delivery to the TWCS capability. Furthermore, all other DSTs with installed mixer pumps are full when the DST leak mitigation strategy is implemented.

To mitigate leaking Tank AW-105, the contents are transferred to TWCS-compatible DSTs as waste is delivered to treatment facilities. Throughput to the treatment facilities is not affected, even though TWCS-compatible tanks are indirectly used for the leak mitigation. The waste is transferred as bulk waste using two large transfers that take approximately 3 months to empty the tank enough for heel-removal equipment to be installed. Mitigating and removing Tank AW-105 from service required approximately 13 months to complete.

5.5.3.4 Life-Cycle Cost Results

The life-cycle cost for Scenario 5 is $122 billion unescalated and $247 billion escalated. This compares to $122 billion unescalated and $247 billion escalated for Scenario 1B. Figure 5-61 shows the cost profile compared to Scenario 1B. From a cost perspective, the consequences of retrieving the five leaking DSTs is negligible. The mission duration is the same in both scenarios, and the total costs for each scenario are also the same. The costs to retrieve the supernatant and hard heel are already included for all DSTs at the end of the mission in Scenario 1B. In Scenario 5, the DST retrieval costs for the leaking tanks are incurred earlier in the mission due to the tank failures.

Figure 5-61. Scenario 5 Comparison – Life-Cycle, Unescalated Cost Profile.

5.5.4 Risks

The purpose of Scenario 5 is to evaluate the realization of the baseline risk of additional leaking DSTs and the effect on mission metrics, cost, and duration. However, Scenario 5 only evaluates five specific DSTs and only with a single, specified timeline. There are the following risks for this scenario.

- If the timeline for mitigation of leaking DSTs is to be maintained for all potential leaking DSTs, the TOC contractor would need to be in a state of readiness, including equipment, personnel, and plans.
- The overall mission treatment and retrieval strategy, as well as mission requirements, could change as a result of leaking DSTs due to the actual or projected failure of the following:
  - DST(s) with critical mission function.
  - A sufficient number of DSTs such that SST retrievals and DST operations cannot operate simultaneously.
- There are many factors that were not modeled in Scenario 5 that could further complicate the retrieval and mitigation of a leaking DST. These complicating factors include the following:
  - Two or more DSTs discovered to be leaking at the same time.
  - A leaking DST with a critical mission function such as those supporting the DFLAW mission.
  - Delayed treatment startup.
  - Lower treatment throughput.
  - A leaking DST known to contain waste that would require special consideration for retrieval if it is discovered to be leaking prior to the planned mitigation for its respective circumstances, including the following:
    - DSTs with complexed concentrate supernatant
    - Group A DSTs or those containing significant saltcake
    - DSTs with significant solids depth
    - DSTs with criticality concerns.

5.5.5 Opportunities

Scenario 5 highlights the following specific opportunities for modeling and planning of which the TOC contractor could take advantage:

- The risk analysis of Scenario 5 highlights several potential complicating factors in a leaking DST retrieval and mitigation scenario. The TOC contractor should take the opportunity to model scenarios with one or more of the complicating factors identified in the risk analysis section, allowing mitigation plans to be in place prior to another possible DST leak that would pose unique risks and challenges.
- The results of Scenario 5 show that it is possible to retrieve and mitigate a leaking DST in a matter of months. An accelerated retrieval is realistically achievable if a state of readiness for leaking DST retrieval and mitigation is maintained.

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6.0 SCENARIO COMPARISON

For each scenario in System Plan Rev. 9, performance against TPA and Consent Decree milestones was assessed, resultant quantities of immobilized waste products were calculated, and the life-cycle cost was estimated. Table 6-1 summarizes the key assumptions that affect the modeling results for each scenario. Table 6-2 summarizes these findings for each scenario in System Plan Rev. 9 versus the System Plan Rev. 8 baseline scenario.

The Baseline Case shows the tank farms, together with the integrated WTP, a LAWST capability, and the potential CH-TRU tank waste treatment process, could retrieve and treat the Hanford tank waste by 2066 with an estimated life-cycle cost of $107 billion ($192 billion escalated), contingent upon receiving adequate funding and successful resolution of the key issues and uncertainties.

The updated planning bases for System Plan Rev. 9 led to the following notable changes in Scenario 1 versus the System Plan Rev. 8 baseline scenario:

- The predicted completion of the “next nine” additional SST retrievals slipped 4 years to 2026 due to the tank vapors-related stop work, the 242-A Evaporator slurry line replacement, and funding constraints.
- The additional constraints modeled for SST retrievals and 242-A Evaporator operations led to a 5-year delay in the completion of all SST retrievals to 2061.
- The slip in SST retrievals and additional constraints modeled for DST retrievals led to a 3-year delay in completing tank waste treatment to 2066.
- The introduction of the 2016 LAW and HLW GFMs reduced the mission-total glass container/canister quantities.
- The scheduled start date for potential TRU waste treatment was shifted from 2031 to 2040, and therefore, the completion of potential TRU waste treatment extended from 2036 to 2045. This was done to help level the mission cost profile. The number of TRU waste drums increased due to an increase in the estimated waste inventory of the tanks containing potential TRU waste.
- The inclusion of leachate trucked to the LERF and rainwater in secondary liquid effluent volumes contributed to increasing the projected mission-total secondary liquid effluent volume by a net 50 Mgal. This amounts to a higher required annual secondary liquid effluent treatment capacity.

Table 6-1. Key Scenario Inputs and Assumptions.

Input	System Plan Rev. 8 Baseline Case	System Plan Rev. 9 Scenarios					
		Scenario 1	Scenario 1B	Scenario 2	Scenario 3	Scenario 4	Scenario 5
DFLAW	2023 - 2033	2023 - 2033	2023 - 2033	Full Mission	Full Mission	Full Mission	2023 - 2033
DF-HLW[a]	No	No	No	Full Mission	Full Mission	Full Mission	No
WTP (and LAWST) TOE	70%	70%	50%	50%	50%	50%	50%
Next SST Farm Retrieved after A/AX Tank Farms	S/SX	S/SX	U	U	U	U	U
TSCR Startup	N/A	03/24/2023	03/24/2023	03/24/2023	03/24/2023	03/24/2023	03/24/2023
TFPT Startup	N/A	03/24/2028	03/24/2028	03/24/2028	03/24/2028	03/24/2028	03/24/2028
WTP LAW Vitrification Facility Startup	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023	12/31/2023
TWCS Capability Startup	06/30/2032	06/30/2032	06/30/2032	N/A	N/A	N/A	6/30/2032
New HFPF Startup	N/A	N/A	N/A	06/30/2032	06/30/2032	06/30/2032	N/A
WTP Pretreatment Facility Startup	12/31/2033	12/31/2033	12/31/2033	N/A	N/A	N/A	12/31/2033
WTP HLW Vitrification Facility Startup	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033	12/31/2033
TFPT Capacity Expansion	N/A	N/A	N/A	12/31/2034	12/31/2034	12/31/2034	N/A
New LAW Feed Evaporator Startup	N/A	N/A	N/A	12/31/2034	12/31/2034	12/31/2034	N/A
LAWST Startup	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034	12/31/2034
Potential CH-TRU Waste Processing	01/01/2031	01/01/2040	01/01/2040	01/01/2040	01/01/2040	01/01/2040	01/01/2040
Other[b]				(1)		(2)	(3)

[a] DF-HLW refers to delivering feed to the WTP HLW Vitrification Facility from a facility other than the WTP Pretreatment Facility.
[b] (1) – TWCS function performed in existing DSTs.
(2) – New DSTs added as needed to 200 East/200 West Areas starting 12/31/2030.
(3) – One additional leaking DST every 5 years from 2025 to 2045.

CH-TRU = contact-handled transuranic.
DF-HLW = direct-feed high-level waste.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
HFPF = High-Level Waste Feed Preparation Facility.
HLW = high-level waste.
LAW = low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TFPT = tank farm pretreatment.
TOE = total operating efficiency.
TSCR = tank-side cesium removal.
TWCS = tank waste characterization and staging.
WTP = Waste Treatment and Immobilization Plant.

Table 6-2. Comparison of Key Scenario Results.

	Metric	System Plan Rev. 8 Baseline Scenario	System Plan Rev. 9 Scenarios				
			Scenario 1	Scenario 1B	Scenario 2, 4[a]	Scenario 3	Scenario 5
Near-Term Regulatory	Complete Five Additional SST Retrievals (Third Amended Consent Decree Milestone B-3, 06/30/2021)	04/2019	07/2020	07/2020	07/2020	07/2020	07/2020
	Complete Nine Additional SST Retrievals (Third Amended Consent Decree Milestone B-2, 09/30/2026)	05/2022	06/2026	06/2026	06/2026	06/2026	03/2027
	Complete Tank 241-A-103 Retrieval (TPA Milestone M-045-15, 09/30/2022)	11/2022	01/2027	04/2027	03/2027	03/2027	11/2027
Retrieval /Storage	First Cross-Site Transfer	2025	2028	2028	2029	2028	2030
	Retrieve all SSTs (TPA Milestone M-045-70, 12/31/2040)	2056	2061	2065	2060	2066	2068
	Close all DSTs (TPA Milestone M-042-00A, 09/30/2052)	2067	2070	2079	2074	2077	2079
Treatment	Treat All Tank Waste (TPA Milestone M-062-00, 12/31/2047)	2063	2066	2076	2069	2076	2075
	Complete Potential CH-TRU Waste Packaging	2036	2045	2045	2045	2045	2045
	IHLW Glass Canisters	7,800	7,300	7,000	9,100	7,200	7,100
	Total ILAW Glass Containers	94,000	89,000	88,000	91,000	101,000	88,000
	WTP ILAW Glass Containers (% Total)	52,000 (55%)	52,000 (59%)	49,000 (56%)	29,000 (32%)	28,000 (28%)	49,000 (55%)
	LAWST ILAW Glass Containers (% Total)	42,000 (45%)	37,000 (41%)	39,000 (44%)	62,000 (68%)	72,000 (72%)	39,000 (45%)
	LAWST Glass Volume, yd^3	118,000	103,000	109,000	174,000	202,000	109,000
	LAWST Equivalent Grout Volume, yd^3	420,000	400,000	430,000	690,000	910,000	440,000
	Potential CH-TRU Tank Waste Drums	8,400	8,800	8,800	8,800	8,800	8,800
	Secondary Liquid Effluent Volume, gal	550M	600M	670M	770M	890M	670M
Cost	Unescalated Life-Cycle Cost (Escalated)[b]	$110B ($223B)	$107B ($192B)	$122B ($247B)	$112B ($208B)	$125B ($256B)	$122B ($247B)

[a] Scenario 2 met the Scenario 4 objective without requiring new DSTs, therefore Scenarios 2 and 4 represent the same scenario.
[b] Life-cycle cost includes $10B in sunk cost fiscal year 1997 through 2019 and LAWST costed as vitrification but does not include WTP capital expenditure.

CH-TRU = contact-handled transuranic.
DST = double-shell tank.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAWST = low-activity waste supplemental treatment.
SST = single-shell tank.
TPA = Tri-Party Agreement.
WTP = Waste Treatment and Immobilization Plant.

6.1 SCENARIO 1

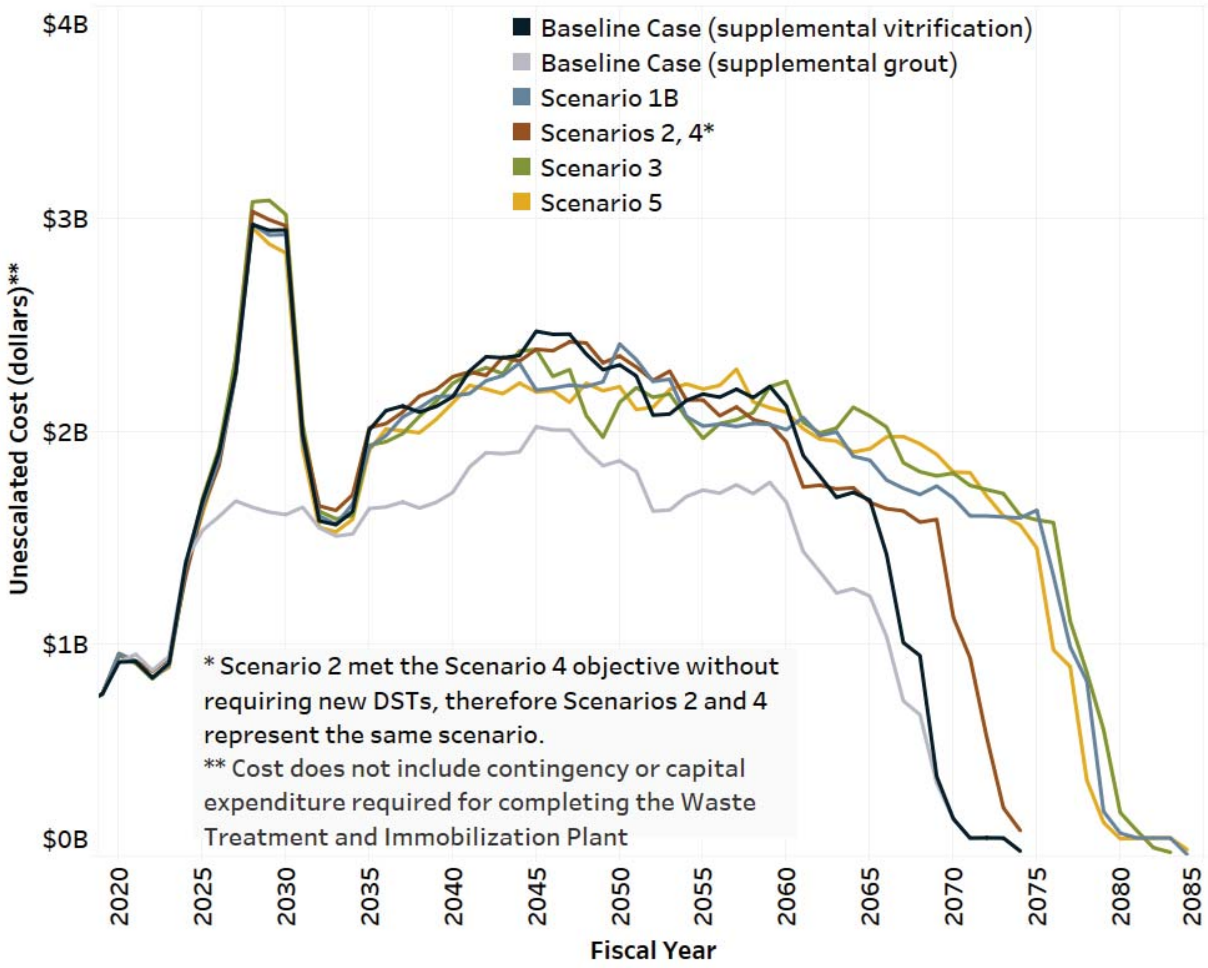
As in the System Plan Rev. 8 baseline scenario, for most of the mission, the duration of the Baseline Case is driven by HLW pretreatment. Specifically, the WTP Pretreatment Facility does not pretreat HLW at a rate that is sufficient to allow the WTP HLW Vitrification Facility to operate at its capacity. As a result, HLW pretreatment is the rate-limiting step as the LAWST capability is sized as large as needed to keep pace with HLW processing. However, as opposed to System Plan Rev. 8, treatment is rate-limited at the end of the mission for the increased time required to retrieve the remaining waste from the DSTs. This is due to the new constraints limiting simultaneous and sequential SST and DST retrievals, extending DST retrieval durations, and capping the annual number of 242 A Evaporator campaigns. These constraints extend the schedule for SST retrievals and require that DSTs can only be retrieved when resources become available following the completion of SST retrievals. The alternative scenarios analyzed in System Plan Rev. 9 all assume a lower throughput for the WTP (and LAWST capability) equivalent to 50 percent TOE versus the 70 percent TOE throughput assumed for the Baseline Case. As a result, and because supplemental treatment capacity is not expanded for these scenarios versus the Baseline Case, none of the alternative scenarios are able to improve upon nor meet the Baseline Case treatment completion date. However, as demonstrated by Scenario 2, full-mission DF-HLW and DFLAW treatment has the potential to accelerate the mission compared to Scenario 1B.

The unescalated life-cycle cost profiles for the System Plan Rev. 9 scenarios are presented in Figure 6-1. For all scenarios evaluated in System Plan Rev. 9, there is a sharp increase in required funding above the current and historical funding levels starting in 2024. This occurs due to costs associated with the design and construction of the LAWST capability (costed as a vitrification facility) and other new facilities supporting waste treatment, as well as DFLAW operations. The annual cost increases steadily to $3 billion (unescalated) in FY 2031 when major construction of these new capabilities is complete. The life-cycle cost does not include WTP construction costs. The costs for completing the WTP Pretreatment and HLW Vitrification Facilities, if included, would further exacerbate the issue of increased funding requirements through the early 2030s. Once the integrated WTP and the LAWST capability start in FY 2034, the costs remain relatively constant at approximately $2 billion (unescalated) annually until the end of treatment. Because the annual operational costs tend to be stable across scenarios, the life-cycle cost is highly correlated with mission duration, and the lower-throughput, alternative scenarios consequentially have a higher cost than the Baseline Case.

In System Plan Rev. 9, the LAWST capability is modeled as vitrification. However, grout is utilized at the Savannah River Site and is being considered as one of the technologies for immobilization of the Hanford LAW. If the LAWST capability is costed as a grout facility,[36] the life-cycle cost can be maintained at under $2 billion annually (unescalated) for the entire mission.

[36] Cost estimates for LAWST as grout are based on SRNL-RP-2018-00687.

Figure 6-1. Unescalated Life-Cycle Cost Profiles for System Plan Revision 9, Scenarios.



6.2 SCENARIO 1B

In Scenario 1B, the reduction in treatment facility throughput made treatment capacity the sole driver for the mission duration. This increased the length of the mission for SST retrievals and treatment by 5 and 10 years, respectively, but the total quantity of immobilized waste products is similar to the Baseline Case.

6.3 SCENARIO 2

The Scenario 2 results show that this full-mission DFLAW and DF-HLW scenario accelerates the mission and reduces the life-cycle cost compared to Scenario 1B. This is achieved by replacing the solids pretreatment function of the WTP Pretreatment Facility with a higher throughput HFPF, thus removing the solids pretreatment bottleneck that exists in the baseline flowsheet. The HFPF is also a less complex and, therefore, likely less expensive facility compared to the WTP Pretreatment Facility. In Scenario 2, SST retrievals and tank waste treatment are completed in 2060 and 2069 respectively, approximately 5 years earlier than

Scenario 1B, while reducing life-cycle cost by $10 billion[37] (unescalated). The following are several other significant results realized from Scenario 2:

- Upon removal of the solids pretreatment limitation (which was due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step, as the capacity of LAWST is sized to match the Baseline Case.
- The reduction in the extent of solids pretreatment in the HFPF versus the WTP Pretreatment Facility (lower temperature caustic leaching, no oxidative leaching) leads to a 29 percent increase in IHLW.
- The addition of two new evaporators (the HEMF evaporator and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little effect to the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility causing a 15-percent increase in secondary liquid effluent produced.

6.4 SCENARIO 3

The Scenario 3 results show no significant acceleration of the overall RPP mission compared to Scenario 1B, despite eliminating the solids pretreatment bottleneck by replacing the solids pretreatment function of the WTP Pretreatment Facility with the HFPF, which has a higher throughput. The following are several other significant results realized from Scenario 3:

- Upon removal of the solids pre-treatment limitation (which was due to the WTP Pretreatment Facility), LAW treatment becomes the new rate-limiting step, as the capacity of LAWST is sized to match the Baseline Case.
- A 50 percent increase in sodium hydroxide added to the HFPF to achieve similar leaching to Scenario 1B (but at a lower temperature) increases the ILAW glass by 15 percent. This prevents Scenario 3 from improving the mission schedule against Scenario 1B because the mission is LAW-treatment driven in Scenario 3.
- As in Scenario 1B, constant constraints on DST space delayed SST retrievals, which also delayed feeding the WTP HLW Vitrification Facility.
- The addition of two new evaporators (the HEMF evaporator and LAW Feed Evaporator) reduces reliance on the aging 242-A Evaporator to the point that its operation could be permanently suspended beginning in 2035 with little effect to the mission.
- The HFPF uses raw water for washing instead of recycled liquid effluent as in the WTP Pretreatment Facility causing a 32-percent increase in secondary liquid effluent produced.

6.5 SCENARIO 4

The objective of Scenario 4 was to add new DSTs to match the Baseline Case SST retrieval completion date of 2061, using the Scenario 2 flowsheet and planning bases. However, Scenario 2 satisfied the Scenario 4 success criteria without requiring new DSTs, completing SST

[37] Life-cycle cost does not include WTP construction costs, and thus the savings in life-cycle cost do not reflect the cost saved by not completing construction of the WTP Pretreatment Facility in Scenario 2.

retrievals in 2060. This demonstrates that increased (or expedited) treatment throughput is ultimately the best way to favor SST retrievals.

6.6 SCENARIO 5

The Scenario 5 results show that removing an additional five leaking DSTs from service results in a 3-year delay in the completion of all SST retrievals, but does not affect the other overall mission metrics. However, it did cause the “next nine” SST retrievals to slip 9 months, missing the milestone date in the Amended Consent Decree. Scenario 5 also demonstrates it is possible, from a tank space management perspective, to retrieve leaking DSTs at various points in the mission in under 1 year while still maintaining the required emergency pumping space.

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7.0 RISK AND OPPORTUNITY MANAGEMENT/CONTINGENCY PLANNING

This section reviews the baseline risks and contingency planning for the six risks identified in TPA Milestone M-062-40 as they are associated with the Baseline Case.

7.1 RISKS ASSOCIATED WITH THE BASELINE CASE

The Baseline Case presented in this system plan includes a number of challenges that need to be successfully addressed to reach the desired performance for the mission. The ORP has a comprehensive risk management program to address these challenges, which is described in TFC-PLN-39, *Enterprise Risk and Opportunity Management Plan*. Risks are flowed down from the mission level to the program level and project level. Each level contains its own risk register, which tracks the risks as well as their potential impact and associated mitigating actions. Key risks associated with the Baseline Case are summarized below. (Refer to the risk registers for a more comprehensive discussion of the risks.)

This section is not intended to provide as much detail as the WTP or Tank Farms Risk and Opportunity Management Plans, and it is not an all-inclusive mission contingency plan. A specific risk analysis was not performed for the System Plan Rev. 9. (Analyses specific to risk are performed for specific components and facilities based on the Risk Management Plan associated with the project and are provided for the RPP mission in other milestone reports).

The following is a list of the key risks associated with the Baseline Case:

- Funding shortfalls relative to projected requirements leading to an increase in mission duration, increased costs, and/or alterations to mission requirements
- Ability of aging infrastructure and facilities to meet mission demands and operating durations (facilities becoming obsolete)
- Safety incidents or issues during construction or operations affect mission execution
- Acts of God or other force majeure that disrupt mission execution
- Regulation changes or interpretation of existing regulations changes
- Labor/skills-mix uncertainties
- Supply-chain management challenges for equipment and components (e.g., limited availability of vendors with an approved nuclear quality assurance program)
- Uncertainty in tank waste chemical/radionuclide inventory, particle size distribution, or predicted waste partitioning leaves orphaned waste streams that are unable to be treated or disposed of as planned
- Uncertainty in the SST retrieval waste composition, retrieval durations, and as-retrieved waste volumes
- Ability to startup the WRFs on time
- WIR determination not received in time for SST closures
- Ability to activate the cross-site transfer lines and successfully perform cross-site transfers

- Ability to maintain sufficient space in the DST system to support competing mission priorities
- Uncertainty in the continued capability of the 242-A Evaporator to meet mission demand
- Continued integrity of the aging DSTs (risk of additional leaking DSTs)
- Ability of the DST system infrastructure to maintain adequate waste feed to the WTP treatment facilities
- Less-than-adequate 222-S Laboratory availability or throughput rates necessary to support mission demand
- Ability of waste feed to meet the WTP WAC
- Delays to the startup of the TSCR and/or TFPT systems
- The TSCR and/or TFPT systems do not achieve the planned throughput rates
- Delayed startup of the WTP facilities
- WTP facilities do not achieve the planned throughput rates
- WTP facilities do not achieve planned waste loading in glass
- Uncertainty in the scope of the TWCS capability and the ability to implement it
- The WTP Pretreatment Facility and WTP HLW Vitrification Facility cannot be constructed and/or operated as currently anticipated due to technical and safety issues (e.g., nuclear safety criticality technical issue for high-density solids)
- Uncertainty in the scope of the LAWST capability and the ability to implement it
- Delays to the startup of facilities required for storage, shipping, and/disposal of IHLW (IHS, HSF, Federal Geological Repository)
- Ability to reclassify and dispose of the potential CH-TRU waste
- Ability to startup the supplemental CH-TRU packaging facility on time and meet projected throughputs
- Ability of the LERF/ETF to meet secondary effluent treatment demands
- Delays to ETF upgrades required to support treatment facilities.

7.2 MILESTONE M-062-40 RISKS

This section addresses contingency planning for six specific risks identified in TPA Milestone M-062-40 as they are associated with the System Plan Rev. 9 Baseline Case. Milestone M-062-40 requires that:

> *The [System] Plan will identify and consider possible contingency measures to address the following risks:*
>
> - *Results from SST integrity evaluations.*
> - *If retrievals take longer than originally anticipated and there is potential impact to the schedule for retrieving specified tanks under this agreement.*

- *If DST space is not sufficient or is not available to support continued retrievals on schedule.*
- *If any portion of the WTP does not initiate cold commissioning on schedule.*
- *If any portion of the WTP does not complete hot start on schedule.*
- *If operation of the WTP does not meet treatment rates that are adequate to complete retrievals under the schedule in this agreement.*

The contingency discussion, focused on six specific risks stated in TPA Milestone M-062-40, is summarized below and followed by a detailed table. Possible contingency measures identified for each of the six risks are presented in Table 7-1 either as a direct contingency (D) or an indirect contingency (I). Possible direct contingency measures may directly mitigate a risk, whereas possible indirect contingency measures may affect a risk indirectly through a related activity, facility, or process step.

Note: This is not intended to be an exhaustive list of all possible contingencies, and while some possible contingency measures are carried in the current baseline, they are included to provide a more thorough analysis of contingencies for given risks.

7.2.1 Possible Contingency Measures: Single-Shell Tank Integrity

If results from the SST integrity evaluations indicate deteriorating SST integrity, possible direct contingency measures are included in Table 7-1 under Risk 1.

Because retrieving SSTs more rapidly hedges against future SST integrity issues, contingencies for expediting SST retrievals (Risk 2, and therefore Risks 3, 4, 5, and 6) may also apply indirectly to this risk.

7.2.2 Possible Contingency Measures: Retrievals Take Longer

This risk focuses on the time required to retrieve the waste from a given SST. A lengthy retrieval may be a symptom of a retrieval technology that is not efficient at mobilizing and retrieving the waste in that particular tank. Retrievals may be directly slowed by retrieval equipment breakdowns or indirectly affected by DST available space (and, therefore, the 242-A Evaporator). Retrievals may also be indirectly affected by stop work orders or field conditions (e.g., tank vapors, COVID-19). Possible contingencies for retrievals taking longer are included in Table 7-1 under Risk 2.

If retrievals are affected by available DST space, contingencies for DST space (Risk 3, and, therefore, Risks 4, 5, and 6) may also apply indirectly to this risk.

7.2.3 Possible Contingency Measures: Double-Shell Tank Space

In general, DST space is a limiting factor to SST retrievals up until all treatment facilities have reached their full capacities. Additionally, DST space is also dependent on startup of the DFLAW mission and continued operation of the 242-A Evaporator to reduce the volume of waste contained in the DSTs. If existing DST space is not sufficient, possible contingency measures are included in Table 7-1 under Risk 3.

Because accelerated treatment or increased treatment throughput reduces the volume of waste contained in the DSTs, contingencies for Risks 4, 5, and 6 may indirectly apply to this risk.

Additionally, faster SST retrieval rates can mitigate slower SST retrieval rates caused by DST space constraints in the near term, so contingencies for Risk 2 may also apply indirectly.

7.2.4 Possible Contingency Measures: Delayed Waste Treatment and Immobilization Cold Commissioning

Contingency measures for a delay in cold commissioning are identified with regard to their effects on hot commissioning if the delay cascades to affect the WTP hot start (Section 7.2.5). Possible contingency measures for delayed cold commissioning are included in Table 7-1 under Risks 4 and 5.

Because increased plant throughput after startup can also indirectly mitigate a delayed startup, the contingencies for Risk 6 may apply indirectly. Furthermore, the contingencies for Risks 2 and 3 may mitigate effects on DST space and, therefore, SST retrievals from delayed treatment startup.

7.2.5 Possible Contingency Measures: Delayed Waste Treatment and Immobilization Plant Hot Start

If any portion of the WTP does not complete hot start on schedule significant gaps in waste processing are expected based on the facility delayed. Possible contingency measures are included in Table 7-1 under Risks 4 and 5.

Because increased plant throughput after startup can also indirectly mitigate a delayed startup, the contingencies for Risk 6 may apply indirectly. Furthermore, the contingencies for Risks 2 and 3 may mitigate the effects to DST space and, therefore, SST retrievals from delayed treatment startup.

7.2.6 Possible Contingency Measures: Waste Treatment and Immobilization Plant Treatment Rates

If operations of the WTP and the DFLAW systems do not meet treatment rates that are adequate to complete retrievals under the TPA schedule, multiple chain-linked delays will ensue. For example, the direct contingency measures may address estimated WTP Pretreatment Facility throughput as affected by ultrafiltration capacity and oxidative leaching requirements. If operations of the WTP facilities do not meet anticipated treatment rates, contingency measures are included in Table 7-1 under Risk 6.

Because decreased plant throughput after startup can be mitigated by an accelerated startup, the contingencies for Risks 4 and 5 may apply indirectly. Furthermore, the contingencies for Risks 2 and 3 may mitigate the effects to DST space and, therefore, SST retrievals from reduced treatment throughput.

Table 7-1. Contingency Measures[a] for Six Risks Identified in Milestone M-062-40. (2 pages)

Contingency Measures	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6
Enhancing the SSTIP and preventative maintenance.	D					
Transferring waste from a leaking SST to a WRF or DST.	D					
Leaving some SSTs unretrieved with appropriate closure measures.	D	I	I	I	I	I
Increasing spare inventories for retrieval equipment.		D				
Developing new or modifying existing waste retrieval technologies (e.g., development of in-tank mechanical waste-gathering system, development of MARS-V alternatives).		D	I			
Developing the risk assessment/performance assessment for each WMA prior to retrieving the waste.		I				
Increasing the number of simultaneous SST retrievals with increased retrieval crews.		I				
Pre-retrieval sampling and process development (e.g., development of 3-D flash lidar to map waste tanks, development of online monitoring using Raman spectroscopy).		I				
Developing new capabilities to mitigate tank farm vapor sources including (e.g., implementation of enhanced vapor monitoring and detection systems within the tank farms, development of the capability to treat n-nitrosodimethylamine tank-side or in the tank headspace).		I				
Permitting, designing, constructing, and operating new DSTs.		I	D			
Increasing current fill limits in the DSTs.		I	D			
Planning waste transfers to consolidate DST space.		I	D			
Selecting and installing additional evaporator unit(s) to supplement 242-A Evaporator.		I	D			
Maximizing evaporator waste concentration without excess salt production.		I	D			
Enhancing the DSTIP and preventative maintenance (e.g., develop capability to perform visual inspection of DST primary tank bottoms, develop tertiary leak detection and foundation robotic inspection capability).			I			
Expanding allowances for deep-sludge-behavior solids currently applied to Tanks AN-101 and AN-106 to additional DSTs (RPP-PLAN-44573, *Project Plan for Implementing a New Buoyant Displacement Gas Release Event Safety Basis*).			I			
Reducing or eliminating effluent returns to the DST system from the WTP during off-normal or degraded flowsheet conditions.			I			
Using caustic-rich tank wastes in lieu of fresh caustic additions to maintain OSD-T-151-00007 limits.			I			
Adjusting SST retrieval order or otherwise pace SST retrievals to reserve DST space for preparation and delivery of feed to treatment facilities.			I			
Accelerating startup of DFLAW and/or increasing throughput for DFLAW (e.g., through additional TSCR units).				D	D	D

Table 7-1. Contingency Measures[a] for Six Risks Identified in Milestone M-062-40. (2 pages)

Contingency Measures	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6
Implementing the LAWST capability as per baseline.				I	I	D
Developing and qualifying a low temperature waste form immobilization or offsite treatment of secondary liquid wastes from LAW vitrification and tank farm operations.				I	I	I
Sending potential CH-TRU waste to a supplemental packaging facility (and not to the DST system) as per baseline.		I	I	I	I	I
Developing alternative tank waste approaches that do not require pretreatment or HLW vitrification (at tank treatment approaches).		I	I	I	I	I
Developing other waste shipping and removal methods for offsite treatment and disposal.				I	I	I
Accelerating waste treatment including HLW vitrification, LAWST, and localized treatment. This may include "direct-feed" flowsheets.				D	D	D
Improving the HLW and LAW GFMs.						D
Continuing efforts to develop and deploying advanced melters (to support 1st melter change-out) as per baseline.						D
Developing dynamic simulation model able to predict plant behavior under all feed conditions to optimize operating envelope and prevent process upsets.						D
Using waste blending approaches to mitigate refractory waste feeds.						D
Developing alternative tank waste pretreatment approaches that lessen the requirements for the WTP Pretreatment Facility (e.g., pretreatment of DSTs AN-102 and AN-107 complexed concentrate via in-tank precipitation as per baseline).						D
Using alternative laboratories (222-S Laboratory and PNNL) or reducing required samples or sample sizes if needed to supplement WTP Analytical Laboratory if throughput is inadequate.						D
Studying and recommending a nitrite hydroxide solubility interaction factor to support aluminum solubility analysis in DFLAW.						I
Performing organic constituent characterization of the WTP (including DFLAW) secondary liquid waste.						I
Identifying soluble neutron absorbers to decrease criticality concerns for the WTP.						I

[a] Possible direct contingency measures are represented with a “D,” and possible indirect contingency measures are represented with an “I.”

CH-TRU	=	contact-handled transuranic.	MARS-V	=	Mobile Arm Retrieval System – Vacuum.
DFLAW	=	direct-feed low-activity waste.	PNNL	=	Pacific Northwest National Laboratory.
DST	=	double-shell tank.	SST	=	single-shell tank.
DSTIP	=	Double-Shell Tank Integrity Program.	SSTIP	=	Single-Shell Tank Integrity Program.
GFM	=	glass formulation model.	WMA	=	waste management area.
HLW	=	high-level waste.	TSCR	=	tank-side cesium removal.
LAW	=	low-activity waste.	WRF	=	Waste Receiving Facility.
LAWST	=	low-activity waste supplemental treatment.	WTP	=	Waste Treatment and Immobilization Plant.

8.0 REFERENCES

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10 CFR 61.55, "Waste Classification," *Code of Federal Regulations*, as amended.

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APPENDIX A

MODEL STARTING ASSUMPTIONS

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CONTENTS

TERMS

Abbreviations, Acronyms, and Initialisms

BDGRE	buoyant displacement gas release event
CH-TRU	contact-handled transuranic
CST	crystalline silicotitanate
CWC	Central Waste Complex
DFLAW	direct-feed low-activity waste
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EMF	Effluent Management Facility
ETF	Effluent Treatment Facility
FY	fiscal year
GFM	glass formulation model
HIHTL	hose-in-hose transfer line
HLW	high-level waste
HSF	Hanford Shipping Facility
IDF	Integrated Disposal Facility
IHLW	immobilized high-level waste
IHS	Interim Hanford Storage
ILAW	immobilized low-activity waste
ISM	Integrated Solubility Model
IX	ion exchange
LAW	low-activity waste
LAWST	low-activity waste supplemental treatment
LERF	Liquid Effluent Retention Facility
ORP	U.S. Department of Energy, Office of River Protection
PMB	performance measurement baseline
RPP	River Protection Project
SALDS	State-Approved Land Disposal Site
SST	single-shell tank
TEDF	Treated Effluent Disposal Facility
TFPT	tank farm pretreatment
TOC	Tank Operations Contract
TRU	transuranic
TSCR	tank-side cesium removal
TWCS	tank waste characterization and staging
WBS	work breakdown structure
WMA	waste management area
WRF	Waste Receiving Facility
WTP	Waste Treatment and Immobilization Plant
WVR	waste volume reduction

Units

°C	degrees Celsius
°F	degrees Fahrenheit
Ci	curie
ft	foot
ft^3	cubic foot
g	gram
gal	gallon
gpm	gallon per minute
kg	kilogram
kgal	kilogallon
L	liter
lb(s)	pound(s)
m^3	cubic meter
M	mega (million)
M	molar
Mgal	megagallon (million gallon)
mL	milliliter
mol	mole
MTG	metric ton of glass
SpG	specific gravity
vol%	volume percent
wt%	weight percent

Definitions

Term	Definition/Description
as-retrieved	The volume of waste retrieved from a single-shell tank (SST), including the chemicals or motive fluids that are added in the process of removing and pumping the waste.
B Complex	The collective term for the 241-B,[38] BX, and BY Tank Farms.
Baseline Update	The updated, contracted cost and schedule for work usually covering a 2-year period.
bottoms	The concentrated stream leaving an evaporator.
buoyant displacement gas release event (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 can 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 size of the tank headspace and capacity of the ventilation system. BDGREs are generally associated with tanks containing low-shear-strength salt slurry.
closure	The deactivation and stabilization of a radioactive waste facility intended for long-term confinement of waste (as per DOE M 435.1-1, *Radioactive Waste Management Manual*). Final closure of the operable units (tank farms) is 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, "Closure and Post-Closure."
emergency space	The 1.265 Mgal of empty waste storage space reserved in the double-shell tank (DST) system for use in the event of an emergency, such as a leak.
enabling assumption	An assumption made because an assumption must be made to enable the River Protection Project (RPP) to be modeled (e.g., because information is not yet available, or a decision has not yet been made).
entrained	When solid particulates are suspended in a liquid due to mixing, pumping, or agitation.

[38] To aid readability of the document, the official designation of "241-" in tank and tank farm names will be omitted. Unless otherwise specified, tanks and tank farms are classified with "241-."

Term	Definition/Description
Envelope waste categories	Waste feeds are defined by the Waste Treatment and Immobilization Plant (WTP) Contract (DE-AC27-01RV14136, *Design Construction and Commissioning of the Waste Treatment and Immobilization Plant*) as “Envelopes:” Envelopes A, B, C, D, and E. Envelopes A, B, and C describe the liquid feed and primarily contain sodium salts (such as nitrate, nitrite, aluminate, sulfate, phosphate, hydroxide) and soluble radionuclides such as cesium-137 and technetium-99. Envelope E is the pretreated liquid waste fed directly from the tank farms to the WTP LAW Vitrification Facility. The HLW slurry contains a mixture of liquids (Envelopes A, B, C) and solids (Envelope D).
Envelope A	A contractual waste composition designation that constitutes the majority of liquid waste to be processed. Envelope A compositional limits are provided in Tables TS-7.1 and TS-7.2 of DE-AC27-01RV14136.
Envelope B	A contractual waste composition designation for liquid waste that has higher cesium-137 levels and higher concentrations of glass-limiting constituents such as sulfate than Envelope A. Envelope B compositional limits are provided in Tables TS-7.1 and TS-7.2 of DE-AC27-01RV14136.
Envelope C	A contractual composition designation for liquid waste containing organic complexing agents that cause the strontium-90 and some transuranic (TRU) waste to remain in solution. These elements must be removed to ensure that immobilized low-activity waste (ILAW) product specifications will be met. Envelope C compositional limits are provided in Tables TS-7.1 and TS-7.2 of DE-AC27-01RV14136.
Envelope D	A contractual waste composition designation that constitutes all HLW solids. The composition range of Envelope D unwashed solids is given in Tables TS-8.1, TS-8.2, TS-8.3, and TS-8.4 of DE-AC27-01RV14136.
Envelope E	A contractual waste composition designation that defines the treated liquid waste from the tank farms directly fed to the WTP LAW Vitrification Facility. Envelope E requirements are described in 24590-WTP-ICD-MG-01-030, *ICD 30 – Interface Control Document for Direct LAW Feed*.
Group A tank	A tank, which because of its waste composition and quantities, has the potential for a spontaneous BDGRE and is conservatively estimated to contain enough flammable gas within the waste that if all was released into the tank headspace, the concentration of the flammable gas would be a flammable mixture.

Term	Definition/Description
high-level waste (HLW)	As used in this system plan, HLW is the fraction of the tank waste containing most of the radioactivity that will be immobilized into glass and disposed of at an offsite repository. This waste includes the solids remaining after pretreatment, plus certain separated radionuclides.
initial plant operations	A term associated with a milestone in the Consent Decree[39] and defined as "over a rolling period of at least 3 months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day, and low-activity waste glass at an average rate of at least 21 MTG/day."
ion exchange (IX)	A technology that uses a resin to remove radioactive cesium from liquid waste by exchanging sodium ions from the resin with cesium ions in the waste.
LAW supplemental treatment	A proposed supplemental treatment process(es) that will complement the WTP LAW Vitrification Facility treatment capacity. The treatment technology is yet to be determined.
low-activity waste (LAW)	Waste that remains following the process of separating as much radioactivity as is practicable from HLW. When solidified, LAW may be disposed of as low-level waste (LLW) in a near-surface facility.
low-level waste (LLW)	Radioactive waste not classified as high-level radioactive waste, TRU waste, spent nuclear fuel, or byproduct material, as defined in Section 11e.(2) of the *Atomic Energy Act of 1954*.
retrieval	The process of removing waste from a given underground storage tank to the maximum extent practical. 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, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, a tank is officially in "retrieval status" if one of two conditions is met: (1) waste has been physically removed from the tank by retrieval operations, or (2) preparations for retrieval operations are directly responsible for rendering the leak or intrusion monitoring instrument "out-of-service."

[39] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (E.D. WA October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

Term	Definition/Description
saltcake	A mixture of crystalline sodium salts that originally precipitated when alkaline liquid waste from the various processing facilities was evaporated to reduce waste volume. Saltcake primarily comprises the sodium salts of nitrate, nitrite, carbonate, phosphate, and sulfate. Concentrations of transition metals such as iron, manganese, 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.
scenario	Defined as a set of assumptions and/or success criteria intended to be used in the system planning process. Technical assumptions and/or success criteria are defined and used as input parameters for modeling or performing calculations. In the event that a scenario does not meet the success criteria or other stated objectives, the reasons will be identified and documented, as appropriate.
simplifying assumption	An assumption made to simplify the modeling and analysis of the RPP mission.
slurry	A term used in two different contexts. • A mixture of solids, such as sludge or undissolved saltcake, suspended in a liquid. For example, a slurry results when the sludge and supernatant in a tank are mixed together. Slurries can be used to transfer solids by pumping the mixture through a pipeline. • A waste produced at Hanford that results from evaporating supernatant 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).
supernatant/supernate	Technically the liquid floating above a settled solids layer. At Hanford, supernatant typically refers to any non-interstitial liquid in the tanks, even if no solids are present. Supernatant is similar to saltcake in composition and contains many soluble radionuclides such as cesium-137 and technetium-99.
T Complex	The collective term for the T, TX, and TY Tank Farms.
tank waste treatment complex	The collective term for the existing and future facilities, pipelines, and infrastructure needed for the storage, retrieval, and treatment of the Hanford tank waste.

Term	Definition/Description
waste oxide loading	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 components in the most prevalent oxide form, plus any halogens.
Waste Receiving Facility (WRF)	A future facility used to support the retrieval of waste involving slurry transfers from SSTs that are located too far away to be readily retrieved directly into a DST. The WRFs, located near the SSTs, will receive, accumulate, and condition retrieved waste before being transferred to a DST. (Note: The WRF was once referred to as a waste retrieval facility.)

A1.0 MODEL STARTING ASSUMPTIONS

The following set of key assumptions defines the Model Starting Assumptions for System Plan Rev. 9. The Consent Decree[40] regulatory commitments are listed in Table A-1.

Table A-1. Regulatory Commitments. (2 pages)

Milestone #	Regulation	Description	Due Date
D-00A-01	Consent Decree	Achieve Initial Plant Operations for the WTP.	12/31/2036
D-00A-02	Consent Decree	WTP HLW Vitrification Facility Construction Substantially Complete.	12/31/2030
D-00A-03	Consent Decree	Start WTP HLW Vitrification Facility Cold Commissioning.	06/30/2032
D-00A-04	Consent Decree	WTP HLW Vitrification Facility Hot Commissioning Complete.	12/31/2033
D-00A-05	Consent Decree	WTP Analytical Laboratory Construction Substantially Complete.	12/31/2012 (COMPLETED)
D-00A-06	Consent Decree	Complete Methods Validations.	06/30/2032
D-00A-07	Consent Decree	WTP LAW Vitrification Facility Construction Substantially Complete.	12/31/2020 (COMPLETED)
D-00A-08	Consent Decree	Start WTP LAW Vitrification Facility Cold Commissioning.	12/31/2022
D-00A-09	Consent Decree	WTP LAW Vitrification Facility Hot Commissioning Complete.	12/31/2023
D-00A-12	Consent Decree	Steam Plant Construction Complete.	12/31/2012 (COMPLETED)
D-00A-13	Consent Decree	Complete Installation of WTP Pretreatment Facility Feed Separation Vessels FEP-SEP-00001A/1B.	12/31/2031
D-00A-14	Consent Decree	WTP Pretreatment Facility Construction Substantially Complete.	12/31/2031
D-00A-15	Consent Decree	Start WTP Pretreatment Facility Cold Commissioning.	12/31/2032
D-00A-16	Consent Decree	WTP Pretreatment Facility Hot Commissioning Complete.	12/31/2033
D-00A-17	Consent Decree	Hot Start of WTP.	12/31/2033
D-00A-18	Consent Decree	Complete Structural Steel Erection Below Elevation 56 ft in WTP Pretreatment Facility.	12/31/2009 (COMPLETED)
D-00A-19	Consent Decree	Complete Elevation 98 ft Concrete Floor Slab Placements in WTP Pretreatment Facility.	12/31/2031
D-00A-20	Consent Decree	Complete Construction of Structural Steel to Elevation 14 ft in WTP HLW Vitrification Facility.	12/31/2010 (COMPLETED)

[40] The "Consent Decree" collectively refers to the Consent Decree in Case No. 2:08-CV-05085-FVS (E.D. WA October 25, 2010), the Amended Consent Decree, Case No. 2:08-CV-05085-RMP (March 11, 2016), the Second Amended Consent Decree, Case No. 2:08-CV-05085-RMP (April 12, 2016), and the Third Amended Consent Decree, Case No. 2:08-CV-5085-RMP (October 12, 2018).

Table A-1. Regulatory Commitments. (2 pages)

Milestone #	Regulation	Description	Due Date
D-00A-21	Consent Decree	Complete Construction of Structural Steel to Elevation 37 ft in WTP HLW Vitrification Facility.	12/31/2012 (COMPLETED)
D-16B-01	Consent Decree	Complete retrieval of tank wastes from the following remaining SSTs in WMA C: C-102, C-105, and C-111.	03/31/2024
D-16B-02	Consent Decree	Complete retrieval of tank wastes from the following SSTs in A and AX Tank Farms: A-101, A-102, A-104, A-105, A-106, AX-101, AX-102, AX-103, and AX-104. Subject to the requirements of Section IV-B-3, DOE may substitute any of the identified nine SSTs and advise Ecology accordingly.	09/30/2026
D-16B-03	Consent Decree	Of the SSTs referred to in Milestones D-16B-01 and D-16B-02, complete retrieval of tank wastes in at least five.	06/30/2021

DOE = U.S. Department of Energy.
Ecology = Washington State Department of Ecology.
HLW = high-level waste.
LAW = low-activity waste.
SST = single-shell tank.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

A1.1 KEY ASSUMPTIONS

The following subsections outline the key starting assumptions for the System Plan Rev. 9 Baseline Case (Scenario 1).

A1.1.1 Model Starting Assumption Alignment

The Model Starting Assumptions for System Plan Rev. 9 align with the following items.

(Note: Revision numbers are provided in this section only. For the remainder of the assumptions, revision numbers will only be provided in the text if the version used is NOT the most up-to-date revision at the time of the approval of System Plan Rev. 9 assumptions. All revisions cited are provided in Section A2.0.)

A1.1.1.1 The schedule given in the Consent Decree for treatment facility start dates and processing rates.

A1.1.1.2 The current Waste Treatment and Immobilization Plant (WTP) flowsheet (24590-WTP-RPT-PT-02-005, Rev. 8, *Flowsheet Bases, Assumptions, and Requirements*).

A1.1.1.3 RPP-40149-VOL1, Rev. 5, *Integrated Waste Feed Delivery Plan, Volume 1 - Process Approach.*

A1.1.1.4 RPP-PLAN-40145, Rev. 6, *Single-Shell Tank Waste Retrieval Plan*, for single-shell tank (SST) retrievals after A and AX Tank Farms.

A1.1.1.5 Minimum SST retrieval durations from RPP-PLAN-40145 and its associated spreadsheet SS-1647, which includes the retrieval duration factors (efficiencies) listed in RPP-40545 (Rev. 5), *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*, with a multiplier of 1, with the exception of SST retrievals in A and AX Tank Farms. Minimum double-shell tank (DST) retrieval durations are assumed to be 128 days per tank based on the time spent actively retrieving the Tank AY-102 heel following the decant to Tank AW-105 as per WRPS-1903385, "DST Retrieval Duration for TOPSim Modeling."

A1.1.1.6 The 2016 low-activity waste (LAW) and high-level waste (HLW) glass formulation models (GFM) (PNNL-25835, 20*16 Update of Hanford Glass Property Models and Constraints for Use in Estimating the Glass Mass to be Produced at Hanford by Implementing Current Enhanced Glass Formulation Efforts*).

A1.1.1.7 Direct-feed low-activity waste (DFLAW) operations prior to the startup of the WTP Pretreatment Facility and WTP HLW Vitrification Facility as described in RPP-40149-VOL1 (Rev. 5).

A1.1.1.8 Near-term operations, including retrievals in A and AX Tank Farms, consistent with the Multi-Year Operating Plan (WRPS-1903490, "WRPS Multi-Year Operating Plan, Revision 8, FY 2020 – FY 2026"). Note that the Multi-Year Operating Plan does not include the third retrieval technologies identified in RPP-PLAN-40145 for the A and AX Tank Farms' retrievals.

A1.1.1.9 A decay date of January 1, 2016 for reporting radionuclides, unless stated otherwise.

A1.2 TANK FARMS

A1.2.1 Single-Shell Tanks

A1.2.1.1 The integrity of the 149 SSTs is described in HNF-EP-0182, *Waste Tank Summary Report for Month Ending March 31, 2019*, with pending changes as agreed to with the Washington State Department of Ecology (Ecology), the U.S. Department of Energy (DOE) Office of River Protection (ORP), and the Tank Operations Contract (TOC) contractor.

Basis: The status of the SSTs is reported monthly in HNF-EP-0182.

A1.2.1.2 Sequencing of interim closure activities does not assume any delays in permitting, assessments, and documents. Although cost and schedule information for closure activities is reflected in the performance measurement baseline (PMB), closure activities are not modeled.

Basis: This assumption is provided in RPP-PLAN-40761, *Integrated Single-Shell Tank Waste Management Area Closure Plan*.

A1.2.1.3 Because closure plans can be approved prior to completing retrieval, sequencing of full closure activities does not assume any delays in permitting, assessments, and documents.

Basis: The basis for this assumption is found in RPP-PLAN-40761 which states, "The [*Resource Conservation and Recovery Act*] RCRA Tier 2 Closure Plan can be approved before all tanks in the WMA have been retrieved."

A1.2.2 Double-Shell Tanks

A1.2.2.1 The 28 DSTs are described in HNF-EP-0182. Twenty-seven of the DSTs are assumed to remain fully operational for the duration of the waste treatment mission, the exception being Tank AY-102.

Basis: This is an enabling assumption. Tank AY-102 will remain out of service after retrieval completion on March 4, 2017 (Settlement Agreement PCHB-14-041c [2014]).

A1.2.2.2 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 tanks in AP Tank Farm, except Tank AP-102, is increased to 454 inches (1.2465 Mgal). The "normal operating limits" for all tanks in the AP Tank Farm, with the exception of Tank AP-102, have already been increased to 454 inches. Tank AP-102 will not immediately have its operating level increased due to flammable gas limitations, but it is assumed to be increased once this issue is resolved.

Basis: This assumption is based on OSD-T-151-00007.

A1.2.2.3 The volume of DST space allocated for tank farm emergencies and emergency returns from the WTP is 1.265 Mgal. This space is distributed among multiple DSTs. Headspace in Group A DSTs, as well as in Tank AP-106 after it is repurposed for DFLAW operations, is not credited towards the emergency space requirement.

Basis: Emergency space is defined in HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program*. Waste transfers into Group A tanks are prevented as a process control on the flammable gas concentration in their headspace. Transferring waste into Tank AP-106 after repurposing would necessitate shutting down DFLAW operations.

A1.2.2.4 No DST space will be reserved for non-emergency returns of supernatant from the WTP. No DST space will be reserved for non-emergency returns of liquid effluents other than 100 kgal reserved in Tank AP-102 for returns during WTP Effluent Management Facility (EMF) downtime.

Basis: This is an enabling assumption. The 100 kgal of space reserved in Tank AP-102 is based on RPP-RPT-60749, *Utilization of Double-Shell Tanks Supporting Key Direct-Feed Low-Activity-Waste Functions*.

A1.2.2.5 Insoluble solids retrieved from the SSTs are assumed to settle in the receiving DST to the same volume percent while in the SST from which the solids were retrieved. This solids loading is maintained when the waste is transferred between DSTs. Solids that precipitate from model solubility calculations are assumed to settle to 24 vol%.

Basis: This is an enabling assumption. The precipitated solids value of 24 vol% is based on an average for the initial DST saltcake inventory in TOPSim.

A1.2.2.6 Controls for buoyant displacement gas release events (BDGRE) are assumed to apply to the DSTs containing an accumulation of settled salts, including the existing restrictions on the current Group A tanks, which will continue to be followed until that waste has been retrieved.

Basis: The solids management strategy for the DSTs is to operate the DSTs so that the tanks do not become Group A tanks (i.e., stay within acceptable BDGRE criteria). For mission planning purposes, a simplified proxy limit of 70 inches of settled salts is used. Preventing accumulation of over 70 inches of settled salts protects against the creation of additional DSTs with BDGRE behavior or that require reduced operating volumes to accommodate flammable gas generation, which is not accounted for by TOPSim.

A1.2.2.7 The depth of settled sludge accumulated in DSTs will be maintained at less than 200 inches with the exception of Tanks AN-101 and AN-106, which will be maintained at less than 300 inches.

Basis: The 200-inch sludge solids limit is based on incremental mixer pump limitations; the solids depth is constrained by the maximum range of vertical placement of a Hanford submersible mixer pump of 12 ft. This assumption is based on RPP-40149-VOL1, Rev. 2.

(Note: Tanks AN-101 and AN-106 may be filled to 300 inches of solids in accordance with WRPS-1403027, “Contract Number DE-AC27-08RV14800, Washington River Protection Solutions LLC Proposed Control of Sludge Depth in 241-AN-101 and 241-AN-106.”)

A1.2.2.8 The strontium and transuranic (TRU) constituents will be precipitated from the Envelope C supernatant currently stored in Tanks AN-102 and AN-107 in the DST system using strontium nitrate ($Sr(NO_3)_2$) and sodium permanganate ($NaMnO_4$) strikes. The supernatant will then be delivered to the WTP LAW Vitrification Facility through the DFLAW process to minimize the possibility of re-complexing.

Basis: This assumption is based on RPP-PLAN-51288, Development Test Plan for Sr/TRU Precipitation Process.

A1.2.2.9 The modeled high-fissile uranium blending strategy concept is assumed to successfully mitigate the uranium enrichment issues with solids in Tank C-104 that have been retrieved to Tank AN-101.

Basis: This assumption is based on RPP-RPT-43828, *Refined Use of AN Farm for C Farm Single-Shell Tank Retrieval*.

A1.2.2.10 Blending of high-zirconium waste currently stored in Tanks AW-103 and AW-105 will be modeled by metering this waste into low-zirconium sludge in the tank farms.

Basis: This assumption is based on HNF-4219, *Alternatives Generation and Analysis for Phase 1 High-Level Waste Feed Tanks Selection*.

A1.2.2.11 Group A tanks—AN-103, AN-104, AN-105, AW-101, and SY-101—will be mitigated by decanting their existing supernatant, then dissolving their saltcake.

Basis: This assumption is based on HNF-4347, *Alternatives Generation and Analysis for Low Activity Waste Retrieval Strategy – Draft*, and the approach defined in RPP-8218, Generalized Feed Delivery Descriptions and Tank Specific Flowsheets.

(Note: The reason Tank AW-106 contains more than 70 inches of settled salts but is not a Group A DST is that it has dilute supernatant [see RPP-10006, *Methodology and Calculations for the Assignment of Waste Groups for the Large Underground Waste Storage Tanks at the Hanford Site*].)

A1.2.2.12 The high-radioactive-cesium Envelope B supernatant currently stored in Tank AZ-101 will be managed as-is, until the startup of the full WTP, at which point it will be delivered to the tank waste characterization and staging (TWCS) capability as slurry feed to the WTP Pretreatment Facility. Until this point, water will be added to Tank AZ-101, as required, to prevent excessive concentration of the supernatant by self-evaporation.

Basis: This assumption is based on preventing the blending of supernatant in Tank AZ-101 with other DST supernatant. Blending of this supernatant results in raising the radioactive cesium concentration in feed to the tank-side cesium removal (TSCR) system, complicating operations, and, also is in opposition to the principle of "as low as reasonably achievable."

A1.2.2.13 During DFLAW operations, the following DSTs will support the DFLAW flowsheet:

- Tank AP-107: TSCR/tank farm pretreatment (TFPT) feed tank
- Tank AP-106: the WTP LAW Vitrification Facility feed tank and TSCR/TFPT pretreated feed receipt tank
- Tank AP-105: TSCR/TFPT feed staging tank
- Tank AP-108: TSCR/TFPT returns receipt tank
- Tank AP-102: the WTP EMF effluent receipt tank (for returns to the tank farms).

Basis: This assumption is based on RPP-RPT-60749.

A1.2.2.14 Tank AW-102 is dedicated as the 242-A Evaporator feed tank for the entire River Protection Project (RPP) mission. Bottoms from the 242-A Evaporator may only be sent to DSTs in the AW and AP Tank Farms.

Basis: All feed lines to the 242-A Evaporator pass through the AW-02E valve pit, making Tank AW-102 the most operationally simple 242-A Evaporator feed tank.

A1.2.2.15 All cross-site slurry transfers from the 200 West Area are delivered to Tank AN-104 and are subject to the available receipt capacity of the tank.

Basis: As per RPP-RPT-47572, *Cross-Site Slurry Line Evaluation Report*, the cross-site slurry transfer line is routed (and terminates) directly into Tank AN-104. Cross-site slurry transfers require a high amount of line pressure to maintain critical velocity over a long distance, and thus must be routed directly into a tank instead of through the lower-pressure-rated 200 East Area transfer lines.

A1.2.3 Waste Retrievals and Transfers

A1.2.3.1 The next group of SSTs to be retrieved after C Tank Farm will be the tanks in AX Tank Farm, then tanks in the A Tank Farm.

Basis: As per RPP-PLAN-40145, "In East Area, C Farm retrieval will be completed first, then A/AX Farm tanks, then the B/BX/BY tank farm grouping."

A1.2.3.2 The modeling goal for sequencing the retrieval of SST waste is to minimize the waste treatment mission duration. This is done by selecting tanks that provide sufficient slurry or supernatant to keep the limiting facilities operating at capacity. In addition, the sequencing must be operationally tractable.

Basis: This is an enabling assumption, which supports the minimization of cost, schedule, and risk in order to support the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement) (Ecology et al. 1989) and Consent Decrees' milestones for completing retrieval of the SSTs and treating the tank waste, such as Milestones D-16B-01, D-16B-02, and D-16B-03.

A1.2.3.3 The retrieval of SSTs will be sequenced using a staggered, overlapping farm-by-farm approach which considers the following:

- Simultaneous retrieval constraints resulting from infrastructure or operational considerations (these are also applied to the retrieval of DSTs at the end of the mission).
- 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 radioactive non-HLW consistent with TRU waste (defined in Public Law 102-579, *The Waste Isolation Pilot Plant Land Withdrawal Act*, as amended by Public Law 104-201).
- Providing a balanced feed to the WTP, such that composition and relative quantities of the feed allow facilities to operate as close to the assumed production curves as is practical, minimizing the overall duration of waste treatment. Priority is given to feeding the more limiting facility.

Basis: This assumption is based on RPP-PLAN-40145.

A1.2.3.4 Although not specifically planned in RPP-PLAN-40145, the SSTs in the S and SX Tank Farms will be the next SSTs retrieved after completion of retrievals in the A and AX Tank Farms. Single-shell tanks containing primarily saltcake will be retrieved first to provide additional feed for DFLAW operations and to limit the amount of sludge stored in the DSTs prior to the startup of the WTP HLW Vitrification Facility. The waste in these SSTs will be retrieved into the DSTs in the SY Tank Farm.

Basis: This assumption is based on RPP-RPT-58854, *Future Tank Retrievals Alternatives Analysis*. The next farms to be retrieved in the 200 West Area are S and SX Tank Farms, which were chosen because they "ensured the availability of adequate feed for DFLAW operations without imposing significant constraints on DST space, provided for good continuity of retrieval operations, and results in a significant reduction of total curies (Ci) stored in the aging SST system."

A1.2.3.5 Prior to starting the SST retrievals in the 200 West Area, the cross-site supernatant line must be operational and the Group A mitigation of Tank SY-103 completed. Additionally, the Group A mitigation of Tank AN-104 must be completed prior to performing cross-site slurry transfers. Required operational dates of the cross-site slurry and supernatant transfer lines will be provided as a model output.

Basis: Tank SY-103 is slated to act as a receiver of 200 West Area SST waste, and, as per RPP-RPT-47572, the cross-site slurry transfer line is routed (and terminates) directly into Tank AN-104. Transfers of waste are not allowed into Group A tanks as per HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*.

A1.2.3.6 The sludge depth in Tanks SY-102 and SY-103 will be limited to 200 inches during retrievals of SSTs in the 200 West Area. However, sludge will be transferred to the 200 East Area when space allows, maintaining levels as low as possible in the tanks in the 200 West Area.

Basis: An increased sludge depth limit in SY Tank Farm is necessary to maintain continuity of SST retrievals in the S and SX Tank Farms prior to the startup of solids processing in the WTP. A limit of 200 inches was chosen due to this being the planned maximum depth for mixer pump operation (see RPP-40149-VOL1, Rev. 2).

A1.2.3.7 Waste retrieved from the B Complex (B, BX, and BY Tank Farms), not including radioactive non-HLW consistent with TRU waste, will be transferred to the B Complex Waste Receiving Facility (WRF), with supernatant 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 stainless-steel lines.

Basis: As per RPP-PLAN-40145, "The waste in the B/BX/BY tank farm grouping, except that handled as [contact-handled transuranic] CH-TRU, will be retrieved and transferred via hose-in-hose transfer lines (HIHTL) to new diversion boxes. From the new diversion boxes, the waste will go via HIHTLs or double-encased stainless-steel lines to the B Complex WRF located nearby. Supernatant used for waste mobilization will preferably be generated at the B/BX/BY complex by dissolution of saltcake with water but could be supplied from a DST to a WRF tank and sent from the WRF tank to the SST."

A1.2.3.8 Waste retrieved from the T Complex (T, TX, and TY Tank Farms), not including waste handled as radioactive non-HLW consistent with TRU waste, will be transferred to a tank in the T Complex WRF, with supernatant 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 stainless-steel lines.

Basis: As per RPP-PLAN-40145, "The waste in the T/TX/TY tank farm grouping, except that handled as CH-TRU, will be retrieved and transferred via HIHTLs to new diversion boxes. From the new diversion boxes the waste will go via HIHTLs or double-encased, stainless-steel lines to the WRF located nearby. Supernatant used for waste mobilization will preferably be generated at the T/TX/TY complex by dissolution of saltcake with water but could be supplied from a DST in the SY Tank Farm to a WRF tank and sent from the WRF tank to the SST."

A1.2.3.9 Each WRF will consist of six tanks, each tank with a 150-kgal operating volume, along with all needed ancillary equipment.

Basis: As per internal memorandum 82400-99-076, "Documentation for SST Retrieval Scope in Phase II," "The WRFs for the [northwest] NW (T, TX, and TY farms) and [northeast] NE (B, BX, and BY farms) quadrants each contain six tanks with an operating volume of 568,000 L (150,000 gal) each [681,000 L (180,000 gal) design capacity per tank]."

A1.2.3.10 The B and T Complex WRFs are assumed to be available as needed to support continuity of retrievals. The dates that the WRFs are first required to be available will be provided as a model output.

Basis: This is an enabling assumption.

A1.2.3.11 The remaining unretrieved SSTs (except those specifically retrieved into WRFs or those handled as radioactive non-HLW consistent with TRU waste) will be retrieved directly into the DST system.

Basis: RPP-PLAN-40145 outlines the current retrieval plan.

A1.2.3.12 During retrieval of waste from SSTs to the DST system, sodium hydroxide (NaOH) and sodium nitrite ($NaNO_2$) will be added, as needed, so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits. Caustic additions for intra-DST transfers and for depletion of caustic soda over time are not modeled.

Basis: This assumption is based on HNF-SD-WM-OCD-015.

A1.2.3.13 For supernatant feed staged for delivery to the WTP Pretreatment Facility from a DST, allow a minimum of 210 days for waste mixing, sampling, and qualification to verify compliance with permits and the safety authorization basis before delivery to the WTP. This time is applied when each staging tank (DST) is filled with feed, but no earlier than the availability of a suitable mixing and sampling capability.

Basis: 24590-WTP-ICD-MG-01-019, *ICD-19 – Interface Control Document for Waste Feed*, calls for 180 days for qualification and 30 days to mix and sample the feed.

A1.2.3.14 A minimum of 112 days is allocated for waste feed sampling and qualification in a DST prior to the waste being delivered to the TCSR or TFPT systems. The first batch of feed will be qualified in Tank AP-107, while subsequent batches will be qualified in Tank AP-105, and then delivered to Tank AP-107.

Basis: Based on RPP-40149-VOL2 (Rev. 5A), *Integrated Waste Feed Delivery Plan Volume 2 – Campaign Plan*, 14 days are required to obtain a sample and 98 days are required for feed qualification.

A1.2.3.15 During full WTP operations, deliveries of feed to the WTP will be timed and sequenced to balance the production of immobilized high-level (IHLW) glass and immobilized low-activity waste (ILAW) glass.

Basis: This is an enabling assumption used to prevent either HLW vitrification or LAW vitrification from running out of feed at any time during the treatment mission.

A1.2.3.16 The use of DSTs to receive retrieved SST waste, manage stored waste, and stage and deliver feed to the WTP in RPP-40149-VOL1, RPP-40149-VOL2, and RPP-40149-VOL3 incorporates information from RPP-PLAN-40145. Rev. 5 of RPP-40149-VOL1 and -VOL3 and Rev. 5A of RPP-40149-VOL2 cover full-mission DST utilization with an emphasis on DFLAW operations, while Rev. 2 of all volumes covers the details of certain aspects of HLW feed delivery operations. Key aspects of RPP-40149-VOL1, -VOL2, and -VOL3 include the following:

- Planned configuration of each DST.
- Timing of upgrades to each DST (based on outputs from the model).
- Entrained solids concentrations or quantities for supernatant transfers.
- The maximum settled solids level that can be effectively mobilized and well mixed using two mixer pumps without incremental insertion capability of 70 inches.
- Mixer pumps with incremental insertion capability (12-ft vertical stroke) can accommodate settled solids layers up to 200 inches, mixing in 70-inch increments.
- Deep sludge tanks with more than 200 inches of settled solids (specifically Tank AN-101) will require another technology, such as sluicing, to retrieve solids down to the 200-inch limit. The use of the second technology, however, is not explicitly modeled at this time.
- After retrieval of the SSTs in S and SX Tank Farms, the goal is to minimize the creation of additional DSTs with more than 70 inches of settled solids.
- In order to simplify operations, mixer pumps will not be operated with less than 72 inches of waste in the DSTs for transfers during normal operations. However, if necessary, mixer pumps can be operated with as little as

36 inches of waste in the tank. This traces to RPP-SPEC-43262, *Procurement Specification for Hanford Double-Shell Tank Submersible Mixer Pumps*, which states mixer pumps are capable of operating in 72 inches of waste depth at 100 percent speed and of being throttled to 30 percent speed. The actual depth is an enabling assumption for what the minimum depth at 30 percent speed might be. Mixer pumps are also limited to mixing a maximum of 300 g/L solids based on the same procurement specification.

- Supernatant transfers from the tank farms to the WTP originate in AP Tank Farm and are transferred through a dedicated supernatant feed line thereby minimizing solids in the supernatant transfers to the WTP. (Letter 10-TPD-131, "Contract No. DE-AC27-08RV14800 – The U.S. Department of Energy, Office of River Protection (ORP) Direction for Washington River Protection Solution LLC (WRPS) to Implement Recommendations for Alternatives for Low-Activity Waste (LAW) Transfers to the Waste Treatment and Immobilization Plant (WTP) as Documented in RPP-RPT-47833, Revision 0, WRPS-1001528 R1 dated September 24, 2010").

Basis: The bases are documented in the individual bulleted items, as applicable.

A1.2.3.17 Slurry batches will be delivered to the TWCS capability for sampling/qualification and subsequent feeding to the WTP Pretreatment Facility.

Basis: This is an enabling assumption.

A1.2.3.18 The residual waste remaining in the SSTs after retrievals are complete will be estimated as described in the following.

- The residual inventory in a 200-series SST will be data that is obtained from the Best-Basis Inventory 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 waste containing 83 wt% water-washed solids with liquids at $5x10^{-4}$ times the concentration (mol/L) of the bulk as-retrieved supernatant.
- The residual waste inventory in a retrieved 100-series SST uses the Best-Basis Inventory data when that information is available, or will be estimated as 300 ft^3 of residual waste containing 83 wt% water-washed solids with liquids at $5x10^{-4}$ times the concentration (mol/L) of the bulk as-retrieved supernatant.

Basis: The residual volumes are conservatively assumed to be the maximum allowed by (Ecology et al. 1989), adjusted downward for a nominal 20 percent estimating uncertainty (as 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.

The wt% solids and liquid remaining in the residual of 200-series SSTs is based on an informal review of post-retrieval waste volume estimates for Tanks C-201, C-202, C-203, and C-204 (e-mail to J.S. Schofield and P.J. Certa, "RE: SST Residual Stuff" [Sasaki 2008]).

The weight percent solids and liquid remaining in the residual of 100-series SSTs is based on an informal review of post-retrieval waste volume estimates for Tanks C-103, C-106, and S-112 (Sasaki 2008).

A1.2.3.19 Double-shell tanks will be retrieved to 300 ft^3 of residual waste, then rinsed three times with 10 kgal of water. The liquid is decanted after each rinse, leaving a final volume of 300 ft^3 of residual waste.

Basis: The residual volumes are conservatively assumed to be the maximum allowed by the Tri-Party Agreement, adjusted downward for a nominal 20 percent estimating uncertainty (as per RPP-37110), until better estimates can be developed. Performing a final, triple rinse of at least three times the residual volume has been a negotiated requirement in past tank waste retrieval work plans (e.g., RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tank Waste Retrieval Work Plan*) and is also included in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, as a method used to avoid requiring a liquid sample from tanks retrieved via sluicing with supernatant. It is assumed that this requirement will apply to future DST retrievals.

A1.2.3.20 For modeling purposes, no waste is assumed to leak from the SSTs during retrieval to ensure that the maximum waste inventory is modeled through the tank waste treatment complex.

Basis: This is an enabling assumption.

A1.2.3.21 SST retrievals are limited to one simultaneous retrieval per area through 2045, and two simultaneous retrievals per area thereafter. This limitation is extended to DST retrievals, which are limited to no more than two simultaneous retrievals per farm, and no more than four total retrievals of either kind (SST or DST) simultaneously.

Basis: Planning for one SST retrieval per area early in the mission is consistent with the current strategy for A/AX Tank Farms' retrievals. Increasing the number of simultaneous retrievals to two after 2045 is required to maintain feed to the WTP. This is a conservative assumption compared to RPP-PLAN-40145 which states, "For planning purposes assume a maximum of two tanks undergoing retrieval in a farm or farm group at one time until WTP operations are close to starting. After WTP startup, the needed infrastructure, DST tank space, and experience are assumed to be in place for up to three simultaneous retrievals in East and West area."

A1.2.3.22 A 2-month delay between the completion of one SST retrieval and the start of the next is assumed.

Basis: Consultation with Washington River Protection Solutions LLC SST Retrieval Field Personnel, Engineering, and Project Controls led to the conclusion that resource availability, particularly funding, was the most important factor in determining time required between retrievals. Available DST space is also a key factor in determining the number of SST retrievals that can occur in a year. Given these findings, it was concluded that system plan modeling scenarios should use 2 months—the maximum time allowed between retrievals without extending the mission.

A1.2.4 Tank Farm Waste Evaporator (242-A Evaporator)

A1.2.4.1 The 242-A Evaporator will be available for no more than six campaigns in any 365-day period to support SST retrievals and to help maintain the sodium concentration in the delivered feed within WTP feed specifications. The evaporator will not be available during known outages, including for the replacement of the failed 242-A Evaporator slurry line.

Basis: As per RPP-RPT-57991 (Rev. 1), *One System River Protection Project Integrated Flowsheet*, six campaigns per year correspond with the capacity of the Treated Effluent Disposal Facility (TEDF) based on the current discharge permit, current usage, and a very conservative assumption of a 25-day campaign duration. The TEDF receives the cooling water from the 242-A Evaporator condenser.

A1.2.4.2 A 104-day 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 processed through the evaporator.

Basis: The 104 days are comprised of 14 days for recirculation and sampling of the feed and 90 days for feed qualification (analysis, evaluation, and approval of the process memo). This is a conservative planning assumption as it has been demonstrated that this process can be completed in 60 days or less by at least two evaporator campaigns because the 242-A Evaporator restarted in 2014.

A1.2.4.3 The 242-A Evaporator processes waste at a slurry rate of 30 to 70 gpm, between a minimum waste volume reduction (WVR) of 15 percent and a maximum boil-off rate of 35 gpm.

Basis: The boil-off rate achieved in the last several evaporator campaigns has been approximately 35 gpm. A minimum fractional WVR of 15 percent has been used in the past as a cut-off for what constitutes a worthwhile evaporator campaign, though it is possible to run a campaign with a lower WVR. See WRPS-1604209, "FW: Guidance Regarding Feed Staging for 242-A," for more information.

A1.2.4.4 Dilute waste will be concentrated until the waste reaches a bulk specific gravity (SpG) of 1.40 or 80 percent of the maximum cesium-137 limit. Feed will not be evaporated if it will achieve less than a 15 percent WVR at the 1.40 bottoms SpG limit or at 80 percent of the maximum cesium-137 limit.

Basis: The bottoms SpG is determined for each 242-A Evaporator campaign based on a balance of minimizing the likelihood of solids precipitation (estimated using boil-down studies) while maximizing available space in the DST system. The historical average bottoms SpG where the optimum balance has occurred is 1.43, but this is projected to shift downward to 1.40 as lower-solubility salts continue to be retrieved from SSTs. This value is used for all modeled 242-A Evaporator campaigns as a simplifying assumption.

A1.2.4.5 The composition of process condensate from the 242-A Evaporator and the releases of non-condensable gases from the condenser to the atmosphere will be estimated dynamically based on the WVR.

Basis: Compositions are estimated using the formulas given in RPP-RPT-52097, *Recommendation for Updating Evaporator Partition Coefficients*. The partition coefficients and split factors used for the aforementioned equations are given in SVF-1778, "HTWOS_Equipment_Splits Rev 8.XLSM." The volume of process condensate will be 1.27 times the WVR to account for the vacuum system steam jets.

A1.2.5 Tank-Side Cesium Removal/Tank Farm Pretreatment

A1.2.5.1 The TSCR system will receive liquid waste from the tank farms beginning March 24, 2023. The TFPT system, which replaces TSCR at the end of its 5-year service life, will receive liquid waste from the tank farms beginning March 24, 2028. These systems will be the source of pretreated supernatant feed for delivery to the WTP LAW Vitrification Facility until the WTP Pretreatment Facility begins operating.

Basis: In order to complete hot commissioning of the WTP LAW Vitrification Facility by December 31, 2023, the TSCR system should be started by March 24, 2023 in order to have a full tank (AP-106) of feed ready to process. This ensures that, during its 5-year design life, the TSCR system is always able to provide feed to the WTP LAW Vitrification Facility at the design rate. The TFPT system must be ready to operate at the end of the design life of the TSCR system.

A1.2.5.2 TFPT will discontinue routine pretreated supernatant deliveries to the WTP LAW Vitrification Facility 3 months before the WTP Pretreatment Facility begins hot commissioning to allow for piping reconfiguration. The TFPT system will serve as an auxiliary source of supernatant feed for the LAW supplemental treatment (LAWST) capability for the remainder of the mission.

Basis: This is an enabling assumption. As per RPP-RPT-55977, *Infrastructure Stewardship Plan*, the scope of this work is not yet defined.

A1.2.5.3 For modeling purposes, waste will be staged between 5 and 6M sodium and with a cesium-137 concentration less than 0.3 Ci/L. Other acceptance criteria constraints are not specifically modeled but can be assessed from the model results.

Basis: MR-50391, *Multi-Year Operating Plan, Revision 8 Pre-Modeling*, and RPP-SPEC-61910, *Specification for the Tank-Side Cesium Removal Demonstration Project (Project TD101)*, provide the basis for this assumption.

A1.2.5.4 For modeling purposes, dead-end filtration will be assumed to remove 100 percent of entrained solids from the TSCR and TFPT systems' feed.

Basis: This is an enabling assumption.

A1.2.5.5 For modeling purposes, both the TSCR and TFPT systems contain three ion-exchange (IX) columns operating in a lead-lag-polish configuration. The instantaneous waste-feed flow rate to the TSCR system is 5 gpm (RPP-SPEC-61910), and the instantaneous waste-feed flowrate to the TFPT system is 9.47 gpm (MR-50461, 20*19 Flowsheet Integration Joint Scenarios)*.

Basis: This assumption is based on RPP-SPEC-61910 and MR-50461. An instantaneous feed rate to the TFPT system of 9.47 gpm is required to supply the WTP LAW Vitrification Facility at an instantaneous rate of 185 kg of sodium per hour (RPP-SPEC-56967, *Project T5L01 Low Activity Waste Pretreatment System Specification*).

A1.2.5.6 The TFPT flowsheet and operating parameters are based on the TSCR system, with a 1.9-volume-scaling factor applied.

Basis: This is an enabling assumption. No decision has been made on the design of the TFPT system. A scaling factor of 1.9 is needed to meet the required feed rate of 9.47 gpm.

A1.2.5.7 The IX media is crystalline silicotitanate (CST), which is non-elutable. The CST maximum loading and decontamination factors are calculated for each cycle using equations that are functions of cesium, potassium, and sodium cation concentrations and a fixed breakthrough cesium-137 concentration endpoint.

Basis: This assumption is based on RPP-SPEC-61910. Loading and decontamination factor functions are based on RPP-RPT-61310, *Tank Side Cesium Removal gPROMS Model (TSCR-SR-06) Cesium Loading Correlation Scenario Acceptance Test Report*.

A1.2.5.8 The number of spent CST columns sent to storage pads is tracked in the model; however, final disposition of the spent CST columns is not addressed. Each storage pad is designed to hold 150 columns.

Basis: As per RPP-SPEC-62054, *TSCR IXC Concrete Storage Pad System: Tank Farm System Infrastructure Upgrades Specification*, the CST column storage pad for DFLAW operations is designed for 150 columns. This is based on the maximum number expected from DFLAW operations. Although viable options have been identified, the strategy for final disposition of the CST columns is not sufficiently developed to allow for modeling.

A1.2.6 Tank Waste Characterization and Staging

A1.2.6.1 The TWCS capability will perform the functions described in internal memorandum 13-ORP-0286, “Request for Approval of the Justification of Mission Need for a Tank Waste Characterization Staging Capability [Update],” in order to perform the following:

- Mitigate the WTP Pretreatment Facility’s technical issues associated with erosion, criticality, and pulse-jet mixing effectiveness.
- Reduce the requirements for the pretreatment pulse-jet mixing full-scale vessel testing program.

- Reduce the time and expense associated with full-scale mixing and sampling demonstration testing in a radioactive waste tank environment at the tank farms.
- Avoid upgrades to the transfer lines and connectors by reducing the need to compensate for transfer line pressure drops over long distances.
- Reduce the need for waste feed delivery online slurry sampling throughout the DST system.
- Meet the particle size criterion in 24590-WTP-ICD-MG-01-019.
- Enable the waste feed to meet the WTP waste acceptance criteria.
- Reduce the potential need for design changes to the WTP Pretreatment Facility driven by difficult-to-mix wastes.
- Enable the WTP design to be finalized and construction completed more expeditiously.
- Provide additional operational flexibility and feed optimization to reduce the future cost and schedule for WTP operations.
- Accommodate operational upsets and reduce the likelihood of the slurry feed being returned to the tank farms.

For modeling purposes, the TWCS capability consists of six 500-kgal tanks that are used for staging slurry feed for delivery to the WTP Pretreatment Facility.

Basis: As per RPP-RPT-45955, *East Area Waste Retrieval Facility Location and Tank Configuration Study*, 500 kgal was chosen as a nominal volume for each vessel in order to meet the waste throughput requirements (given waste sampling time assumptions), which is an enabling assumption in RPP-RPT-44860, *Mission Analysis Report Waste Feed Delivery Projects East Area Waste Retrieval Facility*.

A1.2.6.2 The TWCS capability will be available to receive slurry starting on June 30, 2032.

Basis: In order to meet commitments for treatment of waste identified in the corresponding Consent Decree, the TWCS capability must be available to receive slurry from the tank farms by June 30, 2032.

A1.2.6.3 A minimum of 190 days is allocated to mixing/sampling each TWCS tank of slurry staged for delivery to the WTP Pretreatment Facility.

Basis: This assumption is based on 24590-WTP-ICD-MG-01-019, which requires samples to be delivered to the WTP operations contractor at least 180 days prior to the feed transfer. It is assumed that a TWCS tank full of waste requires 10 days for mixing/sampling. As per email WRPS-1904039, “RE: 242-A Assumption Basis,” DST sampling requires 1 day to complete. The remaining 9 days is allocated to mixing the tank. The reduction in mixing/sampling time from 30 days (for a DST) to 10 days for a TWCS tank was estimated based on each TWCS capability tank having a diameter of 44 ft and being designed specifically for mixing and sampling. Because no formal design has been proposed, a detailed estimate of the actual time required is not available.

A1.2.6.4 The TWCS capability will be the only source of slurry delivered to the WTP Pretreatment Facility.

Basis: This is an enabling assumption.

A1.2.6.5 Transfer line flush volumes for transfers from the TWCS capability to the WTP Pretreatment Facility will be based on a TWCS capability location consistent with Site 5 from RPP-54688/24590-WTP-RPT-ENG-13-030, *One System Consolidated Waste Management Facility Site Evaluation*, which is 15 acres of greenfield (undisturbed ground) located between the 200 East Area tank farms and the WTP HLW Vitrification Facility.

Basis: The location of the TWCS capability, consistent with Site 5 from RPP-54688/ 24590-WTP-RPT-ENG-13-030, is approximately 1,800 ft from the center of the proposed location to the WTP Pretreatment Facility pipe tunnel (as per drawing 24590-PTF-P3-FRP-PZ00002001, "Pretreatment Facility Isometric"). The flush calculates to be approximately 2,700 gal which is rounded to 3,000 gal assuming a 3-inch nominal pipe diameter, allowing for thermal expansion joints (a factor of 1.15); approximately 400 ft of internal piping length from the WTP Pretreatment Facility wall to HLW feed receipt vessel HLP-VSL-00022; and three times the line volume (as per 24590-WTP-ICD-MG-01-01).

A1.2.6.6 All slurry batches delivered to the WTP should be no greater than 145 kgal, including line flushes, and contain between 10 and 200 g of unwashed solids per liter of slurry.

Basis: This assumption is based on 24590-WTP-ICD-MG-01-019, which states that the WTP Pretreatment Facility shall have the capability to receive 145 kgal of slurry per batch, including the line flush from the tank farms. The unwashed solids concentration limit is based on DE-AC27-01RV14136, *Design Construction and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*, and is repeated in 24590-WTP-ICD-MG-01-01. The contract states that the feed concentration will be between 10 and 200 g of unwashed solids per liter, except for feeds from Tanks AZ-101 and AZ-102, where minimum solids content does not apply.

A1.3 WASTE TREATMENT AND IMMOBILIZATION 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.

A1.3.1 General

A1.3.1.1 In the modeling, the WTP is assumed to be operable for as long as the facilities are required. Upgrades are assumed to be performed as necessary to maintain operability, potentially beyond the 40-year design life.

Basis: This is an enabling assumption. DE-AC27-01RV14136 states that WTP shall be designed to have a 40-year operating life. In order to estimate the mission length, it is assumed that each of the WTP facilities will be available to the end of mission, potentially beyond the 40-year design life.

A1.3.1.2 The Balance of Facilities, Analytical 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.

Basis: This is an enabling assumption. In order to estimate the mission length, it is assumed that each of the WTP supporting facilities will be available to the end of mission, potentially beyond the 40-year design life. In the mission modeling, it is assumed that the WTP sampling and analysis will support production.

A1.3.1.3 The integrated facility availability[41] of the WTP is assumed to be 70 percent.

Basis: DE-AC27-01RV14136 requires that the minimum facility availability be equal to or greater than 70 percent. This assumption is implemented by a reduction in LAW and HLW melter rates (Assumptions A1.3.3.1 and A1.3.4.4) and throttling of the WTP Pretreatment Facility rate (Assumption A1.3.2.10) such that the plant availability for the WTP approximates the results of 24590-WTP-RPT-PE-12-002, 20*12 WTP Operations Research Assessment*.

A1.3.1.4 Hot commissioning for the WTP LAW Vitrification Facility will be completed by the end of December 2023. Hot commissioning for the WTP's Pretreatment and HLW Vitrification Facilities will be complete by December 2033. Detailed hot-commissioning plans, however, are not explicitly modeled.

Basis: Startup dates are consistent with the most recent Consent Decree Milestones D-00A-04, D-00A-09, and D-00A-16. Hot commissioning will not affect the mission metrics and, therefore, it is not necessary to simulate the small amount of waste that will be processed during hot commissioning.

A1.3.1.5 Production of ILAW in the WTP LAW Vitrification Facility (via DFLAW operations) will begin at the end of December 2023, after completion of hot commissioning.

Basis: Startup dates are consistent with the most recent Consent Decree Milestone D-00A-09.

A1.3.1.6 Production of IHLW in the WTP HLW Vitrification Facility will begin at the end of December 2033, after completion of hot commissioning.

Basis: As per the most recent Consent Decree Milestone D-00A-17, hot start of the WTP will begin on or before December 31, 2033.

[41] The determination of integrated facility availability for the purpose of WTP facility design compliance is estimated by the Operations Research Assessment (24590-WTP-RPT-PE-12-002) and defined as the total time to treat all tank wastes, with no reliability/availability/maintainability/inspectability failures applied, divided by the total time to treat all tank wastes, with all failures applied (DE-AC27-01RV14136).

A1.3.1.7 The WTP is assumed to not return any waste streams or wastewater back to the DST system.

Basis: This is an enabling assumption. Returns to the DSTs in the tank farms from WTP is considered an off-normal event and is not modeled. The space to receive WTP returns is counted as part of the emergency space allocation.

A1.3.1.8 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 effects on the assumed performance of or the schedule for the WTP. Notwithstanding technical issue resolution, the current version of 24590-WTP-ICD-MG-01-019 is assumed for current mission planning purposes.

Basis: This is an enabling assumption. Startup dates are consistent with the Consent Decree and it is assumed that any issues will be resolved to allow this schedule to be met.

A1.3.1.9 The delivered feed and internal WTP material flows and accumulations are assumed to be consistent with the WTP authorization basis.

Basis: This is an enabling assumption. It is assumed that the integrated management process for 24590-WTP-ICD-MG-01-019, as described in 24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria*, 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.

A1.3.1.10 Feed projected to be delivered to the WTP will be screened 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 but serve to identify areas of further inquiry.

Screening is performed on point estimates of the as-delivered feed composition and associated parameters. The criteria sets to be used are the following:

- Table titled “Waste Feed Acceptance Criteria” from 24590-WTP-ICD-MG-01-019.
- Table titled “Treated LAW Feed Acceptance Criteria” from 24590-WTP-ICD-MG-01-030, *ICD 30 – Interface Control Document for Direct LAW Feed*, for supernatant supplied directly from Tank AP-106 to the WTP LAW Vitrification Facility.

Only the subset of waste feed acceptance criteria with action limits that are currently tracked in the TOPSim model will be used for screening purposes.

Basis: Based on previous feed screening, some delivered feed is expected to fall outside of the screening criteria. To ensure that projected feed batches comply with the final waste acceptance criteria, multiple iterations may be required to fully define an acceptable set of feed requirements and to update the process strategy in RPP-40149-VOL1 (Rev. 5).

A1.3.1.11 The WTP flowsheet (e.g., equipment configuration, capacities, chemical reactions and extents, operating modes and logic, process splits and decontamination factors) used for mission modeling will be based on 24590-WTP-RPT-PT-02-005. Additional details for modeling are available in 24590-WTP-MDD-PR-01-002, *Dynamic (G2) Model Design Document*. Flowsheet and operating mode modifications are approved by ORP, as needed, to implement the other assumptions in this system plan. The following modifications have been made:

- Both WTP HLW Vitrification Facility melter and offgas trains have been combined into one train, with throughput equivalent to two trains.
- Both WTP LAW Vitrification Facility melter and offgas trains have been combined into one train, with throughput equivalent to two trains.
- The internal WTP equipment and line flushes are not modeled.
- The WTP facility and process ventilation systems are not modeled.
- Aqueous and solid phase densities use the tank farms' basis rather than the WTP basis.
- The facility availability includes downtime for major facility equipment changeout (e.g., LAW and HLW melters).
- The glass formulation process is performed using the 2016 GFMs rather than the WTP GFMs.
- The vessels associated with the WTP Balance of Facilities are not specifically modeled; however, the various cold chemicals are modeled.
- The IHLW canister decontamination system is not modeled; however, the chemical additions resulting from this process are included.
- The ILAW container decontamination system is not modeled.
- The WTP Analytical Laboratory is not modeled.
- The impurities associated with the glass formers are not modeled.
- The entrainment of glass oxides in the offgas and subsequent recycle streams are not modeled.

Basis: The WTP flowsheet is defined in 24590-WTP-RPT-PT-02-005, with further details provided in 24590-WTP-MDD-PR-01-002.

A1.3.2 Waste Treatment and Immobilization Plant Pretreatment Facility

A1.3.2.1 When the WTP requests delivery of slurry, the HLW feed receipt tanks at the WTP will have sufficient space to receive no greater than 145 kgal of slurry from the DST system without interruption (including associated transfer line flushes).

Basis: This is based on 24590-WTP-ICD-MG-01-019.

A1.3.2.2 When the WTP requests delivery of supernatant, the LAW feed receipt tanks at the WTP will have sufficient space to receive a nominal 1.125 Mgal of feed from the DST system without interruption (including associated transfer line flushes) to avoid deliveries of small batches tying up a DST for extended periods.

Basis: DE-AC27-01RV14136 requires that 1.5 Mgal of space is provided at the WTP to receive and store supernatant from the DST system. Space allocated for receiving feed is 1.125 Mgal, while the remaining 0.375 Mgal of space is reserved for storage.

A1.3.2.3 The WTP Pretreatment Facility will be configured so that a portion of concentrated pretreated LAW from the treated LAW concentrate tank can be transferred to a LAWST facility as feed. This is downstream of the point to which the condensate from the LAW submerged bed scrubber and wet electrostatic precipitator systems is recycled, so the feed to a LAWST facility will include a proportional fraction of recycled condensate from both LAW treatment facilities. The treated LAW concentrate tank feeds the WTP LAW Vitrification Facility as its first priority, with excess going to a LAWST facility.

Basis: The LAWST capability is not included in the WTP Pretreatment Facility design; however, the flowsheet for the LAW concentrated storage vessel in the WTP Pretreatment Facility provides discharge capability to a future alternate LAW process (24590-WTP-RPT-PT-02-005).

A1.3.2.4 The ultrafiltration process and cesium IX systems are assumed to operate at 113°F (45°C).

Basis: The temperatures of the pretreatment vessels are based on 24590-WTP-MDD-PR-01-002.

A1.3.2.5 The ultrafiltration process system will operate in the “back-end” leaching mode. Back-end leaching is defined as caustic leaching in the ultrafiltration feed vessels as opposed to front-end leaching, where caustic leaching occurs in the ultrafiltration preparation vessels.

Basis: Back-end leaching is the preferred configuration and is the flowsheet described in 24590-WTP-MDD-PR-01-002.

A1.3.2.6 Caustic leaching is performed on any ultrafiltration batch that contains solid gibbsite or boehmite.

Basis: Leaching reduces the amount of IHLW and is required by DE-AC27-01RV14136.

A1.3.2.7 The extent of sludge dissolved by caustic leaching is defined by the Integrated Solubility Model (ISM).

Basis: The ISM is used throughout the model to estimate the phase of components based on the chemistry of a solution. It is described in RPP-RPT-50703, *Development of a Thermodynamic Model for the Hanford Tank Waste Operations Simulator (HTWOS)*, and RPP-RPT-58972, *ISM Simple Solubility Change Evaluation*.

A1.3.2.8 An oxidative leaching process, which removes chromium from the slurry, will be implemented in the ultrafiltration process system. The oxidative leach process will only be applied to slurry feed batches containing at least 0.5 wt% chromium.

Basis: Oxidative leaching is required by DE-AC27-01RV14136 and is described in 24590-WTP-RPT-PT-02-005. The chromium criteria are also available in 24590-WTP-RPT-PT-02-005.

A1.3.2.9 The constituents that remain on the spent cesium IX resin are assumed to be negligible for system planning purposes and will not be modeled at this time.

Basis: This is an enabling assumption. The estimated amount of constituents left on an eluted column is relatively small and will vary with conditions.

A1.3.2.10 The modeled throughput of the WTP Pretreatment Facility is throttled to account for the integrated facility availability described in Assumption A1.3.1.3.

Basis: The WTP Pretreatment Facility availability is defined in DE-AC27-01RV14136, and the approach to implement it in G2 modeling is documented in RPP-RPT-58581, *Facility Availability Application in the Hanford Tank Waste Operations Simulator (HTWOS) Model*.

A1.3.3 Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility

A1.3.3.1 The net WTP HLW Vitrification Facility capacity will be ramped as follows:

Starting	Rate (MTG/Day)
12/31/2033	3.0
12/31/2034	4.0
09/30/2036	4.2 (see basis)
12/31/2038	5.25

Basis: September 30, 2036 is selected such that the Consent Decree's definition for achievement of initial plant operations—"over a rolling period of at least 3 months leading to the milestone date, operating the WTP to produce high-level waste glass at an average rate of at least 4.2 metric tons of glass (MTG)/day…"—allows completion of the most recent Milestone D-00-A01 by December 31, 2036.

A1.3.3.2 The average bulk density of IHLW will be 2.66 kg/L at 20°C; the average density of the molten glass used in the melter will be 2.45 kg/L.

Basis: These requirements are based on crucible density data and estimated volume percent void content as per 24590-WTP-RPT-PT-02-005.

A1.3.3.3 On average, each canister of IHLW will be filled to 39.8 ft^3 (1.127 m^3) and will contain an average of 3.0 MTG.

Basis: This is based on filling a canister with ⅜-inch thick walls to 95 percent full (1.127 m^3) of glass with a bulk density of 2.66 kg/L. DE-AC27-01RV14136, Section C, Specification 1, Section 1.2.2.1.2, requires that, on average, the canisters will be filled to 95 percent of the volume of an empty canister. The corresponding glass volume for nominal canister dimensions is estimated by 24590-HLW-M0C-30-00003, *HLW Glass Canister Weight and Volume Calculations*. This is also consistent with the estimate provided in 24590-HLW-M0-30-00001001, *HLW Test Canister Assembly*.

A1.3.3.4 The composition, properties, and waste oxide loading of IHLW glass will be estimated using the 2016 HLW GFM.

Basis: The 2016 HLW GFM is the current project baseline and is documented in PNNL-25835.

A1.3.3.5 For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals.

Basis: This is a simplifying assumption.

A1.3.3.6 One HLW melter is assumed to be replaced every 2.5 years on average and contains approximately 823 gal of glass. The time required to change spent HLW melters is not explicitly modeled; however, the replacement of spent melters is already accounted for in the net production capacity assumptions.

Basis: This assumes two melters, each with a 5-year minimum design life as defined in 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-inch heel remaining after the maximum pour and includes an allowance for increased volume caused by corrosion of the refractory (memorandum from M. Hall, "HLW Melter Glass Inventory" [Hall 2004]); other contributions to the source term are neglected. No credit is taken for purging the melter with "cold" glass prior to removal from service.

A1.3.3.7 The production rate of an HLW melter may be affected by the composition of delivered feed batches. Specifically, if feed batches are too dilute, the production rate will be reduced to account for energy redirected to evaporating water within the melter.

Basis: 24590-WTP-RPT-PT-02-005 provides an algorithm for calculating the production rate of an HLW melter based on the water content of the feed.

A1.3.4 Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility

A1.3.4.1 When the WTP Pretreatment Facility begins operating, the WTP LAW Vitrification Facility will receive all of its feed from the WTP Pretreatment Facility.

Basis: This is consistent with the WTP flowsheet described in 24590-WTP-RPT-PT-02-005.

A1.3.4.2 Prior to WTP Pretreatment Facility operations (i.e., during DFLAW operations), the WTP LAW Vitrification Facility will receive supernatant exclusively from the TSCR and TFPT systems.

Basis: This assumption is consistent with the current near-term plans outlined in the Multi-Year Operating Plan.

A1.3.4.3 During DFLAW operations, the effluent from the WTP LAW Vitrification Facility offgas submerged bed scrubber and caustic scrubber will be routed to the WTP EMF.

Basis: This assumption is based on the LAW liquid effluents process description for the radioactive liquid waste disposal system in 24590-WTP-RPT-PT-02-005.

A1.3.4.4 The net WTP LAW Vitrification Facility capacity will be ramped as follows.

Starting	Rate (MTG/Day)
12/31/2023	9.0
07/31/2024	18.0
07/31/2025	21.0

Basis: This rate assumes two LAW melters each producing 15 MTG/day designed at a 70 percent total operating efficiency. DE-AC27-01RV14136, Section C.7(b), "Waste Treatment Capacity Requirements," specifies that the WTP LAW Vitrification Facility will support a combined design capacity of 30 MTG/day, with a minimum integrated total operating efficiency of 70 percent.

A1.3.4.5 The average density of molten ILAW glass will be 2.45 kg/L.

Basis: This assumption is based on crucible density data and estimated volume percent void content as per 24590-WTP-RPT-PT-02-005.

A1.3.4.6 The mass of glass contained in a filled ILAW container will be estimated using an average bulk density of 2.58 kg/L.

Basis: This assumption is based on crucible density data and estimated volume percent void content as per 24590-WTP-RPT-PT-02-005.

A1.3.4.7 On average, each package of ILAW will be filled to 564 gal and will contain 5.51 MTG.

Basis: DE-AC27-01RV14136 requires filling a package to 90 percent (2.135 m^3) of glass with a bulk density of 2.58 kg/L.

A1.3.4.8 The total sodium loading of ILAW glass from pretreated feed will be determined using the 2016 LAW GFM.

Basis: The 2016 LAW GFM is the current project baseline and is documented in PNNL-25835.

A1.3.4.9 For modeling purposes, the glass-forming chemicals are assumed to be supplied as pure oxides rather than impure minerals.

Basis: This is a simplifying assumption.

A1.3.4.10 One LAW melter is assumed to be replaced every 2.5 years on average and contains approximately 1,875 gal of glass. The time required to change spent LAW melters is not explicitly modeled; however, the replacement of spent melters is already accounted for in the net production capacity assumptions. In addition, spent LAW melters will be managed and disposed of at the Integrated Disposal Facility (IDF) as mixed low-level waste.

Basis: This assumes two melters, each with a 5-year minimum design life, as 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 caused by corrosion of the refractory and reflects the heel remaining after the maximum pour; other contributions to the source term are neglected. No credit is taken for purging a melter with “cold” glass prior to removal from service.

A1.3.4.11 The LAW melter production rate may be affected by the composition of delivered feed batches. Specifically, if feed batches are too dilute, the production rate will be reduced to account for energy redirected to evaporating water within the melter.

Basis: 24590-WTP-RPT-PT-02-005 provides an algorithm for reducing the melter rate based on feed composition.

A1.3.5 Waste Treatment and Immobilization Plant Effluent Management Facility

A1.3.5.1 During DFLAW operations, the WTP EMF will receive effluent from the WTP LAW Vitrification Facility submerged bed scrubber, wet electrostatic precipitator, caustic scrubber, and plant wash systems.

Basis: This assumption is based on 24590-WTP-MRR-PENG-16-001, *DFLAW 100% Recycle Using 2013 Glass Model*.

A1.3.5.2 The WTP EMF flowsheet consists of a feed tank, a solids filter, an evaporator, a condenser, and evaporator concentrate and condensate tanks. The solids filter is not modeled because solids are not modeled as going to the WTP EMF.

Basis: This assumption is based on 24590-WTP-MRR-PENG-16-001.

A1.3.5.3 The WTP EMF will only operate during DFLAW operations. When the WTP Pretreatment Facility begins operating, the WTP EMF will be shut down.

Basis: The purpose of the WTP EMF is to manage waste treatment effluents prior to the startup of the WTP Pretreatment Facility.

A1.3.5.4 The WTP EMF evaporator concentrates submerged bed scrubber effluent to a target SpG of 1.2, a chlorine anion concentration of 2 wt%, or a cesium-137 concentration of 1.9×10^{-4} Ci/L, whichever is reached first.

Basis: Solids may precipitate as evaporator bottoms near saturation above a SpG of 1.2. The SpG is limited to prevent solids from precipitating. The chlorine anion concentration limit was established to prevent excessive corrosion in the evaporator. The amount of cesium-137 is limited to stay within design criteria.

A1.3.5.5 The WTP EMF evaporator overheads and the caustic scrubber effluent are sent to the Liquid Effluent Retention Facility (LERF)/Effluent Treatment Facility (ETF).

Basis: These streams are defined in RPP-RPT-57991 (Rev. 2).

A1.3.5.6 One hundred percent of the WTP EMF evaporator concentrated bottoms is recycled to the WTP LAW Vitrification Facility feed receipt tank.

Basis: As per 24590-WTP-MDD-PR-01-002, WTP "EMF recycle is sent from DEP-VSL-00003A/B/C to LCP-VSL-00001/2 during normal operations," and WTP "EMF recycle is sent from DEP-VSL-00003A/B/C to tank-farm AP tanks during abnormal operations." However, off-normal operations are not modeled in TOPSim.

A1.3.5.7 The recycled WTP EMF bottoms returned to the WTP LAW Vitrification Facility are blended with incoming supernatant feed such that the variability of recycle volume per LAW vitrification batch is minimized.

Basis: Recycle of dilute secondary waste adds water to the melter feed, which can slow the melter production rate. Leveling the recycle per batch reduces the amount of water in the batch and potentially increases the production rate. It also promotes improved glass loading by minimizing spikes in sulfate and chloride concentrations.

A1.4 SUPPLEMENTAL TREATMENT

A1.4.1 Low-Activity Waste Supplemental Treatment

A1.4.1.1 For the purposes of this system plan, the LAWST capacity is assumed to be provided by a LAWST capability located in the 200 East Area adjacent to the WTP.

Basis: This is an enabling assumption.

A1.4.1.2 The LAWST capability is not assumed to consist of a particular treatment technology. Multiple technologies will be analyzed, and, based on the waste processed by LAWST, estimated amounts of various proposed immobilized waste forms will be reported (e.g., glass, grout). For modeling purposes, the LAWST capability will be a vitrification process with the same design and GFMs as the WTP LAW Vitrification Facility. Waste product quantities will be specified in terms of immobilized glass and a grout waste form.

Basis: This is an enabling assumption. A specific technology and associated design have not been selected.

A1.4.1.3 The LAWST capability will receive "excess" pretreated LAW from the WTP Pretreatment Facility as per Assumption A1.3.2.3.

Basis: This is an enabling assumption required to keep the RPP mission on schedule.

A1.4.1.4 The LAWST capability will receive pretreated supernatant from the TFPT system during full WTP operations, as availability and capacity permits.

Basis: This is an enabling assumption to maximize LAWST utilization and prevent LAW treatment from limiting the mission.

A1.4.1.5 The net capacity of the LAWST capability will be selected with the goal that the combined LAW treatment capacity will be large enough so as to not drive the mission duration.

Basis: This is an enabling assumption included to prevent LAW treatment from limiting the RPP mission.

A1.4.1.6 Hot commissioning of the LAWST capability is not specifically modeled. No ramp-up period for the capability is currently assumed. Instead, the capability is modeled as an additional treatment capacity available as needed to ensure that LAW treatment is not limiting HLW treatment. The LAWST need date and average/surge capacity will be estimated as an output of the model. In order to compare to the WTP, the treatment capacity is specified in terms of an immobilized glass waste form (MTG/day).

Basis: This is a simplifying assumption.

A1.4.2 Supplemental Radioactive Non-High-Level Waste Treatment

A1.4.2.1 A supplemental radioactive non-HLW (consistent with TRU waste as defined in Public Law 102-579) treatment and packaging process will be available as budget and resource constraints allow. The start date will be determined by analyzing the cost profile to pinpoint the timeframe that results in the lowest increase in annual costs.

Basis: The supplemental non-HLW treatment and packaging process is an independent process within the RPP flowsheet, and can be initiated at any time, as funding allows.

A1.4.2.2 The supplemental radioactive non-HLW (consistent with TRU waste as defined in Public Law 102-579) treatment and packaging process will treat a maximum of 8,040 gal per day of slurry retrieved from tanks assumed to contain waste consistent with TRU waste at a 1:1 dilution of solids with water at 67 percent total operating efficiency.

Basis: This is based on RPP-21970, *CH-TRUM WPU&SE 11-Tank Material Balance*.

A1.4.2.3 The SSTs assumed to contain non-high-level radioactive sludge consistent with TRU waste (as defined in Public Law 102-579) are Tanks [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 to match the order reflected in the PMB.

Basis: The CH-TRU SSTs are identified in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site*, Richland, Washington.

A1.4.2.4 The supplemental waste treatment and packaging system for tanks containing radioactive non-HLW consistent with TRU waste will first be located near the B Tank Farm and then moved to the T Tank Farm. There will be a minimum 10-day outage between tank retrievals and a minimum 180-day outage to move equipment between farms.

Basis: This is based on assumptions developed during the initial project planning.

A1.4.2.5 Waste previously assumed to be remote-handled transuranic waste (SSTs T-105, T-107, T-112, B-107, B-110, and B-111 and DSTs SY-102, AW-103, and AW-105) will be retrieved and treated as HLW at the WTP.

Basis: This assumption is based on an email from B.J. Harp to P.J. Certa et al., "HTWOS Model Assumption" (Harp, B.J. 2008-11-02).

A1.4.2.6 The process flowsheet for the treatment of radioactive non-HLW consistent with TRU waste is described in the material balance for the waste tanks. The flowsheet is assumed to use the "dry batch mode." The process flowsheet contains two dryers that are modeled as one continuous dryer of equivalent treatment capacity.

Basis: This is a simplifying assumption based on the information provided in RPP-21970.

A1.4.2.7 The dried waste product from the packaging process for the radioactive non-HLW consistent with TRU waste is assumed to be packaged in 55-gal drums containing no more than 620 lbs of product per drum.

Basis: This assumption is based on RPP-21970.

A1.4.2.8 Liquid effluent will either be transferred to the LERF via tank trucks or recycled to the retrieval project. For planning purposes, the liquid effluent is assumed to be transferred only to LERF (no recycle) and will be modeled as a continuous pipeline transfer. The volume of effluent transferred will be provided as a model output.

Basis: This is an enabling assumption to account for the potential volume of effluent generated.

A1.5 INTERFACING FACILITIES

A1.5.1 Liquid Effluents

A1.5.1.1 The capacities and capability of the ETF, LERF, State-Approved Land Disposal Site (SALDS), and TEDF will be driven by the needs of the waste treatment mission and are assumed to be available when needed.

Basis: This is an enabling assumption.

A1.5.1.2 If the treatment mission requires a new secondary liquid waste treatment facility or that changes are made to the ETF, LERF, SALDS, or TEDF or the associated operating plans, it is assumed that the required facility will be constructed or required changes will be made.

Basis: This is an enabling assumption.

A1.5.1.3 The Secondary Liquid Waste Treatment Project will determine how best to provide the needed treatment capability for the secondary liquid waste—options may include upgrades to ETF or the use of other technologies. For modeling purposes, this system plan assumes that the project will select ETF upgrades to provide the needed capability.

Basis: This is an enabling assumption. RPP-RPT-50967, *Secondary Liquid Waste Treatment Project (T3W08) Conceptual Design Report*, analyzes various options for providing the capacity.

A1.5.1.4 The LERF consists of three basins, each with an operating volume of 7.8 Mgal, which are used to provide lag storage of liquid effluent. For planning purposes, only two of the basins will be allocated to support the waste treatment mission; the third basin will be reserved for *Comprehensive Environmental Response, Compensation, and Liability Act* effluents.

Basis: The LERF is described in HNF-SD-WM-SAD-040, *Liquid Effluent Retention Facility Final Hazard Category Determination*, and RPP-RPT-61923, *Effluent Treatment Facility Assessment of Flowsheet Impacts from the Hanford Tank Waste Treatment and Immobilization Plant Effluent Management Facility Waste Profile*.

A1.5.1.5 The ETF will be modeled as a black box. Chemicals (e.g., those for bulking or stabilization of the solid waste form) will not be tracked.

Basis: The partitioning of feed into solid waste and treated effluent is approximated as per HNF-4573, *Liquid Effluent Retention Facility Basin 44 Process Test Post-Report*.

A1.5.1.6 The SALDS will not be modeled; it is assumed to provide the needed disposal capacity.

Basis: This is a simplifying/enabling assumption. The SALDS is not a radioactive facility.

A1.5.1.7 The TEDF will not be modeled.

Basis: Specific TEDF operations are outside the scope of the system plan.

A1.5.1.8 The inputs to the LERF will include estimated volumes of rainwater that falls on the LERF basins and leachate from the IDF, mixed-waste trenches, and K Basins.

Basis: The volume estimates are provided in WRPS-2001669, "RE: ETF Replacement Cost Estimates and Tanker Delivery Expectations" (email to A.J. Schubick from B.T. Angevine, April 30, 2020).

A1.5.2 Central Waste Complex

A1.5.2.1 The Central Waste Complex (CWC) is assumed to support the needs of the waste treatment mission and to be available when needed. The demand on the CWC will not be modeled.

Basis: This is an enabling assumption.

A1.5.2.2 The packaged radioactive non-HLW consistent with TRU waste is assumed to be stored at the CWC until final disposition of the waste has been determined.

Basis: The requirements in HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, allow the CWC to accept TRU and transuranic mixed wastes in a certifiable form, with no identifiable disposition path only with case-by-case approval from the DOE Richland Operations Office. The CWC is assumed to provide, to the extent practical, permitted waste storage and characterization for potential CH-TRU tank waste that is packaged by the supplemental TRU waste treatment system.

A1.5.3 Interim Hanford Storage

A1.5.3.1 The Interim Hanford Storage (IHS) facility will receive and temporarily store canisters of IHLW, pending the availability of a final disposal alternative.

Basis: WRPS-1003700, "Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Transmits Justification of Mission Need for the Interim Hanford Storage Facility," and RPP-23674, *Immobilized High-Level Waste Interim Hanford Storage System Specification*, address the IHS design.

A1.5.3.2 The IHS facility will be located in the 200 East Area near the WTP HLW Vitrification Facility and will provide interim storage for a minimum of 4,000 IHLW canisters. The IHS facility will be expandable in increments of 2,000 canisters up to a maximum of 16,000 canisters, if needed, to mitigate the risk associated with the availability of offsite geological storage.

Basis: This assumption is based on RPP-23674.

A1.5.3.3 The IHS facility is assumed to be available to support hot commissioning 3 months before the hot start of the WTP HLW Vitrification Facility.

Basis: Additional information on IHS is provided in RPP-RPT-52176, *Interim Hanford Storage Conceptual Design Report*.

A1.5.3.4 The first 2,000-canister IHS vault is assumed to be available when needed to support hot commissioning of the WTP HLW Vitrification Facility.

Basis: This is an enabling assumption.

A1.5.3.5 The second 2,000-canister IHS vault is assumed to be available 1.5 years in advance of the projected need date.

Basis: This assumption is based on RPP-23674.

A1.5.3.6 It is assumed that all IHLW canisters produced meet the waste acceptance criteria of the Federal Geological Repository.

Basis: This is an enabling assumption. Off-normal operations are not modeled.

A1.5.3.7 The average canister receipt and retrieval capability of the IHS facility will each be 800 canisters per year (approximately 25 percent above the average net production capacity required), with a peak handling rate of three canisters per day. This capacity does not constrain IHLW production; instead, this capacity provides information to identify when the IHS facility and Hanford Shipping Facility (HSF) are required.

Basis: This assumption is based on RPP-23674.

A1.5.4 Hanford Shipping Facility

A1.5.4.1 The HSF will be located in the 200 East Area and will provide the capability for shipping IHLW canisters to a potential national repository. The future shipping facility may be located adjacent to the IHS facility such that some IHLW canister handling functions can be shared, eliminating the need for cask transport between two separate facilities.

Basis: This assumption is based on RPP-20270, *Hanford Shipping Facility System Specification*.

A1.5.4.2 Eleven years prior to the third IHS module being needed (based on model output), a decision is assumed to be made to either continue building additional canister storage modules or construct the HSF. For planning purposes, the outcome of this decision is assumed to be that the HSF will be constructed and IHLW canisters are shipped to an offsite final disposal alternative (see Assumption A1.5.5) rather than building additional IHS modules.

Basis: This is an enabling assumption to determine the start date of the HSF and constrain the IHS to two modules.

A1.5.4.3 The canister shipping capability of the HSF is assumed to match the retrieval capability of the IHS facility in Assumption A1.5.3.7. When the HSF begins shipping, the first priority will be given to shipping newly created IHLW canisters beyond those stored at the IHS facility, and second priority will be given to emptying the IHS facility after HLW vitrification is finished. Shipping needs will be estimated with the IHS facility being operated with approximately 1 year’s worth of available capacity to decouple receipt of WTP canisters from shipping to a national repository. This capacity does not constrain IHLW production; instead, this capacity provides information to identify when the IHS facility and HSF are required.

Basis: This is an enabling assumption to determine the start date of the HSF and constrain the IHS to two modules.

A1.5.5 Final Disposal Alternative

A1.5.5.1 The final disposal alternative for IHLW glass canisters is assumed to be at an unidentified offsite national repository.

Basis: This is an enabling assumption. Establishment of a national HLW repository is outlined in the *Nuclear Waste Policy Act*.

A1.5.6 Integrated Disposal Facility

A1.5.6.1 The IDF is assumed to be operational when needed and will provide permanent disposal for the ILAW, other mixed low-level waste, and low-level waste.

Basis: This is an enabling assumption.

A1.5.6.2 As per the PMB, the IDF will receive ILAW glass packages from the WTP; solid waste from the TOC and WTP, including spent LAW melters; 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 cumulatively modeled (e.g., the cumulative inventory that is retained on disposable filters will be modeled, but the mass, composition, and volume of the filter media will not be tracked).

Basis: The final disposition of spent HLW melters has not yet been determined. The many alternatives in DOE/EIS-0391 assume that these spent HLW melters will be packaged in an overpack and stored at the IHS facility until the melters can be removed for disposition. For planning purposes, the final disposition of the 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 that addresses HLW melter disposal is published.

A1.5.6.3 For planning purposes, the IDF can be expanded as needed, up to six cells, to support the mission without interference from other projects that dispose of waste at IDF.

Basis: Additional information is provided in DOE/RL-2012-57, *Annual Summary of the Integrated Disposal Facility Performance Assessment 2012*.

A1.5.7 222-S Laboratory

A1.5.7.1 The laboratory services required to support waste characterization for TOC projects and operations are assumed to be available and provided in a timely manner.

Basis: This is an enabling assumption.

A1.5.7.2 The 222-S Laboratory is assumed to transfer 5 kgal/year of waste (see Assumption A1.6.1.2) to the tank farms (Tank SY-101) before the startup of the WTP, and 10 kgal/year thereafter.

Basis: This is estimated based on past waste volume transfers from the 222-S Laboratory as provided in RPP-33715, *Double-Shell and Single-Shell Tank Inventory Input to TOPSim*.

A1.5.8 Waste Encapsulation and Storage Facility

A1.5.8.1 Cesium and strontium capsules are assumed to be dispositioned by the DOE Richland Operations Office outside of the WTP and tank-farm facilities.

Basis: This is an enabling assumption pending a formal decision.

A1.5.9 Waste Isolation Pilot Plant

A1.5.9.1 Permitting and operational requirements to accept the Hanford radioactive non-HLW consistent with TRU waste that is planned to be disposed of at the Waste Isolation Pilot Plant will not affect the schedule’s critical path.

Basis: This is an enabling assumption.

A1.5.10 Other Hanford Site Facilities

A1.5.10.1 Sludge generated from cleanup of the Hanford K Basins is assumed to be dispositioned by the DOE Richland Operations Office outside of the WTP and tank-farms facilities.

Basis: This is an enabling assumption pending a formal decision.

A1.5.10.2 The T Plant facility is assumed to transfer a one-time, 15-kgal batch of waste circa 2032 to the tank farms as part of its deactivation. The transfer will include a flush equal to 22 vol% of the waste transferred.

Basis: This is an enabling assumption to account for the waste that may be generated.

A1.5.10.3 Waste from the retrieval of the miscellaneous underground storage tanks (6/*9active and inactive) will be transferred to the tank farms in a series of transfers starting when WTP begins full operations. The intent is to eventually update the Project Life-Cycle Schedule with this information.

Basis: This is an enabling assumption to account for the waste that may be generated.

A1.6 CROSS-CUTTING ASSUMPTIONS

A1.6.1 General

A1.6.1.1 In general, the inventory for tanks with waste-intrusive activities are updated in the Tank Waste Information Network System once per quarter.

Basis: The tank inventory update for the process assumptions and related calculations in System Plan Rev. 9 are described in RPP-33715.

A1.6.1.2 Wastes from the miscellaneous underground storage tanks, deactivation of miscellaneous Hanford facilities, and operation of the 222-S Laboratory are transferred to the DSTs and treated in the WTP.

Basis: Estimates of the inventory for these facilities are based on RPP-33715.

A1.6.1.3 All solubility activities (including water washing and caustic leaching) will be modeled using the ISM.

Basis: The ISM is described in RPP-RPT-50703 and RPP-RPT-58972.

A1.6.1.4 Supernatant liquid density and SpG will be estimated based on composition.

Basis: Estimates are based on the correlations described in RPP-14767, *Hanford Tank Waste Operations Simulator Specific Gravity Model – Derivation of Coefficients and Validation*.

A1.6.1.5 For modeling purposes, solid particulate density is assumed to be a constant 3 g/mL.

Basis: This assumption is based on RPP-9805, *Values of Particle Size, Particle Density, and Slurry Viscosity to Use in Waste Feed Delivery Transfer System Analysis*.

A1.6.1.6 The modeled composition of waste retrievals from the SSTs will be homogeneous. The modeled composition of waste transferred from a DST will reflect the composition of the specific layers (e.g., supernatant, dissolved salts, mobilized solids) being transferred.

Basis: This is a simplifying assumption required for a tractable model.

A1.6.1.7 Permit preparation activities of external agencies are not modeled and do not affect the timing of modeled activities.

Basis: This is an enabling assumption.

A1.6.1.8 The model scenario is assumed to be consistent with and bounded by the outcome of the *National Environmental Policy Act* process.

Basis: This is an enabling assumption.

A1.6.1.9 The model scenario is assumed to be consistent with and bounded by the appropriate facility authorization basis.

Basis: This is an enabling assumption.

A1.6.1.10 When appropriate, Critical Decision-2 must be approved before regulatory approval of permits can begin. A range of 33 to 36 months is assumed for permitting activities. (Note: Permitting activities are not explicitly modeled; these activities will be tracked manually.)

Basis: This assumption is based on an email from D. McDonald to M. N. Wells, “Scenario 1 and 2 Summaries – Revised Per Yesterday’s Discussion.”

A1.6.2 Lifecycle Cost Model Cost and Schedule

A1.6.2.1 Life-cycle costs are reported by federal fiscal year.

Basis: The Hanford Site uses the federal fiscal year calendar for planning and execution of projects, which is consistent with federal funding.

A1.6.2.2 The Lifecycle Cost Model Cost and Schedule baseline schedule includes all activities that are required to meet the RPP mission objectives, except WTP capital costs and the cost of IHLW canister shipping and disposal.

Basis: WTP capital expenditures to date and cost at completion are not available for inclusion in System Plan Rev. 9. In addition, final disposition of IHLW canisters has not been determined, so shipping and disposal costs are not currently known.

A1.6.2.3 The unescalated base year for System Plan Rev. 9 life-cycle cost estimates is fiscal year (FY) 2020.

Basis: System Plan Rev. 9 will be produced in FY 2020 and will incorporate the FY 2020 PMB.

A1.6.2.4 Escalation is applied to System Plan Rev. 9 life-cycle cost estimates at 2.4 percent per year, starting in 2021, to generate escalated life-cycle costs.

Basis: An escalation rate of 2.4 percent was used in the 2019 Out-Year Planning Estimate Range and will be used in System Plan Rev. 9 for consistency.

A1.6.2.5 Activity start dates and durations are driven by output from TOPSim at Work Breakdown Structure (WBS) level six in Primavera®[42]. In the life-cycle cost report's mission schedule, cost detail is rolled up to level five of the WBS for reporting purposes. The WBS level defines the amount of detail included in the estimate.

Basis: This is an enabling assumption.

A1.6.2.6 For cost modeling purposes, unless specifically defined in the Lifecycle Cost Model results, decontamination and decommissioning is spread over the 5 years following the completion of operations of a facility.

Basis: This is an enabling assumption.

A1.6.2.7 There is no cost assumed for interim storage of potential CH-TRU waste at CWC. Costs for disposing of radioactive non-HLW consistent with TRU waste from CWC are assumed to be the same as those for disposing of the waste directly from the packaging facility.

Basis: This is a simplifying assumption.

A1.6.2.8 Cost estimates and scheduled activities from the 2016 Baseline Update (escalated to current dollars), 2019 Out-Year Planning Estimate Range, and the 2020 Baseline Update will form the basis of the cost analyses in System Plan Rev. 9, as appropriate.

Basis: Using the most current estimate for activities (FY 2020 PMB), along with the existing out-year estimates, will result in the most current and complete life-cycle cost and schedule estimate.

A1.6.2.9 The WTP operations costs are aligned with the 2019 Independent Government Cost Estimate performed for the DOE by independent estimators.

Basis: The results of the Independent Government Cost Estimate were provided by DOE for use in System Plan Rev. 9 scenario cost estimates. The new operations costs and the direction to use those costs are provided in WRPS-2001169, "Costs to Use for WTP Operations."

[42] Primavera® is either a trademark or registered trademark of Oracle and/or its affiliates in the United States and/or other countries.

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APPENDIX B

MATRIX OF TRI-PARTY AGREEMENT SYSTEM PLAN REQUIREMENTS

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Table B-1. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (4 pages)

Item	TPA Milestone M-062-40 Requirement	Implementation in System Plan Rev. 9	Cross-Reference
1	Submit a System Plan to Ecology describing the disposition of all tank waste managed by ORP and completion of the treatment mission.	All scenarios treat and/or disposition all waste managed by ORP and are described in detail in this system plan.	Section 4.0, Key Accomplishments and Updates Since System Plan Revision 8 Section 5.0, Scenarios
2a	Update every 3 years to document optimizations in retrievals and treatment.	This revision of the system plan was submitted to Ecology by October 31, 2020. The previous revision was submitted by October 31, 2017. The system plan discusses the most up-to-date optimizations and studies of retrieval sequencing and retrieval and treatment technologies.	2020 System Plan submittal letter[a] 2017 System Plan submittal letter[b] Section 4.0, Key Accomplishments and Updates Since System Plan Revision 8 Section 5.0, Scenarios
2b	Those optimizations are to complete such retrievals (SST retrievals) as quickly as is technically feasible (but not later than the date established in Milestone M-045-70 [currently 12/31/2040]) and complete such treatment (tank waste treatment) as quickly as is technically feasible (but not later than the date established in Milestone M-062-00 [currently 12/31/2047]).	This information is provided for each scenario in Section 5.0	Section 5.0, Scenarios
3	For each scenario evaluated, present: a system description for each system used; planning bases; description of key issues, assumptions, and vulnerabilities and how they are addressed; sensitivity analysis for select key assumptions; estimated schedule impacts relative to the baseline, including cost for a limited subset of scenarios; identification of new equipment, technology, or actions needed; identification of issues, techniques, or technologies that need further evaluation to accelerate retrievals and treatment; and impacts on closure activities.	The system descriptions, planning bases, and risks (key issues and vulnerabilities) for the Baseline Case are described in Sections 3.0, A1.0, and 7.0, respectively. The schedule and cost for the Baseline Case and for each alternative scenario, as well as unique system descriptions, planning bases, and risks for the alternative scenarios, are found in Section 5.0.	Section 3.0, System Descriptions Section 5.0, Scenarios Section 5.0, Risk and Opportunity Management/Contingency Planning Section A1.0, Model Starting Assumptions
4	**Tank Waste Treatment** The Plan will evaluate scenarios and identify potential near- and long-term actions to optimize tank waste treatment and, at a minimum:	Potential near- and long-term actions to optimize tank waste treatment are discussed as the actions pertain to each scenario in Section 5.0.	Section 5.0, Scenarios
4a	Describe how the tank waste treatment mission can pretreat 100% of the retrievable tank waste (at a rate sufficient to operate the HLW Facility, LAW Facility and Supplemental Treatment System simultaneously at their estimated average production rates).	The results for each of the scenarios, found in Section 5.0, describe how 100% of the waste can be pretreated in various forms. Forms of pretreatment, including the WTP Pretreatment Facility and the HFPF, are described in Section 3.3.4 and Section 5.2, respectively.	Section 3.3, Treatment Section 5.1, Scenario 1 – Baseline Case Section 5.2, Scenario 2 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks Section 5.3, Scenario 3 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Independent High-Level Waste Sampling and Pretreatment Facility Section 5.4, Scenario 4 – Retrieval-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks and Add New Double-Shell Tanks Section 5.5, Scenario 5 – Periodic Double-Shell Tank Failures

Table B-1. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (4 pages)

Item	TPA Milestone M-062-40 Requirement	Implementation in System Plan Rev. 9	Cross-Reference
4b	Describe how the tank waste treatment mission can vitrify 100% of the separated high-level waste stream at estimated average production rates.	All scenarios describe how the tank waste treatment mission can vitrify 100% of the separated high-level waste stream.	Section 5.1, Scenario 1 – Baseline Case Section 5.2, Scenario 2 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks Section 5.3, Scenario 3 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Independent High-Level Waste Sampling and Pretreatment Facility Section 5.4, Scenario 4 – Retrieval-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks and Add New Double-Shell Tanks Section 5.5, Scenario 5 – Periodic Double-Shell Tank Failures
4c	Describe how the tank waste treatment mission can vitrify 100% of the separated LAW stream at estimated average production rates, and appropriately manage secondary waste streams.	All scenarios describe how the tank waste treatment mission can vitrify 100% of the separated LAW stream. All scenarios address management of secondary waste. Facilities associated with separated LAW vitrification and secondary waste management are described in the system descriptions (Section 3.0).	Section 5.0, Scenarios Section 3.4.1, Central Waste Complex Section 3.4.2, State-Approved Land Disposal Site Section 3.4.3, Integrated Disposal Facility Section 3.4.4, Consolidated Waste Management Facility
5	The Plan will take into account the results from testing of the Pretreatment Engineering Platform and other studies.	See System Plan Rev. 8[c], and the updates provided in Section 4.0.	Section 4.0, Key Accomplishments and Updates Since System Plan Revision 8
6	**Supplemental Treatment**		
6a	The Plan will also describe how much total sodium will need to be treated.	Sodium quantities requiring treatment are reported in the results for each scenario.	Section 5.0, Scenarios Section 6.0, Scenario Comparison
6b	The Plan will also describe the needed capacity for supplemental treatment to have all the tank waste treated by a date that is as quickly as is technically feasible (but not later than the date established in Milestone M-062-00 [currently 12/31/2047]) both with and without consideration of whether such further optimization would be excessively difficult or expensive within the context of such activities and any impact on the RPP cleanup mission.	Discussions in Section 5.0 and Section 6.0 describe the supplemental treatment capacity needed so that this system does not limit the overall treatment capacity.	Section 5.0, Scenarios Section 6.0, Scenario Comparison
6c	The System Plan will outline specific options to treat all the LAW. Such options include build and operate a 2nd Vitrification Facility and build and operate a Bulk Vitrification Facility.	All scenarios outline options to treat all LAW using either vitrification or grout technologies for supplemental treatment.	Section 5.1, Scenario 1 – Baseline Case Section 5.2, Scenario 2 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks Section 5.3, Scenario 3 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Independent High-Level Waste Sampling and Pretreatment Facility Section 5.4, Scenario 4 – Retrieval-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks and Add New Double-Shell Tanks Section 5.5, Scenario 5 – Periodic Double-Shell Tank Failures
7	**Tank Waste Retrieval**		
7a	The Plan will evaluate scenarios and identify potential near- and long-term actions to optimize tank waste retrieval.	The most recent version of RPP-PLAN-40145[d] was used as an input to the modeling, which provided estimated minimum retrieval durations based on tank properties and retrieval technologies. The model optimized the retrieval sequence to maintain sufficient feed to the treatment facilities for all scenarios.	Section 5.0, Scenarios
7b	The Plan will consider SST integrity information, including the SST integrity assurance review provided under Milestone M-045-91 and any further integrity assessments.	SST integrity information is an input to the model and to RPP-PLAN-40145,[d] and is accounted for in the modeled retrieval sequences and durations for all scenarios.	Section 5.0, Scenarios

Table B-1. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (4 pages)

Item	TPA Milestone M-062-40 Requirement	Implementation in System Plan Rev. 9	Cross-Reference
7c	The Plan will consider waste retrieval rates sufficient to operate all waste treatment facilities at their full capacities, considering optimized waste feed rates.	Changed assumptions agreed to by DOE and Ecology for System Plan Rev. 9 for SST retrievals and 242-A Evaporator operation led to a 5-year delay in the completion of all SST retrievals. The slip in SST retrievals and additional constraints modeled for DST retrievals led to a 3-year delay in completing tank waste treatment.	Section 5.1, Scenario 1 – Baseline Case Section 5.2, Scenario 2 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks Section 5.3, Scenario 3 – Treatment-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Independent High-Level Waste Sampling and Pretreatment Facility Section 5.4, Scenario 4 – Retrieval-Favored Direct-Feed Low-Activity Waste and Direct-Feed High-Level Waste with Early Characterization in Double-Shell Tanks and Add New Double-Shell Tanks Section 5.5, Scenario 5 – Periodic Double-Shell Tank Failures
7d	The Plan will consider the effect on waste retrieval rates of the waste retrieval technologies selected through the TWRWP process.	RPP-PLAN-40145[d] and RPP-40545[e] include the retrieval technologies already selected via the TWRWP process for specific tanks, and the retrieval technologies anticipated to be chosen for future retrieval efforts in other tanks. The parameters and rates associated with each technology and each tank are included in the updates to TOPSim, and therefore underpin the scenario-specific results presented in System Plan Rev. 9. (Note: The waste retrieval information used in TOPSim is for modeling purposes only; the TWRWP process determines which retrieval technologies will be deployed in a given tank.)	Section 5.0, Scenarios
7e	The Plan will consider sequences for remaining SSTs and DSTs to be retrieved based on a risk prioritization strategy, waste treatment feed optimization as affected by blending, and WMA closure considerations.	All scenarios incorporate risk and waste treatment feed optimization in the modeled retrieval sequences. Sensitivity case Scenario 1A evaluates the retrieval of U Tank Farm after A/AX Tank Farms.	Section 5.0, Scenarios
7f	The Plan will also take into account the results from previous waste retrievals and other waste treatment studies, including the retrieval methodologies that could be employed and estimated waste volumes to be generated for transfer to the DST or other safe storage, DST space evaluations for the waste retrieval sequence, and proposed improvements to reduce waste retrievals durations.	RPP-PLAN-40145[d] takes into account results from previous waste retrievals. Retrieval processes selected for specific tanks are reflected in RPP-PLAN-40145[d] and RPP-40545,[e] which give estimated waste volumes that are used as inputs to the model. All scenarios examine the effect on DST space of SST retrievals. Scenarios 2, 3, and 4 evaluate adding new DSTs to support SST retrievals. Scenario 5 evaluates the effects on the mission from a sequence of DST failures.	Section 5.0, Scenarios
8	**Contingency Planning**		
8a	The Plan will identify and consider possible contingency measures to address the following risks:	All of the scenarios defined for System Plan Rev. 9 explicitly address elements listed in the milestone. Details are provided in Section 7.0.	Section 7.0, Risk and Opportunity Management/Contingency Planning
8b	Results from SST integrity evaluations	Details are provided in Section 7.2.	Section 7.2.1, Possible Contingency Measures: Single-Shell Tank Integrity
8c	If retrievals take longer than originally anticipated and there is potential impact to the schedule for retrieving specified tanks under this agreement	Details are provided in Section 7.2.	Section 7.2.2, Possible Contingency Measures: Retrievals Take Longer
8d	If DST space is not sufficient or is not available to support continued retrievals on schedule	Details are provided in Section 7.2.	Section 7.2.3, Possible Contingency Measures: Double-Shell Tank Space
8e	If any portion of the WTP does not initiate cold commissioning on schedule	Details are provided in Section 7.2.	Section 7.2.4, Possible Contingency Measures: Delayed Waste Treatment and Immobilization Cold Commissioning
8f	If any portion of the WTP does not complete hot start on schedule	Details are provided in Section 7.2.	Section 7.2.5, Possible Contingency Measures: Delayed Waste Treatment and Immobilization Plant Hot Start
8g	If operation of the WTP does not meet treatment rates that are adequate to complete retrievals under the schedule in this agreement	Details are provided in Section 7.2.	Section 7.2.6, Possible Contingency Measures: Waste Treatment and Immobilization Plant Treatment Rates

Table B-1. Matrix of System Plan Requirements Cross-Referenced to Location in Document. (4 pages)

Item	TPA Milestone M-062-40 Requirement	Implementation in System Plan Rev. 9	Cross-Reference
8h	The contingency measures identified for consideration should include, but not be limited to, providing new, compliant tanks with sufficient capacity and in sufficient time to complete retrievals under this agreement, regardless of WTP operational deficiencies or retrieval conditions.	Details are provided in Section 7.2.	Section 7.2, Milestone M-062-40 Risks

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[b] 17-WSC-0048, 2017, "U.S. Department of Energy, Office of River Protection Submittal of ORP-11242, *River Protection Project System Plan*, Rev. 8 in Completion of Hanford Federal Facility Agreement and Consent Order Milestone M-062-40D," (Letter to J.A. Hedges, Washington State Department of Ecology), from K.W. Smith, U.S. Department of Energy, Office of River Protection, Richland, Washington, October 31.
[c] ORP-11242, 2017, *River Protection Project System Plan*, Rev. 8, U.S. Department of Energy, Office River Protection, Richland, Washington.
[d] RPP-PLAN-40145, 2016, *Single-Shell Tank Waste Retrieval Plan*, Rev. 6, Washington River Protection Solutions LLC, Richland, Washington.
[e] RPP-40545, 2016, *Quantitative Assumptions for Single-Shell Tank Waste Retrieval Planning*, Rev. 5, Washington River Protection Solutions LLC, Richland, Washington.

DOE = U.S. Department of Energy.
DST = double-shell tank.
Ecology = Washington State Department of Ecology.
HFPF = High-Level Waste Feed Preparation Facility.
LAW = low-activity waste.
ORP = U.S. Department of Energy, Office of River Protection.
SST = single-shell tank.
TPA = Tri-Party Agreement.
TWRWP = tank waste retrieval work plan.
WMA = waste management area.
WTP = Waste Treatment and Immobilization Plant.

APPENDIX C

SCENARIO RESULTS SUMMARY FIGURES

CONTENTS

The following figures were generated from the System Plan Rev. 9 modeling. Any comparison between or among documents containing data based upon model simulation(s) must be made in the context of the input assumption sets and programmatic objectives for each simulation. The assumptions for these scenarios are provided in the main text of the document and should be reviewed with the modeling results presented.

Figure C-1. Baseline Case Results Summary. (2 pages)

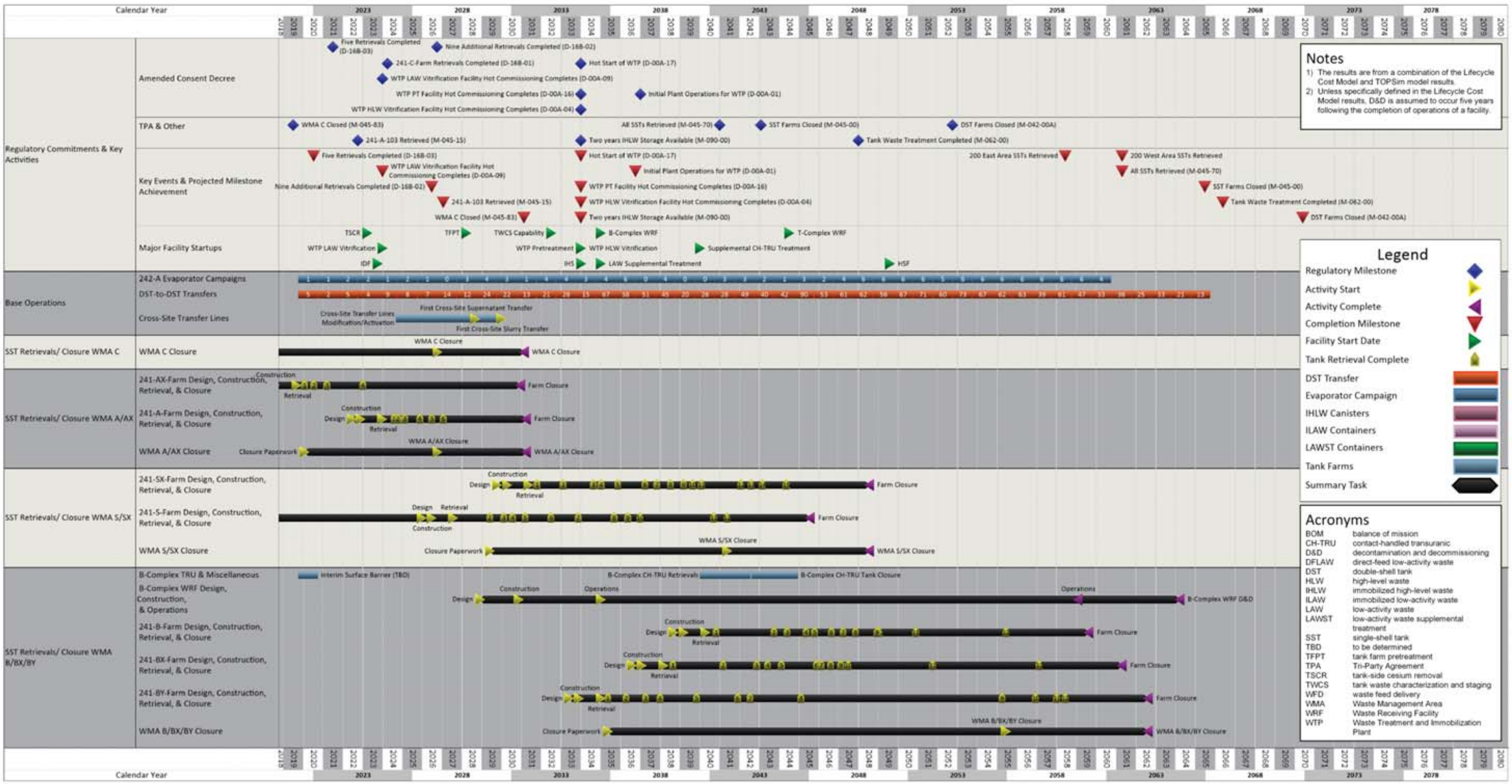


Figure C-1. Baseline Case Results Summary. (2 pages)

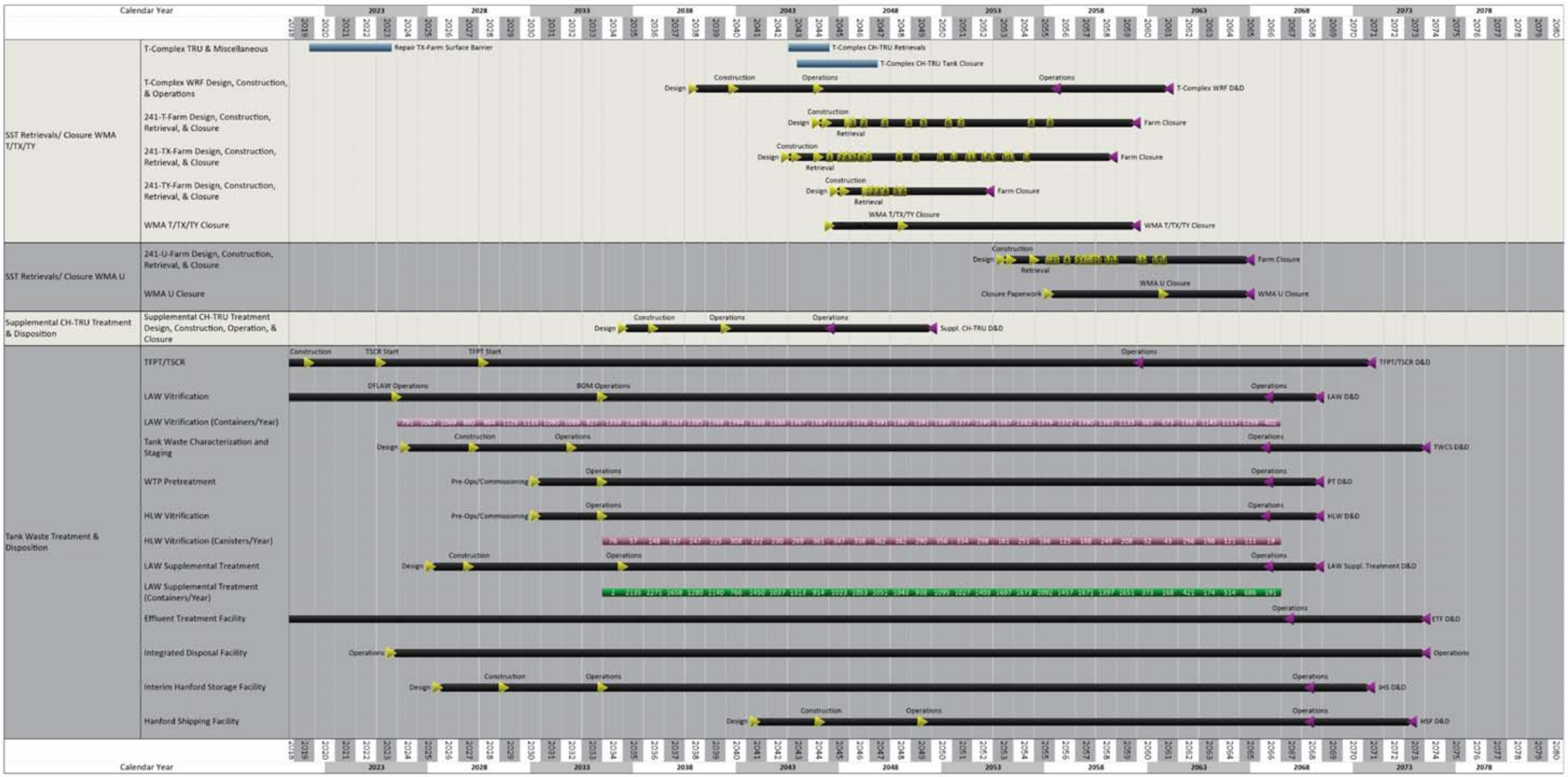


Figure C-2. Scenario 1B Results Summary. (2 pages)

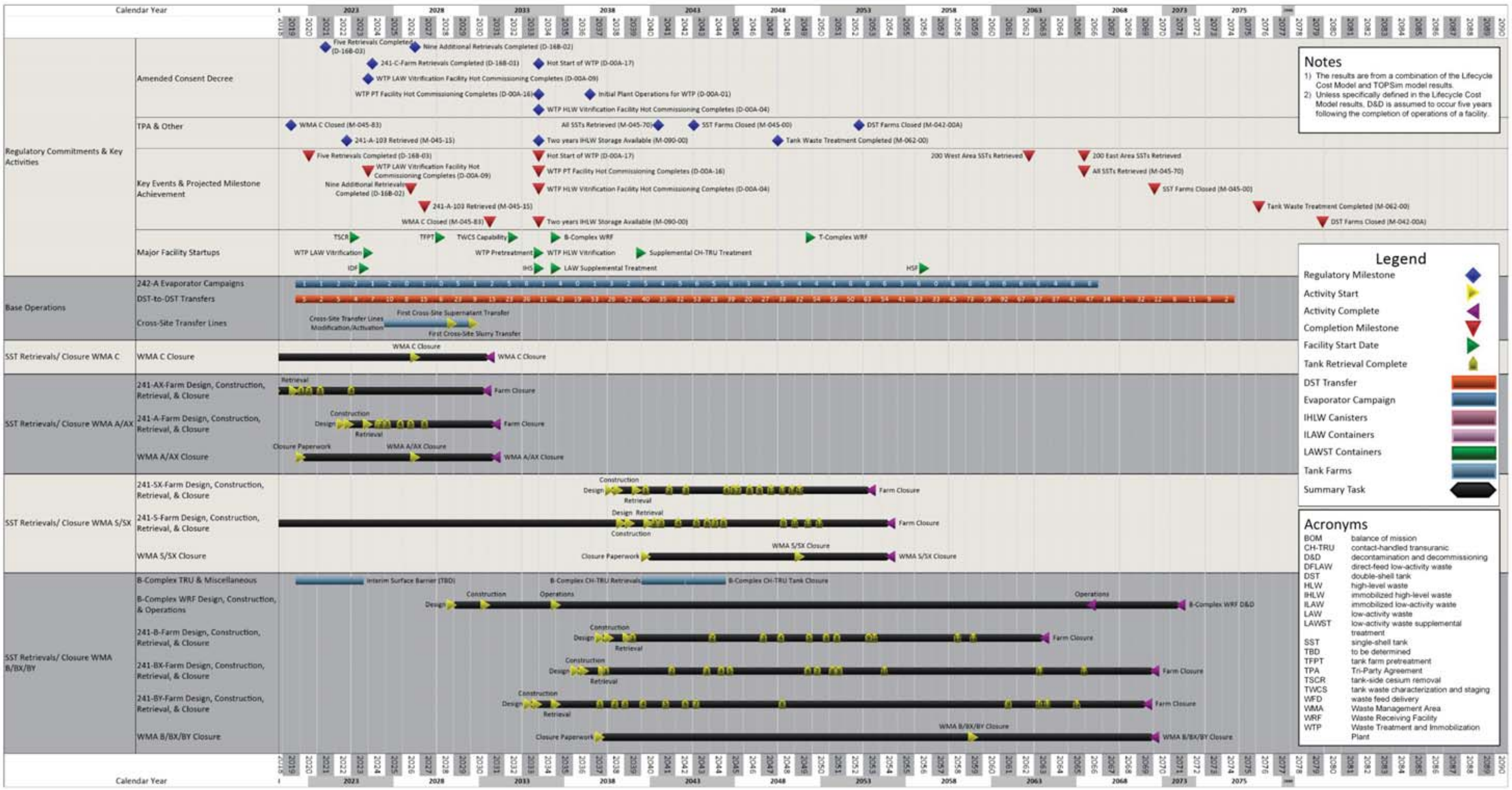


Figure C-2. Scenario 1B Results Summary. (2 pages)

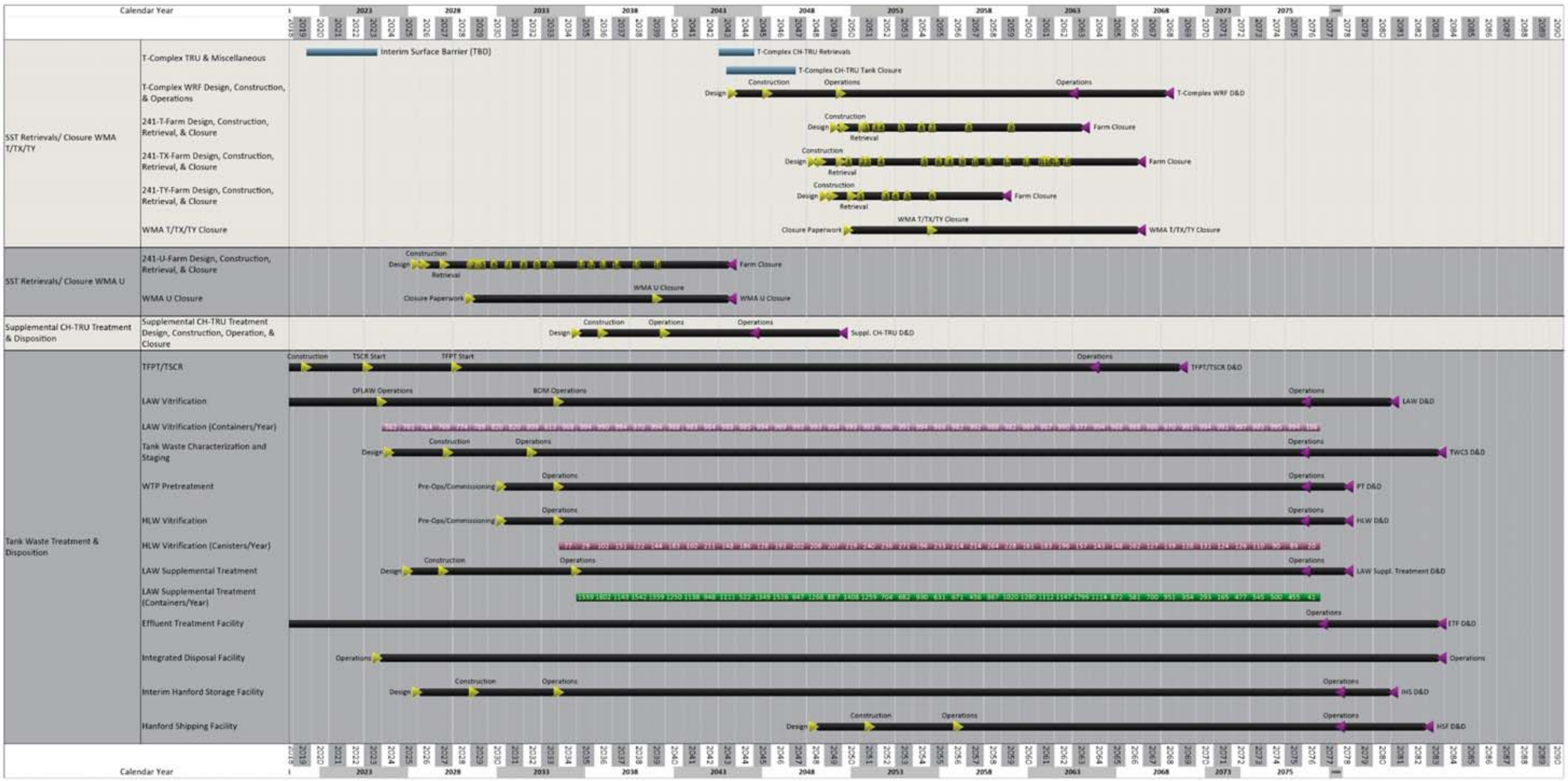


Figure C-3. Scenario 2 Results Summary. (2 pages)

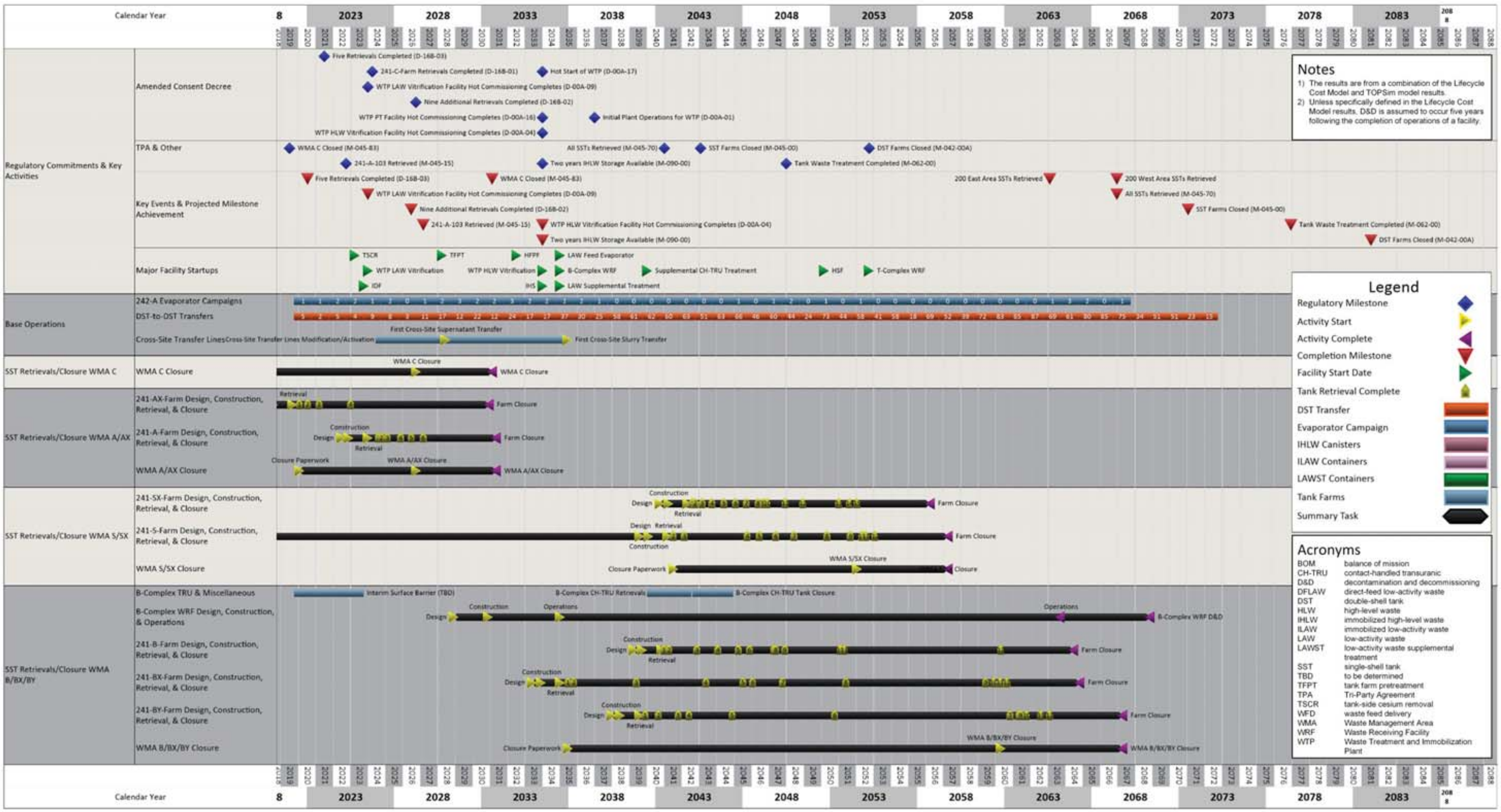


Figure C-3. Scenario 2 Results Summary. (2 pages)

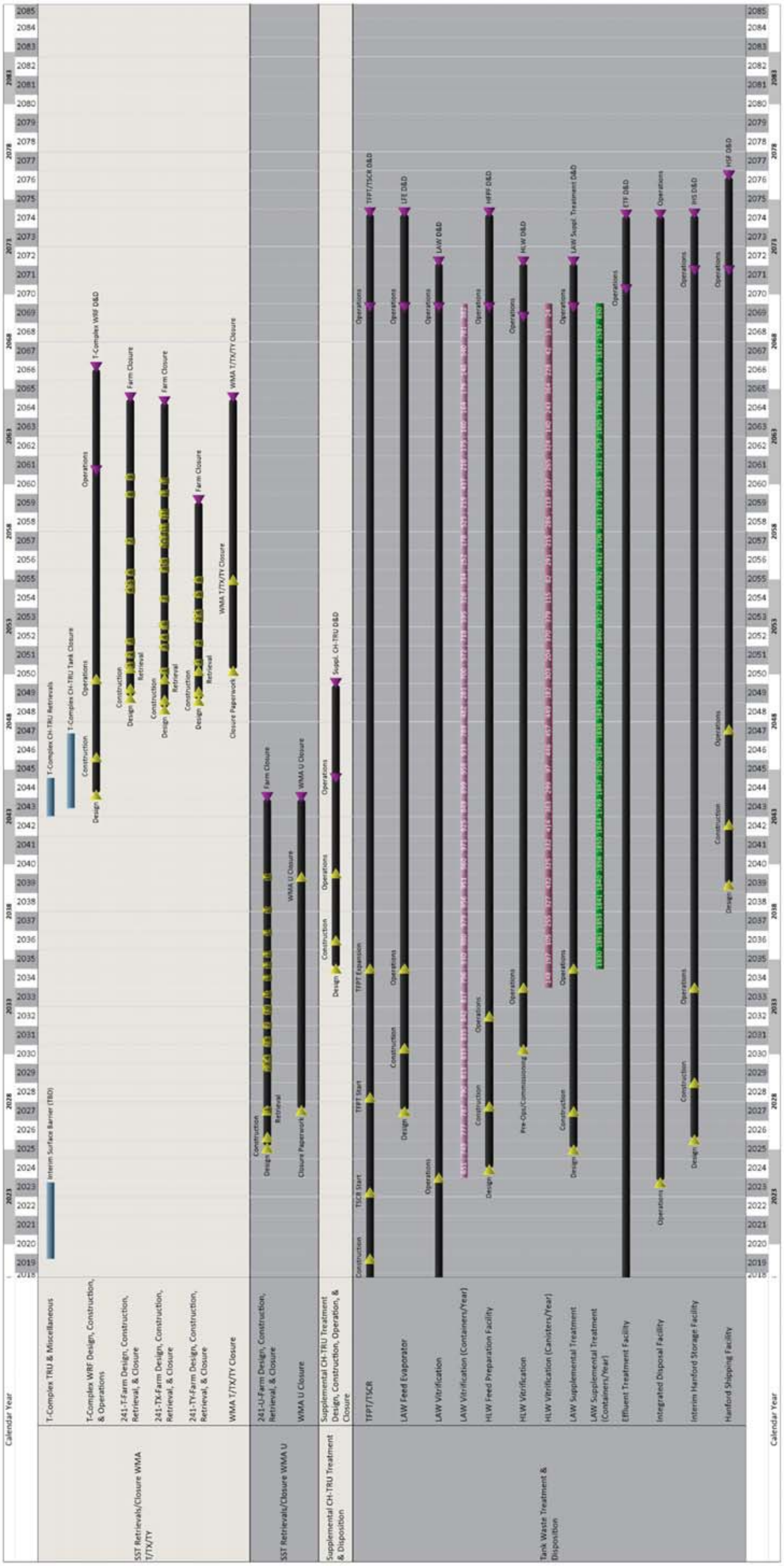


Figure C-4. Scenario 3 Results Summary. (2 pages)

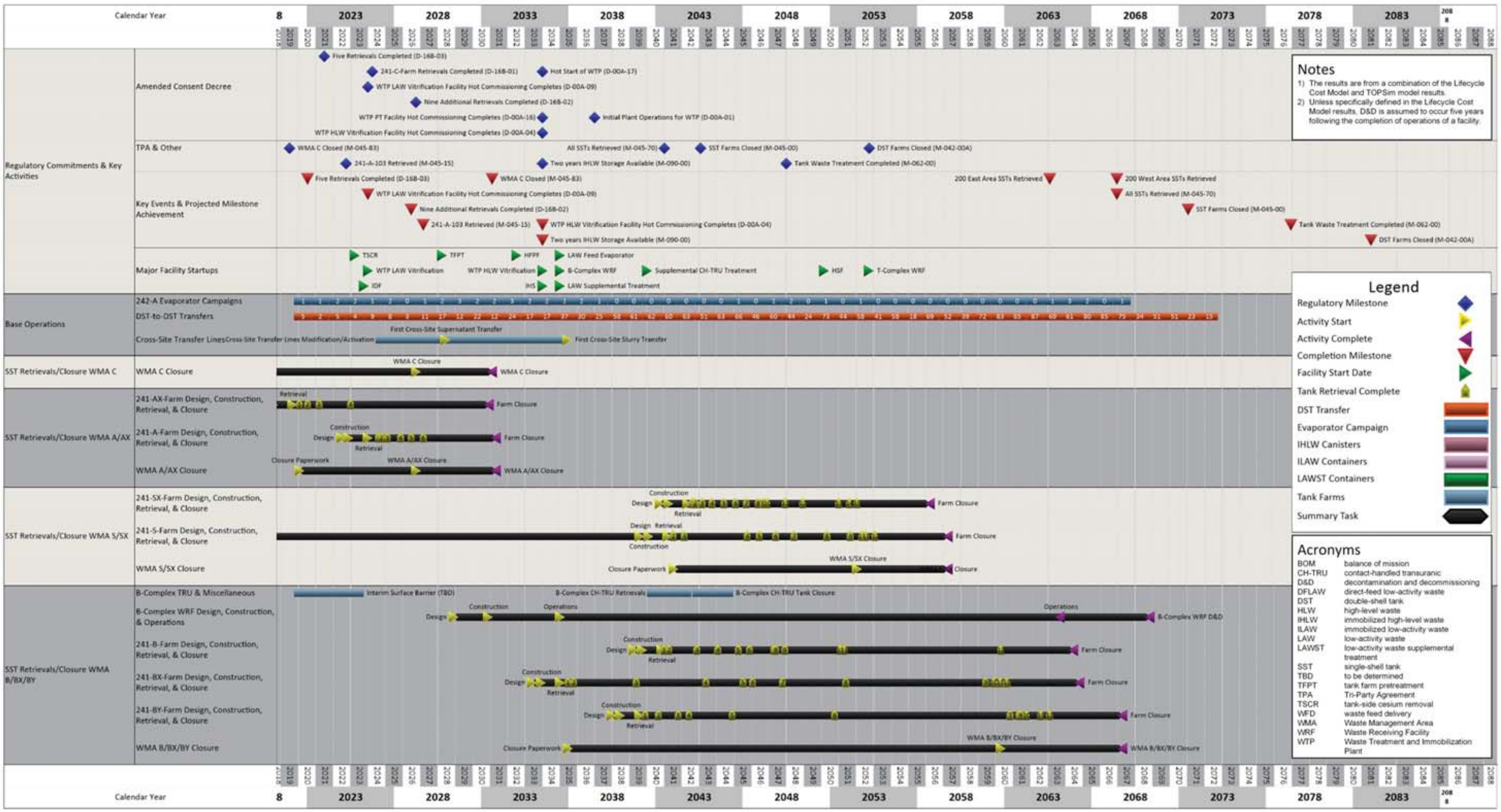


Figure C-4. Scenario 3 Results Summary. (2 pages)

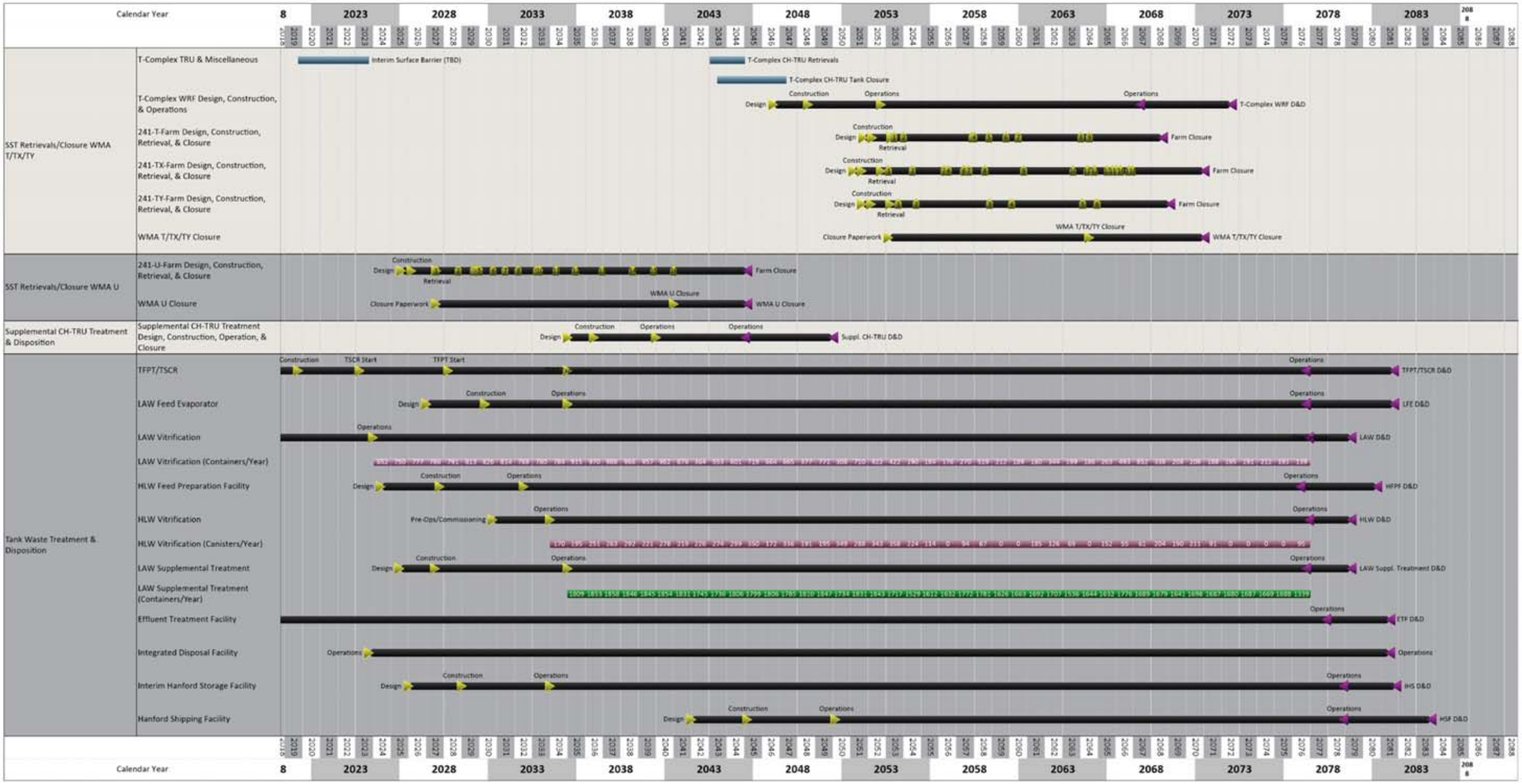


Figure C-5. Scenario 5 Results Summary. (2 pages)

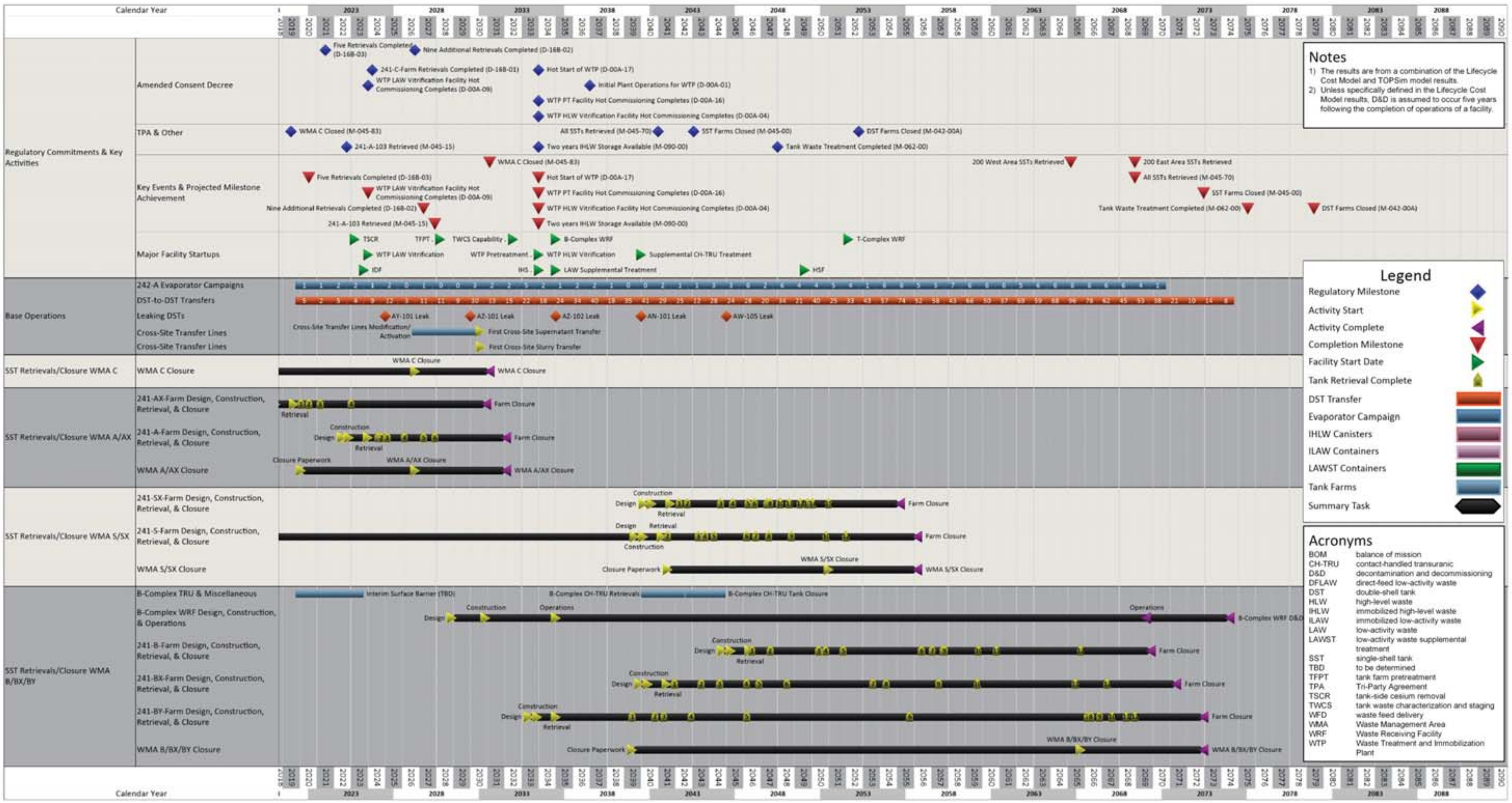
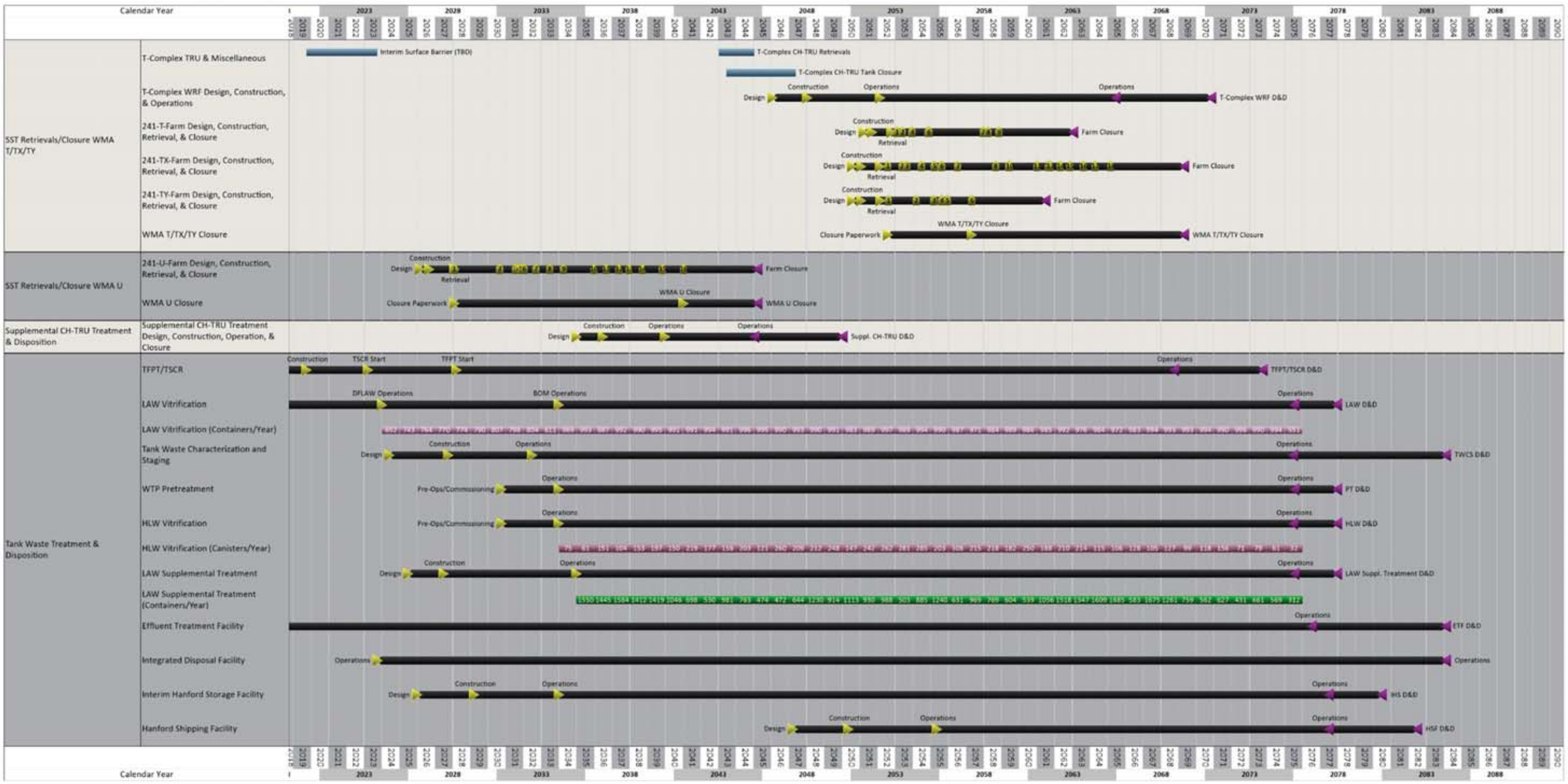


Figure C-5. Scenario 5 Results Summary. (2 pages)



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